Lower Feather River Corridor Management Plan

State of California
The Natural Resources Agency
Department of Water Resources
Division of Flood Management

FloodSAFE CALIFORNIA

PUBLIC SAFETY ENVIRONMENTAL STEWARDSHIP ECONOMIC STABILITY

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Cover Photo: Shanghai Rapids, River Mile 24.2, Lower Feather River. Photo taken August 11, 2011 by Tony Danna

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The Natural Resources Agency
Department of Water Resources
Division of Flood Management
3310 El Camino Ave, Suite 140
Sacramento, CA 95821

Contact:

Earl Nelson
Environmental Program Manager
916/263-0297

Prepared by:

AECOM
2020 L Street, Suite 400
Sacramento, CA 95811

Contact:

Susan Sanders
Senior Wildlife Biologist
916/414-5800

60217656
06.23.14

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EXECUTIVE SUMMARY

The California Department of Water Resources Division of Flood Management (DWR DFM) has prepared the Lower Feather River Corridor Management Plan (LFRCMP) to establish a long-term vision and strategy for managing the 20-mile-long, 12,000-acre river corridor between the cities of Yuba City and Marysville at the north end, and the Sutter Bypass at the south end. The LFRCMP proposes implementing management actions to facilitate floodway management and maintenance of flood control facilities, enhance habitat and ecosystem functions, and support agricultural and recreational activities. The LFRCMP also describes a programmatic permitting approach that would efficiently link regulatory permitting and habitat restoration actions to more than offset habitat impacts in advance and thereby simplify obtaining permits for maintaining flood management facilities. This LFRCMP provides a planning tool and informational resource for flood managers at DWR and Local Maintaining Agencies, resource agencies, environmental and recreation advocates, farmers, and the public, and was created with input from many of these parties.

Management actions proposed in the LFRCMP would:

- maintain the conveyance capacity of the managed floodway for public safety;
- simplify the regulatory permitting process for flood facility maintenance activities;
- provide opportunities to increase the extent and connectivity of seasonal shallow aquatic habitat, frequently inundated floodplains, and shaded riverine aquatic and riparian habitats;
- improve connections for nutrient and biomass exchange between terrestrial and aquatic systems;
- create conditions promoting successional stages of riparian habitat intermixed with mosaics of upland habitat, which would foster species diversity;
- improve habitat for special-status wildlife and fish species;
- promote the recovery and stability of native species populations, overall biotic community diversity;
- conserve agricultural lands and supporting infrastructure while maintaining the floodway and improving habitat values; and
- enhance recreational opportunities where compatible with adjacent land uses.

A paramount goal of DWR's DFM is to provide flood protection to safeguard life and property. Therefore, hydraulic and hydrologic modeling was a crucial element of the LFRCMP analysis. Modeling was conducted to determine whether management actions, when combined with recent levee setback and revegetation projects, could affect public safety by increasing either major flood stages or scour velocities near levees. Flood modeling confirmed that the proposed actions would not increase flood risk. Additional hydrodynamic and sediment transport modeling was then conducted to assess opportunities to enhance ecosystem functions, create new habitats, and reduce the burden of floodway maintenance in specific locations. The management actions included in the LFRCMP were informed and refined by the results of the hydraulic and hydrologic modeling. The resulting

flood models for this reach of river have been added to DWR's Library of Models, and are expected to be used by the Central Valley Flood Protection Board in reviewing applications for encroachment permits in the floodway.

DWR will continue to collaborate with all parties with an interest in the flood management and environmental stewardship of the Lower Feather River corridor. In addition, DWR will work to integrate the management actions and permitting approach described in the LFRCMP with similar efforts undertaken as part of the ongoing Central Valley Flood Protection Plan Conservation Strategy. The LFRCMP thus provides a regional contribution to DWR's overarching statewide efforts to improve public safety, environmental stewardship, and long-term economic stability.

REPORT OVERVIEW

ES.1 PURPOSE AND BACKGROUND

The California Department of Water Resources (DWR) has prepared the *Lower Feather River Corridor Management Plan* (LFRCMP) to establish a long-term vision and strategy for managing the 20-mile-long river corridor between the cities of Yuba City and Marysville and the Sutter Bypass. The purpose of the LFRCMP is to offer an approach and recommendations for management of the Lower Feather River (LFR) corridor that would:

- protect public safety by facilitating management of the flood protection system and maintenance of flood control facilities;
- conserve, enhance, and restore habitat and ecosystem functions;
- support agricultural productivity;
- promote economic sustainability and land use compatibility, and
- improve compatible recreational opportunities

DWR's Division of Flood Management developed the LFRCMP in the context of a much larger systemwide plan, DWR's *Central Valley Flood Protection Plan* (CVFPP), the most comprehensive flood management planning effort ever undertaken in California's Central Valley. The CVFPP proposes a systemwide investment approach for sustainable, integrated flood management that will reduce flood risk, improve ecosystem function, and create a more sustainable flood management system that facilitates ongoing operations and maintenance of Central Valley flood control facilities. A key element of the CVFPP is the *Central Valley Flood System Conservation Framework* (Conservation Framework), which describes how environmental stewardship can be integrated into flood management activities.

Based on the principles and goals described in the Conservation Framework, DWR is developing the *Central Valley Flood System Conservation Strategy* (Conservation Strategy). The approach and management actions proposed in the LFRCMP have been informed by collaboration and coordination with the ongoing CVFPP and Conservation Strategy efforts. Development of the LFRCMP has also been informed by the ongoing work of the Feather River Regional Flood Management Planning (RFMP) efforts, a CVFPP program designed to assist local agencies to develop long-term regional flood management plans that address local needs.

This LFRCMP provides a planning tool and informational resource for flood managers at DWR and other Local Maintaining Agencies, resource agencies, environmental and recreation advocates, farmers, and the general public, and was created with input from many of these parties. The LFRCMP incorporates the expertise and advice of the LFRCMP Work Group (Work Group), an assemblage of knowledgeable stakeholders comprising representatives from State, federal, and local agencies, including maintenance districts; nongovernmental organizations; agricultural interests; and elected officials.

ES.2 MANAGEMENT CHALLENGES ON THE LOWER FEATHER RIVER

The Work Group was tasked with identifying key issues that should be addressed in the LFRCMP, and completed a Delphi exercise to assist with that task. (See Chapter 2, "Factors Affecting Development of the Lower Feather River Corridor Management Plan," for more information.) DWR and the Work Group identified the stressors and challenges highlighted below, which prompted subsequent development of proposed future scenarios and potential management actions to address those challenges. Chapter 4, "Management Goals, Challenges, and Opportunities," provides an in-depth discussion of these management challenges.

ES.2.1 FLOODWAY MANAGEMENT

With construction of the Feather River, Bear River, and Star Bend levee setback projects and other recent flood control system improvements, nearly all levees in the study area now have adequate freeboard (i.e., greater than 3 feet) above the 100- and 200-year flood stage. Only one location on the Feather River, between RM 17 and Wilkie Avenue (RM 16), has less than 3-feet of freeboard on the right (west) levee during a 200-year flood event. However, some challenges related to maintaining floodways in the LFRCMP study area remain, including managing deposition of sediment. Sediment deposition in the Sutter Bypass is an ongoing concern for flood risk in the LFRCMP study area because it contributes to a cumulative decrease in flow capacity and increases flood risk over time. The area of convergence between the Sutter Bypass, Feather River, and Sacramento River is an area where three major watershed drainages converge, resulting in backwater effects during high flows that increase sedimentation and further reduce floodway capacity with each flood. The main channel of the Feather River has reduced capacity from extensive sand deposition and shallow shoaling downstream of the Bear River to the Sutter Bypass.

Another challenge for flood managers who maintain the LFR floodway is the need to address environmental concerns during flood maintenance activities. Completing routine floodway maintenance, repairs, and flood management projects while complying with federal and State environmental laws that protect sensitive resources is a major challenge for flood managers working in the LFRCMP study area. Acquiring permits and securing compensatory mitigation for floodway management can be expensive and time consuming, and can delay the implementation of needed work. Vegetation growing in the floodway can restrict floodwater conveyance capacity, particularly where riparian vegetation has been allowed to become mature, dense, and multilayered. Concerns about maintaining the floodway are particularly acute in the constricted areas described above. Flood management agencies responsible for maintaining the floodway on the LFR seek to minimize cost and delays for work such as vegetation clearing and sediment removal. These agencies also strive to minimize conflicts between floodway maintenance, habitat enhancement, recreation, and agriculture.

ES.2.2 ECOSYSTEM AND HABITAT

The LFRCMP study area supports a diversity of native plant communities and significant fish and wildlife resources, and much of the area is managed for its natural resource values by the State as part of the Feather River Wildlife Area, Bobelaine Audubon Sanctuary, and the Feather River and Bear River setback areas. Additionally, numerous riparian and wildlife habitat restoration projects have been planned for the LFRCMP study area. If funded and implemented these projects would increase the area's current and potential value for biological resources. However, riparian ecosystems in the LFRCMP study area and in the region have been fragmented and degraded by a variety of stressors. During the last 150 years, floodplain inundation and channel meander migration have been substantially altered by hydraulic mining and construction of dams and levees, resulting in perturbations to natural sediment transport and hydrologic regimes. Channel incision at various locations on the Feather River, combined with these other factors, has significantly reduced the frequency and duration of natural floodplain inundation. The Feather River floodplain is so disconnected from the channel that ecologically significant, frequent flood flows have been substantially curtailed compared with historic conditions.

The Feather River Levee Setback Project removed a levee that separated the river's floodplain from the river, offering restoration opportunities in the new setback area. Still, the elevation of the floodplain relative to the river channel remains a barrier to restoring the natural dynamic processes that support aquatic and terrestrial floodplain ecosystems. Natural riverine processes have been further altered by installation of bank protection and revetment on eroding banks in the LFRCMP study area. The presence of this bank protection and revetment has reduced the availability of shaded riverine aquatic (SRA) habitat for terrestrial and aquatic species; it also has reduced habitat for species such as bank swallow, which rely on natural eroding banks for nesting habitat.

Populations of terrestrial species in the LFRCMP study area, including special-status species such as western yellow-billed cuckoo, Swainson's hawk, bank swallow, and valley elderberry longhorn beetle, have been adversely affected by these changes in hydrologic and geomorphic processes, and by the loss and fragmentation of riparian, upland, and SRA habitats. Aquatic habitats for salmonids and other native fishes, including special-status fish species such as Chinook salmon, Central Valley steelhead, and Sacramento splittail, have also been substantially reduced or degraded by these changes in hydrologic and geomorphic processes, and by reduction of SRA habitat. Loss of seasonal floodplains adversely affects the survivorship of juvenile salmonids, and isolated pools can strand fish, including juvenile salmonids, when flood flows recede. Another source of fish mortality in the LFRCMP study area is the presence of unscreened water diversions.

Other stressors affecting the ecosystems and habitats of the LFR include the spread of nonnative, invasive plant species. Such plant species can alter the structure, function, and composition of plant communities in riparian and adjacent habitats, and can compete with and displace native vegetation. They also generally provide low-quality wildlife habitat. Dense stands of invasive species can alter channel morphology by retaining sediments and increasing the channel's hydraulic roughness, restricting flows and reducing flood conveyance.

ES.2.3 RECREATION

The LFRCMP study area offers many recreation opportunities, including hunting, fishing, hiking, and bird watching, to the residents of Yuba and Sutter counties and to visitors, but no trail system exists to provide connectivity throughout the LFRCMP study area.

In addition, opportunities for public access to the river are limited. A shortage of safe, public river access points can promote the use of unsafe ad-hoc access points, increase boating accidents, and increase the number of boats

stranded without safe egress points. By contrast, providing such access/egress points can improve safety, allow for easier patrols, and reduce accidents from attempts to climb steep slopes. Boat access in the Nelson Slough area has been identified as a key need. Developing watercraft river access here would create new access along a long stretch of the river that lacks river access, and would support additional opportunities for fishing.

Another recreation challenge in the LFRCMP study area is the illegal use of off-road vehicles (ORVs), which can put other recreational activities, sensitive habitats, agricultural infrastructure, and flood management structures at risk.

ES.2.4 AGRICULTURE

Agriculture in and near the LFRCMP study area provides substantial economic and societal benefits locally and in the region, and provides some habitat benefits to wildlife. A crucial challenge for agricultural users is to protect the approximately 3,000 acres of orchards in the LFRCMP study area and support the agricultural lands outside the levees.

Some of the management difficulties associated with sustaining agriculture in the LFRCMP study area include the increased frequency of inundation of orchards located on the waterside of the levee (since completion of the Feather River Levee Setback Project). Once every 2–3 years on average, orchards at the lower elevations in the southern portion of the Feather River setback area are inundated throughout much of the growing season. Exposure to flood flows and saturated, anaerobic soil conditions threaten the long-term viability of these areas for use as orchards.

Some of the challenges to recreation management are also concerns for agricultural users of the LFRCMP study area. For example, in some locations, ORV access to agricultural lands increases the risk of vandalism, theft, crop damage, and wildfire. Conserving agricultural lands and supporting infrastructure while maintaining the floodway, habitat values, and recreational access is a key concern and challenge.

ES.3 MANAGEMENT GOALS

Informed by an understanding of these challenges, DWR and the Work Group established the following goals and objectives for the LFRCMP:

Flood Management

- Minimize floodway maintenance costs and avoidable delays in implementing floodway maintenance.
- Minimize conflicts between floodway maintenance and ecosystem function/habitat goals.
- Ensure design floodway conveyance capacity in all reaches.
- Improve sediment management.
- Prevent processes that adversely affect levee integrity, such as erosion and animal burrows.

Ecosystem and Habitat Enhancement

- Increase the extent and connectivity of riparian/upland habitat mosaics (including riparian forest and native grasslands) for terrestrial wildlife and restore degraded wildlife habitat.
- Increase the extent and connectivity of seasonal shallow aquatic habitat, frequently inundated floodplains, SRA habitat, and riparian habitats to benefit fish and other river-dependent wildlife.
- To the extent feasible, restore dynamic channel formation processes that enable a dynamic succession and mosaic of floodplain habitat types.
- Reduce the extent and proliferation of nonnative invasive plants that interfere with floodway maintenance and restoration goals.
- Reduce existing fish entrapment conditions in the floodplain.
- Contribute to conservation and recovery of special-status species.

River Recreation

- Increase and improve river recreation access with boat ramps and locations for canoe, raft, and kayak access in underserved reaches of the river.
- Increase and improve public access and develop pedestrian trails and bank fishing sites in areas that would not disturb sensitive resources.
- Promote connectivity and access between trails, facilities, along levee roads, and open space to increase opportunities for compatible recreation and reduce trespass and gate vandalism.
- Increase public awareness of the benefits of natural ecosystem processes and provide interpretive resources to build public understanding and support for corridor management activities.
- Maintain and enhance opportunities for hunting and fishing in the California Department of Fish and Wildlife's (CDFW's) Feather River Wildlife Area.

Agriculture

- Conserve agriculture and supporting infrastructure.
- Promote integration of agricultural sustainability and ecosystem benefits.

ES.4 Hydraulic and Ecological Modeling

DWR and the Work Group began developing new management approaches for the LFRCMP study area by assessing existing channel habitat and ecological conditions, geomorphology, and hydrology. Based on that assessment and the Work Group's knowledge of constraints and opportunities in the LFRCMP study area, the group envisioned and discussed an array of conceptual future scenarios that would improve floodway

management for public safety, and ecosystem function. DWR then developed a vision of future conditions by creating a spatial rendering of project footprints and anticipated vegetation changes within the floodway to be evaluated in the hydraulic and ecological modeling.

As described in Chapter 5, "Hydraulic, Hydrologic, and Sediment Transport Modeling of Potential Future Conditions," modeling of hydraulic and hydrologic conditions and sediment transport was conducted to simulate baseline and potential future conditions under frequent and major flood scenarios in the LFRCMP study area. The modeling evaluated the effects of implementing the proposed management actions on flood hydraulics and ecosystem function. Modeling assessed channel-conveyance and sediment-transport patterns; flow constrictions; changes in floodplain inundation; and vegetation changes with altered topography and maintenance. The modeling results identified opportunities to improve passage of flood flows and sediment in the system, and to increase the extent of riparian vegetation and frequently inundated floodplain without diminishing flood protection. Specifically, the modeling evaluated how proposed management actions would affect hydraulic capacity, river stage, levee freeboard, and levels of flood protection and floodway function; enhance ecosystem processes; and increase the extent of ecologically important habitats.

The modeling was conducted by MBK Engineers (MBK) and cbec, Inc. (cbec). MBK conducted hydraulic modeling for the 100- and 200-year floods using a two-dimensional, finite-element numerical hydrodynamic model, RMA-2; cbec used a two-dimensional hydrodynamic and sediment-transport model, MIKE_21C, to simulate changes in flood hydraulics and geomorphic trends for the 100-, 10-, and 2-year-frequency flood hydrographs and to simulate a Floodplain Activation Flood[1] flow. In addition, cbec modeled the effects of the recent breach at Shanghai Rapids, including a potential maximum future expansion of breach conditions.

The first priority for hydraulic modeling in support of the LFRCMP was to determine whether the composite effect of the management actions that were initially proposed, when combined with all recent levee setback and revegetation projects, could affect public safety by increasing either major flood stages or scour velocities near levees. Therefore, the RMA-2 modeling for major floods focused on a hydraulic-sensitivity analysis of the cumulative effects of 100- and 200-year floods. The MIKE_21C model was used to evaluate the effect of a 100-year flood on channel and floodplain deposition and scour. The purpose of this sediment-transport model was to evaluate whether proposed management actions would have any beneficial or adverse effects on floodplain sediment storage, river channel incision, or sediment accumulation that would affect the main channel's conveyance capacity or the function of secondary swales. Flood modeling, based on a representative set of assumed management actions, demonstrated that the proposed actions would not increase flood risk if all the management actions are implemented as proposed. Some of the proposed actions differ slightly from the modeled actions, and the sequence for implementing the management actions was not considered in the modeling. Therefore, the potential effects of each action on conveyance capacity should be considered during implementation, to ensure the combination and sequence for implementation of the proposed actions maintains the necessary conveyance capacity to preserve public safety from flood risk.

After the first priority flood modeling was completed, additional MIKE_21C hydrodynamic modeling focused on the intended beneficial effects of LFRCMP management actions—that is, enhancing ecosystem functions,

[1] The Floodplain Activation Flood is an ecologically significant flow that can produce a characteristic set of ecological functions and outcomes, such as producing organic matter and invertebrates to fuel food webs both on and downstream of floodplains, and creating habitat that supports spawning and rearing by native fishes.

creating new habitats, and reducing the burden of floodway maintenance in specific locations. A major purpose of hydrodynamic modeling was to map and compare the effects of frequent floods (the Floodplain Activation Flood, 2-year, and 10-year flows) on the following hydraulic parameters considered important to ecosystem functions and habitat quality:

- The location, extent, and duration of floodplain inundation
- Floodplain drainage, backwater, and secondary flow pathways
- Sediment deposition and scour on floodplains

Hydrodynamic modeling was conducted in multiple phases as new hydrologic information became available and variations in potential future conditions were evaluated. The modeling was used as a culling tool to iteratively reject, modify, or add management actions and revise the conceptual design in response to preliminary results.

The results of the hydrodynamic modeling were used to identify river discharge and stage thresholds required in different locations to activate floodplains and overbank swales throughout the LFRCMP study area. The results were then used to adjust sill elevations or reject grading modifications throughout the future-conditions conceptual design process. In these ways, the results of the hydrodynamic modeling informed the development of many of the proposed management actions described below.

ES.5 PROPOSED MANAGEMENT ACTIONS

DWR proposes the following management actions to fulfill the management goals listed above. See Table 6-1 in Chapter 6, "Proposed Management Actions," for a summary of how these proposed actions would contribute to fulfilling the goals of the LFRCMP, the CVFPP, and the Conservation Strategy.

Flood Management Actions

1. Skim Sediment Mounds, Remove Berm, and Maintain Uniform Gradient in Upper State Cut from the Yuba River to Island Avenue.
2. Skim Sediment Mounds, Remove Mid-channel Ridge, and Maintain Uniform Gradient in Lower State Cut from Island Avenue to Eliza Bend.
3. Design Future Vegetation and Grading Patterns on the Feather River Setback (FRS) Floodplain to Maintain Floodway Capacity and Levee Freeboard above minimum approved by CVFPB.
4. Improve Drainage of Waterside Levee Borrow Channels at Abbott Lake and O'Connor Lakes.
5. Improve Levee Borrow Channel Drainage at Lake of the Woods, and Shorten Pump Plant 2 Drainage Ditch.
6. Cease Vegetation Clearing at Lake of the Woods from RM 13.5 to RM 12.5.
7. Set Back Corner Levee at Constriction from RM 7.7 to RM 7.4 (Left Bank).
8. Reevaluate and Realign Portions or All of the Sutter Bypass Hook Levee.
9. Incorporate Invasive Plant Control Best Management Practices into Routine Maintenance.
10. Monitor Floodway Roughness and Vegetation Patterns.
11. Continue Periodic Levee Integrity Inspections.

Ecosystem Management Actions

1. Restore Intermittent Flow to the Old Feather River Channel at Eliza Bend.
2. Restore 500 Acres of Riparian and Upland Habitat in the FRS Area.
3. Distribute Overbank Flows in Swales and Revegetate the Northern FRS Floodplain.
4. Enlarge Existing Swale to Improve Drainage in the Southern FRS Floodplain, and Plant Riparian Forest and Willow Scrub.
5. Create High-Ground Flood Refugia for Wildlife in the FRS Area.
6. Replace Frequently Inundated Orchard Areas near Lower Messick Lake with Riparian Forest/Scrub Habitats.
7. Restore 169 Acres of Riparian and Upland Habitat, and Enhance 270 Acres at Abbott Lake.
8. Improve Drainage at Abbott Lake and O'Connor Lakes.
9. Increase Overbank Flow Across the Low Ground at Star Bend and Expand Riparian Habitat.
10. Create an Overbank Swale and Vegetated Bench at O'Connor Lakes.
11. Create an Inlet Swale to Increase Overbank Flow into and through Lake of the Woods.
12. Allow Natural Vegetation Succession to Occur at Lake of the Woods from RM 13.5 to RM 12.5.
13. Create SRA Habitat and a Mosaic of Riparian/Upland Habitat at Nelson Slough.
14. Designate Bank Swallow Potential Habitat Areas.
15. Reduce Unscreened Fish Diversions.
16. Identify and Implement Feasible Opportunities to Modify Reservoir Operations for Ecosystem Benefit.
17. Identify Suitable Locations for and Plant Live Cuttings on Suitable Low-Flow Shoreline Sites to Increase SRA Habitat.

Recreation Management Actions

1. Create Trails and River Access in the Three Rivers Levee Improvement Authority FRS Area.
2. Develop Existing Canoe/Kayak Access Ramp at the Bear River.
3. Develop Multi-use Trail Network on East Bank Levee and Access Road.
4. Establish River Access to "The Riffles" at Shanghai Bend.
5. Improve Trails to Shanghai Bend Fishing/Scenic Sites and Expand Parking.
6. Develop Boat Access and Parking at Nelson Slough.
7. Expand Equestrian Access at Star Bend.
8. Develop a Loop Trail between Star Bend and the Bear River Setback Area.
9. Develop Multi-use Levee Trail from Boyd's Pump to the Yuba City Boat Ramp.
10. Develop Nature Trails at Halprin Lagoon.

11. Develop Park at Yuba City's Mosquito Beach Recreation Area.

Agricultural Management Actions

1. Designate Agricultural Conservation Areas.
2. Protect Agricultural Assets from Vandalism, Theft, and Wildfire.
3. Use Agricultural Lease Income to Support Operations and Maintenance on Restoration Sites.
4. Replace Low-Lying, Flood-prone Orchards with New Orchards on High Ground.
5. Offer Extended Leases to Orchards.
6. Implement Wildlife-Friendly Agricultural Practices.

Chapters 4 and 6 describe how these proposed management actions would maintain conveyance capacity for public safety and provide increased opportunities for floodplain inundation in the LFRCMP study area, increasing the extent and connectivity of seasonal shallow aquatic habitat, frequently inundated floodplains, and SRA and riparian habitats. Implementing these actions would also improve connections for nutrient exchange between terrestrial and aquatic systems; would improve habitat for special-status wildlife species; and would promote the recovery and stability of native species populations and overall biotic community diversity. Increasing the extent and connectivity of riparian forests would augment and enhance nesting habitat for raptors, neotropical migrants, and herons and egrets. Increasing the expanse of riparian vegetation would also provide conditions suitable for species that require large areas of such habitat for reproduction, including western yellow-billed cuckoo. The management actions would create conditions promoting successional stages of riparian habitat intermixed with mosaics of upland habitat, which would foster species diversity. In addition, these actions would create high-ground wildlife refugia to provide terrestrial habitat that would otherwise be inundated during flood events.

The proposed management actions would also fulfill many of the LFRCMP's goals for improving flood management, recreation, and agriculture in the LFRCMP study area. Chapter 6 describes management actions that could relieve the constriction along the toe of the east levee downstream of RM 8, minimize channel scour in the river by reducing mid-channel velocities, and promote sediment transport and flood bypass conveyance in the Upper State Cut channel

Many of the proposed ecosystem management actions, including creation of swales and increasing overbank flows and access to seasonal floodplains, would increase the amount and quality of rearing habitat for Chinook salmon and provide habitat during winter and spring outmigration. Reducing fish entrapment conditions and unscreened fish diversions would also improve survivorship of salmonids and other fish species.

The proposed management actions described in Chapter 6 would enhance the recreational resources of the LFRCMP study area by increasing connectivity between trails, facilities, and open space, and by improving access for nonmotorized boats in the lower, underserved reaches of the river. In addition, the management actions would reduce trespass, vandalism, and unauthorized ORV use in areas that provide significant habitat values and important agricultural lands. The proposed management actions would also enhance the agricultural community's ability to sustain the long-term viability and productivity of agricultural lands in the LFRCMP study area, by helping farmers protect agricultural lands and infrastructure and fostering the compatible goals of agricultural lands and ecosystem enhancement.

ES.6 PERMITTING

One of DWR's goals for the LFRCMP is to work collaboratively with resource agencies to develop an efficient, programmatic approach to expedite the permitting of flood management facility maintenance and implementation of flood management and ecosystem/habitat enhancement projects. The approach described in Chapter 7, "Permitting Strategy," offers a framework for permitting the activities of DWR, the Central Valley Flood Protection Board (CVFPB), and Local Maintaining Agencies. This approach would reduce overall regulatory costs and timelines for seeking incidental-take permit coverage and satisfying requirements of the federal Endangered Species Act (ESA) and California Endangered Species Act (CESA), and/or Natural Community Conservation Planning Act. The approach is organized around implementing conservation measures that would allow for the issuance of incidental take permits by the U.S. Fish and Wildlife Service and National Marine Fisheries Service under ESA Section 10 and by CDFW under CESA Section 2081.The permitting strategy would also facilitate compliance with Section 1600 of the California Fish and Game Code; Sections 404, 402, and 401 of the Clean Water Act; Section 10 of the Rivers and Harbors Act; Section 106 of the National Historic Preservation Act. It would also help secure Safe Harbor Agreements and CVFPB encroachment permits.

The permitting approaches described in the LFRCMP would be integrated with the permitting efforts that are under way as part of the Conservation Strategy. DWR and other State and federal resource agencies are developing a permitting strategy for ESA and CESA compliance for the Central Valley Flood Protection Plan, specifically for the Feather River Conservation Planning Area. (See Chapter 1, "Introduction," for a discussion of the relationship of the LFRCMP to the Conservation Strategy and other DWR planning and coordination efforts.) The ESA and CESA compliance options described in Chapter 7 will be integrated with the permitting for the larger Feather River Conservation Planning Area. Permitting for the LFRCMP would involve closely collaborating and coordinating with all parties engaged in developing the permitting approach for the Conservation Strategy.

ES.7 IMPLEMENTATION, TRACKING, AND MONITORING

DWR would oversee the implementation of some of the actions described in the LFRCMP: flood management projects, ongoing routine floodway maintenance, and related restoration and ecosystem improvement projects, and would encourage activities supporting recreation and agriculture in the LFRCMP study area. DWR would also monitor and report on implementation of the LRFCMP, and would support an adaptive management process (see Chapters 7 and 8 for a discussion of adaptive management).

A 30-year timeline is proposed for implementing the LFRCMP management actions proposed in Chapter 6, and for developing and implementing the permitting strategy described in Chapter 7. Updates to the LFRCMP would be integrated with the CVFPP update process, which is scheduled to occur every 5 years.

As described in Chapter 8, "Implementation Tracking and Monitoring," DWR would also serve as the clearinghouse for LFRCMP information. Specifically, DWR would compile, store, and share information on the status of ecosystem and habitat restoration projects, flood management improvement projects, and maintenance activities. This process would also provide a forum for sharing updated hydrological analyses using the models developed as part of the LFRCMP, as well as any new model development and analyses.

The implementation tracking and data dissemination approach described in Chapter 8 would be integrated with similar efforts for the CVFPP and the Conservation Strategy. Consistent with the Conservation Strategy approach, implementation tracking and data dissemination for the LFRCMP would serve the following purposes:

- Document compliance with the terms and conditions of grants, agreements, permits, and other authorizations.
- Track the effects of maintenance activities on the environment (positive and negative).
- Offer a forum that allows agency and public review of the implementation of LFRCMP management actions and related permits.
- Provide information to support adaptive management decisions.

Chapter 8 also discusses potential funding sources to implement LFRCMP management actions, update information and models, and conduct ongoing maintenance and land management. Funding sources would vary according to the type of project or program, beneficiaries, availability of funds, urgency, and other factors. Implementing LFRCMP management actions is likely to involve cost sharing among federal, State, and local entities.

ES.8 CONCLUSION

The LFRCMP articulates a strategy, vision, and recommendations for future management, restoration, and maintenance of flood control facilities, conveyance channels, agricultural lands, and floodplain and associated habitat on this 20-mile reach of the river. Improving flood management in the LFRCMP study area by implementing management actions and environmental stewardship efforts could enhance natural geomorphic and hydrologic processes, reduce flood risks, and substantially increase and improve riparian and aquatic habitats. This effort would contribute to the recovery of special-status fish and wildlife, and would minimize the need for and cost of flood system operations and maintenance.

DWR will continue to collaborate with all parties with an interest in the flood management and stewardship of the LFR corridor: local, State, and federal agencies; environmental interests; farmers; recreational advocates; and other parties. In addition, DWR will work to integrate the management actions and permitting approach described in the LFRCMP with the ongoing Conservation Strategy, CVFPP, and the Feather River RFMP. The LFRCMP thus provides a regional contribution to DWR's overarching statewide efforts to improve public safety, environmental stewardship, and long-term economic stability.

ES.9 ORGANIZATION OF THE LFRCMP

The chapters and appendices of the LFRCMP are as follows:

- Chapter 1, "Introduction," describes the purpose of the LFRCMP and its relationship with the CVFPP and the Conservation Strategy, and summarizes current challenges and concerns for floodway management, ecosystem/habitat enhancement, recreation, and agriculture.

- Chapter 2, “Factors Affecting Development of the Lower Feather River Corridor Management Plan,” describes the factors that shaped LFRCMP development, including activities of the LFRCMP Work Group, stakeholder engagement, and guidance from other plans and programs.

- Chapter 3, “Existing Corridor Conditions,” describes the hydrology, flood operations and maintenance, biological resources, recreational and agricultural activities, and infrastructure of the LFRCMP study area.

- Chapter 4, “Management Goals, Challenges, and Opportunities,” describes the challenges and opportunities for flood management, ecosystem and habitat enhancement, recreation, and agriculture, and the goals developed by the LFRCMP Work Group to address those challenges.

- Chapter 5, “Hydraulic, Hydrologic, and Sediment Transport Modeling of Potential Future Conditions,” summarizes the methods, results, and conclusions of the modeling of hydraulic, hydrologic, and ecological conditions and sediment transport that was conducted to assess LFRCMP baseline and future conditions.

- Chapter 6, “Proposed Management Actions,” describes proposed management actions that would fulfill the LFRCMP’s goals for flood management, ecosystem and habitat enhancement, recreation, and agriculture.

- Chapter 7, “Permitting Strategy,” describes a conceptual permitting approach for routine floodway maintenance, flood management, and ecosystem/habitat improvement projects associated with the LFRCMP.

- Chapter 8, “Implementation Tracking and Monitoring,” describes the implementation, tracking, and monitoring of LFRCMP activities; the adaptive management process; and funding considerations and mechanisms.

- Chapter 9, “References,” provides references for the citations presented in the text.

- Chapter 10, “Preparers,” lists the individuals who contributed to preparation of the LFRCMP.

- Appendix A, “Agency Staff, Consultants, and Stakeholders Participating in the Development of the Lower Feather River Corridor Management Plan,” lists the names and affiliations of individuals who participated in the LFRCMP Work Group or its subcommittees, or who otherwise contributed to LFRCMP development.

- Appendix B, “Other Planning Efforts Relevant to the Lower Feather River Corridor Management Plan,” describes planning efforts that have been completed or are under way in the LFRCMP study area, the larger Feather River watershed, and adjacent portions of the Sacramento Valley.

- Appendix C, “Aerial Photo Vegetation Maps of the Lower Feather River Corridor Management Plan Study Area,” consists of five color aerial images of the LFRCMP study area at a scale of 1 inch = 500 feet, depicting vegetation classification polygons for the following reaches:

  - C-1: Nelson Slough to Bobelaine Audubon Sanctuary (RM 7.5 to RM 12)
  - C-2: Bear River to Lake of the Woods (RM 12 to RM 16)
  - C-3: Lake of the Woods to Abbott Lake (RM 15.5 to RM 20)
  - C-4: Abbott Lake to Marysville Disposal Ponds (RM 20 to RM 24)
  - C-5: Shanghai Bend to Yuba River and SR 20 (RM 24 to RM 29)

- Appendix D, “Photographs of the Lower Feather River Corridor Management Plan Study Area,” provides color photographs of plant communities, terrestrial and aquatic habitats, and geomorphic features.
- Appendix E, “Lower Feather River Corridor Management Plan Bank Swallow Monitoring Summary,” describes the results of bank swallow surveys conducted by DWR in the Feather River system.
- Appendix F, “Lower Feather River Corridor Management Plan Hydraulic Analysis—Baseline Model Documentation,” documents baseline hydraulic conditions and describes the hydrology of the corridor and development of the hydraulic model for the 100-year and 200-year flood analysis.
- Appendix G, “Lower Feather River Corridor Management Plan Flood Hydraulic Analysis of Future Conditions,” evaluates the effects of large flood events under proposed future conditions, including the effects on water surface elevations, levee freeboards, and velocity.
- Appendix H, “Lower Feather River Corridor Management Plan Geomorphic and Ecological Modeling,” describes the results of two-dimensional hydrodynamic and sediment transport modeling for the Floodplain Activation Flood, 2-year, and 10-year flood events, and assesses the geomorphic changes and ecological benefits of implementing management actions proposed in the LFRCMP.
- Appendix I, “Flood Hydrograph Modifications and Floodplain Activation Flood Update,” describes modifications to the LFR flood hydrographs using updated flood frequency analyses, published flood flows, and hydrologic routing to more accurately conduct hydrodynamic and sediment transport modeling for the 2-year, 10-year, and Floodplain Activation Flood events.
- Appendix J, “Shanghai Rapids Field Data Collection,” describes the methods and results of surveys to collect data on the topography, bathymetry, flow velocity, stage, and bed material at Shanghai Rapids.
- Appendix K, “Geomorphic Assessment of the Feather River from RM 6.9 to RM 12.5,” describes the hydrology, geology, and soils of the LFR; the historical influences on its hydrology and geomorphology; and the geomorphology of the LFR from the Sutter Bypass to the Bear River.
- Appendix L, “Lower Feather River Corridor Management Plan Flood Facility Maintenance Plan,” describes typical floodway and levee district maintenance practices in the LFR corridor. Appendix L also recommends guidelines for future maintenance activity consistent with the multi-objective management actions of the LFRCMP, including maximum roughness thresholds and minimum floodway capacity, based on hydraulic and sediment transport modeling results.
- Appendix M, “Lower Feather River Corridor Management Plan Conceptual Restoration Plan,” describes appropriate restoration measures and target habitats suitable for the FRS area and other managed floodplains of the LFRCMP study area. Appendix M also presents a conceptual layout of the distribution of vegetation types recommended for implementation of future restoration projects.
- Appendix N, “Lower Feather River Corridor Management Plan Conceptual Recreation Plan,” describes opportunities to enhance recreational resources by improving pedestrian trails and providing increased opportunities for boating, fishing, hunting, and nature appreciation.

- Appendix O, “Programmatic Permitting Strategy for the Lower Feather River Corridor Management Plan Technical Memo, June 14, 2012,” describes conceptual permitting strategy outlines, authorizations that would be required for the activities described in the LFRCMP, potential mechanisms for obtaining the associated permits, and approximate permitting timelines.

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ACRONYMS AND OTHER ABBREVIATIONS

Δ ft	change, in feet
2-D	two-dimensional
ADA	Americans with Disabilities Act
AEP	annual exceedance probability
BMP	best management practice
BMX	bicycle motocross
CASP	California State Plane Coordinate System
CCR	California Code of Regulations
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CMS	Corridor Management Strategy
CNDDB	California Natural Diversity Database
CNPS	California Native Plant Society
Comp Study	1999 Sacramento–San Joaquin Rivers Comprehensive Study
Conservation Framework	Central Valley Flood System Conservation Framework
Conservation Strategy	*Central Valley Flood System Conservation Strategy*
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
CWA	Clean Water Act
Delta	Sacramento–San Joaquin Delta
DWR	California Department of Water Resources
EIP	Early Implementation Program Funding Agreement
EIR	environmental impact report
EIS	environmental impact statement
Elev	elevation
EPA	U.S. Environmental Protection Agency
ESA	federal Endangered Species Act
ESU	ecologically significant unit
FAF	Floodplain Activation Flood
FMA	Flood Management Action
fps	feet per second

ACRONYMS AND OTHER ABBREVIATIONS

FRS	Feather River Setback
FRWA	Feather River Wildlife Area
FSRP	Flood System Repair Project
ft	feet
HCP	habitat conservation plan
IAC	Interagency Advisory Committee
LB	Left Bank
LCWD	Linda County Water District
LD	Levee District
LFR	Lower Feather River
LFRCMP	*Lower Feather River Corridor Management Plan*
LMA	Local Maintaining Agency
LSAA	lake or streambed alteration agreement
LC	Levee Commission
LOW	Lake of the Woods
MA	Maintenance Area
Master LSAA	master lake and streambed alteration agreement
Max	maximum
MOU	memorandum of understanding
MS Access	Microsoft Access
NA	not available
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOI	notice of intent
NPDES	National Pollutant Discharge Elimination System
O&M	operations and maintenance
ORV	off-road vehicle
PA	programmatic agreement
PG&E	Pacific Gas and Electric Company
R (in river miles)	right bank

ACRONYMS AND OTHER ABBREVIATIONS

RD	Reclamation District
RGP	regional general permit
RM	River Mile
RMSAA	Routine Maintenance Streambed Alteration Agreement
RWQCB	Regional Water Quality Control Board
RV	recreational vehicle
SAA	streambed alteration agreement
SERP	Small Erosion Repair Program
SHPO	State Historic Preservation Officer
SSJDD	Sacramento/San Joaquin Drainage District
SPFC	State Plan of Flood Control
SR	State Route
SRA	shaded riverine aquatic (habitat)
SRFCP	Sacramento River Flood Control Project
SSIA	State Systemwide Investment Approach
SWPPP	storm water pollution prevention plan
SWRCB	State Water Resources Control Board
TRLIA	Three Rivers Levee Improvement Authority
USACE	U.S. Army Corps of Engineers
USC	U.S. Code
USFWS	U.S. Fish and Wildlife Service
VELB	valley elderberry longhorn beetle
Work Group	LFRCMP Work Group
WPIC	Western Pacific Intercept Canal
WPRR	Western Pacific Railroad
WSE	water surface elevation
WSP	water surface profile

PREFACE—PURPOSE AND GOALS

The *Lower Feather River Corridor Management Plan* (LFRCMP) describes a long-term vision and an integrated strategy for managing the 20-mile-long river corridor between the cities of Yuba City and Marysville and the Sutter Bypass. The LFRCMP provides guidance and recommendations for planners, land managers, and decision-makers to manage the Lower Feather River in a way that accomplishes the following primary purposes: to protect public safety, facilitate flood protection system management and maintenance of flood control facilities, and conserve and enhance or restore habitat and ecosystem functions. The plan also has secondary purposes to promote economic stability, land use compatibility, and recreational opportunities.

The LFRCMP provides guidance to achieve specific goals, with information and analyses to support integrated floodway resource and facilities management decisions and policy recommendations. While the LFRCMP is specifically focused on a 20-mile reach of the Feather River, it is intended that the approaches for corridor management and regulatory compliance described in this document be used similarly in other Central Valley river corridors and Central Valley flood control system facilities, for future implementation of actions included in the Central Valley Flood Protection Plan and supported by the Central Valley Flood System Conservation Strategy.

This document incorporates the expertise and advice of the LFRCMP Work Group, which is a diverse group of State, federal, and local agencies; nongovernmental entities; elected officials; landowners; and other interested parties. It describes the results of hydraulic modeling and analyses of potential restoration opportunities and priorities for floodway maintenance. Based on this information, the LFRCMP provides recommendations to achieve the purposes listed above.

This collaborative, science-based approach to management was developed to achieve the following goals and objectives on the Lower Feather River corridor:

Goal 1: Protect and maintain flood protection facilities and floodways to facilitate and promote public safety while preserving and enhancing fish and wildlife habitat and ecosystem functions.

Objectives:

a) Evaluate current floodway corridor vegetation patterns, flow conveyance conditions, topography, and channel profile to identify needs and opportunities to improve flood protection and ecosystem functions.

b) Develop one-dimensional and two-dimensional hydraulic modeling tools to evaluate the effects of changes to channel topography and vegetation on channel conveyance capacity, flow rates, and flood stage elevation in the channel.

c) Evaluate current management practices and maintenance needs to identify ways to improve maintenance and management efficiency.

d) Develop a conceptual corridor maintenance plan that fulfills flood system operations and maintenance obligations in a manner that protects public safety while preserving river system dynamics, ecosystem vitality, and species and habitat diversity.

e) Develop conceptual ecosystem restoration projects that could be implemented in conjunction with, and without impeding, flood facility maintenance activities to improve habitat conditions for listed and sensitive species, contribute to their recovery, and increase species diversity.

f) Define methods to enhance and sustain connectivity to adjacent conservation lands for species migration, dispersal, and movement corridors.

Goal 2: Promote economic and recreational opportunities.

Objectives:

a) Assess current agricultural and recreational practices within the study area, and develop policy recommendations that define conditions under which existing and potential future agriculture and recreational uses may be compatible with other land uses in the corridor.

b) Identify opportunities to optimize agricultural and recreational activities and services while minimizing adverse effects on adjoining land uses and flood management facilities.

Goal 3: Define a permitting approach that provides full regulatory coverage for routine, as well as less frequent, maintenance activities of the flood control system that is focused on minimizing flood risk and protecting public safety (preserving design flow channel capacities and levee integrity) while also minimizing adverse environmental effects from these activities and maximizing ecosystem benefits (i.e., including restoration activities in the permitting approach).

Objectives:

a) Identify the types of permits and permit conditions (and any other agreements, clearances, easements, etc.) that would authorize and support the maintenance work needed to preserve channel capacity and levee integrity, along with providing/enhancing/increasing habitat in the corridor to meet mitigation and conservation needs.

b) Describe a comprehensive permitting and advance mitigation/conservation approach that links permitting for flood management facility maintenance with habitat restoration activities, and includes the flexibility to adapt to river channel and vegetation changes over time.

c) Develop a permitting approach and obtain permits for near term (i.e., less than five years) routine and less frequent flood facilities maintenance work and restoration in the corridor. The LFRCMP also identifies actions that could be undertaken farther out in the future; permits and clearances for these would be obtained as partners are identified and funding is secured.

1 INTRODUCTION

1.1 OVERVIEW OF THE CORRIDOR MANAGEMENT STRATEGY

The California Department of Water Resources (DWR) has developed the *Lower Feather River Corridor Management Plan* (LFRCMP) to establish a vision of and strategy for the management of 20 miles of the Lower Feather River (LFR) from the Yuba River to the Sutter Bypass (Exhibits 1-1 and 1-2). The LFRCMP is a pilot effort for DWR's Corridor Management Strategy (CMS), a new concept for improving flood management and ecosystem conditions at a scale that is manageable and flexible.

The CMS focuses on management in a geographic area that is small enough to foster strong local partnerships and address regional opportunities and constraints, but broad enough to enable diverse projects to collectively meet multiple needs. The CMS process involves developing a vision, strategy, and plan for managing a corridor that integrates flood risk management, restoration of ecosystem function, and integrated water management over a long-term (more than 30-year) planning horizon.

As described further in Chapter 2, "Factors Affecting Development of the Lower Feather River Corridor Management Plan," development of the LFRCMP was founded on collaboration and cooperative working relationships among the members of the LFRCMP Work Group (Work Group). This group is an assemblage of knowledgeable stakeholders that consists of State, federal, and local agencies; nongovernmental organizations; maintenance districts; agricultural interests; and landowners. Appendix A lists the members of the Work Group, and other agency staff, consultants, and stakeholders who participated in development of the LFRCMP.

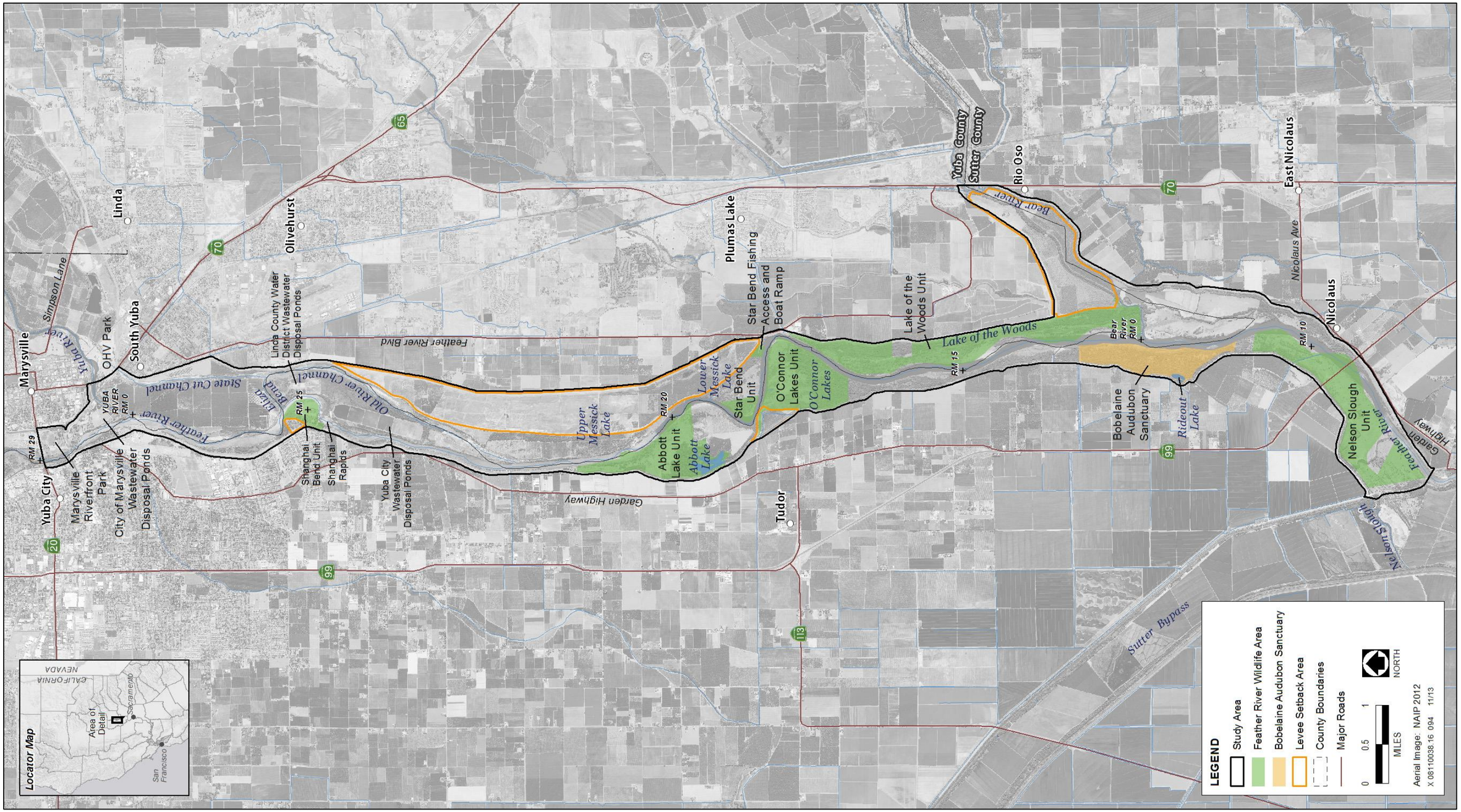
To start the process for developing new management approaches for the LFR corridor, DWR and its consultants provided the Work Group with an updated assessment of existing channel habitat and ecological conditions, geomorphology, and hydrology. Based on that assessment and the Work Group's knowledge of constraints and opportunities within the corridor, the group envisioned and discussed an array of conceptual future scenarios. The Work Group assessed how the river channel and associated floodplains could be better managed in terms of public safety, ecological function, recreation, and agriculture. From this assessment, DWR and its consultants developed a vision of future conditions by creating a spatial rendering of project footprints and anticipated vegetation changes within the floodway so that hydraulic and ecological modeling could be conducted.

As described in Chapter 5, "Hydraulic, Hydrologic, and Sediment Transport Modeling of Potential Future Conditions," modeling was then conducted to assess the effects of implementing the proposed management actions on flood hydraulics and ecosystem function. The modeling assessed channel-conveyance and sediment-transport patterns, flow constrictions, changes in floodplain inundation, and vegetation changes with altered topography and maintenance. The modeling results identified opportunities to improve passage of flood flows and sediment in the system, and to increase the extent of riparian vegetation and frequently inundated floodplain without diminishing flood protection.

The products of the Work Group's efforts and the subsequent hydraulic and ecological analysis created the foundation for the proposed management actions described in Chapter 6, "Management Actions". These management actions will help DWR to strategically manage flood protection facilities, conveyance channels, and floodplains, and will improve ecosystem function and habitat in the corridor. Implementing the management

Source: AECOM 2012

Exhibit 1-1 **Regional Setting of the LFRCMP Study Area**



Source: AECOM 2012

Exhibit 1-2 **Overview of the LFRCMP Study Area**

actions will also promote compatible land uses within the corridor, such as agriculture and recreation. To expedite agency coordination and permitting for these flood management and ecosystem enhancement actions, and for ongoing maintenance activities, LFRCMP Chapter 7, "Permitting Strategy," provides a conceptual approach for securing programmatic approvals.

The LFRCMP articulates a strategy, vision, and recommendations for future management, restoration, and maintenance of flood control facilities, conveyance channels, agricultural lands, and floodplain and associated habitat on this 20-mile reach of the river. Improving flood management on the LFR by implementing management actions and environmental stewardship efforts can enhance natural geomorphic and hydrologic processes, reduce flood risks, substantially increase and improve riparian and aquatic habitats, contribute to the recovery of special-status fish and wildlife, and improve efficiency of flood system operations and maintenance.

1.2 RELATIONSHIP OF THIS PLAN TO THE CENTRAL VALLEY FLOOD PROTECTION PLAN AND CONSERVATION STRATEGY

The Central Valley Flood Protection Act of 2008 directed DWR to prepare the *Central Valley Flood Protection Plan* (CVFPP) for adoption by the Central Valley Flood Protection Board. The CVFPP is the most comprehensive flood management planning effort ever undertaken in California; it addresses flood risks in an integrated manner while improving ecosystem functions, operations and maintenance practices, and institutional support for flood management. DWR has developed the CVFPP to describe existing flood risks and recommend actions to reduce the probability and consequences of flooding in the Sacramento and San Joaquin valleys (DWR 2011). The CVFPP proposes a systemwide investment approach for sustainable, integrated flood management that will reduce flood risk, improve ecosystem function, and create a more sustainable flood control system that facilitates ongoing operation and maintenance of flood control facilities.

In addition to the directives of the Central Valley Flood Protection Act of 2008 and related CVFPP goals, DWR adopted an Environmental Stewardship Policy in 2010 (DWR 2010a). Environmental stewardship is a concept that involves committing to responsibly manage and protect natural resources (water, air, land, plants, and animals) and ecosystems in a sustainable manner to ensure that they are available for future generations.

A key element of the CVFPP is the Central Valley Flood System Conservation Framework (Conservation Framework), which describes how environmental stewardship can be integrated into flood management activities. The Conservation Framework (DWR 2012) addressed the following major goals:

- Contributing to the recovery and stability of native species populations and overall biotic community diversity
- Improving and enhancing natural dynamic and geomorphic processes
- Increasing and improving the quantity, diversity, quality, and connectivity of riverine habitats, including agricultural and ecological values
- Integrating wildlife-friendly farming practices into conventional agricultural farming operations

Based on the key principles and goals described in the Conservation Framework, development of the *Central Valley Flood System Conservation Strategy* (Conservation Strategy) began in 2012. The Conservation Strategy

provides the systemwide context and direction for DWR's environmental stewardship activities to improve integrated flood management in the Central Valley.

Concurrent with development of the Conservation Strategy, DWR launched planning and coordination efforts for major implementation actions of the CVFPP, including the State-led Basin-Wide Feasibility Studies and the locally led Regional Flood Management Planning. The Conservation Strategy subdivides the Systemwide Planning Area for the CVFPP into five Conservation Planning Areas, which overlap with the six flood management planning areas that are the focus of the Basin-Wide Feasibility Studies. The LFRCMP study area falls within the Feather River Conservation Planning Area (Exhibit 1-3).

Corridor management strategies can provide the tools used by the CVFPP to tailor and apply practices and policies to a given management area, and can be integrated with implementation of the Conservation Strategy. The resulting corridor management plans would effectively support the objectives of the CVFPP in providing an integrated management plan to reduce flood risk, improve ecosystem function, and create a more sustainable system that allows for ongoing operation and maintenance and of flood management facilities.

The LFRCMP is a pilot project that can serve as a template for the development of future corridor management plans for other waterways, and the lessons learned from this effort can be applied to future plans. The approaches described in this document could have systemwide applicability for the management of Sacramento Valley and San Joaquin Valley flood control activities, including implementation of the Conservation Strategy. The LFRCMP will provide information about flood management and ecosystem restoration and can demonstrate approaches that local governments, State and federal agencies, flood managers, conservation organizations, and agricultural interests can follow as they plan and implement their projects.

1.3 PHYSICAL BOUNDARIES OF THE STUDY AREA

The study area for the LFRCMP is an approximately 20-mile reach of the LFR and encompasses approximately 12,000 acres (Exhibits 1-1 and 1-2). The northern study area boundary is SR 20 (Colusa Avenue). On the Yuba and Bear Rivers, the study area extends to State Route (SR) 70. The downstream end of the study area is the Feather River's confluence with the Sutter Bypass. The exterior boundary of the study area extends only to the landside toe of the levee. The hydraulic-analysis area extends beyond the study area; its boundaries are described in Chapter 5.

1.4 SUMMARY OF CURRENT CHALLENGES AND CONCERNS

The goals of the LFRCMP are to protect and maintain the LFR's flood management facilities and floodways, while preserving and enhancing fish and wildlife habitat and ecosystem functions; to promote conservation of agriculture and its infrastructure; and to enhance recreational opportunities. Chapter 4 details the management issues that prompted development of these goals. The following discussion summarizes the primary challenges and concerns that led to the Work Group's goals for flood management, ecosystem and habitat enhancement, and management of recreation and agriculture on the LFR. Chapter 8 discusses a challenge common to all the management issues discussed in the LFRCMP, which is to secure funding to implement actions that would remedy these issues.

Source: DWR 2013

Exhibit 1-3 Location of the LFRCMP Study Area in the Feather River Conservation Planning Area

1.4.1 FLOOD MANAGEMENT

As a result of recent levee setback projects and other flood management system improvements, the current risk of flooding of the LFR has declined substantially relative to historical conditions (see Chapters 3 and 5 for discussions of LFR hydrology, historical flood risks, and recent levee setback projects). However, continued sediment deposition in the Sutter Bypass contributes to a cumulative decrease in flow capacity and increased flood risk. The area where the Sutter Bypass, Feather River, and Sacramento River converge has long been an area where drainages have been compressed. This compression has resulted in backwater effects during high flows that have caused sedimentation and further reduced floodway capacity with each flood. The capacity of the main channel of the Feather River has been reduced by extensive sand deposition and shallow shoaling from downstream of the Bear River to the Sutter Bypass.

In addition to backwater flooding effects from the Sutter Bypass, the risk of levee failure (from erosion, slumpage, seepage boils, or breaching) or overtopping remains a concern along portions of the LFR where levee improvements have not occurred. Levees threatened by erosion and seepage, or areas where levees are constricted at pinch points, are the areas of greatest concern. Most levees in the study area have adequate freeboard above the 100- and 200-year flood stages; however, as described in Chapter 5, short segments occur where levee height does not provide adequate freeboard (i.e., less than 3 feet above flood stage). Levee underseepage through a porous medium is a concern along the LFR's west levee and the east levee of the lower Sutter Bypass. For most of the riverbank length in the study area, levees are set back a safe distance from potentially eroding riverbanks, or the banks are stabilized by rock slope protection or naturally erosion-resistant geologic features.

Another challenge for flood managers who maintain the LFR floodway is the need to address environmental concerns during flood management activities. Acquiring permits and securing compensatory mitigation for floodway management can be expensive and time consuming, and can delay the implementation of needed work. Vegetation growing in the floodway can restrict floodwater conveyance capacity, particularly where riparian vegetation has been allowed to become mature, dense, and multilayered, and can slow velocity which can increase sediment deposition. Similarly, planting new riparian vegetation raises concerns that those new plantings will eventually impede flood flows and raise floodwater surface elevations. Concerns about maintaining the floodway are particularly acute in constricted areas. Flood management agencies responsible for maintaining the floodway on the LFR seek to minimize cost and delays for work such as vegetation clearing. The agencies also want to minimize conflicts between floodway maintenance, habitat enhancement, recreation, and agriculture.

Implementing the flood management actions described in Chapter 6 and the permitting approach discussed in Chapter 7 offers opportunities to address the challenges and concerns described above, and to integrate flood management and ecosystem/habitat enhancement goals.

1.4.2 ECOSYSTEM/HABITAT ENHANCEMENT

Hydraulic mining and construction of dams and levees have significantly altered natural riverine processes on the LFR over the past 150 years, resulting in alterations to the natural sediment and hydrologic regime. Native plant communities, wildlife, and fisheries of the LFR and surrounding regions have been adversely affected by these changes to dynamic river processes, by flood control projects that have disconnected channels from their floodplains, and by habitat loss resulting from development and agriculture within the floodplain.

Installation of bank protection and revetment on eroding banks of the LFR has adversely affected terrestrial and aquatic species by reducing the availability of shaded riverine aquatic habitat, and has precluded the formation of cut banks used by wildlife, including nesting habitat for the state-threatened bank swallow. The fragmentation and reduction in the overall area of aquatic habitat, inundated floodplains, and riparian forest have reduced the diversity and abundance of terrestrial wildlife species supported by these habitats.

Altered river flows, loss of habitat, and the other factors noted above are important causes of declines in the populations of special-status species occupying the waterways, floodplains, and riparian forests of the LFR and the region since human settlement of the area expanded in the 19th century. Connectivity among remaining riparian forests and other native terrestrial habitats along the LFR, as well as floodplain processes that shaped these habitats, have been reduced or altered. Habitat loss and degradation and the associated loss of connectivity are a primary reason why so many terrestrial species dependent on Central Valley riparian and aquatic systems have become listed as threatened or endangered.

Aquatic habitats for salmonids and other native fishes have also been substantially reduced or degraded by changes in hydrologic and geomorphic processes. Among these effects have been the loss of important fish rearing habitat and reduced productivity of aquatic food webs. Alterations from the natural flow regime promote conditions that favor nonnative predatory fish species over native species. Other risks for fish inhabiting the LFR are receding river flows that can leave fish stranded in isolated pools in the study area, and entrainment of fish in unscreened water diversions and pumps. The combined impact of fish stranding, entrainment, and competition from nonnative fish has had a negative effect on anadromous and other native fish species.

To address these challenges, management actions are proposed in Chapter 6 to expand the extent and connectivity of riparian vegetation and other valuable habitat types along the LFR, and to increase opportunities for natural riverine floodplain processes to prevail. Increasing shaded riverine aquatic habitat, seasonal wetlands, and the potential for flood inundation would benefit fish, particularly salmonids. The proposed management actions also address enhancing habitat for special-status fish and wildlife; minimizing reduction of habitat values from the proliferation of nonnative, invasive species; and eliminating fish entrapment areas, which strand fish when floodwaters recede.

1.4.3 RIVER RECREATION

The LFRCMP study area offers many motorized and nonmotorized recreation opportunities to the residents of Yuba and Sutter counties and to visitors, and is an important source of support for the local economy. The California Department of Fish and Wildlife's Feather River Wildlife Area provides diverse opportunities for hunting, fishing, and nature appreciation. However, local, regional, and State entities recognize that there is a general lack of adequate trails and public access to the river and open space within the LFRCMP study area and floodway, and that the area between the levee and the river has been largely underused.

Illegal off-road vehicle (ORV) access and use in several areas of the LFRCMP study area is a source of concern because of damage to levee slopes, patrol roads, and seepage berms, and because of damage to native vegetation and restoration plantings. ORV use can also threaten flood management facilities because motor vehicles driving on levee slopes create ruts that make the levees vulnerable to erosion and may affect levee stability. As described in Chapter 4, several areas in the LFR study area are subject to high levels of trespassing and vandalism from unauthorized ORV use.

Recreation advocates would like to increase and improve public access, pedestrian trails, hunting opportunities, and bank fishing sites in areas that would not harm sensitive biological resources or agricultural activities, and to improve boating access in the lower, underserved reaches of the river. Other recreation needs are to increase connectivity between trails, facilities, and open space to and reduce trespass, vandalism, and unauthorized ORV use in areas that provide significant habitat values and important agricultural lands. In addition, the LFR offers ample but underused opportunities for the development of interpretive resources to build public understanding of natural ecosystem processes, and support for ecosystem and habitat enhancement activities. Implementation of the management actions described in Chapter 6 will provide opportunities to fulfill these recreation goals.

1.4.4 AGRICULTURE

Agriculture in and near the LFRCMP study area provides substantial economic and societal benefits locally and in the region; it also supports habitat for some wildlife species. Thus, an important challenge for agricultural users is to protect the approximately 3,000 acres of orchards within the levees along this portion of the LFR and support the agricultural lands outside the levees.

One of the challenges facing agricultural users is an outcome of the setback of the Feather River levee, which caused some orchards to be on the waterside of the levee and subject to frequent flooding. As described in Chapter 4, some of the orchards at the lower elevations of the Feather River setback area are inundated throughout much of the growing season an average of once every 2–3 years. Exposure to flood flows and saturated, anaerobic soil conditions has resulted in incremental mortality and stunted growth in recent years, threatening the long-term viability of these areas for use as orchards. In addition, agricultural users within the LFRCMP study area typically have only short-term leases, a condition that does not promote economic sustainability because orchards require a long-term investment and 15- to 30-year planning horizon.

Some of the recreation management challenges described above are also concerns for agricultural users of the LFR. In some locations ORV access to agricultural lands increases the risk of vandalism, theft, crop damage, and wildfire. Conserving agricultural lands and supporting infrastructure while maintaining the floodway, habitat values, and recreational access is a key concern and challenge.

The agricultural community recognizes the importance of ecosystem functions on its farmlands, and is committed to protecting the long-term viability and productivity of agricultural lands and their compatibility with ecosystem protection. Implementation of the management actions described in Chapter 6 will help farmers protect agricultural lands and infrastructure in the LFRCMP study area, and will foster the joint goals of compatible uses of agricultural lands and ecosystem enhancement.

1.5 CONCLUSION

The LFRCMP proposes management actions in Chapter 6 that address many of the challenges and concerns described above. By implementing actions that improve ecosystem function and enhance the LFR's biological resource values, and by verifying through hydraulic modeling that the actions should have no adverse effect on public safety, the LFRCMP offers a path to achieving multiple ecosystem and flood maintenance objectives.

For example, one of the management actions proposed in Chapter 6 is to cease routine vegetation clearing on a mile-long corridor in the Lake of the Woods Unit of the Feather River Wildlife Area, near the location of the Bear

River setback area. This change in maintenance practices would facilitate natural regrowth and maturation of approximately 100 acres of riparian vegetation. As described in Chapter 5, this newly established riparian vegetation should not result in an increase in flood water surface elevation. In the absence of recurring vegetation maintenance, this management action would reduce the costs of floodway maintenance by eliminating the need for frequent vegetation removal and would improve the extent and connectivity of riparian habitat along the river in the Lake of the Woods Unit.

Similarly, a floodway management and ecosystem enhancement action proposed in Chapter 6 calls for integrating invasive plant control best management practices into routine maintenance activities. Vegetation management conducted for floodway maintenance would target nonnative, invasive plants during maintenance operations to minimize and prevent the spread of species that harm native plant and wildlife communities, impede inspection of levee slopes, and diminish floodway capacity.

In preparing the LFRCMP, DWR and the Work Group have developed an array of management actions that will support ongoing routine floodway maintenance and flood management projects, enhancement of ecosystem processes and restoration of native habitats, and agricultural and recreation uses on the LFR. In addition, the LFRCMP includes a programmatic approach to permitting that will make floodway and ecosystem management projects more efficient and cost effective, and will provide better conservation outcomes. The LFRCMP provides a planning tool and informational resource for flood managers at DWR and other local maintaining agencies, resource agencies, environmental and recreation advocates, farmers, and the general public.

DWR will continue to collaborate with all parties with an interest in the flood management and stewardship of the LFR: local, State, and federal agencies; environmental interests; farmers; recreational advocates; and other parties. In addition, DWR will work to integrate the management actions and permitting approach described in the LFRCMP with the ongoing Conservation Strategy and CVFPP, and to coordinate these efforts with flood management priorities of the Feather River Regional Flood Management Plan (DWR 2014). The LFRCMP thus provides a regional contribution to DWR's overarching statewide efforts to improve public safety, environmental stewardship, and long-term economic stability.

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2 FACTORS AFFECTING DEVELOPMENT OF THE LOWER FEATHER RIVER CORRIDOR MANAGEMENT PLAN

Development of the *Lower Feather River Corridor Management Plan* (LFRCMP) has been governed by a stakeholder-driven process to identify goals and objectives and to refine the scope and approach. In addition to guidance from stakeholders, the LFRCMP considered other regional planning efforts implemented or being planned for the Feather River or adjacent parts of the Sacramento Valley with which it shares geographic coverage, goals, and objectives.

These related plans and programs were not considered to the same degree as stakeholder input during scoping for the LFRCMP or development of management actions. Still, developing and implementing the LFRCMP may simultaneously contribute to achievement of the shared goals and objectives of these related planning efforts. Likewise, implementing the related efforts may positively contribute to achievement of LFRCMP goals and objectives.

Finally, the LFRCMP management actions were developed to reflect applicable State and federal regulations. The stakeholder engagement process, regional planning efforts potentially related to the LFRCMP, and applicable State and federal regulations are described in more detail below.

2.1 STAKEHOLDER ENGAGEMENT

As described in Chapter 1 and above, development of the LFRCMP has been shaped by the active involvement of a stakeholder group, the LFRCMP Work Group (Work Group), which met monthly throughout the early development of the LFRCMP. The Work Group is composed of DWR staff members and staff members from other State, federal, and local government agencies and nongovernmental organizations with an interest in or jurisdiction over activities potentially occurring within the Feather River corridor. The following agencies and organizations are represented in the Work Group:

- *State and federal agencies:* California Department of Fish and Wildlife (including staff members representing the Feather River Wildlife Area), DWR, Central Valley Flood Protection Board, Central Valley Regional Water Quality Control Board, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and National Marine Fisheries Service

- *Local agencies:* Sutter County Board of Supervisors, Three Rivers Levee Improvement Authority, Reclamation Districts 784 and 1001, Levee District 1, Sutter County Resource Conservation District, and Sutter-Butte Flood Control Agency

- *Local nongovernmental organization*: River Partners

DWR also engaged in several outreach meetings to keep the Yuba and Sutter County boards of supervisors, the Sutter-Butte Flood Control Agency's board of directors, and the Yuba-Sutter Farm Bureau informed of LFRCMP development activities.

Stakeholder engagement activities consisted of monthly meetings led by DWR; two DWR-organized field tours along the left and right banks of the Feather River in the study area; a boat tour of the Feather River in the study

area; and periodic meetings of stakeholder subgroups focused on regulatory permitting, hydrologic and hydraulic modeling, and funding options for LFRCMP implementation. During these meetings, a variety of topics were discussed in an effort to identify and organize issues that were potentially relevant for development of the LFRCMP. A meeting of maintaining agencies in the corridor was also held to discuss flood operations and maintenance practices and needs. Stakeholder review and approval of consultant scopes of work, intermediary deliverables (e.g., technical memoranda), and the overall project objectives and approach were sought where appropriate.

The specific topics discussed or activities completed by the LFRCMP Work Group are as follows:

- Refinement of the LFRCMP goals
- Identification of potential projects and other management actions potentially included in the LFRCMP
- Review and refinement of an initial permitting and environmental compliance strategy
- Discussion of floodway maintenance requirements within the LFRCMP study area
- Review of pending and planned habitat restoration projects in the LFR corridor
- Review of existing public uses (including existing issues with trespass and vandalism) and potential future public use of the LFR corridor
- Identification of hydrologic and hydraulic modeling requirements for the LFRCMP, and review of proposed future conditions to be modeled
- Refinement of consultant scopes of work
- Table 2-1 provides a chronological summary of the meetings by the Work Group, Work Group subcommittees, and resource agencies, as well as outreach meetings, that have occurred during development of the LFRCMP.

A significant component of the stakeholder engagement effort was the completion of a Delphi exercise, led by DWR staff members, to identify key issues to be addressed in the LFRCMP. A Delphi exercise is a structured process developed to solicit feedback on a pertinent topic or topics from a group of interested stakeholders or experts. As a first step, DWR staff members developed a free-form questionnaire that allowed the Work Group to identify relevant issues that should be addressed in the LFRCMP. Specifically, Work Group members were asked to respond to the following question: “What do you think will happen within the next 50 years in the Lower Feather River CMP study area?” The list of issues submitted in response to this question was organized into major categories (e.g., recreation or habitat restoration); duplicates (topics addressing essentially the same issue) were combined into a single issue by DWR staff members. At the conclusion of this first step, 156 distinct issues were identified.

As a second step, Work Group members were asked to assign each of the 156 issues to an ordinal scale of desirability (highly desirable, somewhat desirable, not desirable), significance (highly significant, somewhat significant, not significant), and likelihood of occurrence (very likely, somewhat likely, unlikely). Completing this

Table 2-1
Chronological Summary of LFRCMP Meetings

Date	Meeting
3/18/10	Work Group
4/15/10	Work Group
5/13/10	Work Group (field tour covering LFRCMP study area)
5/27/10	Operations & Maintenance Funding Subcommittee
7/15/10	Work Group
8/16/10	Permitting Subcommittee
8/16/10	Hydraulic Modeling Subcommittee
9/16/10	Work Group
11/18/10	Work Group
1/10/11	Permitting Subcommittee
2/17/11	Work Group
3/17/11	Work Group
3/28/11	Hydraulic Modeling Subcommittee
4/21/11	Work Group
5/11/11	Permitting Subcommittee
5/19/11	Work Group (boat trip and field tour covering LFRCMP study area)
6/8/11	Permitting Subcommittee
6/16/11	Work Group
7/12/11	Outreach—Yuba County Board of Supervisors
7/20/11	Outreach—Yuba-Sutter Farm Bureau
7/21/11	Work Group
7/26/11	Outreach—Sutter County Board of Supervisors
8/10/11	Permitting Subcommittee
8/10/11	Outreach—Sutter-Butte Flood Control Agency
8/15/11	Maintenance—DWR and Local Maintaining Agencies
8/18/11	Work Group
9/15/11	Work Group
10/19/11	Conservation approach—DWR and resource agencies
10/20/11	CDFW management goals—DWR and resource agencies
10/26/11	Fish habitat enhancement—DWR and resource agencies
11/15/11	Permitting Subcommittee
11/17/11	Work Group
11/18/11	Hydraulic Modeling Subcommittee
1/19/12	Work Group
3/1/12	Hydraulic Modeling Subcommittee
10/4/12	Work Group
11/27/12	Hydraulic Modeling Subcommittee
12/10/12	Permitting Subcommittee
12/13/12	Hydraulic Modeling Subcommittee
5/18/13	Hydraulic Modeling Subcommittee
6/8/13	Hydraulic/Ecological Modeling Results—DWR and resource agencies

Source: Data compiled by AECOM in 2013

step resulted in 16 distinct groupings of issues, ranging from issues that were highly desirable, highly significant, and with a high likelihood of occurrence to issues that were not significant. (The latter were dismissed regardless of desirability or likelihood of occurrence.)

Finally, the Work Group was asked to assign each issue to one of three categories: issues to be addressed and solutions sought within the LFRCMP; issues to be acknowledged in the LFRCMP but for which solutions are not necessary; and issues that would not be addressed in the LFRCMP. A Delphi exercise is especially helpful to identify future events or conditions that are significant but undesirable and likely to occur, so the appropriate intervention action can be taken to avoid the likely problem. Similarly, the Delphi exercise can identify future events or conditions that are significant and desirable but unlikely to occur without intervention, so actions can be taken to promote the desired outcome. It was assumed that issues that were highly significant and very likely to occur, whether or not they were desirable, would be addressed in the LFRCMP, and that other issues may be addressed depending on stakeholder responses. DWR tallied responses from Work Group members and each issue was assigned to the category receiving the most member votes.

At the conclusion of the Delphi exercise, 22 issues were identified for inclusion and resolution in the LFRCMP; 101 issues were identified for inclusion in the LFRCMP, but not resolution; and 17 issues were determined to not require inclusion in the LFRCMP. The description of management challenges in Chapter 4 captures the key results of the Delphi exercise.

2.2 OTHER PLANS AND PROGRAMS

Numerous planning efforts have been completed or are under way in the LFRCMP study area, the larger Feather River watershed, and adjacent portions of the Sacramento Valley. In many cases, these efforts overlap the LFRCMP study area and/or the goals and objectives of these planning efforts overlap those of the LFRCMP. As a result, a significant potential exists for the LFRCMP to positively affect these planning efforts and, similarly, for the LFRCMP to be positively affected by these efforts. Appendix B describes the potential synergies between the LFRCMP and the following related planning efforts:

1. Feather River Parkway Strategic Plan
2. Sutter County General Plan
3. Yuba County General Plan
4. CALFED Multi-Species Conservation Strategy
5. Restoration Plan for the Anadromous Fisheries Restoration Program
6. Riparian Bird Conservation Plan
7. Lower Feather River Complex Operations and Maintenance Plan
8. The Lower Yuba River Accord
9. Regional Advance Mitigation Planning
10. Yuba Sutter Regional Conservation Plan
11. Valley Elderberry Longhorn Beetle Recovery Plan

12. Central Valley Joint Venture
13. Central Valley Project–State Water Project Operations Criteria and Plan and associated biological opinions
14. Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead
15. Feather River Region Regional Flood Management Plan
16. Feather River Regional Environmental Permitting Program

2.3 REGULATORY AGENCY REQUIREMENTS

Many of the LFRCMP's proposed management actions described in Chapter 6 will require appropriate regulatory agency permits, approvals, or authorizations. Development of a permitting strategy that would allow programmatic approval of management actions described in the LFRCMP has been one focus of Work Group discussions, and a preliminary programmatic permitting strategy for LFRCMP implementation is described in detail in Chapter 7. Table 2-2 provides a brief summary of regulatory agency permits or approvals potentially relevant to implementation of LFRCMP management actions.

Table 2-2
Summary of LFRCMP Regulatory Agency Requirements

Agency	Authority	Permit/Agreement	Potential LFRCMP Applicability
Applicable federal government agencies	National Environmental Policy Act (42 USC 4321 et seq.)	Environmental impact statement, environmental assessment, or categorical exclusion	Any activity with potential environmental effects requiring a permit or funding from a federal government agency
Applicable State and local government agencies	State California Environmental Quality Act Guidelines (14 CCR Section 15000 et seq.)	Environmental impact report, mitigated negative declaration, or categorical exemption	Any activity with potential environmental effects requiring discretionary permission (e.g., permit or approval) of a California or local government agency
U.S. Army Corps of Engineers	Clean Water Act Section 404 and Rivers and Harbors Act Section 10	Regional General Permit	Habitat restoration, maintenance, sediment removal, or similar activities, construction of utilities or recreation facilities
U.S. Fish and Wildlife Service and National Marine Fisheries Service	Federal Endangered Species Act Section 7 or 10, Fish and Wildlife Coordination Act, Magnuson-Stevens Fishery Conservation and Management Act, Marine Mammal Protection Act, Migratory Bird Treaty Act	Programmatic biological opinion or Not Likely to Adversely Affect concurrence letter, conservation recommendations for Essential Fish Habitat	Habitat restoration, maintenance, sediment removal, or similar activities, construction of utilities or recreation facilities
State Historic Preservation Officer	National Historic Preservation Act Section 106	Programmatic agreement	Habitat restoration, maintenance, sediment removal, or similar activities, construction of utilities or recreation facilities
Central Valley Regional Water Quality Control Board	Clean Water Act Section 401	Clean Water Act Section 401 programmatic water quality certification for Regional General Permit	Habitat restoration, maintenance, sediment removal, or similar activities, construction of utilities or recreation facilities
California Department of Fish and Wildlife	California Fish and Game Code Section 1600 et seq.	Streambed alteration agreement Memorandum of Agreement	Habitat restoration, maintenance, sediment removal, or similar activities, construction of utilities or recreation facilities
	California Endangered Species Act	2081 permit	
Central Valley Flood Protection Board	California Code of Regulations Title 23 Section 106	Encroachment permit	Habitat restoration, construction of recreation improvements or other structures within the floodway
California State Lands Commission	State CEQA Guidelines Section 15386(c)	Project review as trustee agency; may require lease to conduct work on State-owned sovereign lands such as the beds of navigable waters	Construction of recreation improvements (e.g., boat ramps) within the bed of the Feather River, utilities?

Source: Data compiled by AECOM in 2012

3 EXISTING CORRIDOR CONDITIONS

3.1 HYDROLOGY, HYDRAULICS, AND GEOMORPHOLOGY

The study area for the *Lower Feather River Corridor Management Plan* (LFRCMP) is located in the eastern Sacramento River watershed approximately 20-40 miles north of Sacramento, California, specifically within the watershed of the Feather River (Sutter County 2010a) (Exhibit 1-2). The Lower Feather River extends from Oroville Dam south to the Sacramento River near Verona. The watershed drains approximately 803 square miles along the western slope of the Sierra Nevada and the eastern slope of the Sutter Buttes in Butte, Sutter, and Yuba counties. Flows from the Yuba and Bear rivers and Butte Creek, and those resulting from Sacramento River flood flows in the Sutter Bypass, are all conveyed into the Feather River watershed (Sutter County 2010a).

The Lower Feather, Yuba, and Bear rivers are the primary waterways in the study area. The State Cut channel and the Sutter Bypass are also important hydrologic features in the study area (see Exhibit 1-2). State Cut is a diversion channel that was created at the start of the 20th century to divert flood flows in the lower Yuba River; the mouth of the Yuba River had rapidly been filling with sediment from upstream hydraulic mining, and this project was intended to improve flood protection by diverting flows away from Marysville and the confluence with the Feather River (James et al. 2009).

Exhibit 3-1 shows the study area as it appeared on 1910 and 1911 U.S. Geological Survey maps. Several other diversion canals were created along the Feather River around the same time as the State Cut channel, primarily near the present-day Shanghai Bend, historic Eliza Bend, and farther downstream. Some of these "cutoff" channels have become deeper and wider and are now a part of the current alignment of the Feather River channel. At the downstream boundary of the study area (River Mile [RM] 7.4), the Lower Feather River floodway and floodplain converges with the Sutter Bypass. The Sutter Bypass is an engineered overflow channel that takes on excess flood flows to increase floodway capacity during flood events along the Sacramento River. Additional floodway features in the study area include remnant channels on the floodplain, some of which have now become seasonal or perennial lakes, wetlands, or backwater areas as a result of sedimentation from the hydraulic mining era (James et al. 2009).

The following sections describe the study area's hydrology, geomorphology, and sediment-transport patterns (erosion and deposition) and their collective influence on current floodway capacity.

3.1.1 RIVER HYDROLOGY

The study area is characterized by cool, relatively mild wet winters and hot, dry summers. Precipitation occurs primarily from late fall to early spring and is followed by a dry season from late spring to early fall (Sutter County 2010b). Therefore, river flows in the study area result primarily from winter storm events with limited seasonal snowmelt. Rivers in the study area have similar seasonal distributions of flows; mean monthly flows are greatest in winter and early spring (January–March) and lowest in late summer and early fall (July–October). Upstream dams and operation of the reservoirs along the Feather, Yuba, and Bear rivers (i.e., Oroville, Thermalito Forebay and Afterbay, New Bullards Bar, Englebright, Rollins, and Camp Far West) have altered river hydrology by attenuating peak spring runoff and maintaining base flows more consistently throughout the summer. These reservoirs also reduce the load of coarse sediment delivered to downstream reaches.

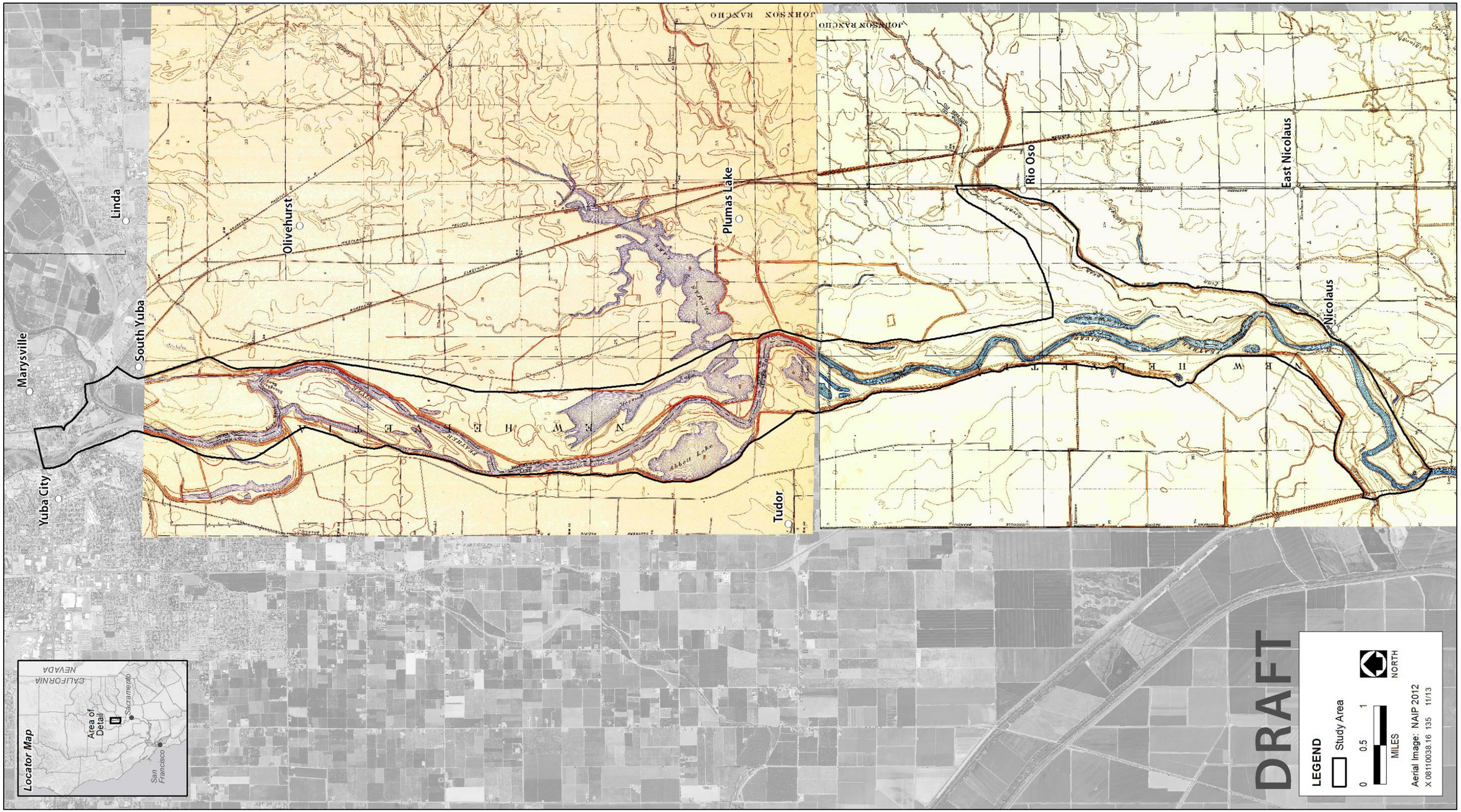
The Feather River watershed drains an approximately 5,500-square-mile area of the northern Sierra Nevada at its confluence with the Bear River (TRLIA 2009a). Oroville Dam, located approximately 40 miles upstream of the study area, regulates flows in the Lower Feather River. Flows at Oroville average between 1,890 and 2,760 cubic feet per second (cfs) during winter and between 518 and 571 cfs during summer, and are nearly uniform year to year because of the large storage capacity of Lake Oroville (Yuba County 2011a).

Despite flow regulation, major flood events have occurred on the Feather and Yuba rivers numerous times in recent history—in 1907, 1909, 1928, 1937, 1940, 1950, 1955, 1963, 1964, 1986, and 1997 (Yuba County 2011a). However, 2,000 acres of expanded floodway have recently been added to the Lower Feather River with the construction of setback levees in the study area, on both sides of the Lower Feather River from Shanghai Bend to Star Bend and on the north side of the Bear River at the Feather River confluence. The resulting increase in floodway capacity is expected to lower water levels in the Feather and Yuba rivers during large flood events (DWR 2010a) and to reduce or eliminate backwater effects at former choke points (TRLIA 2010a).

During large flood events, backwater conditions still occur in the lowermost reaches of the Feather River at the confluence with the Sutter Bypass, creating areas of commingled flows with Sacramento River and bypass flows (cbec 2011); similar conditions occur in the lower Bear River at the confluence with the Feather River (River Partners 2006). During modeled flood events (e.g., the 100- and 200-year events), estimated flow velocities along the Feather River ranged from 0 to 5 feet per second on broad floodplains within the floodway. Higher velocities of 5–15 feet per second occurred within main channels, around remnant levees or other earth-fill structures (e.g., levee road access ramps), and in association with major grade transitions in the channel or floodplain surface. The greatest flood flow velocities, identified by hydraulic modeling of the 100-year, 200-year, and 1957 design flow events (MBK 2011a), occurred at three locations:

- At the top of Shanghai Bend
- In the relatively narrow portion of the floodway between O'Connor Lakes (RM 16) and the Bear River (RM 12)
- In the lowermost reaches above and at the confluence with the Sutter Bypass (RM 11 to RM 6)

The Yuba River drains a portion of the western slope of the Sierra Nevada and flows generally southwesterly to its confluence with the Feather River at Marysville. The main stem of the Yuba River forms at the juncture of the Middle and North Yuba rivers just south of New Bullards Bar Reservoir; the South Yuba River joins the main stem a few miles downstream near Bridgeport in Nevada County, east of the study area. The main stem of the Yuba River drains approximately 1,390 square miles at the confluence with the Feather River in Marysville. Major portions of the Yuba River drainage (the Middle and South Forks) are largely unregulated with respect to flood flows; however, flow on the lower Yuba River is controlled by Englebright Dam, located approximately 20 miles upstream of Marysville. Flows near Marysville average 4,090–4,330 cfs in winter and 1,070–1,440 cfs during summer (Yuba County 2011a). Flows on the lower Yuba River are more dependent than Lower Feather River flows on annual weather conditions because New Bullards Bar and Englebright Reservoirs have less carryover storage capacity than Lake Oroville. In wet years, maximum monthly flows on the Yuba River may exceed those on the Lower Feather River despite the Yuba River's much smaller drainage area (Yuba County 2011a).



Source: AECOM 2013

Exhibit 3-1 **LFRCMP Study Area as Shown by the Nicolaus 1919 and Ostrom (Olivehurst) 1911 U.S. Geological Survey Quadrangle Maps**

The Bear River also drains a portion of the western slope of the Sierra Nevada and flows south-southwest to its confluence with the Feather River approximately 1 mile upstream of Nicolaus (Sutter County 2010b). The entire Bear River watershed encompasses approximately 550 square miles (Yuba County 2011a). Much of the lower Bear River has been diverted into ditches and canal systems for agricultural irrigation; the watershed is one of the most heavily managed in California for water conveyance (Robertson-Bryan Inc. 2011). Water is imported from the South Yuba River into the Bear River watershed at the Bear River's headwaters and other locations downstream. Additionally, the conveyance facilities operated by the Nevada Irrigation District and Pacific Gas and Electric Company (PG&E) export water, primarily to support communities in the Auburn area. Water exports are greater than imports. In some years, as much as 44,000 acre-feet of water is diverted from the Bear River. Bear River flows are controlled by Rollins and Camp Far West Reservoirs in the upper and lower watersheds, respectively; Camp Far West Reservoir is located approximately 20 miles upstream from the confluence with the Feather River (Sutter County 2010b).

Natural runoff in the lower Bear River, below Wheatland, averaged 418 cfs between 1929 and 1994 (DWR 2007). By 2007, a setback levee was constructed along the north side of the Bear River floodplain immediately upstream of its confluence with the Feather River. The setback project improved levee integrity and expanded floodway capacity both along an approximately 10,000-foot-long section of the lower Bear River and in the Feather River floodway, where a mile-long segment of the east levee was removed.

3.1.2 LANDFORMS AND CHANNEL MORPHOLOGY

The topography of the study area is generally flat or very low gradient; land elevations range from approximately 25 feet to 80 feet. Natural landforms in the study area consist of floodplains and basins, stream terraces, fan terraces, and point bars (TRLIA 2009b). The primary human-made landforms are levees. Historically, channels along the Feather, Yuba, and Bear rivers were moderately sinuous, with occasional large, stable islands (James et al. 2009).

As a result of hydraulic mining in the upper watersheds, massive deposition of sediment, ranging from 3 feet to 30 feet or more, occurred in most of the study area. Sediment deposition occurred disproportionately along the Yuba and Bear rivers compared with the Lower Feather River because of their intentionally different flood-control management strategies (James et al. 2009). At the turn of the 20th century, levee channel spacing was modified to encourage sediment deposition in the tributaries and minimize deposition in the navigable reaches of the Feather River downstream. Levee cross-channel spacing was much wider (nearly 2.5 miles) along the Yuba and Bear rivers than along the Feather River (from less than 1.2 miles to as little as 800 feet in some locations).

Following the extensive floodplain and channel aggradation caused by hydraulic mining, a phase of incision ensued as dam construction and the end of hydraulic mining reduced sediment inputs. This shift dramatically reduced the frequency and duration of natural floodplain inundation compared to pre–mining era conditions (cbec 2011).

The timing and types of changes to river morphology during the postmining era differed between the tributaries (Yuba and Bear rivers) and the Feather River. The Yuba and Bear rivers experienced their most dramatic morphological changes before the 20th century, whereas major changes did not begin along the Feather River until the start of the 20th century (James et al. 2009). Generally during this period, the overall river planform was simplified and sinuosity decreased (cbec 2011). River meanders were subsequently abandoned in favor of human-

made cutoff channels,[2] channel avulsions shifted river courses, and distributary channels formed where the tributaries joined the Feather River (James et al. 2009).

In many cases, islands once present in rivers in the study area have become point bars and abandoned channels have become the current oxbow lakes (e.g., Abbott Lake, O'Connor Lakes, and Rideout Lake). Additionally, sand shoals dominate the Feather River below its confluence with the Bear River; this reach is characterized by reduced sinuosity as a result of historic mining deposits. Extensive channel narrowing has also occurred here because alternating sandbars have developed along the channel margins, covering nearly half the channel's width (cbec 2011; James et al. 2009). During the mid-20th century, many of the levees along the Feather River were set back as a result of repeated levee failures. A more detailed description of pre–mining era conditions and historic morphological changes along the Feather River and its tributaries in the study area is provided in James et al. (2009).

Although river morphology has largely stabilized under current conditions, areas of instability persist. Lateral bank erosion is an ongoing concern (cbec 2011), particularly where susceptible mining sediments remain as the primary bank material. The banks at Shanghai Bend are the area currently subject to the greatest shear stress (TRLIA 2009b); hydraulic modeling of this location indicates some of the highest velocity flows in the study area (MBK 2011a). Evidence of several remnant channels indicates that the potential exists for channel avulsion in this area (TRLIA 2009b). In some areas (southeast of Marysville, along the south levee of the Yuba River), locations of historic channels occur beneath existing levee alignments; it is unknown whether these areas are unstable. Additionally, a notable landform called the Shanghai Rapids (or "the Riffles") occurs just below Shanghai Bend. At the Shanghai Rapids, an area of consolidated riverbed material (Modesto Formation) has formed an erosion-resistant bench where the riverbed drops approximately 10 feet in the form of a headcut (James et al. 2009). This landform and recent changes to it are described below (see "Sediment Transport: Patterns of Erosion and Deposition").

3.1.3 SEDIMENT TRANSPORT: PATTERNS OF EROSION AND DEPOSITION

The Lower Feather River in the study area is relatively stable; the most dramatic changes occurred by the mid to late 20th century as a result of hydraulic mining and its subsequent prohibition. No large-scale degradation is expected to occur in the near term, in part because of sufficient influxes of sediment from the outflows of the Yuba and Bear rivers and the backwater effects from the Sutter Bypass and Sacramento River during high flows (TRLIA 2008a). Construction of the various setback levee projects along the Feather and Bear rivers in the last decade also has reduced anticipated flow velocities along the new levees relative to velocities along the original levees, resulting in lower erosional forces along those reaches (TRLIA 2009b).

However, the Lower Feather River has very low sinuosity relative to comparable rivers, and future reductions in sediment delivery from the Yuba and Bear rivers could trigger instability by causing the channel to migrate laterally (TRLIA 2008a). Additionally, active erosion and deposition continue to occur, with primarily localized effects on the study area. The locations of major erosion and deposition areas are described below. More detailed

[2] River meanders along tributaries in the study area (Yuba and Bear Rivers) were abandoned primarily as a result of cumulative patterns of sediment deposition over time; by contrast, abandonment of river meanders along the Feather River was caused largely by large-scale channelization efforts and levee projects (James et al. 2009). Most of the Feather River downstream of Shanghai Bend follows a historically dredged cutoff channel (James et al. 2009).

information about erosion concerns in the study area by reach is presented in TRLIA (2008) and cbec (2011). Chapter 5 describes the results of sediment-transport modeling conducted by cbec, Inc. (cbec) for the LFRCMP.

The most severe and extensive areas of active erosion in the study area are located along the Feather River at and below both Shanghai Bend and Star Bend (TRLIA 2008a; cbec 2011). The reach encompassing Shanghai Bend and areas downstream (RM 26.5 to RM 22) has the greatest continuous extent of erosion in the study area. Along this reach, severe erosion occurs on the outside banks of Shanghai Bend and the unnamed bend just downstream; erosion also occurs on the inside banks and in the straight sections below Shanghai Bend where the channel is relatively confined. Banks on both sides of the headcut at Shanghai Rapids are also actively eroding with high, near-vertical banks. Along the reach that includes Star Bend and the adjacent bend downstream (RM 19 to RM 17), locally severe erosion occurs on the banks of outside bends; however, erosion is generally less severe and less extensive there than near Shanghai Bend, potentially because the floodplain is wider near Star Bend.

The potential consequences of erosion for levee integrity depend on the proximity to adjacent levees and rate of lateral erosion. Near Star Bend, active erosion is occurring much closer to adjacent levees (within 100 feet) than at Shanghai Bend, where active erosion is occurring approximately 2,000 feet from the levee (TRLIA 2008a). However, approximate rates of lateral channel migration, according to Water Engineering & Technology, Inc. (WET 1990, cited in TRLIA 2008a), are much greater at Shanghai Bend and the bend below Shanghai Bend (10.3 and 22.7 feet per year, respectively) than at Star Bend (1.6 feet per year).

One area of active erosion that is of particular concern is the headcut or knickpoint at Shanghai Rapids that forms a nearly 10-foot drop in the channel bed. The headcut on the Modesto Formation, the consolidated river bed material that forms an erosion-resistant bench underlying Shanghai Rapids, has been migrating upstream at a rate of 11.1 feet per year (cbec 2011). A complete channel-wide breach could occur within 50–100 years (cbec 2011). In January 2012, the river cut through the upper layer of the Modesto Formation, creating a narrow, high-velocity chute at the former position of the east lobe of the headcut. The consequences of this breach (discussed in Chapter 5) may include the risk of more rapid upstream migration of channel bed incision and lateral channel instability because materials upstream of Shanghai Rapids are less resistant to erosion than the Modesto Formation. This would likely initiate further degradation of the riverbed upstream, subsequently lowering the water surface elevation and further disconnecting the river from its floodplain, and increased aggradation of eroded channel sediment downstream of the Modesto Formation (cbec 2011).

Another area of moderate to severe erosion along the Feather River is the constricted reach upstream of the confluence with the Bear River where the right bank has migrated close to the levee toe. This migration was probably a response to deflected flows from a historic levee and high ground along the left bank. The areas along the right bank in the lowermost reach adjacent to Nelson Slough are also of concern because of moderate to high erosion, as are the areas at the Sutter Bypass upstream of (left bank) and opposite (right bank) “Beer Can Beach” (RM 7.5).

Elsewhere along the Lower Feather River, low to moderate levels of erosion are concentrated in areas with steep banks on outside bends. These more stable areas are typically characterized by a wider floodplain between the river and adjacent levees (e.g., setback levee areas) and by more highly vegetated bank conditions and/or other natural bank protection. The most stable reach is located just downstream of the unnamed bend below Star Bend.

Along the lower Yuba River, moderate to high levels of erosion are found on the steep right bank, and deposition of gravel and cobbles occurs on bars along the left bank (TRLIA 2008a). Despite being deeply incised, the lower Bear River at its confluence with the Feather River has low levels of erosion, likely because of the backwater conditions that occur there (cbec 2011).

Sediment deposition in the study area occurs primarily in three areas:

- At the Yuba and Bear River outflows
- In backwater areas (such as the Lower Feather River at and above the Sutter Bypass and the lower Bear River above the confluence with the Feather River)
- More generally, on floodplains (e.g., Feather River setback area and floodplains in backwater areas) and on sandbars along inside bends of the rivers

Cyclical scouring and redeposition appears to be ongoing, with flood events occurring along the mostly straightened reach of the Feather River below the Bear River from RM 13 to RM 0 at the confluence with the Sacramento River (cbec 2011).

3.1.4 FLOODWAY CAPACITY

Currently, the State of California operates State Plan of Flood Control facilities and manages floodway capacity based on the 1957 design flow water-surface profile rather than on flows from operations and maintenance (O&M) manuals (DWR 2010b). Floodway capacity depends on a variety of factors: levee spacing, design, and integrity; channel bathymetry and floodplain topography; and vegetation and topographic roughness.

As mentioned above (see Section 3.1.2, “Landforms and Channel Morphology”), levee cross-channel spacing in the study area varies from approximately 820 feet to up to approximately 1.2 miles. Cross-channel spacing causes flow constrictions and limits capacity in some areas; overall, the Feather River floodway corridor is narrowest in capacity in the section just above the confluence with the Bear River between RM 16.5 and RM 13.5 (cbec 2011).

The existing floodway also contains a mosaic of land cover types and resulting variation in hydraulic roughness that influences localized capacity. Mature riparian forest and orchard cover have greater resistance to flood flows (i.e., have higher roughness “n” values) than grasslands or other low-growing or sparse vegetative cover (see Appendix F for discussion of vegetation roughness values); however, land cover alone does not dictate floodway capacity. Recent hydraulic modeling accounted for variations in channel bathymetry and floodplain topography, and in topographic and vegetation roughness within the floodway, using information such as high-water marks and river gauge recordings from past flood events (MBK 2011a). Detailed maps showing estimated roughness values are provided by MBK Engineers (MBK) (MBK 2011a). Chapter 5 and Appendices F and H provide additional information about the baseline conditions and assumptions for modeling efforts completed by MBK and cbec as part of the LFRCMP analysis.

Levee design and integrity also contribute substantially to floodway capacity. As a result of numerous levee improvement projects during the past decade, a 200-year level of flood protection is incrementally being achieved for urban areas in the LFRCMP study area. Recent levee improvements occurred primarily along the east side of the study area in Yuba County; these improvements have included construction of the Feather River and Bear

River setback levee projects in the past decade. The more localized Star Bend and Shanghai Bend setback levee projects were completed on the west side of the study area in Sutter County (DWR 2010a). These setback levee projects have increased floodway size by more than 2,000 acres; the Feather River levee setback alone is expected to lower water levels in the Yuba and Feather rivers by more than 1.5 feet during large flood events (DWR 2010a). However, levees in the western and southeastern portions of the study area, in Sutter County, currently provide less flood protection (Sutter County 2010b).

3.2 FLOOD OPERATIONS AND MAINTENANCE

3.2.1 HISTORICAL AND CURRENT FLOOD RISK

Historical flood risk in the Feather River watershed has varied over time as a result of mining activities, incremental construction of the flood control system, and agricultural and urban development on the floodplain. Hydraulic mining in the 1800s washed large volumes of sediment into the lower portions of the Feather River watershed, including rivers in the study area, thus increasing the flood risk (DWR 2008, cited in TRLIA 2009b). This led to the development of a flood management system focused on the construction of small earthen "debris dams" to detain sediment and lower flood risk downstream. Failure of many of these early dams shifted the flood-management emphasis to channelization and levee construction. Eventually a coordinated strategy evolved that involved spacing levees more widely to encourage sediment deposition in waterways above the Feather River (e.g., the Yuba and Bear rivers) and establishing narrow levee spacing along the Feather River to encourage channel scour and maintain navigability for commercial boat traffic on the river (James et al. 2009). Establishing the flood management system generally lowered the flood risk for communities and infrastructure in the study area and vicinity. Despite establishment of the flood control system, floods continue to occur in the study area and regional vicinity.

The U.S. Army Corps of Engineers (USACE) has implemented major upgrades to segments of the Feather River left bank levee, including segments within the study area, in response to deficiencies identified during flood events (TRLIA 2011). During the 1955 and 1958 flooding and high-water events, USACE installed shallow groundwater relief wells to alleviate "sand boils" (water seepage through and under levees). In 1964, USACE enlarged the landside berms reinforcing levees in response to the formation of additional boils during 1963 high-water conditions (TRLIA 2011). Despite these measures, sand boils continued to form beyond the berms; boils and sinkholes also affected levee integrity. Despite efforts to reinforce the flood control system, in 1986 the Yuba River south levee was breached near the communities of Linda and Olivehurst when flows were well below design levels, and in 1997 the east levee of the Feather River failed near Arboga when flows were at the design level (TRLIA 2011).

In 2005, USACE determined that this region had areas that were not protected from the 100-year flood and ran the risk of being mapped in Federal Emergency Management Agency flood zones (TRLIA 2011). In response, the Three Rivers Levee Improvement Authority (TRLIA) performed additional evaluations to assess problems in the existing flood control system, finding extensive reaches where levees did not meet regulatory seepage and stability criteria (TRLIA 2011).

To address the identified deficiencies, TRLIA has implemented a comprehensive levee improvement program for Reclamation District (RD) 784 and Yuba County (TRLIA 2011). Phase I of TRLIA's Feather River Levee Setback Project increased overbank storage in the study area and created approximately 26,000 acre-feet of

transitory storage for floodwaters during a 100-year flood. The storage would occur for the time period that flood flows exceed the top of bank for the Feather River and would last for several days during a 100-year flood. Also during Phase I, TRLIA modified the levee system in southwestern Yuba County to address deficiencies in the system and reduce the flood stage of the river by setting back a portion of the eastern Feather River levee 0.5 mile east of the old levee for a length of 5.7 river miles.

The reduction in flood elevations caused by these modifications improved flood protection for Yuba City, Marysville, Linda, Olivehurst, and Plumas Lake in RD 784. Constructing the Feather River setback levee reduced flood risk in RD 784 from a 1-in-20-year chance of flooding to a 1-in-200-year chance. Flood-risk reductions also occurred in Yuba City and Marysville with the lowering of flood-surface water elevations, but such reductions have been limited because geotechnical problems continue to affect the stability of the levees protecting those communities (TRLIA 2011). The levee setback also addressed the many underseepage issues affecting southern Yuba County because the new levee was built according to modern engineering standards and on top of the more stable Modesto Formation, and because soil cement slurry walls (seepage barriers) were incorporated as needed (TRLIA 2011).

TRLIA is also working to address potential flood risk to south Yuba County from the Yuba Goldfields (Goldfields). The Goldfields, which encompass approximately 6,855 acres along the south side of the Yuba River, were formed by dredging hydraulic mining debris from the Yuba River floodplain. In the early 1990s training walls and other embankments were constructed of dredge tailings to provide some flood protection to south Yuba County. However, the Yuba River continues to modify and erode the training wall and embankments, and recent hydraulic modeling results indicate a risk of flooding for floods more frequent than the 100-year (MBK 2011b). TRLIA is currently evaluating potential alternatives to reduce the flood risk by containing floodwaters within the Goldfields (TRLIA 2013a). TRLIA also installed a setback levee on the north side of the lower Bear River to address deficiencies in the levee system in southwestern Yuba County, and to reduce river stages by increasing Bear River floodway capacity (DWR 2011a). The setback levees replaced portions of existing levees along the Bear and Feather rivers at the confluence of the two rivers. Additionally, through a partnership, River Partners planted a corridor of riparian trees and shrubs to create a buffer against wind/wave erosion to protect the new east levee within the expanded floodway (TRLIA 2012).

In 2009, Levee District (LD) 1 of Sutter County constructed the Feather River Setback Levee and Habitat Enhancement Project at Star Bend (known as the “Star Bend Project”) to replace a portion of existing levee that constricted the floodway and posed a high risk of failure (DWR 2011a). The Star Bend Project straightened out and further stabilized the levee in this location where it was originally constructed with a sharp bend protruding into the floodway. Straightening the levee relieved a constriction point that had caused previous backwater effects during high-flow conditions in the floodway (LD 1 2012). In 1999, LD 1 also constructed the smaller Shanghai Bend Setback Levee Project to straighten the section of levee at Shanghai Bend and eliminate levee seepage and erosion concerns there (LD 1 2012).

The Marysville–Yuba City Area Levee Reconstruction Project (part of the Sacramento River Flood Control Project) involved approximately 25 miles of levee work at various sites along the Feather and Yuba rivers (DWR 2011a). The improvements involved adding new toe drains and slurry cutoff walls to minimize seepage, increasing levee height, and backfilling drainage ditches (DWR 1997).

Future flood management projects anticipated within the LFRCMP study area include the Sutter Butte Flood Control Agency's Feather River West Levee Project, which is intended to reduce flood risk in the Sutter Basin. The area for that project is focused on the corridor along the west levee of the Feather River from Thermalito Afterbay on the north to approximately 4 miles north of the Sutter Bypass on the south (ICF 2013). The Feather River West Levee Project corridor is located roughly 500 feet toward the landside of the existing levees and 100 feet toward the waterside. This corridor was determined to be the area in which levee improvements, such as seepage berms, stability berms, relief wells, setback levees, erosion protection, and slurry cutoff walls, are likely to occur (ICF 2013).

3.3 LAND OWNERSHIP/MANAGEMENT

Land in the study area is mostly undeveloped (nonurban); devoted to flood management, agriculture, river recreation, and habitat conservation; and owned and managed by State and local agencies, local governments, and private parties. These owners and managers include the California Department of Fish and Wildlife (CDFW), the Sacramento/San Joaquin Drainage District (SSJDD), DWR, and local governments or agencies such as TRLIA, RD 784, RD 1001, LD 1, Linda County Water District (LCWD), Yuba City, the City of Marysville, and Sutter County. Several farmers own or lease land for agricultural purposes in the study area, and the National Audubon Society owns land in the study area. These landowners and land managers are described below.

3.3.1 STATE OR LOCAL AGENCY LANDOWNERS OR MANAGERS

FEATHER RIVER WILDLIFE AREA

The Feather River Wildlife Area is owned and managed by CDFW and includes six management units (Table 3-1 and Exhibit 1-2): Shanghai Bend, Abbott Lake, Star Bend, O'Connor Lakes, Lake of the Woods, and Nelson Slough. CDFW manages these lands to protect and enhance wildlife habitat while also providing public access that is compatible with the well-being of wildlife and their associated habitats (DFG 1988). All units are Type C wildlife areas (i.e., self-serve properties that are not staffed and charge no fees), and no passes, permits, or reservations are needed for routine public use. Some areas are accessible only by boat. In addition to the six habitat management units, CDFW owns the Star Bend Boat Ramp and Fishing Access facility, which includes a small dock and a parking area for boat trailers.

SACRAMENTO/SAN JOAQUIN DRAINAGE DISTRICT

The SSJDD was created in 1913 by the California Legislature to survey the Sacramento and San Joaquin rivers and their tributaries to inform flood management planning by the State of California Reclamation Board (now called the Central Valley Flood Protection Board). The SSJDD, which is under the management and control of the Central Valley Flood Protection Board, owns several parcels along the Bear, Yuba, and Feather rivers in the study area. Local Maintaining Agencies and DWR conduct management activities on these parcels. The following agencies maintain the levees in the study area:

- Sutter County LD 1 maintains the levee on the right (west) bank of the Feather River from its confluence with the Yuba River to the Feather River/Sutter Bypass confluence, except for a 5-mile section above the confluence with the bypass (Maintenance Area 3), which DWR maintains.

Table 3-1 Management Units of the California Department of Fish and Wildlife's Feather River Wildlife Area				
Management Unit	**Acres**	**Location Description**	**River Miles**	**Adjacent Land Use**
Shanghai Bend	130	Southeast of Yuba City limits, across the river from the Linda County Water District Wastewater Treatment Facility; upstream of Shanghai Rapids	24.8 to 25.4 Right Bank	Development (residential subdivision)
Abbott Lake	439	Seven miles south of Yuba City and approximately 1 mile north of Star Bend Road	20 to 21.5 Right Bank	Agriculture (row crops and orchards)
Star Bend	50	Directly north and across the Feather River from the O'Connor Lakes Unit and Star Bend setback levee	18.2 to 19.3 Left Bank	Riparian habitat owned by Central Valley Flood Protection Board
O'Connor Lakes	471	East of the Star Bend setback levee and across the river from the Star Bend boat ramp	16.5 to 18.8 Right Bank	Agriculture, mitigation sites, and privately owned riparian habitat
Lake of the Woods	698	Five-mile reach on the east side of the Feather River, from the Star Bend boat ramp to the mouth of the Bear River	12.5 to 17.5 Left Bank	Agriculture and riparian mitigation site (Bear River levee setback area)
Nelson Slough	750	Approximately 17 miles south of Yuba City, across the Feather River from the town of Nicolaus; the Sutter Bypass lies to the west	7.5 to 10.8 Right Bank	Privately owned riparian habitat; hunting club; agriculture; flood bypass
Source: DFG 2012a				

- RD 784 maintains the levee on the left (east) bank of the Feather River from its confluence with the Yuba River to the Feather/Bear River confluence, the right (north)-bank levee of the Bear River, and the left (south)-bank levee of the Yuba River.
- RD 1001 maintains the levee on the left (east) bank of the Feather from the Feather/Bear River confluence down to the Sutter Bypass (DWR 2010a), and the left (south)-bank levee of the Bear River.

The Sutter Yard of DWR's Maintenance Area 3 and the Local Maintaining Agencies conduct management activities in accordance with the *Standard Operation and Maintenance Manual for the Sacramento Flood Control Project* (USACE 1955a) and supplemental manuals designed for specific reaches of the river. Management activities are summarized in the following sections by maintaining agency, and in Table 3-2.

THREE RIVERS LEVEE IMPROVEMENT AUTHORITY

TRLIA is a joint-powers agency established by Yuba County and RD 784 in 2004. TRLIA was formed to finance and construct levee improvements in southern Yuba County with the mission of providing 200-year flood protection to the area. TRLIA owns and manages approximately 1,600 acres along the left bank of the Feather River from Shanghai Bend downstream to Star Bend, as well as 695 acres along the right bank of the Bear River from its confluence with the Feather River upstream to RM 3.2. TRLIA has strengthened and set back levees and established new stormwater pumping stations along the Feather and Bear rivers.

Management activities on the 1,600 acres along the Feather River include levee maintenance, habitat mitigation, habitat restoration, and agricultural production (primarily walnut orchards and a smaller area of fruit tree

orchards) (River Partners 2009). Levees in this area are maintained and operated by RD 784 under the supervision of DWR (GEI Consultants 2009).

TRLIA currently owns and manages lands within the floodway along the Feather River, although TRILIA's grant funding agreement for the property ownership acquisition funds requires transfer to DWR (River Partners 2009). In this area, TRLIA manages 31.1 acres identified as mitigation lands for compliance with Section 404 of the Clean Water Act (River Partners 2011a) and 38 acres identified as mitigation lands for compliance with the Endangered Species Act (River Partners 2011b). In addition, TRLIA holds lease agreements with local farmers on approximately 443 acres of land (River Partners 2009) that are currently under mixed orchard production.

Management activities on the 695 acres along the Bear River include levee maintenance, habitat mitigation, habitat restoration, and maintenance of flood conveyance (River Partners 2006). Levees in this area are owned by the SSJDD and are maintained and operated by RD 784 under the supervision of DWR (GEI Consultants 2005). TRLIA currently owns the lands within the floodway. Of these floodway lands, TRLIA manages 693 acres, which have been restored to native plant communities (River Partners 2011c). Included in the restoration are 44.18 acres identified as mitigation lands for compliance with Section 404 of the Clean Water Act, 10.16 acres identified as mitigation lands for compliance with the Endangered Species Act, and 39.04 acres identified as mitigation lands for compliance with the California Endangered Species Act (River Partners 2005). To facilitate flood conveyance throughout the site, TRLIA manages specific areas of the restoration area that were designed to lower the vegetative roughness coefficient. Management actions include mowing, tree removal, and sediment removal.

RECLAMATION DISTRICT 784

RD 784 encompasses nearly 29,000 acres, including 37 miles of levees, in Yuba County (RD 784 2012). Within the study area, RD 784 operates and maintains levees, irrigation structures, drainage structures, and channels on the left bank of the Yuba River; the left bank of the Feather River from its confluence with the Yuba River down to the Feather/Bear River confluence; and the levee along the right bank of the Bear River. RD 784 conducts management activities in accordance with the *Standard Operation and Maintenance Manual for the Sacramento River Flood Control Project* (USACE 1955a) and the supplement to the manual for Unit No. 145—Part No. 1 (USACE 1955b).

RECLAMATION DISTRICT 1001

RD 1001 encompasses approximately 32,000 acres in Sutter County and 4,000 acres in Placer County (Sutter LAFCO 2011a). Within the study area, RD 1001 operates and maintains the levee on the left bank of the Feather River from its confluence with the Bear River down to Feather River/Sutter Bypass confluence and the levee on the left bank of the Bear River. RD 1001 conducts management activities in accordance with the *Standard Operation and Maintenance Manual for the Sacramento River Flood Control Project* (USACE 1955a) and the supplements to the manual for Unit No. 141—Part No. 1 and Part No. 2 (USACE 1955c, 1955d).

LEVEE DISTRICT 1 OF SUTTER COUNTY

LD 1 encompasses approximately 41,083 acres in Sutter County (Sutter LAFCO 2011b). Within the study area, LD 1 operates and maintains the right-bank levee of the Feather River from the State Route (SR) 20 Bridge down to the northern boundary of the neighboring reclamation district, RD 823. LD 1 conducts management activities

in accordance with the *Standard Operation and Maintenance Manual for the Sacramento River Flood Control Project* (USACE 1955a) and the supplement to the manual for Unit No. 144 (USACE 1955e). LD-1 maintains the Abbott Lake Unit of the FRWA and private orchard land east of the west levee from RM 21.5 to the Star Bend setback area.

CITY OF MARYSVILLE

Within the floodway, the City of Marysville owns and maintains the Riverfront Park complex community park, located adjacent to downtown Marysville. Park facilities include paved parking areas, multiple soccer fields, picnic areas, a pavilion, a boat ramp, a golf driving range, and softball fields. Management activities include landscaping and maintenance of park facilities.

The City of Marysville maintains a wastewater treatment facility outside of the study area on the south side of Marysville (landside of the levee) west of the SR 70/E Street Bridge on Bizz Johnson Drive. Approximately 100 acres of associated wastewater disposal ponds are maintained by the City of Marysville within the floodway on the north side of the confluence of the Feather and Yuba rivers. The Marysville wastewater treatment plant provides secondary wastewater treatment, discharging most of the effluent to these 13 ponds.

LINDA COUNTY WATER DISTRICT

LCWD maintains a wastewater treatment facility located adjacent to the study area on Myrna Avenue in Yuba County. The facility was originally designed for secondary wastewater treatment standards, with effluent being discharged into seven disposal ponds located within the floodway adjacent to the wastewater treatment facility (Yuba County 2009). In 2009, LCWD began construction on an expansion of and upgrade to its wastewater treatment facility to increase the facility's capacity from 1.8 to 5.0 million gallons per day. The new construction will upgrade the facility to full nitrification-denitrification and tertiary filtration systems to comply with Central Valley Regional Water Quality Control Board (RWQCB) Waste Discharge Requirements Order R5-2006-0096 (Central Valley RWQCB 2011). Currently, LCWD maintains and operates the disposal ponds and all associated access roads, pipelines, pumps, and equipment.

YUBA CITY

Yuba City maintains a wastewater treatment facility outside of the study area, within its city limits. However, the facility discharges treated wastewater directly into the Feather River north of Shanghai Bend (Sutter County 2010b). The wastewater treatment facility also maintains 150 acres of disposal fields and ponds and additional buffer land within the floodway, on the left (east) bank of the Feather River from just downstream of Shanghai Rapids (RM 24.7) to RM 23.5. Yuba City maintains and operates the treatment ponds, outfall diffuser pipelines, and associated access roads, buried pipelines, pumps, and equipment.

SUTTER COUNTY

Sutter County maintains Boyd's Pump Boat Ramp off of Garden Highway on the Feather River at RM 22.3. Facilities include a paved parking area. Management activities include maintenance of the facilities.

3.3.2 PRIVATE AND AGRICULTURAL LANDS

Approximately 3,053 acres of private lands occur within the study area. Much of this acreage is devoted to agricultural production including orchards, row crops, pasture, and fallow fields. The predominant agricultural use within the floodway is walnut production. Numerous agricultural facilities exist within the floodway, such as irrigation wells, water supply and drainage ditches, generators, and associated power lines and water lines. Management activities on these lands include soil preparation, planting, irrigation, weed control, harvesting, pruning, and access road maintenance. However, no agricultural structures such as barns, silos, or equipment storage facilities are located within the floodway.

Private and actively farmed lands in this area are maintained by respective owners or lessees; agricultural practices on these lands are required to follow the *Sacramento Valley Best Management Practices Handbook*. Maintenance in these areas may include control of weeds and invasive species and upkeep of irrigation facilities.

BOBELAINE AUDUBON SANCTUARY

One of the largest privately owned parcels in the study area is the Bobelaine Audubon Sanctuary, owned by the National Audubon Society and managed by Sacramento Audubon Society volunteers (Schmoldt, pers. comm., 2012). The Bobelaine Audubon Sanctuary is a 430-acre wildlife reserve located on the right bank of the Feather River, just north of the SR 99 Bridge (RM 13.3 to RM 10.8). The sanctuary consists of riparian forest and valley oak woodland opposite the confluence of the Bear River and adjacent to the Nelson Slough Unit of the Feather River Wildlife Area. The sanctuary is about 2.5 miles long and 0.3 mile wide, and features 4.6 miles of looping, unpaved trails (including several shorter loops).

The Bobelaine Audubon Sanctuary has been declared an ecological reserve by the California Fish and Game Commission and thus is protected by CDFW under Title 14, Section 630 of the California Code of Regulations. As such, it is open to the public from sunrise to sunset, 7 days a week. Recreational opportunities include birding, wildlife viewing, photography, hiking, and outdoor educational activities. Hunting is not allowed. The nearly 5 miles of grassy trails are mowed and maintained to provide access throughout the sanctuary. In addition to trail maintenance, the Sacramento Audubon Society performs weed control activities and maintains a 15-foot-wide fire break along the northern boundary of the site (Schmoldt, pers. comm., 2012).

3.4 CURRENT FLOOD MANAGEMENT AND MAINTENANCE

The State-federal flood protection system in California's Central Valley is composed of federally authorized levees, bypasses, weirs, flood relief structures, and related facilities that are collectively referred to as the State Plan of Flood Control. It is part of a larger system that includes flood storage reservoirs, private levees, locally operated drainage systems, and other facilities that work in concert to provide flood protection for the Central Valley (DWR 2010a). Approximately 40 miles of levees and other supporting infrastructure in the study area (e.g., drainage facilities, weirs, flow gauges, bypasses [State Cut Channel], and pumping stations) make up the Lower Feather River's flood control system (Exhibit 3-2). Additionally, seven dams (including Oroville Dam) and associated reservoirs operate upstream of the study area to provide flood protection along the Feather River and its tributaries (Sutter County 2010b). Coordinated operation of these reservoirs, based on river runoff and peak-flow forecasting, is critical to the functioning of the flood control system in the study area (DWR 2011a). Dam operations are dictated by flood-control rule curves developed for each dam. Rule curves define the

maximum-allowable reservoir elevation and the minimum flood-storage pool volume for each day of the year; the curves reflect seasonal runoff patterns, basin hydrology, and downstream channel capacity at the time of development (Willis et al. 2011). O&M of the flood control system in the study area is described further below.

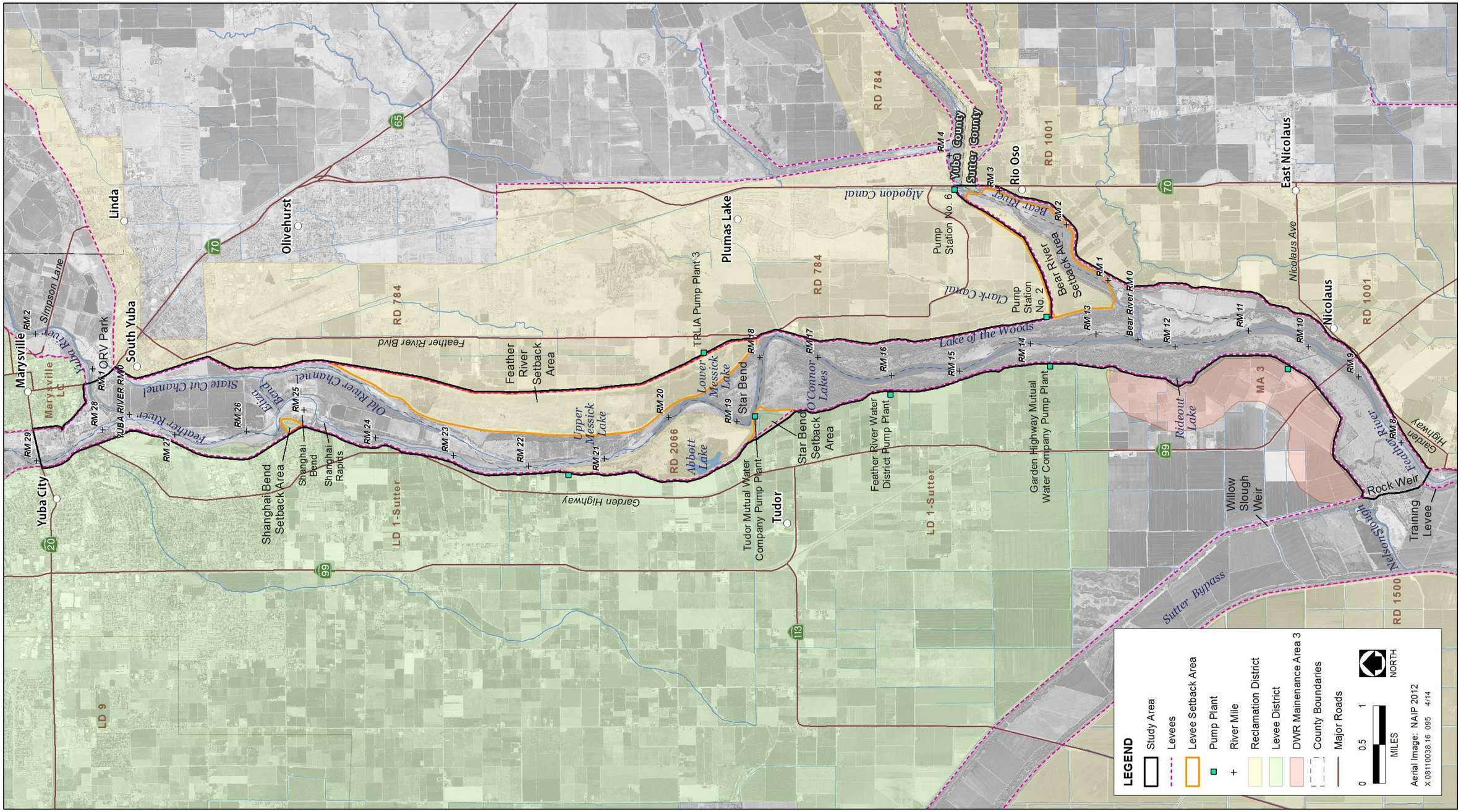
Flood system maintenance efforts include routine maintenance, project-level maintenance repairs, and emergency-level repairs. Routine O&M of the flood control system is necessary to sustain the channel's design flow capacity, flood control facilities (e.g., pumping stations, weirs), and levee integrity in the study area. Small-scale, routine O&M activities generally occur every 1–5 years to maintain standard flood-system functions. Project-level repairs of larger scope are subject to California Environmental Quality Act (CEQA) compliance and permitting by regulatory agencies; unanticipated emergency repairs occurring immediately before or during flood events are subject to postproject environmental review. Larger scale project-level and emergency repairs and system improvements are implemented primarily under federal and State authorized programs such as the Sacramento River Bank Protection Project, the Levee Stability Program, the Public Law 84-99 Rehabilitation, and the Sacramento–San Joaquin Erosion Repairs Project (DWR 2011b). DWR has also initiated the Small Erosion Repair Program to streamline the process for identifying, obtaining regulatory authorization for, and constructing small levee repairs on levees maintained by DWR within the Sacramento River Flood Control Project area (DWR 2013). These project-level programs, system improvements, and streamlining efforts will not be discussed further in this chapter, but routine O&M occurring in the study area is described further below.

Routine operations of the flood control system in the study area are mostly limited to operation of pumping plants and water control structures, flood fighting as needed, and patrolling along levees during high-water conditions. Routine maintenance typically includes all of the following activities (DWR 2011c):

- Inspection and evaluation of levees and the floodway
- Clearance of channels and structures (e.g., removal of vegetation, debris, and sediment from the floodway, intake/outtake structures, pipes and culverts, bridges, and weirs) to maintain flow capacity
- Repair of damage by burrowing mammals or other damage (e.g., erosion, seepage, slumping) to flood system channels or levees, and control of burrowing mammals
- Vegetation management along levee slopes associated with easement corridors
- Upkeep of pumping plants or other flood system structures (e.g., weirs, gates, signs, and barriers), including minor grading and surface repair of levee system roads

Vegetation management along levees and within channels typically includes a variety of actions. These actions include manually or mechanically controlling vegetation by disking, mowing, or trimming; burning; grazing; and/or using herbicides. The intent of these actions is to reduce floodway roughness and increase or maintain floodway capacity, and to preserve the ability to inspect and patrol levees and maintain access by flood-fighting equipment.

The State and the Local Maintaining Agencies share responsibilities for O&M of the flood control system in the study area. The State maintains major flood system structures (e.g., weirs), all channels and high-flow bypasses (e.g., the State Cut channel and Sutter Bypass), and a limited extent of specific levee reaches; the Local



Source: AECOM 2012, DFG 2011

Exhibit 3-2 **LFRCMP Study Area Flood Control Facilities and Maintenance Jurisdictions**

Maintaining Agencies maintain all remaining levee reaches (Exhibit 3-2). Specifically, the DWR Sutter Maintenance Yard is responsible for maintaining all river channels and floodways in the study area, including the State Cut channel (however, active maintenance occurs on only the northern half of the State Cut cutoff channel). The DWR Sutter Maintenance Yard is also responsible for maintaining approximately 6 miles of levees along the right (west) bank of the Lower Feather River above the confluence with the Sutter Bypass (within Maintenance Area 3) and the Nelson Slough rock weir and training levee (DWR 2010b).

Several agencies are responsible for O&M of distinct units of land in the study area (Table 3-2):

- LD 1 maintains levees along the right (west) bank of the Lower Feather River in Sutter County from north of Yuba City to approximately 5 miles north of the confluence with Sutter Bypass; the lowermost 5 miles of the right-bank levees are maintained by the State (Maintenance Area 3).
- The Marysville Levee Commission maintains levees along the right (north) bank of the Yuba River near Marysville (DWR 2010b).
- RD 784 maintains levees along the left (south) bank of the Yuba River, the left (east) bank of the Feather River between the Yuba and Bear rivers, and the right (north) bank of the Bear River; this includes maintaining all levees improved by TRLIA as specified in a memorandum of understanding (TRLIA 2010b). RD 784 also maintains drainage facilities and pumping stations associated with these levees (TRLIA 2010b) and portions of the Feather River setback area (TRLIA 2010c).
- TRLIA manages floodway capacity and restoration and mitigation areas within the Bear River setback area and portions of the Feather River setback area (River Partners 2006; TRLIA 2010c).
- RD 1001 maintains the remaining levees along the left (south) bank of the Bear River and the left (east) bank of the Feather River from the Bear River to the Sutter Bypass, and continuing southward along the Feather and Sacramento rivers to the Natomas Cross Canal (DWR 2010c).

O&M work for the flood control system is conducted under Title 23 of the California Code of Regulations (DWR 2010c). Requirements for O&M activities occurring in the study area are included in the *Standard Operation and Maintenance Manual for the Sacramento River Flood Control Project* (USACE 1955a). Additional project (unit-specific) O&M manuals supplement USACE's standard O&M manual for a given unit of the flood control system (e.g., individual segments of a levee, pumping plant, weir, or bypass). These manuals describe each agency's responsibilities for inspection and operation under high-water conditions and their ongoing maintenance responsibilities for sustaining the flood control system's function.

The DWR Sutter Maintenance Yard also conducts routine maintenance to manage floodway capacity on some CDFW lands (O'Connor Lakes, Lake of the Woods, and Nelson Slough) in the study area, consistent with guidance provided in the January 2011 *Streambed Alteration Agreement between the California Department of Fish and Game and the Division of Flood Management of the Department of Water Resources for Routine Maintenance of Flood Control Projects by the Sacramento and Sutter Maintenance Yards* (the Routine Maintenance Streambed Alteration Agreement [RMSAA]) (DFG 2011). The phrase "routine maintenance work" means work performed regularly (approximately every 1–5 years) in identified areas of the stream zones, as required to safely convey design flows and promote ecosystem functions. DWR performs routine maintenance

Table 3-2 Responsible Agencies for Sacramento River Flood Control Project Standard Operations and Maintenance in the LFRCMP Study Area		
Responsible Agencies	**Land Units Within the Study Area**	**Guidance Document**
LD 1	West levee of the Feather River from the north boundary of the LFRCMP project area to the north boundary of MA 3; Abbott Lake Unit of the FRWA and private orchard land east of the west levee from RM 21.5 to the Star Bend setback area	*Supplement to the Standard Operation and Maintenance Manual, Sacramento River Flood Control Project: Unit No. 144* (USACE 1955e)
DWR—Sutter Yard (MA 3)	West levee of the Feather River from the south boundary of LD 1 to the confluence with the Sutter Bypass; all floodway channels, State Cut, and the Sutter Bypass; Nelson Slough rock weir and training levee; Lake of the Woods and O'Connor Lakes units of the FRWA	*Supplement to the Standard Operation and Maintenance Manual, Sacramento River Flood Control Project: Unit No. 143* (USACE 1955f)
RD 784	East levee of the Feather River from its confluence with the Yuba River to the Feather/Bear River confluence; south levee of the Yuba River; north levee of the Bear River; eastside TRLIA pumping plants	*Supplement to the Standard Operation and Maintenance Manual, Sacramento River Flood Control Project: Unit No. 145—Part No. 1* (USACE 1955b) and *Addendum to the Supplement to the Standard Operation and Maintenance Manual, Sacramento River Flood Control Project: Unit No. 145—Part 1* (USACE 2010)
LD 1001	East levee of the Feather River from its confluence with the Bear River to the Sutter Bypass and Natomas Cross Canal; south levee of the Bear River	*Supplement to the Standard Operation and Maintenance Manual, Sacramento River Flood Control Project: Unit No. 141—Part 1* (USACE 1955c) *Supplement to the Standard Operation and Maintenance Manual, Sacramento River Flood Control Project: Unit No. 141—Part 2* (USACE 1955d)
TRLIA	Restoration and mitigation areas within the Bear River setback area and portions of the Feather River setback area	*Operations and Maintenance Plan for Riparian and Upland Habitats and Mitigation Features of the Bear River Setback Levee Project.* (River Partners 2006); *Feather River Setback Area and Adjacent Lands Interim Operation and Management Plan* (TRLIA 2010c).
Marysville LC	Levees surrounding the city of Marysville, including the east levee of the Feather River north of the Yuba River, and the north levee of the Yuba River	*Supplement to the Standard Operation and Maintenance Manual, Sacramento River Flood Control Project: Unit No. 147* (USACE 1955g)
Sources: USACE 1955b, 1955c, 1955d, 1955e, 1955f; MBK 2010		

work to maintain the functional and structural integrity of its facilities. Routine maintenance work includes the following tasks:

- Removing debris, sediment, vegetation, rubbish, downed trees, and other material that could obstruct the natural flow of water
- Controlling weeds, grasses, emergent vegetation, and woody vegetation
- Maintaining restoration and mitigation areas

- Controlling burrowing mammals and grouting burrow holes
- Dragging (blading), track walking, and burning levee slopes
- Repairing gates, barricades, and small structures
- Making repairs to control erosion and stabilize banks
- Maintaining crown and toe roads as well as fire breaks
- Repairing bridges and culverts
- Conducting minor geotechnical sampling
- Other work necessary to maintain the functional and structural integrity of DWR floodways or DWR facilities

The *Lower Feather River Complex Operations and Maintenance Manual* (DFG 1988) provides additional guidance for O&M activities occurring on CDFW lands in the study area. This document provides the following general guidance for management of CDFW lands in the study area:

- Prevent unauthorized vehicle access.
- Maintain signage at all units.
- Maintain dirt roads to the river's edge to allow fire crews access throughout the units.
- Restrict the installation of riprap on all CDFW-managed units of the Feather River Wildlife Area.
- Plant valley oak trees and elderberry shrubs.
- Construct and maintain weirs on lake outlets.
- Enhance habitat for bank swallows.
- Monitor shore erosion.
- Monitor targeted wildlife species.
- Manage hunting and fishing activities according to the California Fish and Game Code.
- Retain large dead trees and snags for habitat purposes.

Approximately 15% of the study area is under CDFW jurisdiction (e.g., Feather River Wildlife Area, all natural channels). For areas within the Lower Feather River floodway that are under the jurisdiction of CDFW, routine O&M requirements are further defined in an RMSAA as described above. The RMSAA defines the agreement between DWR and CDFW to mutually manage the Abbott Lake, O'Connor Lakes, Lake of the Woods, and Star Bend units for the benefit of fish, wildlife, and plants and to reduce the loss of life or property damage resulting from floods.

In recent years, the primary maintenance activities conducted by the Sutter Maintenance Yard in the study area consisted mostly of removing vegetation on the left (east)-bank floodplain between RM 17 and RM 12.5 (Lake of the Woods Unit) and in a 400-foot-wide by 2,000-foot-long corridor in the O'Connor Lakes Unit. In addition, there was some removal of debris and sediment (e.g., at State Cut) and, to a lesser extent, mowing of levee slopes in Maintenance Area 3. Table 3-3 summarizes the floodway maintenance activities in each unit of the Feather River Wildlife Area.

The Bear and Feather River setback areas are maintained by RD 784 to ensure proper floodway conveyance, maintain the habitat value of restoration areas, and meet requirements for protecting project mitigation features (River Partners 2006). Guidance for O&M activities in the Feather River setback area is based on TRLIA's *Messick Lake and Floodplain Drainage Swale Mitigation Areas Long-term Operations and Maintenance Plan* (TRLIA 2008b) and includes the following elements:

- Mow at least twice annually to control invasion of exotic plants and establishment of elderberry shrubs, and to prevent wildfire.
- Remove nonnative plants, as needed.
- Minimize the potential for invasion of nonnative plants.
- Maintain low roughness values throughout the area.
- Patrol daily to minimize unauthorized activities.
- Conduct routine clearing of sediment and debris from culverts.
- Clear debris after flood events.
- Conduct preventive maintenance at well sites.
- Conduct remedial maintenance activities, as needed (e.g., replant vegetated wave-buffer areas and restoration or mitigation sites).
- Maintain mitigation areas to meet USACE Regulatory standards for 8 years after construction, and conduct annual qualitative and quantitative monitoring of the Clean Water Act Section 404 mitigation areas for 8 years after construction.

In the Bear River setback area, O&M activities are based on the *Operations and Maintenance Plan for Riparian and Upland Habitats and Mitigation Features of the Bear River Setback Levee Project* (River Partners 2006). O&M activities in this area are as follows:

- Remove nonnative vegetation where it threatens restored habitats and floodway conveyance (e.g., floodplain swale, areas of low hydraulic roughness areas).
- Remove debris, vegetation, or beaver dams from the floodplain swale and adjacent floodplain.
- Conduct multiple mowing events and targeted herbicide treatment as needed.

Table 3-3 Floodway Maintenance in Management Units of the Feather River Wildlife Area		
FRWA Units	**Responsible Agencies**	**Additional Maintenance Details**
Lake of the Woods	CDFW	Retaining an area of dense cottonwoods along the east levee to serve as a buffer from wave wash (DWR 2010c)
		Selective manual and mechanical clearing of vegetation and debris and sheep/goat grazing in densely vegetated areas conducted by hand crews (DWR 2010c)
		Removal of nonnative vegetation and occasional use of herbicides in cleared areas to assist with ongoing maintenance of these areas (DWR 2010c)
	DWR	Easement held by DWR to disk large swaths through the unit to maintain flood-carrying capacity through the site Selective manual and mechanical clearing of vegetation and debris, use of herbicides in cleared areas to assist with ongoing maintenance of these areas, debris removal
O'Connor Lakes	CDFW	Clearing of drainage ditches from naturally revegetated borrow area to prevent ponding and potential fish stranding during retreat of floodwaters (DWR 2010c)
	DWR	Vegetation management to maintain a 400- to 600-foot buffer of low-lying grassland adjacent to and parallel to the river channel (DWR 2010c; USFWS 2005)
Abbott Lake	CDFW	CDFW developing Management Plan as part of CVFPB permit process
	DWR	
Star Bend *	CDFW	
	DWR	
Nelson Slough	CDFW	A fringe of dense cottonwood forest along the west bank and levee is being retained as a protective buffer from wave wash (DWR 2010c)
		Open areas maintained by sheep grazing through an agreement between CDFW and a local rancher (DWR 2010c)
	DWR	Additional mowing and vegetation clearing
Shanghai Bend	CDFW	Managed by Sutter County until 2005; current administration and management of this unit is in the process of being determined by CDFW (formerly California Department of Fish and Game) (DWR 2010c)

Sources: DWR 2010c; USFWS 2005
* LD1 is responsible for vegetation management for enlarged floodplain of approximately 49.5 acres, including VELB mitigation and enhancement area, future mitigation/enhancement site (DWR 2011d).

- Conduct remedial maintenance activities, as needed (e.g., replanting, weed control, removal of vegetation, debris or other barriers to fish passage), to maintain restoration and mitigation areas (Jones & Stokes 2006; River Partners 2005).
- Avoid additional roads, utility lines, trails, benches, equipment or fuel storage, grading, firebreaks, mowing, grazing, planting, disking, pesticide use, burning, or other structures or activities, except as described in the O&M plan for this area.
- Conduct qualitative and quantitative monitoring of Clean Water Act Section 404 mitigation areas and elderberry transplants in the valley elderberry longhorn beetle (VELB) mitigation area.
- Monitor the drainage swale and adjacent floodplain after flood inundation.

Maintenance activities also occur at the Bobelaine Audubon Sanctuary, and include mowing as needed to maintain approximately 5 miles of hiking trails, mowing a 15-foot-wide fire break along the north property boundary, and controlling invasive weeds when feasible. Volunteers from the Sacramento Audubon Society are responsible for this maintenance.

3.5 VEGETATION, WILDLIFE, AND FISHERIES

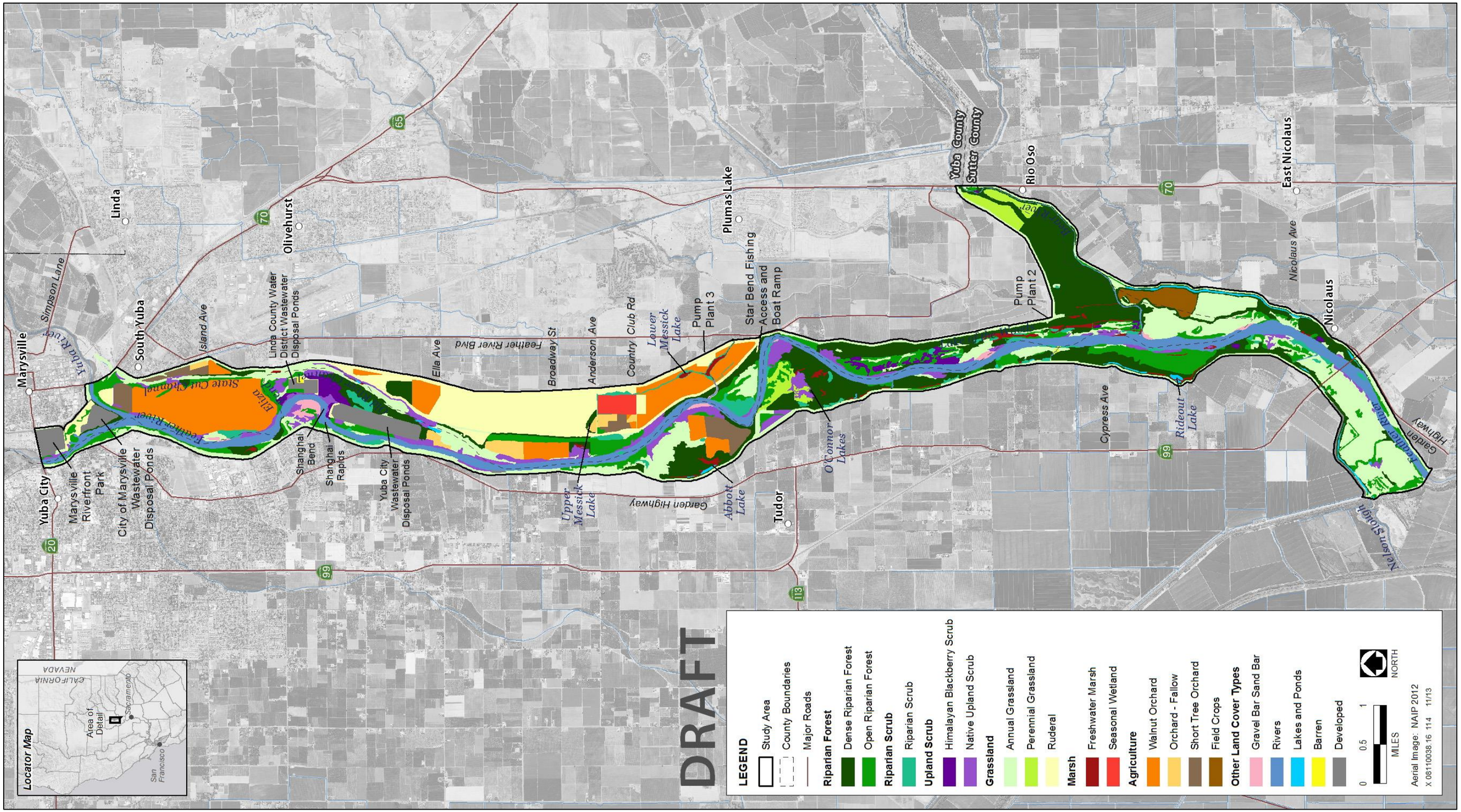
The study area is located in the northern portion of the Great Central Valley adjacent to the Sierra Nevada foothills, in a region of significant biological value. The Central Valley is positioned at the southerly end of the Pacific Flyway, the westernmost of four flyways in North America, a migration route connecting bird breeding grounds in the north with wintering grounds in the south. The rivers of this region, which drain the Sierra Nevada, are critically important to native fisheries, including Central Valley steelhead, Chinook salmon, and Sacramento splittail. This region also supports some of the most extensive and significant expanses of riparian habitat remaining in the Central Valley.

The study area supports a diversity of native plant communities and significant fish and wildlife resources. Much of the study area is managed, in part, for wildlife values by the State as part of the Feather River Wildlife Area, Bobelaine Audubon Sanctuary, and the Feather River and Bear River setback areas. Additionally, numerous riparian and wildlife habitat restoration projects have been implemented and are planned for the study area, increasing the area's current and potential biological value by promoting greater habitat connectivity throughout the riparian corridor. Areas of existing and restored native vegetation and wildlife habitat occur most notably in and adjacent to the O'Connor Lakes Unit of the Feather River Wildlife Area, and throughout the Bear River setback area (Exhibit 3-3).

The study area also includes disturbed areas that lack native habitats because of vegetation disturbances or invasive nonnative plants. These areas include the borrow area of the Feather River setback area; portions of the Abbott Lakes Unit where little native riparian habitat occurs and invasive vegetation dominates; portions of the Nelson Slough Unit where mining and farming have denuded the native vegetation and infrequent floodplain inundation has limited the potential for reestablishment of natural vegetation; and portions of Marysville Riverfront Park. Agricultural areas also make up a portion of the study area, with orchards (mostly walnut) the predominant agricultural land use. Existing vegetation communities and land cover types; major habitat restoration and mitigation efforts; key plant, wildlife, and fish habitat; and sensitive resources are described below.

3.5.1 VEGETATION COMMUNITIES AND LAND COVER TYPES

Vegetation communities and land cover types in the study area were mapped and described by AECOM (DWR 2011b) based on reconnaissance surveys conducted in 2010 and 2011 and vegetation maps generated from the National Aerial Imagery Program's aerial images (Geographic Information Center 2008). Vegetation communities are based on the Holland (1986) classification, but have been generalized from the medium-scale mapping units described by California State University, Chico (2011). Appendix C provides five color aerial images at a scale of 1 inch = 500 feet depicting vegetation classification polygons in the LFRCMP study area.



Sources: DWR 2011c; data compiled by AECOM in 2012

Exhibit 3-3 **Existing Land Cover in the LFRCMP Study Area**

Table 3-4 provides a brief description and corresponding acreage of each vegetation community and land cover type that occurs in the study area, and Appendix D provides photographs of these vegetation communities and cover types. Of the vegetation communities occurring in the study area, freshwater marsh, riparian forest, and riparian scrub (where it occurs as Great Valley willow scrub, buttonbush scrub, and elderberry savanna [Holland 1986]) are considered rare and sensitive community types by the State. More detailed descriptions of each cover type and a general summary of the wildlife that use them are provided by DWR (2011c). The distribution of vegetation community and cover types in the study area is shown in Exhibit 3-3.

The description and categorization of vegetation communities and cover types provided below was developed to inform the hydrologic modeling described in Chapter 5. For the sake of clarity, Exhibit 3-4 combines some of the plant communities and cover types described below, but Chapter 5 (Table 5-1) provides a crosswalk explaining how each of these cover types translated to "roughness," or resistance to the flows of floodwaters, in the hydrologic modeling.

RIPARIAN FOREST

Dominant shrub species within the riparian forest include shrub-like forms of the willow species (*Salix* sp.), saplings of overstory species, buttonbush (*Cephalanthus occidentalis*), California rose (*Rosa californica*), blue elderberry (*Sambucus mexicanus*), Himalayan blackberry (*Rubus discolor*), California blackberry (*R. ursinus*), and coyote brush (*Baccharis pilularis*). Lianas such as California grape (*Vitis californica*), California pipevine (*Aristolochia californica*), and virgin's bower (*Clematis ligusticifolia*) are also found in the shrub layer, as well as poison oak (*Toxicodendron diversilobum*).

Dominant species in the herbaceous layer include various grasses and grass-like plants such as creeping wild-rye (*Leymus triticoides*) and blue wildrye (*Elymus glaucus*), sedges such as Santa Barbara sedge (*Carex barbarae*), and rushes such as Baltic rush (*Juncus balticus*) and spreading rush (*J. patens*). Forbs commonly seen include mugwort (*Artemesia douglasiana*), goose grass (*Galium aparine*), and stinging nettle (*Urtica dioica*). Disturbed areas in riparian forest may include an herbaceous layer dominated by weedy species, such as Bermuda grass (*Cynodon dactylon*), carrot (*Daucus carota*), cocklebur (*Xanthium strumarium*), common velvet grass (*Holcus lanatus*), and horseweed (*Conyza canadensis*).

Dense Riparian Forest

Dense riparian forest has a moderately dense to dense tree canopy that includes several co-dominant species. The upper canopy is typically dominated by valley oak (*Quercus lobata*), Fremont cottonwood (*Populus fremontii*), boxelder (*Acer negundo*), Goodding's willow (*S. gooddingii*), shining willow (*S. lucida* spp. *lasiandra*), red willow (*S. laevigata*), and Oregon ash (*Fraxinus latifolia*). White alder (*Alnus rhombifolia*) and western sycamore (*Platanus racemosa*) are occasionally found in the upper canopy. The lower shrub canopy is very dense and thicket-like. The herbaceous understory ranges from very developed to sparse, depending on the amount of light filtering through the upper canopies. Where dense riparian forest is dominated by a mix of overstory species, it is found away from the active river channel on higher floodplains where flooding and associated disturbances are infrequent. Portions of the dense riparian forest that are dominated primarily by Fremont cottonwood and Goodding's willow are found in areas lower on the floodplain that frequently experience spring flooding. This community type is high in stature (i.e., 20–40 feet tall).

Table 3-4
Acreage of Vegetation Communities and Land Cover Types in the LFRCMP Study Area

Habitat Type	Acres	Location in the Study Area
Riparian Forest		Present in broad to narrow bands on floodplains and banks of the Feather, Yuba, and Bear rivers, and along sloughs, lakes, and irrigation canals. The most extensive areas occur in the Feather River Wildlife Area, including the Abbott Lake Unit, in and adjacent to the O'Connor Lakes Unit, and in the Lake of the Woods Unit, as well as in the Bobelaine Audubon Sanctuary.
Dense riparian forest	2,269.18	
Open riparian forest	1,108.17	
Riparian Scrub	251.06	Patchily distributed along main river channels, high-flow overbank channels and scoured floodplains, and along drainage and irrigation canals.
Upland Scrub		Patchily distributed along the main river channels and along drainage and irrigation canals. Areas dominated by Himalayan blackberry are prevalent between Shanghai Bend and the Old Feather River and scattered throughout the northern portion of the Lake of the Woods Unit.
Himalayan blackberry scrub	142.81	
Native Upland scrub	534.11	
Grassland		
Annual grassland	2,439.95	Common on high ground and grazing land, and along levees and disturbed areas (e.g., along access roads, in fallow agricultural fields, and in unplanted levee setback areas). Areas of seeded native perennial grassland occur in the Bear River setback area and in the O'Connor Lakes Unit.
Perennial grassland	196.34	
Ruderal	1,089.32	
Wetlands		Exists in patches within the Feather, Yuba, and Bear River floodways; Messick Lakes; and along drainage and irrigation canals.
Freshwater marsh	19.60	
Seasonal wetland	168.21	
Agriculture		Occurs primarily in the northern half of the study area on the east side of the Feather River and throughout the Feather River levee setback area. Also occurs on the west side of the Feather River south of Abbott Lake Unit and on the east side of the Feather River south of the Bear River.
Walnut orchard	1,185.86	
Short tree orchard	211.97	
Orchard—fallow	125.98	
Field crops	127.88	
Open Water		Open water occurs in the active channel of the Feather, Bear, and Yuba rivers and other permanently flooded areas with little to no vegetative cover (i.e., irrigation canals, lakes, and ponds).
Lakes and ponds	68.16	
Rivers	1,405.33	
Other Land Cover Types		
Gravel bar sandbar	65.79	Scattered along margins of the Feather and Yuba rivers. The most notable areas are along the left (south) bank of the Yuba River near State Cut, at Shanghai Bend, and as alternating point bars and exposed sand shoals in the southern portion of the study area.
Barren	5.78	Most notably occurring in the borrow area of the Feather River levee setback area, and occasionally at actively eroding sites.
Developed	346.18	Wastewater disposal ponds and fields occur north of the mouth of the Yuba river and east of the Feather River below Shanghai Bend.
Grand Total	**11,761.67**	

Source: Data compiled by AECOM in 2013

Open Riparian Forest

Open riparian forest is similar is species composition to dense riparian forest, but has a more open canopy and understory. It is found throughout the floodplain. This vegetation community includes valley oak woodland, which features a closed to somewhat open canopy that is dominated by valley oak. The lower canopy includes scattered Oregon ash, boxelder, western sycamore, black walnut (*Juglans hindsii*), and young valley oak. The shrub layer is sparse to dense; and climbing vines are apparent in openings but may also be found scattered in the shady understory. The herbaceous layer is dense to sparse. This riparian forest type is found in the highest parts of the floodplain where there is less physical disturbance from flooding. It is also high in stature.

RIPARIAN SCRUB

Dense Willow Scrub

Dense willow scrub is a shrub-dominated plant community that exists in patches along the main river channels and is also found along drainage and irrigation canals. Characteristic species in the dense willow scrub are Goodding's willow, Arroyo willow (*S. lasiolepis*), sandbar willow (*S. exigua*), red willow, and buttonbush. California grape is common in areas away from the active channel. Herbaceous understory is generally lacking but may include some annual grasses. This community typically creates dense, impenetrable thickets and is medium in stature (i.e., 3–10 feet tall).

Open Willow Scrub

Open willow scrub is similar in species composition to dense willow scrub, but shrubs are more widely spaced. This community also exists in patches along the main river and is medium in stature.

UPLAND SCRUB

Upland Scrub

Upland scrub is a shrub-dominated plant community that exists in patches throughout the higher parts of the floodplain. Blue elderberry, poison oak, and coyote brush are common; buttonbush, Himalayan blackberry, and riparian tree saplings may also be present. This community is fairly open and the herbaceous understory is dominated by annual grasses. It is medium in stature.

Himalayan Blackberry Scrub

Himalayan blackberry scrub exists in patches throughout the floodplain. It is dominated primarily by Himalayan blackberry, which creates dense thickets. Scattered riparian saplings and shrubs may also be present. It is medium in stature. Native upland scrub also occurs in one portion of the O'Connor Lakes restoration area where California rose and California blackberry have been planted in wide rows. This community type is described as "low-velocity scrub" in the restoration plan. It is low in stature (i.e., less than 3 feet tall).

GRASSLAND

Annual Grassland

Annual grassland and savanna is an herbaceous community dominated by grasses and broad-leaf plants. A few shrubs such as blue elderberry and coyote brush, and widely spaced riparian and oak trees may be scattered throughout annual grasslands, but herbaceous species dominate this community type. Common species include Bermuda grass, common velvet grass, Italian ryegrass (*Lolium multiflorum*), wild oats (*Avena fatua*), ripgut brome (*Bromus diandrus*), soft chess (*B. hordeaceus*), Johnson grass (*Sorghum halepense*), and medusahead (*Taeniatherum caput-medusae*). Annual grassland is an open and short-statured community.

Perennial Grassland

Perennial grassland is found on portions of the floodplain that have been restored and where native grasses have been planted (e.g., the Bear River setback area and the O'Connor Lakes restoration area). Common grasses include blue wildrye, creeping wild-rye, meadow barley (*Hordeum brachyantherum*), purple needlegrass (*Nasella pulchra*), telegraph weed (*Heterotheca grandiflora*), mugwort, Santa Barbara sedge, gumplant (*Grindelia camporum*), Spanish clover (*Lotus purshianus*), dogbane (*Apocynum cannabinum*), evening primrose (*Oenothera elata*), lupine (*Lupinus* spp.), and California poppy (*Eschscholzia californica*). Perennial grassland is low in stature and forms a hummocky herbaceous landscape.

Ruderal

Ruderal areas exist where the native vegetative cover has been removed and weedy broadleaf species are dominant. Ruderal areas are common where recent construction has taken place, such as in the Feather River setback area. Common species include annual grasses, black mustard (*Brassica nigra*), longbeak stork's bill (*Erodium botrys*), shortpod mustard (*Hirschfeldia incana*), common vetch (*Vicia sativa*), pricklylettuce (*Lactua serriola*), wild radish (*Raphanus sativus*), woolly mullein (*Verbascum thapsus*), perennial pepperweed (*Lepidium latifolium*), Canada thistle (*Cirsium arvense*), and yellow star-thistle (*Centaurea solstitialis*). Ruderal areas are low in stature and vegetative cover is sparse.

MARSH

Freshwater Marsh

Freshwater marsh is found in a few scattered locations on the floodplain. It is permanently flooded and dominated by emergent perennial grass-like plants, such as cattails (*Typha angustifolia*, *T. latifolia*), sedges, rushes, and tule (*Schoenoplectus acutus*). Other characteristic species are water primrose, smartweed, South American vervain (*Verbena bonariensis*), and reed canarygrass (*Phalaris arundinacea*). Freshwater marsh is open to dense and of medium stature.

Seasonal Wetland

Seasonal wetlands can be found in patches throughout the floodplain and along drainage and irrigation ditches. This community is permanently or seasonally flooded and is dominated by sedges, rushes, smartweed (*Polygonum* spp.), water primrose (*Ludwigia peploides*), and grasses (e.g., Bermuda grass, dallisgrass [*Paspalum dilatatum*]). Seasonal wetland is open to dense and relatively low in stature.

AGRICULTURE

Walnut Orchard

Walnut orchards are present in several areas throughout the floodplain. Orchards are intensively managed to reduce understory vegetation (e.g., through mowing and spraying) and pruned to encourage fruit production. Walnut orchards are relatively high in stature (i.e., 20–40 feet tall) and are planted somewhat densely.

Short Tree Orchard

Short tree orchards (e.g., persimmons, stone fruits) are uncommon but present in a few areas in the floodplain. These areas are also managed to reduce understory vegetation and pruned to encourage fruit production, but are lower in stature (i.e., 10–16 feet tall) than walnut orchard. They are also planted somewhat densely.

Orchard—Fallow

Fallow orchards are areas that were previously cultivated for fruit or nut tree crops, but that have been abandoned or removed. These lands are characterized primarily by annual grasses and weedy forbs (see "Annual Grassland and Savanna" and "Ruderal," above), but they may also include remnant orchard trees either still intact or removed and left on the ground.

Field Crops

Field crops are found south of the Bear River on the northeast side of Sheiber Ranch. These areas include low stature (i.e., 1-3 feet tall) herbaceous crops, as well as fallow fields and some ruderal vegetation along the margins of the fields.

OPEN WATER

Open water occurs in the active channel of the Feather, Bear, and Yuba rivers and other permanently flooded areas with little to no vegetative cover. Open water also include permanently flooded areas of slow-moving or standing open water that supports floating aquatic vegetation, such as duck weed (*Lemna* spp.) and water primrose. These include some ponds and sloughs, as well as drainage and irrigation ditches.

OTHER LAND COVER TYPES

Gravel Bar/Sandbar

Gravel bars and sandbars generally do not support significant vegetation cover, although these areas can eventually support early successional riparian habitat as sediment accretion occurs. These areas experience frequent scouring flows and deposition and are found along the main river channels.

Developed

Developed areas on the floodplain consist of some buildings, yards, roads, and parking areas, and three areas of wastewater disposal ponds. Many of the developed areas are devoid of vegetation, but where vegetation exists, it ranges from sparse cover of weedy species to horticultural plantings.

Barren

Barren areas are found within the Feather River Setback area where recent grading has taken place. These areas may be completely devoid of vegetation (i.e., bare soil) or may have some sparse cover of ruderal species.

3.5.2 Sensitive Habitats and Special-status Species

This section describes special-status species that occur in the LFRCMP study area and the habitats that support them. Special-status species are those identified as sensitive or special-status in local or regional plans, policies, or regulations; or by CDFW, the National Marine Fisheries Service, or the U.S. Fish and Wildlife Service. These species include those listed as threatened or endangered under the federal Endangered Species Act or California Endangered Species Act, candidates for listing, Fully Protected under the California Fish and Game Code, California Species of Special Concern, and on California Rare Plant Ranks 1A, 1B, and 2. Habitats that provide the highest value to special-status species in the LFRCMP study area are riparian forest and scrub, associated shaded riverine aquatic (SRA) habitat, seasonally inundated floodplains, nearshore areas, and freshwater marsh. These habitats are described below.

Riparian Forest and Riparian Scrub

Riparian forest and scrub serve important ecological functions, such as linking upland and aquatic habitats, providing corridors for wildlife movements, supporting high levels of biodiversity, contributing to the quality of instream fish habitat, and buffering the erosive forces of floodwaters. They also provide overstory and midstory vegetation that numerous raptors and other birds use for nesting and roosting. Riparian forest understory and scrub provide important nesting and foraging habitats and shelter for resident, migratory, and wintering birds, and several bat species roost and nest in the riparian trees and tree hollows and forage nearby on insects over open areas or water. Small to medium-sized mammals also make extensive use of these habitats.

Riparian areas in the study area support numerous special-status species including the State-listed Swainson's hawk (*Buteo swainsoni*) and western yellow-billed cuckoo (*Coccyzus americanus occidentalis*). Additionally, blue elderberry shrubs that occur here are known to support VELB (*Desmocerus californicus dimorphus*), which is federally listed as threatened. SRA habitat, seasonal floodplains, and nearshore areas serve as especially important habitats for native fish in the Sacramento River watershed (DWR 2010d). SRA habitat is the nearshore aquatic habitat that occurs adjacent to riparian woodlands. This habitat is characterized by natural banks that support overhanging or protruding riparian vegetation and adjacent nearshore areas with woody debris and organic material, such as leaves, logs, branches, and roots and variable water depths, velocities, and currents (DWR 2010d).

Shaded Riverine Aquatic

SRA habitat is the result of a dynamic process. As riparian vegetation matures and banks erode, plant material sloughs off into the rivers. This process creates a structurally complex habitat consisting of instream woody debris that provides refugia for fish from predators, creates higher and more variable water velocities, and provides habitat for terrestrial and aquatic invertebrates (DWR 2010d). The overhanging vegetation also provides shaded areas that keep water temperatures low during the summer (River Partners 2011d). For these reasons, many fish

species are attracted to SRA habitat, particularly native salmonids, such as federally listed Chinook salmon (*Oncorhynchus tshawytscha*) and Central Valley steelhead (*O. mykiss*).

SEASONALLY INUNDATED FLOODPLAIN, NEARSHORE HABITAT, SEASONAL WETLANDS

Seasonally inundated floodplains and nearshore areas provide important spawning and rearing habitat for many native fish, including special-status species that are adapted to the dynamic pattern of seasonal inundation (Sommer et al. 2001, 2003). In particular, the Sutter Bypass (at the southern boundary of the study area) and floodplain terraces now available because of recent levee setback projects offer access to broad, inundated floodplain habitat during wet years. These areas provide access to vast areas of spawning and rearing habitat for native fish, with an enhanced food web for fish and wildlife.

Unlike most other aquatic habitats in the region, floodplains and nearshore areas (including bypasses) are seasonally dewatered during late spring through autumn as high flows recede. This dewatering and the timing of seasonal inundation provide conditions that favor native fish rather than introduced predatory fish species (Sommer et al. 2004). Moreover, many of the native fish are adapted to spawn and rear in winter and early spring (Moyle 2002) during the winter flood pulse. Introduced fish typically spawn during late spring through summer when most of the floodplain is not available to them.

Marsh habitats in shallow backwater edges of the river and lake margins also provides diverse habitats in the study area, providing high-quality nesting, foraging, and migrating habitat for an abundance of waterbirds. Marshes support a variety of songbirds and other bird species typically associated with wetland habitat. Special-status wildlife that may occur in freshwater marshes include northern harrier (*Circus cyaneus*), tricolored blackbird (*Agelaius tricolor*), giant garter snake (*Thamnophis gigas*), and western pond turtle (*Actinemys marmorata*).

ERODING VERTICAL RIVER BANKS

The eroding vertical river banks generally support fewer species than the habitats described above. However, unique features in these areas provide habitat elements that support bank swallow (*Riparia riparia*), which is known to use exposed high, steep banks along the Feather River (Appendix E). Bank swallows locate their colonies along eroded, vertical banks within river systems with friable alluvial soils. Dynamic riverine processes create these conditions as rivers meander and expose fresh soil (Bank Swallow Technical Advisory Committee 2013). These banks also provide habitat for other burrow–nesting species, such as belted kingfisher (*Megaceryle alcyon*) and northern rough-winged swallow (*Stelgidopteryx serripennis*).

3.5.3 SPECIAL-STATUS SPECIES KNOWN OR WITH POTENTIAL TO OCCUR IN LFRCMP STUDY AREA

Most of the special-status species occurring within the Lower Feather River study area are dependent on these sensitive plant communities or habitat types. Tables 3-5 and 3-6 summarize the status of special-status plants and wildlife known to occur or with potential to occur in the study area. Exhibit 3-4 depicts the locations of special-status plant species and terrestrial communities recorded in the California Natural Diversity Database (CDFW 2013), and Exhibit 3-5 depicts the locations of special-status wildlife species and critical habitat recorded in the database.

Table 3-5 Special-Status Plant Species Known to Occur or with Potential to Occur in the LFRCMP Study Area				
Species	**Status[1]**		**Habitat and Blooming Period**	**Potential for Occurrence[2]**
	USFWS	**CDFW**		
Ferris' milk-vetch *Astragalus tener* var. *ferrisiae*	–	1B.1	Vernally mesic meadows and seeps, subalkaline flats in valley and foothill grassland; 2–75 meters elevation; blooms April to May.	Unlikely to occur; no suitable habitat present.
Dwarf downingia *Downingia pusilla*	_	2.2	Vernal pools, mesic sites in valley and foothill grassland, in clay soils; 1–445 meters elevation; blooms March to May.	Unlikely to occur; no suitable habitat present.
Boggs Lake hedge-hyssop *Gratiola heterosepala*	_	E, 1B.2	Lake margins, vernal pools, in clay soils; 10–2,375 meters elevation; blooms April to August.	Unlikely to occur; no suitable habitat present.
Woolly rose-mallow *Hibiscus lasiocarpos* var. *occidentalis*	_	1B.2	Freshwater marshes and swamps; 0–120 meters elevation; blooms June to September.	Could occur; suitable habitat present and recorded by CNDDB within the Sutter Bypass, approximately 2 miles from the study area.
Ahart's dwarf rush *Juncus leiospermus* var. *ahartii*	_	1B.2	Vernal pool margins, grassland swales, gopher mounds; 30–229 meters elevation; blooms March to May.	Unlikely to occur; no suitable habitat present.
Red Bluff dwarf rush *Juncus leiospermus* var. *leiospermus*	_	1B.1	Vernal pool margins, wet places in chaparral, woodland; 35–1,020 meters elevation; blooms March to May.	Unlikely to occur; no suitable habitat present.
Legenere *Legenere limosa*	_	1B.1	Vernal pools; 1–880 meters elevation; blooms April to June.	Unlikely to occur; no suitable habitat present.
Veiny monardella *Monardella douglasii* ssp. *venosa*	_	1B.1	Cismontane woodland, valley and foothill grassland, in heavy clay soils; 60–410 meters elevation; blooms May to July.	Unlikely to occur; some grassland habitat present, but poor quality because of nonnative and weedy plant species.
Baker's navarretia *Navarretia leucocephala* ssp. *bakeri*	_	1B.1	Cismontane woodland, lower montane coniferous forest, meadows and seeps, valley and foothill grassland, and vernal pools, in mesic areas; 5–1,740 meters elevation; blooms April to July.	Unlikely to occur; some grassland habitat present, but poor quality because of nonnative and weedy plant species.
Ahart's paronychia *Paronychia ahartii*	_	1B.1	Cismontane woodland, valley and foothill grassland, vernal pools; 30–510 meters elevation; blooms March to June.	Unlikely to occur; some grassland habitat present, but poor quality because of nonnative and weedy plant species.
Hartweg's golden sunburst *Pseudobahia bahifolia*	E	E, 1B.1	Cismontane woodland, valley and foothill grassland, in clay and often acidic soils; 15–150 meters elevation; blooms March to April.	Unlikely to occur; some grassland habitat present, but poor quality because of nonnative and weedy plant species; CNDDB record in study area believed to be extirpated.
Sanford's arrowhead *Sagitarria sanfordii*	_	1B.2	Shallow freshwater marshes and swamps; 0–650 meters elevation; blooms May to October.	Could occur; suitable habitat present, and nearest CNDDB occurrence overlaps the study area in the Star Bend area.
Wright's trichocoronis *Trichocoronis wrightii* var. *wrightii*	_	2.1	Meadows and seeps, marshes and swamps, riparian forest, vernal pools, in alkaline soils; 5–435 meters elevation; blooms May to September.	Unlikely to occur; suitable habitat present; however, believed by CNPS to be extirpated from the Central Valley.

Table 3-5
Special-Status Plant Species Known to Occur or with Potential to Occur in the LFRCMP Study Area

Species	Status[1] USFWS	Status[1] CDFW	Habitat and Blooming Period	Potential for Occurrence[2]

.[1] Legal Status Definitions

U.S. Fish and Wildlife Service:
E Endangered (legally protected)
California Department of Fish and Wildlife:
E Endangered (legally protected)

CNPS Rare Plant Ranks:
1B Plant species considered rare or endangered in California and elsewhere (protected under the California Environmental Quality Act [CEQA], but not legally protected under the federal Endangered Species Act [ESA] or California Endangered Species Act [CESA])
2 Plant species considered rare or endangered in California but more common elsewhere (protected under CEQA, but not legally protected under ESA or CESA)
CNPS Rare Plant Rank Extensions:
.1 Seriously endangered in California (>80% of occurrences are threatened and/or high degree and immediacy of threat)
.2 Fairly endangered in California (20 to 80% of occurrences are threatened)

[2] Potential for Occurrence Definitions
Unlikely to occur: Species is unlikely to be present on the project site due to poor habitat quality, lack of suitable habitat features, or restricted current distribution of the species.
Could occur: Suitable habitat is available at the project site; however, there are few to no other indicators that the species might be present.
Likely to occur: Habitat conditions, known occurrences in the project vicinity, or other factors indicate a relatively high likelihood that the species would occur at the project site.
Known to occur: The species, or evidence of its presence, was observed at the project site during reconnaissance surveys, or was reported by others.
Sources: CDFW 2013; CNPS 2013; USFWS 2013; Hickman 1993; data compiled by AECOM in 2013.

Table 3-6
Special-Status Wildlife and Fish Species with Potential to Occur in the LFRCMP Study Area

Species	Status[1] USFWS/ NMFS	Status[1] CDFW	Habitat	Potential for Occurrence[2]
Invertebrates				
Conservancy fairy shrimp *Branchinecta conservatio*	E	–	Vernal pools.	Unlikely to occur; no suitable habitat present in the study area.
Vernal pool fairy shrimp *Branchinecta lynchi*	T	–	Vernal pools.	Unlikely to occur; no suitable habitat present in the study area.
Valley elderberry longhorn beetle *Desmocerus californicus dimorphus*	T	–	Elderberry shrubs, typically within riparian habitat.	Known to occur in two locations within the study area; suitable habitat present throughout the study area.
Vernal pool tadpole shrimp *Lepidurus packardi*	E	–	Vernal pools.	Unlikely to occur; no suitable habitat present in the study area.
Reptiles				
Western pond turtle *Actinemys marmorata*	FSC	CSC	Ponds, marshes, sloughs, ditches, and other slow-water habitat, preferably with basking sites; nests in nearby uplands with low, sparse vegetation.	Known to occur; suitable habitat present within the study area; one CNDDB occurrence recorded in the southern portion of the study area south of the confluence with the Bear River; observed during 2010 AECOM reconnaissance surveys.

Table 3-6 Special-Status Wildlife and Fish Species with Potential to Occur in the LFRCMP Study Area				
Species	**Status[1]**		**Habitat**	**Potential for Occurrence[2]**
	USFWS/ NMFS	**CDFW**		
Giant garter snake *Thamnophis gigas*	T	T	Ponds, marshes, sloughs, slow-moving streams, rice fields, and ditches with emergent vegetation for cover; requires upland refugia not subject to flooding in the inactive season.	Could occur intermittently during the later spring and summer months; suitable habitat present in marsh, slough, and areas of slow water, including drainage ditches and canals; the main river and riparian floodplain corridor is unsuitable because of high flows and predatory fish; little to no suitable over-wintering refugia within the study area; several CNDDB occurrences recorded within 5 miles of the study area, primarily in the Sutter Bypass, and a single record east and upstream along the Bear River corridor.
Amphibians				
California tiger salamander *Ambystoma californiense*	T	T	Vernal pools and other seasonal water sources for breeding, and underground refuges, especially ground squirrel burrows.	Unlikely to occur; no suitable habitat present in the study area; no occurrences recorded in Yuba or Sutter County.
California red-legged frog *Rana draytonii*	T	CSC	Foothill and central coast streams with dense shrubby or emergent riparian vegetation, minimum 11–20 weeks of water for larval development, and upland refugia for aestivation.	Unlikely to occur; species has been extirpated from most of the Central Valley floor; no suitable habitat in the study area (outside Coast Ranges and does not include foothill habitats).
Western spadefoot *Spea hammondii*	–	CSC	Vernal pools and surrounding grasslands; can also be found in valley foothill hardwood woodlands.	Unlikely to occur; no suitable habitat present within the study area.
Birds				
Tricolored blackbird *Agelaius tricolor*	FSC	CSC	Forages in grasslands and agricultural fields; nests in freshwater marsh with dense cattails and tules, riparian scrub, and other dense shrubs and herbs.	Likely to occur; suitable habitat present within the study area; several recent CNDDB occurrences recorded within 3–5 miles of the study area.
Burrowing owl *Athene cunicularia*	–	CSC	Forages and nests in grasslands, scrub, and agricultural areas with low vegetation cover, especially where ground squirrel burrows are present.	Could occur; suitable habitat present throughout the study area; nearest CNDDB occurrence is more than 5 miles from the study area.
Swainson's hawk *Buteo swainsoni*	–	T	Forages in grasslands and agricultural fields; nests in open woodland or scattered trees.	Known to occur; suitable habitat present and numerous CNDDB occurrences are recorded within the study area.

Table 3-6 Special-Status Wildlife and Fish Species with Potential to Occur in the LFRCMP Study Area				
Species	**Status[1]**		**Habitat**	**Potential for Occurrence[2]**
	USFWS/ NMFS	**CDFW**		
Mountain plover *Charadrius montanus*	C	CSC	Forages in short grasslands and plowed agricultural fields where vegetation is sparse and trees are absent.	Could occur; suitable habitat present within the study area; nearest CNDDB occurrence recorded more than 11 miles southwest of the study area.
Northern harrier *Circus cyaneus*	–	CSC	Nests and forages in open grassland, marsh, and agricultural fields.	Known to occur; suitable habitat present throughout the study area; observed by AECOM during 2010 reconnaissance surveys.
Western yellow-billed cuckoo *Coccyzus americanus occidentalis*	C	E	Occurs in valley, foothill, and desert riparian forest with dense deciduous trees and shrubs, especially willows; other associated vegetation includes cottonwood trees, blackberry, nettle, and wild grape.	Known to occur; suitable habitat present in several locations within the study area; two CNDDB occurrences recorded within the southern end of the study area and two within 1–2 miles of the northern end of the study area.
White-tailed kite *Elanus leucurus*	–	FP	Forages in marshes, sloughs, agricultural fields, ditches, and slow-moving streams; nests in nearby uplands with scattered tall trees, and low vegetation.	Known to occur; suitable habitat present in several locations within the study area; observed during 2010 AECOM reconnaissance surveys.
Greater sandhill crane *Grus canadensis tabida*	–	T	Winters in the Central Valley, in relatively treeless plains, pastures, flooded grain fields, wet meadow, shallow lacustrine, and fresh emergent and seasonal wetland habitats.	Could occur; suitable habitat present with the study area; nearest CNDDB occurrence recorded more than 15 miles north of the study area.
Bald eagle *Haliaeetus leucocephalus*	–	E	Forages primarily in large inland fish-bearing waters with adjacent large trees and occasionally in uplands with abundant rabbits, small mammals, or carrion. Often roosts communally in winter.	Could occur; suitable habitat present within the study area; nearest CNDDB occurrence recorded more than 13 miles north of the study area along the Feather River.
California black rail *Laterallus jamaicensis coturniculus*	–	T	Nests and forages in saline, freshwater, or brackish emergent marshes with gently grading slopes and vegetative cover above the high-water line.	Could occur; suitable habitat present within the study area; nearest CNDDB occurrence is recorded approximately 6 miles west of the study area.
Song sparrow (Modesto population) *Melospiza melodia*		CSC	Nests in emergent freshwater marshes dominated by tules and cattails and riparian willow thickets; also in riparian forests (e.g., Valley Oak) with blackberry understory and along vegetated irrigation canals and levees.	Could occur; suitable habitat present within the study area; one CNDDB record in the vicinity of the confluence of the Yuba and Feather rivers.

Table 3-6 Special-Status Wildlife and Fish Species with Potential to Occur in the LFRCMP Study Area				
Species	**Status[1]**		**Habitat**	**Potential for Occurrence[2]**
	USFWS/ NMFS	**CDFW**		
Bank swallow *Riparia riparia*	–	T	Forages in a variety of habitats; nests in vertical banks or bluffs, typically adjacent to water, devoid of vegetation, and with friable, eroding soils.	Known to occur; suitable habitat present in several locations and numerous CNDDB and other occurrences recorded within the study area.
Least Bell's vireo *Vireo bellii pusillus*	E	E	Obligate riparian breeder generally preferring early successional habitat. Typically inhabits structurally diverse woodlands along watercourses, including cottonwood-willow woodlands, oak woodlands, and mule fat scrub.	Unlikely to occur; suitable habitat present in the study area, but species was considered extirpated from the Sacramento and San Joaquin valleys in 1986; a single nesting pair, however, was documented in 2006 in the San Joaquin River National Wildlife Refuge, more than 80 miles south of the study area. Singing males were also observed in the Yolo Bypass Wildlife Area in 2010 and 2011
Mammals				
Western red bat *Lasiurus blossevillii*	–	CSC	Roosts primarily in riparian trees and snags, especially in sycamore and cottonwood; prefers habitat edges, dense overstory, and open understory; typically forages in grassland, shrubland, and open woodland habitats.	Could occur; suitable habitat present within the study area; nearest CNDDB occurrence is recorded more than 8 miles southwest of the study area.
Sacramento Valley red fox *Vulpes vulpes ssp. nov.*	–	PFM[3]	Den sites associated with grasslands and away from flooded agriculture and wetlands. Current range estimated to be from Cottonwood to the Delta, west of the Sacramento River, and from Chico to Sacramento, east of the Sacramento River	Could occur; suitable habitat present within the study area. Species not tracked in the CNDDB, however, evidence of occupancy has been documented in the lower Feather River drainage (Sacks et al 2010).
Fish				
Green sturgeon Southern DPS *Acipenser medirostris*	T	–	Requires cold, freshwater streams with suitable gravel for spawning; rears on seasonally inundated floodplains and in rivers, tributaries, and the Delta.	Known to occur; suitable habitat is present in and species is known to occasionally occur in the lower Feather River.
Pacific lamprey *Lampetra tridentada*	–	CSC	Requires cool, freshwater streams with suitable gravel for spawning.	Known to occur; suitable habitat is present in and species is known to occur in the lower Feather River.
California roach *Lavinia symmetricus*	–	CSC	Spawning occurs in pools and side pools of rivers and creeks; juveniles rear in pools of rivers and creeks.	Known to occur; suitable habitat is present in and species is known to occur in the lower Feather River.

Table 3-6
Special-Status Wildlife and Fish Species with Potential to Occur in the LFRCMP Study Area

Species	Status[1]		Habitat	Potential for Occurrence[2]
	USFWS/ NMFS	CDFW		
Hardhead *Mylopharodon conocephalus*	–	CSC	Spawning occurs in pools and side pools of rivers and creeks; juveniles rear in pools of rivers and creeks, and in shallow to deeper water of lakes and reservoirs.	Known to occur; suitable habitat is present in and species is known to occur in the lower Feather River.
Central Valley steelheadDPS *Oncorhynchus mykiss*	T	–	Requires cold, freshwater streams with suitable gravel for spawning; rears on seasonally inundated floodplains and in rivers, tributaries, and the Delta.	Known to occur; suitable habitat is present in and species is known to occur in the lower Feather River.
Sacramento River winter-run Chinook salmon ESU *Oncorhynchus tshawytscha*	E	E	Requires cold, freshwater streams with suitable gravel for spawning; rears on seasonally inundated floodplains and in rivers, tributaries, and the Delta.	Likely to occur; known from the Sacramento River and tributaries; adults and juveniles may occasionally stray into the Feather River.
Central Valley spring-run Chinook salmon ESU *Oncorhynchus tshawytscha*	T	T	Requires cold, freshwater streams with suitable gravel for spawning; rears on seasonally inundated floodplains and in rivers, tributaries, and the Delta.	Known to occur; suitable habitat is present in and species is known to occur in the lower Feather River.
Central Valley fall/late fall–run Chinook salmon ESU *Oncorhynchus tshawytscha*	–	CSC	Requires cold, freshwater streams with suitable gravel for spawning; rears on seasonally inundated floodplains and in rivers, tributaries, and the Delta.	Known to occur; suitable habitat is present in and species is known to occur in the lower Feather River.
Sacramento splittail *Pogonichthys macrolepidotus*	DT	CSC	Spawning and juvenile rearing from winter to early summer in shallow weedy areas inundated during seasonal flooding in the lower reaches and flood bypasses of the Sacramento River, including the Yolo Bypass.	Known to occur; suitable habitat is present in and species is known to occur in the lower Feather River.

Notes: CDFW = California Department of Fish and Wildlife (formerly California Department of Fish and Game); CNDDB = California Natural Diversity Database; Delta = Sacramento–San Joaquin Delta; ESU = Evolutionarily Significant Unit; NMFS = National Marine Fisheries Service; USFWS = U.S. Fish and Wildlife Service

[1] Legal Status Definitions

U.S. Fish and Wildlife Service and National Marine Fisheries Service Federal Listing Categories:

E Endangered (legally protected)
T Threatened (legally protected)
DT Recently delisted from threatened status
C Candidate for listing
FSC Federal Species of Concern

California Department of Fish and Wildlife State Listing Categories:

E Endangered (legally protected)
T Threatened (legally protected)
FP Fully protected
PFM Protected Furbearing Mammal

Table 3-6 Special-Status Wildlife and Fish Species with Potential to Occur in the LFRCMP Study Area				
Species	**Status[1]**		**Habitat**	**Potential for Occurrence[2]**
	USFWS/ NMFS	**CDFW**		
CSC California Species of Special Concern				

[2] Potential for Occurrence Definitions

Unlikely to occur: Species is unlikely to be present on the project site due to poor habitat quality, lack of suitable habitat features, or restricted current distribution of the species.

Could occur: Suitable habitat is available at the project site; however, there are few to no other indicators that the species might be present.

Likely to occur: Habitat conditions, known occurrences in the project vicinity, or other factors indicate a relatively high likelihood that the species would occur at the project site.

Known to occur: The species, or evidence of its presence, was observed at the project site during reconnaissance surveys, or was reported by others.

[3] Protected Furbearing Mammal (California Code of Regulations Title 14, Section 460). Sacramento Valley red fox also meets the criteria for California Species of Special Concern (see Sacks et al. 2010).

Sources: CDFW 2013; USFWS 2013; DWR 2010b; TRLIA 2006; Sacks et al. 2010; USFWS 1998; data compiled by AECOM in 2013

3.5.4 RESTORATION AND MITIGATION EFFORTS

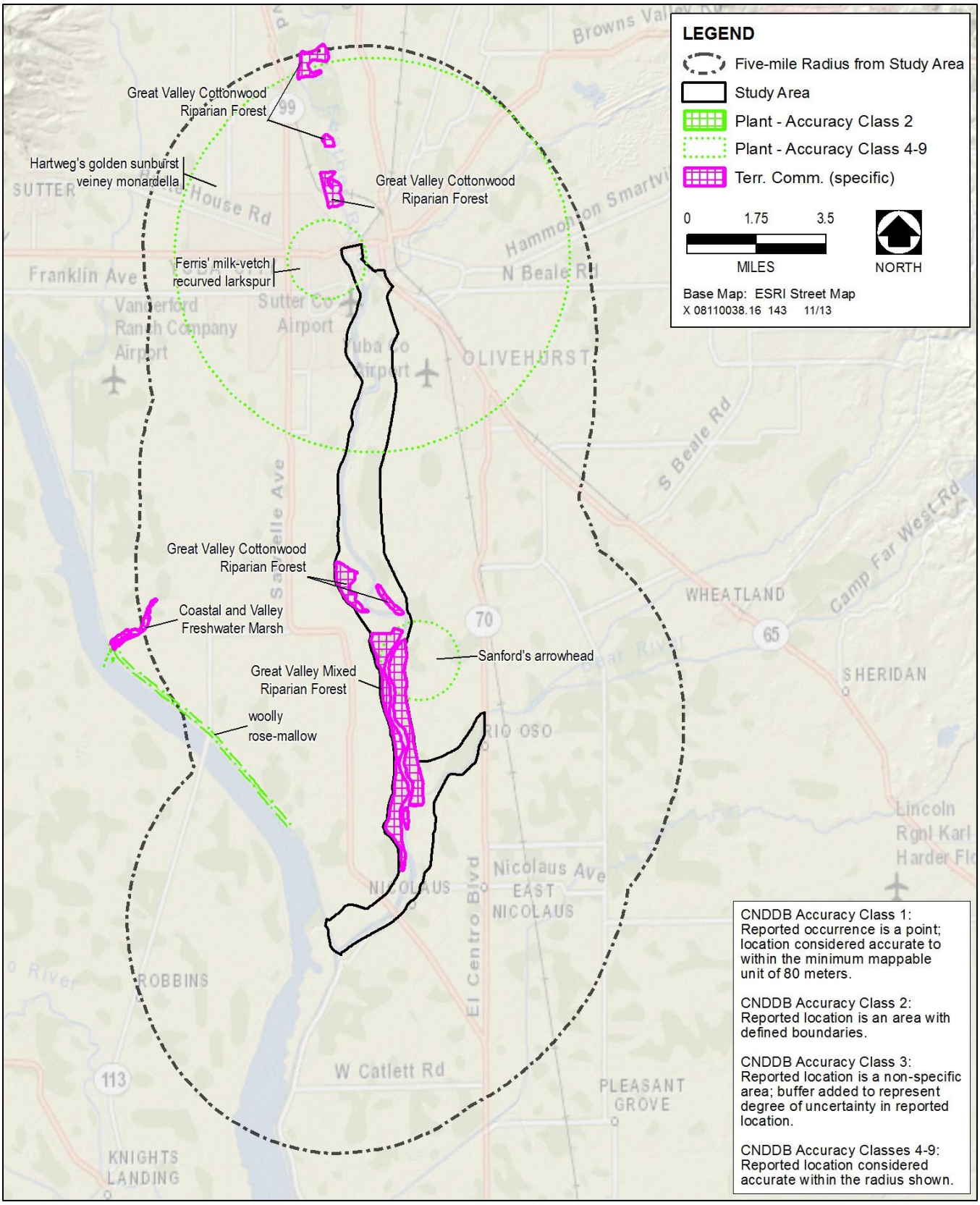
Several major restoration and mitigation efforts have been recently completed on public and local-government lands in the study area. Collectively, these projects have contributed and will continue to contribute substantially to enhanced biological resource values within the Lower Feather River study area. These projects particularly affect vegetation communities such as riparian forest and scrub and seasonally inundated floodplains, and habitat for special-status species such as Chinook salmon, Central Valley steelhead, Sacramento splittail, VELB, Swainson's hawk, and western yellow-billed cuckoo. Table 3-7 summarizes the targeted habitat types and the extent of habitat restored. Additional details about these projects have been provided by DWR (2011c) and can also be found in the environmental review or planning documents associated with these projects.

3.6 RECREATION

The Lower Feather River study area offers diverse recreation opportunities to Yuba and Sutter County residents and visitors to the area. Recreational uses in the study area include motorized and nonmotorized boating, hiking, biking, horseback riding, fishing, wildlife viewing, picnicking, and off-road vehicle (ORV) use. The floodway is a significant recreation resource and an important source of support for the local economy. Revenues from fishing and hunting stamps directly bring revenue to the region; money spent on food, drinks, bait, equipment, and guides also contributes to the local economy

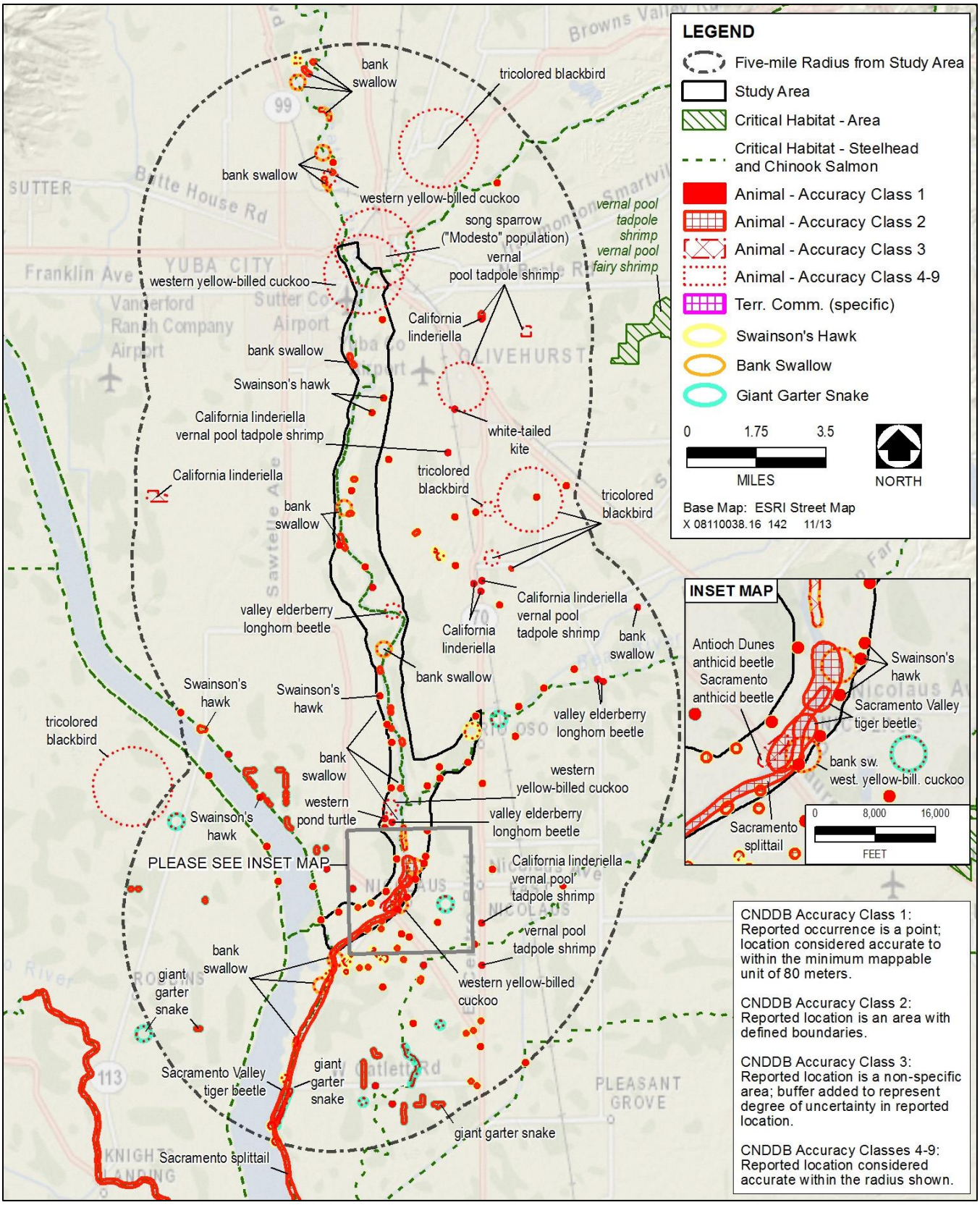
3.6.1 RECREATIONAL FACILITIES AND RIVER ACCESS

Riverfront access in the study area is substantially restricted by lack of public parking, a series of gates on the levee system, and perceived conflicts with adjoining private property owners and agricultural interests (Stoll Engineering 2009). Except at the public boat ramps and beaches described below, vehicular access to the river is prohibited. Gates and signs along the levees remind the public that no motorized vehicles are allowed, but they do not prohibit pedestrian, equestrian, or bicycle use. The system of levees offers an exceptional opportunity for



Source: CNDDB 2012, AECOM 2012

Exhibit 3-4 Recorded Occurrences of Special-status Plants Species and Terrestrial Communities in the LFRCMP Study Area



Source: CNDDB 2012, AECOM 2012

Exhibit 3-5 Recorded Occurrences of Special-status Wildlife Species and Critical Habitat in the LFRCMP Study Area

Table 3-7 Completed Restoration Projects in the Study Area	
Restoration/Mitigation Project	**Habitat Types and Approximate Acres Restored**
Feather River Setback Levee Project	VELB habitat via elderberry shrub transplanting (38 acres) Open water, Great Valley buttonbush scrub, Great Valley mixed riparian, and Great Valley valley oak woodland (30.4 acres)
Bear River Setback Levee and Riparian Restoration Project	Riparian forest and scrub, native perennial grasslands, shaded riverine aquatic habitat, freshwater marsh, and drainage swales (639 acres)
Star Bend Setback Levee and Habitat Enhancement Project	Riparian scrub, including elderberry mitigation via transplanting (20 acres)
O'Connor Lakes Unit Riparian Restoration Plan	Riparian forest and scrub (228 acres connecting existing disjunct patches), and native perennial grasslands
Marysville–Yuba City Area Levee Reconstruction Project	Riparian forest and scrub, freshwater marsh, VELB habitat (35 acres)
Sources: River Partners 2006, 2009	

public access on both sides of the river, and facilitates public access to the water's edge. Additional access points for foot traffic only are available along the right bank near Boyd's Pump. The levee is heavily walked here and on the east side of the river adjacent to the study area, where Yuba City operates a wastewater treatment facility. There is unofficial access across the levee and past the secondary treatment pond facilities to access the river at the Shanghai Rapids ("the Riffles") across from Shanghai Bend. Current users are attracted to the popular spot primarily for fishing. The existing system of maintenance access roads also provides passable surfaces for hiking, biking, and equestrian access. Allowing public access to the river at this location would be consistent with Yuba City's past commitment to developing its riverfront lands (RRM Design Group 2002).

Numerous recreational facilities owned and operated by the Ctiy of Marysville, Sutter County, State, or private parties exist in the study area, although many are undeveloped and need improvements. These include developed boat ramps with associated picnic areas; beaches; unofficial bank-fishing access points; soccer fields; a paintball site; multiple scenic viewing areas; ORV parks; and foot, bike, and equestrian trails. Table 3-8 provides details about the four developed boat ramps in the study area.

Additional recreational facilities at the north end of the study area include Riverfront Park, a large complex located on Bizz Johnson Drive adjacent to the Feather River. Amenities include a golf driving range, an ORV motocross course, soccer fields, a picnicking area known as Lion's Grove, softball fields, and a bicycle motocross

(BMX) track (City of Marysville 2012). A private paintball facility is located at the south end of the study area on the left (east) bank at RM 10.6 (Neubert, pers. comm., 2011).

Three sandy public beaches provide recreation opportunities along the river corridor. Mosquito Beach, located at RM 27, is a flat sandy bank at the river's edge that stretches for close to one-half mile (RRM Design Group 2002). A road connecting to Second Street provides vehicle access to the beach. This beach was much larger historically, but its size has been diminished over time by the river's sedimentation patterns, which have resulted

Table 3-8 Public Boat Ramps and Beaches in the Study Area			
Name	**Owner/Party Responsible for Maintenance**	**Location**	**Amenities**
Riverfront Park	City of Marysville	South of the Twin Cities memorial bridge on Bizz Johnson Drive, Marysville (RM 29 to RM 28 Left Bank)	Large complex including a boat ramp, golf driving range, ORV motocross course, soccer fields, softball fields, and BMX track
Yuba City Boat Ramp	Sutter County	Off Second Street near the north end of the Sutter County Airport, directly across from the mouth of the Yuba River, Yuba City (RM 27.5 Right Bank)	Marina, boat ramp, dry boat storage, RV park, showers, picnic area, paved parking, campsites, swimming area, fish cleaning station, and boat wash area
Mosquito Beach	Sutter County	Off Second Street, Yuba City (RM 27R)	Undeveloped sandy beach
Shanghai Bend Sandbar	California Department of Fish and Wildlife (formerly California Department of Fish and Game)	Upstream of Shanghai Rapids (RM 25 Right Bank)	Undeveloped sandy beach and sand/gravel bar
Boyd's Pump Boat Ramp	Sutter County	On the Feather River, off Garden Highway at the boat ramp sign; closest cross street is Oswald Avenue, Yuba City (RM 22.4 Right Bank)	Boat ramp, paved parking
Star Bend Boat Ramp	California Department of Fish and Wildlife (formerly California Department of Fish and Game)	Feather River Boulevard (RM 18 Left Bank)	Boat ramp, paved parking
Beer Can Beach		Off Lee Road near River Oaks Golf Club (RM 7.5 Left Bank)	Undeveloped sandy beach
Sources: City of Marysville 2012; Sutter County 2010b			

in greater sediment deposition along the opposite bank. Sutter County is interested in improving the facilities at Mosquito Beach, which are currently limited (Cleveland, pers. comm., 2012).

The sandbar at Shanghai Bend, situated near RM 25 in the northern reach of the study area, is considered an additional beach. The Feather River meanders around this large sandbar during low-flow periods. Shanghai Bend is a unique open-space feature in the study area. The Shanghai Rapids, known as "the Riffles," are a set of rapids that provide a scenic view of jumping salmon in the late fall. This picturesque setting offers a rare recreation resource in the Lower Feather River study area (RRM Design Group 2002). Beer Can Beach is a frequently visited beach off of Lee Road near River Oaks Golf Club. This sandy beach is located west of Nicolaus and downstream of the Nelson Slough Unit and Sutter Bypass. Recreationists also use the beaches near the Feather River levee setback area and along the west side of the Marysville wastewater treatment facility, although the area alongside the wastewater treatment facility is not designated or maintained as a public beach.

E Street MMX, a privately owned motocross facility, is open to the public and located along the lower Yuba River near the SR 70 Bridge. Three tracks of various sizes and jumps are available for practice and competitions. The main track, open to motorcycles and all-terrain vehicles of all sizes, lies just east of SR 70. Two smaller tracks for beginners and smaller motorcycles and all-terrain vehicles are situated west of SR 70.

3.6.2 WILDLIFE VIEWING, HUNTING, AND FISHING OPPORTUNITIES

Wildlife viewing opportunities, especially birding, provide enjoyment for residents and visitors and generate revenue for both Yuba and Sutter counties. Units of CDFW's Feather River Wildlife Area offer opportunities for wildlife viewing year round, as does the Bobelaine Audubon Sanctuary. More than 190 species of birds have been observed, including Swainson's hawk, yellow-billed magpie, greater sandhill crane, and purple martin. A wide variety of mammals are also found such as fox, deer, river otter, beaver, muskrat, skunk, and raccoon (Schmoldt, pers. comm., 2012).

The Lower Feather River study area also provides ample hunting and fishing opportunities. Table 3-9 lists some of the frequently used boat and bank fishing sites along this reach of the river. Chinook salmon are common in the Feather River in October and November and shad are present in April and May. Table 3-10 summarizes hunting and fishing opportunities within CDFW management units of the Feather River Wildlife Area.

Table 3-9
Bank and Boat Fishing Opportunities in the LFRCMP Study Area

Location	Type of Fishing Opportunity
West bank near the confluence of Yuba River to Mosquito Beach	Boat and bank
West bank just north of RM 24	Bank
RM 25 to RM 24	Boat
Boyd's Pump, RM 22	Boat
Left (east) and right (west) banks near Star Bend and LD 1 land, RM 19	Bank
Right (west) bank Feather River irrigation pumps	Bank
Confluence of Bear River	Boat
Left (east) bank RM 10	Bank

Source: Neubert, pers. comm., 2011

Table 3-10
Hunting and Fishing Opportunities in the California Department of Fish and Wildlife's Feather River Wildlife Area

CDFW Unit	Dates	Game Species	Area Regulations	Fishing
Shanghai Bend	Closed to hunting	NA	NA	Bank fishing
Abbott Lake	July 1 to January 31 and spring turkey season	Wild turkey, deer, pheasant, rabbit, tree squirrel, waterfowl, quail, and dove	Shotgun and archery only. No rifles or pistols may be used or possessed.	Fishing for bluegill, black crappie, and largemouth bass year round in Abbott Lake
Star Bend	July 1 to January 31 and spring turkey season	Wild turkey, deer, pheasant, rabbit, tree squirrel, waterfowl, quail, and dove	Shotgun and archery only. No rifles or pistols may be used or possessed.	Bank fishing, but accessible only by boat
O'Connor Lakes	July 1 to January 31 and spring turkey season	Wild turkey, deer, pheasant, rabbit, tree squirrel, waterfowl,	Shotgun and archery only. No rifles or pistols may be used or	Bank fishing, but accessible only by boat

Table 3-10 Hunting and Fishing Opportunities in the California Department of Fish and Wildlife's Feather River Wildlife Area				
CDFW Unit	**Dates**	**Game Species**	**Area Regulations**	**Fishing**
	No hunting in special closure area March 1 to June 30 without special authorization from CDFW	quail, and dove	possessed.	
Lake of the Woods	July 1 to January 31 and spring turkey season	Wild turkey, deer, pheasant, rabbit, tree squirrel, waterfowl, quail, and dove	Shotgun and archery only. No rifles or pistols may be used or possessed.	Bank fishing, but accessible only by boat
Nelson Slough	July 1 to January 31 and spring turkey season	Wild turkey, deer, pheasant, rabbit, waterfowl, and coyote	Shotgun and archery only. No rifles or pistols may be used or possessed.	Bank fishing, but accessible only by boat
Source: DFG 2012b				

3.7 AGRICULTURE

The agricultural sector is vital to the economic health of Sutter and Yuba counties and heavily influences the social structure of these areas. In 2010, the gross value of agricultural production was $195,479,000 in Yuba County (Yuba County Department of Agriculture 2011) and $520,992,190 in Sutter County (Sutter County 2011). The *Sutter County General Plan* (Sutter County 2010c) and the *Yuba County General Plan* (Yuba County 2011b) identify significant agricultural resources in the floodplain, which have largely been set aside for agricultural production. Agriculture in this area benefits from rich soils, plentiful water resources, a temperate climate, extensive farming knowledge passed down through the generations, and well-developed infrastructure.

In Sutter County, the lands designated as agriculture comprise 328,208 acres (Sutter County 2010b). The county has set these areas aside for long-term conservation of agriculture and they are highly valued by county residents. Approximately 91% of Sutter County's unincorporated acreage is agriculture, with an undetermined number of acres in the study area. More than 86% of the county's lands are classified as agriculture, with roughly 48% of those lands designated as Prime Farmland and another 31% as Farmland of Statewide Importance, although again, the exact acreage of these lands in the study area is undetermined (Sutter County 2010b).

Agriculture is the most extensive land use in Yuba County, and is a crucial component of its economic fabric. Approximately 278,943 acres, or 68% of the county's total area, are made up of agricultural croplands and pasture (Yuba County 2011b). The study area contains nearly 3,000 acres of agricultural land on the Yuba County side of the floodplain (Yuba County 2010). This plan recognizes the value of preserving agricultural lands across both counties.

TRLIA owns most local agency–owned lands in the study area, leasing the agricultural portions of these lands to private parties that maintain the orchards. The lease arrangement provides flexibility for TRLIA or some future owner to either: (1) extend current agricultural leases, (2) lease the property to alternative private agricultural

users, (3) convert the leases into an agricultural stewardship use, or (4) terminate the agricultural use in favor of a restoration/environmental use and/or stewardship (TRLIA 2011).

This land is leased to seven farmers and one revocable easement and profit agreement in the access corridor for the landside levee toe (Table 3-11). The TRLIA Board of Directors intends to maintain as much of the setback area in agricultural use as economically feasible, with approximately one-third of the setback area in agriculture. TRLIA and/or the State could extend these leases if sustained agriculture is desired. The primary crop is walnuts; the level of walnut production varies from 0.5 ton to 2 tons per acre. Existing infrastructure includes irrigation delivery systems (including wells, canals, and ditches), established trees, and access roads (Dacus, pers. comm., 2012). The agricultural leases are in the fifth year of the 5-year leases and TRLIA and/or the State are in the process of extending these leases (TRLIA 2013b).

Table 3-11
Three Rivers Levee Improvement Authority Lease Agreements in the Feather River Setback Area

Crop	Acres	Lease Terms
Walnut	20.00	August 15, 2013
Walnut, persimmon, mandarin, chestnut, and jujube	27.38	August 15, 2013
Walnut	9.00	November 30, 2013
Peach orchard	4.82	December 31, 2013
Walnut	66.00	December 31, 2013
Walnut and peach	99.00	December 31, 2014
Walnut	248.00	December 31, 2014

Source: TRLIA 2011.

Some land in the study area is privately owned; most of that land is under agricultural production. Agricultural lands include orchard crops such as walnuts, pome fruit (e.g., pears), and persimmons; field crops, pasture; and fallow fields. Some agricultural facilities are also present on these parcels. There are also larger privately owned parcels that are largely undeveloped and support native riparian habitat. Approximately 2,600 acres of private agricultural land exists on the Yuba County side of the floodplain (Yuba County 2010). The total acreage on the Sutter County side is undetermined; however, the property located between the Abbott Lake and O'Connor Lakes management units of the Feather River Wildlife Area is planted in walnuts and prunes (Neubert, pers. comm., 2011). The net agricultural acreage is approximately 75 acres. The entire property is located inside the floodway. Additional crop information may be obtained from the U.S. Department of Agriculture's Farm Service Agency, which receives annual crop-acreage reporting data and compiles an annual crop production and harvest report.

3.8 INFRASTRUCTURE

3.8.1 BRIDGES

Six bridges are located within the study area. The northern end of the study area is bounded by the four-lane SR 20 Bridge (Colusa Avenue) on the Feather River and the four-lane SR 70 Bridge on the Yuba River. Three additional bridges operate within the study area in this urban center:

- The two-lane Twin Cities Memorial Bridge (Fifth Street), just south of the SR 20 Bridge on the Feather River
- A Union Pacific railroad bridge, adjacent and parallel to the Twin Cities Memorial Bridge on the downstream side
- A second Union Pacific railroad bridge on the Yuba River, downstream of the SR 70 Bridge

Two bridges are located just beyond the study area boundary (SR 70 Bridge) on the Yuba River: the Simpson Lane Bridge 1 mile upstream of SR 70 and a railroad bridge at A Street 2,000 feet upstream of SR 70. Near the southern end of the study area, the two-lane SR 99 Bridge crosses the Feather River just south of the unincorporated community of Nicolaus.

3.8.2 PUBLIC UTILITIES

TELECOMMUNICATIONS, ELECTRICAL, AND NATURAL GAS FACILITIES

AT&T is the primary phone service provider in Sutter and Yuba counties (Yuba County 2009). Phone cables in the study area may exist above ground on power poles or be buried.

PG&E is the provider of electricity for all of Sutter and Yuba counties. Several distribution lines located within the floodway serve agricultural operations such as major irrigation pumps and private wells. Lines may run either above ground, attached to wooden telephone poles, or buried below ground. PG&E also owns and maintains a 115-kilovolt transmission line, referred to as the Bogue Loop. The line crosses the Feather River setback levee in Yuba County between Murphy Road and Ella Road. Steel transmission towers support the line within the floodway. The towers also have distribution lines that run east, serving residential and agricultural operations, and west across the Feather River, serving a river diversion pump on the right (west) bank (TRLIA 2006).

The Western Area Power Administration owns and maintains a 230-kilovolt transmission line that crosses the Feather River in the study area. The crossing is located just south of the SR 99 Bridge. This segment of transmission line was recently reconstructed and upgraded. It runs approximately 31 miles from the Western Area Power Administration's O'Banion substation in Sutter County to the Sacramento Municipal Utility District's Elverta substation in Sacramento County.

PG&E is also the provider of natural gas for all of Sutter and Yuba counties. Gas lines within the floodway serve both agricultural and urban operations, and include three lines: (1) a line that crosses the Feather River's left-bank levee near Island Road; (2) a line following the crest of the Feather River's left levee embankment from SR 70 south to the end of Garden Avenue; and (3) a line that is installed within the levee, running parallel to the aforementioned lines (TRLIA 2006).

WASTEWATER TREATMENT FACILITIES

Three wastewater treatment plants that serve the cities of Marysville and Yuba City and LCWD have facilities (e.g., disposal ponds, disposal fields/orchards, outfall pipelines) within the study area.

The City of Marysville maintains a wastewater treatment plant outside of the study area in southeastern Marysville (on the landside of the levee). However, associated wastewater disposal ponds are maintained within

the floodway on the north side of the confluence of the Feather and Yuba rivers. The Marysville wastewater treatment plant provides secondary wastewater treatment, discharging most of the effluent to these ponds. The ponds are capable of receiving 1.7 million gallons per day. The remaining effluent is diverted before the ponds and is used to irrigate walnut orchards within the floodway (Yuba County 2009). The disposal ponds are not currently protected from a 100-year flood event. Because of this lack of protection, the Marysville wastewater treatment facility has been operating under a cease-and-desist order (No. R5-2009-0014) from the Central Valley RWQCB since 2004. Under this order, the operator of the wastewater treatment facility is responsible for protecting the ponds from a 100-year flood event. To meet the requirements of the cease-and-desist order, the City of Marysville completed a feasibility study and master plan results report that outlined a regionalization of facilities as the primary alternative, rather than modifying, upgrading, or relocating the facilities. Currently, Marysville is planning to export its wastewater to the Linda County Water District's wastewater treatment plant (Kennedy/Jenks Consultants 2010). In the interim, Marysville is responsible for O&M of the disposal ponds and all associated pipelines, pumps, and equipment.

LCWD maintains a wastewater treatment plant adjacent to the landside toe of the levee on the east side of the study area south of Myrna Avenue in Yuba County. LCWD's facility is designed for secondary wastewater treatment standards. Effluent is discharged into one of seven disposal ponds located within the study area floodway adjacent to the wastewater treatment plant. The plant also maintains an outfall pipeline for discharge directly into the Feather River (Yuba County 2009). However, LCWD began expanding and upgrading its system in 2009. The new construction upgrades the facility to full nitrification-denitrification and tertiary filtration systems to comply with Central Valley RWQCB Waste Discharge Requirements Order R5-2006-0096.

Yuba City maintains a wastewater treatment plant outside of the study area, within its city limits. However, the wastewater treatment plant discharges treated wastewater directly into the Feather River north of Shanghai Bend (Sutter County 2010b), via a diffuser pipeline in a gravel trench at the upstream end of Shanghai Rapids. The plant also maintains six disposal fields and ponds on 150 acres within the floodway, along the left (east) bank of the Feather River just downstream of Shanghai Bend. On January 30, 2012, a major pressurized pipeline also buried under Shanghai Rapids was severed, causing secondary treated effluent to be released into the Feather River. This pressurized sewer line was buried in a gravel-lined trench approximately 5 feet below the surface of the Modesto Formation (Moffatt & Nichol 2012). A new pipeline has since been installed, using a hydraulic directional drilling method, at a much greater depth of 20–40 feet below ground level (see Chapter 5 for more information).

STORMWATER DRAINAGE SYSTEMS

Sutter County includes 11 stormwater drainage districts. Facilities from two of the districts drain into the Feather and Bear rivers in the study area; the remaining nine drain into the Sacramento River or the Sutter Bypass. RD 823, the smallest district in Sutter County, is located north of the confluence of the Feather River and the Sutter Bypass. RD 823 drains in a southerly direction via numerous ditches that lead to a privately owned pumping station that discharges into the Feather River near its confluence with the Sutter Bypass (Sutter County 2010b). RD 1001 is located on the east side of the Feather River from SR 70 south to the Natomas Cross Canal. Most of the district drains to the south and discharges drainage into the Feather River south of the study area. However, RD 1001 drains its northern communities of Nicolaus, East Nicolaus, Trowbridge, and Rio Oso via

three small pumping stations that discharge into Yankee Slough, a tributary of the Bear River (Sutter County 2010b).

In Yuba County, the City of Marysville, the City of Wheatland, Beale Air Force Base, RD 784, and the county itself are responsible for O&M of stormwater discharge facilities (Yuba LAFCO 2008). However, RD 784 is responsible for all stormwater drainage in this portion of the study area. RD 784 is bounded by the Yuba River in the north, the Western Pacific Interceptor Canal in the east, the Feather River in the west, and the Bear River in the south. The district provides drainage for Olivehurst, Linda, and the Plumas Lake community, with three pumping stations discharging into the Feather River and one into the Bear River (Yuba County 2011b).

WATER SUPPLY

Most of Sutter County in the vicinity of the study area, with the exception of Yuba City, obtains potable water via groundwater pumped from privately owned wells. Yuba City's supply of potable water, however, consists mainly of surface water diverted from the Feather River. Using four water right permits (Table 3-12), Yuba City is authorized to divert up to 29,600 acre-feet per year (Sutter County 2010b). Yuba City also operates a single groundwater well to supplement the surface water rights. This well is located within the city limits at the wastewater treatment plant.

Table 3-12
Current Surface Water Right Permits for Yuba City

Water Right Permit/Contract	Acre-feet Per Year
State Water Resources Control Board Permit 1405	6,500
State Water Resources Control Board Permit 18558	9,000
Yuba County Water District Contract	4,500
California Department of Water Resources, State Water Project Contract	9,600

Source: Sutter County 2010b

Groundwater is the exclusive source of potable water in Yuba County in the vicinity of the study area (Yuba County 2011b). Municipal water purveyors within and adjacent to the study area include the California Water Service, LCWD, and the Olivehurst Public Utilities District (Yuba County 2011b). The California Water Service supplies water to Marysville via 13 wells with a capacity of 9,990 gallons per minute. LCWD operates seven wells that serve the Linda area, with a capacity of 8,420 gallons per minute. The Olivehurst Public Utilities District operates 13 wells that serve Olivehurst and Plumas Lake, with a capacity of 24,070 gallons per minute (Atkins 2011). However, none of these purveyors operate or maintain wells within the floodway.

Sources of irrigation water in the study area include surface-water diversions from the Feather River and groundwater pumped from privately owned irrigation wells. The agricultural irrigation entities that divert surface water from the Feather River in the study area include the Feather Water District, Tudor Mutual Water Company, the Garden Highway Mutual Water Company, and the Plumas Mutual Water District.

Feather Water District operates and maintains two diversion pumping stations along the right bank of the Feather River at approximately RM 16 and RM 21.5. In 2008, the district diverted 11,997 acre-feet of water to irrigate

7,398 acres of prunes, peaches, walnuts, melons, alfalfa, and rice (Reclamation 2010). Tudor Mutual Water Company and Volcano Vista Farms operate and maintain a single diversion pumping station (City of Yuba City 2007) at the Star Bend levee setback area (approximately RM 19). In 2006, they diverted 3,300 acre-feet to irrigate orchards (DWR 2008).

Garden Highway Mutual Water Company operates and maintains a single diversion pumping station near RM 13.5 (right bank). In 2006, the company diverted 13,200 acre-feet for irrigation purposes (DWR 2008). Plumas Mutual Water District operates and maintains a single diversion pumping station south of the Star Bend Boat Ramp (approximately RM 18 left bank). In 2006, the district diverted 3,909 acre-feet (DWR 2008) to irrigate approximately 2,500 acres (SACOG 2011). Numerous privately owned wells are operated and maintained within the floodway for irrigation purposes.

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4 MANAGEMENT GOALS, CHALLENGES, AND OPPORTUNITIES

4.1 MANAGEMENT GOALS

The overall goal of the *Lower Feather River Corridor Management Plan* (LFRCMP) is to maximize public safety by protecting and maintaining flood management facilities and floodways of the Lower Feather River (LFR) while preserving and enhancing fish and wildlife habitat and ecosystem functions, promoting economic stability, conserving agriculture and its infrastructure, and enhancing recreational opportunities. The LFRCMP Work Group developed the following specific goals and objectives for the LFRCMP:

Flood Management

- Minimize floodway maintenance costs and avoidable delays in implementing floodway maintenance.
- Minimize conflicts between floodway maintenance and ecosystem function/habitat goals.
- Ensure design floodway conveyance capacity in all reaches.
- Improve sediment management.
- To the extent feasible, prevent processes that adversely affect levee integrity, such as erosion and animal burrows.

Ecosystem and Habitat Enhancement

- Increase the extent and connectivity of riparian/upland habitat mosaics (including native grasslands) for terrestrial wildlife and restore degraded wildlife habitat.
- Increase the extent and connectivity of seasonal shallow aquatic habitat, frequently inundated floodplains, shaded riverine aquatic (SRA), and riparian habitats to benefit fish and other river-dependent wildlife.
- To the extent feasible, restore dynamic channel formation processes that enable a dynamic succession and mosaic of floodplain habitat types.
- Reduce the extent and proliferation of non-native invasive plants that interfere with floodway maintenance and restoration goals.
- Reduce existing fish entrapment basins in the floodplain.
- Contribute to conservation and recovery of special-status species.

River Recreation

- Increase and improve river recreation access with boat ramps and locations for canoe, raft, and kayak access in underserved reaches of the river.

- Increase and improve public access and develop pedestrian trails and bank fishing sites in areas that would not disturb sensitive resources.
- Promote connectivity and access between trails, facilities, along levee roads, and open space to increase opportunities for appropriate recreation and reduce trespass and gate vandalism.
- Increase public awareness of the benefits of natural ecosystem processes and provide interpretive resources to build public understanding and support for corridor management activities.
- Maintain and enhance opportunities for hunting and fishing in the California Department of Fish and Wildlife's (CDFW's) Feather River Wildlife Area.

Agriculture

- Conserve substantial agricultural acreage and supporting infrastructure.

Promote integration of agricultural sustainability and ecosystem benefits. This chapter describes the management challenges and opportunities that led to creation of these goals and objectives, and discusses how management actions described in Chapter 6 would help achieve the goals and objectives.

4.2 FLOOD MANAGEMENT CHALLENGES AND OPPORTUNITIES

4.2.1 SEDIMENT DEPOSITION

Recent flood control system improvements in the LFRCMP study area, including the Feather and Bear rivers and Star Bend levee setback projects, have substantially increased the channel capacity of the LFR. When completed, these and other future projects will help achieve a 200-year level of flood protection for the study area (see Chapter 3, Section 3.1.4, "Floodway Capacity"). Flood protection has been improved for the communities of Olivehurst, Linda, Arboga, Plumas Lake, Marysville, and Yuba City, and for major interstate transportation corridors. The Feather River east levee now protects approximately 29,000 acres of mixed-use land in southern Yuba County, including more than $1 billion worth of residential, commercial/industrial, and public buildings and infrastructure (TRLIA 2011).

Despite implementation of recent flood control system improvements, some challenges remain for maintaining floodways in the LFRCMP study area, including managing deposition of sediment. Sediment deposition in the Sutter Bypass is an ongoing concern for flood risk in the LFRCMP study area because it contributes to a cumulative decrease in flow capacity and increased flood risk over time (Singer et al. 2008). The area of convergence between the Sutter Bypass, Feather River, and Sacramento River is an area where three major watershed drainages converge, resulting in backwater effects during high flows that cause sedimentation and further reduce floodway capacity with each flood. The main channel of the Feather River has reduced capacity from extensive sand deposition and shallow shoaling downstream of the Bear River to the Sutter Bypass (between River Mile [RM] 13 and RM 7—see Exhibit 5-33 in Chapter 5).

Chapter 5 describes sediment transport modeling that was conducted to evaluate the effects of a 2-, 10-, and 100-year flood on channel and floodplain deposition and scour. The purpose of the sediment transport model was to evaluate whether potential management actions addressing sediment deposition would have any beneficial or

adverse effects on floodplain or channel sediment storage or sediment accumulation affecting the river's conveyance capacity. Chapter 6 describes the proposed actions intended to improve sediment management, and to promote sediment transport and flood bypass conveyance in the Upper State Cut channel as part of floodway management in this area. Sediment transport modeling was also used to evaluate the efficacy of excavating two wide terraces on the right bank of the river at Nelson Slough Unit to increase sediment capture on lower floodplain surfaces.

4.2.2 FLOODWAY CONSTRICTIONS AND LEVEE INTEGRITY

In addition to backwater flooding effects from the Sutter Bypass, flooding concerns in the study area include levee failure (from erosion, slumpage, seepage boils, or breaching) or overtopping. The potential for levee failure or overtopping is influenced by the structural integrity and design capacity of levees. Levees threatened by erosion and seepage, or areas where levees are constricted at pinch points, are of the greatest concern for this type of flooding in the study area.

As described in Chapter 5, nearly all of the levees in the study area have adequate freeboard above the 100- and 200-year flood stage. Only one location on the Feather River, between RM 17 and Wilkie Avenue (RM 16), has less than 3-feet of freeboard on the right (west) levee during a 200-year flood event (MBK 2012, Appendix F (see Section 5.3.2, "Results of Flood Modeling"). During the 1-in-200 flood event, the Bear River levees (RM 0.3 to RM 4.75) have freeboard ranging from 3 feet to 6. Under the Upper Feather River Centering flood scenario, slightly less than 3 feet of freeboard occurs in two short segments upstream of the Western Pacific Interceptor Canal (RM 4.1) at approximately RM 4.2 and 4.7 (MBK 2012, Appendix F, Figure 23). The floodway is constricted in the following locations: between RM 13.7 and RM 17 (which includes portions of Lake of the Woods); between RM 8.7 and RM 11 which includes the State Route 99 Bridge crossing and the upstream portion of Nelson Slough Unit; and between the right bank Hook Levee and the left bank (east) levee, from RM 7 to RM 7.5. Chapter 5 and Appendix F (MBK 2012) provide details about the modeling results assessing the mid-channel velocities and floodway capacity at the constricted locations. Chapter 6 describes potential management actions that could relieve the constriction along the toe of the east levee downstream of RM 8, and may also minimize channel scour in the river by reducing mid-channel velocities.

Levee underseepage through porous media is a concern along portions of the west levee of the Feather River and the east levee of the lower Sutter Bypass. As described in Chapter 3, the Sutter Butte Flood Control Agency's Feather River West Levee Project is intended to address these levee concerns and to reduce flood risk in the Sutter Basin (ICF 2013). For most of the LFRCMP study area, levees are set back a safe distance from potentially eroding riverbanks, or banks are stabilized by rock slope protection or naturally erosion-resistant geologic features (e.g., exposed Modesto formation).

4.2.3 ENVIRONMENTAL CONSTRAINTS FOR FLOOD MANAGEMENT

Implementing routine floodway maintenance, repairs, and flood management projects while complying with federal and State environmental laws that protect sensitive resources is a major challenge for flood managers working in the LFRCMP study area. Addressing the needs of special-status species that could occupy the floodway is particularly problematic for flood managers. For example, small mammals create subterranean burrow networks in levees that provide potential nesting sites for burrowing owls and refugia for the threatened giant garter snake. However, these burrow networks adversely affect levee integrity because they can facilitate

piping of water through the levee, shorten seepage paths, create voids that lead to partial levee collapses, and promote soil erosion that alters the levee profile (Bayoumi and Meguid 2011). Repairs to levees riddled with burrows require excavating and backfilling or grouting to fill all voids, actions that could affect giant garter snakes if they are present. Timely completion of repairs can therefore be delayed by the need to secure permits to comply with the State and federal endangered species acts.

Similar constraints affect vegetation management activities; the timely and efficient completion of routine vegetation management to maintain the floodway and protect water control structures is sometimes impeded by work windows and buffer zones designed to protect migratory birds and habitat for special-status species. Delays and increased costs can also occur with efforts to repair water control structures or remove debris from culverts, pipes, and inlets or outlets, if the work involves activities within waters of the United States or the State. Such delays can adversely affect flood safety because failure of a pipe or culvert caused by corrosion, blockage, or collapse can lead to internal erosion of a levee, road base, or other nearby structure and create serious risk. Prolonged delays in vegetation management can also affect public safety because dense vegetation in constricted reaches can increase water surface elevations under flood conditions, thus increasing the risk for levee overtopping or failure.

Additional challenges occur when flood managers need to secure permits and develop compensatory mitigation for non-routine flood management projects. Securing permits for these projects often requires time-consuming permit applications, focused surveys, and negotiations that can delay necessary improvements to the flood management system. The delays and challenges associated with obtaining permits and establishing mitigation can adversely affect construction costs and timelines for vital flood management projects, and can delay and increase the cost of mitigation.

Chapter 7 describes a strategy to address these challenges with a programmatic approach that would expedite permitting for maintenance of flood management facilities and implementation of flood management and ecosystem/habitat enhancement projects. This approach would involve working collaboratively with resource agencies to integrate flood management and ecosystem/habitat enhancement goals in a way that also fulfills permit and mitigation requirements.

4.3 ECOSYSTEM AND HABITAT CHALLENGES AND OPPORTUNITIES

4.3.1 REDUCED AND FRAGMENTED RIPARIAN AND UPLAND HABITATS

The riparian plant communities of the LFRCMP study area provide crucial habitat for terrestrial wildlife, but riparian ecosystems in the study area have been fragmented and degraded by a variety of stressors, including alterations in natural riverine processes as a result of construction of dams, diversions, revetment, levees, and hydraulic mining. As described in Chapter 3, within the approximately 12,000-acre LFRCMP study area there are only approximately 3,700 acres of riparian forest and scrub. The most extensive tracts of riparian forest occur in the Abbott Lake Unit, in and adjacent to the O'Connor Lakes and Lake of the Woods units, and in the Bobelaine Audubon Sanctuary. Narrow to broad bands of riparian habitat also occur along the Feather, Yuba and Bear rivers, and along sloughs, lakes, and agricultural irrigation canals. (See Exhibit 3-4 in Chapter 3 for a depiction of vegetation communities in the LFRCMP study area.)

Expanding and connecting riparian habitat in the LFRCMP study area is a particular focus of ecosystem enhancement efforts because riparian vegetation communities contain the most species-rich and abundant communities of birds and provide critically important habitat for many other wildlife taxa (Knopf et al. 1988). Increasing the connectivity of riparian habitat is also a very important goal because the number of wildlife species in riparian corridors increases with corridor size, width, and continuity (e.g., Hagar 1999, Heath and Ballard 2003). CDFW has identified increased connectivity of habitat and natural communities in the LFRCMP study area as an important management goal (Barker, pers. comm., 2014).

Widening and connecting riparian corridors is also crucial because for some species, particularly for smaller, less mobile animals, narrow or fragmented corridors do not provide a suitable corridor for dispersal (Rosenberg et al. 1997). For more widely distributed species, the value of wide, contiguous corridors may be related to increased habitat heterogeneity in larger corridors; the absence of interior habitats in narrower, fragmented corridors; and the ability of larger corridors to support species with larger home ranges.

Upland habitats in the LFRCMP study area also provide valuable resources for terrestrial wildlife, particularly where those uplands occur as a mosaic with riparian forest, willow scrub, and other native plant communities. Many wildlife species require several habitat features and use different vegetation types at various times during their life cycles. In the Sacramento Valley, many riparian-associated species use, and often require, both riparian and other adjacent habitats, including uplands, for reproduction, cover, and/or foraging (Placer County Planning Department 2005). Therefore, a mosaic of riparian habitats, and habitats that are diverse in the composition of vegetation species and physical habitat structure, are more likely to accommodate a wider variety of wildlife compared to homogenous habitats (RHJV 2004). Creating upland habitat that is intermixed with riparian and other habitats is therefore a high priority for restoration efforts in the LFRCMP study area, and is consistent with CDFW goals for enhancing habitat for special-status wildlife species and for improving overall biological diversity (Barker, pers. comm., 2014).

Upland habitat comprises approximately 4,100 acres within the LFRCMP study area, consisting mostly of annual grassland (2,430 acres) and ruderal habitat (1,003 acres). This habitat type occurs on high ground and along levees and disturbed areas, including along access roads and in fallow agricultural fields in the Feather River setback area. Only 196 acres of the upland habitat consist of native perennial grassland, and this occurs in the Bear River setback area and O'Connor Lakes Unit.

Upland habitat on high ground provides important flood refugia for wildlife occupying habitats between the levees of the LFRCMP study area (Barker, pers. comm., 2014). With the construction of setback levees, the width between levees has increased greatly, exceeding 1 mile in the Feather River setback area. As described in Chapter 5, most of this area is inundated during a 10-year flood (Exhibit 4-1), and the entire floodway, from levee to levee, is under water during a 100-year flood event. Terrestrial wildlife such as large and small mammals, reptiles, and amphibians need high-ground refuge and cover during small and large flood events; however, with the greatly expanded floodway, high-ground refuge provided by the levees can be very far away. One of the management actions described in Chapter 6 is to use material generated by swale excavation to create ridge mounds that provide high-ground refuge for terrestrial wildlife during flood events. To provide cover as well as foraging and breeding opportunities, the high ground would be planted with upland scrub vegetation and valley oak woodland.

Many of the management actions described in Chapter 6 would increase the extent and quality of riparian and upland habitat for terrestrial wildlife in the LFRCMP study area. These actions would create a mosaic of riparian

and upland habitats that more closely replicate primordial conditions, with varying successional stages of riparian habitat intermixed with native upland habitats. The management actions include revegetation and restoration, and as described below, some would result from excavating swales and creating topographic and hydrological conditions that support natural riverine and successional processes. These actions would expand and connect existing swathes of riparian habitat in the LFRCMP study area, replace ruderal and annual grassland with native perennial grasses or valley oak woodland, and improve the diversity and quality of existing riparian forests.

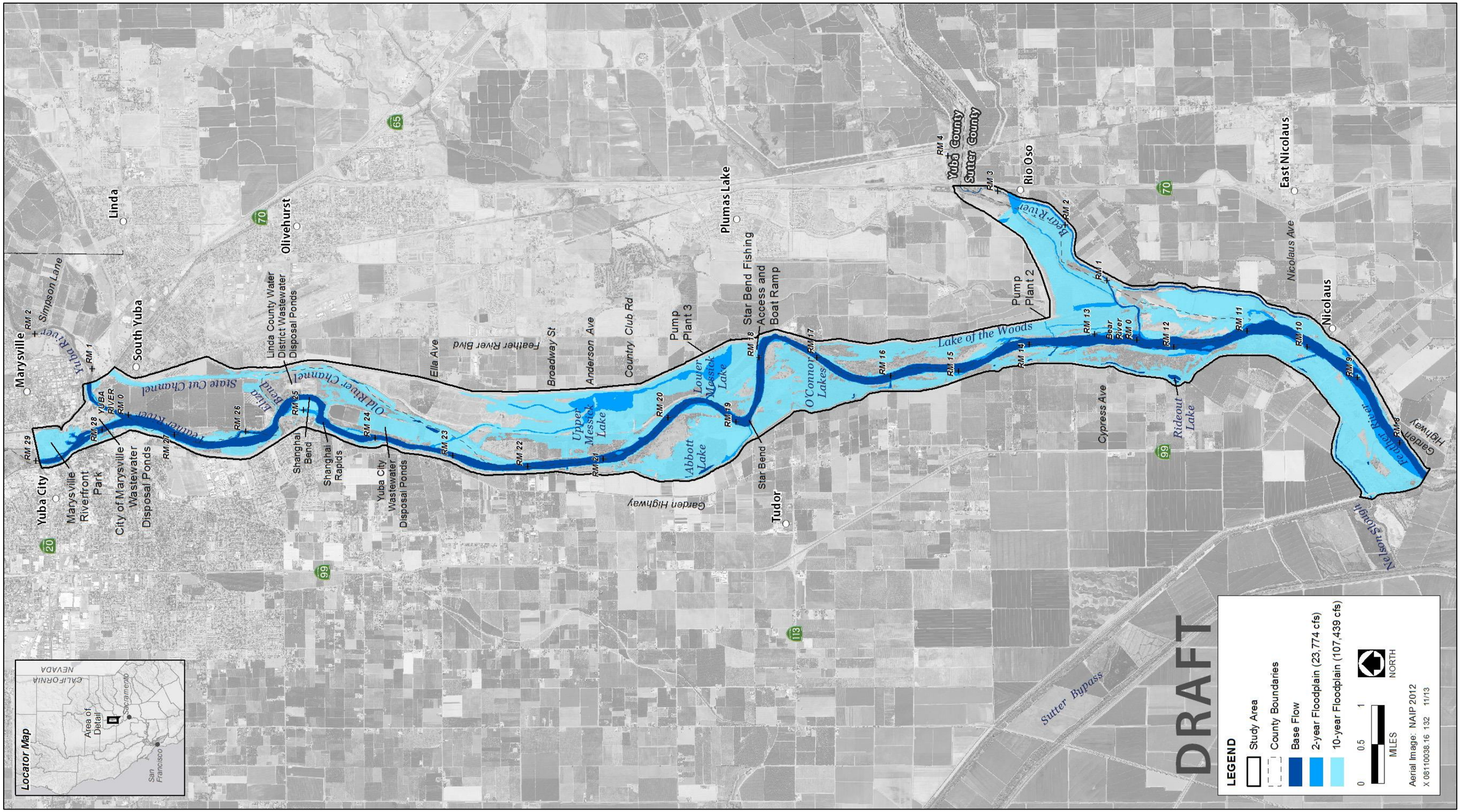
4.3.2 Alterations to Riverine Processes and Resulting Impacts on Ecosystems and Species

Natural river processes like floodplain inundation and channel meander migration maintain the complex mosaic of riverine and floodplain habitats that support a diversity of native species (Naiman et al. 1993; Lytle and Poff 2004). Along the LFR these natural processes have been significantly altered over the past 150 years by hydraulic mining and construction of dams and levees, with resulting perturbations to the natural sediment transport and hydrologic regimes (see Chapter 5 and Appendix H). As a result of reduced sediment supply and extensive levee projects, dredging, and channelization, a period of channel incision through an aggraded bed condition occurred from the early to mid-20th century. As described briefly below, and in detail in Chapter 5 and Appendix H, this channel incision has dramatically reduced the frequency and duration of natural floodplain inundation in the LFRCMP study area.

Floodplain inundation is a crucial ecosystem process that is vital to the sustenance of riverine and riparian ecosystems; it occurs when river flows exceed channel capacity and overflow onto adjacent land. Typically, floodplain inundation is associated with storms occurring more frequently than once every 2 years (Leopold et al. 1964). These frequent, ecologically significant flows, sometimes referred to as the Floodplain Activation Flood (FAF) (PWA 2005), support highly beneficial ecological functions and outcomes. These benefits include producing organic matter and invertebrates to fuel food webs both on and downstream of floodplains, creating habitat that supports spawning and rearing by native fishes, and promoting conditions that support recruitment of riparian vegetation.

Channel morphology is a key driver of floodplain inundation, as are watershed characteristics and reservoir operations. As detailed in Chapter 5, the Feather River floodplain is so disconnected from the channel that ecologically significant FAF flows have been substantially curtailed compared with historic conditions. The Feather River Levee Setback Project removed a levee that separated the river floodplain from the river, offering tremendous restoration opportunities in the new setback area, but the high elevation of the floodplain relative to the incised river channel remains a barrier to restoring the natural dynamic processes that support aquatic and terrestrial floodplain ecosystems.

Channel meander is another crucial riverine process that has been significantly altered in the LFRCMP study area. Channels of large, alluvial rivers tend to migrate laterally when not constrained by levees or natural erosion-resistant banks (Johannesson and Parker 1989). The “meander potential” of a river is the area of floodplain that has the potential to be reworked by the meandering channel because it is within the river’s natural meander zone, not underlain by substrates resistant to erosion, and not isolated by revetment and/or levees. Meander migration is one of the primary processes driving riparian ecosystem functions; channel migration of meandering rivers establishes and maintains structurally diverse riparian habitats, oxbow lakes, and riverbank ecosystems (Hupp and



Source: CBEC adapted by AECOM 2013

Exhibit 4-1 **Extent of 2-Year and 10-Year Floodplains in the LFRCMP Study Area**

Osterkamp 1996; Scott et al. 1996; Ward et al. 2001). Some minimal meander potential exists at Shanghai Bend and Star Bend; however, in general the meander migration potential in the LFRCMP study area is small, with few opportunities for realization of ecological benefits such as floodplain reworking, channel cut-off, and oxbow lake formation (Larsen, pers. comm., 2012).

Channel incision, levee construction, and other changes to natural riverine processes that have reduced floodplain inundation and meander migration have had far-reaching and adverse consequences for the aquatic and terrestrial ecosystems of the LFRCMP study area. The extent and diversity of riparian vegetation is reduced without frequent floodplain inundation; opportunities for natural recruitment of cottonwoods and willows, which require moist, bare, mineral soil during periods of seed release (mid-May through July), have been diminished in the absence of such inundation. Successional processes of riparian vegetation that normally occur through disturbance, vegetation recruitment, and the formation of off-channel habitats have been substantially reduced in the LFRCMP study area, with associated adverse effects on the terrestrial wildlife dependent on these diverse riparian habitat mosaics.

The adverse effects of altering natural riverine processes have been aggravated by installation of bank protection and revetment on eroding banks in the LFRCMP study area, which has reduced the availability of SRA habitat for terrestrial and aquatic species. SRA habitat is important to fish and wildlife because overhanging vegetation provides shade, habitat complexity, and cover for aquatic species, as well as nutrients (plant material and invertebrates); it also provides cover, foraging, and breeding habitat for terrestrial species. Revetment, bank protection, and disruption of natural river processes such as bank erosion and deposition have also significantly diminished habitat for species like the bank swallow, which excavates nest burrows in vertical banks created by natural river processes (BANS TAC 2013).

Climate change is expected to aggravate the effects of the stressors described above on the aquatic, riparian, and upland ecosystems of the Sacramento River and its tributaries (DWR 2008), including the LRF. Climate change has affected natural ecosystems for thousands of years, but the pace of change is far more rapid now than historically recorded (Staudinger et al. 2012). Climate change is likely to aggravate fragmentation of habitat corridors, alter flow regimes and associated reservoir operations (i.e., fewer low flow flood events, more frequent major flood events), increase water temperatures, and reduce connectivity between channels and floodplains because of reduced frequency of flows that connect channels and floodplains (DWR 2008).

Aquatic habitats for salmonids and other native fishes, including special-status fish species such as Chinook salmon, Central Valley steelhead, and Sacramento splittail, have been substantially reduced or degraded by these changes in hydrologic and geomorphic processes, and by reduction of SRA habitat. The consequences of these changes have included loss of important fish rearing habitat and reduced productivity of aquatic food webs. The loss of overbank flows has decreased the amount and quality of rearing habitat for Chinook salmon, and reduced access of overbank flows to seasonal floodplains adversely affects salmonid rearing habitat by decreasing primary production and food availability (Junk et al. 1989, cited in TNC 2007). Loss of seasonal floodplains has also adversely affected juvenile salmonid survivorship; seasonal floodplains are typically free of non-native predatory fish that prey on juveniles, and lower velocity flows and greater structural diversity of inundated floodplains enhance the survival rate of juvenile salmonids (Sommer et al., 2003). Floodplain inundation also disperses nutrients and seeds of riparian species onto the floodplain and provides water to floodplain habitats. Inundated

floodplains provide expanses of shallow water that supports seasonal habitat for wintering waterfowl, shorebirds, and wading birds.

Populations of terrestrial wildlife species in the LFRCMP study area, including special-status species, have been adversely affected by the changes in hydrologic and geomorphic processes, and by loss and fragmentation of riparian and upland habitats and SRA habitat. For example, the endangered western yellow-billed cuckoo, a species that requires broad expanses of mature riparian forest (Laymon and Halterman 1987; USFS 1989), now occurs only rarely in the LFRCMP study area (see Chapter 3). The reduction and fragmentation of riparian forests in the LFRCMP study area have diminished the habitat for the threatened valley elderberry longhorn beetle and have reduced the availability of suitable nesting sites for the threatened Swainson's hawk.

The management actions discussed in Chapter 6 would provide increased opportunities for floodplain inundation in the LFRCMP study area. They also would increase the extent and connectivity of seasonal shallow aquatic habitat, frequently inundated floodplains, and SRA and riparian habitats. Implementing these actions would improve connections for nutrient exchange between terrestrial and aquatic systems by bringing nutrients and aquatic invertebrates to higher terraces during inundation and back to the aquatic system as floods recede. Some of the ecosystem enhancement actions described in Chapter 6 focus on restoring high flows to the Old Feather River channel and distributing overbank flows to its floodplain, and increasing overbank flow at the Star Bend and O'Connor Lakes units of the Feather River Wildlife Area. Creating swales and floodplain terraces would greatly expand the extent of SRA and riparian vegetation, and would enhance the value of the LFR corridor for terrestrial and aquatic species.

The ecosystem management actions described in Chapter 6 would also improve habitat for special-status wildlife species that currently occur or could potentially occur in the LFRCMP study area, and would promote the recovery and stability of native species populations and overall biotic community diversity. Increasing the extent and connectivity of riparian forests would provide habitat for raptors such as Swainson's hawk and Cooper's hawk, and for neotropical migrants such as black-headed grosbeak, Bullock's oriole, and yellow-breasted chat. Increasing the expanse of riparian vegetation would provide conditions suitable for reproduction by western yellow-billed cuckoo and expand suitable nesting and roosting sites for herons and egrets. CDFW considers the Feather River Setback area to be one of the few areas in the LFRCMP study area corridor where restoration actions could improve connectivity and create extensive swathes of riparian vegetation adequate to support breeding habitat for yellow-billed cuckoo (CDFW 2014).

Creating successional stages of riparian habitat with mosaics of upland habitat fosters species diversity. For example, early successional woodland provides habitat for game species such as California quail, mourning dove, and black-tailed deer. Wide-ranging species such as grey fox, Sacramento valley red fox, and black-tailed deer would benefit from the increased connectivity of riparian forest and scrub. In addition, developing high-ground refugia with material excavated from swales would provide terrestrial habitat that would otherwise be inundated during flood events and provide readily available escape areas for species that would otherwise be a risk of drowning.

Chapter 6 also proposes designation of areas where natural erosion can occur on steep and eroding river banks to create suitable habitat for a variety of species such as bank swallow, rough-winged swallow, belted kingfisher, mink, and river otter. These bank-dwelling species may use the banks and their cavities as access points from the water or for nesting. Erosion of natural bank substrates would also provide instream spawning substrate for

aquatic species, including salmonids. The proposed natural erosion areas described in Chapter 6 are located in areas where erosion would not threaten levees or other flood management structures.

Salmonids and other fish would benefit from many of the ecosystem management actions described in Chapter 6, including creation of swales and increasing overbank flows and access to seasonal floodplains. These actions would increase the amount and quality of rearing habitat for Chinook salmon (fall-/late fall–run, winter-run, and spring-run) and provide habitat during winter and spring outmigration. Reducing the number of fish entrapment basins and unscreened fish diversions (see discussion below) would also improve survivorship of salmonids and other fish species.

4.3.3 NON-NATIVE INVASIVE SPECIES

Invasive plant species degrade habitats by altering ecosystem processes and displacing native plants, and have become especially abundant in stream reaches where geomorphic processes have been disturbed. Dense stands of invasive species can alter channel morphology by retaining sediments and increasing the hydraulic roughness of the channel, thereby restricting flows and reducing flood conveyance (Bossard et al. 2000). Species with shallow root systems, such as giant reed and red sesbania, promote bank undercutting, collapse, and erosion (Bossard et al. 2000). Invasive plants can also reduce the integrity of native riparian plant communities by outcompeting native plant species and reducing habitat quality and food supply for wildlife (Bossard et al. 2000, Cal-IPC 2011).

Non-native invasive species such as giant reed, tree-of-heaven, perennial pepperweed, star thistle, and Himalayan blackberry are established throughout the LFRCMP study area. Some of these species, particularly giant reed and tree-of-heaven, can impede the flow of floodwaters and raise water surface elevations, and can capture sediment and create depositional mounds. Tree-of-heaven forms clonal colonies that can take over native riparian plant communities and may destabilize levee banks. Giant reed is highly flammable, increasing the risk of wildfire in the corridor. All of these invasive species can alter the structure, function, and composition of plant communities in riparian and adjacent habitats, and compete with and displace native vegetation. They also generally provide low-quality wildlife habitat.

Chapter 6 includes a management action that would reduce the extent of non-native invasive plants, prevent their spread into new areas, and minimize potential for the introduction of additional invasive non-natives, such as red sesbania, salt cedar, and fig. This would help satisfy floodway and ecosystem management objectives.

4.3.4 FISH MORTALITY RISKS: ENTRAPMENT AND ENTRAINMENT

Receding river flows can leave fish, including juvenile salmonids, stranded in isolated pools of natural or artificial features of the LFR corridor. Exhibit 4-2 depicts the location of natural and created basins in the LFRCMP study area that retain water and become isolated after floodwaters recede. Several of the proposed management actions described in Chapter 6 would eliminate many of these fish entrapment basins by improving drainage and flow-through at the Feather River setback area, Abbott Lake, and O'Connor Lakes. These floodplain modifications involve creating or improving secondary channels and overflow swales to increase riverine and floodplain habitat values by providing resting or rearing areas for fish migrating downstream and escape routes for fish during receding flows. Floodplain inundation is beneficial for salmonids and other native fishes, but can also lead to topographic changes that result in fish stranding; therefore actions that expand areas of floodplain inundation or any other project in the LFRCMP study area that involves grading should be accompanied by monitoring and

adaptive management to avoid creation of fish entrapment basins. Some of the flood management actions described in Chapter 6 also reduce the risk of fish stranding by recommending that routine maintenance in the State Cut channel include regular grading to smooth out sediment mounds and depressions.

In addition to fish stranding, another source of fish mortality in the LFRCMP study area is the presence of unscreened water diversions, as shown in Exhibit 4-3. Although there are few quantitative estimates of the total number of fish killed, these diversions are undoubtedly a stressor on salmonids (Moyle and White 2002). Installation of screens to prevent entrainment at these diversions has been a major conservation action undertaken to benefit salmonids. One of the management actions proposed in Chapter 6 is to work with resource agencies and stakeholders to reduce the number of unscreened diversions in the LFRCMP study area.

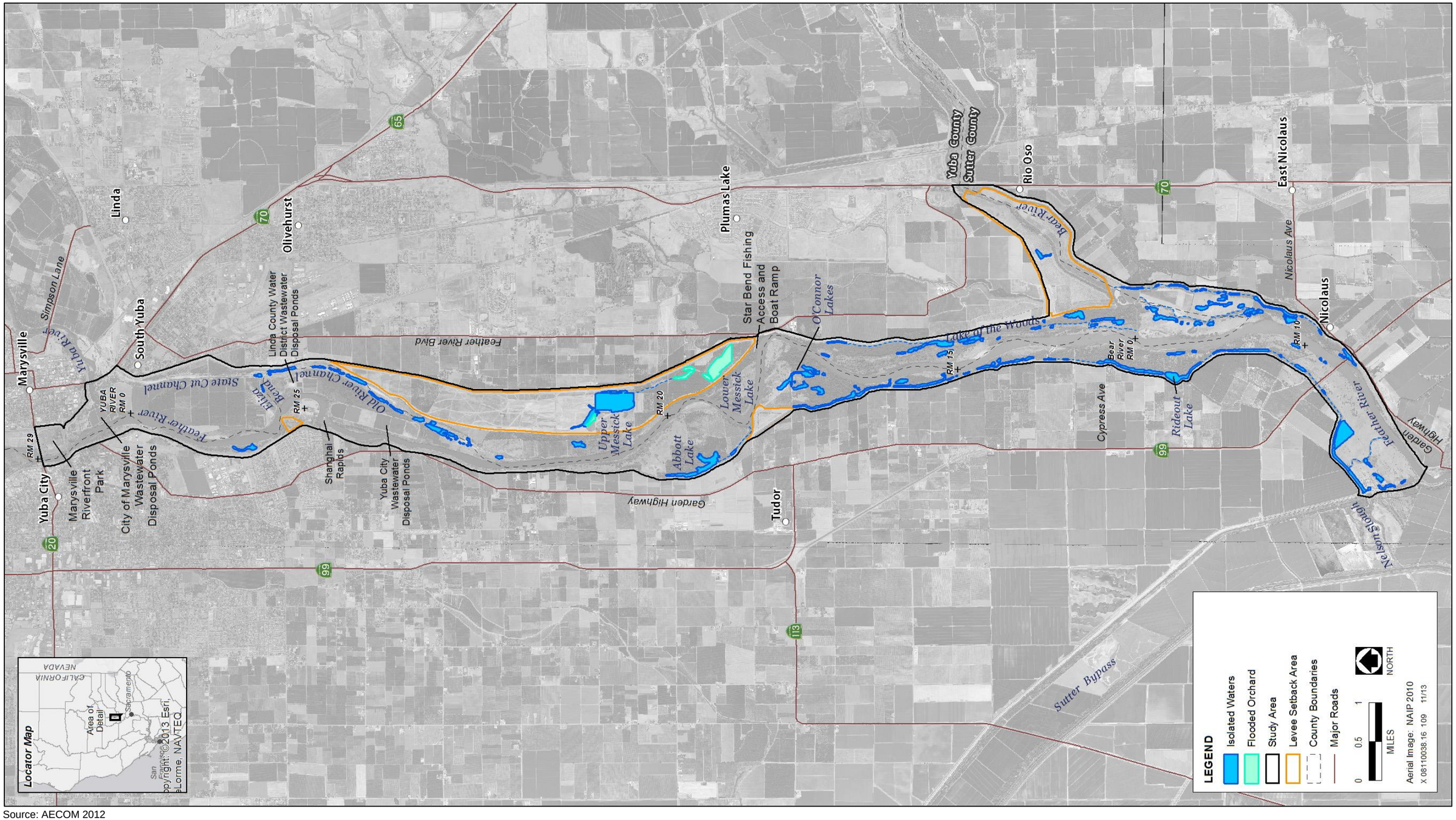
4.4 RIVER RECREATION CHALLENGES AND OPPORTUNITIES

As described in Chapter 3 and Appendix N, the LFRCMP study area offers many recreation opportunities to the residents of Yuba and Sutter counties and to visitors. It is a significant recreation resource and an important source of support for the local economy. However, the LFRCMP study area lacks adequate trails and public access to the river and open space, and the area between the levees and the river has been largely underused (City of Yuba City 2004; Yuba County 2011). No trail system exists to provide connectivity throughout the LFRCMP study area, with areas to stop and rest, orient, and learn. The LFRCMP study area offers ample but underused opportunities for the development of interpretive resources to build public understanding of natural ecosystem processes, and to promote support for ecosystem and habitat enhancement activities.

More opportunities for public access to the river are also needed in the LFRCMP study area. Providing safe river access is consistent with the State's interest in public safety and environmental stewardship. Increased access for canoes, rafts, and kayaks in underserved areas of the river can reduce boating accidents and the incidence of boats stranded without safe egress points, prevent drowning deaths, allow for easier patrols, and reduce accidents from attempts to climb steep slopes. A shortage of safe public river access points can promote the use of unsafe ad-hoc access points. The area downstream of Star Bend is very popular for kayaks and canoes, and additional kayak/canoe access points are needed in this reach. Boat access in the Nelson Slough area has also been identified as a key need. This area is frequently used for rafting, canoeing, and kayaking and would be an ideal location for boaters to end their floats. Developing canoe, raft, and kayak river access here would create new access along a long stretch of the river that has no river access, and would support additional opportunities for fishing. It would also improve rafting, canoeing, and kayaking opportunities by reducing float distances between existing boat access points.

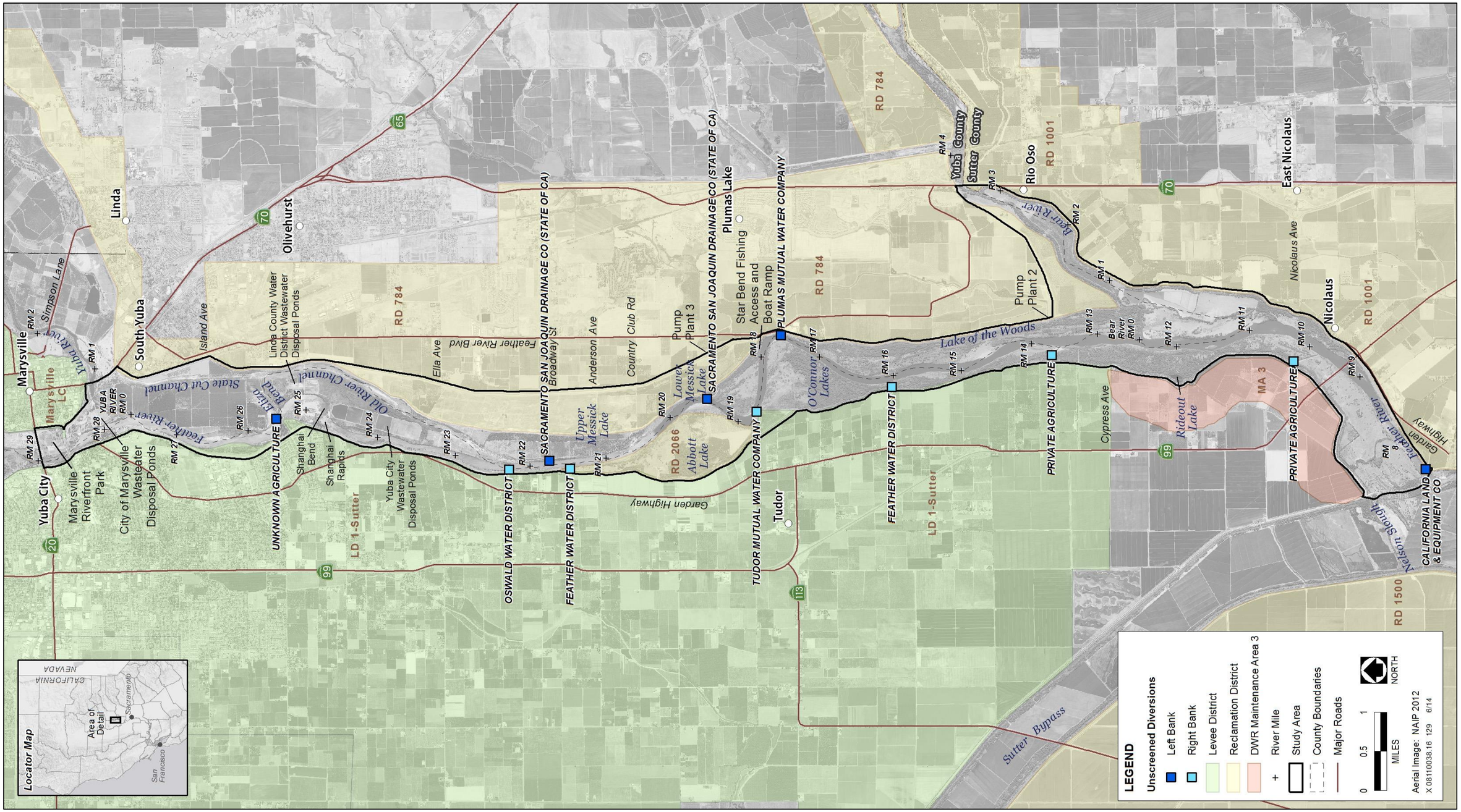
Recreational activities such as the illegal use of off-road vehicles (ORVs) pose challenges for other recreational activities and put sensitive habitats, agricultural infrastructure, and flood management structures at risk. Illegal ORV use can damage private property and levee slopes, tear up patrol roads, and destroy seepage berms (Fordice, pers. comm., 2012).

The overall desire and vision for recreation in the LFRCMP study area is to create a safe, attractive, and active public parkway using the Feather and Bear rivers and the land between these rivers and adjacent levees. The focus for improving recreational opportunities is to enhance connectivity with existing public amenities, adjoining urban areas, and the more than 3,000 acres of existing natural areas. Recreation advocates would like to increase and improve public access, pedestrian trails, and bank fishing sites in areas that would not harm sensitive



Source: AECOM 2012

Exhibit 4-2 **Locations of Isolated Waters after Flood Water Recession in the LFRCMP Study Area**



Source: AECOM 2013, CDFW 2013

Exhibit 4-3 **Unscreened Water Diversions in LFRCMP Study Area**

biological resources or agricultural activities, and to improve access for non-motorized boats in the lower, underserved reaches of the river. Other recreation needs are to increase connectivity between trails, facilities, and open space and reduce trespass, vandalism, and unauthorized ORV use in areas that provide significant habitat values and important agricultural lands. In addition, the LFRCMP study area offers ample but underused opportunities for the development of interpretive resources to build public understanding of natural ecosystem processes and support for ecosystem and habitat enhancement activities. Implementing the management actions described in Chapter 6 would provide opportunities to fulfill these recreation goals.

These management actions would also bring greater access to public trust lands of the LFRCMP study area; the State Lands Commission (SLC) has jurisdiction and management control over certain public lands of the state, including the beds of California's navigable rivers and lakes. The SLC is responsible for safe-guarding the public's rights to use the public trust lands, including those of the LFRCMP study area. The proposed public-access opportunities described in the LFRCMP recreation management actions are consistent with the SLC policies of providing the greatest possible benefit to the public of public trust lands.

4.5 AGRICULTURAL CHALLENGES AND OPPORTUNITIES

Agriculture within and near the LFRCMP study area provides substantial economic and societal benefits locally and in the region, and provides habitat for some wildlife species. DWR recognizes the value of agricultural lands protected by the flood management system, and one of DWR's systemwide goals is to support sustainable farm operations and production (DWR 2010). DWR and the agricultural community also recognize and value the importance of ecosystem functions on their lands. As stewards of the land, they are committed to protecting the long-term viability and productivity of agricultural lands and generally support compatibility of agricultural practices with ecosystem protection. A crucial challenge for agricultural users is to protect the approximately 3,000 acres of orchards within the LFRCMP study area and support the agricultural lands outside the levees.

Some of the management difficulties associated with sustaining agriculture within the LFRCMP study area include the increased frequency of inundation of orchards located on the waterside of the levee (since completion of the Feather River levee setback project). As described in Chapter 5, some of the orchards at the lower elevations of the Feather River setback area are inundated throughout much of the growing season an average of once every 2–3 years. Exposure to flood flows and saturated, anaerobic soil conditions has resulted in incremental mortality and stunted growth in recent years, threatening the long-term viability of these areas for use as orchards. Some of the recreation management challenges described above are also concerns for agricultural users of the LFRCMP study area. In some locations, ORV access to agricultural lands increases the risk of vandalism, theft, crop damage, and wildfire. Conserving agricultural lands and supporting infrastructure while maintaining the floodway, habitat values, and recreational access is a key concern and challenge.

The management actions described in Chapter 6 would enhance the agricultural community's ability to sustain the long-term viability and productivity of agricultural lands. Implementing these management actions would help farmers protect agricultural lands and infrastructure in and near the LFRCMP study area, and would foster the joint goals of compatible uses of agricultural lands and ecosystem enhancement.

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5 HYDRAULIC, HYDROLOGIC, AND SEDIMENT TRANSPORT MODELING OF POTENTIAL FUTURE CONDITIONS

5.1 INTRODUCTION

This chapter of the *Lower Feather River Corridor Management Plan* (LFRCMP) summarizes the results of hydraulic, hydrologic, and sediment-transport modeling conducted to simulate the baseline and potential future conditions under frequent and major flood scenarios in the LFRCMP study area. Specifically, the modeling evaluated how management actions described in this chapter would enhance ecosystem processes; increase the extent of ecologically important habitats; and affect hydraulic capacity, river stage, levee freeboard, and levels of flood protection and floodway function.

The modeling was conducted by MBK Engineers (MBK) and cbec, Inc. (cbec). MBK conducted hydraulic modeling for the 100- and 200-year floods using a two-dimensional (2-D), finite-element numerical hydrodynamic model (RMA-2); cbec used a 2-D hydrodynamic and sediment-transport model (MIKE_21C) to simulate changes in flood hydraulics and geomorphic trends for the 100-, 10-, and 2-year-frequency flood hydrographs and to simulate a Floodplain Activation Flood (FAF)[3] flow. In addition, cbec modeled the effects of the recent breach at Shanghai Rapids, including a potential maximum future expansion of breach conditions.

The methods and results of flood hydraulic modeling conducted by MBK are presented in detail in two technical reports, included as the following appendices to this plan:

- *Lower Feather River Corridor Management Plan Hydraulic Analysis—Baseline Model Documentation* (MBK 2012a) (Appendix F)
- *Lower Feather River Corridor Management Plan Flood Hydraulic Analysis of Future Conditions* (MBK 2012b) (Appendix G)

The methods and results of geomorphic and hydrologic assessments and modeling conducted by cbec are described in one technical report and three technical memoranda, included as the following appendices to this plan:

- *Lower Feather River Corridor Management Plan Geomorphic and Ecological Modeling* (cbec 2013a) (Appendix H)
- *Flood Hydrograph Modifications and Floodplain Activation Flood Update* (cbec 2013b) (Appendix I)
- *Shanghai Rapids Field Data Collection* (cbec 2012) (Appendix J)
- *Geomorphic Assessment of the Feather River from RM 6.9 to RM 12.5* (cbec 2011) (Appendix K)

[3] The Floodplain Activation Flood is an ecologically significant flow that can produce a characteristic set of ecological functions and outcomes, such as producing organic matter and invertebrates to fuel food webs both on and downstream of floodplains, and creating habitat that supports spawning and rearing by native fishes.

This chapter of the LFRCMP summarizes key findings of and reproduces selected exhibits and tables found in the six technical reports and memoranda listed above.

5.2 SUMMARY OF RECENT AND POTENTIAL FUTURE HYDRAULIC CHANGES

This chapter of the LFRCMP describes a host of proposed management actions for floodway management and for ecosystem function and habitat enhancement. Many of these actions have the potential to affect the hydraulic and geomorphic responses of the Lower Feather River (LFR) and its floodway. As described in more detail below under "Baseline Condition and Model Calibration," the baseline-condition model of the LFRCMP study area was developed to represent vegetation conditions and levee setback configurations as of 2011. The following are the recent and potential future changes most likely to affect hydraulics and sediment transport in the LFRCMP study area:

- Increases in floodway capacity that affect flood stage and flow velocity from completion of several recent levee setback projects
- Increases or decreases in floodplain roughness, caused primarily by vegetation changes, modified floodway maintenance, and recent or proposed restoration projects over large expanses of floodplain
- Changes in floodplain topography and flow paths caused by potential future floodplain and swale excavation projects
- Alteration of the main channel's bathymetry and floodplain topography as a result of incremental sediment deposition and scour erosion
- Alteration of the main channel's bathymetry and bed load transport, caused by recent breaching and expected long-term expansion and incision of the natural grade-control feature (resistant Modesto Formation) at Shanghai Rapids
- Future modifications of reservoir releases below major dams at Oroville and New Bullards Bar could also affect river and floodway hydraulics and ecosystem functions. An assessment of operational flow modifications below reservoirs is beyond the scope of the LFRCMP and was not conducted.

5.3 APPROACH TO HYDRAULIC AND HYDRODYNAMIC MODELING

The study area for the hydraulic modeling includes the entire LFRCMP study area and extends beyond its boundaries to incorporate adjacent upstream areas of the Feather, Yuba, and Bear rivers and a segment of the Sutter Bypass. The RMA-2 modeling study area begins at River Mile (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; it also extends a short distance upstream in the bypass to approximately RM 68. The Bear River was simulated from RM 4.75 to the confluence with the Feather River at RM 12.1, and a short portion of the Yuba River was simulated from the confluence with the Feather River up to RM 1.2. (See the model mesh boundaries in Exhibit 5-1 below for a depiction of the RMA-2D hydraulic modeling study area.)

The first priority for hydraulic modeling in support of the LFRCMP was to determine whether the composite effect of management actions that were initially proposed, when combined with all recent levee setback and revegetation projects, could affect public safety by increasing or decreasing either major flood stages or scour velocities near levees. Therefore, the RMA-2 modeling for major floods focused on a hydraulic-sensitivity analysis of the cumulative effects of 100- and 200-year floods under different storm-centering scenarios in the Feather/Yuba River watersheds. A separate sediment-transport model (MIKE_21C) was used to evaluate the effect of a 100-year flood on channel and floodplain deposition and scour. The purpose of the sediment-transport model was to evaluate whether proposed management actions would have any beneficial or adverse effects on floodplain sediment storage, river channel incision, or sediment accumulation affecting the main channel's conveyance capacity or the ecological function of secondary swales across floodplains.

The MIKE_21C study area was similar but not identical to the RMA-2 study area. (See Exhibit 5-13 in Section 5.4.2, "Hydrodynamic and Sediment Transport Modeling Objectives and Modeling Study Area," for a depiction of the sediment-transport modeling study area.) The model domain for the MIKE_21C hydrodynamic model was also made larger than the LFRCMP study area and slightly larger than the RMA-2D flood model boundaries to minimize forcing effects from the model boundaries that could result in inaccurate results within the LFRCMP study area. Extended boundaries for the MIKE_21C model is especially important to the accuracy of model sediment transport functions.

After major flood modeling was completed, additional MIKE_21C hydrodynamic modeling focused on demonstrating the intended beneficial effects of LFRCMP management actions—that is, enhancing ecosystem functions, creating new habitats, and reducing the burden of floodway maintenance in specific locations. A major purpose of hydrodynamic modeling was to map and compare the effects of frequent floods (the FAF, 2-year, and 10-year flows) on the following hydraulic parameters considered important to ecosystem functions and habitat quality:

- The location, extent, and duration of floodplain inundation
- Floodplain drainage, backwater, and secondary flow pathways
- Sediment deposition and scour on floodplains

Hydrodynamic modeling was conducted in multiple phases as new hydrologic information became available and variations in potential future conditions were evaluated. The modeling was used as a culling tool to iteratively reject, modify, or add management actions and revise the conceptual design in response to preliminary results. The results of the hydrodynamic modeling were used to identify river discharge and stage thresholds in different locations to activate floodplains and overbank swales throughout the LFRCMP study area. The results were then used to iteratively adjust sill elevations or reject grading modifications throughout the future-conditions conceptual design process. Section 5.3.3, "Modifications to Future Conditions after Completion of the RMA-2 Flood Model," below describes the process of incorporating new information derived from the preliminary modeling results into the subsequent modeling efforts.

5.3.1 FLOOD MODELING METHODS AND ASSUMPTIONS

MODELING SOFTWARE

MBK used RMA-2, Version 4.5, flood hydraulic modeling software for its analysis. RMA-2 is a 2-D, finite-element numerical hydrodynamic model that computes water surface elevation and horizontal velocity components for subcritical, free-surface, 2-D flow fields. The RMA-2 model was used because it is well suited to modeling flood hydraulics in major rivers and floodways that have complex overland flows; complex, highly variable topography; and multiple secondary channels and flow paths across floodplains. RMA-2 models have been used in numerous prior evaluations of the SRFCP, including a recent effort by the CVFPB to model the Sutter Bypass.

MESH DEVELOPMENT

MBK created a network of connected elements, called a *mesh* or *finite-element mesh*, as a framework to describe the physical properties of the river channel and its floodplain at each unique mesh element. Physical properties entered as model elements include surface elevation, structures, and turbulence or roughness coefficients (i.e., resistance to flow). Model output properties at each node of the mesh include flow depth, depth-averaged velocity (feet per second [fps]), discharge (cubic feet per second [cfs]), and direction of flow at each node.

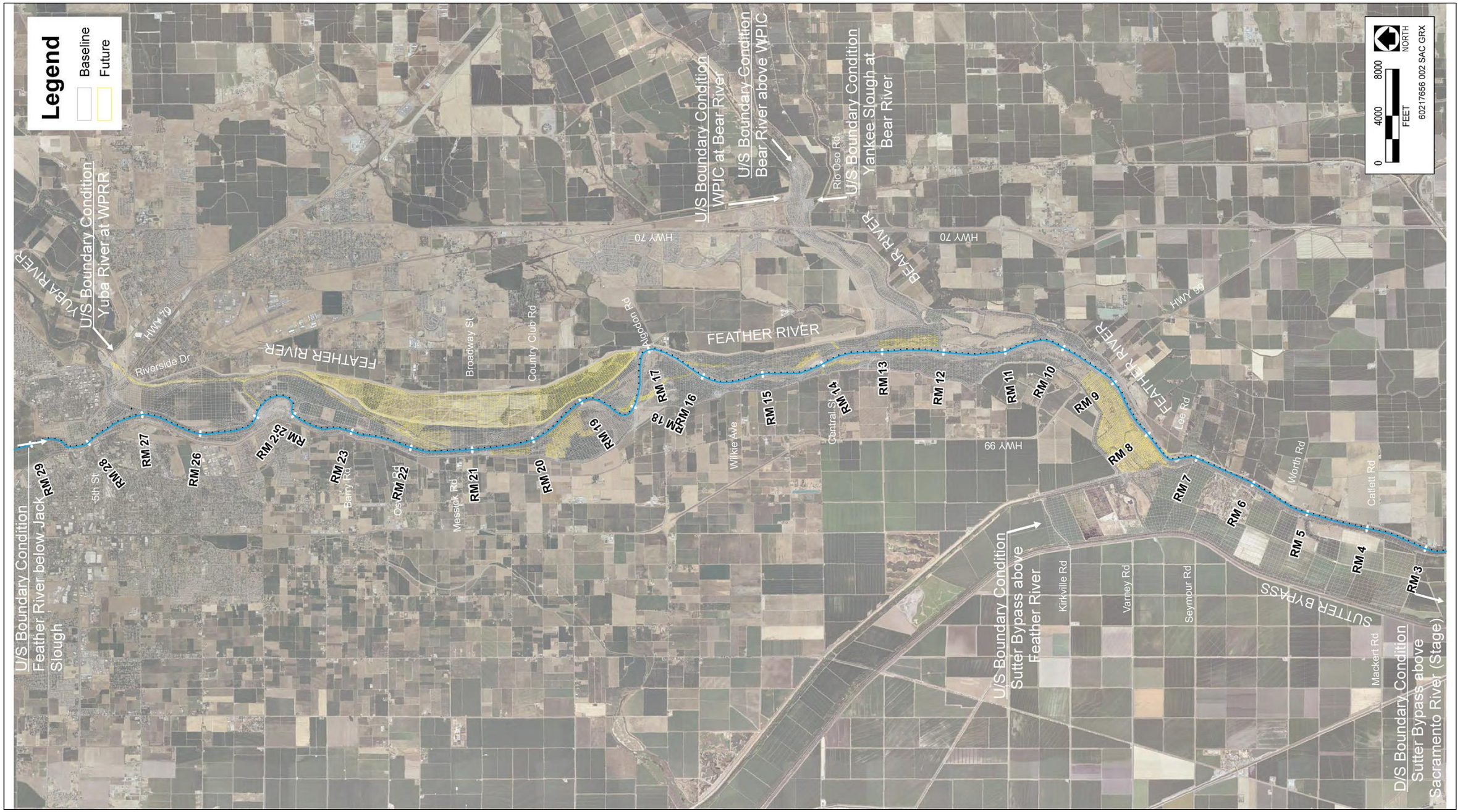
MBK developed a finite-element mesh of the Feather, Bear, and Yuba rivers; part of the Sutter Bypass near the confluence with the Feather River; and associated floodplain topography for the analysis of baseline conditions (Appendix F). The baseline mesh was subsequently modified to reflect the initial proposed management actions that would alter floodplain topography or change vegetation roughness levels at specific locations under potential future conditions (Appendix G). This future-condition modeling mesh is shown in Exhibit 5-1.

SOURCES OF TOPOGRAPHIC DATA

MBK compiled topographic and hydrographic data from numerous sources. The data were based primarily on topographic and bathymetric surveys conducted by the U.S. Army Corps of Engineers (USACE) Sacramento District and used in hydraulic analyses for the 1999 Sacramento–San Joaquin Rivers Comprehensive Study (Comp Study) (Ayres 2003).

Topography and bathymetry in areas of the floodway modified or updated since the 1999 Comp Study were patched into the composite surface of the model to represent 2011 baseline conditions. Modified and updated areas included the Shanghai Bend setback area and old levee degrade, Feather River setback (FRS) area and old levee degrade, Star Bend (Levee District 1 [LD1]) setback area and old levee degrade, and Bear River setback area and old levee degrade (see Exhibit 3-3 in Chapter 3 for the locations of these areas). In addition, recent Light Detection and Ranging (i.e., LIDAR), acquired in 2008, and bathymetric data were used to generate a digital terrain surface in the lower Sutter Bypass.

The horizontal datum used for topography in the RMA-2 model is the North American Datum of 1983 (NAD83), California State Plane Coordinate System (CASP) Zone 2. The vertical datum used in the actual model is the National Geodetic Vertical Datum of 1929 (NGVD29). Elevation data with a vertical datum in the North American Vertical Datum of 1988 (NAVD88) were converted to NGVD29 by applying a conversion of minus (-) 2.3 feet. The conversion was based on CSURFACE —Lower Sacramento, Upper Sacramento and Upper Feather



Source: MBK 2012b:Figure 1

Exhibit 5-1 **RMA-2 Model — Future-Condition Finite-Element Mesh**

River Areas—Datum Conversion Surface Map, from HJW Geospatial Pacific Aerial Surveys (HJW 2010). Graphic output results are shown in NAVD88 for consistency with the hydrodynamic and sediment-transport model results developed by cbec.

BASELINE CONDITION AND MODEL CALIBRATION

Baseline Conditions

The baseline-condition model of the LFRCMP study area was developed to represent vegetation conditions and levee setback configurations as of 2011. Since 1997, various levees in the study area have been set back to improve floodway conveyance and levee stability. These new areas of the LFR floodway were incorporated into the baseline model by using as-built or setback-grading-design information and other updated topography. Levee setbacks include the Feather and Bear River setback areas, Shanghai Bend setback area, and the Star Bend (LD1) setback area (see Exhibit 3-3 in Chapter 3).

Vegetation types assigned to elements in a 1997 calibration modeling mesh were converted to 2011 vegetation types, as mapped by AECOM using aerial photo interpretation coupled with ground verification surveys (DWR 2011). Calibrated roughness values were then assigned to elements in the baseline modeling mesh (Table 5-1). The FRS area, Star Bend (LD1) setback area, and Bear River setback area were assigned conservatively high roughness values, associated with design vegetation plans approved by the Central Valley Flood Protection Board as part of the overall designs for the levee setback projects. Therefore, the roughness values in these areas do not necessarily reflect the existing vegetation and other land cover types as mapped in 2011 (DWR 2011). In particular, substantial portions of the FRS area where orchards had recently been removed were approved for dense riparian planting projects, but were in a temporary barren condition in 2011, soon after construction of the levee setback project.

Baseline-Model Calibration using the 1997 Flood

The January 1997 flood event was simulated in the RMA-2 model under steady-state conditions for calibration. Upstream boundary conditions require flow or base-level stage inputs at the following locations:

- Feather River below Jack Slough, RM 28.75
- Yuba River at the Western Pacific Railroad, RM 1.23
- Bear River above the Western Pacific Interceptor Canal, RM 4.75
- Yankee Slough at Bear River, RM 0.54
- Western Pacific Interceptor Canal at Bear River, RM 0.06
- Sutter Bypass above Feather River, RM 68.13

Table 5-2 shows the stages and peak flows for the calibration boundary conditions.

The calibration results of simulated water surface elevations were plotted in profile along with surveyed high-water marks. The computed values compare closely with surveyed high-water marks, and most computed water-surface elevation values fall within plus or minus 1 foot of observed high-water marks (Table 3 in Appendix F).

Table 5-1
Baseline Roughness Values Assigned in RMA-2 Flood Model

Description	Habitat Code	Manning's n Roughness Value
Channel bed	–[1]	0.018 to 0.035
Annual grassland and savanna; also includes tilled fields and pasture	ANG	0.03
Barren	BARREN	0.03
Developed	DEV	0.03
Low herbaceous marsh	LHM	0.03
Open urban park	PARK	0.03
Open water	OW	0.03
Open water/floating aquatic	OWF	0.03
Perennial grassland	PGR	0.03
Ruderal	RUD	0.03
Sutter Bypass—agricultural use (field crops)	–[1]	0.03
Railroad bridge and embankment at the Lower Yuba River	–[1]	0.03
SR 70 on the Lower Bear River	–[1]	0.03
SR 99 at Nicolaus on the Feather River	–[1]	0.03
Gravel bar/sandbar	GBSB	0.035
High herbaceous marsh	HHM	0.035
Himalayan blackberry scrub	HBS	0.045
All other bridge crossings	–[1]	0.045
Open riparian forest, valley oak woodland	ORF	0.05
Orchard—fallow	OFA	0.05
Short tree orchard	STO	0.05
Upland scrub, open willow scrub, elderberry scrub, bramble	UPS	0.055
Bear River setback area—upper setback area design conditions	–[1]	0.06
Dense willow scrub	DWS	0.065
Bear River setback area—lower setback area design conditions	–[1]	0.07
Star Bend (LD1) setback area—design conditions	–[1]	0.07
Walnut orchard	WOR	0.08
Dense riparian forest	DRF	0.09
Feather River setback area—design conditions	–[1]	0.10
Bear River setback area—lower setback area design conditions	–[1]	0.10
Shanghai Bend—areas behind remnant levee	–[1]	0.10

Notes:
[1] Unvegetated or agricultural areas with assigned roughness values that do not reflect AECOM vegetation mapping. The roughness values assigned are for modeling design roughness values, bridge crossings, or assigned for model stability.
Source: MBK 2012a:Table 4

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		

Baseline-Condition Modeling Results

Water surface profiles (WSPs) from the RMA-2 model were plotted with corresponding top-of-levee elevations. The plots displayed water surface elevations at baseline conditions for the 1-in-100 annual exceedance probability (AEP), 1-in-200 AEP, and 1957 Sacramento River Flood Control Project (SRFCP) design flows. Velocity contours were calculated for the baseline condition for the 1-in-100 AEP, 1-in-200 AEP, and USACE's 1957 SRFCP design flow. Baseline WSPs were then used to compare flood stage effects of future conditions throughout the LFRCMP study area for all modeling runs.

Future Conditions Used to Develop the Flood Model

Like the baseline-condition modeling runs, future-condition modeling runs were simulated with the 1-in-100 AEP, 1-in-200 AEP, and 1957 SRFCP design flow. The two AEP hydrology scenarios and the SRFCP design flows were then subdivided further into two hypothetical storm centerings to simulate larger flows on the upper reaches of the Feather River watershed (the "Upper Feather Centering") and in the lower reaches of the Feather River watershed (the "Lower Feather Centering").

Model Boundary Conditions

The boundary conditions for the AEP hydrology scenarios were obtained from a HEC-RAS model developed by Peterson Brustad Inc. (referred to in this chapter as the "PBI model") for the Sutter-Butte Flood Control Agency as part of the Feather River West Levee Rehabilitation Project (PBI 2011). The PBI model is a current and improved version of the Comp Study's technical studies documentation (USACE 2002). The procedures for selecting boundary conditions and the assumptions are documented in Appendix F (MBK 2012a). Boundary conditions for Lower Feather Centering flows are shown for the 1-in-100 AEP, 1-in-200 AEP, and 1957 SRFCP design flow in Tables 5-3 through 5-5, respectively (see Tables 2, 4, and 6 in Appendix G for boundary conditions for Upper Feather River Centering).

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'

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'

FUTURE CONDITIONS MODELED

The conceptual design features and proposed management actions incorporated into the flood model for future conditions are listed in Table 5-6 and shown in Exhibits 5-2 and 5-3. Some features are intended to improve floodway conveyance and reduce flood stage, or to reduce the need for periodic vegetation removal in certain areas. Other features are designed to promote the ecological functions and values of natural and created floodplain areas under more frequent flood flows.

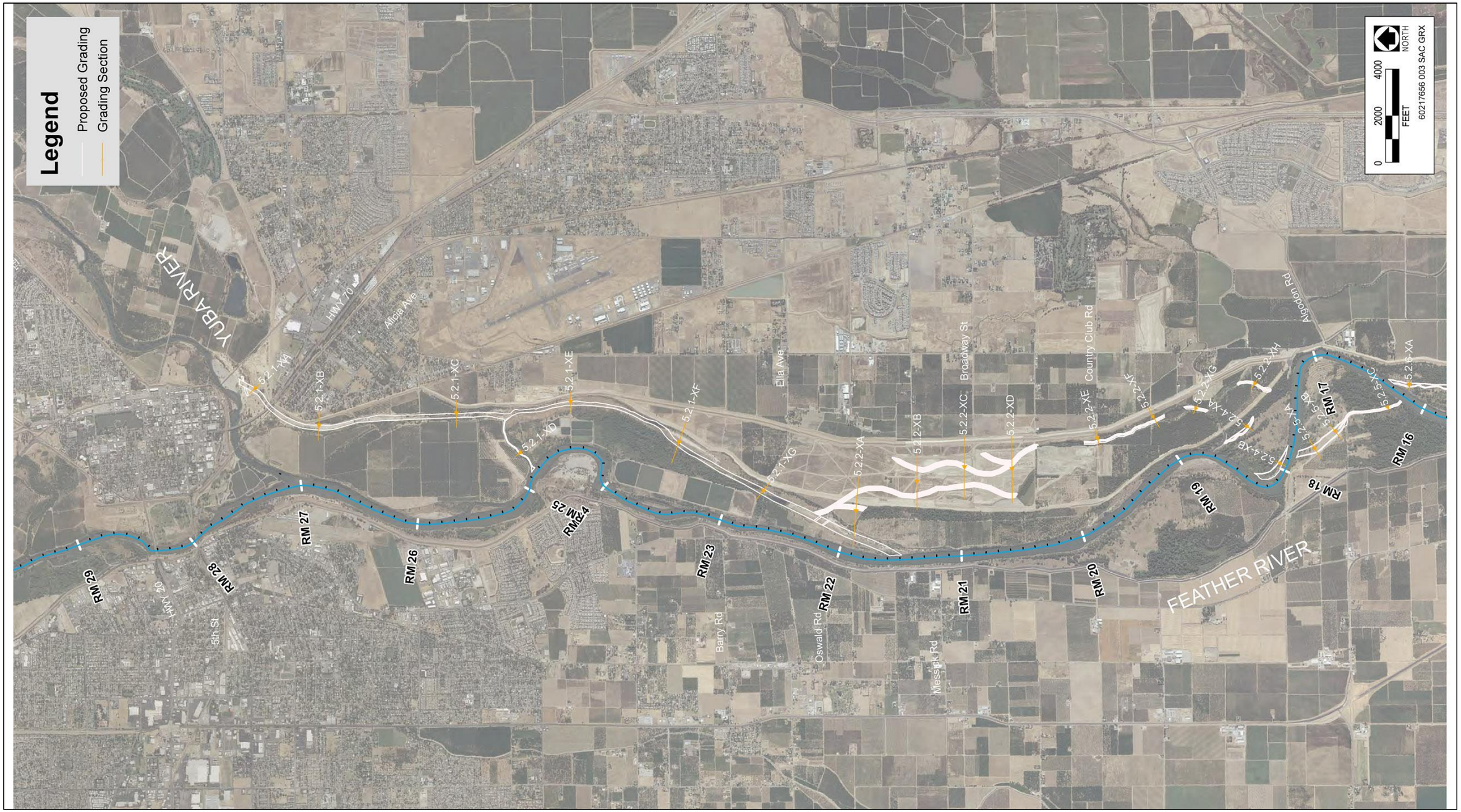
Future changes in vegetation roughness are intended to create or enhance a diverse mosaic of habitat types, to anticipate gradual vegetation succession that occurs as floodplain hydrology and topography changes, or to anticipate an increase in roughness that results as vegetation management ceases in specific locations.

The future-condition roughness values modeled are listed below in Table 5-7. The distribution of future-roughness values, based on the conceptual plan, is shown in Exhibits 5-4 and 5-5.

Table 5-6
Conceptual Design Features and Management Actions Incorporated in the RMA-2 Flood Model for Future Conditions

Locations of Proposed Actions	Proposed Actions
State Cut channel from Yuba River to Island Road (Yuba RM 1 to approximately east of Feather RM 26.5)	Degrade unused berm near Riverfront MX Park on left bank of Yuba River, RM 1. Excavate a deeper State Cut channel (8–10 feet below grade) and create a uniform gradient and width of 200 feet. Excavate the entry sill of State Cut to 48-foot elevation.
State Cut channel from Island Road to Eliza Bend channel (approximately east of RM 26.5 to RM 25.5)	Deepen channel as described above. Remove or side-cast high mid-channel ridge; maintain 200-foot minimum width; create uniform gradient and unobstructed flow to Eliza Bend. Plant native shade trees on new channel margins.
Eliza Bend channel from Feather River to State Cut (old Feather River meander channel) (RM 25.3 to eastside floodplain)	Remove channel plug at left bank of Feather River; remove high mounds and excavate a deeper channel by approximately 8 feet; maintain 40-foot minimum channel width. Set entry sill of Eliza Bend channel at Feather River to approximately 39-foot elevation.
Old Feather River channel from Eliza Bend channel to Feather River Setback (approximately east of RM 25.3 to RM 22)	Excavate a deeper channel (5–10 feet below grade) and create a uniform gradient and width of 200 feet. Create a positive, uniform gradient and increase flow capacity. Connect and divert the lower end of Old Feather River to an excavated swale at the upper end of the FRS (approximately RM 23). Plant native shade trees along new channel margins and benches.
Feather River setback floodplain (approximately east of RM 23 to RM 21)	Excavate two branched swales, 8–12 feet below grade, connecting the south end of the Old Feather River to Upper Messick Lake and the FRS floodplain. Deepen the existing drainage swale by 10–12 feet between Upper and Lower Messick Lakes. Plant an extensive mosaic of riparian forest and scrub, oak woodland, scrubland, and native perennial grassland.
Abbott Lake Unit (RM 20.8 to RM 18.8)	*No grading features are proposed in the Abbott Lake area.* Plant riparian trees, upland shrubs, and native grassland using the modified CDFW/River Partners planting plan.

Table 5-6 Conceptual Design Features and Management Actions Incorporated in the RMA-2 Flood Model for Future Conditions	
Locations of Proposed Actions	**Proposed Actions**
Star Bend Unit (RM 19.5 to RM 18) **and lower end of Feather River setback floodplain**	Excavate 8–10 feet to create a new FRS drainage swale from the south end of Lower Messick Lake to the low, forested floodplain at the southeast corner of Star Bend. On Star Bend, excavate 4 feet below grade to create a new overbank swale and bench branching from the existing FRS drainage swale, flowing into the existing forested swale and floodplain. Lower high ground by 2–7 feet at the apex of the bend to increase channel capacity. Plant native shade trees along the new swale margins and bench.
O'Connor Lakes Unit (RM 18.8 to RM 16)	Excavate a 5-foot-deep notch in the high right bank. Create a 100- to 300-foot-wide swale and bench across the floodplain and through the existing DWR-managed floodway corridor. Remove debris, mounds, and sediment blocking drainage to the river. Plant native shade trees along the new swale margins and bench.
Lake of the Woods Unit (upstream of Bear River setback) (RM 17 to RM 13.5)	Degrade 3–5 feet of high ground on the river's left and right banks that constricts flood flow, RM 14.6 to RM 15. Continue to manage the vegetation corridor to maintain floodway capacity. Create inlet and outlet swales to reduce fish entrapment and improve through-flow and drainage to the river. At the upstream end of Lake of the Woods, excavate the existing overbank swale to 4 feet deep to increase inundation frequency.
Bear River setback on Lake of the Woods Unit (adjacent to where levee was removed) (RM 13.5 to RM 12.4)	Cease clearing vegetation in the lower mile of the Lake of the Woods corridor where the old levee was removed for the Bear River levee setback project.
Nelson Slough floodplain (RM 9 to RM 7.3)	Excavate two wide terraces (200–600 feet) along the right bank of the river at depths below existing grade of 8–10 feet (Upper Terrace) and 15–18 feet (Lower Terrace). Plant riparian forest on the Lower Terrace, oak woodland on the north side, and native grassland savanna on high-ground floodway east of the Sutter Bypass. Place higher roughness vegetation on the existing grade within the ineffective flow zone between sharp bends of the north levee.
Corner levee at constriction (RM 7.4 to RM 7.7)	Set back the sharp corner of the eastside levee at RM 7.4 to RM 7.7 up to 150 feet landside to reduce mid-channel velocities and increase river floodway capacity.
Sutter Bypass hook levee (RM 7.3 to RM 7)	Set back the upstream entry end of the hook-shaped training levee on the right bank of Feather River by approximately 120 feet westward to reduce mid-channel velocities and increase river floodway capacity.
Source: Data compiled by AECOM in 2013	

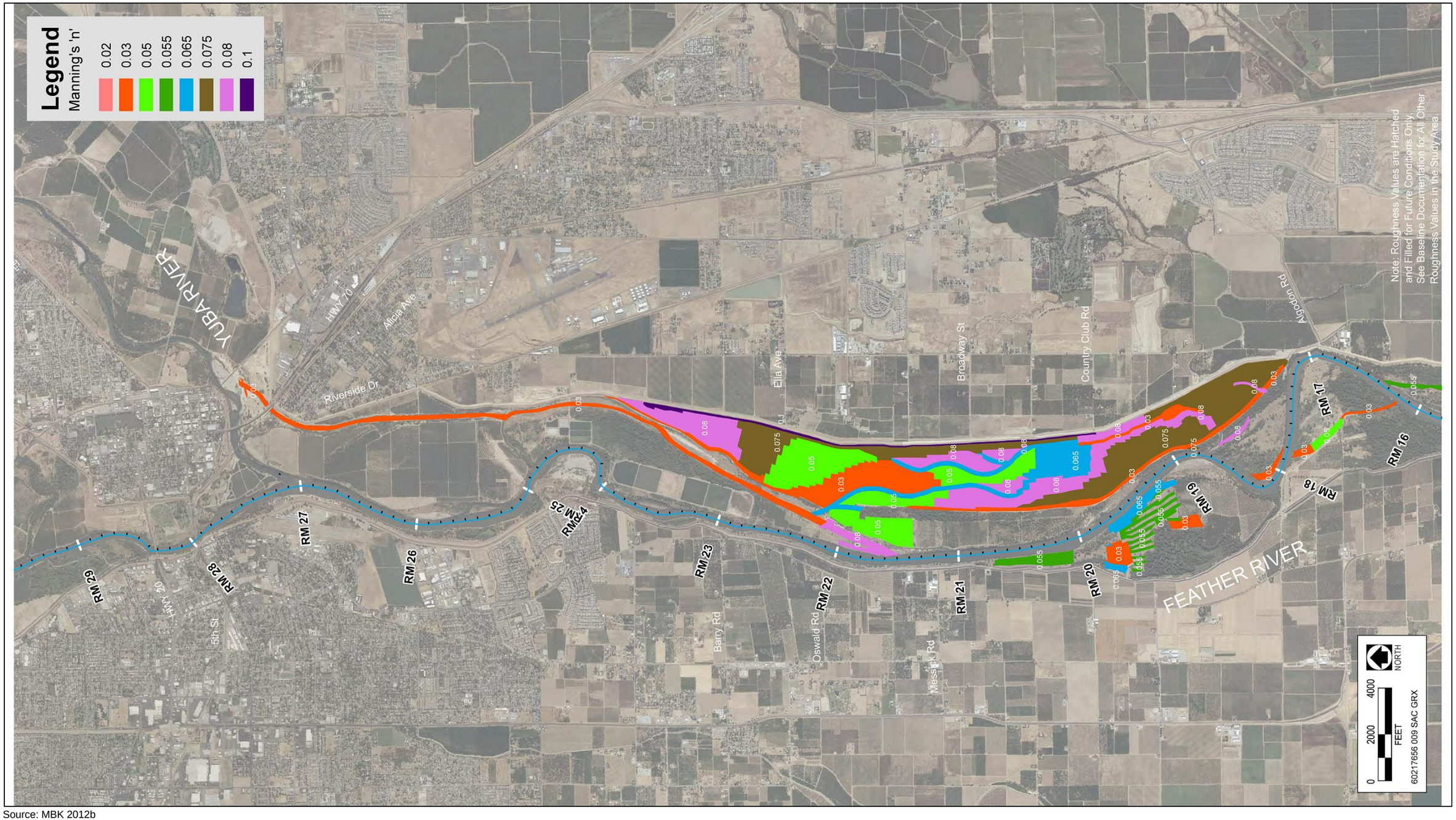


Source: MBK 2012b

Exhibit 5-2 **RMA-2 Model — Future-Condition Conceptual Grading Design (North Study Area)**

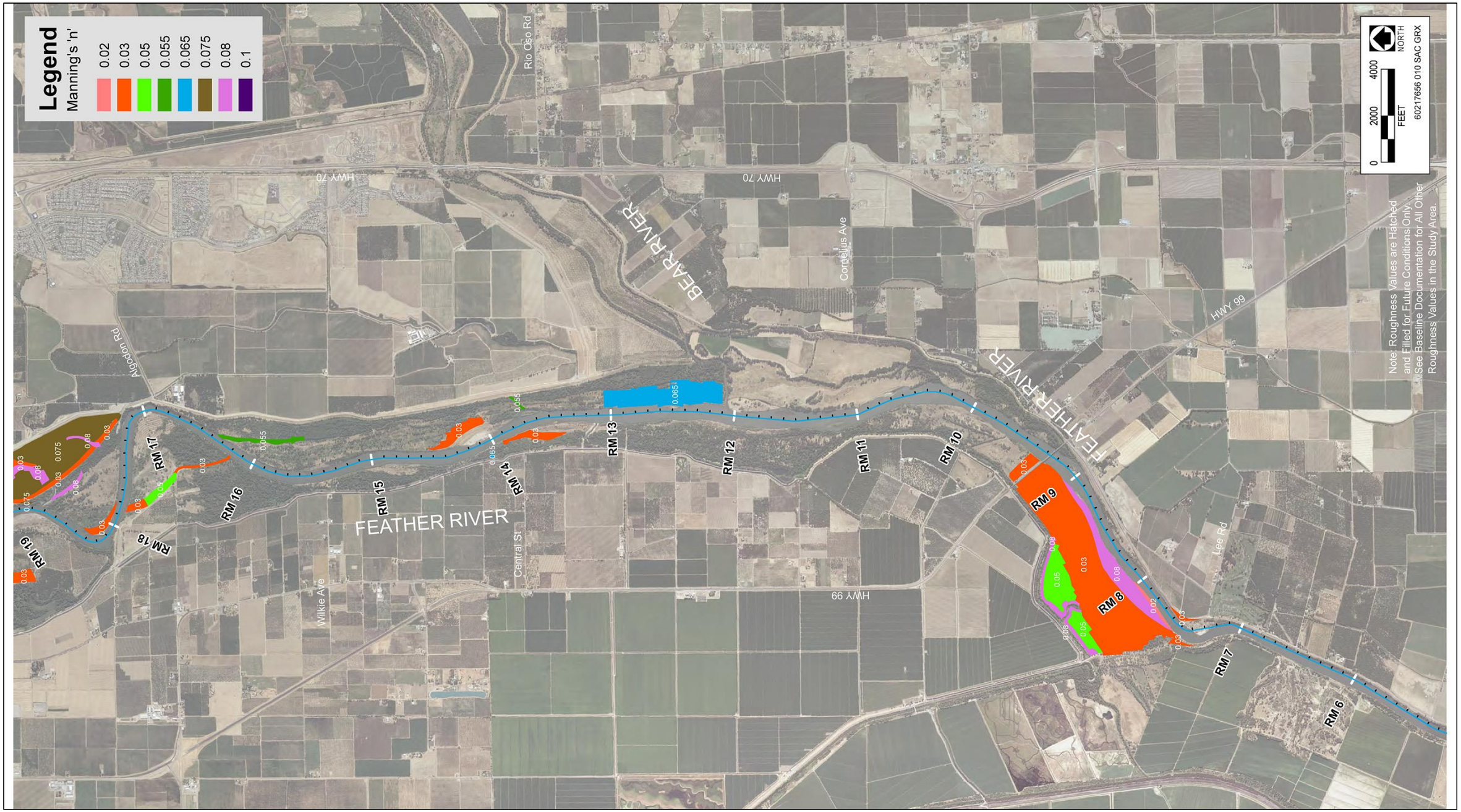
Source: MBK 2012b

Exhibit 5-3 **RMA-2 Model — Future-Condition Conceptual Grading Design (South Study Area)**



Source: MBK 2012b

Exhibit 5-4 **RMA-2 Model — Future-Condition Roughness Values (North Study Area)**



Source: MBK 2012b

Exhibit 5-5 **RMA-2 Model — Future-Condition Roughness Values (South Study Area)**

Table 5-7 Future-Condition Roughness Values Assigned in the RMA-2 Flood Model	
Description	**Manning's n Roughness Value**
Channel widening at RM 7.5 to RM 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
Source: MBK 2012b:Table 1	

5.3.2 RESULTS OF FLOOD MODELING

EFFECTS ON WATER SURFACE ELEVATIONS

Water-surface elevation profiles were plotted with corresponding top-of-levee elevations on both sides of the floodway. Each plot displays water-surface elevation profiles under baseline conditions and future conditions to illustrate the relative difference between these conditions during the 1-in-100 AEP, 1-in-200 AEP, and 1957 SRFCP design flow. The profile plots are referenced in NAVD88 datum and the water-surface elevation profiles combined with the levee profiles show the available freeboard. .Current requirements for the Feather River are a minimum levee freeboard of 3 feet based on the 1957 Design Flow and profile. Exhibits 5-6 and 5-7 are examples of baseline and future water-surface elevation profiles along the right and left banks of the modeling study area.

Across all simulated events, the future-condition water surface elevations were subtracted from the baseline-condition water surface elevations, and the differences were calculated and averaged for each profile. Tables 5-8 through 5-10 summarize the average differences in water surface elevations for the 1-in-100 AEP, 1-in-200 AEP, and 1957 design flow simulation runs, respectively, and for both Upper Feather and Lower Feather centerings.

Table 5-8 Water Surface Differences of the 1-in-100 Annual Exceedance Probability Simulation Run (average difference, future minus baseline) for the 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	-0.6
Feather River left bank (RM 2.9 to RM 12.2)	-0.3	-0.2
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)	-0.2	-0.2
Yuba River left bank (RM 0.3 to RM 1.2)	-1.2	-1.2
Source: MBK 2012b:Table 9		

Table 5-9 Water Surface Differences of the 1-in-200 Annual Exceedance Probability Simulation Run (average difference, future minus baseline) for the 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	-0.6
Feather River left bank (RM 2.9 to RM 12.2)	-0.3	-0.2
Feather River left bank (RM 13.2 to RM 27.2)	-0.8	-0.7
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 8		

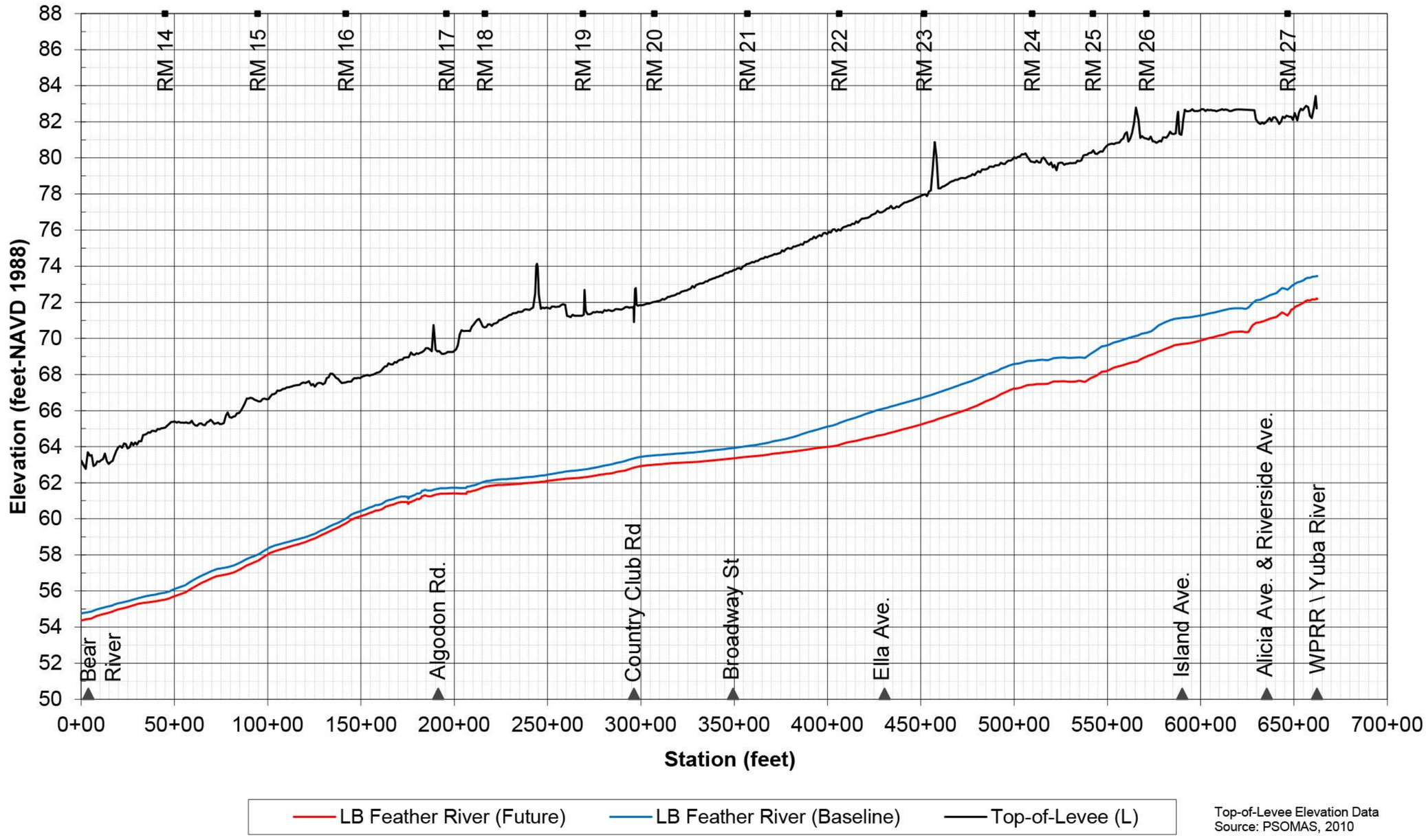
Table 5-10 Water Surface Differences of the 1957 Design Flow Simulation Run (average difference, future minus baseline) for the Upper and Lower Feather River Flow Centerings		
Water-Surface Elevation Profile	**Upper Centering (Δ ft)**	**Lower Centering (Δ ft)**
Feather River right bank (RM 7.8 to RM 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		

In general, the average differences across all simulated events follow a similar trend of reduction in future-condition water surface elevations compared to the baseline. Therefore, the modeling results demonstrate that future conditions reduce water surface elevations and increase levee freeboard throughout the LFRCMP study area. During the 1-in-100 AEP, the Feather River levees (RM 2.9 to RM 28.7) have freeboard ranging from 5 feet to 8 feet, and the Bear River levees (RM 0.3 to RM 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 RM 28.7) generally have freeboard ranging from 3 feet to 6 feet (less than 3 feet between approximately RM 16.0 and RM 16.8 on the right [west] levee), and the Bear River levees (RM 0.3 to RM 4.75) have freeboard ranging from 3 feet to 6 feet.

EFFECTS ON WATER VELOCITIES

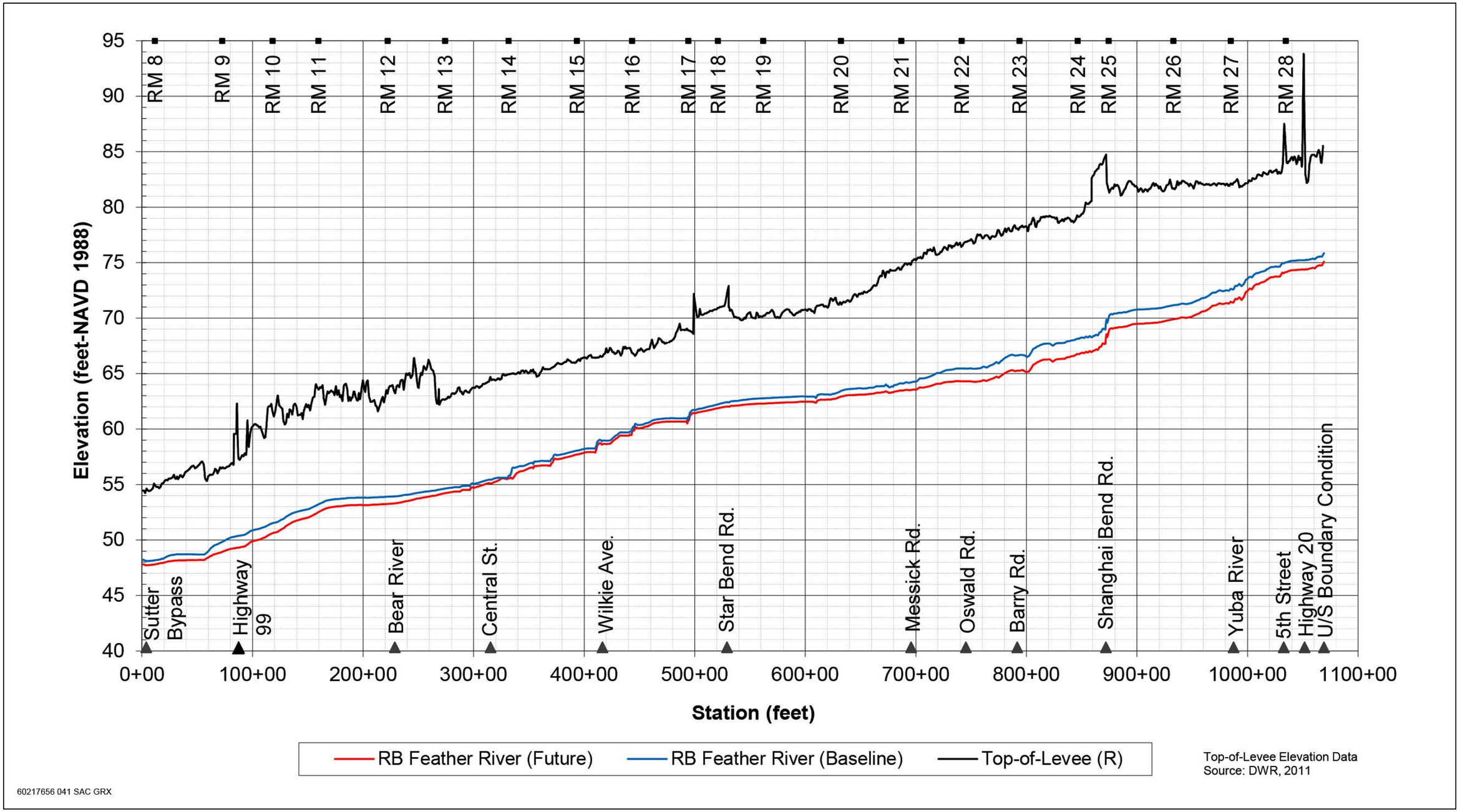
Contoured velocity magnitudes were computed and mapped throughout the modeling study area for the 1-in-100 AEP, 1-in-200 AEP, and 1957 SRFCP design flow. Contoured velocity figures in the flood modeling report (Appendix G) only display flow centering runs having the dominant effect in a project reach. Examples of contoured velocity figures are shown in Exhibits 5-8 and 5-9.

Effects on flow velocities that would result from implementation of the modeled features are best understood by analyzing the relative changes from baseline conditions. Velocity differences between the baseline study and future conditions were calculated at all model mesh nodes. The resulting data points were contoured and mapped to visualize the spatial distribution of velocity differences. Exhibits 5-10 through 5-12 illustrate examples of the



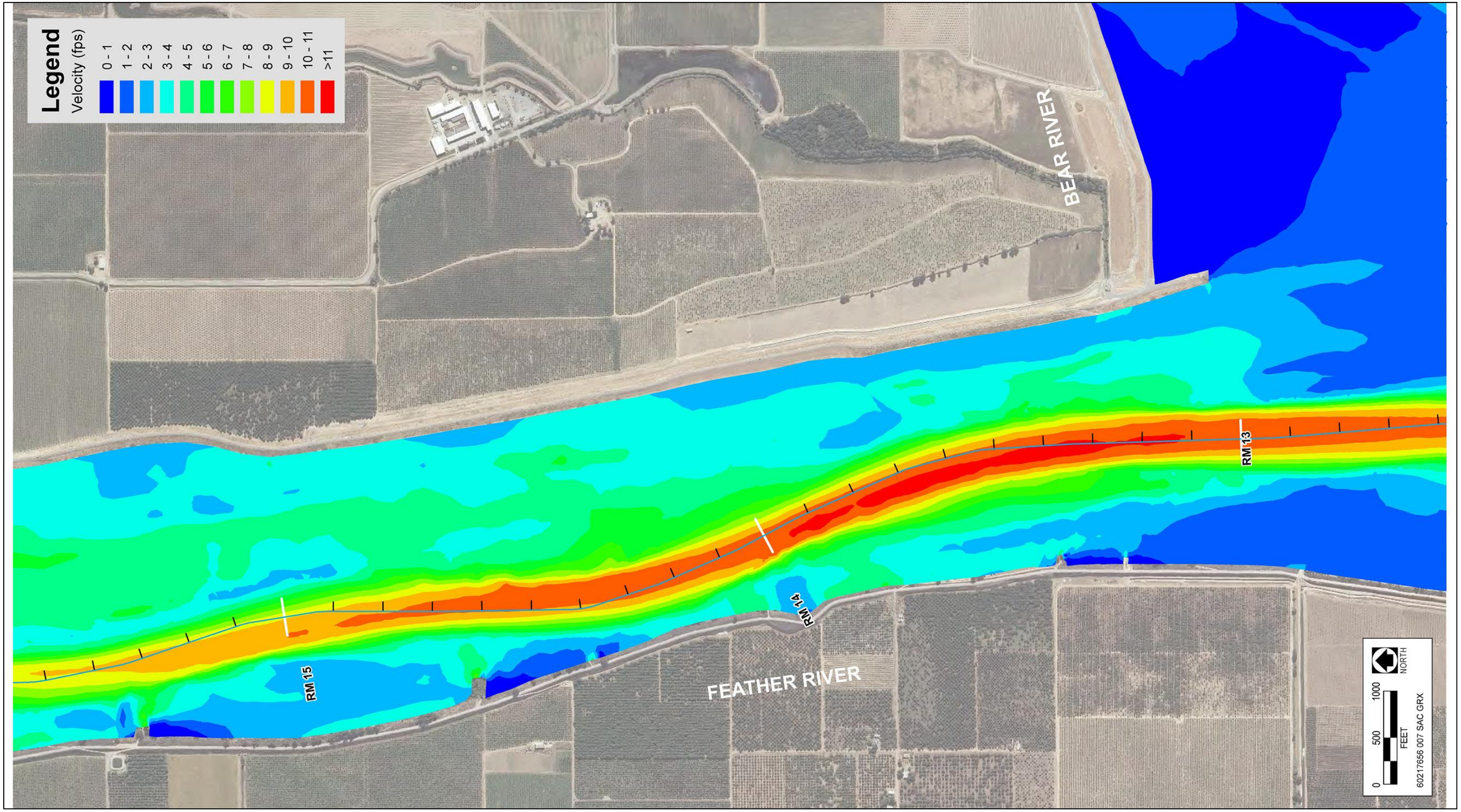
Source: MBK 2012b

Exhibit 5-6 **Feather River Left Bank (River Miles 13.2 to 27.2) Maximum Water Surface Profile (RMA-2 Model)—1-in-100 Annual Exceedance Probability, Lower Feather Centering**



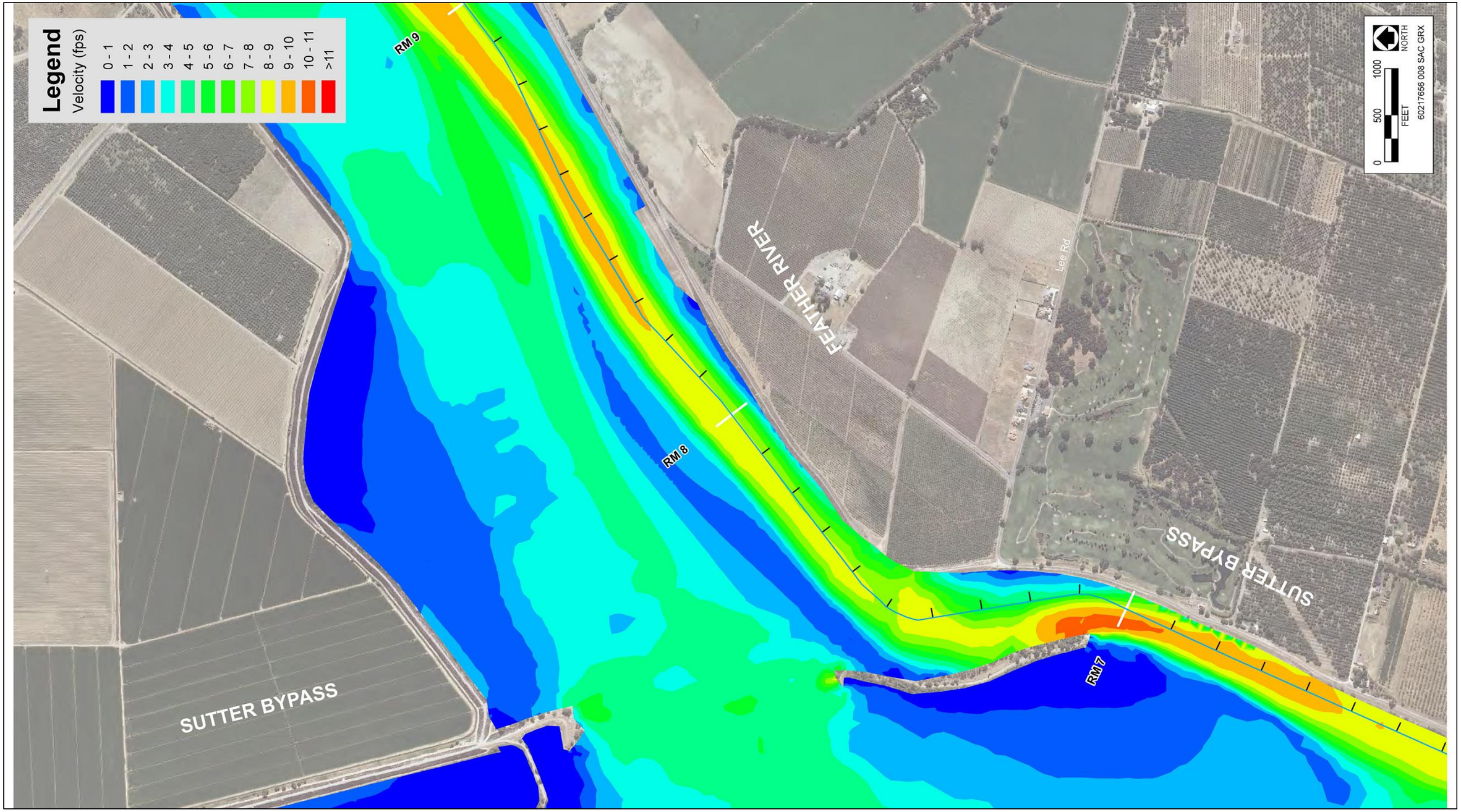
Source: MBK 2012b

Exhibit 5-7 **Feather River Right Bank (River Miles 7.8 to 28.7) Maximum Water Surface Profile (RMA-2 Model)—1-in-200 Annual Exceedance Probability, Lower Feather Centering**



Source: MBK 2012b

Exhibit 5-8 **Lake of the Woods: 1-in-200 Annual Exceedance Probability Velocity Contours (Upper Feather Centering)**



Source: MBK 2012b

Exhibit 5-9 **Nelson Slough: 1-in-200 Annual Exceedance Probability Velocity Contours (Lower Feather Centering)**

contoured velocity difference maps. For most of the study area, the modeling indicated minimal or no difference in velocity, so the figures were screened to not display fill-hatching where the velocity difference was between -1 and +1 fps. Velocity differences less than -1 fps indicate a simulated velocity reduction under future conditions; velocity differences greater than +1 fps indicate an increase in velocity under future conditions.

In general, changes in flow velocity between baseline and future conditions range from a net reduction of 4 fps to a net increase of up to 8 fps across all simulated flow events. Future conditions at State Cut and the FRS area (RM 27.0) 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 show a decrease in average channel velocities. These effects are considered to represent a balance of resistance through a wide portion of the floodway, because future conditions provide less resistance than baseline conditions through the FRS setback area, thereby increasing floodway capacity across the floodplain and relieving flows in the main channel.

At Star Bend (RM 17.9 to RM 18.2), future conditions reflect an increase in flow velocities through the degraded bend, because the Star Bend future-condition degrade is a widening of the main channel on the left bank, with a resulting decrease in roughness.

The simulated effects of changes in vegetation cover at Abbott Lake and excavation and vegetation changes at O'Connor Lakes showed minimal or no change in flow velocities relative to baseline conditions.

At Lake of the Woods (RM 12.1 to RM 16.1), simulated future conditions show an increase in flow velocities through the graded floodplain bench areas in comparison to baseline conditions. However, the velocity increase does not exceed 3 fps across all simulated events. Eliminating vegetation removal in the 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 that corresponds to an assumed gradual increase in floodplain roughness after vegetation management ceases and riparian vegetation subsequently grows in this segment.

Comparing the simulated future conditions at Nelson Slough (RM 7.5 to RM 10.5) to baseline conditions shows an overall decrease in flow velocities through the main channel and across large portions of the floodplain. Flow velocity in the main channel is reduced by channel widening, levee realignments, and excavated terraces. Overbank flow velocity is reduced on the lower terrace because of an increase in roughness from grassland to dense riparian forest and in the north floodplain area where roughness increases from predominantly grassland to oak woodland.

Realigning the hook levee in the Sutter Bypass (RM 7.4 to RM 7.6 on the right bank of the Feather River) results in an increase in velocity at the upstream end of the training levee because an overall increase in floodway capacity causes flows to converge at that location. The minor levee setback area on the left bank at the sharp bend of the east levee (RM 7.4 to RM 7.7) is outside of the existing floodway and is not included in the baseline finite-element mesh; therefore, velocity differences at this location are the absolute velocities for future conditions (i.e., there is no flow under the baseline).

Overall, under future conditions, areas of increased velocity generally occur on broad floodplains and in overbank swales and low-flow bypass channels located at a distance 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 vegetation roughness.

5.3.3 MODIFICATIONS TO FUTURE CONDITIONS AFTER COMPLETION OF THE RMA-2 FLOOD MODEL

RMA-2 flood hydraulic modeling conducted by MBK (2012a) was based on future conditions that would result from potential management actions proposed at the time the flood model was under development (2011 through July 2012). A series of modifications to the management actions were subsequently made, but the modified actions were not simulated in the RMA-2 flood modeling results summarized above. The following new information and resulting modifications to management actions, future conditions, and modeling approach were made after the RMA-2 hydraulic modeling was completed:

- Results of flood modeling conducted by MBK and preliminary results of hydrodynamic modeling conducted by cbec indicated an insignificant benefit of grade lowering or channel bank widening features at Lake of the Woods (locations at approximately RM 14 to RM 15) that were intended to reduce flood stage in this most-constricted reach of the study area. Therefore, these proposed modifications were withdrawn from further consideration.

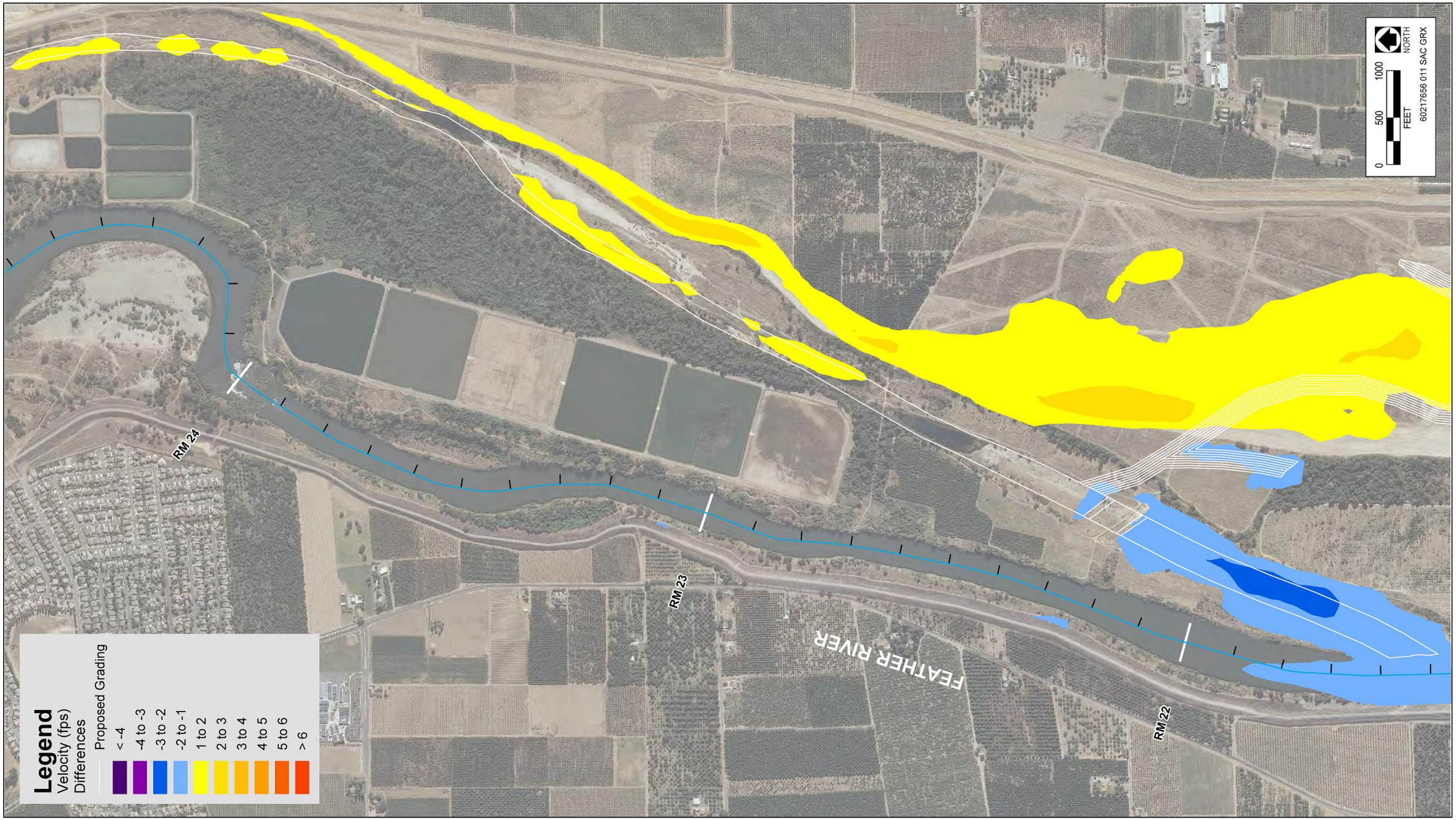
- The natural grade-control feature at Shanghai Rapids was breached in January 2012. Future scour of the Modesto Formation is anticipated to cause breach expansion and incision and to alter bathymetry and flow stage in this reach.

- Based on input from DWR (Nelson, pers. comm., 2012), it was determined that hydrologic data derived from the USACE Comp Study (USACE 2008; PBI 2011) and used in the MBK 100- to 200-year flood modeling were not appropriate for modeling more frequent flood events (e.g., 2-year, 10-year), because the data likely overestimate flood peaks and volumes for such events. See the "Boundary Conditions" discussion in Section 5.4.3, "Development of the Hydrodynamic Model," for a more detailed discussion.

- Preliminary results of cbec's hydrodynamic modeling (using revised hydrology for 2- and 10-year peak flows) indicated that grade excavation and channel widening along the State Cut, Eliza Bend, and Old Feather River channels did not significantly increase the frequency of flow diversions or the extent of floodplain activation. Therefore, these proposed modifications were withdrawn from further consideration.

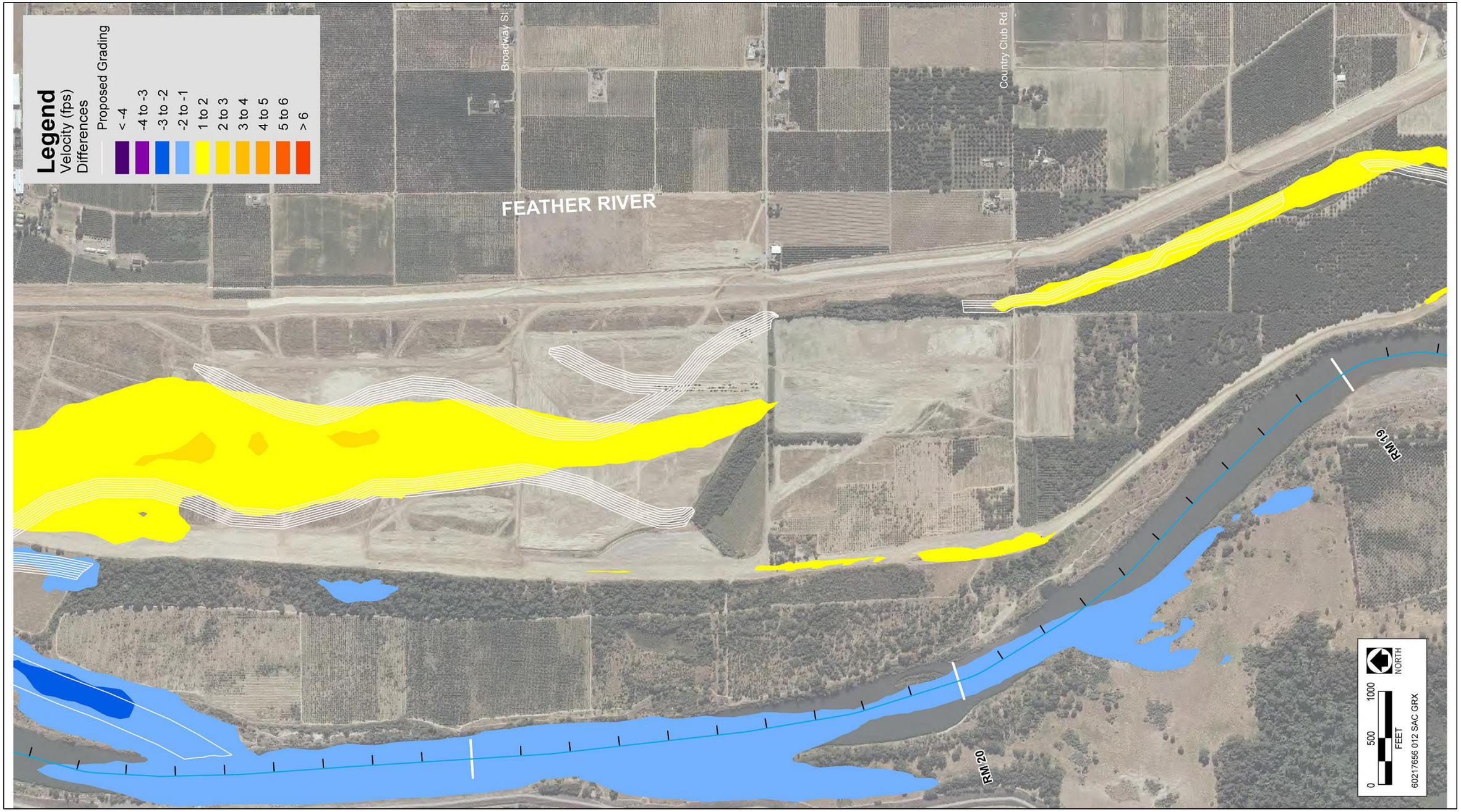
- Preliminary results of cbec's hydrodynamic modeling indicated that 2-year to 10-year flood stage elevations near RM 24 to RM 23 could be tapped as a previously unanticipated source of floodplain activation inflow. Modeling of frequent flood hydrographs revealed that the river could be reconnected to the low floodplain in the FRS area by cutting a notch in the left (east) bank and excavating a relatively short swale through a natural ridge separating the river from its historic floodplain. As a result, an overbank flow diversion swale was added at RM 23.3 as an element of the FRS conceptual design, and floodplain grade lowering on the FRS at Upper Messick Lake is intended to increase the areal extent of frequent flood inundation.

- Other modifications were made to incrementally reduce the overall extent and cost of future floodplain excavations and associated material handling and off-site haulage costs. These modifications include placing excavated material as spoils ridges throughout the upper FRS floodplain, which would also benefit wildlife by creating high-ground flood refugia to escape high water events.



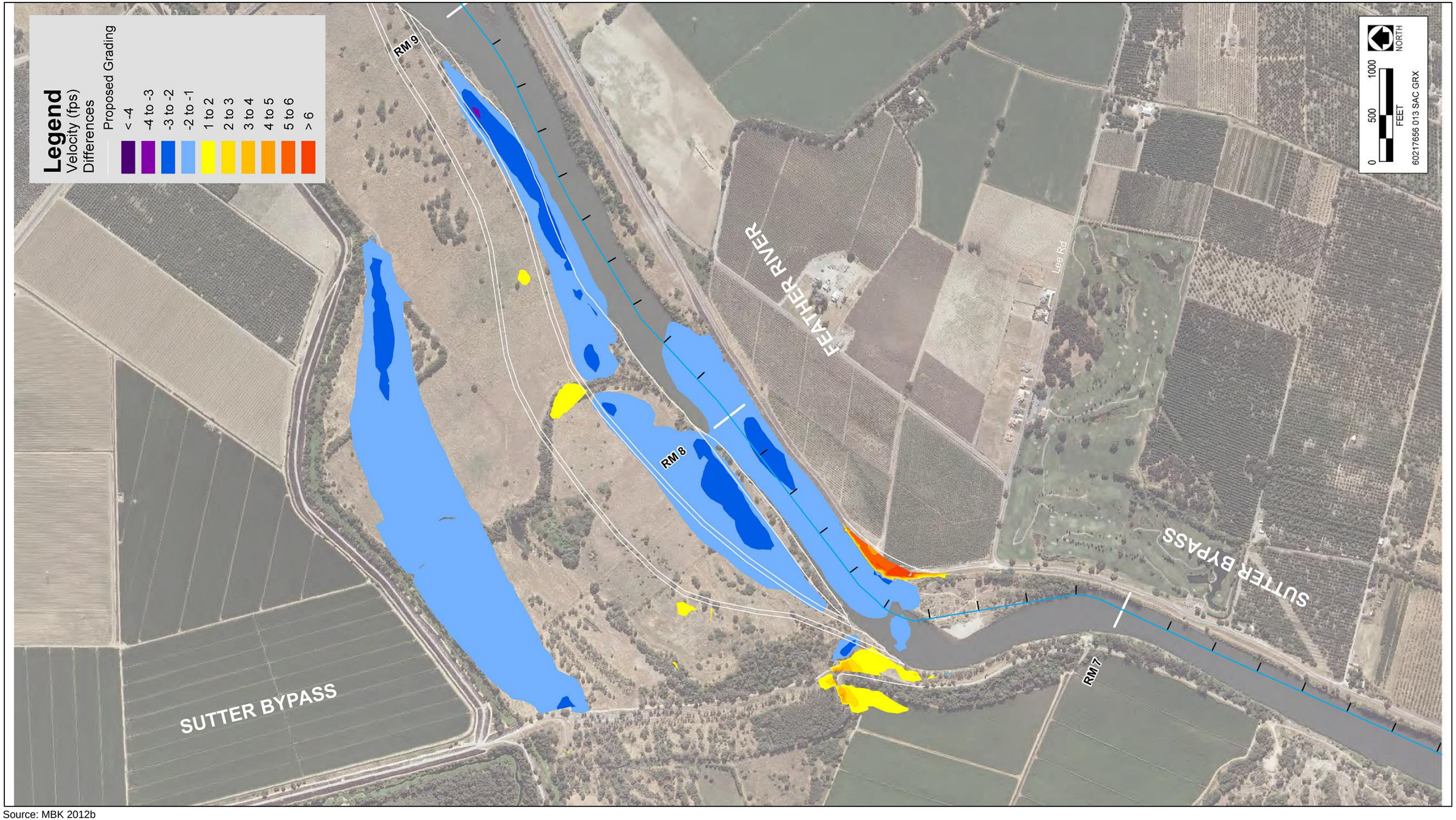
Source: MBK 2012b

Exhibit 5-10 **State Cut, Feather River Setback Area: 1-in-200 Annual Exceedance Probability Velocity Differences (Upper Feather Centering)**



Source: MBK 2012b

Exhibit 5-11 **Feather River Setback Area: 1-in-200 Annual Exceedance Probability Velocity Differences (Upper Feather Centering)**



Source: MBK 2012b

Exhibit 5-12 **Nelson Slough: 1-in-200 AEP Velocity Differences (Lower Feather Centering)**

All the modifications to the conceptual design listed above were subsequently incorporated into the final versions of cbec's hydrodynamic and sediment transport models, as described below in Section 5.4, "Hydrodynamic, Geomorphic, and Sediment Transport Modeling."

Some modifications made to future conditions were not included in subsequent modeling simulations. A qualitative interpretation of the RMA-2 model results suggests, however, that these unmodeled modifications are unlikely to result in significant differences in velocity or stage under 100- and 200-year AEP floods for the following reasons:

- Topographic and swale modifications are minor compared to the substantial width of the floodway throughout the levee setback reaches, and under the greater depth of major flood stage above floodplain elevations.
- Vegetation roughness patterns are substantially the same except for minor reconfigurations in limited areas.
- There is a dominant, overriding effect of backwater conditions from flood stage in the Sutter Bypass and the lower river, and from the constricted width of the floodway between levees in the middle reach of the LFRCMP study area (RM 13.5 to RM 16.5).
- Earlier hydraulic modeling of a hypothetical breach at Shanghai Rapids showed no effect under major flood events (MEI 1999).

MBK's RMA-2 flood model, which is available for use as part of DWR's Library of Models, could be used to verify these qualitative assumptions of no or little effect prior to any actual construction

5.4 HYDRODYNAMIC, GEOMORPHIC, AND SEDIMENT TRANSPORT MODELING

5.4.1 PHYSICAL SETTING AND GEOMORPHIC EVOLUTION OF THE LOWER FEATHER RIVER

As described in Chapter 3, the geomorphology of the LFR has been altered by historic perturbations within the watershed that have substantially affected the river's sediment and hydrologic regime over the last 150 years. As a result of hydraulic mining in the mid- to late 1800s, more than 950 million cubic yards of sediment were delivered from the upper Feather, Yuba, and Bear River watersheds into the LFR corridor, which caused up to 20 feet of aggradation near Marysville (Ayres 1997), and was distributed throughout the Sacramento River and Delta regions over the past 150 years after the cessation of hydraulic mining at the end of the 19th century. With the cessation of hydraulic mining in the early 1900s and the construction of dams through the middle of the 20th century, the supply of sediment to the system declined dramatically. As a result of the reduced sediment supply and extensive levee building, dredging, and channelization, a period of channel incision through an aggraded bed condition occurred from the early to mid-20th century. This process was influenced by the backwater conditions (reduced velocity) at the confluence of the Feather River with the Sutter Bypass (James et al. 2009), after which the channel began to rest on pre–hydraulic mining era deposits, which are much more resistant to erosion.

The extensive aggradation of floodplain deposits during the hydraulic mining era, followed by post-mining incision, has dramatically reduced the frequency and duration of natural floodplain inundation that occurred

before the hydraulic mining era. Bed incision has abated in the last 20–30 years, but lateral bank erosion and knickpoint migration at Shanghai Rapids is an ongoing concern. This process is controlled by the composition of the river banks, bank armoring (riprap), the supply of sediment from the watershed below the major reservoirs (Ayres 1997), and the integrity of the geologically resistant Modesto Formation.

More recently, the Modesto Formation that forms Shanghai Rapids, which had been retreating up-channel at a rate of 11.1 feet per year (cbec 2011), episodically breached in January 2012. This unanticipated breach event damaged a major Yuba City pressurized sewer line buried in a gravel-lined trench approximately 5 feet below the surface of the Modesto Formation (Moffatt & Nichol 2012), causing effluent to spill into the river. A new pipeline has since been installed, using a hydraulic directional drilling method, at a much greater depth of 20–40 feet below ground level.

The fate of Shanghai Rapids is particularly important because of the potentially significant hydraulic and geomorphic changes that could ensue after breaching of the rapids (MEI 1999; James et al. 2009; cbec 2011). Enlargement of the chute channel or full breaching could trigger substantial upstream degradation of the river bed. Upstream channel degradation and sediment mobilization could be followed by downstream aggradation, accompanied by bank instability and possibly remobilization of mercury-laden sediments (James et al. 2009). These hydraulic and geomorphic changes could result in the loss of salmonid habitat upstream and a reduction in the frequency of inundation of natural floodplains. These changes would also reduce the frequency of inundation of newly created swales and floodplain features.

5.4.2 Hydrodynamic and Sediment Transport Modeling Objectives and Modeling Study Area

The objectives of cbec's hydrodynamic and sediment transport modeling, which was conducted in addition to and not duplicative of the RMA-2 flood modeling discussed above, were as follows:

- Demonstrate the ecological benefits and sediment transport effects of more frequent, dynamic flood hydrographs under both existing and future conditions.
- Evaluate modifications to future conditions under frequent and 100-year floods that were not considered in the RMA-2 flood modeling.
- Simulate and understand the near-term and long-term effects of the recent breach at Shanghai Rapids (which also occurred after the RMA-2 flood modeling was completed).
- Evaluate the ecological and/or floodway capacity benefits of implementing conceptual future projects that involve moderate to major grade excavations.

As with the RMA-2 model, cbec created a modeling domain (study area) that was larger than the boundary of the LFRCMP study area to minimize forcing effects (model instability) from confining model boundaries to within the LFRCMP study area. Exhibit 5-13 shows the modeling domain, which extends slightly beyond the landside of the levees and includes the following boundary extensions:

- Feather River at RM 30.1
- Yuba River at RM 2.8
- Bear River at RM 2.7
- Sutter Bypass at RM 68.1
- Feather River at RM 2.5

MODELING SOFTWARE

MIKE_21C is a 2-D, curvilinear grid model developed by DHI Water & Environment to simulate changes in river morphology, flow velocity, and stage in response to hydraulic and hydrologic variation over time, like a typical flood hydrograph. The hydrodynamic model solves the vertically integrated equations of continuity and conservation of momentum (the Saint Venant equations) in two directions and describes helical flow and vertical velocity profiles. These descriptions are important for simulating the physical processes associated with secondary flow in meandering systems. The morphological model, following the calculation of bed material transport (bed load and suspended load), solves the equation for sediment continuity and simulates how the river bed and active floodplain develop in response to fluvial erosion (bed and bank), deposition, and shoaling. The available formulas in MIKE_21C successfully describe the transport of Feather, Yuba, and Bear River sediments ranging from fine sand to small cobbles.

5.4.3 DEVELOPMENT OF THE HYDRODYNAMIC MODEL

Compared to the data required to simulate major flood events in the RMA-2 model, MIKE_21C requires more detailed and accurate bathymetric, topographic, and hydrologic data to simulate the effects of frequent flood flows, and construction of a more complex modeling mesh (Exhibit 5-14). Existing and future vegetation patterns and roughness must also be described and input at a finer scale of resolution and detail. The sources of data for cbec's hydrodynamic modeling are described below.

BASELINE BATHYMETRY AND TOPOGRAPHY

Bathymetry and topography for the MIKE_21C model domain were based on those compiled by MBK (2012a) from multiple sources, but primarily from the 1999 surveys performed by USACE as part of the Comp Study (Ayres 2003). Several topographic and bathymetric updates to the 1999 Comp Study data (USACE 2002) were prepared by MBK for the RMA-2 flood model (see "Sources of Topological Data" in Section 5.3.1, "Flood Modeling Methods and Assumptions") and used in the MIKE_21C model.

In addition to MBK's updates, cbec conducted post-breach surveys at Shanghai Rapids on foot and by boat on June 22 and 29, August 24, and September 7, 2012 (cbec 2012). Additional data were collected on the low-flow channel bathymetry, bed material, and surface detail for the Modesto Formation in the vicinity of Shanghai Rapids (RM 24) (Exhibit 5-15). These data were collected after the initial breaching of the Modesto Formation and failure of a major Yuba City pressurized sewer line in late January 2012 (Moffatt & Nichol 2012). After the breach, the river flow was concentrated in a much deeper and more narrow chute through the Modesto Formation, and a large expanse of channel bed that formerly was inundated by the rapids became exposed.

The composite surface model developed by MBK was prepared with a horizontal projection of NAD83 CASP Zone 2 feet and a vertical datum based on NGVD29 feet. For modeling in MIKE_21C, the data were re-projected

from CASP feet to Universal Transverse Mercator meters and converted from NGVD29 feet to NAVD88 meters based on applying a conversion of 2.3 feet (HJW 2010) and then converting to meters.

BOUNDARY CONDITIONS

Boundary source (hydrologic) data in the MIKE_21C model differ from the data used in the RMA-2 model developed by MBK (2012a, 2012b). The RMA-2 model used the Comp Study's synthetic flood hydrology with storm centering at Shanghai Bend (USACE 2002, 2008), as routed through an updated HEC-RAS model prepared by Peterson Brustad, Inc. (PBI 2011) for the Sutter-Butte Flood Control Agency. For the 100- to 200-year flood modeling, MBK used the synthetic flood hydrology from the PBI model.

However, based on information provided by DWR (Nelson, pers. comm., 2012), the synthetic flood hydrology is likely to overestimate flood peaks and volumes for more frequent flood events (e.g., 2-year, and 10-year). Thus, it could result in the overprediction of floodplain inundation, duration, geomorphic response, and associated ecological benefits. Therefore, cbec (2013b) modified the more frequent flood hydrology at the modeling boundaries by using a combination of updated flood frequency analyses, published flood flows, and hydrologic routing.

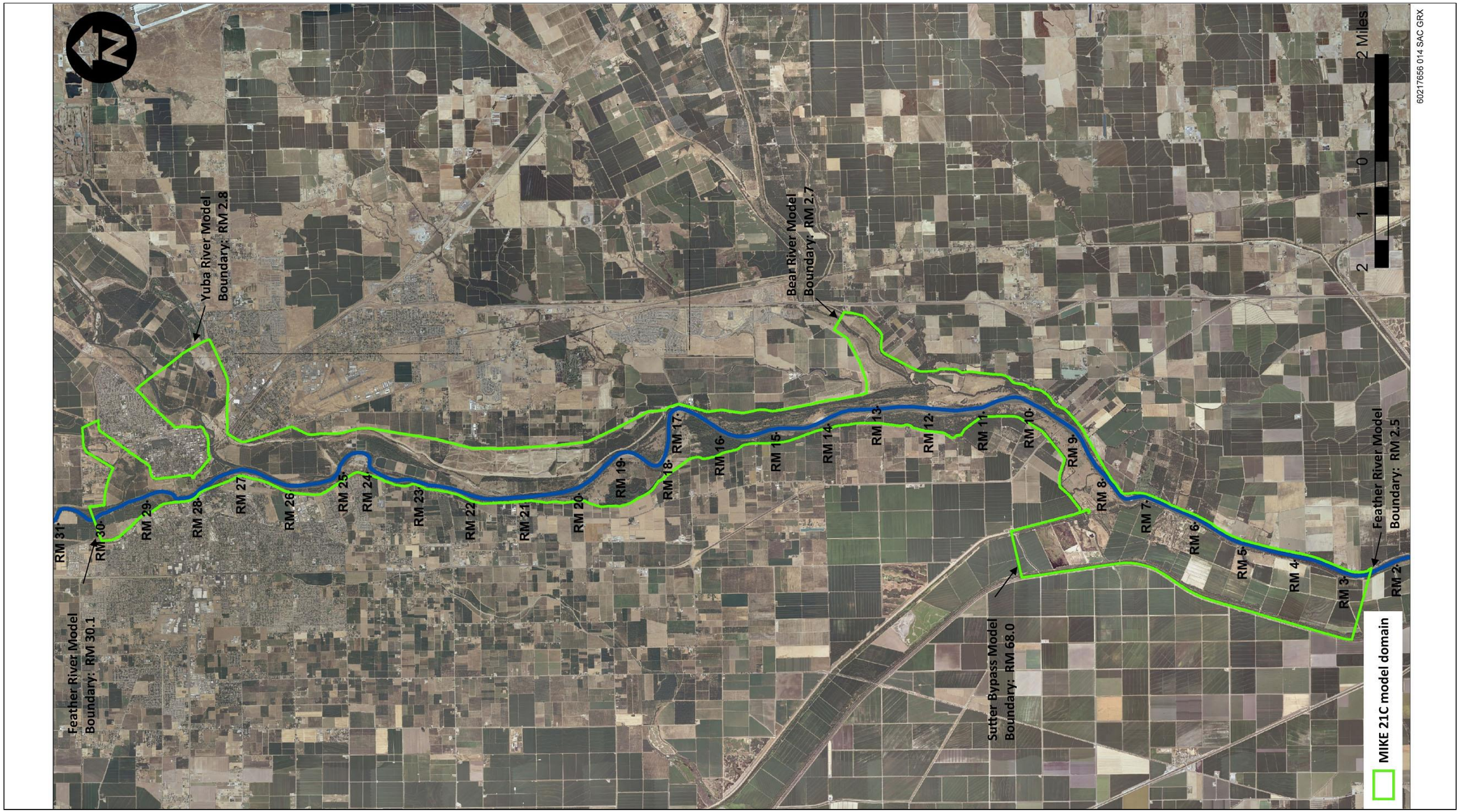
Exhibits 5-16 and 5-17 show the modified flood hydrology for the 2- and 10-year floods, and Exhibit 5-18 shows the synthetic flood hydrology for the 100-year flood. Table 5-11 summarizes the peak flows and stages from both hydrograph sources for frequent flood events; it clearly shows that the flood peaks based on modified hydrology for the 2- and 10-year floods are substantially smaller than those based on the synthetic hydrology.

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

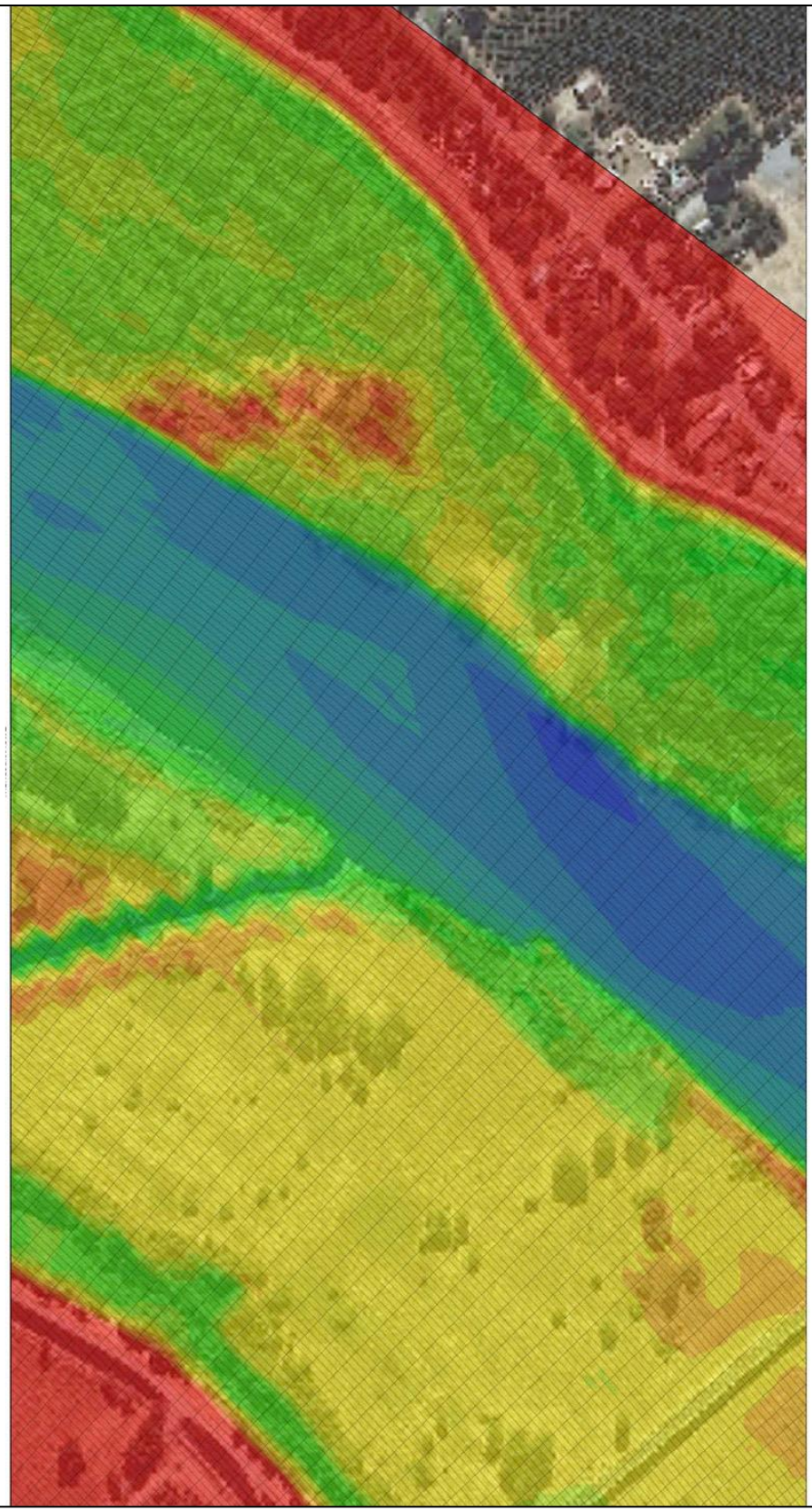
Notes:
1 Based on the Shanghai Bend—Yuba River Centering flood hydrographs at the modeling boundaries as provided by MBK (2012b).
2 Based on updated flood frequency analysis and historical flood hydrographs (cbec 2013b).

The FAF flow estimates also were updated by cbec (2013b) compared to those developed by PWA (2005, 2008) to understand flow activation by the proposed future features. The FAF is a representative flow at which optimum ecological flood benefits are expected to accrue during small-magnitude springtime floods (PWA 2006). For LFRCMP modeling purposes, FAF is defined as the flow required in spring (March 15 through May 15) to escape the channel (i.e., initiate floodplain activation) in 2 out of 3 years for at least 7 consecutive days. The calculation



Source: cbec 2013a

Exhibit 5-13 **MIKE_21C Modeling Domain**



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

60217656 015 SAC GRX

Source: cbec 2013a

Exhibit 5-14 **MIKE_21C Model Mesh (typical)**

by cbec of FAF flow on the Feather River upstream of the Bear River confluence was reduced from 8,414 cfs (PWA 2005, 2008) to 5,170 cfs. The FAF flow on the Feather River downstream of the Bear River confluence was reduced from 9,030 cfs (PWA 2005, 2008) to 5,522 cfs.

Limited model calibration was performed for low-flow conditions on the Feather River using data collected by cbec (2012) during the Shanghai Rapids field data-collection effort. Two low-flow conditions were observed and modeled—a calibration flow at 8,360 cfs and a validation flow at 6,052 cfs to water surface elevations at six gauge locations bounding Shanghai Rapids (see Exhibit 5-19).

HYDRAULIC ROUGHNESS

Baseline- or existing-conditions hydraulic roughness was informed by vegetation mapping (see Exhibit 3-4 in Chapter 3) conducted by AECOM in the LFRCMP study area in 2010 and 2011 (DWR 2011) and hydraulic-model calibration performed by MBK (2012a). For modeled areas outside the boundaries of the LFRCMP study area, vegetation mapping prepared by California State University at Chico (CSUC) (2011) was used to supplement the AECOM vegetation mapping. As part of the limited model calibration performed by cbec (see Section 4.1 in cbec 2013a), Manning's n values for the Feather River low-flow channel were modified slightly from the MBK values. This and other modifications, such as aggregation of some land cover types, are reflected in the baseline roughness values assigned in the MIKE_21C model (Table 5-12).

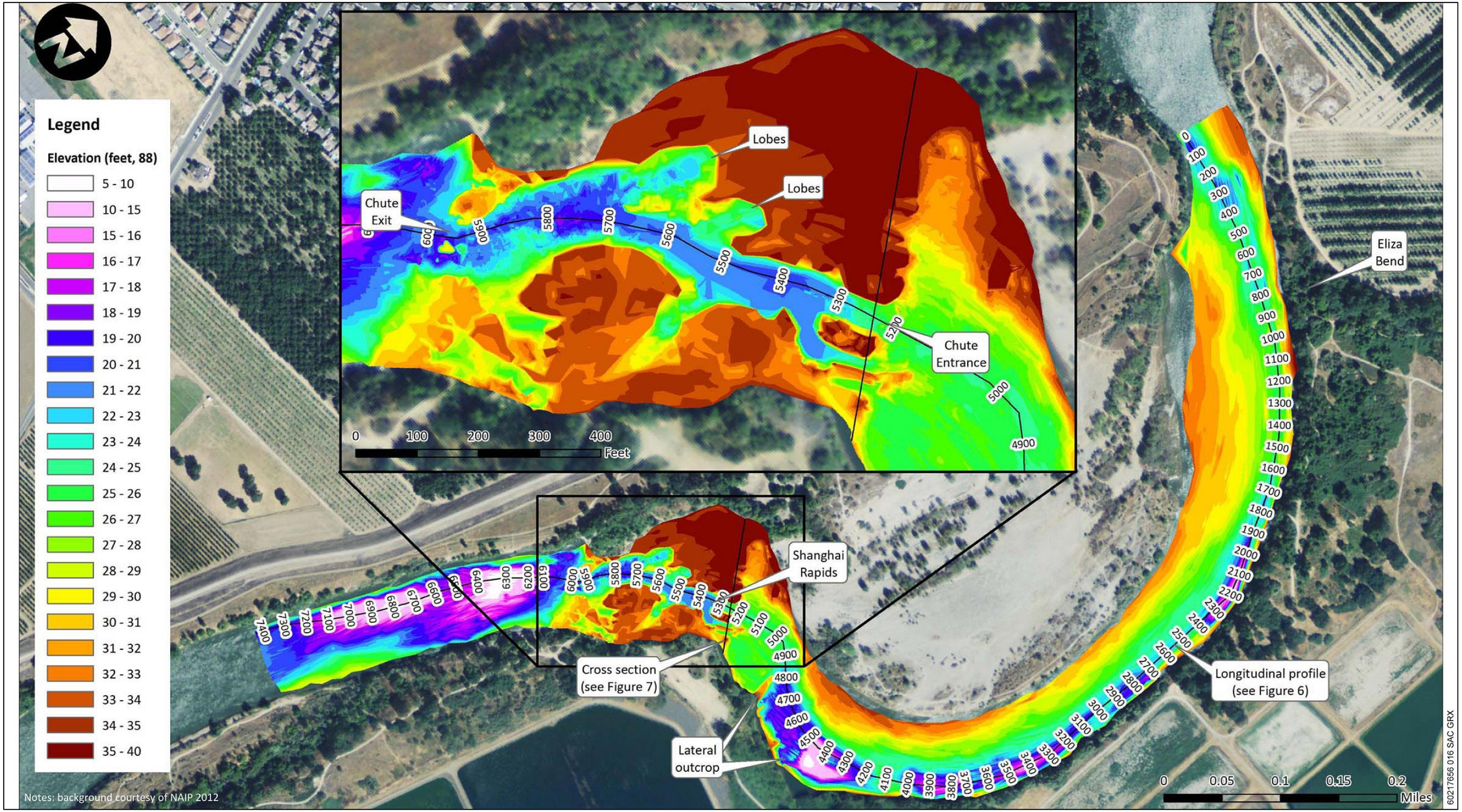
5.4.4 FUTURE CONDITIONS SIMULATED IN HYDRODYNAMIC MODEL

The purpose of the hydrodynamic modeling was to assess the effects of implementing management actions designed to fulfill the ecosystem and flood management goals of the LFRCMP. The ecosystem goals of the LFRCMP focus on improving riverine ecosystem function to benefit fish and wildlife and promoting natural dynamic, hydrologic, and geomorphic processes. Specific objectives include:

- increasing the extent and connectivity of:
  - seasonal shallow aquatic habitat,
  - frequently inundated floodplains,
  - shaded riverine aquatic habitat, and
  - riparian habitat and riparian/upland habitat mosaics;
- promoting the recovery and stability of native species populations and overall biotic community diversity; and
- removing or filling fish entrapment depressions.

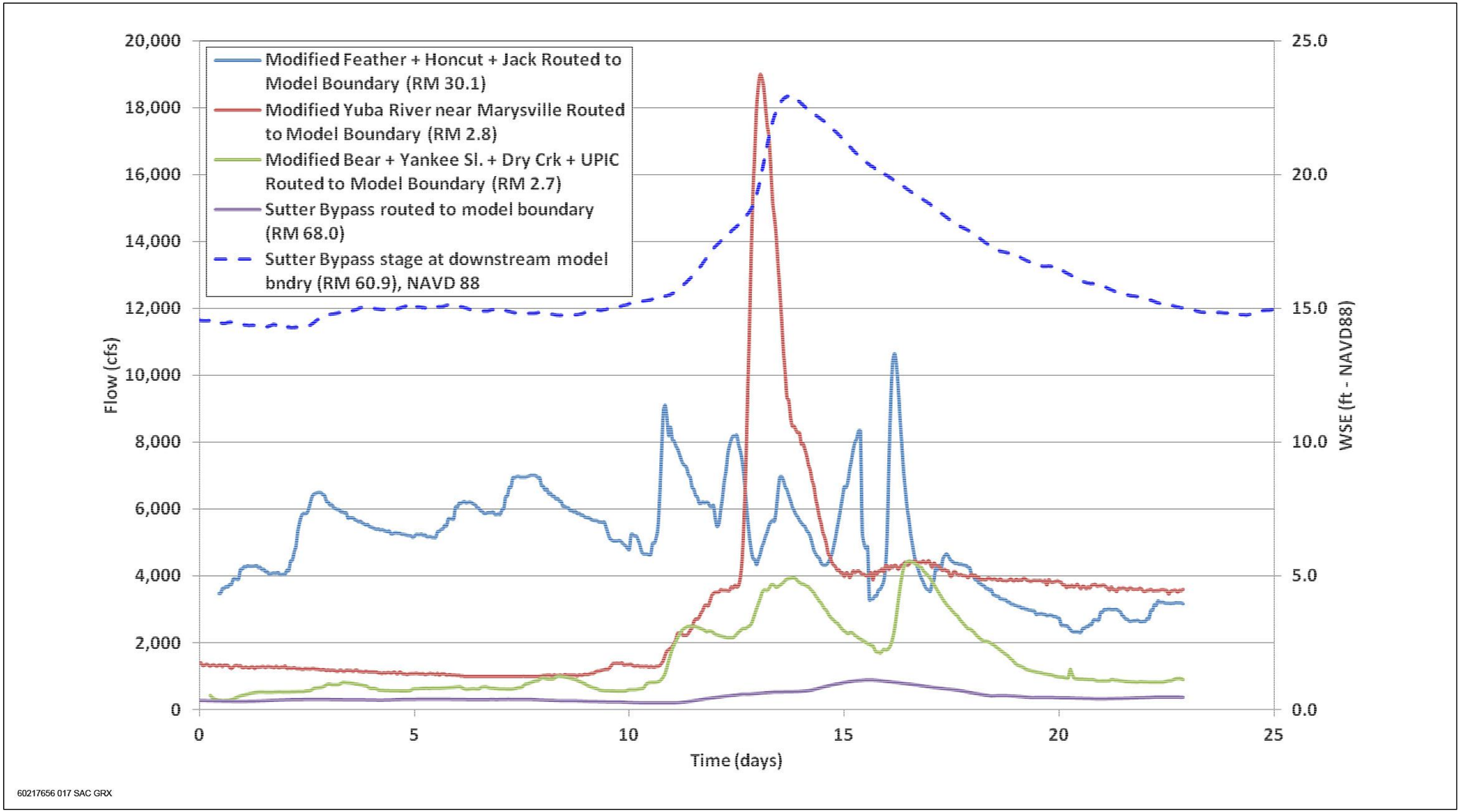
The flood management goals of the LFRCMP focus on minimizing the flood management system's operation and maintenance requirements while protecting human life, health, and safety from flooding, including protection of public safety infrastructure. Specific objectives include:

- minimizing floodway maintenance costs,
- minimizing conflicts between floodway maintenance and ecosystem function/habitat goals,
- ensuring that adequate floodway conveyance capacity exists in constricted reaches,
- improving sediment management, and
- reducing erosion on and near levees and other flood control structures.



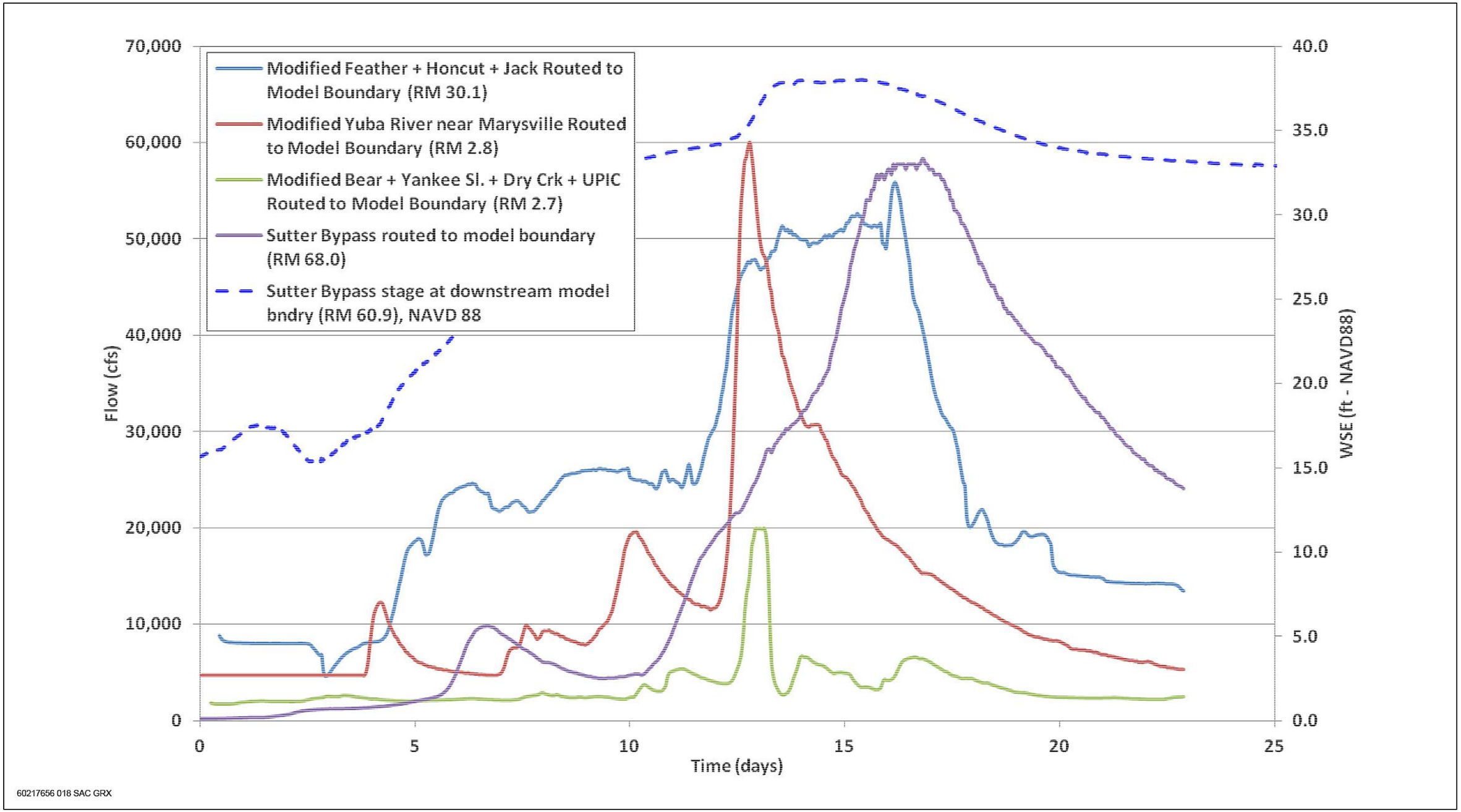
Source: cbec 2012

Exhibit 5-15 **MIKE_21C Shanghai Rapids Surface Model**



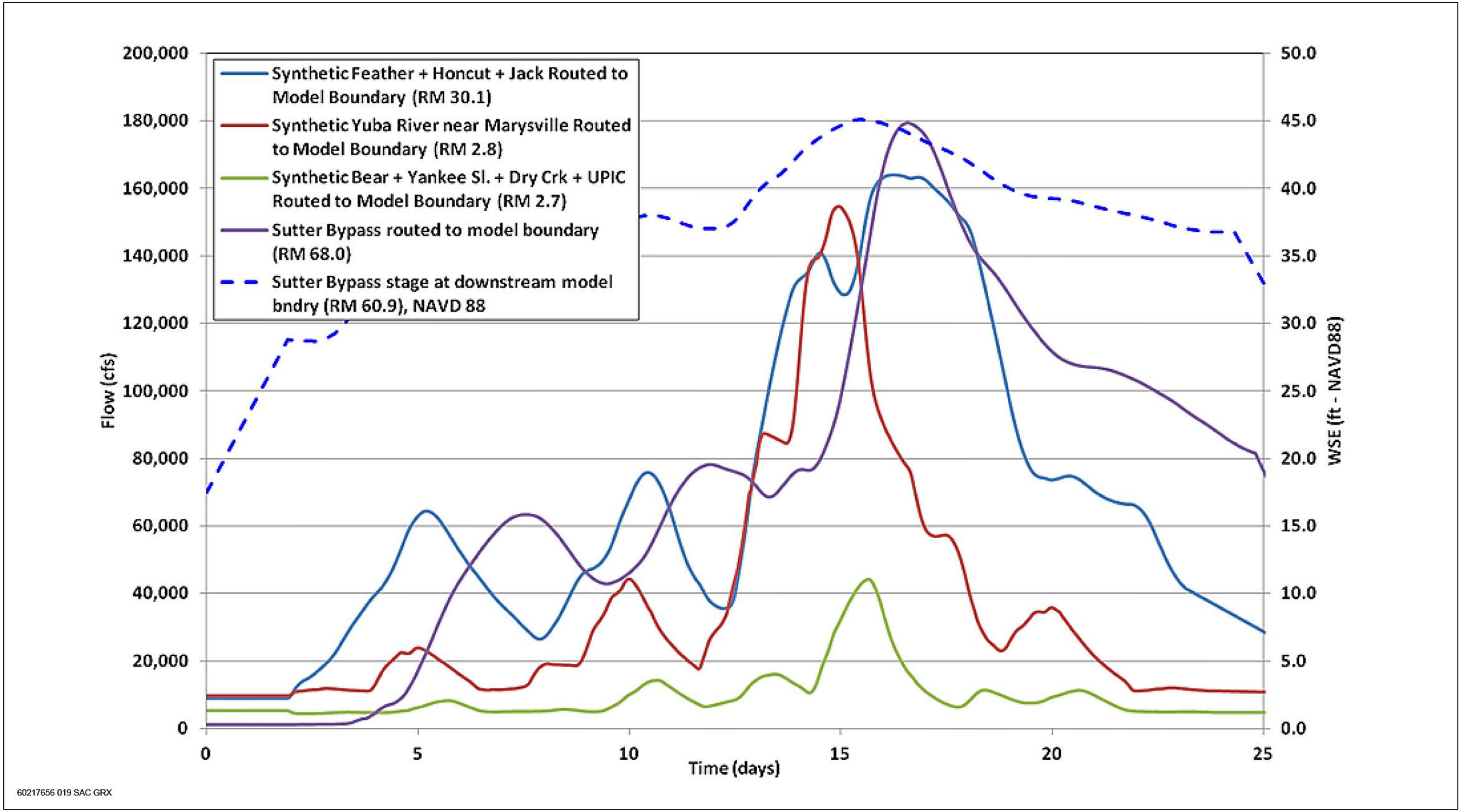
Source: cbec 2013a

Exhibit 5-16 **MIKE_21C Boundary Conditions—2-Year Flood Hydrograph**



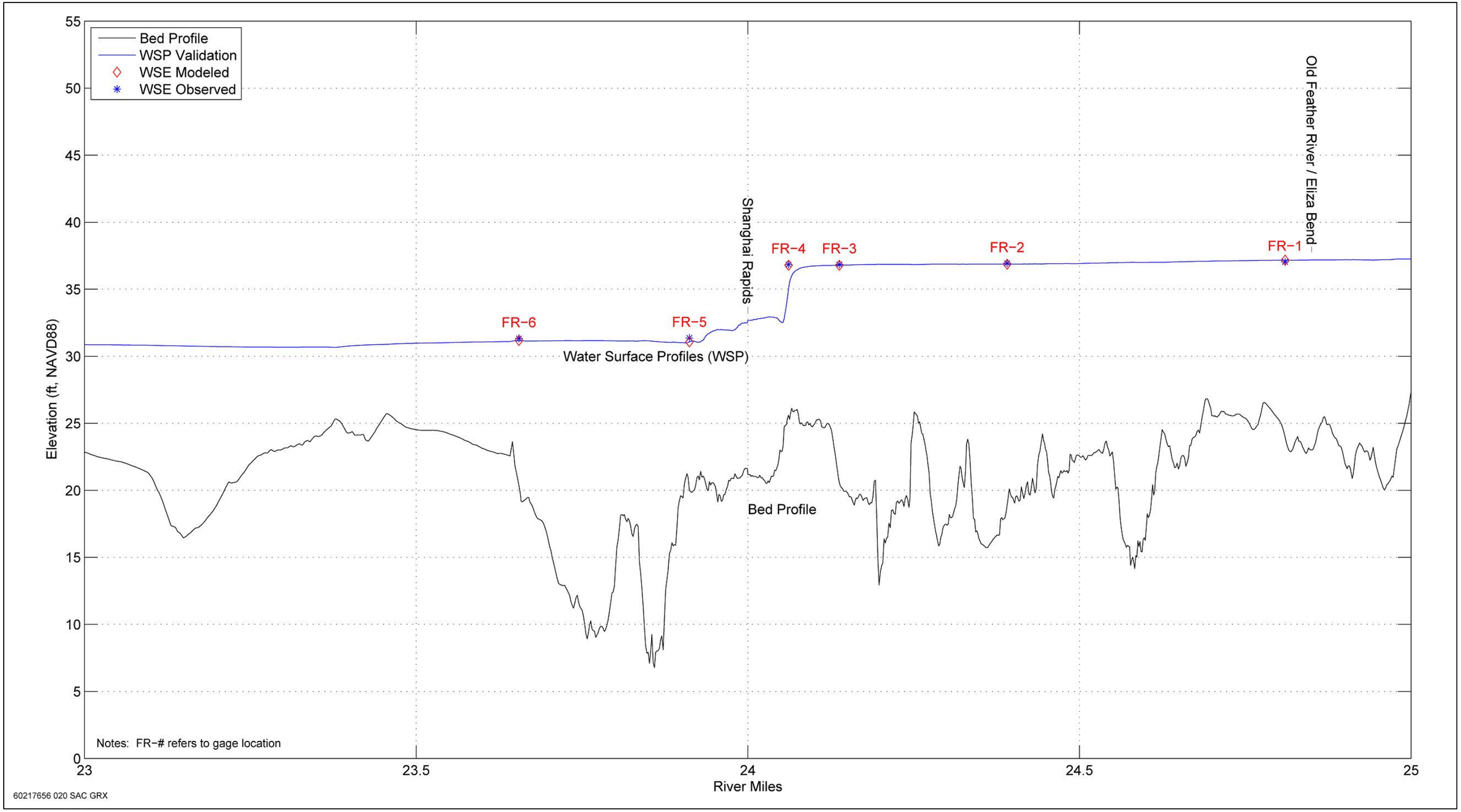
Source: cbec 2013a

Exhibit 5-17 **MIKE_21C Boundary Conditions—10-Year Flood Hydrograph**



Source: cbec 2013a

Exhibit 5-18 **MIKE_21C Boundary Conditions—100-Year Flood Hydrograph**



Source: cbec 2013a

Exhibit 5-19 **Water Surface Profiles — Low-Flow Validation at Shanghai Rapids**

Table 5-12 Baseline Roughness Values Assigned in the MIKE_21C Model				
AECOM Vegetation Community/Land Cover Type	**AECOM Code**	**CSUC Description**	**CSUC Code**	**Manning's n Roughness**
More than one type	–	Agriculture—all types	AGR	0.03
Walnut orchard	WOR	Dense orchard	AGR	0.07
Short tree orchard	STO	Sparse orchard	AGR	0.05
Annual grassland, field crops	ANG, OFA	Cultivated field crops	AGR	0.052
Gravel bar, sandbar	GBSB	Bare gravel and sand	BGS	0.035
Annual grassland	ANG	Annual grassland, nonnative	CAI	0.03
Dense or open riparian forest	DRF, ORF	Forest, nonnative; eucalyptus	IMF	0.08, 0.05
Himalayan blackberry scrub	HBS	Riparian scrub, nonnative	RIS	0.045
Dense or open riparian forest, or dense willow scrub	DRF, ORF, or DWS	Riparian woodland/forest	RWF	0.08, 0.05, 0.065
Dense willow scrub, or upland scrub	DWS, UPS	Riparian wash/scrub	RWS	0.065, 0.055
Ruderal or developed	RUD, DEV	Urban and roads	URB	0.03
Open water	OW	Standing water	WAT	0.03
Dense or open riparian forest	DRF, ORF	Broadleaf woodland; oaks	WVO	0.08, 0.05
Sources: cbec 2013a; CSUC 2011; DWR 2011; MBK 2012b				

Table 5-13 summarizes the revised proposed actions (arranged from upstream to downstream) under future conditions on the LFR, as modeled in MIKE_21C simulations, that would help achieve these ecosystem enhancement and flood management objectives. The locations of the actions listed in Table 5-13 as modeled are shown in Exhibit 5-20. These actions were developed through an iterative process, based on results of the RMA-2 hydraulic modeling conducted by MBK, results of preliminary MIKE_21C hydrodynamic modeling conducted by cbec, evaluation of the effects of the Shanghai Rapids breach, and other contributing factors described above in Section 5.3.3, "Modifications to Future Conditions After Completion of the RMA-2 Flood Model."

TOPOGRAPHIC MODIFICATIONS

The baseline topography developed by MBK (2012a) was modified by cbec (2013a) to generate future topographic conditions based on excavation and fill necessary to implement the revised management actions described in Table 5-13. These modifications are generally classified as swale excavation (e.g., Star Bend Unit), floodplain lowering or terrace excavation (e.g., Nelson Slough Unit and FRS floodplain), skim grading (e.g., locally balanced cut/fill in the upper State Cut channel), and fill/spoil ridges (e.g., the FRS floodplain). Estimated excavation and fill volumes associated with the topographic modifications are presented in Table 5-14, and the resulting future features are depicted in Exhibit 5-21.

The extensive topographic manipulations specifically associated with the FRS floodplain are shown in Exhibit 5-22, which is a conceptual design of how the setback area could be configured to enhance inundation frequency through flow, habitat complexity, and on-site reuse of excavated materials. Estimated volumes of excavated material produced by creating swales, lowering the floodplain in the FRS, and creating benches and terraces, and of the amount of material that would be used in creating spoils ridges that provide high-ground

Table 5-13 Descriptions and Locations of Proposed Actions Simulated in MIKE_21C Modeling Runs		
Action Area	**Locations of Proposed Actions**	**Proposed Actions**
A	**Upper State Cut channel** Yuba RM 1 to Feather RM 26.5	Fill depressions and skim high mounds in the State Cut channel to create a uniform gradient south of SR 20, and widen the narrow bend to 200 feet minimum width.
B	**Lower State Cut channel** RM 26.5 to RM 25.5	Remove or side-cast the high mid-channel ridge; maintain 200 feet minimum width; create a positive gradient and unobstructed flow to Eliza Bend. Plant native shade trees on new channel margins.
C	**Eliza Bend channel** RM 25.3	Remove the channel plug at the left bank of the Feather River; remove high mounds.
D	**Old Feather River channel** RM 25.3 to RM 22	Remove mounds and fill depressions in the historic channel. Connect and divert the lower end of Old River to an excavated swale at the upper end of the FRS (approximately RM 23.3). Plant native shade trees along the new channel margins and benches.
E1	**Feather River Setback diversion and floodplain swales** RM 23.3 to RM 21	Create a diversion swale from the Feather River in the left bank at RM 23.3; excavate a swale through the ridge of high ground at the northwest end of the FRS; connect the swale to the low flood basin of Upper Messick Lake. Create parallel, interconnected east-west swales traversing the floodplain, converging into low ground at the north end of the Upper Messick Lake basin. Plant an extensive mosaic of riparian forest and scrub, oak woodland, scrubland, and native perennial grassland.
E2	**Lower Feather River setback floodplain above Upper Messick Lake** RM 22 to RM 21	In the lower FRS area, north of Upper Messick Lake basin, lower the existing floodplain by several feet, tapered to existing grade, and surrounding the east-west swales. Plant dense riparian forest and willow scrub in the lowered floodplain and swales.
E3	**Feather River setback floodplain spoils ridges** RM 23 to RM 21	Use excavated material to create a pattern of spoils ridges and high ground refugia for wildlife above the 50- to 100-year floodplain. Orient ridges in linear shapes that parallel flood flow paths across the FRS. Plant upland vegetation (oak woodland, grassland, and upland scrub) on side slopes and tops of ridges.
F1	**Expanded riparian habitat surrounding Upper Messick Lake**	Expand riparian forest and willow scrub habitat to the north and west surrounding the Upper Messick Lake mitigation site. Create habitat connectivity with existing and future riparian vegetation to the north and south of this area.
F2	**Constructed Messick Lake drainage swale**	Excavate a wider drainage swale between Upper and Lower Messick Lakes to improve drainage and through-flow capacity, and increase the frequency and extent of backwater inundation.
F3	**Frequently flooded orchards at Lower Messick Lake**	Convert frequently flooded orchards on low ground (within the 2-year floodplain) to riparian forest bordering Lower Messick Lake.
F4	**Existing commercial orchards, north & south area**	Maintain existing commercial orchards (north and south areas) as agricultural conservation areas, including equipment and agricultural vehicle access routes.

Table 5-13 Descriptions and Locations of Proposed Actions Simulated in MIKE_21C Modeling Runs		
Action Area	**Locations of Proposed Actions**	**Proposed Actions**
G	**Abbott Lake Unit** RM 20.8 to RM 18.8	Remove debris, culverts, and sediment blocking drainage to the river. Install a water control structure at the outlet to the river. Plant riparian trees and shrubs using the modified CDFW/River Partners planting plan.
H	**Star Bend Unit** RM 19.5 to RM 18	Create a new swale and bench branching from the existing FRS drainage swale, into existing forested swale. Plant native shade trees along the new swale margins and bench.
I	**O'Connor Lakes Unit** RM 18.8 to RM 16	Create a notch in the high right bank. Create a 100- to 300-foot-wide swale and bench across the floodplain and through the existing DWR-managed corridor. Remove debris, mounds, and sediment blocking drainage to the river. Plant native shade trees along the new swale margins and bench.
J1, J2, J3	**Lake of the Woods Unit** RM 17 to RM 13.5	Create a terrace on the right overbank at the back side of the relict levee, RM 14.6 to RM 15 (J2). Manage the vegetation corridor upstream of the Bear River setback levee to maintain floodway capacity. Create inlet (J1) and outlet (J3) swales to reduce fish entrapment and improve through-flow and drainage to the river.
K	**Lake of the Woods corridor at Bear River setback levee** RM 13.5 to RM 12.4	Cease clearing vegetation in lower Lake of the Woods in a 3-mile-long corridor where the floodway was widened when the old levee was removed for the Bear River setback project.
L1, L2, L3	**Nelson Slough floodplain and terraces** RM 9 to RM 7.3	Excavate two wide terraces along the right bank of the river, with the lower terrace being excavated 12 feet to achieve inundation during the FAF/2-year flows and the upper terrace being excavated 5 feet. Plant a mosaic on the low terrace and existing floodplain of oak woodland (L1), native perennial grassland (L2), and riparian forest (L3).
M	**Setback corner levee at constriction,** RM 7.4 to RM 7.7	Set back the sharp corner of the eastside levee at RM 7.4 to RM 7.7 to reduce mid-channel velocities and increase river floodway capacity.
N	**Sutter Bypass hook levee** RM 7.3 to RM 7	Lower, realign, or remove a portion or all of the hook-shaped training levee on the right bank of the Feather River.
Source: cbec 2013a		

wildlife refugia are included in Table 5-14. The volumes for excavated swales, lowered floodplains, and spoils ridges are flexible and can vary depending on the desired depth and width of the swale or floodplain, and the number, height, and width of spoils ridges.

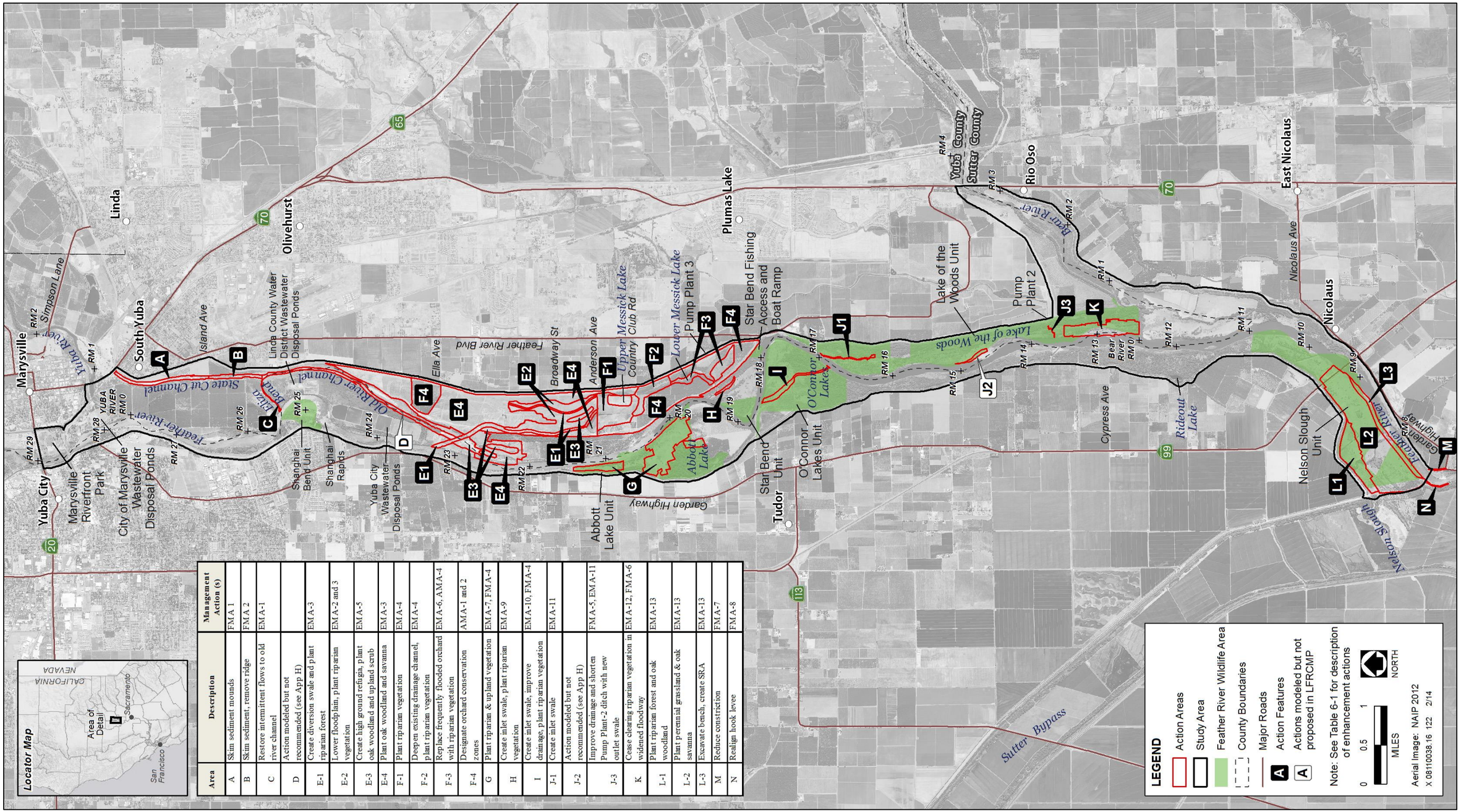
Bathymetric Changes at Shanghai Rapids

As discussed in Section 5.4.1, "Physical Setting and Geomorphic Evolution of the Lower Feather River," Shanghai Rapids was partially breached in late January 2012. To understand the role of Shanghai Rapids in

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 the Woods, RM 14.5	35,000		Widened floodway, left bank
Lake of the 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			

controlling water levels, floodplain inundation, and channel morphology, three bathymetric conditions were considered (see Exhibit 5-23):

- The post-breach condition was measured by cbec (2012) several months after the initial failure of the Modesto Formation (Exhibits 5-15 and 5-24).
- The pre-breach channel size and position of the falls were approximated by cbec based on existing bathymetry data and aerial photos.
- The hypothetical maximum-breach channel size and upstream bed condition were approximated by cbec based on limited available information and field investigation (cbec 2012) and anticipated expansion of the large chute bisecting the Modesto Formation. The low-flow width at the upstream crest of the Modesto Formation was assumed to increase from 100 feet to 250 feet and the depth was assumed to lower (incise) to 18 feet in elevation (5–6 feet deeper than the existing breach chute). Complete failure of the Modesto Formation over a width of 550 feet and depth of 20 feet was not modeled, given the likely long geomorphic time scale associated with such episodic failure.

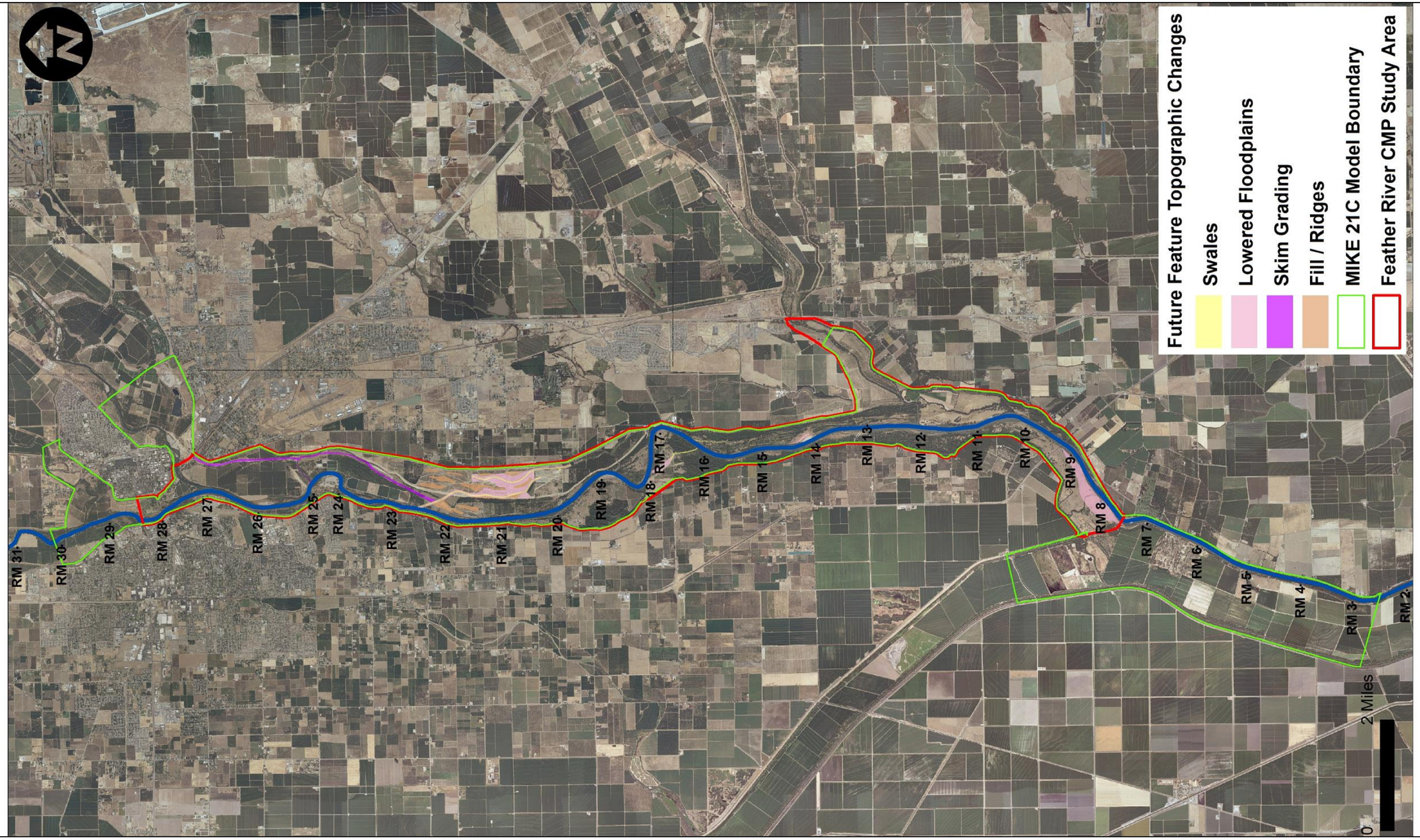


Area	Description	Management Action (s)
A	Skim sediment mounds	FM A 1
B	Skim sediment, remove ridge	FM A 2
C	Restore intermittent flows to old river channel	EM A-1
D	Action modeled but not recommended (see App H)	
E-1	Create diversion swale and plant riparian forest	EM A-3
E-2	Lower floodplain, plant riparian vegetation	EM A-2 and 3
E-3	Create high ground refugia, plant oak woodland and upland scrub	EM A-5
E-4	Plant oak woodland and savanna	EM A-3
F-1	Plant riparian vegetation	EM A-4
F-2	Deepen existing drainage channel, plant riparian vegetation	EM A-4
F-3	Replace frequently flooded orchard with riparian vegetation	EM A-6, AM A-4
F-4	Designate orchard conservation zones	AMA-1 and 2
G	Plant riparian & upland vegetation	EM A-7, FM A-4
H	Create inlet swale, plant riparian vegetation	EM A-9
I	Create inlet swale, improve drainage, plant riparian vegetation	EM A-10, FM A-4
J-1	Create inlet swale	EM A-11
J-2	Action modeled but not recommended (see App H)	
J-3	Improve drainage and shorten Pump Plant-2 ditch with new outlet swale	FM A-5, EM A-11
K	Cease clearing riparian vegetation in widened floodway	EM A-12, FM A-6
L-1	Plant riparian forest and oak woodland	EM A-13
L-2	Plant perennial grassland & oak savanna	EM A-13
L-3	Excavate bench, create SRA	EM A-13
M	Reduce constriction	FM A-7
N	Realign hook levee	FM A-8

Source: cbec 2013a

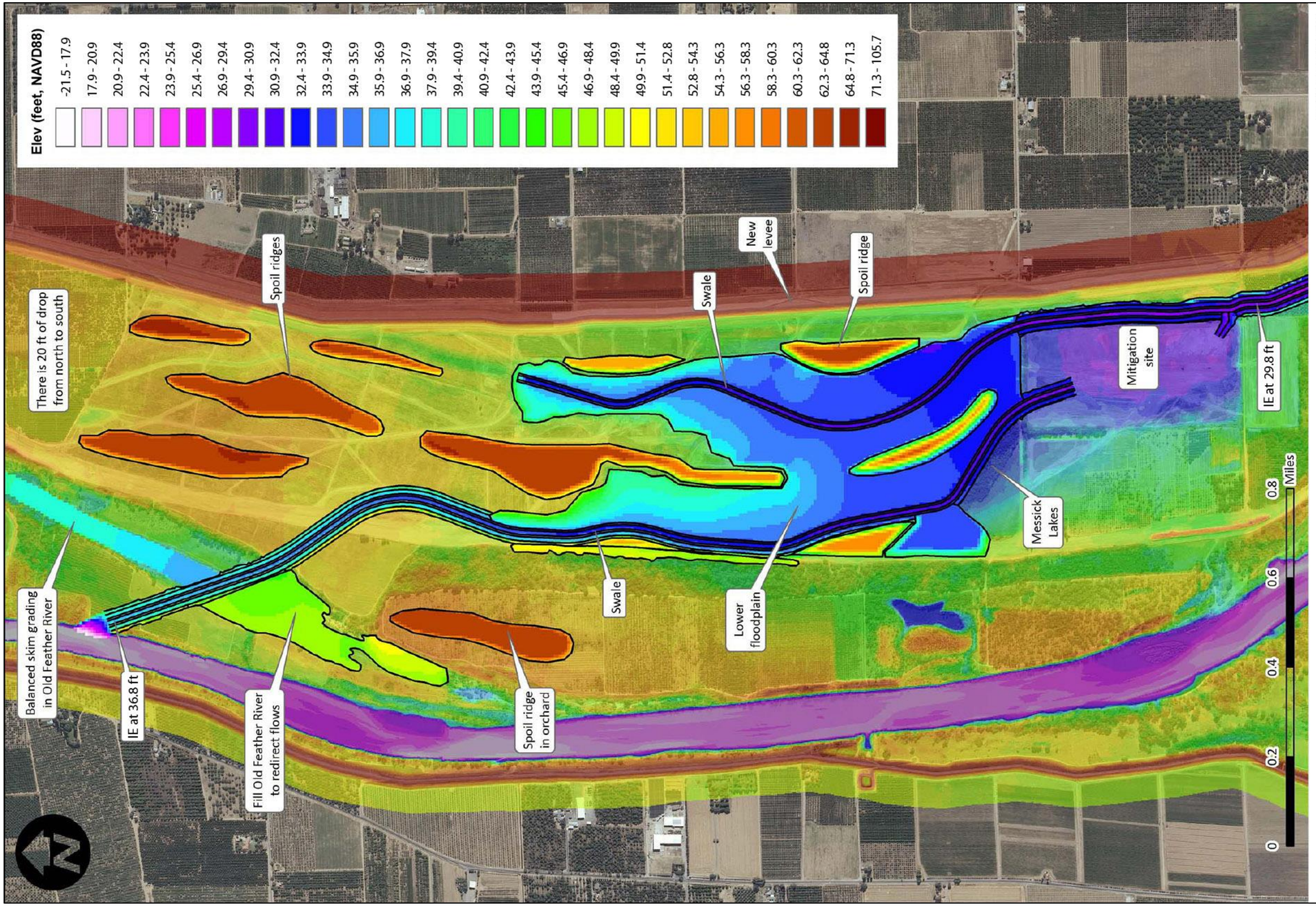
Exhibit 5-20

MIKE_21C Model — Locations of Proposed Future Features



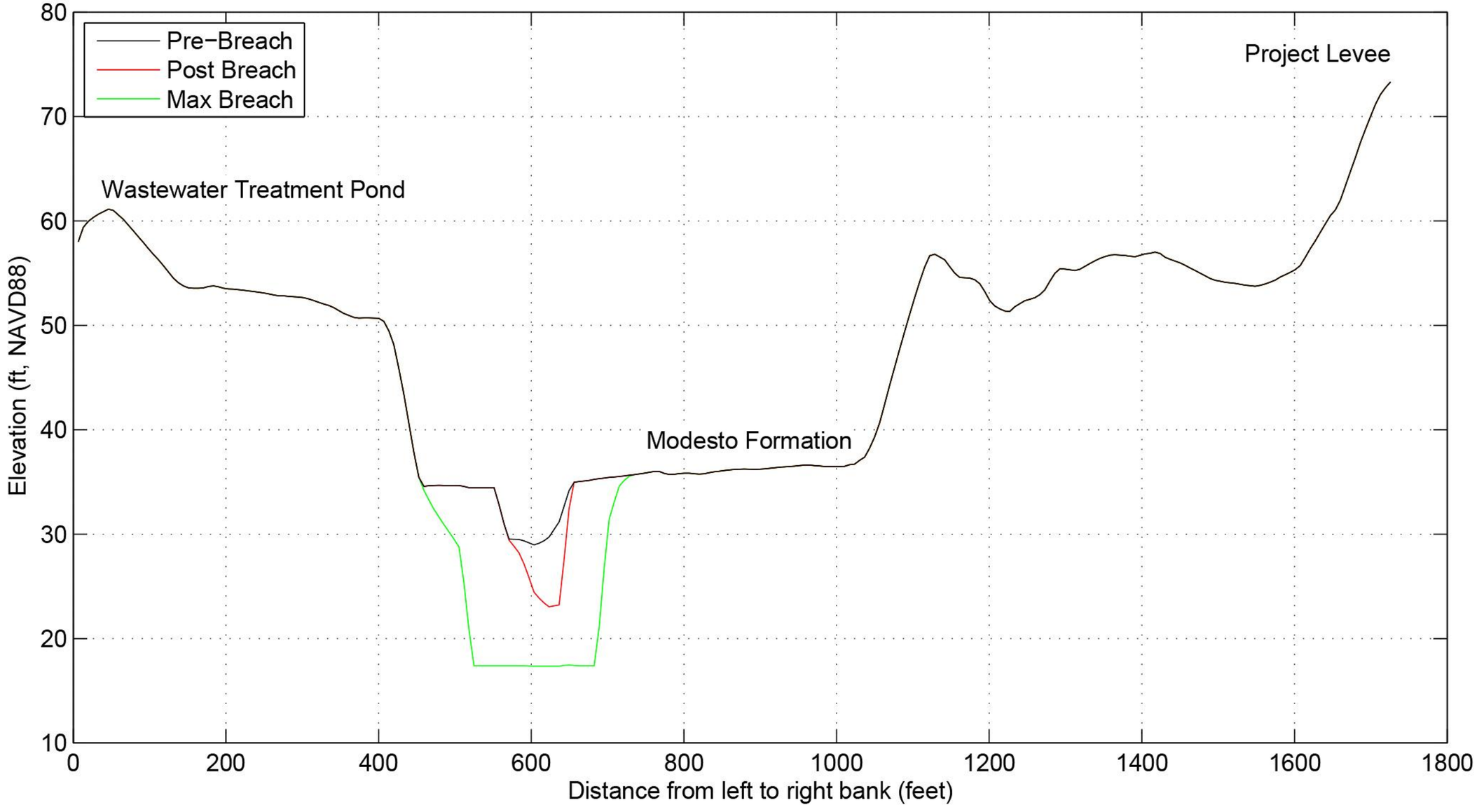
Source: cbec 2013a

Exhibit 5-21 **MIKE_21C Model — Future Features and Topographic Changes**



Source: cbec 2013a

Exhibit 5-22 **MIKE_21C Model — Feather River Setback Floodplain Topography**

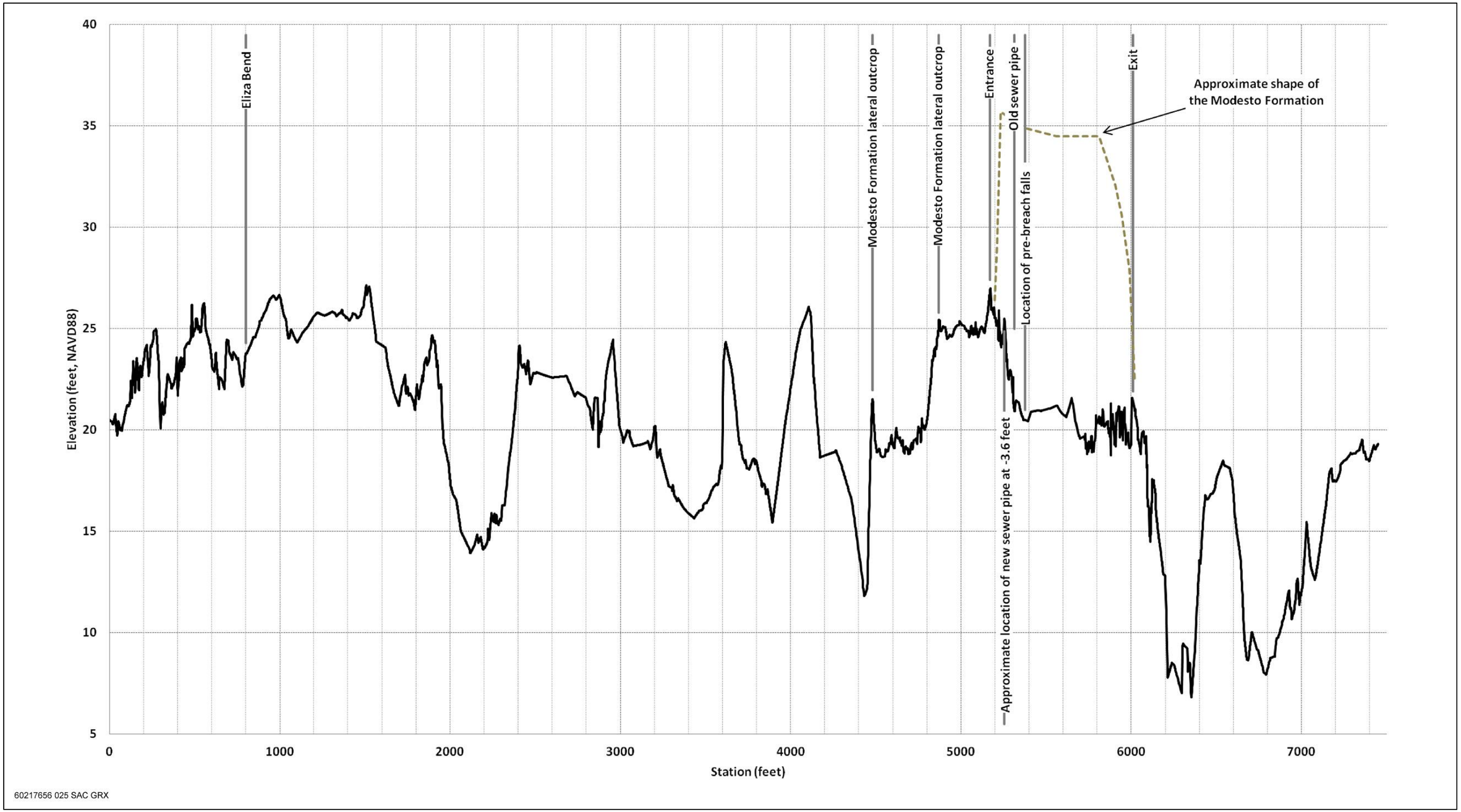


Note: shown as implemented in the MIKE 21C model; post breach condition surveyed on June 29, 2012

60217656 024 SAC GRX

Source: cbec 2013a

Exhibit 5-23 **Shanghai Rapids Breach Bathymetry Cross Sections**



Source: cbec 2012

Exhibit 5-24 **Shanghai Rapids Longitudinal Bed Profile**

FUTURE CHANGES IN VEGETATION AND HYDRAULIC ROUGHNESS

The baseline vegetation described in Chapter 3 (see Exhibit 3-4), augmented by CSUC data as described above, was modified as shown in Exhibit 5-25 to represent potential future conditions. Exhibit 5-25 shows the extent of the vegetation modifications to accommodate the future features. Table 5-15 presents the change in acreage of vegetation community and land cover types that would result from implementing the future conditions depicted in Exhibit 5-25. The calibrated baseline roughness coefficients in Table 5-12 were then cross referenced to derive the future-conditions roughness values (Manning's n value) shown in Table 5-16. The overall roughness of 0.10 under existing conditions for the FRS area (which was based on assumed restoration of riparian forest throughout the setback) was reduced under future conditions based on a more complex mosaic of low-, medium-, and high-roughness vegetation types. This change was also expected to provide a flood conveyance and stage reduction benefit.

5.4.5 RESULTS OF HYDRODYNAMIC MODELING

Geomorphic, hydraulic, and ecological evaluations of implementing the proposed management actions described in Table 5-13 were conducted using MIKE_21C. Table 5-17 provides a catalog of modeling run formulation. The model was calibrated and validated for Shanghai Rapids post-breach conditions using measured low flows and measured water surface elevations. After model calibration and validation, the proposed actions (i.e., future topographic conditions) were evaluated relative to baseline conditions for four hydrologic conditions and three geomorphic conditions describing the state of Shanghai Rapids. The FAF (approximately a 1.1 year recurrence on lower Feather River) and the 2- and 10-year flows are ecologically significant flows; of these, however, only the 2- and 10-year floods were evaluated using the coupled sediment transport model. The 100-year flood was also evaluated using the sediment transport model. To understand the importance of Shanghai Rapids in controlling water levels, floodplain inundation, and channel morphology in this reach of the Feather River, existing conditions were simulated for all three breach conditions while the proposed actions were typically simulated for pre-breach conditions.

MAXIMUM WATER SURFACE PROFILES AND MAXIMUM INUNDATION EXTENTS

Maximum Inundation Extents

Exhibit 5-26 shows the maximum WSP for the 2-year flood, and Table 5-18 summarizes the frequent-inundation characteristics for the future features. Maximum WSP for the 10- and 100-year floods are provided in Appendix H (cbec 2013a). In addition, Exhibits 5-27 through 5-29 show the maximum-inundation extents for future features for pre-breach conditions for the FAF flow and the 2-, 10-, and 100-year floods. The near-absence of floodplain inundation under FAF flow and the somewhat limited extent of the 2-year flood reflect the incised condition of the Feather River channel relative to the elevation of its historic floodplain. Table 5-19 summarizes the area inundated within the LFRCMP study area under future conditions. The observations demonstrated by these exhibits and tables are described below.

Floodplain Activation Flood Flow Inundation

Only the existing constructed Messick Lake swale and Nelson Slough lowered floodplain were inundated during the FAF flow. The water surface elevation in the Messick Lake swale was adequate to inundate Lower Messick Lake, but was insufficient to create a backwater on the FRS floodplain and in the Upper Messick Lake basin. The

water surface elevation adjacent to the Nelson Slough floodplain was just sufficient to provide shallow floodplain inundation of the lower terrace.

2-year Flood Inundation

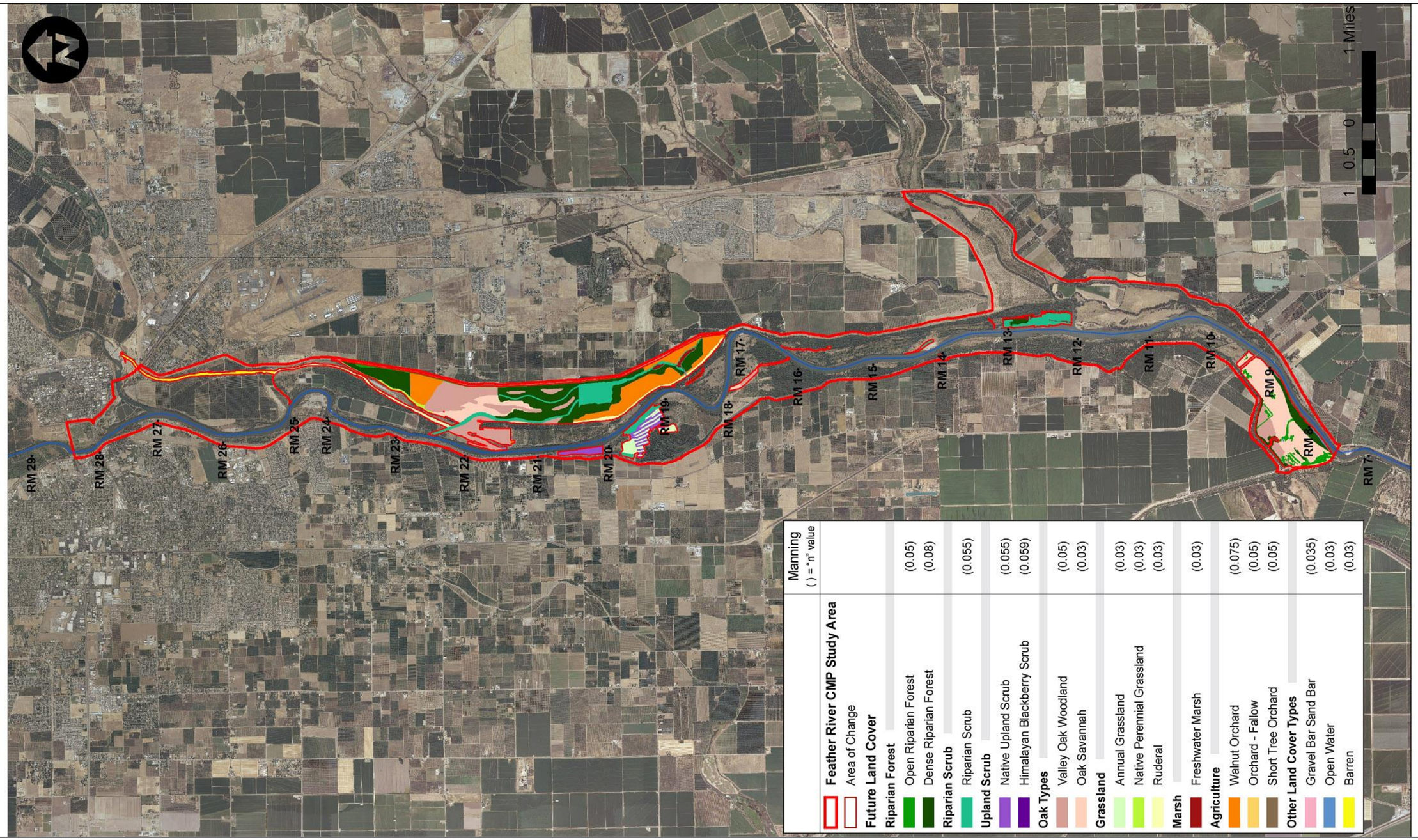
The FRS diversion swale, FRS lowered floodplain, constructed Messick Lake swale, and Nelson Slough lowered floodplain (lower terrace only) were inundated during the 2-year flood. The FRS lowered floodplain was inundated primarily via backwater conditions from the constructed Messick Lake swale. The extent of the 2-year flood was limited to inundation of the FRS excavated swales and the Upper Messick Lake basin. However, upstream inflow from the river also occurred at RM 23.3, and the FRS diversion swale was activated briefly. The lower terrace of the Nelson Slough lowered floodplain was inundated up to a depth of 5 feet. As shown by Table 5-18, the Eliza Bend channel (inlet to the Old Feather River) was within 1.3 feet of being inundated, the O'Connor Lakes swale was within 2.4 feet of being inundated, the Lake of the Woods swale was within 1.2 feet of being inundated, and the upper terrace of the Nelson Slough lowered floodplain was within 1.1 feet of being inundated under the 2-year flood hydrograph. The existing swale in the Bear River setback area and a secondary cutoff channel on Shanghai Bend were also inundated.

10-year Flood Inundation

All future features were inundated during the 10-year flood. The Yuba River spilled over the left-bank berm into the State Cut channel for 5 days with a maximum flow depth of 1.3 feet, then merged downstream into the Old Feather River. The Feather River created a backwater into Eliza Bend for 4 days and flowed east through the Eliza Bend inlet channel to the Old Feather River for 8 days. The Feather River also overtopped its left bank just upstream of the Modesto Formation and commingled with Yuba River flows in the Old Feather River. Feather River flow also spilled into the FRS diversion swale. The water on the Feather River floodplain largely flowed south as a result of inflows from the Old Feather River and the FRS diversion swale.

100-year Flood Inundation

Most of the LFRCMP area between the levees was inundated during the 100-year flood, with the exception of the tops of the spoil ridge features within the FRS floodplain.



Source: cbec 2013a

Exhibit 5-25 **MIKE_21C Model — Future-Condition Vegetation**

Table 5-15 Net Change in Vegetation Communities and Land Cover Types within the Feather River Setback Area and Other Areas of Proposed Vegetation Change				
Vegetation Community/ Land Cover Type	**Baseline (acres)**	**Future (acres)**	**Net Change (acres)**	**Notes**
Dense riparian forest	121.1	595.4	474.3	492% increase
Open riparian forest	128.9	108.4	-20.6	New open riparian forest not included in future vegetation restoration sites
Valley oak woodland	0.0	317.1	317.1	Net increase; not included in baseline vegetation mapping because oaks were not distinguishable from other trees on aerial photos
Oak savanna/perennial grassland	0.0	512.4	512.4	Net increase; scattered oaks throughout predominantly grassland cover
Riparian scrub	43.3	307.2	263.9	712% increase
Himalayan blackberry scrub	6.4	0.0	-6.4	
Native upland scrub	85.6	222.1	136.5	260% increase
Annual grassland	787.1	146.9	-640.2	535% decrease
Perennial grassland	14.9	26.2	11.3	Dominated by native grass species
Ruderal	892.6	59.8	-832.8	1,488% decrease; weedy herbaceous
Freshwater marsh	15.0	29.6	14.6	
Seasonal wetland	91.9	0.0	-91.9	Not an actual loss of wetland habitat; the basin at Upper Messick Lake was flooded when the baseline vegetation mapping was conducted and categorized as wetland; it is and will remain willow scrub
Walnut orchard	377.5	316.8	-60.7	Frequently flooded orchards at Lower Messick Lake to be converted to riparian forest/willow scrub
Short tree orchard	30.7	21.0	-9.7	Orchard was removed after baseline vegetation mapping was completed
Orchard—fallow	90.4	1.6	-88.9	Fallow and abandoned orchard sites converted to native vegetation types
Lakes/ponds	6.8	6.8	0.0	
Rivers	9.2	16.3	7.1	
Gravel bar/sandbar	0.3	0.0	-0.3	Only includes bars exposed above water surface
Barren	0.0	14.5	14.5	Recently graded or other disturbed areas
Total	**2,702**	**2,702**	**0**	
Source: Data compiled by AECOM in 2013				

Table 5-16
Future Conditions Roughness Values Assigned in the MIKE_21C Model

Description	Manning's n Roughness
Channel widening at RM 7.5 to RM 8.0, right bank	0.020
Grassland	0.030
Open water/floating aquatic	0.030
Open riparian forest, valley oak woodland	0.050
Upland scrub, open willow scrub, elderberry scrub, blackberry bramble	0.055
Dense willow scrub	0.065
Walnut orchard (mature)	0.075
Dense riparian forest	0.080
Wind-wave buffer along Feather River setback levee	0.100

Notes: RM = River Mile
Source: cbec 2013a

Table 5-17
MIKE_21C Modeling Run Catalog

Hydrology	Topography and Bathymetry	Shanghai Rapids Breach Condition	Hydrodynamics Simulations	Plus 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

Source: cbec 2013a

Table 5-18
Summary of Inundation and Water Surface Elevation on the Lower Feather River

Location	Topography	Hydrology	Max WSE (ft)	Sill Elev (ft)*	Inundated?
Eliza Bend Inlet	Pre-breach	Revised FAF	37.7	43.1	N
	Post-breach		37.1	43.1	N
	Pre-breach	Modified 2-year	41.8	43.1	N
	Post-breach		41.6	43.1	N
FRS Diversion Swale Inlet	Pre-breach	Revised FAF	31.6	36.8	N
	Post-breach		31.6	36.8	N
	Pre-breach	Modified 2-year	38.0	36.8	Y
	Post-breach		38.0	36.8	Y
Existing Lower Messick Lake Drain	Pre-breach	Revised FAF	30.0	22.0	Y
	Post-breach		30.0	22.0	Y
	Pre-breach	Modified 2-year	35.9	22.0	Y
	Post-breach		35.9	22.0	Y
Star Bend Swale	Pre-breach	Revised FAF	28.5	35.1	N
	Post-breach		28.5	35.1	N
	Pre-breach	Modified 2-year	33.7	35.1	N
	Post-breach		33.7	35.1	N
O'Connor Lakes Swale	Pre-breach	Revised FAF	29.4	37.5	N
	Post-breach		29.4	37.5	N
	Pre-breach	Modified 2-year	35.1	37.5	N
	Post-breach		35.1	37.5	N
Lake of the Woods Swale	Pre-breach	Revised FAF	28.6	35.1	N
	Post-breach		28.6	35.1	N
	Pre-breach	Modified 2-year	33.9	35.1	N
	Post-breach		33.9	35.1	N
Nelson Slough Lowered Floodplain (lower/upper terrace)	Pre-breach	Revised FAF	23.8	23.5/30	Y/N
	Post-breach		23.8	23.5/30	Y/N
	Pre-breach	Modified 2-year	28.9	23.5/30	Y/N
	Post-breach		28.9	23.5/30	Y/N

Notes: All elevations based on NAVD 1988 datum
Source: cbec 2013a

Table 5-19
Areas of Floodplain Inundation in the LFRCMP Study Area under Different Shanghai Rapids Breach Scenarios

Hydrology	Topography	Shanghai Rapids Breach Scenario	Inundated Floodplain Acres[2]	Change (acres)
Revised FAF	Existing	Pre	1,422	–
		Post	1,421	-2
		Max	1,412	-10
	Future	Pre	1,425	73[1]
Modified 2-year	Existing	Pre	1,766	–
		Post	1,765	-1

Table 5-19 Areas of Floodplain Inundation in the LFRCMP Study Area under Different Shanghai Rapids Breach Scenarios				
Hydrology	**Topography**	**Shanghai Rapids Breach Scenario**	**Inundated Floodplain Acres[2]**	**Change (acres)**
	Future	Max	1,729	-37
		Pre	1,926	161
		Post	1,928	163
Modified 10-year	Existing	Pre	7,632	–
		Post	7,364	-268
		Max	7,324	-308
	Future	Pre	7,341	-291
Synthetic 100-year	Existing	Pre	11,193	–
		Post	11,196	3
		Max	11,196	3
	Future	Pre	11,132	-61

Notes:

[1] The value of 73 acres was calculated in a geographic information system (i.e., GIS) because the water surface elevation exceeded the lower terrace elevation of 23.5 feet;(NAVD88); however, the model's flooding depth function of 0.7 foot (indicated as a wet cell in the model) prevented the area from being shown as inundated. In addition, decreasing the amount of excavation at Nelson's Slough to a 50-foot-wide lower terrace, the 73 acres would be reduced to 15 acres.

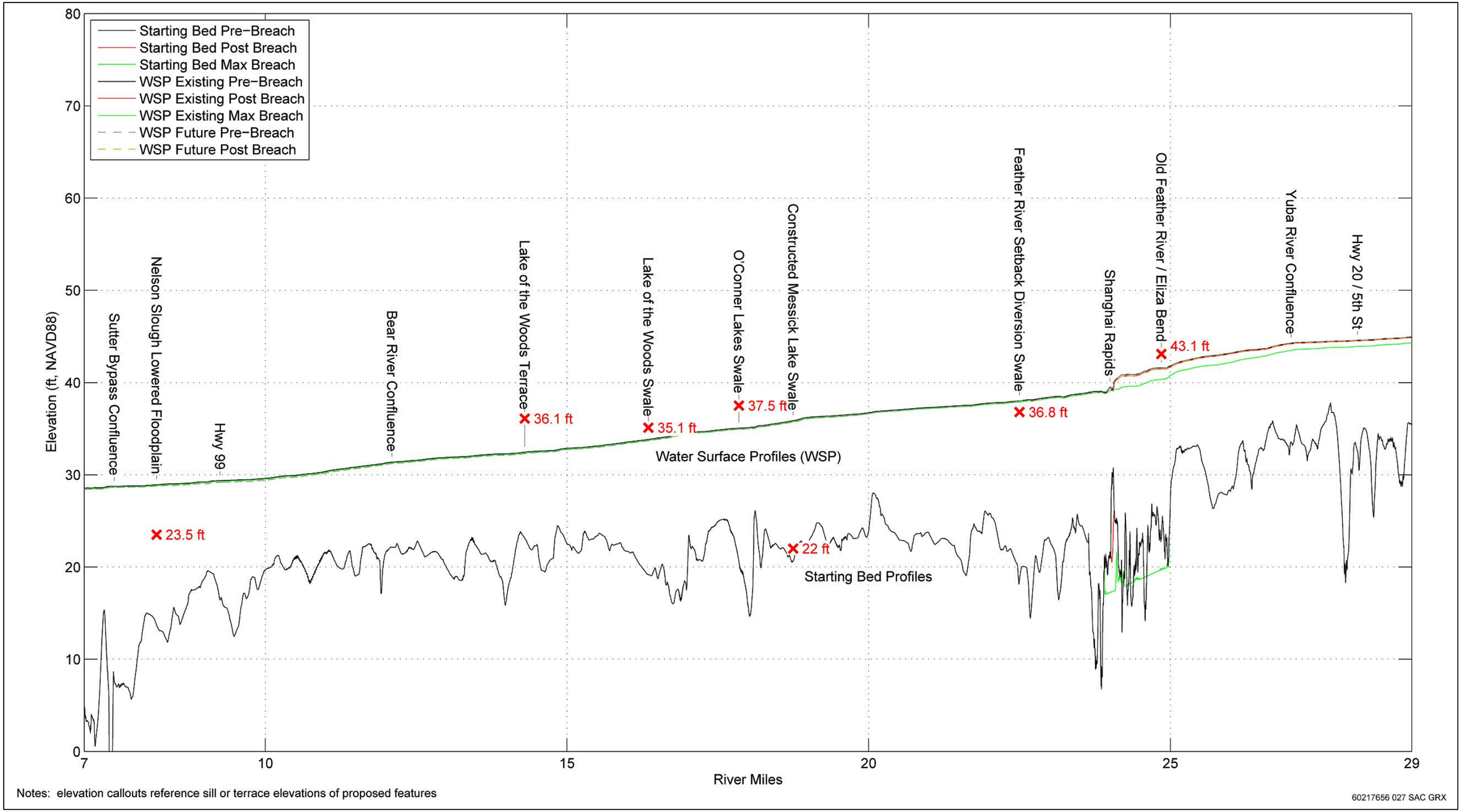
[2] The total acreage of the LFRCMP study area is 11,751 acres.

Source: cbec 2013a

Maximum Water Surface Profiles

Compared to existing conditions before the breach, the future-features WSPs were generally lower than the WSPs for existing conditions. The FAF WSP was nearly identical to the existing-conditions WSP, given the limited amount of inundation with future features. The 2-, 10-, and 100-year WSPs averaged 0.1 foot, 0.3 foot, and 0.3 foot lower, respectively, than WSPs under existing conditions; this was also the decrease in water surface elevation experienced at the State Route (SR) 20 Bridge. The largest water surface elevation decreases for the 2-, 10-, and 100-year WSPs were up to 0.5 foot, 0.6 foot, and 0.8 foot lower, respectively. These water surface elevation decreases occurred opposite the FRS lowered floodplain and Nelson Slough lowered floodplain because of an overall decrease in floodplain roughness and an increase in conveyance capacity, respectively.

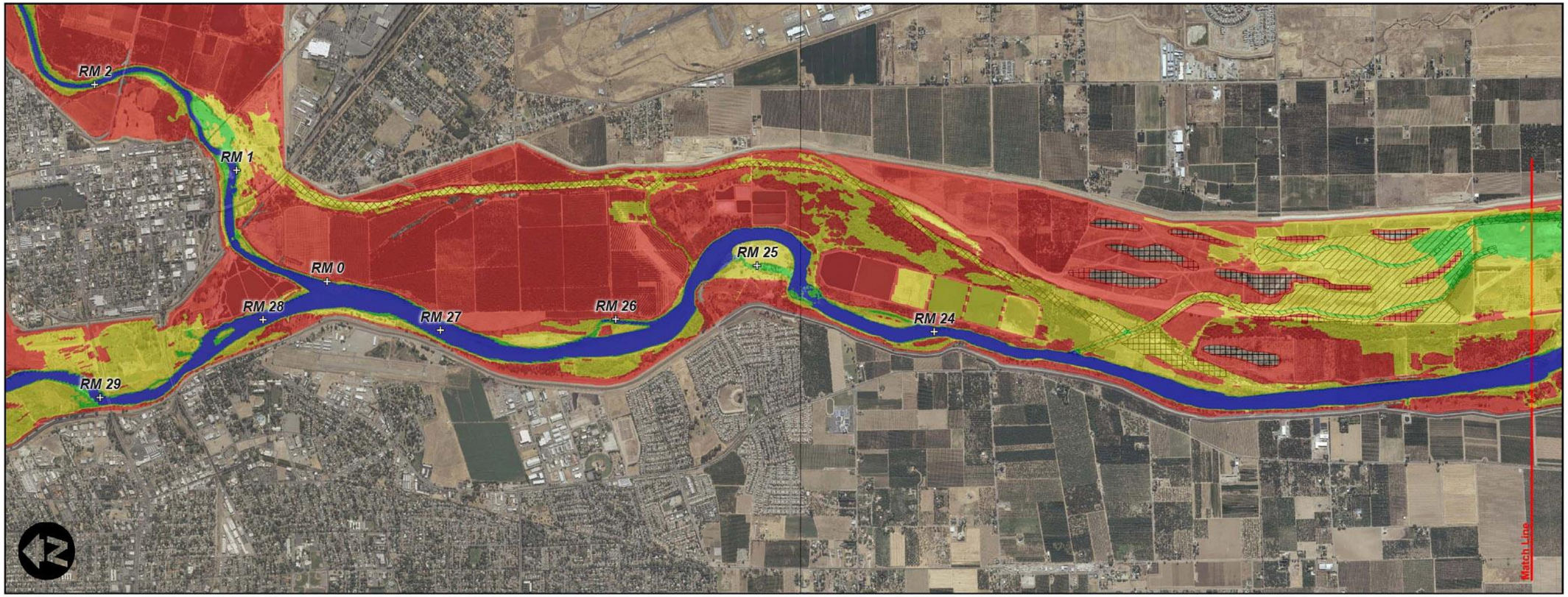
The changes in maximum water surface elevation for the 100-year WSP in the MIKE_21C modeling results are consistent with the RMA-2 flood modeling results (MBK 2012b). This is largely because of the reduction in composite roughness from the conservatively high design value of 0.10, as approved by the Central Valley Flood Protection Board for the original FRS project (TRLIA 2011). Both models indicate that there would be no adverse impacts on flood conveyance under the proposed LFRCMP future conditions.



Notes: elevation callouts reference sill or terrace elevations of proposed features

Source: cbec 2013a

Exhibit 5-26 **Water Surface Profiles — 2-Year Flood**



60217656 028 SAC GRX

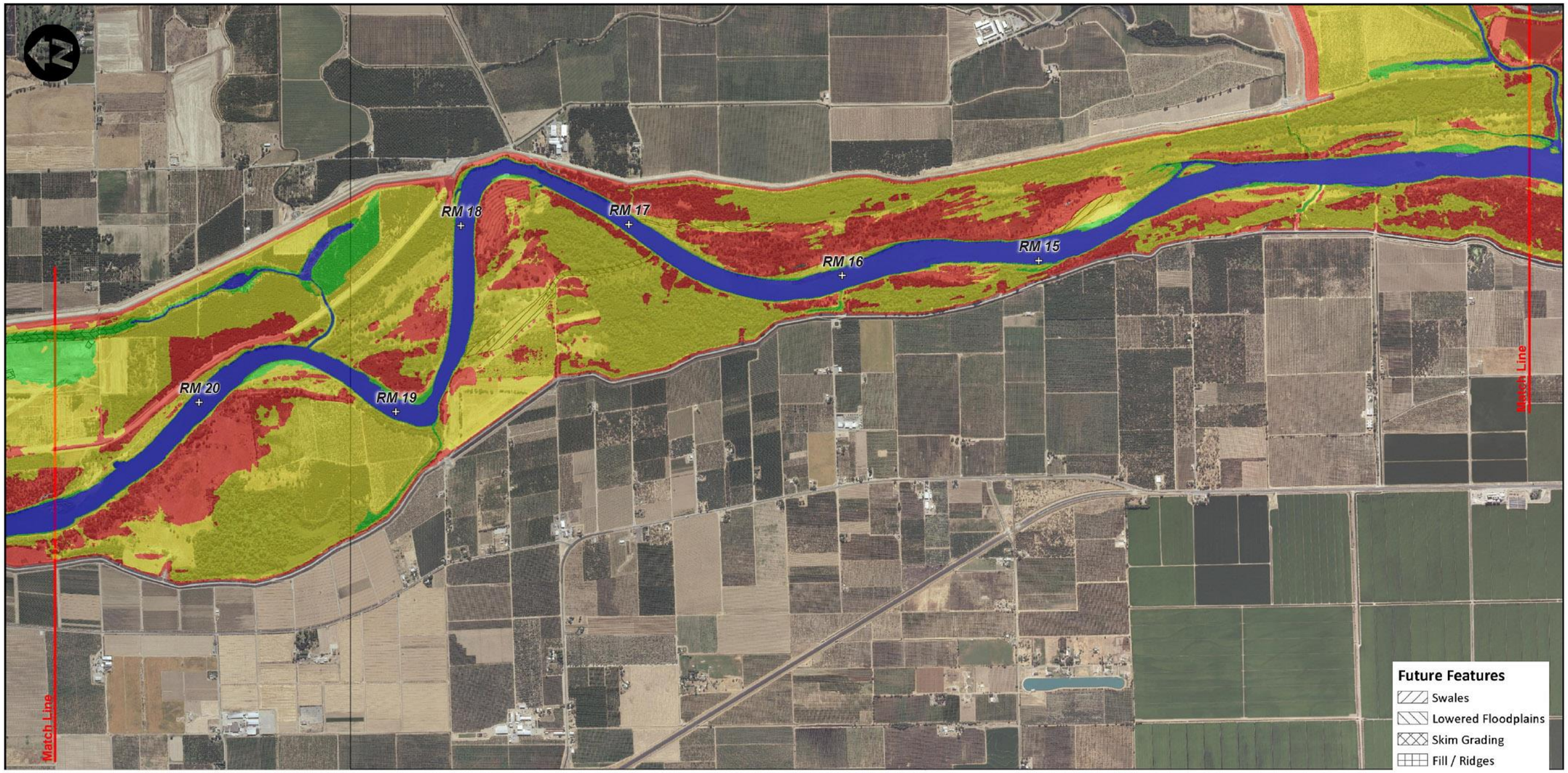
Notes: Graphic depicts the maximum inundation extents associated with a given n-year flood event.
Source: MIKE 21C model output.
Scale: 1 in = 3000 ft

Future Features
- Swales
- Lowered Floodplains
- Skim Grading
- Fill / Ridges

Inundation
- FAF
- Q2
- Q10
- Q100

Source: cbec 2013a

Exhibit 5-27 **Future Inundation Extents — North Study Area**



60217656 029 SAC GRX

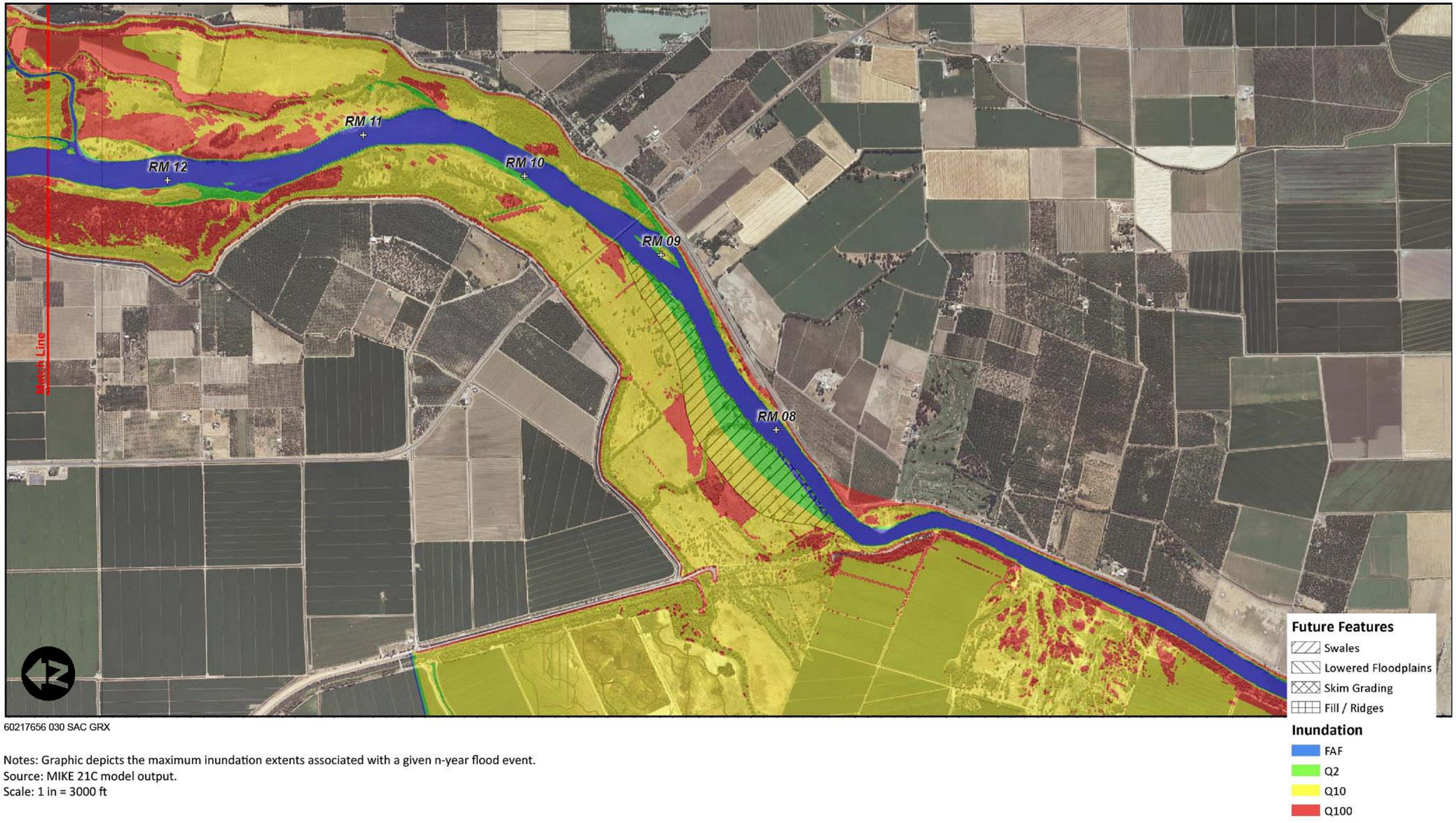
Notes: Graphic depicts the maximum inundation extents associated with a given n-year flood event.
Source: MIKE 21C model output.
Scale: 1 in = 3000 ft

Future Features
- Swales
- Lowered Floodplains
- Skim Grading
- Fill / Ridges

Inundation
- FAF
- Q2
- Q10
- Q100

Source: cbec 2013a

Exhibit 5-28 **Future Inundation Extents — Central Study Area**



60217656 030 SAC GRX

Notes: Graphic depicts the maximum inundation extents associated with a given n-year flood event.
Source: MIKE 21C model output.
Scale: 1 in = 3000 ft

Source: cbec 2013a

Exhibit 5-29 **Future Inundation Extents — South Study Area**

The maximum WSP did not change downstream of Shanghai Rapids from pre-breach to post-breach (existing) conditions, nor did the maximum hypothetical breach affect the downstream maximum WSP. The effects of post-breach conditions and the hypothetical maximum breach on water surface elevation compared to pre-breach conditions are as follows:

- Post-breach (Existing) versus Pre-breach Conditions:
  - At Shanghai Rapids, the maximum decreases in water surface elevation were 0.6 foot, 0.2 foot, 0.1 foot, and 0.0 foot for the FAF, 2-year, 10-year, and 100-year WSPs, respectively.
  - At SR 20 (RM 29), the maximum decreases in water surface elevation were 0.1 foot, 0.1 foot, 0.0 foot, and 0.0 foot for the FAF, 2-year, 10-year, and 100-year WSPs, respectively.
- Hypothetical Maximum Breach versus Pre-breach Conditions:
  - At Shanghai Rapids, the maximum decreases in water surface elevation were 4.8 foot, 1.4 foot, 0.3 foot, and 0.0 foot immediately upstream of the Modesto Formation for the FAF, 2-year, 10-year, and 100-year WSPs, respectively.
  - At SR 20, the maximum decreases in water surface elevation were 0.3 foot, 0.7 foot, 0.2 foot, and 0.0 foot for the FAF, 2-year, 10-year, and 100-year WSPs, respectively.

EXTENT OF INUNDATED AREAS UNDER FUTURE CONDITIONS

Effects of Future Conditions on Inundation

Development of a lower terrace floodplain at Nelson's Slough created a net gain of 73 acres of frequent inundation under FAF flows (cbec 2013a). A net gain of 162 acres of inundation occurred under 2-year flows as a consequence of the frequent inundation of the lower terrace floodplain at Nelson's Slough and backwater inundation of the FRS floodplain swales and Upper Messick Lake basin (cbec 2013a).

The modeling showed a net loss of 291 acres of inundation under the 10-year flow, but this apparent loss is largely an artifact of the very conservative assumption that was made for baseline roughness conditions for the original approved design of the FRS project (TRLIA 2011). This approved design incorporated a Manning's n value of 0.10, reflecting the conservative assumption that dense, mature riparian vegetation would be uniformly established throughout the 1,600-acre FRS area. In the LFRCMP's future-conditions scenario, overall composite hydraulic roughness was reduced, and therefore water surface elevation was lowered, by developing a mosaic of different vegetation types having Manning's n values ranging from 0.03 to 0.08. The corresponding reduction in water surface elevation was accompanied by a reduction in inundated area.

For the 100-year flood, the modeling showed a net loss of 61 acres of inundation (cbec 2013a). This decrease was largely associated with protrusion through the water surface of the tops of upland spoils ridges in the FRS floodplain.

Effects of Shanghai Rapids Breach Scenarios on the Extent of Inundated Area

The following inundation effects were shown in the modeling of the Shanghai Rapids breach scenarios:

- In general, the modeling likely understated the loss of inundated areas and floodplain that would be caused by continued expansion and deepening of the Shanghai Rapids breach under the FAF and the 2- and 10-year flows. The modeling did not include simulations of long-term channel morphology and did not assume complete failure of the Modesto Formation.

- A net loss of approximately 10 acres of floodplain under the FAF scenario was associated mostly with the loss of edge habitat upstream of Shanghai Rapids to the Yuba River confluence. Most of the loss occurred between Shanghai Rapids and Eliza Bend because of the large drop in the WSP.

- A net loss of approximately 40 acres (2.1%) of floodplain habitat under the 2-year flow scenario was associated mostly with the loss of edge habitat upstream of Shanghai Rapids, given that a local drop in water surface elevation of 1 foot at the rapids propagated upstream and resulted in a drop in water surface elevation of 0.7 foot at the SR 20 Bridge (and the boundary of upstream modeling). This would suggest that the loss of floodplain habitat was even greater along the Feather River upstream of SR 20.

- A net loss of approximately 300 acres (4.0%) of floodplain habitat under the 10-year flow scenario was associated mostly with a change in floodplain inundation as a result of a 0.3-foot decline in the maximum water surface elevation upstream of Shanghai Rapids as well as the Yuba River. That decline resulted in a decrease in overbank contributions from the State Cut channel, Eliza Bend, and the left bank just upstream of the Modesto Formation, which ultimately combines in the Old Feather River before flowing into the FRS area.

- Minor losses of floodplain inundation under the 100-year flow scenario were caused by very small reductions in water surface elevations along the levees.

BED LEVEL AND FLOODPLAIN ELEVATION CHANGES

Appendix H includes a series of exhibits (Figures 28–33) that depict, in profile, final bed level elevations and bed level changes under existing and future conditions for the 2-year, 10-year, and 100-year events. The following conclusions can be drawn from a review of these figures:

- The 2-year flood bed level with future features was very similar to the existing bed level, with no significant changes upstream and downstream of Shanghai Rapids. This lack of significant changes reflected that future-features inundation was limited during the 2-year flood.

- The 2-year flood bed level under the maximum-breach condition at Shanghai Rapids showed the channel bed immediately upstream of Eliza Bend degrading or lowering up to 2 feet in response to the enlarged and deepened breach. Little to no additional bed change occurred at the SR 20 Bridge relative to pre-breach conditions.

- The 10-year flood bed level under future conditions was very similar to the existing bed level. The only notable difference occurred near the FRS diversion swale and at Nelson Slough. Localized deposition

occurred at each feature and was followed by localized scour immediately downstream. On the whole, no significant reach-wide changes occurred between existing and future features; both conditions showed 0.3 foot of channel incision (averaged over the reach) between Shanghai Rapids and the Bear River. Also, no significant volume of sediment trapping occurred during the 10-year flood on either terrace of the Nelson Slough lowered floodplain.

- The 100-year bed level with future features was very similar to the existing bed level, generally mirroring areas of deposition and erosion. As under the 10-year scenario, the most notable areas of localized deposition occurred in a small area at the inlet to the FRS diversion swale. Deposition at Nelson Slough was especially noteworthy, as in-channel deposition there was accompanied by deposition on the lower and upper terraces up to 5 feet in places. Reach-average bed conditions were generally erosional by 0.8 foot under the 100-year flood with existing conditions. By comparison, the following relative reach-average conditions were observed for future features:
  - Upstream of Shanghai Rapids, the bed was erosional by an additional 0.2 foot (or 1.0 foot in total).
  - Between Shanghai Rapids and the Bear River, the bed was less erosional by 0.1 foot (or depositional relative to existing conditions).
  - Downstream of the Bear River, the bed was less erosional by 0.6 foot (or depositional relative to existing conditions) because of the increased flow conveyance area and slower velocities attributed to the terraces on the Nelson Slough lowered floodplain.

As shown in Exhibits 5-30 through 5-32, the following conclusions can be made about geomorphic responses to future conditions:

- Depositional and erosional processes in the State Cut channel and Old Feather River are dynamic (Exhibit 5-30). During large floods, the upper end of the State Cut channel tends to be erosional where the channel coincides with the toe of the levee; this is a concern because this section of the levee has been hardened recently. Also, two large existing scour pools proposed to be skim-graded in Old Feather River to minimize fish stranding would appear to re-erode. Therefore, proposed skim-grading activities in this portion of Old Feather River to smooth out the topographic highs and lows may be warranted as an initial proposed action, but not as a long-term maintenance activity after large floods.

- Exhibits 5-30 and 5-31 show that the inlets to Eliza Bend, the FRS diversion swale, and the constructed Messick Lake swale may be prone to aggrading with sediment on the receding limb of the 10- and 100-year floods, but may be less so during the 10-year flood. Potential deposition up to 8 feet at the inlet to Eliza Bend occurred where removal of the existing sediment plug was proposed. Potential deposition in the FRS diversion swale occurred near the confluence of the swale with the Old Feather River, and would depend largely on the timing of flows coming down State Cut. Deposition in the constructed Messick Lake swale could be confirmed with future surveys, which could help verify model findings and inform the design of the FRS diversion swale; however, the constructed Messick Lake swale, which has a bed elevation similar to the elevation of the river bed, is deeper than the proposed swales, which would be perched above the river at base flow.

The modeling shows that Shanghai Bend is very dynamic during the 100-year flood (Exhibit 5-30). This finding was expected, considering that the primary flow direction through Shanghai Bend was north to south. As a result, the point bar upstream of the rapids was eroded, and material was deposited immediately downstream of the Modesto Formation in the historically dredged section of the river. Significant deposition occurred in the present-day river channel immediately upstream of the Modesto Formation. Although this outcome could be very real immediately after a major flood event, the flow and sediment dynamics were likely not fully captured in the model because of the overall complexity of the flow structure at Shanghai Bend and limitations in the sediment-transport assumptions. Because simulations of long-term morphology were not performed, Exhibit 5-30 does not show the expected longer-term outcome where the sandbar could potentially rebuild, and the channel deposits may re-erode under more frequent flows. However, significant knickpoint migration could occur through Shanghai Bend from the active widening and deepening breach at Shanghai Rapids.

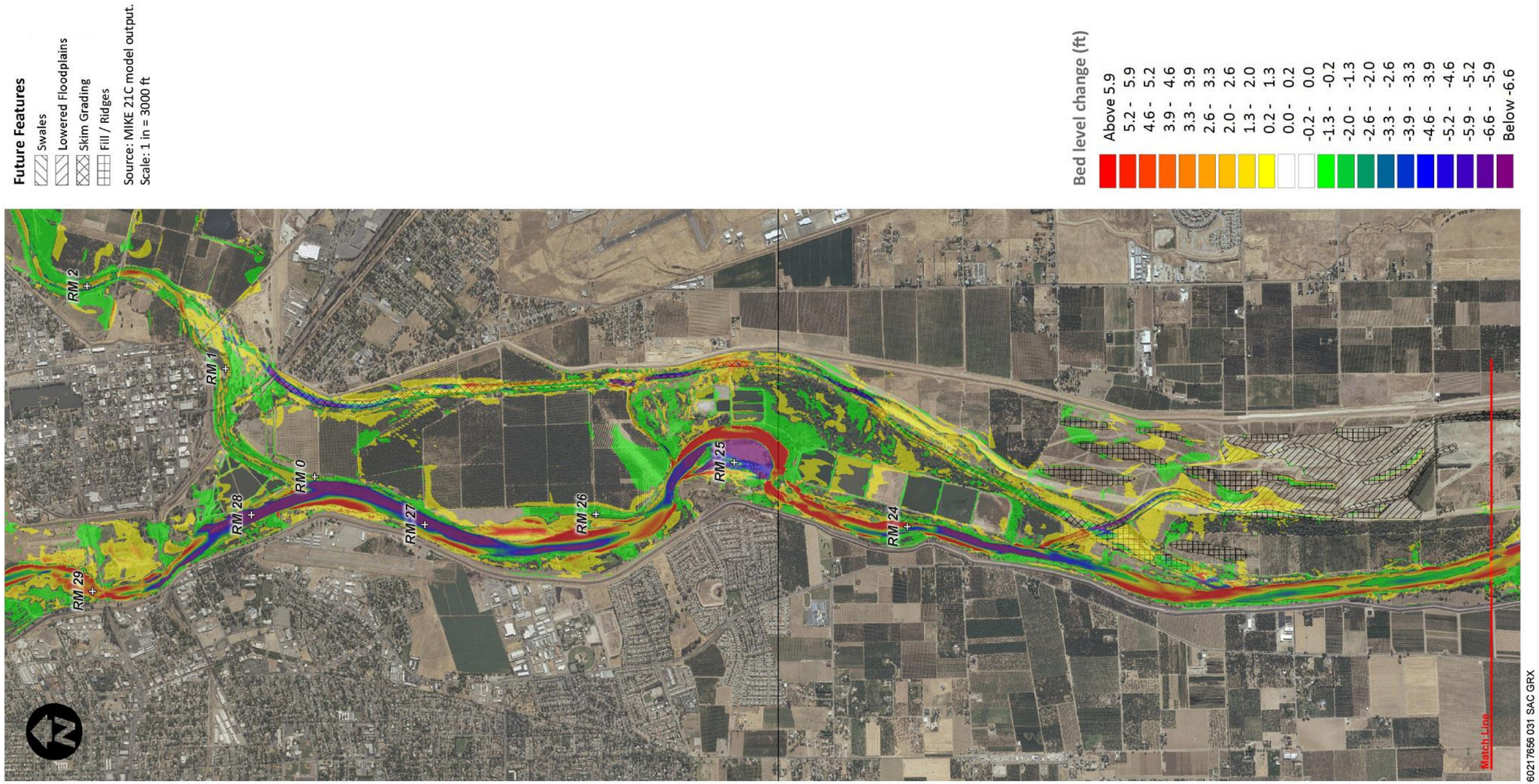
- The O'Connor Lakes swale may experience some deposition at portions of the inlet and at the connection to the existing, densely forested lake (Exhibit 5-31). This figure also indicates an erosional trend at the upstream third of the O'Connor Lakes Unit as flood flows cut across the existing floodplain. However, during a site visit in August 2011 (after the more frequent March/April 2011 flood—approximately a 3- to 5-year flood), sand splays were observed after riparian scrub uprooted at the water's edge. This observation suggests that this area is more depositional.

- Exhibit 5-31 shows that in the Lake of the Woods, the channel is prone to deposition between the Lake of the Woods terrace and the Bear River confluence. This trend can be verified with aerial photographs that show alternating sandbars and bar formation in the shadow of the relict levee feature (see Exhibit 5-33). Excavating a terrace at this location (i.e., widening the left overbank channel) does not appear to reduce the 100-year flood stage, and therefore does not provide an obvious flood reduction benefit. In addition, excavating the terrace in the shadow of the relict levee feature may be unjustified, given the tendency for deposition to occur at this location.

- The modeling results demonstrate that the model is reliably predicting the presence of alternating sandbars in the channel downstream of the Bear River, as documented by both cbec's geomorphic field survey and aerial photo imagery (see Exhibits 5-32 and 5-33).

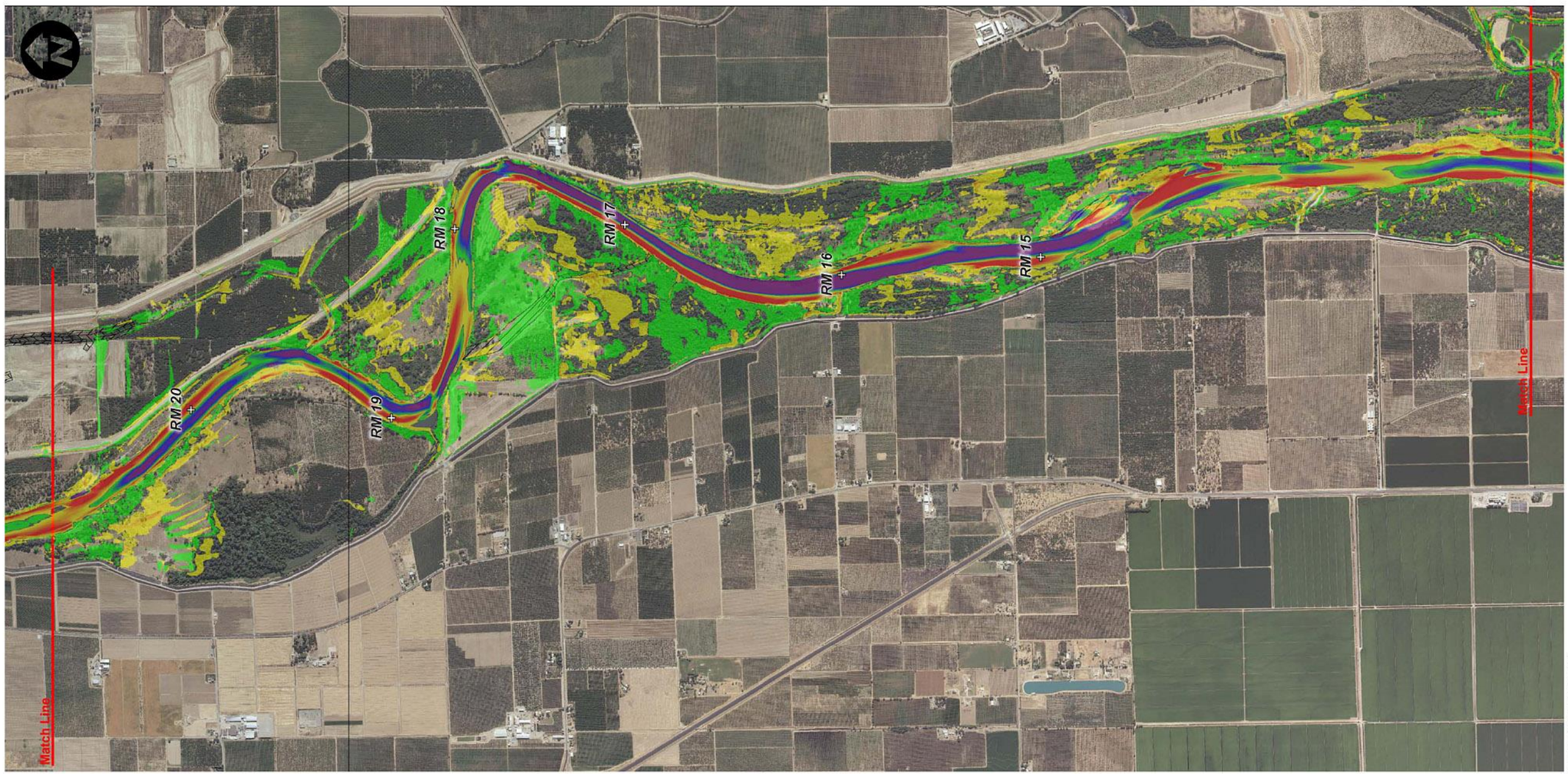
- Exhibit 5-32 shows up to 5 feet of deposition during the 100-year flood on the lower and upper terraces of the Nelson Slough lowered floodplain. It should be noted that very little deposition was observed during the 10-year flood, and that no deposition was observed during the 2-year flood. Therefore, extensively excavating the floodplain to increase sediment capture may not be warranted.

- Downstream of the Nelson Slough lowered floodplain, and near the Sutter Bypass hook levee and Feather River east levee setback, the modeling shows increased potential for channel scour downstream of RM 8 (Exhibit 5-32). Bed profile analysis shows a significant drop in the average bed profile after the 100-year flood. This could be attributable to a combination of sediment becoming trapped on the floodplain terraces and the flow constriction moving farther downstream of RM 7.



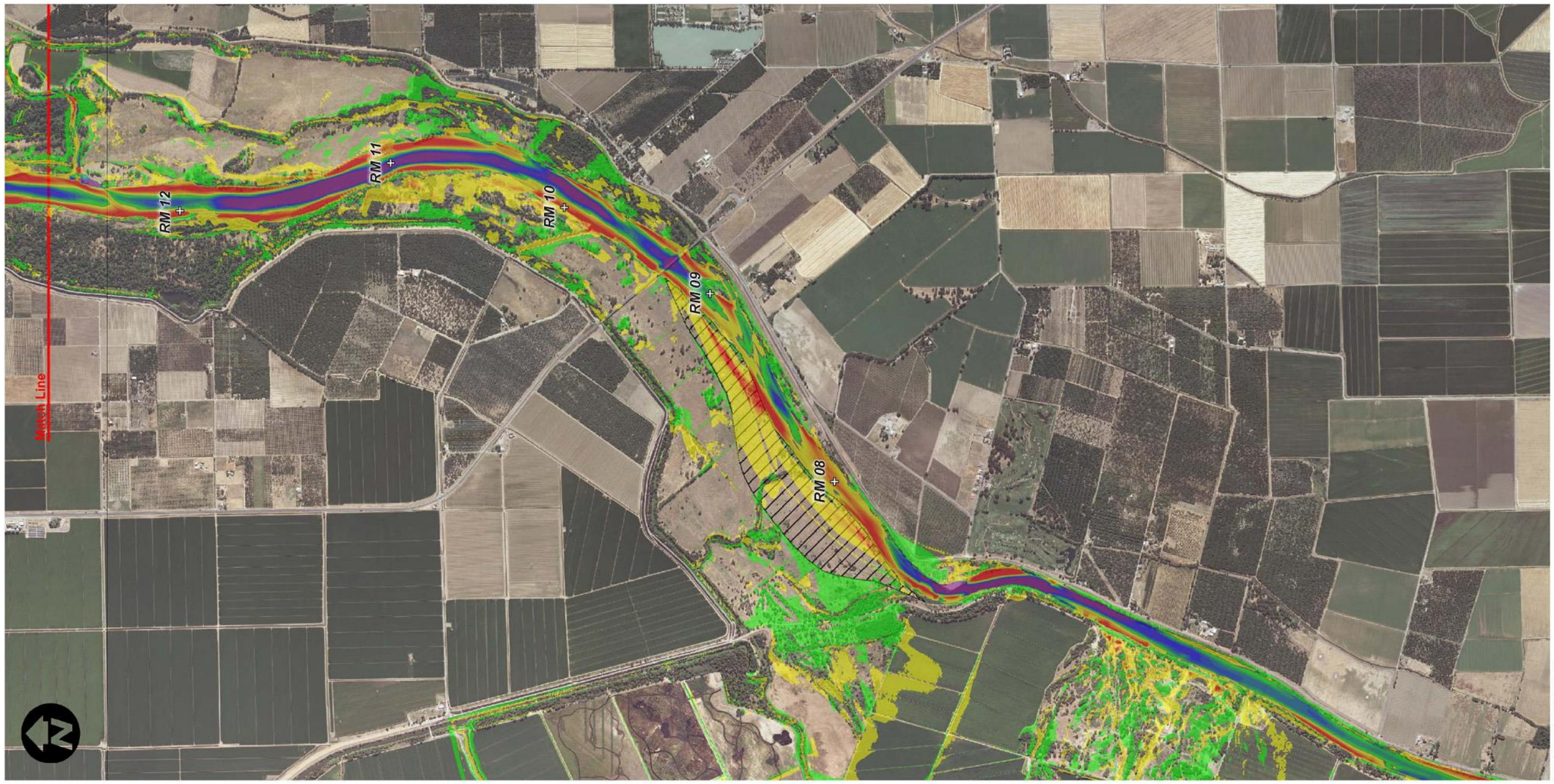
Source: cbec 2013a

Exhibit 5-30 **Future 100-Year Final Bed-Level Change — North Study Area**



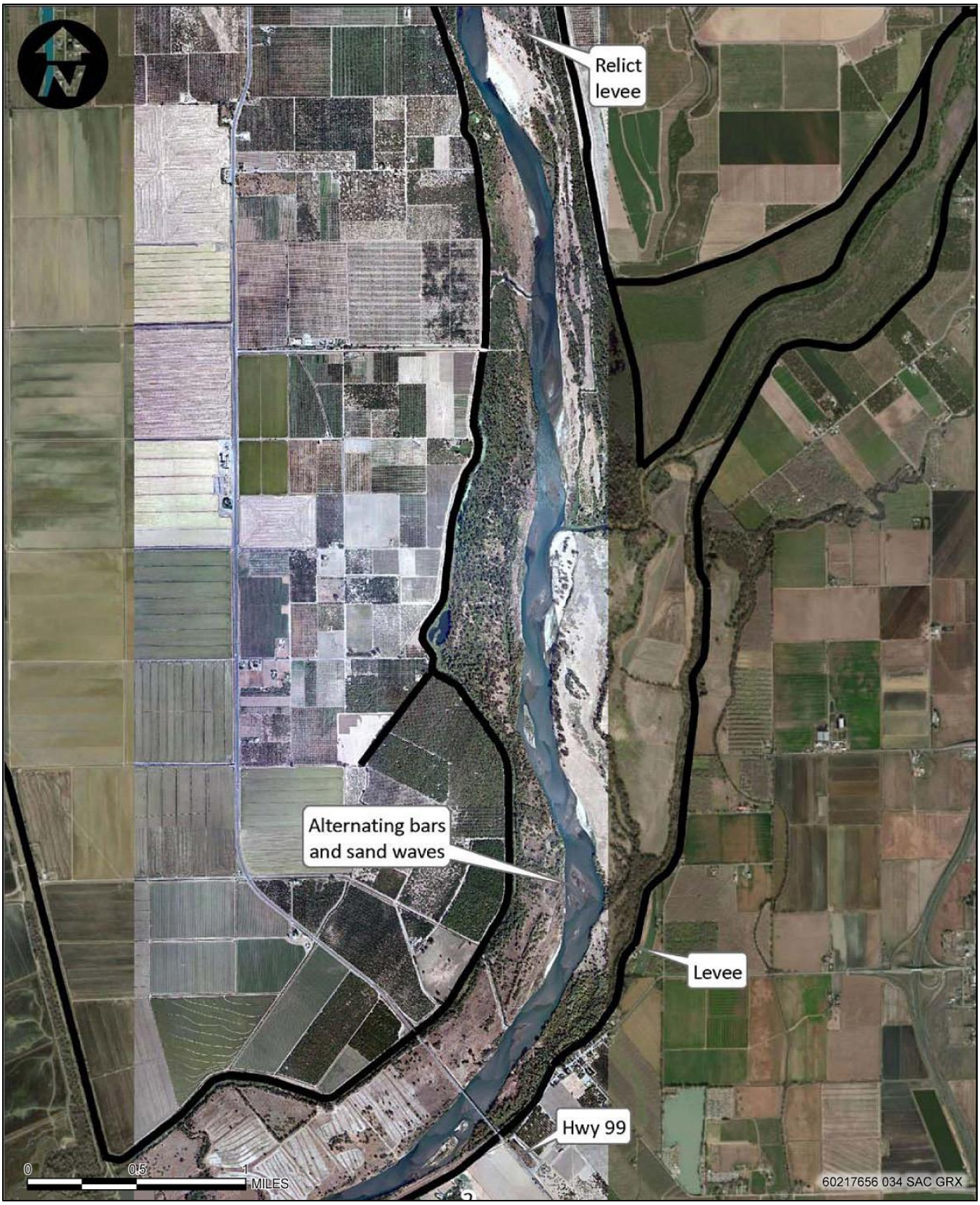
Source: cbec 2013a

Exhibit 5-31 **Future 100-Year Final Bed-Level Change — Central Study Area**



Source: cbec 2013a

Exhibit 5-32 **Future 100-Year Final Bed-Level Change — South Study Area**



Source: cbec 2013a

Exhibit 5-33 **Alternating Bars on the Lower Feather River**

- Overall, deposition on the floodplains throughout the LFRCMP study area was rather limited. One notable location was deposition upstream of RM 10 on the right bank and in the ditch supplying the Major Pump Plant. Floodplain erosion was also limited, often coinciding with dense riparian areas where erosion would not be expected because of the soil-stabilizing effects of vegetation. This further confirms the use of the 0.3-foot active bed material thickness on the floodplains in the model as a surrogate for stabilizing vegetation.

Bed-Level Effects of Breach at Shanghai Rapids

The 100-year flood bed level under the maximum-breach condition at Shanghai Rapids showed small perturbations in bed level upstream of the rapids, but these changes diminished at SR 20. Small perturbations also occurred downstream of the rapids, but the net effect was no change in reach-averaged conditions. However, these results are based on a single flood event without a simulation of long-term morphology. The maximum breach does not have a significant effect on extreme flood hydrodynamics, which partially explains why the modeling did not indicate more significant changes in the bed profile.

In relative terms, the modeling results for a 100-year flood under the maximum-breach scenario are similar to the results of a sediment transport study performed by MEI (1999) that evaluated failure of the Modesto Formation using a different model and set of working assumptions. Based on the MEI (1999) study, additional erosion at SR 20 on the order of a foot can be expected based on long-term one-dimensional sediment-transport simulations. However, the modeling conducted for the LFRCMP differs from the modeling for the MEI (1999) study because MEI simulations were not performed in 2-D and did not assume complete failure of the Modesto Formation. However, Ayres (1997) and James et al. (2009) further suggest that the upstream migration of the knickpoint through Shanghai Bend to the older channel position may have potentially more serious ramifications; channel incision there could lower the base bed level and expose a less resistant deposit beneath the cohesive Modesto Formation, allowing channel incision to migrate upstream more rapidly.

Summary of Hydrodynamic Modeling Results and Recommendations

A 2-D hydrodynamic and sediment-transport model was developed by cbec for the LFR and updated with data from bathymetric and topographic surveys conducted in 2012 near Shanghai Rapids (cbec 2012). This model was successfully calibrated and validated for low flows to better characterize the hydraulic conditions associated with frequent floods. The hydrology for the frequent floods was also updated to reflect actual reservoir operations over the past few decades (cbec 2013b) rather than relying on the Comp Study's hydrological data (USACE 2008; PBI 2011). The model was used to assess the geomorphic response and ecological benefits and impacts of the proposed management actions. The model also assessed the geomorphic changes and ecological impacts of initial breaching and continued breach enlargement of the Modesto Formation forming Shanghai Rapids. The following discussion summarizes the results of the cbec modeling, describes the implications for future breach expansion of Shanghai Rapids, and offers recommendations to modify the proposed plan. The MIKE-21 hydrodynamic 2D model is available for use as part of DWR's Library of Models.

Floodplain Activation Flood Flow Effects

A net gain of 73 acres of inundated floodplain occurred under future conditions as a result of shallow inundation on the lower terrace at the Nelson Slough lowered floodplain. However, the net gain in acres would be reduced in

proportion to any narrowing of the lower terrace's width to reduce the substantial volume of floodplain excavation required.

2-Year Flood Effects

A net gain of 162 acres of inundated floodplain occurred under future conditions as a result of backwater inundation into the FRS lowered floodplain and Upper Messick Lake basin, along with inundation on the lower terrace of the Nelson Slough lowered floodplain. The FRS diversion swale was activated briefly and other proposed features were within 1–3 feet of being activated during the peak of the 2-year flood. Because 2-year flows did not activate large floodplain areas with the future features, changes in the Feather River's WSP and bed level were minimal.

10-Year Flood Effects

A net loss of 291 acres of inundated floodplain occurred under future conditions even though all proposed features were inundated, including the State Cut channel. The net loss of inundated floodplain was attributed to a decrease in the WSP of up to 0.6 foot in the Feather and Yuba rivers as a result of floodplain excavation (increase in flow conveyance area) and a reduction in the composite roughness within the FRS floodplain, compared to the baseline condition that assumed dense riparian forest throughout.

The increase in flow conveyance area through the Nelson Slough lowered floodplain also contributed to the loss of inundated floodplain, which was partially offset by the increase in inundated terraces at the Nelson Slough lowered floodplain. The reduction in the WSP caused less water to flow from the Yuba River into the State Cut channel and reduced the flow overtopping the left bank of the Feather River just upstream of the Modesto Formation.

In contrast to the reach-wide reductions in the WSP, no reach-wide changes occurred in the bed profile. Only localized increases in the bed profile occurred as a result of deposition within the river channel near the FRS diversion swale and the Nelson Slough lowered floodplain. Even with channel deposition adjacent to the Nelson Slough lowered floodplain, no significant volume of sediment trapping occurred throughout the excavated terraces from the 10-year flood event.

100-Year Flood Effects

In the 100-year flood the tops of the upland spoil ridges in the FRS floodplain protruded above the water surface, resulting in a net loss of 61 acres of inundated floodplain. The net loss of inundated floodplain was also largely attributed to a decrease in the WSP of up to 0.8 foot as a result of floodplain excavation and a reduction in the composite roughness within the FRS floodplain. The changes in the 100-year WSP were consistent with the RMA-2 flood modeling results (MBK 2012b).

Unlike the 10-year flood modeling, the 100-year flood modeling demonstrated that the future conditions are slightly more erosional upstream of Shanghai Rapids because of a steepening of the hydraulic gradient, and more depositional downstream of Shanghai Rapids. This is especially true near the FRS diversion swale and the Nelson Slough lowered floodplain, with up to 5 feet of deposition on the terraces of the Nelson Slough lowered floodplain. Overall, the future FRS floodplain and both Upper and Lower Messick Lakes appear to be stable relative to deposition and scour.

Overall, the risk of avulsion of the excavated FRS swales during a 100-year event is considered low, based on results of the sediment transport modeling, This conclusion was also reached after considering the frequent backwater preceding inflow from upstream into the lower end of the FRS floodplain, as well as the topographic complexity in the setback area (i.e., swales, floodplains, and spoil ridges).

Shanghai Breach Effects

The maximum WSP downstream of Shanghai Rapids did not change as a result of the 2012 breach condition of the Modesto Formation. As expected, a local decrease of up to 0.6 foot occurred at Shanghai Rapids under the FAF flow; this decrease was reduced to 0.1 foot under the 10-year flood and diminished to no change under the 100-year flood. The maximum reduction in the WSP at SR 20 was 0.1 foot under the 2-year flood.

The maximum WSP did not change downstream of Shanghai Rapids under the hypothetical maximum breach scenario. As expected, a local decrease of up to 4.8 feet occurred at Shanghai Rapids under the FAF flow; this decrease was reduced to 0.3 foot under the 10-year flood and diminished to no change under the 100-year flood. The maximum reduction in the WSP occurred during the 2-year flood and measured 0.7 foot at SR 20 and 0.3 foot on the Yuba River. The WSP reduction translated to a net loss of inundated floodplain under the FAF flow and 2-, and 10-, year floods ranging from 10 to 300 acres, and a negligible loss for the 100-year flood, respectively.

The largest decreases in inundated floodplain occurred because less water flowed from Yuba River into the State Cut channel and less Feather River flow overtopped the left bank of the river just upstream of the Modesto Formation under the 10-year flood. This result is similar to the proposed action's pre-breach 10-year findings. This suggests that reductions in inundated floodplain would be even greater under a combined proposed-action/maximum-breach condition.

Furthermore, the loss of inundated floodplain may be understated because simulations of long-term morphology were not performed. The largest changes from the pre-breach condition occurred during the 2-year flood; the hydraulic gradient across the rapids was greatest during smaller flows because the hydraulic effect of the rapids tends to diminish during larger, deeper flood flows across a wider floodway. Another possible factor is that the modeled maximum-breach configuration was not as extreme with respect to its assumed expansion and deepening, and thus the remaining Modesto Formation still behaved as a hydraulic and sediment grade control. Based on the MEI (1999) study, additional erosion at SR 20 on the order of a foot can be expected based on long-term one-dimensional sediment-transport simulations. However, Ayres (1997) and James et al. (2009) further suggest that the upstream migration of the knickpoint through Shanghai Bend to the older channel position may have potentially more serious ramifications; channel incision there could lower the base level and expose a less resistant deposit beneath the cohesive native formation, allowing channel incision to migrate upstream more rapidly.

Recommendations Based on the Results of Hydrodynamic Modeling

The following recommendations, designed to maximize ecosystem functions while continuing operations and maintenance of the flood system in the LFRCMP study area, were developed based on an assessment of the results of the hydrodynamic and sediment-transport simulations:

- Degrade the left-bank berm on the Yuba River at the north end of the State Cut channel to allow more frequent inflow to the Old Feather River and inundation of the FRS floodplain. Lowering the left-bank berm

would offset the effects of continued expansion and deepening of the breach at Shanghai Rapids, which would lower the WSP and bed elevations upstream of the rapids and contribute to a loss of inundated floodplain. This recommendation was incorporated into Flood Management Action 1, "Skim Sediment Mounds, Remove Berm, and Maintain Uniform Gradient in Upper State Cut from the Yuba River to Island Avenue," as described in Chapter 6, "Proposed Management Actions."

- Skim-grade and remove the mid-channel ridge in the lower State Cut channel (downstream of Island Avenue) to promote a positive flow gradient toward the FRS floodplain, and a more uniform channel width and roughness condition than in upper State Cut. This recommendation was incorporated into Flood Management Action 2, "Skim Sediment Mounds, Remove Mid-Channel Ridge, and Maintain Uniform Gradient in Lower State Cut from Island Avenue to Eliza Bend."

- Remove the plug at Eliza Bend to enhance flow in the Old Feather River toward the FRS floodplain, and to provide shaded backwater habitat in the absence of flow-through conditions. Sediment at Eliza Bend may need to be removed after major, infrequent flood events to maintain this enhanced flow. The recommendation to remove the channel plug at Eliza Bend was incorporated into Ecosystem Management Action 1, "Restore Intermittent Flow to the Old Feather River Channel at Eliza Bend."

- Increase excavation depth at the FRS diversion swale by 2 feet to allow more frequent flow-through inundation into the FRS floodplain. Implementing this recommendation would increase excavation volumes; the action would need to be modeled to assess its potential to create excessive sedimentation within the swale itself, and to promote overly erosive swale conditions. This recommendation has not been incorporated into Ecosystem Management Action 3, "Distribute Overbank Flows in Swales and Revegetate the Northern FRS Floodplain," and requires further study.

- Consider hardening (rock armoring) the entrance to the FRS diversion swale, given the erodibility of the overlying hydraulic mining sediments (as informed by geotechnical data) and the need to minimize the risk of channel avulsion. However, it appears that the risk of avulsion is minor, based on three factors: the results of the sediment transport modeling; the frequent backwater flow into the lower end of the Feather River setback floodplain; and the setback area's topographic and hydraulic complexity (i.e., swales, floodplains, spoils ridges, and dense vegetation). This recommendation was incorporated into Ecosystem Management Action 3, "Distribute Overbank Flows in Swales and Lower Floodplain and Revegetate the Northern FRS Floodplain."

- Expand excavation (and lowering) of the FRS floodplain farther north to maximize the frequently inundated floodplain by creating a backwater through the existing constructed Messick Lake swale and inflow from the proposed FRS diversion swale. Implementing this recommendation would increase excavation volumes. Additional study is needed to determine whether the ecological benefits of further expanding the 2-year floodplain would justify the additional excavation volumes and costs. This recommendation has not been incorporated into Ecosystem Management Action 3, "Distribute Overbank Flows in Swales and Lower Floodplain and Revegetate the Northern FRS Floodplain," and requires further study.

- Design the FRS floodplain's spoils ridges so that the primary axis is oriented in the streamwise direction. With this orientation the spoil ridges would be flood neutral, and would be positioned strategically to provide an additional wind-wave buffer to augment the function of the existing vegetated wind-wave buffer near the

east levee toe. This recommendation was incorporated into Flood Management Action 3, "Design Future Vegetation and Grading Patterns on the FRS Floodplain to Maintain Floodway Capacity and Levee Freeboard."

- Set back the Feather River training levee ("hook levee") farther (westward) from the left bank of the river at the south end of the Sutter Bypass hook levee to minimize channel scour in the river along the toe of the east levee downstream of RM 8. This action would occur in conjunction with realigning the upper end of the hook levee and setting back the eastside corner levee upstream of RM 7.3. This recommendation was incorporated into Flood Management Action 8, "Reevaluate and Realign Portions or All of the Sutter Bypass Hook Levee."
- Consider sedimentation patterns when developing proposed boat-launch facilities, especially downstream of RM 15. Alternating sandbars and the typically shallow conditions across the channel during low flows increase the need for annual maintenance at ramps and channel inlets, and create potentially hazardous situations for motorized boating. This recommendation was incorporated into Recreation Management Action 6, "Develop Boat Access and Parking at Nelson Slough."

Management Actions Considered but Rejected

All proposed actions described in this chapter should be pursued as conceptualized except the actions described below. The results of the hydrodynamic and sediment-transport simulations indicated that the following actions did not necessarily provide the anticipated floodway and ecosystem enhancement benefits, and therefore, the level of effort required to implement them is not justified.

- Refrain from skim-grading to fill scour pools in the Old Feather River to minimize fish stranding unless the benefits to fish outweigh the excavation costs. The results of the sediment modeling predicted that major floods may re-erode some of the deeper, perennial pools, so long-term skim-grading maintenance may not be warranted in some locations. However, filling minor depressions and unauthorized sand borrow sites that do not hold water long enough to support seasonal wetland vegetation should still be considered to reduce the potential for fish stranding.
- Refrain from excavating the left overbank at the Lake of the Woods terrace, which is situated in the shadow of a relict levee feature in the middle of the narrowest section of the flood corridor. The modeling results demonstrated that the left overbank is prone to sedimentation during major floods; excavation would provide no apparent reduction of major flood stage.
- Refrain from excavating the wide upper and lower terraces of the Nelson Slough lowered floodplain that were included in the MIKE_21C model runs. The results of the sediment-transport modeling demonstrated that the sediment-trapping capabilities of the lowered floodplain terraces were insignificant during the 2- and 10-year floods, but potentially significant during the 100-year flood. The lack of frequent sediment capture, especially on the upper terrace where periodic sediment removal is proposed, may not justify excavating to reduce the accretion of sediment in the Sutter Bypass. Furthermore, removing sediment on the lower terrace would result in the periodic removal of mature riparian vegetation, with associated requirements for mitigation.

Table 5-20 summarizes the potential management actions that were proposed and evaluated in the RMA-2 flood model and/or the MIKE_21C hydrodynamic model, but were rejected or modified based on the modeling results. Table 5-21 summarizes the flood and ecosystem management actions that were evaluated in the RMA-2 flood model and/or the MIKE_21C hydrodynamic model and carried forward as actions proposed in Chapter 6 of the LFRCMP.

Table 5-20
Management Actions Considered but Rejected or Modified Based on Modeling Results

Description of Management Action	RMA-2D Flood Model	Hydrodynamic MIKE_21 Model	Proposed LFRCMP Action	Rationale for Rejection or Modification
Deepen Upper State Cut, and Remove Cross Berm Obstructing Overbank Flow, to Increase Frequency of Flows Diverted from Yuba River into Bypass Channel		Modified excavation to skim sediment mounds, remove cross berm at inlet, and maintain uniform gradient, but not deepen Upper State Cut		Modeling results indicated that deeper excavation would not adequately increase diversion flows to justify cost of increased excavation. Ecologic evaluation of modeling results indicated minimal ecological benefits from deep excavation.
Deepen Lower State Cut, and Remove Center Ridge, to Maintain Capacity and Frequency of Flows from Yuba River via State Cut to Old Feather River		Modified excavation to skim sediment mounds, remove mid-channel ridge, and maintain uniform gradient, but not deepen Lower State Cut		Modeling results indicated that deeper excavation would not adequately increase diversion flows to justify cost of increased excavation. Ecologic evaluation of modeling results indicated minimal ecological benefits from deep excavation.
At Eliza Bend, Remove Plug at Mouth and Deepen Channel to Increase Frequency of Flows Diverted from Feather River Upstream of Shanghai Bend, RM 24.8, to Convergence with Lower State Cut		Modified excavation limited to removal of plug at the mouth and high deposition mounds in the channel		Modeling results indicated that channel deepening would not adequately increase diversion flows to justify cost and impacts of increased excavation.
Deepen Old Feather River Channel to Convey Diverted Flows from Yuba and Feather Rivers into FRS Floodplain at Upper Messick Lake		Action rejected		Modeling results indicated that channel deepening would not adequately increase flows to justify cost and impacts of increased excavation.
Excavate a Lowered Floodplain on FRS North of Upper Messick Lake to Increase Extent of 2-Year Inundated Area	Not considered in flood model	Added FRS floodplain excavation		Modeling results indicated that lowering of the floodplain would substantially increase the inundation area in a 2-year flood event.
Use Three-Quarters of Excavated Material on FRS as Spoils Ridges Throughout Floodplain, Oriented to Flood Flow Paths, and Create High Ground Refugia for Wildlife	Not considered in flood model	Added spoils ridges		Use of excavated material from floodplain lowering to construct ridges would provide wildlife refugia in a 100-year event and would avoid soil disposal costs.
Excavate Drainage Swale from South Arm of Lower Messick Lake to Low Floodplain on Star Bend, Crossing under Old Levee Road		Action rejected		Eliminating drainage swale at this location avoids need for bridge crossing on Old Levee Road.

Table 5-20
Management Actions Considered but Rejected or Modified Based on Modeling Results

Description of Management Action	RMA-2D Flood Model	Hydrodynamic MIKE_21 Model	Proposed LFRCMP Action	Rationale for Rejection or Modification
Widen Channel Constriction at Apex of Star Bend to Reduce Velocities, RM 18.3 to RM 17.8, by Excavating (Lowering) High Ground		Action rejected		Modeling results indicated that channel widening would result in higher velocities rather than the desired reduction.
Excavate (Lower) High Ground on Left and Right Banks, RM 18.5 to RM 17.4, to Lower Flood Stage in the Most Constricted Reach of LFR Floodway		Action rejected (modified as described below)		Modeling results indicated the desired flood capacity increase and stage reduction could not be achieved by this action.
Excavate Left Bank, RM 14.5 to RM 14.0, Above Base Flow Elevation to Increase Floodway Capacity in Constricted Reach	Not considered in flood model	Added as alternative to previous measure		Introduced as an alternative means to increase flood capacity and reduce stage (see previous measure).
Excavate Drainage Swale to Improve Through Flow to River at Lake of the Woods at RM 13.7		Moved swale to coincide with shortened Pump Plant 2 drainage ditch at RM 13.2		Modeling results indicated through flow and drainage improvements could be achieved in combination with significantly shortening the Pump Plant 2 drainage ditch.
On Nelson Slough Unit, Excavate Two Wide (100-foot), Stepped Flood Terraces to Capture Sediment and Create a Low Forested Floodplain, RM 9.2 to RM 7.5 Right Bank			Action rejected (modified as described below)	Modeling results indicated sediment trapping would be insignificant in the 2- and 10-year events and would not justify cost or impacts of extensive excavation.
On Nelson Slough Unit, Excavate a 20- 50-Foot-Wide, Low Riparian Bench, RM 9.2 to RM 7.5 Right Bank	Not considered in flood model	Not considered in hydrodynamic model	Added as alternative to previous measure	Introduced as an alternative, lower-cost means of creating low, frequently inundated, forested floodplain (see previous measure).

Notes: shading is used to indicate the action associated with a given model or proposed in the LFRCMP is carried forth as described in the column to the left, with modifications described when relevant

Sources: cbec 2013a; MBK 2012b; data compiled by AECOM in 2013

Table 5-21 Proposed LFRCMP Management Actions Modeled by MBK and cbec		
Actions Included in One or More Model Simulation	**RMA-2 Flood Model**	**MIKE_21 Hydrodynamic Model**
FLOOD MANAGEMENT ACTIONS		
Skim Sediment Mounds, Remove Berm, and Maintain Uniform Gradient in Upper State Cut from the Yuba River to Island Avenue	Included deep excavation in State Cut	
Skim Sediment Mounds, Remove Mid-Channel Ridge, and Maintain Uniform Gradient in Lower State Cut from Island Avenue to Eliza Bend	Included deep excavation in State Cut	
Design Future Vegetation and Grading Patterns on the FRS Floodplain to Maintain Floodway Capacity and Levee Freeboard		Added new diversion swale, spoils ridges, and lowered north floodplain
Improve Levee Borrow Channel Drainage at Lake of the Woods, and Shorten Pump Plant 2 Drainage Ditch	Shortened Pump Plant 2 ditch not included	Moved Lake of the Woods drainage swale to shortened Pump Plant 2 ditch
Cease Vegetation Clearing from RM 13.5 to RM 12.5 at Lake of the Woods		
Set Back Corner Levee at Constriction from RM 7.7 to RM 7.4 (Left Bank)		
Reevaluate and Realign Portions or All of the Sutter Bypass Hook Levee		
ECOSYSTEM MANAGEMENT ACTIONS		
Restore Intermittent Flow to the Old Feather River Channel at Eliza Bend		Eliminated Old Feather River channel deepening
Restore 500 Acres of Riparian and Upland Habitat in the FRS Area		
Distribute Overbank Flows in Swales, Lower Floodplain, and Revegetate the Northern FRS Floodplain	West swale not connected to Feather River and north floodplain not lowered	
Enlarge Existing Swale to Improve Drainage in the Southern FRS Floodplain, and Plant Riparian Forest and Willow Scrub		
Create High-Ground Flood Refugia for Wildlife in the FRS Area	Not included	
Replace Frequently Inundated Orchard Areas near Lower Messick Lake with Riparian Forest/Scrub Habitats	Not included	
Restore 169 Acres of Riparian and Upland Habitat, and Enhance 270 Acres at Abbott Lake		
Increase Overbank Flow Across Low Ground at Star Bend, and Expand Riparian Habitat		
Create an Overbank Swale and Vegetated Bench at O'Connor Lakes		
Create an Inlet Swale to Increase Overbank Flow into and through Lake of the Woods		
Allow Natural Vegetation Succession to Occur at Lake of the Woods from RM 13.5 to RM 12.5		
Create Shaded Riverine Aquatic Habitat and a Mosaic of Riparian/Upland Habitat at Nelson Slough		
Sources: cbec 2013a; MBK 2012b; data compiled by AECOM in 2013		

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6 PROPOSED MANAGEMENT ACTIONS

The overall goal of the *Lower Feather River Corridor Management Plan* (LFRCMP) is to maximize public safety by protecting and maintaining flood management facilities and floodways of the Lower Feather River (LFR) while preserving and enhancing fish and wildlife habitat and ecosystem functions, promoting economic stability, conserving agriculture and its infrastructure, and enhancing recreational opportunities. This goal is consistent with the CVFPP objective of promoting multi-benefit projects along with improving operations and maintenance, promoting ecosystem functions, and improving institutional support.

This chapter describes the management actions for achieving goals developed by the LFRCMP Work Group for flood management, ecosystem and habitat enhancement, recreation, and agriculture. Table 6-1 summarizes how these actions contribute to fulfilling the goals of the LFRCMP, the Central Valley Flood Protection Plan (CVFPP) (DWR 2011), and the Conservation Strategy, as described in the CVFPP Conservation Framework (DWR 2012). The management actions described below are generally ordered from upstream to downstream.

Implementation of these management actions will involve close coordination and collaboration with key stakeholders. In particular, implementation of actions proposed in the Feather River Wildlife Area (FRWA) management units must be a collaborative effort with CDFW to ensure that proposed restoration activities and floodway improvements are consistent with CDFW management goals and plans (Barker, pers. comm., 2014).

6.1 FLOOD MANAGEMENT ACTIONS

Flood Management Action 1: Skim Sediment Mounds, Remove Berm, and Maintain Uniform Gradient in Upper State Cut from the Yuba River to Island Avenue. Periodically skim (i.e., remove or balance shallow cut and fill locally) sediment mounds to redistribute depositional material into depressions created by natural scouring in Upper State Cut, from the Yuba River to the Island Avenue crossing (Yuba River Mile [RM] 1 to east of Feather RM 26.5; Exhibit 6-1, Area A). A remnant berm at the inlet to the State Cut bypass on the left bank of the Yuba River should be removed (graded to the surrounding floodplain elevation) to restore unobstructed inflow into the bypass from the Yuba River at high stage. Creating a more uniform channel gradient would promote sediment transport and flood bypass conveyance in Upper State Cut as part of floodway management in this area. The objective of this action is to maintain a relatively uniform gradient, a minimum channel width, and a bypass inlet sill elevation at or below 45.0 feet National Geodetic Vertical Datum (NGVD). In addition, widening the narrow bend along the right (west) bank of Upper State Cut to a minimum channel width of 200 feet across (from where the east levee was rocked in 2010) would reduce scour erosion of the waterside levee toe. Balancing cut and fill in the upper bypass would maintain adequate sediment transport and conveyance capacity in the State Cut bypass to divert a portion of high flood flows from Yuba River. Sediment accumulation in the State Cut bypass is a variable, unpredictable condition in response to episodic and infrequent high flows from the Yuba River.

Flood Management Action 2: Skim Sediment Mounds, Remove Mid-Channel Ridge, and Maintain Uniform Gradient in Lower State Cut from Island Avenue to Eliza Bend. To promote sediment transport and flood conveyance in Lower State Cut, periodically skim or remove accumulated sediment deposits in Lower State Cut from the Island Avenue crossing to the confluence with the Eliza Bend channel (Exhibit 6-1, Area B), to maintain a relatively uniform flood bypass gradient and a minimum bypass channel width. Use skimmed material to fill deep channel depressions formed by the recent sand excavation activity in State Cut, just above the

confluence with Old Feather River at Eliza Bend. Maintain a minimum bypass channel width and unobstructed flow to the confluence with Old Feather River east of Eliza Bend. These actions would maintain adequate sediment transport and conveyance capacity in the State Cut bypass to the confluence with Old Feather River (approximately west of Myrna Avenue), and would reduce fish entrapment in isolated depressions and sand mining pits within Lower State Cut. Ongoing monitoring and maintenance after storm events would be needed to ensure retention of adequate conveyance capacity and to eliminate newly created fish entrapment basins.

Flood Management Action 3: Design Future Vegetation and Grading Patterns on the FRS Floodplain to Maintain Floodway Capacity and Levee Freeboard Above Minimum Approved by the Central Valley Flood Protection Board. To provide a high conveyance flow path from north to south, orient swales, spoils ridges, and newly planted dense vegetation parallel to the direction of flood flow. The proposed conceptual design of the Feather River setback (FRS) floodplain and swale complex incorporates a deliberate pattern of low- and high-roughness vegetation, enlarged drainage capacity (swales), and spoils ridges (oriented parallel to flood flow) that, in combination, provide a high conveyance flow path from north to south without compromising habitat diversity or quality (Exhibits 6-1, 6-2, and 6-3). As described in Chapter 5, "Hydraulic, Hydrologic, and Sediment Transport Modeling of Potential Future Conditions," results of modeling conducted by both MBK Engineers and cbec, Inc. (Appendix G and Appendix H) demonstrate that under 100- and 200-year floods in this reach of the floodway, the water surface is well below the minimum 3-foot standard for levee freeboard elevation under the Future Conditions conceptual design. In addition, for all flood frequencies modeled, the results demonstrated that overall velocities are low across the floodplain after implementation of the conceptual design depicted in Exhibit 6-3. Although the actual boundaries and alignments of vegetation types and swales could be shifted relative to the concept plan envisioned for these future restoration projects, the overall composite roughness and general flow paths across the floodplain should be maintained (see also Flood Management Action 10). For example, a central corridor of low-roughness perennial grassland and oak savanna (widely scattered trees) is designed to efficiently route flood flows coming from Old Feather River to the north and overbank flow from the left (east) bank of the Feather River into and through the swale complex and lowered floodplain surrounding Upper Messick Lake.

Flood Management Action 4: Improve Drainage of Waterside Levee Borrow Channels at Abbott Lake and O'Connor Lakes. Improve drainage of borrow channels bordering the waterside toe of levees at the Abbott Lake and O'Connor Lakes units of the FRWA by clearing culverts and removing debris, beaver dams, and other barriers to drainage away from the levee toe (Exhibit 6-4). The objective is to prevent or minimize the risk to levee integrity from burrowing mammals (muskrat and beaver) that are attracted to prolonged, deep ponding near the levee slope. Appropriate seasonal water levels could be managed at interior lakes and ponds in these units by constructing water-level control weirs on drainage ways that circumvent or bypass levee toe ditches. Potential reductions of permanent ponding at the toe of levee slopes by drainage improvement projects should be evaluated and considered at other possible locations where historic borrow ditches are adjacent to levees, such as at Lake of the Woods and Nelson Slough units of the FRWA, Bobelaine Audubon Sanctuary, and other private lands within the floodway. The two water control structures in the Abbott Lake Dam, the under-dam control gate and overflow pipes, are no longer functional and should be replaced (CDFW, pers. comm., 2014). Implementation of this management action would require close involve close coordination and collaboration with the appropriate resource agencies and key stakeholders.

Table 6-1
Contributions of Proposed LFRCMP Management Actions to Goals of the CVFPP (DWR 2011), Conservation Strategy (DWR 2012), and LFRCMP

ID #	Management Action	Contribution to Goals														
		Promote natural hydrologic and geomorphic processes	Restore nutrient recycling and input of organic matter to river and floodplain	Maintain flood conveyance capacity, sediment transport & storage	Reduce costs of floodway management & maintenance	Protect flood control levees and other structures from erosion	Increase extent, diversity of riparian and seasonally inundated habitats	Increase frequency and duration of floodplain inundation and through-flow	Increase extent, diversity of shaded riverine aquatic habitat	Increase diversity of upland habitats and high ground refuge from floods	Contribute to recovery of special-status species	Promote stability of native species populations and overall biotic community diversity	Minimize introduction and spread of non-native invasive plants	Reduce fish entrapment and other sources of fish mortality	Conserve agriculture and supporting facilities	Expand recreational uses and opportunities
Flood Management Actions																
FMA-1	Skim Sediment Mounds, Remove Berm, and Maintain Uniform Gradient in Upper State Cut from the Yuba River to Island Avenue			✓		✓										
FMA-2	Skim Sediment Mounds, Remove Mid-Channel Ridge, and Maintain Uniform Gradient in Lower State Cut from Island Avenue to Eliza Bend			✓										✓		
FMA-3	Design Future Vegetation and Grading Patterns on the FRS Floodplain to Maintain Floodway Capacity and Levee Freeboard			✓	✓											
FMA-4	Improve Drainage of Waterside Levee Borrow Channels at Abbott Lake and O'Connor Lakes		✓	✓	✓	✓								✓		
FMA-5	Improve Levee Borrow Channel Drainage at Lake of the Woods, and Shorten Pump Plant 2 Drainage Ditch	✓	✓		✓		✓				✓	✓		✓		
FMA-6	Cease Vegetation Clearing at Lake of the Woods from RM 13.5 to RM 12.5				✓		✓		✓		✓	✓				
FMA-7	Set Back Corner Levee at Constriction from RM 7.7 to RM 7.4 (Left Bank)			✓		✓										
FMA-8	Reevaluate and Realign Portions or All of the Sutter Bypass Hook Levee			✓		✓										
FMA-9	Incorporate Invasive Plant Control BMPs into Routine Maintenance Activities			✓								✓	✓			
FMA-10	Monitor Floodway Roughness and Vegetation Patterns			✓	✓	✓										
FMA-11	Continue Periodic Levee Integrity Inspections				✓	✓										

Table 6-1
Contributions of Proposed LFRCMP Management Actions to Goals of the CVFPP (DWR 2011), Conservation Strategy (DWR 2012), and LFRCMP

ID #	Management Action	Contribution to Goals														
		Promote natural hydrologic and geomorphic processes	Restore nutrient recycling and input of organic matter to river and floodplain	Maintain flood conveyance capacity, sediment transport & storage	Reduce costs of floodway management & maintenance	Protect flood control levees and other structures from erosion	Increase extent, diversity of riparian and seasonally inundated habitats	Increase frequency and duration of floodplain inundation and through-flow	Increase extent, diversity of shaded riverine aquatic habitat	Increase diversity of upland habitats and high ground refuge from floods	Contribute to recovery of special-status species	Promote stability of native species populations and overall biotic community diversity	Minimize introduction and spread of non-native invasive plants	Reduce fish entrapment and other sources of fish mortality	Conserve agriculture and supporting facilities	Expand recreational uses and opportunities
Ecosystem Function and Habitat Enhancement Management Actions																
EMA-1	Restore Intermittent Flow to the Old Feather River Channel at Eliza Bend	✓	✓				✓	✓	✓		✓	✓				
EMA-2	Restore 500 Acres of Riparian and Upland Habitat in the FRS Area		✓				✓		✓	✓	✓	✓	✓			
EMA-3	Distribute Overbank Flows in Swales and Revegetate the Northern FRS Floodplain	✓	✓	✓			✓	✓	✓	✓	✓	✓				
EMA-4	Enlarge Existing Swale to Improve Drainage in the Southern FRS Floodplain, and Plant Riparian Forest and Willow Scrub	✓	✓	✓			✓	✓	✓		✓	✓		✓		
EMA-5	Create High-Ground Flood Refugia for Wildlife in the FRS Area					✓				✓	✓	✓				
EMA-6	Replace Frequently Inundated Orchard Areas near Lower Messick Lake with Riparian Forest/Scrub Habitats						✓		✓		✓	✓			✓	
EMA-7	Restore 169 Acres of Riparian and Upland Habitat, and Enhance 270 Acres at Abbott Lake			✓			✓			✓	✓	✓	✓			
EMA-8	Improve Drainage at Abbott Lake and O'Connor Lakes	✓	✓			✓		✓			✓	✓		✓		
EMA-9	Increase Overbank Flow Across Low Ground at Star Bend, and Expand Riparian Habitat	✓	✓				✓	✓	✓		✓	✓				
EMA-10	Create an Overbank Swale and Vegetated Bench at O'Connor Lakes.		✓	✓			✓		✓		✓	✓		✓		
EMA-11	Create an Inlet Swale to Increase Overbank Flow into and through Lake of the Woods		✓	✓			✓		✓		✓	✓		✓		
EMA-12	Allow Natural Vegetation Succession to Occur at Lake of the Woods from RM 13.5 to RM 12.5				✓		✓				✓	✓				

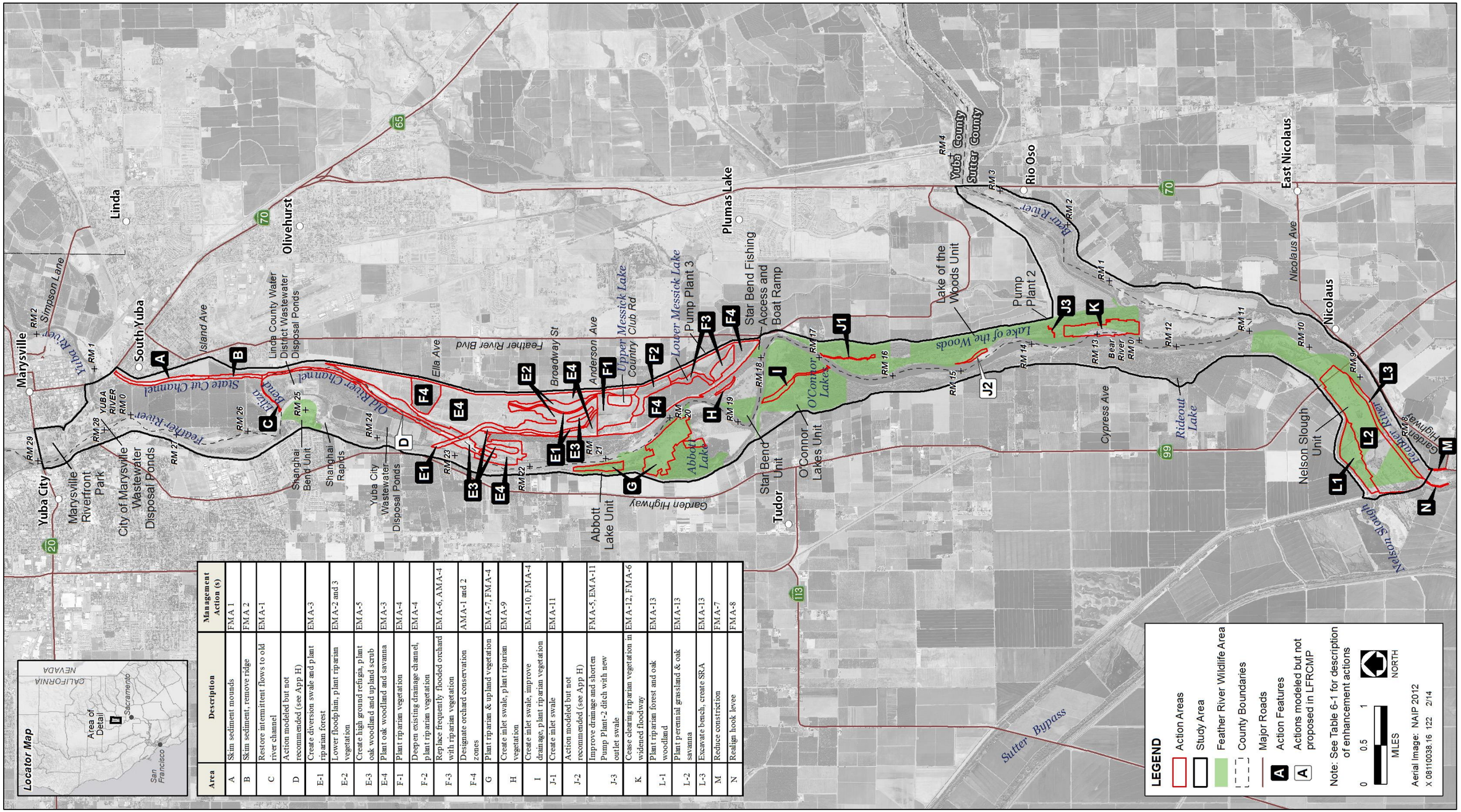
Table 6-1
Contributions of Proposed LFRCMP Management Actions to Goals of the CVFPP (DWR 2011), Conservation Strategy (DWR 2012), and LFRCMP

ID #	Management Action	Contribution to Goals														
		Promote natural hydrologic and geomorphic processes	Restore nutrient recycling and input of organic matter to river and floodplain	Maintain flood conveyance capacity, sediment transport & storage	Reduce costs of floodway management & maintenance	Protect flood control levees and other structures from erosion	Increase extent, diversity of riparian and seasonally inundated habitats	Increase frequency and duration of floodplain inundation and through-flow	Increase extent, diversity of shaded riverine aquatic habitat	Increase diversity of upland habitats and high ground refuge from floods	Contribute to recovery of special-status species	Promote stability of native species populations and overall biotic community diversity	Minimize introduction and spread of non-native invasive plants	Reduce fish entrapment and other sources of fish mortality	Conserve agriculture and supporting facilities	Expand recreational uses and opportunities
EMA-13	Create Shaded Riverine Aquatic Habitat and a Mosaic of Riparian/Upland Habitat at Nelson Slough		✓	✓			✓		✓	✓	✓	✓				
EMA-14	Designate Bank Swallow Potential Habitat Areas	✓									✓	✓				
EMA-15	Reduce Unscreened Fish Diversions										✓	✓		✓		
EMA-16	Identify and Implement Feasible Opportunities to Modify Reservoir Operations for Ecosystem Benefit	✓					✓	✓			✓	✓				
EMA-17	Identify Suitable Locations for and Plant Live Cuttings on Suitable Low Flow Shoreline Sites to Increase Shaded Riverine Aquatic Habitat								✓		✓	✓				
Recreation Management Actions																
RMA-1	Create Trails and River Access in the TRLIA FRS Area															✓
RMA-2	Develop Existing Canoe/Kayak Access Ramp at Bear River															✓
RMA-3	Develop Multi-Use Trail Network on East Bank Levee and Access Road															✓
RMA-4	Establish River Access to "The Riffles" at Shanghai Bend															✓
RMA-5	Improve Trails to Shanghai Bend Fishing/Scenic Sites and Expand Parking															✓
RMA- 6	Develop Boat Access and Parking at Nelson Slough															✓
RMA-7	Expand Equestrian Access at Star Bend															✓
RMA-8	Develop a Loop Trail between Star Bend and the Bear River Setback Area															✓

Table 6-1
Contributions of Proposed LFRCMP Management Actions to Goals of the CVFPP (DWR 2011), Conservation Strategy (DWR 2012), and LFRCMP

ID #	Management Action	Contribution to Goals														
		Promote natural hydrologic and geomorphic processes	Restore nutrient recycling and input of organic matter to river and floodplain	Maintain flood conveyance capacity, sediment transport & storage	Reduce costs of floodway management & maintenance	Protect flood control levees and other structures from erosion	Increase extent, diversity of riparian and seasonally inundated habitats	Increase frequency and duration of floodplain inundation and through-flow	Increase extent, diversity of shaded riverine aquatic habitat	Increase diversity of upland habitats and high ground refuge from floods	Contribute to recovery of special-status species	Promote stability of native species populations and overall biotic community diversity	Minimize introduction and spread of non-native invasive plants	Reduce fish entrapment and other sources of fish mortality	Conserve agriculture and supporting facilities	Expand recreational uses and opportunities
RMA-9	Develop Multi-Use Levee Trail from Boyd's Pump to the Yuba City Boat Ramp															✓
RMA-10	Develop Nature Trails at Halprin Lagoon															✓
RMA-11	Develop Park at Yuba City's Mosquito Beach Recreation Area															✓
Agricultural Management Actions																
AMA-1	Designate Agricultural Conservation Areas									✓	✓				✓	
AMA-2	Protect Agricultural Assets from Vandalism, Theft, and Wildfire														✓	
AMA-3	Use Agricultural Lease Income to Support Operations and Maintenance on Restoration Sites				✓										✓	
AMA-4	Replace Low-Lying, Flood-Prone Orchards with New Orchards on High Ground				✓										✓	
AMA-5	Offer Extended Leases to Orchards				✓										✓	
AMA-6	Implement Wildlife-Friendly Practices										✓	✓			✓	

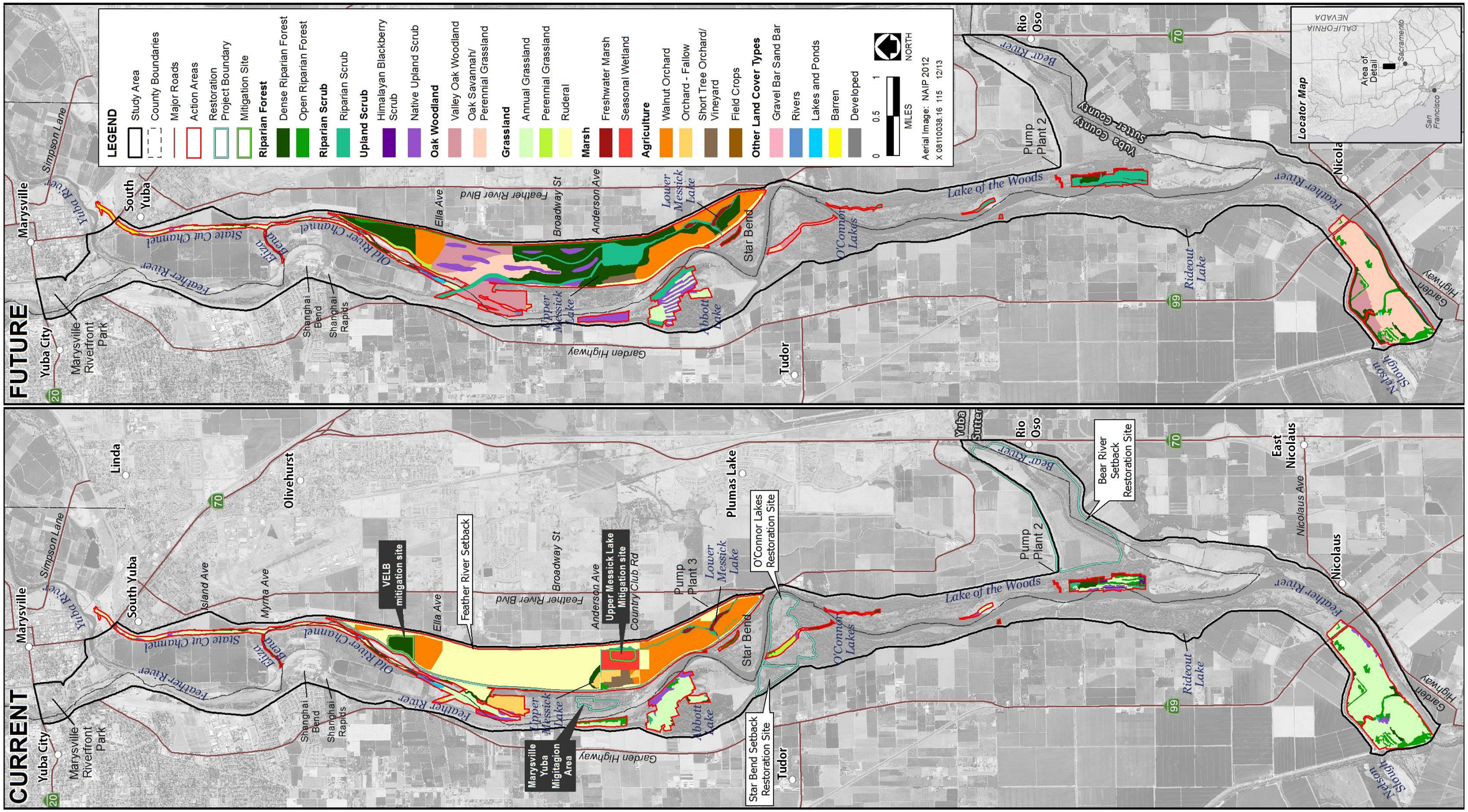
Notes: AMA = Agricultural Management Action; EMA = Ecosystem Function and Habitat Enhancement Management Action; FMA = Flood Management Action; RMA = Recreation Management Action
Source: Data compiled by AECOM in 2013



Area	Description	Management Action (s)
A	Skim sediment mounds	FM A 1
B	Skim sediment, remove ridge	FM A 2
C	Restore intermittent flows to old river channel	EM A-1
D	Action modeled but not recommended (see App H)	
E-1	Create diversion swale and plant riparian forest	EM A-3
E-2	Lower floodplain, plant riparian vegetation	EM A-2 and 3
E-3	Create high ground refugia, plant oak woodland and upland scrub	EM A-5
E-4	Plant oak woodland and savanna	EM A-3
F-1	Plant riparian vegetation	EM A-4
F-2	Deepen existing drainage channel, plant riparian vegetation	EM A-4
F-3	Replace frequently flooded orchard with riparian vegetation	EM A-6, AM A-4
F-4	Designate orchard conservation zones	AM A-1 and 2
G	Plant riparian & upland vegetation	EM A-7, FM A-4
H	Create inlet swale, plant riparian vegetation	EM A-9
I	Create inlet swale, improve drainage, plant riparian vegetation	EM A-10, FM A-4
J-1	Create inlet swale	EM A-11
J-2	Action modeled but not recommended (see App H)	
J-3	Improve drainage and shorten Pump Plant-2 ditch with new outlet swale	FM A-5, EM A-11
K	Cease clearing riparian vegetation in widened floodway	EM A-12, FM A-6
L-1	Plant riparian forest and oak woodland	EM A-13
L-2	Plant perennial grassland & oak savanna	EM A-13
L-3	Excavate bench, create SRA	EM A-13
M	Reduce constriction	FM A-7
N	Realign hook levee	FM A-8

Sources: cbec 2013; data compiled by AECOM in 2013

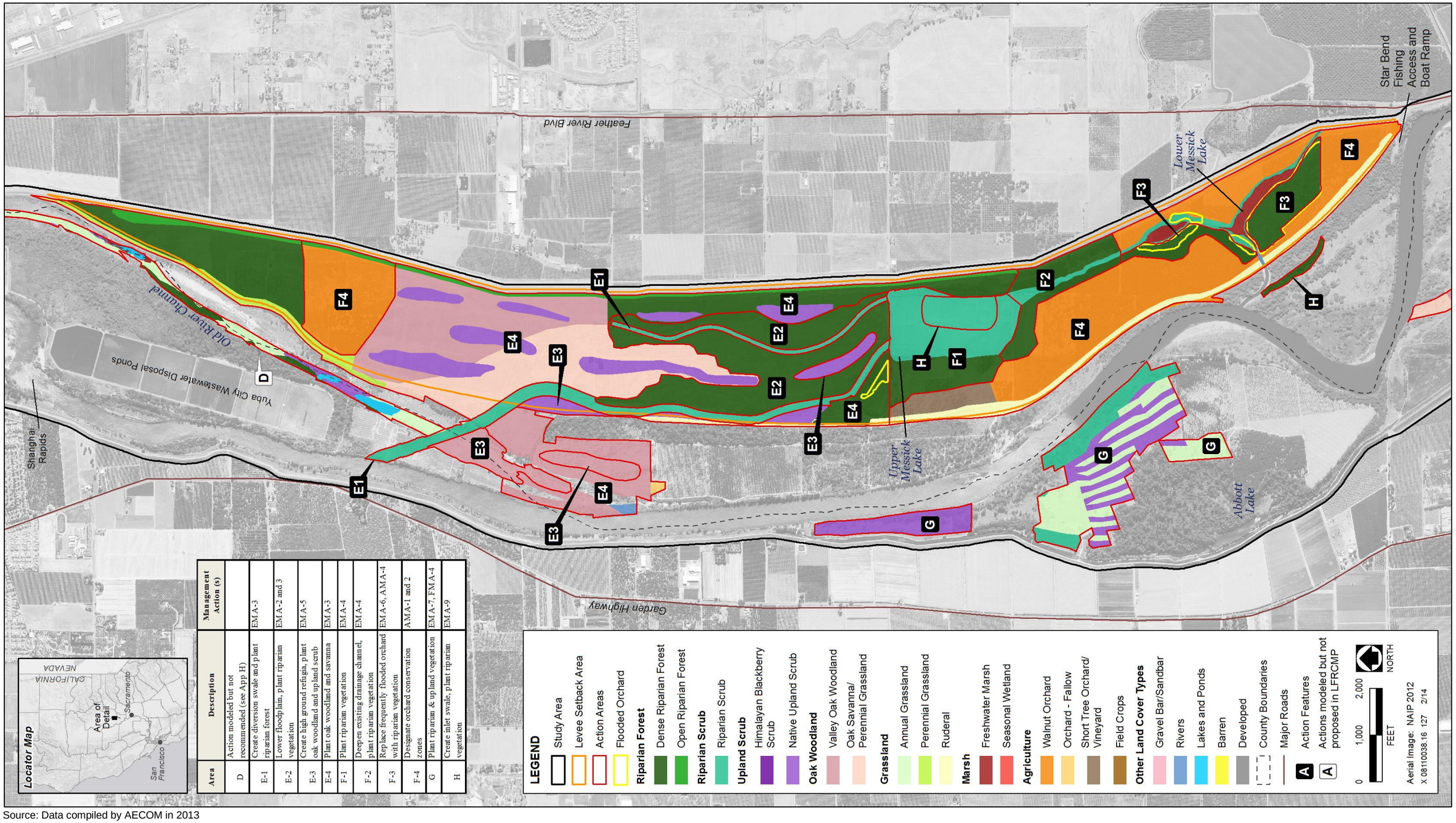
Exhibit 6-1 **Locations of Proposed Floodway/Ecosystem Enhancement Actions in the LFRCMP Study Area**



Sources: cbec 2013; data compiled by AECOM in 2013

Exhibit 6-2

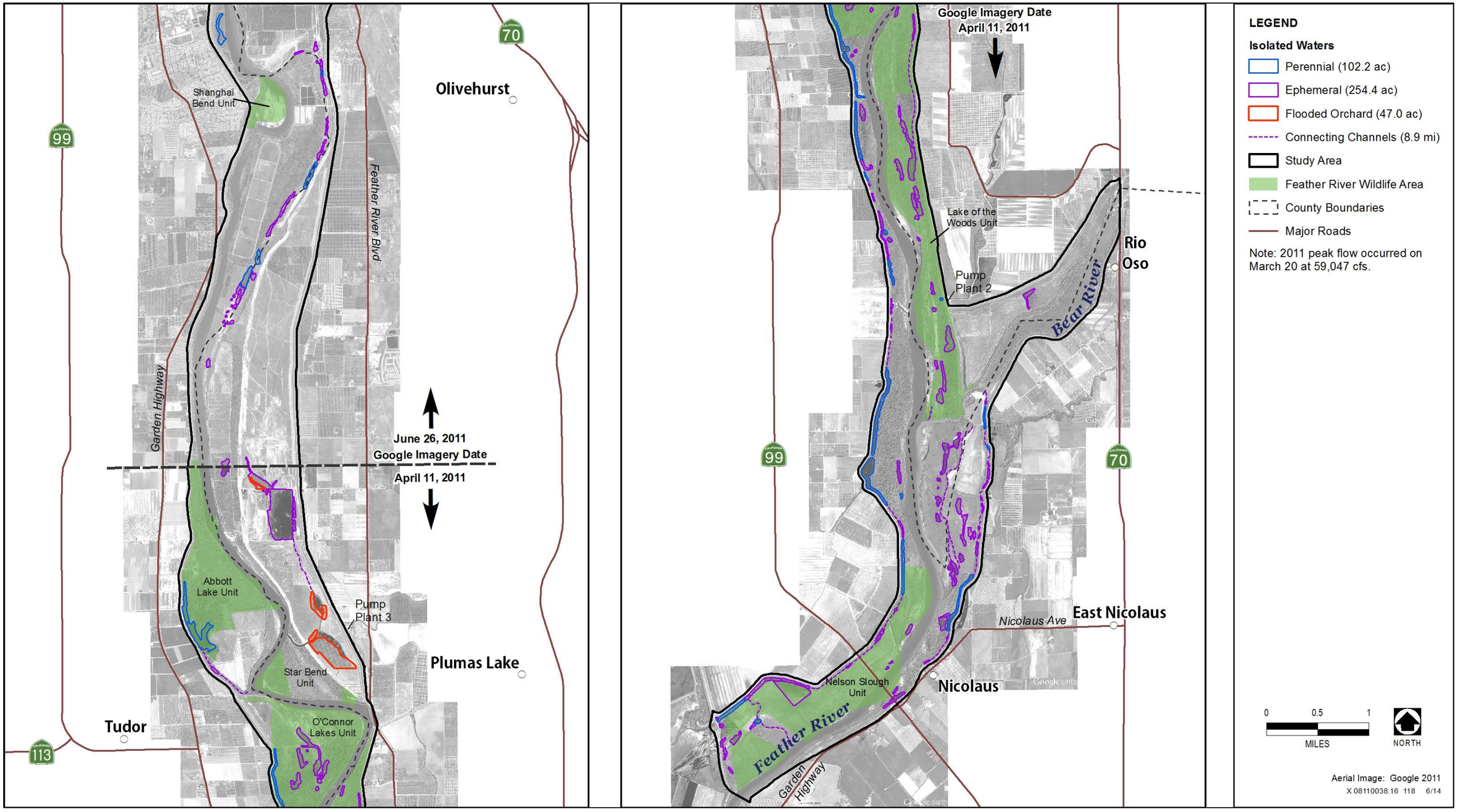
Current and Future Vegetation in the Proposed LFRCMP Action Areas



Area	Description	Management Action (s)
D	Action modeled but not recommended (see App H)	
E-1	Create diversion swale and plant riparian forest	EM A-3
E-2	Lower floodplain, plant riparian vegetation	EM A-2 and 3
E-3	Create high ground refugia, plant oak woodland and upland scrub	EM A-5
E-4	Plant oak woodland and savanna	EM A-3
F-1	Plant riparian vegetation	EM A-4
F-2	Deepen existing drainage channel, plant riparian vegetation	EM A-4
F-3	Replace frequently flooded orchard with riparian vegetation	EM A-6, AMA-4
F-4	Designate orchard conservation zones	AMA-1 and 2
G	Plant riparian & upland vegetation	EM A-7, FM A-4
H	Create inlet swale, plant riparian vegetation	EM A-9

Source: Data compiled by AECOM in 2013

Exhibit 6-3 **Future Vegetation in the Feather River Setback Area**



Source: Data compiled by AECOM in 2013

Exhibit 6-4 **Isolated Waters After Recession of 2011 High Flows in the LFRCMP Study Area**

Flood Management Action 5: Improve Levee Borrow Channel Drainage at Lake of the Woods, and Shorten Pump Plant 2 Drainage Ditch. At approximately RM 13.5 on the left bank, excavate an improved drainage swale (Exhibit 6-1, Area J-3 and Exhibit 6-4) to drain the waterside levee borrow channel at Lake of the Woods, reduce fish entrapment, and create more frequent flow-through to the river. This action, coupled with Ecosystem Management Action 11, would increase the frequency of floodplain activation, improve the water quality of stagnant isolated ponds and back channels, and periodically contribute natural organic matter to the river ecosystem. The new drainage swale would also enable replacement of the existing 7,000-foot-long stormwater drainage ditch for Pump Plant 2 (Exhibit 6-1, Area J-3) with a much shorter, 700-foot drainage route. These two actions would combine two important LFRCMP objectives: benefiting flood management through a ten-fold reduction in the extent of maintenance and periodic clearing of vegetation along the existing drainage ditch that flows 1.3 miles across Lake of the Woods to the Bear River confluence; and enhancing the ecological function of a natural floodplain. This new drainage swale would also eliminate the need for vegetation clearing and disturbance of riparian and aquatic habitats on more than 1 mile of existing maintenance road. The new swale could be designed to avoid or minimize removal of existing riparian vegetation by routing the swale through existing corridors, where woody vegetation has been thinned or cleared by DWR to maintain floodway capacity. Periodic inspections and maintenance of the new swale would be needed to ensure it functions as designed and is not overtaken with invasive vegetation. The swale design could also incorporate an eleveated “all-weather” side road with adequate width, stable bank slopes, and vehicle turnouts to facilitate easy access for inspections and maintenance. The existing ditch that would be abandoned would continue to function as both a seasonal wetland and perennial marsh, supported by backwater from a frequent, higher stage in Feather River at the Bear River confluence.

Flood Management Action 6: Cease Vegetation Clearing at Lake of the Woods from RM 13.5 to RM 12.5. Cease vegetation clearing in the Lake of the Woods Unit of the FRWA along a mile-long corridor from RM 13.5 to RM 12.5, west of where the old levee was removed for the Bear River levee setback project (Exhibit 6-1, Area K and Exhibit 6-2), to facilitate natural regrowth and maturation of riparian vegetation with no increase in flood water surface elevation. Flood simulation modeling, described in Chapter 5, “Hydraulic, Hydrologic, and Sediment Transport Modeling of Potential Future Conditions,” demonstrates that this portion of the Bear River setback area provides adequate floodway capacity even if fully vegetated with dense riparian habitat. In the absence of recurring vegetation maintenance, this management action would reduce the costs of floodway maintenance by eliminating the need for frequent vegetation removal on approximately 95.8 acres. By allowing natural revegetation to occur, this action would also improve the extent and connectivity of riparian habitat in the Lake of the Woods Unit. Weed monitoring and non-native vegetation control should occur within this corridor until native plant species are well established.

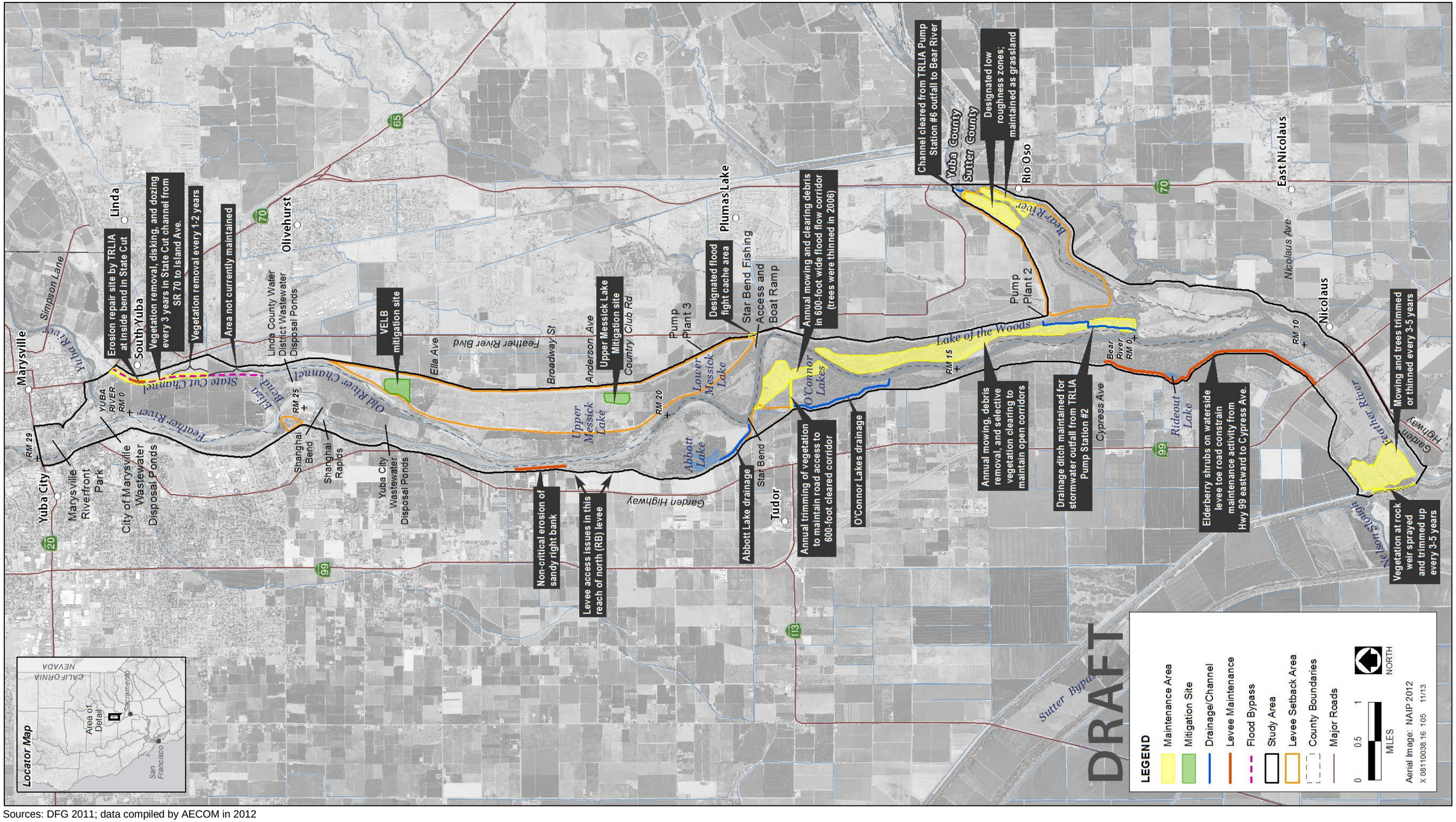
Flood Management Action 7: Set Back Corner Levee at Constriction from RM 7.7 to RM 7.4 (Left Bank). Set back the corner levee on the left bank at the sharp bend in the Feather River from RM 7.7 to RM 7.4 (Exhibit 6-1, Area M), to expand the width and capacity of the river channel in this highly constricted reach. As described in Chapter 5, “Hydraulic, Hydrologic, and Sediment Transport Modeling of Potential Future Conditions,” hydraulic model analyses (Appendix G and Appendix H) showed very high velocities and bed scour potential in the channel at this location, which is close to the east levee on one side and abuts the Sutter Bypass hook levee on the opposite right (west) bank of the river. A relatively small setback levee at the corner bend would reduce channel velocity and the risk of levee toe scour by increasing the radius of curvature in the levee, creating a wider flow pathway for the river channel between the two levees, and a wider berm and margin of

safety between the levee and the river bank. The public safety benefits of implementing Flood Management Action 7 would be amplified if combined with Flood Management Action 8 at the confining hook levee.

Flood Management Action 8: Reevaluate and Realign Portions or All of the Sutter Bypass Hook Levee. Realign portions or all of the Sutter Bypass hook levee (RM 7.3 to 7.0), a discontinuous training levee on the right bank of the Feather River at Nelson Slough (Exhibit 6-1, Area N). This action would increase river floodway capacity at this constriction, reduce the high velocity of flood flows in the channel bend, and reduce scour of the river bed near the left-bank levee. Hydraulic and sediment transport modeling of the 10- and 100-year floods conducted by cbec, Inc. (Appendix H) indicates deep channel scour and very high velocity within the constricted channel, between the training hook levee and the east levee of Feather River, and depositional patterns upstream of the artificial constriction. Additional hydraulic and geomorphic analysis is needed to determine the best realignment of the training levee, and to evaluate the feasibility of relocating the hook levee westward, farther from the left bank of the Feather River. The hook levee and a rock weir at Nelson Slough were constructed in 1950, before construction of flood control dams at Oroville and New Bullards Bar, to reduce sediment deposits in the Sutter Bypass and prevent avulsion of the Feather River into the bypass. Since 1950, the bed of the river has continued to incise relative to the elevation of the high floodplain at Nelson Slough. Recent sediment-transport modeling does not indicate a tendency for channel migration at this location, but deep scour potential at the levee toe is a concern.

Flood Management Action 9: Incorporate Invasive Plant Control BMPs into Routine Maintenance Activities. Vegetation management needed for floodway maintenance would integrate flood protection and ecosystem enhancement by targeting non-native, invasive plants during maintenance operations (Exhibit 6-5). The Maintenance Plan (Appendix L) recommends incorporating invasive plant control in routine maintenance activities, specifically targeting control of established non-native species such as Himalayan blackberry, black locust, tree of heaven, arundo (false bamboo), eucalyptus, and perennial pepperweed, and preventing introduction of new, highly invasive plants such as red sesbania, tamarisk, and fig. These species harm native plant and wildlife communities, impede inspection of levee slopes, and diminish floodway capacity. Invasive plants should be managed on DWR-maintained land and at DWR facilities to prevent the establishment of new infestations of invasive plants and control existing infestations. These prevention and control measures could be accomplished through development of a comprehensive set of best management practices (BMPs), integrated with LFRCMP maintenance activities. Invasive plant control BMPs should also be applied to maintenance activities on CDFW and FRS area lands. The CVFPP Conservation Strategy will also include an invasive species management plan, and the LFRCMP Maintenance Plan BMPs will be consistent with that plan.

Flood Management Action 10: Monitor Floodway Roughness and Vegetation Patterns. Monitor and maintain records of ongoing revegetation and mitigation projects within the floodway, and periodically monitor vegetation trends in other areas. One of the purposes of this monitoring is to prevent future roughness patterns and proposed planting projects from exceeding the overall density of vegetation or vegetation types assumed under future conditions, as described in Appendix M and as depicted in Exhibits 6-2 and 6-3. Chapter 8, "Implementation, Tracking, and Monitoring," and Appendix L provide additional information on monitoring floodway roughness and how this monitoring would be used to inform decisions about maintenance practices and proposed restoration activities.



Sources: DFG 2011; data compiled by AECOM in 2012

Exhibit 6-5 **Floodway Maintenance Areas and Activities in the LFRCMP Study Area**

Flood Management Action 11: Continue Periodic Levee Integrity Inspections. Ongoing levee integrity inspections should continue in the LFRCMP study area; in particular, monitor sub-critical bank erosion identified at RM 21.6 to RM 22.1 right bank (west levee), and the left bank (east levee) at RM 7.5 to RM 8.0 at the Nelson Slough hook levee constriction and at Star Bend downstream of the boat ramp (Exhibit 6-5). Construct bank protection projects as necessary to prevent any risk of levee instability at these or other future locations. Minimal threats exist to levee integrity from riverbank erosion in the LFRCMP study area because of the width of the floodway, distance from levees to the active channel, channel planform stability, and the occurrence of naturally resistant geology exposed in banks at some locations (Modesto and Riverbank formations).

6.2 ECOSYSTEM FUNCTION AND HABITAT ENHANCEMENT MANAGEMENT ACTIONS

Ecosystem Management Action 1: Restore Intermittent Flow to the Old Feather River Channel at Eliza Bend. Restore intermittent backwater and periodic flow by allowing more frequent high flows into Old Feather River (from the river mouth at RM 25.3 to the eastside floodplain at the State Cut bypass; Exhibit 6-1, Area C). By removing the channel plug on the left (east) bank of the Feather River, a portion of high river flows would be diverted into the historic Old Feather River channel at Eliza Bend. To further enhance periodic flows in the Old Feather River channel, remove high deposition mounds in the channel and establish a minimum channel width and gradient (see Chapter 5 and Appendix H) from the Feather River to the confluence with the lower State Cut channel. Restoring ecosystem processes (i.e., greater frequency and volume of flows to the historic Feather River floodplain) with this action would increase seasonal shallow aquatic habitat and frequently inundated floodplain, and would enhance the existing riparian and shaded riverine aquatic habitat. Restoration of intermittent flows to the eastside floodplain would also enhance nutrient recycling and input of organic matter to the river and floodplain.

Ecosystem Management Action 2: Restore 500 Acres of Riparian and Upland Habitat in the FRS Area. Implement the restoration plan, described in the Three Rivers Levee Improvement Authority (TRLIA) Feather River Floodway Corridor Restoration Project (TRLIA 2013), to establish approximately 300 acres of mixed riparian forest, riparian scrub, and valley oak woodland, and approximately 200 acres of grassland in the FRS area (Exhibits 6-3 and 6-6). (See Appendix M for additional information.) TRLIA will secure the permits for the project and undertake all restoration activities, and will be responsible for managing and maintaining the restored area during the establishment phase. TRLIA has also established an endowment fund to cover the costs of long-term management and maintenance (TRLIA 2013). The property was purchased by TRLIA for the State and is currently being managed under TRLIA fee ownership until it is transferred to either DWR or CDFW (TRLIA 2013).

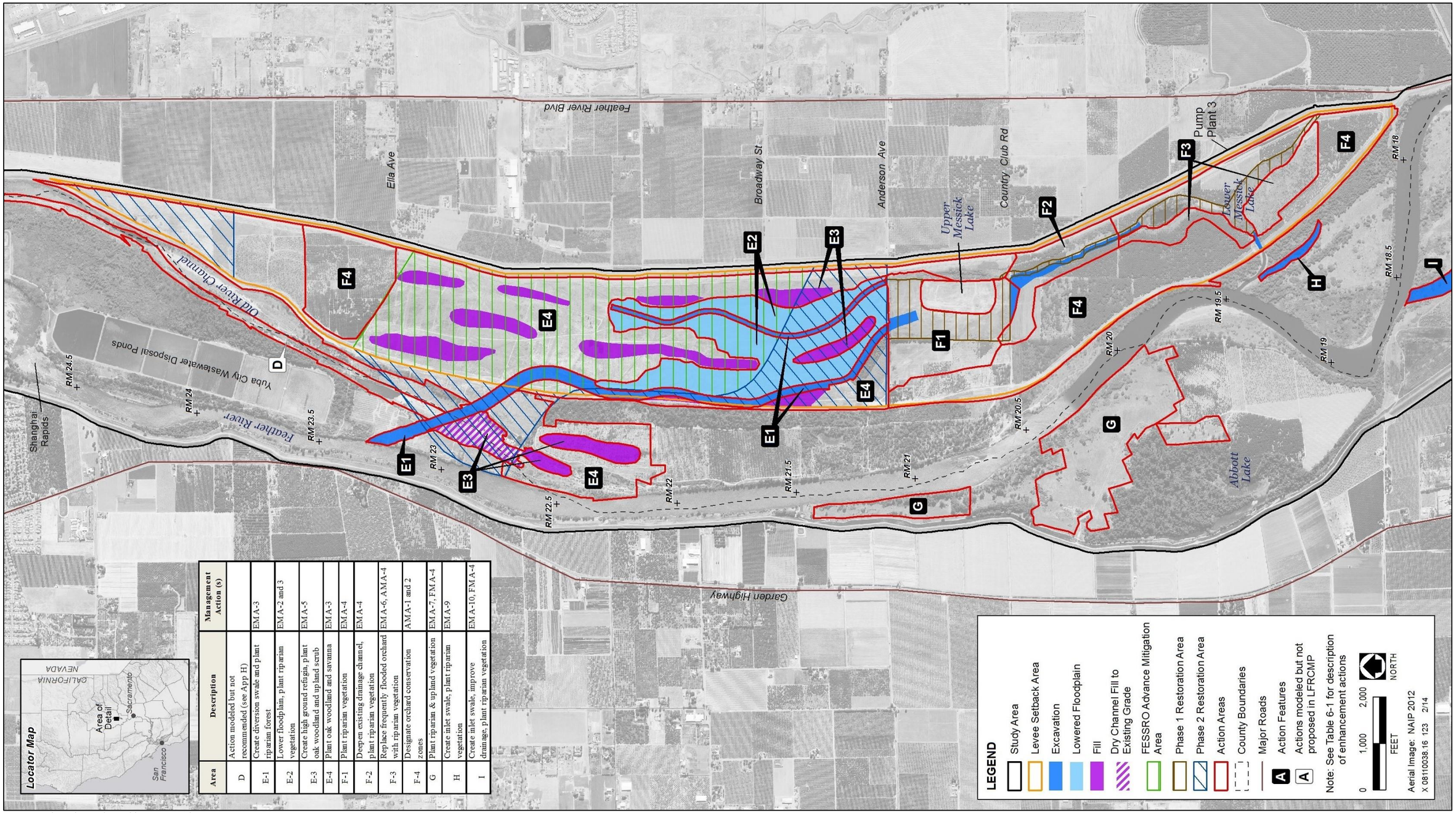
Ecosystem Management Action 3: Distribute Overbank Flows in Swales and Revegetate the Northern FRS Floodplain. Create a high-flow diversion swale from the Feather River at RM 23.3, left (east) bank, and excavate a swale through the high ground at the northwest end of the FRS (Exhibits 6-1 and 6-6, Area E-1). In creating the swale, evaluate the possible need for hardening (rock armoring) the entrance to the diversion swale, given the erodibility of the overlying hydraulic mining sediments at this location. Connect this diversion swale with the low floodplain and an east drainage swale north of Upper Messick Lake. Lower/excavate the floodplain grade north of the basin at Upper Messick Lake, to increase the extent of the frequently inundated floodplain (Exhibits 6-1 and 6-6, Area E-2). Plant native shade trees and shrubs along the east and west swale margins and on swale benches;

plant an extensive mosaic of riparian forest and scrub, oak woodland, and native perennial grassland throughout the FRS floodplain and swale complex (Exhibit 6-3). By distributing more frequent overbank flows across a revegetated FRS floodplain through existing and created riparian swales, and into and through Upper Messick Lake seasonal wetlands to Lower Messick Lake (Ecosystem Management Action 4), these two management actions would increase the extent, diversity, and connectivity of seasonal shallow aquatic habitat, frequently inundated floodplain, shaded riverine aquatic habitat, riparian habitat, and riparian/upland habitat mosaics. These actions would also improve water quality and increase the frequency of flushing flows that cross the FRS floodplain and pass through Upper and Lower Messick lakes, then drain to the Feather River. In addition, distribution of overbank flows on the floodplain would provide transitory storage for floodwaters.

Ecosystem Management Action 4: Enlarge Existing Swale to Improve Drainage in the Southern FRS Floodplain, and Plant Riparian Forest and Willow Scrub. Improve drainage and through-flow of the basin formed at the Upper Messick Lake mitigation site by enlarging the existing drainage channel that begins at the southeast corner of the basin, where it passes under Country Club Road. Improve (deepen and widen) this existing, undersized drainage channel between Upper and Lower Messick lakes (Exhibits 6-1 and 6-6, Area F-2), while maintaining a minimum excavation distance of 400 feet from the new levee toe. Plant riparian forest and scrub in the west and south portions of the Upper Messick Lake basin (Exhibits 6-1 and 6-3, Area F-1), and along the banks of the enlarged drainage channel between Upper and Lower Messick lakes (Exhibit 6-1 and 6-3, Area F-2). These actions would expand the area of frequently inundated, forested floodplains to promote nutrient recycling and add organic matter to the river, and would increase the extent, frequency, and connectivity of perennial and intermittent shaded riverine aquatic habitat (Exhibit 6-3). In addition, by enlarging the existing drainage outlet and channel to Lower Messick Lake, this action would enhance the drainage capacity of the FRS floodplain, slowing the recession of high flows, and would reduce fish entrapment in the Upper Messick Lake basin.

Ecosystem Management Action 5: Create High-Ground Flood Refugia for Wildlife in the FRS Area. Using excavated material from the swales and lowered floodplain (as described above), create ridge mounds as high-ground refuge for terrestrial wildlife during flood events. To provide cover as well as foraging and breeding opportunities, plant mounds with upland scrub vegetation and valley oak woodland (Exhibits 6-1, 6-3, and 6-6, Area E-3). As described in Chapter 5, “Hydraulic, Hydrologic, and Sediment Transport Modeling of Potential Future Conditions,” and in Appendix H, by creating linear mounds aligned with the direction of flood flow in combination with excavated swale flow paths, and by placing the mounds on existing high ground, the newly created refugia would not cause an increase of flood water surface elevation. Approximately two-thirds of these mounds would provide refuge in a 100-year flood event, and all mounds would provide refuge during a 10-year flood event. Under existing conditions, the east and west levees and levee roads are the only high-ground refuge under major flood conditions. Sediment transport modeling of 10- and 100-year flood events indicates minor, inconsequential potential for deposition or scour on the floodplain surrounding the ridge mounds.

Ecosystem Management Action 6: Replace Frequently Inundated Orchard Areas near Lower Messick Lake with Riparian Forest/Scrub Habitats. With the setback of the Feather River levee, orchards bordering Lower Messick Lake are now on the waterside of the levee. Approximately 60 acres of orchard on lower elevations are inundated throughout much of the growing season, every 2–3 years on average (see the frequently flooded orchard area in Exhibit 6-4). These flood-prone orchards have suffered considerable, incremental mortality and stunted growth in recent years. Hydraulic modeling by cbec, Inc. (Appendix H) confirms that these



Area	Description	Management Action (s)
D	Action modeled but not recommended (see App H)	
E-1	Create diversion swale and plant riparian forest	EMA-3
E-2	Lower floodplain, plant riparian vegetation	EMA-2 and 3
E-3	Create high ground refugia, plant oak woodland and upland scrub	EMA-5
E-4	Plant oak woodland and savanna	EMA-3
F-1	Plant riparian vegetation	EMA-4
F-2	Deepen existing drainage channel, plant riparian vegetation	EMA-4
F-3	Replace frequently flooded orchard with riparian vegetation	EMA-6, AMA-4
F-4	Designate orchard conservation zones	AMA-1 and 2
G	Plant riparian & upland vegetation	EMA-7, FMA-4
H	Create inlet swale, plant riparian vegetation	EMA-9
I	Create inlet swale, improve drainage, plant riparian vegetation	EMA-10, FMA-4

Sources: cbec data adapted by AECOM in 2013; TRLIA 2013

Exhibit 6-6 **TRLIA/FESSRO Advance Mitigation Area and Restoration Phases in the Feather River Setback Area**

orchard areas are within the 2-year floodplain. With exposure to flood flows and saturated, anaerobic soil conditions, this low-lying area now is unsuitable for orchards and other perennial crops, and is topographically and hydrologically better suited to support flood-tolerant riparian forest and willow scrub (Exhibits 6-1 and 6-3, Area F-3). As described below under "Agricultural Management Actions," the conversion of frequently flooded orchard could potentially be offset, if necessary, with creation of new orchards or cropland on higher ground in areas that currently support only ruderal habitat or annual grassland and wildlife habitat values are low. Such areas are located at the north end of the FRS or on State land or on TRLIA parcels located on high ground between the FRS Old Levee Road and the Feather River.

Ecosystem Management Action 7: Restore 169 Acres of Riparian and Upland Habitat, and Enhance 270 Acres at Abbott Lake. Implement the proposed CDFW/River Partners plan for restoration and enhancement activities in the Abbott Lake Unit of the FRWA (River Partners 2010). The Abbott Lake restoration plan calls for planting a valley foothill riparian woodland community on 36 acres and three variations of a shrubland community on 98 acres. Native perennial grasslands would cover 35 acres, making the total size of the restoration 169 acres (Exhibits 6-1 and 6-3, Area G). The project would include habitat enhancement on the remaining 270 acres of the Abbott Lake Unit, which has remnant riparian forest, focused mainly on control of invasive species, such as tree-of-heaven, Himalayan blackberry, and black locust. The proposed restoration and enhancement would increase the quality and continuity of riparian habitat along the river corridor.

Ecosystem Management Action 8: Improve Drainage at Abbott Lake and O'Connor Lakes. Remove debris and clear culverts and sediment that are blocking drainage to the river, and install one or more water-control weirs at outlets to the river (see Exhibit 6-5). These actions would improve drainage to the river as high flows recede and would reduce fish entrapment in poorly drained isolated depressions and the back channels of levee toe ditches (Exhibit 6-4). In addition to enhancing seasonal wildlife habitat with managed water levels, these actions would minimize levee threats by managing water levels in the back channel adjacent to the levee. These actions would be similar to and would complement Flood Management Action 4.

Ecosystem Management Action 9: Increase Overbank Flow Across the Low Ground at Star Bend and Expand Riparian Habitat. Excavate a high-water overbank swale, branching from the existing FRS drainage swale into the existing forested swale (RM 19.5 to RM 18; Exhibits 6-1 and 6-6, Area H) and plant native shade trees along the new swale margins (Exhibit 6-3). This action would increase the extent, diversity, and connectivity of floodplain habitats by increasing the frequency of the overbank flow across the natural low ground at Star Bend, and would restore more frequent nutrient recycling and input of organic matter to the river and floodplain.

Ecosystem Management Action 10: Create an Overbank Swale and Vegetated Bench at O'Connor Lakes. Excavate a notch in the high right bank at the O'Connor Lakes Unit of the FRWA and create a 100- to 300-foot-wide overbank swale and bench across the floodplain and through the existing DWR-managed floodway corridor and grassland area (RM 18.8 to RM 16; Exhibits 6-1 and 6-6, Area I). Remove debris, clear culverts and sediment in back channels that are blocking drainage to the river, and install a water-control weir at the outlet to the river (see also Flood Management Action 9). Plant native shade trees along the new swale margins and bench (Exhibit 6-2). These actions would increase the frequency of overbank flow onto the floodplain and into and through the O'Connor Lakes Unit; would improve habitat and water quality of the natural lakes by introducing more frequent flushing flows; would improve through-flow and drainage of the forested floodplain to the river; and would increase nutrient recycling and input of organic matter to the river. In addition, these actions would reduce fish

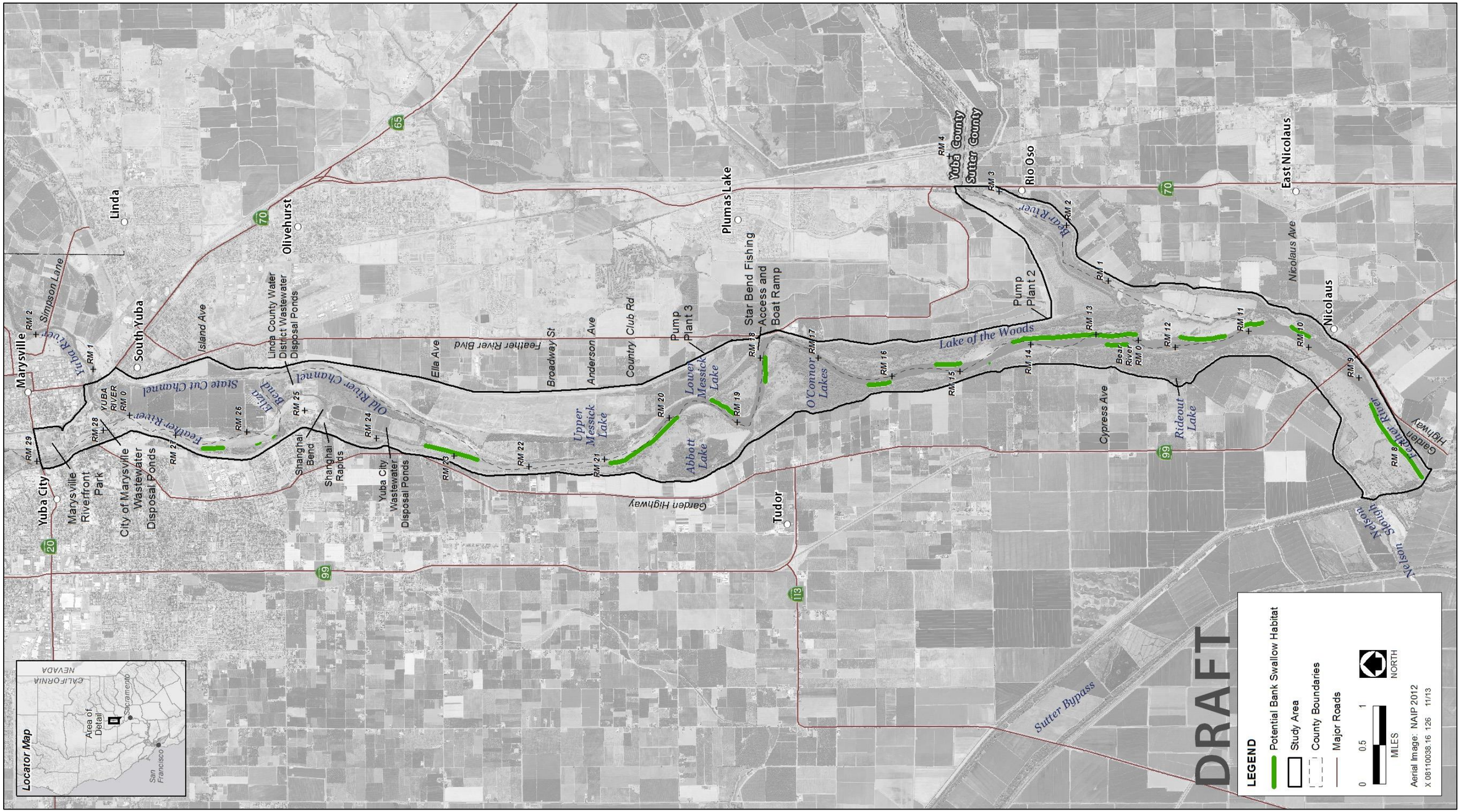
entrapment and would enhance seasonal wildlife habitat while minimizing levee threats, by managing water levels and improving drainage in the back channel near the levee.

Ecosystem Management Action 11: Create an Inlet Swale to Increase Overbank Flow into and through Lake of the Woods. Create an overflow inlet swale in the left bank of the Feather River at RM 17 (Exhibit 6-1, Area J-1) and improve the outlet swale at RM 13.5 (see Recreation Management Action 3 below; Exhibit 6-1, Area J-3), to increase the frequency and duration of floodplain inundation and improve through-flow to the river. Exhibit 6-4 shows a network of isolated depressions and historic levee borrow canals that are laced through the floodplain of Lake of the Woods, which become disconnected ephemeral ponds as high flows recede. The proposed swale would connect and drain many of these isolated depressions and back channels, to reduce fish entrapment, improve water quality, and enhance through-flow to the river. Other uncharted constrictions and barriers to natural drainage may exist that would need to be surveyed and improved as necessary. Close coordination with NMFS, USFWS, and CDFW will be needed during planning and implementation of this management action.

Ecosystem Management Action 12: Allow Natural Vegetation Succession to Occur at Lake of the Woods from RM 13.5 to RM 12.5. Flood Management Action 6 would eliminate vegetation clearing in the Lake of the Woods Unit of the FRWA along a mile-long corridor from RM 13.5 to RM 12.5, parallel to where the old levee was removed for the Bear River levee setback project (Exhibit 6-1, Area K). In the absence of annual vegetation management by DWR-Maintenance Area 3 in this reach, this would allow natural vegetation succession to occur along approximately 96 acres of Lake of the Woods adjacent to the river (Exhibit 6-2). Flood modeling has shown that this segment of the Bear River setback area, where the east levee was removed, provides adequate floodway capacity even if fully vegetated with dense riparian habitat. By allowing natural succession to occur, this action would also increase the extent and improve connectivity of riparian and shaded riverine aquatic habitat along the river, and would eliminate habitat disturbance from frequent vegetation removal in the southern portion of Lake of the Woods. Weed monitoring and non-native vegetation control should occur within this corridor until native plant species are well established.

Ecosystem Management Action 13: Create Shaded Riverine Aquatic Habitat and a Mosaic of Riparian/Upland Habitat at Nelson Slough. Excavate a 20- to 50-foot-wide low bench on the mostly barren right bank of the river at the Nelson Slough Unit of the FRWA and plant dense riparian vegetation on the bench to create perennial shaded riverine aquatic habitat along the river bank in Area L-3 (Exhibits 6-1 and 6-2). Plant a mosaic of riparian forest and oak woodland in Area L-1 (Exhibits 6-1 and 6-2), and native perennial grassland and oak savanna in Area L-2 (Exhibits 6-1 and 6-2) on the existing high floodplain of the Nelson Slough Unit (RM 9 to RM 7.3). These actions would increase the extent and diversity of riparian floodplain habitats and riparian/upland habitat mosaics, and would create additional shaded riverine aquatic habitat along a mostly steep, barren bank of the lower Feather River. Enhanced aquatic and terrestrial habitat values would be increased without compromising floodway capacity of the river and the Sutter Bypass, by limiting higher roughness vegetation to the ineffective flow zone at the north side of Nelson Slough and on the excavated low bench.

Ecosystem Management Action 14: Designate Bank Swallow Potential Habitat Areas. As part of the permitting efforts described in Chapter 7, “Permitting Strategy,” protect current and future bank swallow habitat by establishing conservation areas or another protective designation for potential bank swallow habitat (Exhibit 6-7). The areas shown in this exhibit are river banks that meet criteria important for bank swallow habitat



Source: Data compiled by AECOM in 2013

Exhibit 6-7 **Potential Bank Swallow Habitat in the LFRCMP Study Area**

(BANS TAC 2013), such as being adjacent to the river shoreline on steep and/or eroding river banks, especially at outside bends. Because bank migration is a natural process that may create suitable swallow habitat conditions, these potential habitat areas were established only in areas where a potential bank retreat poses no risk to levees, infrastructure, commercial orchards, or private property. An exception is a location on a large, privately owned parcel that supports one of only two large colonies of bank swallows on the LFR. This nest site borders unimproved grazing land, and the landowner may be amenable to a conservation agreement to provide long-term protection of a significant bank swallow nesting colony. In addition, management actions within the LFRCMP should follow the Bank Swallow Technical Advisory Committee's conservation recommendations (BANS TAC 2013) to avoid, minimize and mitigate any potential impacts to bank swallow habitat, colonies or individuals. These recommendations include evaluating the feasibility of revetment removal in areas where bank protection is no longer deemed necessary, in order to promote restoration of natural riverine process and create SRA habitat and bank swallow nesting opportunities.

Ecosystem Management Action 15: Reduce Unscreened Fish Diversions. Collaborate with local landowners, water districts, and the Family Water Alliance (see http://fwafishforum.com/), to encourage water users to screen unscreened diversions and pumps to minimize mortality of listed salmonids and other fish species (Exhibit 6-8). Juvenile salmonids are particularly vulnerable to unscreened water diversions during outmigration and while rearing and feeding in shallow zones on channel margins near water intake facilities.

Ecosystem Management Action 16: Identify and Implement Feasible Opportunities to Modify Reservoir Operations for Ecosystem Benefit. Operational changes to floodwater storage, reservoir forecasting, dam and weir operations, coordinated operation of multiple reservoirs (e.g., Oroville, Thermalito, New Bullards Bar, Englebright, Camp Far West), and conjunctive management of groundwater could provide opportunities to enhance the ecological benefits of bankfull and overbank flows, improve water quality and nutrient recycling, and facilitate natural establishment of riparian habitats and early successional vegetation. This management action is consistent with one of the recommendations in the CVFPP Conservation Framework (DWR 2012): to collaborate with others on the planning and implementation of the Federal Energy Regulatory Commission license and settlement agreement for Oroville Reservoir, to potentially provide river flows that produce environmental benefits such as frequently inundated floodplains and improved spawning habitat conditions. DWR’s System Reoperation Program evaluates reoperations strategies with respect to their ability to improve water supply reliability, flood hazard reduction, ecosystem protection and restoration, and water quality improvement. Opportunities for enhancing natural riverine processes in the LFR corridor would be assessed in the context of existing laws, agreements, and regulation. If operational modifications were implemented for the benefit of restoring ecosystem processes and enhancing habitat, the modifications would not result in any increase of flood risk.

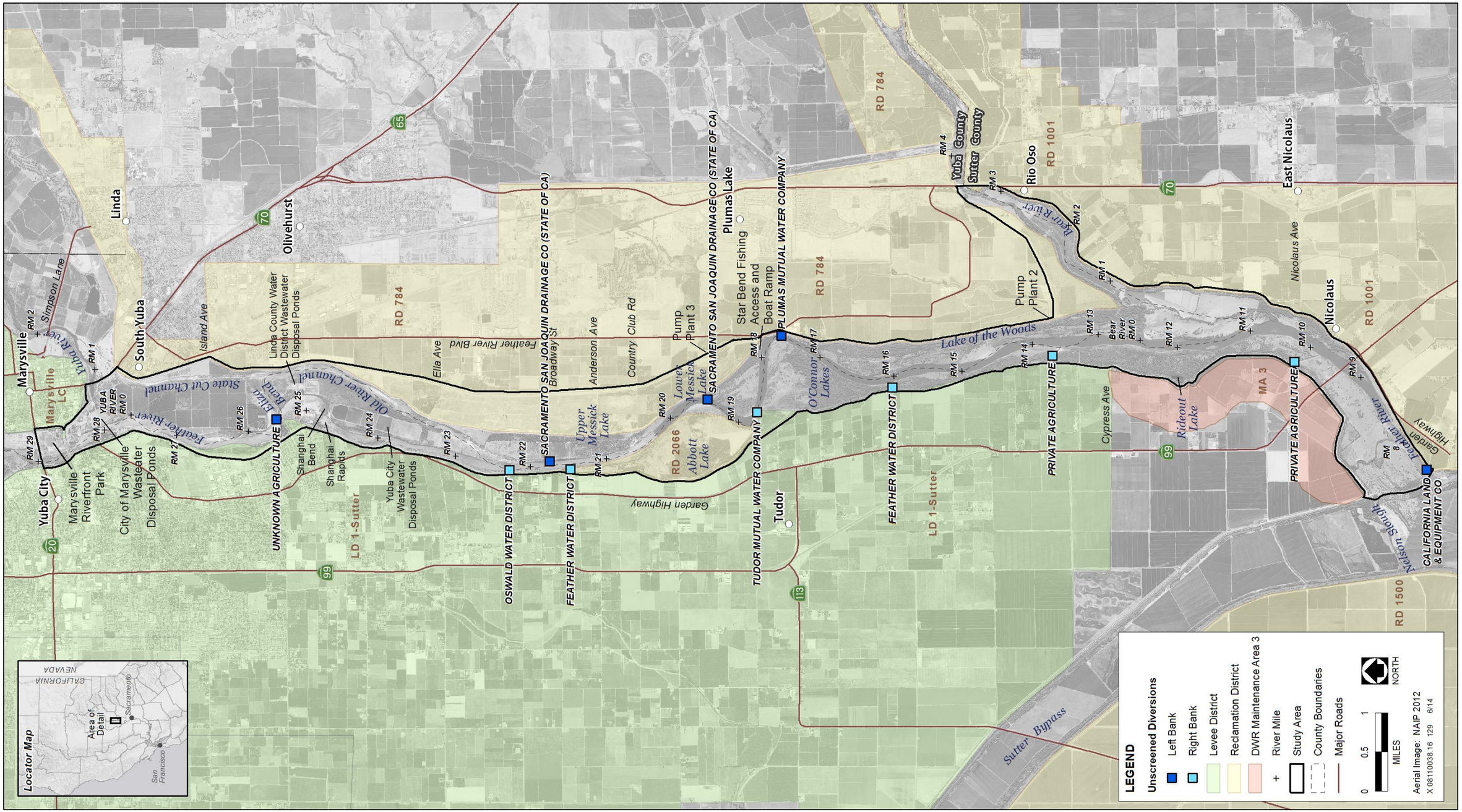
Ecosystem Management Action 17: Identify Suitable Locations for and Plant Live Cuttings on Suitable Low Flow Shoreline Sites to Increase Shaded Riverine Aquatic Habitat. During typical summer/fall low-flow conditions, large stretches of the riverbank are barren or devoid of overhanging riparian vegetation because of channel incision, steep banks, and altered river hydrology that is unfavorable to natural colonization of native trees and shrubs. However, moist soil on the lower banks and sand bars at river’s edge could potentially be live-staked with cottonwood and willow cuttings, without irrigation, in a narrow band along the river shorelines where capillary moisture conditions are favorable. Acorns of valley oak could also be planted on moist floodplains and in low, moist depressions, by harvesting acorns from existing oak woodlands in the

fall. Valley oaks have a respectable survival rate without irrigation under favorable soil conditions, and once established, are very tolerant of prolonged inundation in the dormant season. An important criterion for identifying suitable locations for shoreline plantings of cuttings and acorns is that planting should not occur where additional roughness in the floodway is unacceptable because of inadequate floodway capacity, or in potential bank swallow habitat areas.

6.3 RIVER RECREATION RECOMMENDED MANAGEMENT ACTIONS

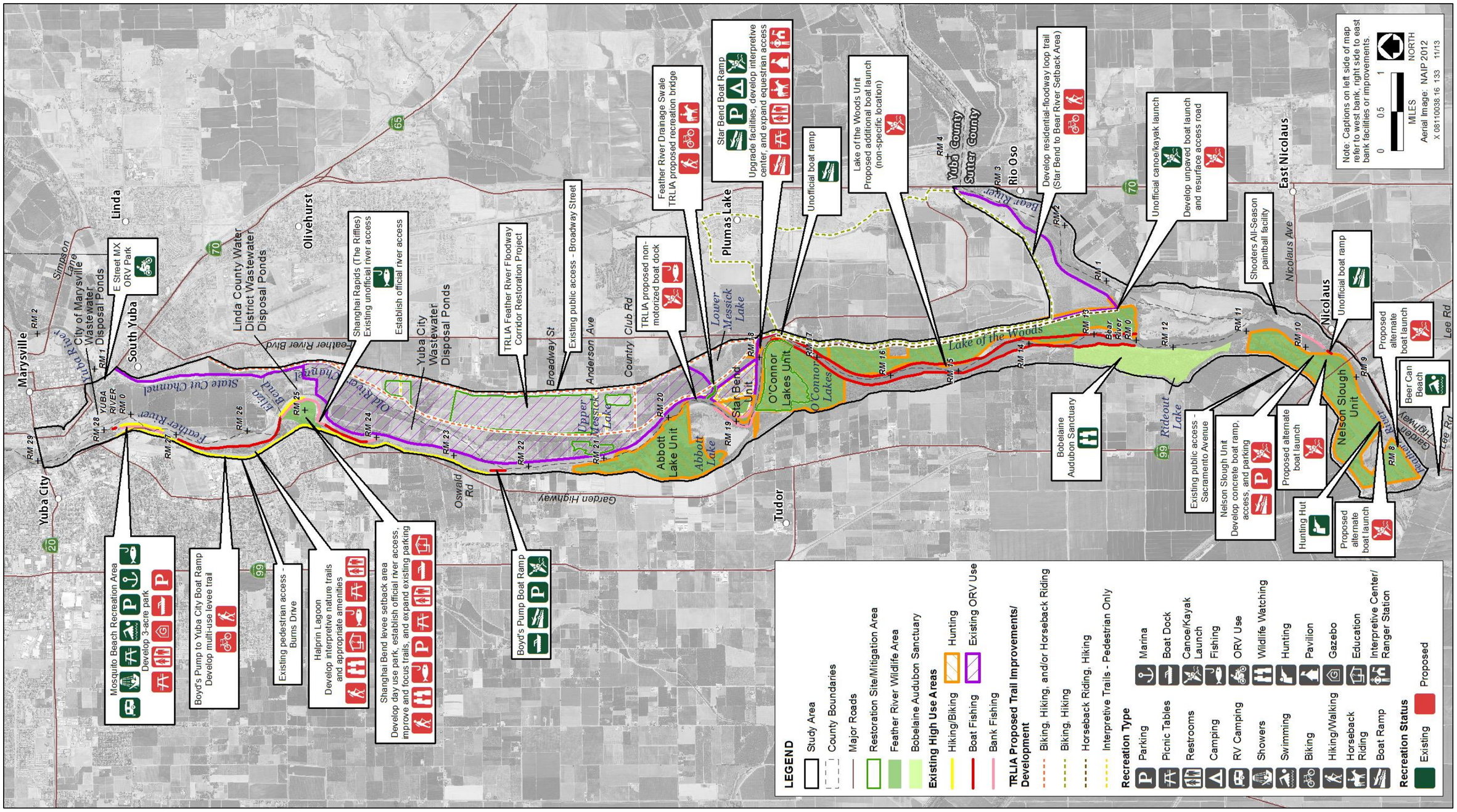
Recreation Management Action 1: Create Trails and River Access in the TRLIA FRS Area. Develop trails and river access consistent with improvements described in the TRLIA's Feather River Floodway Corridor Restoration Project (TRLIA 2013). TRLIA has identified opportunities to improve recreational amenities in the FRS area and provide access to the 500 acres being restored as part of the project. Potential recreation opportunities described by TRLIA include developing biking, hiking, and equestrian trails, and providing access to the Feather River for bank fishing and launching canoes and kayaks via development of a boat dock. To facilitate development of a connected trail system in this location, TRLIA also has proposed construction of a recreation bridge, connecting Old Levee Road across the FRS drainage swale at Star Bend. Development of these amenities would have further benefits if connected to other facilities in the south at Star Bend Boat Ramp, where recent improvements have been made by Yuba County. The specific locations of the proposed trails would be designed to integrate with existing trails where feasible, keep trails away from sensitive habitat and areas where trail use might interfere with agricultural operations, and take advantage of opportunities for interpretation (e.g., at mitigation areas), where feasible. Exhibit 6-9 depicts the general location of the following recommended recreational improvements to the FRS area (Stoll Engineering 2009; TRLIA 2013):

- Improve (e.g., widen, grade, resurface with gravel) the existing levee top road from the northern end of the setback levee south to and along the north levee of the Bear River setback area, primarily for biking (see also Recreation Management Action 3).
- Improve existing access along Old Levee Road, the maintenance road along the waterside of the setback levee, and the east-west side roads across the floodplain connecting to the existing public access point at the levee ramp at Broadway Street for hiking, biking, and/or equestrian uses, as appropriate.
- Develop a new access road (including a foot bridge over the drainage swale) along existing user-created trails between the drainage swale and Star Bend Boat Ramp and Day Use Area, to further connect hiking, biking, and equestrian trails between the FRS area and other public use areas to the south, including Lake of the Woods and the Bear River setback area.
- Construct a boat dock for canoe, kayak, and fishing access via Old Levee Road in the southern portion of the Feather River setback area, in the vicinity of RM 19.
- Develop a trailhead and non-motorized trail for equestrian and pedestrian use along the waterside of the levee on the east side of Lake of the Woods, between Star Bend and the Bear River setback area.
- Develop trailheads and interpretive trails to existing mitigation and restoration sites within the FRS area.



Sources: CDFW 2013; data compiled by AECOM in 2013

Exhibit 6-8 **Unscreened Water Diversions in the LFRCMP Study Area**



Sources: City of Yuba City 2002; Stoll Engineering 2009; Neubert 2011; TRLIA 2013; data compiled by AECOM in 2013

Exhibit 6-9 **Existing and Proposed Recreational Improvements in the LFRCMP Study Area**

Recreation Management Action 2: Develop Existing Canoe/Kayak Access Ramp at Bear River. Provide additional canoe/kayak access points downstream of Star Bend to offer more options for canoeing and kayaking, which is very popular in this portion of the river corridor. One option for enhanced access is to develop the existing unimproved kayak access point near the mouth of the lower Bear River into a launch ramp for designated canoe/kayak access, and to grade and resurface the access road and ramp for better usability (Stoll Engineering 2009) (Exhibit 6-9). This access road was developed as part of the levee setback project to facilitate maintenance of the drainage swale constructed in this area, but it also used by the public as an unofficial canoe/kayak access point.

Recreation Management Action 3: Develop Multi-Use Trail Network on East Bank Levee and Access Road. Develop a multi-use trail network on the existing levee and access roads along the east bank from the FRS to the Bear River setback. The existing system of levee and maintenance roads provides a potential basis for a trail network that could be improved to better facilitate multi-use recreation by hikers, bikers, and equestrian users, and provide connectivity along the floodway corridor. However, continuity and access currently is restricted by a series of gates that were installed to limit access to the levee road system. To better facilitate multi-use and continuity in this area, the following trail improvements have been proposed (Stoll Engineering 2009) (Exhibit 6-9): replace the existing vehicle gates on the levee road with bollards that facilitate non-vehicular multiple use; resurface the levee road and maintenance roads on the waterside of the levee from State Route (SR) 70 to Star Bend with a combination paved/aggregate surface; widen and resurface the narrow user-created trails on State land north of the Star Bend Boat Ramp to accommodate multiple uses and provide a key linkage between the boat ramp area and adjacent access roads and trails; and resurface levee and maintenance roads from Star Bend to the Bear River for separated use by equestrians, hikers, and bikers. The dirt maintenance road (i.e., along the alignment of the old levee) is in good condition and follows mature oak woodland on the north side of a historic channel of the Bear River. The road should be developed as a low-impact, multi-use interpretive trail from SR 70 to the drainage swale on the west side of the Bear River setback area.

Recreation Management Action 4: Establish River Access to "The Riffles" at Shanghai Bend. Establish official access to the river's edge at "The Riffles" on the east bank of the Feather River, south of Shanghai Bend, via access roads across the east levee and past the wastewater disposal ponds (Stoll Engineering 2009, Exhibit 6-9). Currently, users are attracted to these popular areas, primarily for bank fishing. Land ownership and eastside road access to this location are controlled by two separate water treatment utilities. In developing approved river access at this site, both utilities should be consulted and engaged in exploratory planning for potential public access and use of the east side of the river at Shanghai Rapids. River access enhancements may not include access for vehicles; CDFW has been coordinating with local agencies to discuss placing a gate at the entrance of the unit to restrict vehicle access, in an effort to reduce trash and illegal activities (CDFW, pers. comm., 2014).

Recreation Management Action 5: Improve Trails to Shanghai Bend Fishing/Scenic Sites and Expand Parking. Improve and focus trails to the best fishing and most scenic sites at Shanghai Bend, and develop and expand existing unpaved parking. One area of particular beauty and interest, identified as a scenic and wildlife viewing opportunity, is "The Riffles" at Shanghai Bend (Exhibit 6-9), where a viewing platform and trailhead along the right (west) bank could serve as a gateway to encourage users to explore the surrounding natural area of Shanghai Bend to the north.

Trails in the Shanghai Bend area would be developed with preservation of sensitive resources as a primary goal, using raised platforms where necessary and restricting motor vehicle access (City of Yuba City 2004). Specific developments could include improving existing user-created trails that provide access to and between the two best fishing sites (immediately upstream of the rapids and farther upstream at Jesus Hole) and incorporating interpretive exhibits along the trails (Bartlett, pers. comm., 2011). Observation decks could highlight the Dunes (i.e., sandbar area of Shanghai Bend) and Riffles (City of Yuba City 2004), and picnic facilities could be developed for day users in areas away from sensitive resources (Stoll Engineering 2009). To support proposed trail developments, expanded public parking at the end of Shanghai Bend road is also proposed. The parking area would be screened from the adjacent residential area and could be developed to provide Americans with Disabilities Act (ADA)–compliant wheelchair and bike ramps from the parking lot to the top of the levee and the viewing platform at "The Riffles" (Bartlett, pers. comm., 2011). In addition, a small passive park is proposed in the "levee bowl" area of Shanghai Bend (formed by the horseshoe shape of the old levee setback), with open turf areas, picnic and restroom facilities, and a boat dock. Development of an information center in the park would provide opportunities for educating the public about the sensitive resources present in the area.

Recreation Management Action 6: Develop Boat Access and Parking at Nelson Slough. Expand opportunities for boating by developing boat access and parking at the Nelson Slough Unit of the FRWA, an area that currently lacks these amenities. Currently, access to this area is through locked gates. This area is frequently used for rafting, canoeing, and kayaking, and would be an ideal location for non-motorized boaters to end their floats. Good fishing opportunities also occur along this stretch of river. Developing a boat ramp for trailered motorboats in the Nelson Slough area has been proposed in a number of locations between RM 10 and RM 7.5: right (west) bank at RM 9.5, right (west) bank 1,000 feet upriver from RM 9.5, right bank at RM 8.4 (the mouth of Nelson Slough), or left bank at RM 8 (Neubert, pers. comm., 2011) (Exhibit 6-9). CDFW has proposed to locate the boat ramp along the irrigation diversion canal on the right bank north of the SR 99 Bridge, at approximately RM 9.8 (Bartlett, pers. comm., 2011). If boat access and parking are developed at this site, it could be served by a dirt road at the existing access point to the Nelson Slough Unit of the FRWA, via Sacramento Avenue and the west levee road. This site would create new boat access along a long stretch of the river that has no river access, and it would support additional opportunities for fishing, as well as improve rafting, canoeing, and kayaking opportunities by reducing float distances between existing boat access points. CDFW proposes to develop a concrete boat ramp with a gravel access road, create a gravel parking area for 100 cars on the levee side of the road, and possibly pave the levee road and portions of Sacramento Avenue from SR 99 to accommodate increased access and use (Bartlett, pers. comm., 2011). In developing proposed boat-launch facilities, especially downstream of RM 15, sedimentation patterns should be considered. Alternating sandbars and the typically shallow conditions across the channel during low flows would increase the need for annual maintenance at ramps and channel inlets, and create potentially hazardous situations for motorized boating.

Recreation Management Action 7: Expand Equestrian Access at Star Bend. Expand, repave, and re-stripe the parking area at the Star Bend Boat Ramp to accommodate horse trailers and add other equestrian amenities to the trailhead (Stoll Engineering 2009). These improvements would enhance equestrian trail accessibility along the majority of the left (east) bank of the floodway, primarily north of the Bear River setback area. An equestrian loop trail could also be developed at Lake of the Woods if compatible with recreational uses approved for this FRWA unit.

Recreation Management Action 8: Develop a Loop Trail between Star Bend and the Bear River setback area. Develop a loop trail for bikes and pedestrians between Star Bend and the Bear River setback area. This loop would connect the east end of the Bear River levee at SR 70 and the community of Plumas Lake to the Star Bend Boat Ramp (Exhibit 6-9) (Stoll Engineering 2009). The loop would use existing levee roads and would connect existing bike lanes and sidewalks along River Oaks Boulevard and within the Plumas Lake residential area.

Recreation Management Action 9: Develop Multi-Use Levee Trail from Boyd's Pump to the Yuba City Boat Ramp. Develop a multi-use trail for bikers, walkers, and runners along the section of levee road between Boyd's Pump and the Yuba City Boat Ramp (Exhibit 6-9). This section of levee road currently receives high use and would benefit from improvements to the existing road system to facilitate continuity and multiple uses. Similar to suggestions for the left (east) bank trails, improvements could include replacing some of the existing vehicle gates on the levee road with bollards to facilitate non-vehicular multiple uses and resurfacing the levee road and maintenance roads.

Recreation Management Action 10: Develop Nature Trails at Halprin Lagoon. Develop unpaved nature trails with informational kiosks and appropriate amenities at Halprin Lagoon (Exhibit 6-9). North of Shanghai Bend is a natural area along the right (west) bank with has a mix of forests and wetlands that provide ample opportunity for interpretive nature trails, wildlife viewing areas, and an outdoor classroom (City of Yuba City 2004). Three miles of unpaved nature trails could be developed in this area, including connections to significant viewing areas such as Halprin Lagoon. Similar to Shanghai Bend, this area is generally targeted for minimal impacts of human use, because of the presence of high-quality riparian habitat. The inclusion of information kiosks along trails here would provide educational opportunities. A fishing platform/rest area is also proposed, including picnic areas along the woodland edge of the lagoon, with tables, a shade structure, and restroom facilities on the landside of levee.

Recreation Management Action 11: Develop Park at Yuba City's Mosquito Beach Recreation Area. Develop a 3-acre park at Yuba City's Mosquito Beach Recreation Area (Exhibit 6-9) to enhance and expand the use of this popular location. This area is heavily used by anglers and other recreationists (Neubert, pers. comm., 2011), and it generally lacks the sensitive nature of fish and wildlife habitats found in other areas within the floodway (e.g., Shanghai Bend and woodland/wetland areas to the north and FRWA units). Therefore, developing a park here would not adversely affect sensitive biological resources but would directly address recreation priorities near the Yuba City urban area. The improvements would include picnic areas along the beach, with tables, barbeques, shade, turf, and restrooms; hard-surface plazas and gazebo for events; and boat docking facilities south of the existing marina. Brush clearing and native plantings could improve the natural character of the beach park. Parking and improved access would be developed at the park and adjacent marina.

6.4 AGRICULTURE MANAGEMENT ACTIONS

Agricultural Management Action 1: Designate Agricultural Conservation Areas. Designate two Agricultural Conservation Areas within the FRS area as long-term agricultural lease areas, primarily for orchard production (Exhibits 6-1 and 6-3, Area F-4; Exhibit 6-10). The primary conservation area would be at the south end of the FRS area. This 267-acre south zone is dominated by mostly mature walnut orchards that existed before construction of the FRS levee project. The approximately 80-acre north Agricultural Conservation Zone is located in the northern portion of the FRS area, north of Ella Avenue, and has an existing walnut orchard. Agricultural access to the conservation areas is described in Agricultural Management Action 2. Long-term leases are

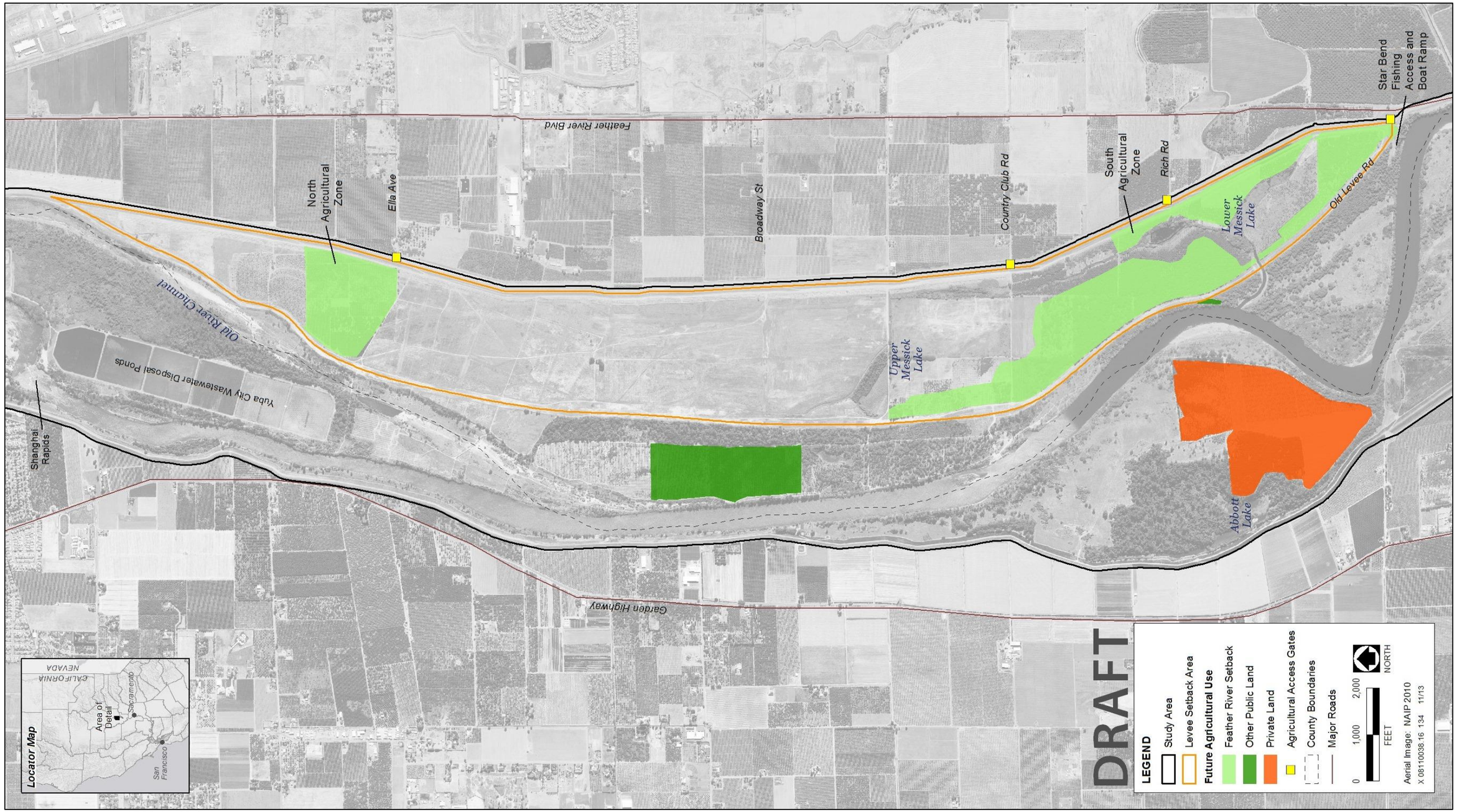
described in Agricultural Management Action 5. Agricultural lessees would continue to be responsible for property care, environmentally responsible pesticide and fertilizer usage, and maintenance and repair of existing irrigation wells and other irrigation and local drainage infrastructure.

Agricultural Management Action 2: Protect Agricultural Assets from Vandalism, Theft, and Wildfire. Install vehicle gates and create access roads for agricultural users to minimize the risk of vandalism, theft, crop damage, and wildfire, by providing secure access roads and gate control wherever possible. Physical vehicle barriers, such as steep-sided ditches and mounds or fences, could also be used to limit or discourage trespassers from entering commercial orchard lease areas. For example, the primary orchard area at the south end of the FRS area could be accessed by growers from the east via ramps at Rich Road and Country Club Road, or from the south via Levee Road and Feather River Boulevard, where the roadways converge at Star Bend Boat Ramp. In general, the commercial lease areas south of Country Club Road and north of Ella Ave would be off limits to the general public, except for the south end of Old Levee Road, where access would be provided to a proposed canoe/kayak launch at the existing FRS outlet drainage swale. A mostly separate public vehicle access route could also use the Anderson Avenue and/or Broadway Street levee access ramps and the interior east side road traveling south to Country Club Road, and from there to designated river access locations via Old Levee Road.

Agricultural Management Action 3: Use Agricultural Lease Income to Support Operations and Maintenance on Restoration Sites. Use income from the approximately 450 acres of orchards in the FRS area that are under a TRLIA/DWR lease to support maintenance activities in the restoration areas. TRLIA and DWR receive a percentage of the gross profit from these orchards, and this revenue stream could be utilized to offset/reduce the cost of maintaining the restoration and recreation use areas. Potentially, other parts of the LFRCMP study area (e.g., other parts of the FRS area) could be planted in agriculture to provide additional revenue to maintain the corridor. Currently the TRLIA Early Implementation Program Funding Agreement (EIP) requires TRLIA to transfer all the orchard property to the State. After the transfer, the State must send the revenues from the leases to the State general fund. To make this proposed management action feasible, the EIP would need to be amended to allow TRLIA to retain ownership of the property until the orchard property is no longer used for that purpose. If the property use changes, TRLIA would transfer the property to the State.

Agricultural Management Action 4: Replace Low-Lying, Flood-Prone Orchards with New Orchards on High Ground. Convert orchards located near Lower Messick Lake that regularly flood to riparian habitats (Exhibits 6-1 and 6-3, Area F-3). As noted in Ecosystem Management Action 6, the flood-prone orchards have suffered considerable, incremental mortality and stunted growth in recent years. Loss of these orchards could be offset by replanting comparable acreages on higher ground located in the northern FRS area, or on public land south of the proposed river diversion swale, which lies between the western FRS boundary and the river (Exhibit 6-10). Alternatively, the grade of flood-prone orchards could be raised to the level of other adjacent, productive orchards by using future FRS area excavation projects as a nearby source of fill.

Agricultural Management Action 5: Offer Extended Leases to Orchards. To support sustainable, long-term land management, offer long-term rather than short-term leases for agricultural lands in the LFR corridor. Short-term leases do not promote a commitment to good land management and economic sustainability, because orchards require a long-term investment and 15- to 30-year planning horizon. Extended leases and in-kind service exchange agreements could be offered to orchard lessees with a good track record of maintenance and sensitivity to ecological objectives and multiple use of the FRS area. For example, lessees with grading equipment could



Source: Data compiled by AECOM in 2013

Exhibit 6-10 **Agricultural Conservation Areas and Access Roads in the Feather River Setback Area**

participate in road and gate repair and maintenance, and could take responsibility for cooperative "neighborhood watch" programs in their area to discourage trespassers, illegal campers, and wildlife poachers.

Agricultural Management Action 6: Implement Wildlife-Friendly Agricultural Practices. Encourage operators of all publicly owned agricultural lease lands within in the floodway to implement wildlife-friendly agricultural practices, including minimizing pesticide and fertilizer use to the degree feasible. Pesticide or fertilizer drift can occur via physical movement of pesticides through the air; as agricultural tail water returns, where these harmful substances can accumulate in shallow-water juvenile salmonid rearing habitat; and through bioaccumulation in insects and other species that use both agricultural and natural habitat areas. To reduce the risk of adverse effects of pesticide or fertilizers on fish and wildlife species, operators of all agricultural lease lands in the floodway would follow organic or low-impact farming practices, as feasible. Native hedgerows or woodland buffers could be planted to reduce edge effects near sensitive wildlife areas and water bodies. CDFW encourages the installation of native hedgerows and woodland buffers, which provide benefits for agricultural lands and native plants and wildlife (CDFW, pers. comm., 2014). Landowner incentives and cooperative agreements could be used as tools to encourage implementation of these wildlife-friendly practices.

7 PERMITTING STRATEGY

7.1 GOALS AND APPROACH FOR THE PERMITTING STRATEGY

Flood managers face several challenges to implementing routine maintenance and nonroutine flood management projects while still protecting sensitive environmental resources. For example, constraints imposed by work windows and buffer zones to protect migratory birds and habitat for special-status species can interfere with the timely and efficient completion of annual maintenance activities, such as mowing grass and trimming trees and brush. If habitat is improved and expanded in and near flood management facilities, restrictions caused by the presence of special-status species in restored areas can sometime limit maintenance activities, thereby increasing flood risks and costs.

Additional challenges occur when flood managers try to secure permits and develop compensatory mitigation for nonroutine flood management projects. Traditional project-by-project environmental permitting for such projects often requires time-consuming permit applications, focused surveys, and negotiations that can delay needed improvements to the flood management system. In addition, mitigation sites established for those projects are often small restoration areas that are isolated and difficult to manage; these sites may not connect with existing habitat or provide the best conservation outcomes. The delays and challenges associated with obtaining permits and establishing mitigation can adversely affect construction costs and timelines for vital flood management projects, and can delay and increase the cost of mitigation.

One of DWR's goals for the *Lower Feather River Corridor Management Plan* (LFRCMP) is to address these challenges by working collaboratively with resource agencies. The intent is to avoid project-by-project permitting of and accounting for compensatory mitigation requirements, and to rely instead on more efficient and programmatic mechanisms that could be used in advance of impacts and would meet resource agencies' requirements. DWR's other goals are to integrate flood management actions with ecosystem and habitat enhancement actions wherever possible, and to plan and design flood management projects to help reduce constraints on ecosystem processes and conservation.

This chapter describes a programmatic permitting approach that would support these goals by facilitating more comprehensive and efficient permitting for maintenance of flood management facilities and implementation of flood management and ecosystem/habitat enhancement projects.

This permitting approach offers a framework for permitting the activities of DWR, the Central Valley Flood Protection Board (CVFPB), and Local Maintaining Agencies (LMAs). The programmatic permitting strategy described here would reduce overall regulatory costs and timelines for seeking incidental take permit coverage from the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and California Department of Fish and Wildlife (CDFW). The permitting strategy would satisfy requirements of the federal Endangered Species Act (ESA) and the California Endangered Species Act (CESA). It would also help secure Safe Harbor Agreements and CVFPB encroachment permits.

The programmatic permitting approach described in this chapter is organized around implementation of environmentally beneficial management actions (conservation measures) that would allow for issuance of incidental take permits under ESA Section 10 and CESA Section 2081 while minimizing or avoiding the need for

additional mitigation. The permitting approach would also facilitate compliance with Section 1600 of the California Fish and Game Code; Sections 404, 402, and 401 of the Clean Water Act (CWA); Section 10 of the Rivers and Harbors Act; and Section 106 of the National Historic Preservation Act (NHPA).

As described in Appendix O, a variety of mechanisms are available for compliance with the permits listed above. Appendix O discusses the roles and responsibilities of the State and federal permitting agencies relevant to LFRCMP actions, provides details about mechanisms for obtaining permits, lists the approximate permitting timelines, and describes the pros and cons of the different proposed approaches.

The LFRCMP permitting approaches described below will be integrated with the permitting efforts that are under way as part of the Central Valley Flood Protection Plan (CVFPP) Conservation Strategy, as described in the Conservation Framework (DWR 2012). DWR and State and federal resource agencies are developing permitting strategies for ESA and CESA compliance for the larger State Plan of Flood Control Planning Area (see Chapter 1 for a discussion of the relationship of the LFRCMP to the Conservation Strategy and other DWR planning and coordination efforts.) The ESA and CESA compliance options described below will become part of the permitting for the larger Feather River Conservation Planning Area. Permitting for the LFRCMP will involve closely collaborating and coordinating with all parties engaged in developing the permitting approach for the Conservation Strategy, and with the Feather River Regional Flood Management Planning.

7.2 FEDERAL AND CALIFORNIA ENDANGERED SPECIES ACT COMPLIANCE

Both ESA and CESA prohibit unauthorized "take" of species listed as threatened or endangered. The federal and State definitions of take differ, but both include actions that would adversely affect individual plants or animals. The federal definition of take also includes habitat modification or degradation that harms individuals by modifying behavioral patterns, and the destruction or adverse modification of designated critical habitat. ("Designated critical habitat" encompasses areas that are essential to the conservation of threatened and endangered species.). Both ESA and CESA allow for authorization of take that is incidental to otherwise lawful activities. For most activities, this authorization could be obtained by preparing and implementing a federal habitat conservation plan together with a State 2081 permit. An environmental impact statement/environmental impact report (EIS/EIR) would need to be prepared to analyze the potential effects of implementing the HCP/2081 permit and providing measures to avoid, minimize, and mitigate potential effects in compliance with the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA), and to support other programmatic permits and authorizations.

The proposed approaches to securing ESA and CESA coverage for Lower Feather River (LFR) routine and nonroutine floodway maintenance and ecosystem enhancement projects are to prepare and implement an HCP/2081 permit. The LFR HCP/2081 permit would provide for authorized incidental take of covered species resulting from DWR activities and projects described in the LFRCMP, and could also cover related activities of LMAs and other organizations that chose to participate. An HCP is proposed for ESA compliance rather than a section 7 consultation because given routine maintenance activities and many of the proposed management actions may not have a federal nexus (see Appendix O for additional information).

For permits other than ESA and CESA coverage, the LFR HCP/2081 permit may be accompanied by the following programmatic permits intended to expedite permit processing:

- a master streambed alteration agreement, issued by CDFW, authorizing activities that would substantially obstruct or divert the natural flow of State waters; substantially change or use materials from a bed, bank, or channel; or deposit materials into a river, dam, or lake (Section 1600 of the California Fish and Game Code);
- a regional general permit (RGP) issued by the U.S. Army Corps of Engineers (USACE), authorizing at least a portion of the HCP activities that involve discharges of dredged or fill material into waters of the United States (Section 404 of the CWA) or that obstruct or alter navigable waters (Section 10 of the Rivers and Harbors Act);
- a Section 401 water quality certification, issued by the Central Valley Regional Water Quality Control Board (RWQCB), authorizing compliance with CWA Section 402 through development of a programmatic storm water pollution prevention plan (SWPPP); and
- a programmatic agreement (PA) for NHPA Section 106 compliance, obtained through the process defined in Title 36, Part 800.14 of the Code of Federal Regulations (36 CFR 800.14), that would include USACE (Regulatory and Operations), USFWS, and NMFS.

These programmatic permitting approaches would be applied to the routine, recurring maintenance work described in Appendix L; to the proposed flood management and ecosystems enhancement actions discussed in Chapter 6; and to proposed future flood management and ecosystem enhancement projects. The recreation and agricultural management actions described in Chapter 6 are not proposed for a programmatic approach; individual permits would be sought for these activities if needed.

Ample opportunities exist for ecosystem enhancement and habitat creation within the LFR corridor, as described in Chapter 6. The net benefits to natural communities and ecosystem processes of implementing these ecosystem management actions would more than offset the impacts of flood management projects proposed within the LFR corridor. These actions also would provide surplus habitat enhancements that could be applied elsewhere in the Feather River Conservation Planning Area to offset anticipated impacts of flood system construction or maintenance for programmatic permitting purposes.

7.3 FEDERAL AND CALIFORNIA ENDANGERED SPECIES ACT COMPLIANCE—HABITAT CONSERVATION PLAN/NATURAL COMMUNITIES CONSERVATION PLAN OR 2081 PERMIT

The LFR HCP/2081 permit would include the elements described below. These elements are required by USFWS and NMFS (1998) (*Federal Register* Title 65, page 106 [65 FR 106], June 1, 2000), and by CESA Section 2081. As discussed in Appendix O, some of the elements described below would not be required as part of a 2081 permit.

7.3.1 PLAN PARTICIPANTS

DWR would be the primary participant in the HCP/2081 permit. Additional plan participants that might desire permit coverage could also include local LMAs (Reclamation Districts 784 and 1001, Levee District 1, and Marysville Levee District); the Three Rivers Levee Improvement Authority; and the Sutter Butte Flood Control Agency. The “project proponent” would be the entity with primary responsibility for implementing a specific

project. Here, a "project" refers to a project that requires a discretionary approval by the CVFPB; as defined by the California Public Resources Code (Section 21065), a "project" is an activity that may cause either a direct physical change in the environment or a reasonably foreseeable indirect physical change in the environment.

7.3.2 PLANNING AGREEMENT

Development of an LFR HCP would include preparation of a planning agreement, as required by the NCCPA (Section 2810). This agreement would be binding on participating federal, State, and local agencies. It would define the geographic scope of the plan, provide a preliminary list of natural communities and covered species, and identify preliminary conservation objectives for the study area. The planning agreement also establishes a process for independent scientific input to assist DWR and plan participants in developing the LFR HCP, and a process for public participation. A 2081 permit would not require preparation of a planning agreement.

7.3.3 PUBLIC PARTICIPATION AND INDEPENDENT SCIENCE PANEL

USFWS and NMFS strongly encourage providing ample public involvement opportunities during HCP planning and implementation and using scientific advisory committees. In addition to public participation, development of the LFR HCP will involve independent scientific input and analysis to assist plan participants in creating a scientifically based plan. An independent science panel will be formed to identify foundational principles for landscape and habitat conservation, species protection, and adaptive management. No public participation or outreach is required for a 2081 permit other than that needed to satisfy CEQA, nor is establishment of an independent science panel required.

7.3.4 INTEGRATION WITH THE YUBA SUTTER REGIONAL CONSERVATION PLAN

The LFR corridor is contained within the *Yuba-Sutter Regional Conservation Plan* (Yuba-Sutter RCP) area (see Appendix B, Exhibit B-1). DWR seeks to develop the LFR HCP/2081 permit in collaboration with the Yuba-Sutter RCP. Thus, DWR will coordinate to support recovery of special-status species in areas covered by both plans. For example, DWR may want ESA take coverage for potential impacts on giant garter snakes associated with grouting of rodent holes on levees (see Appendix L), but little opportunity exists for mitigation and conservation of giant garter snake habitat within the LFR floodway. DWR coordination with the Yuba-Sutter RCP could provide opportunities to support conservation actions that would maintain sustainable populations of giant garter snake.

The feasibility of DWR's formal participation in the Yuba-Sutter RCP was explored by DWR as part of the Conservation Strategy permitting efforts (McNearney, pers. comm., 2013). The intent was to incorporate State Plan of Flood Control flood management actions and projects as covered activities under the Yuba-Sutter RCP. DWR withdrew its proposal to join the Yuba-Sutter RCP because of the complexity, timing, extent of activities, limits for coverage, and recommended role of DWR. DWR seeks a plan that is led by DWR for its flood management activities within its floodway and associated levees. Continued collaboration with the counties will ensure that the needs of the Yuba-Sutter RCP and DWR's HCP/2081 permit for the State Plan of Flood Control within Yuba, Sutter, Butte, and Placer counties will be met. Mitigation outside of the floodway may continue to be a need of DWR; the intention is to work with the counties to find a solution that can meet the needs of both planning entities, while also accommodating limitations related to meeting mitigation goals. DWR coordination with the Yuba-Sutter RCP could provide opportunities to support conservation actions that would maintain

sustainable populations of giant garter snake. CDFW encourages coordination with the Yuba-Sutter RCP to ensure that DWR's planning efforts complement those of the Yuba-Sutter RCP (CDFW, pers. comm., 2014).

7.3.5 Covered Species and Communities

Covered species would likely include the target species discussed in Chapter 3 that are listed as threatened and endangered (and those likely to become so listed) that could potentially be affected by covered activities. Covered natural communities would include shaded riverine aquatic, riparian forest and scrub, marsh, inundated floodplain communities, and other plant communities that provide habitat for covered species affected by covered activities. The LFR HCP/2081 permit would describe biological goals and objectives, avoidance and minimization measures, and compensatory mitigation and contributions to recovery of the species, all of which would be consistent with those of the CVFPP Conservation Strategy. The list for covered species would be developed in consultation with USFWS, NFMS, CDFW, and the independent science panel, and is likely to include the following species:

- Valley elderberry longhorn beetle
- California Central Valley steelhead Distinct Population Segment
- Chinook salmon—Central Valley fall-/late fall–run Evolutionarily Significant Unit (ESU)
- Chinook salmon—Central Valley spring-run ESU
- Chinook salmon—Sacramento River winter-run ESU
- Green sturgeon—Southern Distinct Population Segment
- Giant garter snake
- Bank swallow
- Least Bell's vireo
- Swainson's hawk
- Western yellow-billed cuckoo

7.3.6 Covered Activities

The LFR HCP/2081 permit would cover the activities described in Appendix L and the proposed floodway and ecosystem management actions described in Chapter 6. The recreation and agricultural management actions included in Chapter 6 are not proposed as covered activities. Additional flood management and ecosystem/habitat enhancement projects not described in Chapter 6 are likely to be proposed over the course of implementing the LFR HCP/2081 permit. For large-scale projects not described in the LFRCMP, CDFW and USFWS would confer with plan participants to determine whether those projects are consistent with authorized take or whether a plan amendment would be necessary to provide coverage.

7.3.7 Assessment of Baseline Conditions

Chapter 3 of this document provides the starting point for this component of the LFR HCP/2081 permit, with Exhibit 3-4 showing the current extent of riparian habitat and other land cover types. The data on some of these existing conditions would become part of the baseline for measuring progress toward biological goals and objectives or for determining take (e.g., land cover). Where applicable, these descriptions would include information about biological diversity, environmental gradients, and ecological integrity, to support the development of a conservation program.

7.3.8 EFFECTS ANALYSIS AND ESTIMATED LEVEL OF TAKE

The effects analysis would describe the direct and indirect effects of the covered activities on each covered species and natural community, and the level of incidental take that would result. For most covered species, impact acreages would typically be used to quantify incidental take by covered activities, with other factors such as habitat quality and likelihood of occurrence of the species taken into consideration for the effects analysis. For some resources, however, metrics other than acreage may be needed both to identify baseline conditions and to quantify impacts on riparian and aquatic habitat, as necessary (e.g., distribution of invasive plants in the floodway, linear extent of shaded riverine aquatic habitat). The acreage of impacts on suitable habitat generally would be used as a proxy for quantifying the number of individuals of covered species harmed or harassed, because quantifying such a precise number is challenging.

Because changes in habitat acreages or other metrics would be used to determine take, the effects analysis would identify the baseline for those conditions, from which adverse and beneficial changes would be measured. USFWS, NMFS, CDFW, and the independent science panel would collaborate to develop the foundations of the effects analysis and the estimated level of take for covered species. As discussed in Chapter 8, DWR would work with the resource agencies to develop a relatively easy-to-measure metric (for example, review of aerial photos) to assess habitat changes over time to evaluate adverse and beneficial ecosystem changes from baseline conditions.

7.3.9 CONSERVATION STRATEGY

The goal the LFR HCP/2081 permit conservation strategy is to contribute to the recovery of covered species by improving ecosystem processes and habitats. The first step toward achieving this goal would begin with determining the intended ecosystem and habitat enhancement outcomes in the LFRCMP study area based on the inherent physical, hydrological, and biological constraints and opportunities present. Conservation plans would then be developed to describe the means to achieve these conservation strategy outcomes. The conservation strategy would include specific and measurable biological goals and objectives as a comprehensive set of conservation measures, all based on maximizing the habitat quality potential that can reasonably be achieved based on the natural site conditions and limitations. These measures would be designed to improve the conservation of covered species and the habitat values and quality of the natural communities upon which they depend.

Development of the LFR HCP/2081 permit conservation strategy would include “jump start” and “stay ahead” provisions. “Jump start” refers to the initiation of habitat conservation before covered activities affect those habitats. “Stay ahead” refers to maintenance of a substantial portion of the jump start habitat improvements while covered activities are underway. The stay ahead provision ensures that habitat enhancement for covered species is always maintained at levels well above baseline (consistent with the HCP's conservation strategy). Potential and actual habitat enhancements would be compared against pre-enhancement baseline conditions to define the amount of habitat quality improvement referenced in programmatic permits for covered activities. Habitat quality and values would always be maintained at levels substantially above baseline such that covered activities could adversely affect the improved habitat without triggering the need to provide additional mitigation. Additionally, best management practices would be included in the conservation plan to appropriately avoid, minimize, and offset the impacts of the covered activities on these resources. As discussed below, the conservation strategy

would also provide for the establishment of monitoring and adaptive management programs to ensure that the conservation measures evolve as new information becomes available.

7.3.10 IMPLEMENTATION SCHEDULE

The LFR HCP, which would be implemented over a period of 30 years, would include an approximate time frame and completion sequence for proposed floodway—and ecosystem—enhancement management actions. The schedule would necessarily include some flexibility, which would be addressed through the adaptive management process described below. A 2081 permit would have a much shorter permit term than an HCP; the specific duration of a 2081 permit would be determined in consultation with CDFW and the project proponents.

7.3.11 GOVERNANCE AND ADMINISTRATION

The LFR HCP would describe the organizational structure for implementing the plan, and the roles and responsibilities of the entities that would participate in its implementation. Implementation would begin with execution of the implementing agreement with USFWS and NMFS, and issuance of Section 10(a)(1)(B) incidental take permits (USFWS, NMFS). DWR would oversee implementation of the LFR HCP and would be responsible for:

- developing annual work plans and budgets;
- establishing and facilitating the work of the independent science review panel and other appropriate committees (e.g., stakeholder committee, technical review committee);
- developing a decision-making process for all plan participants for dispute resolution regarding interpretation of avoidance, minimization, and mitigation measures and other HCP requirements;
- developing and maintaining compliance and effects databases to assure that mitigation and conservation measures are being implemented roughly proportional in time and extent to the impact on habitat/covered species authorized under the plan;
- developing and maintaining a data repository updated with project reports and data and updated species occurrence data provided by CDFW, NMFS, and USFWS;
- preparing and submitting an annual report to CDFW, NMFS, and USFWS summarizing HCP/2081 permit implementation, as well as 5-year comprehensive review reports;
- facilitating coordination among DWR, the CVFPB, CDFW, NMFS, USFWS, and third-party participants as necessary for plan implementation, including organizing and facilitating a technical review committee;
- implementing the adaptive management plan; and
- coordinating plan amendments.

7.3.12 GOOD NEIGHBOR POLICY

Implementing the ecosystem management actions described in Chapter 6 could increase the extent and populations of terrestrial covered species on private lands adjacent to reserves and other areas in which habitat is restored. Recognizing that such expansion could restrict the activities of neighboring landowners, the LFR LFR HCP/2081 permit would include a "Good Neighbor Policy." This policy would provide for take of any incremental increases in the population of covered species beyond baseline conditions on adjacent lands. The policy would not provide for take of existing populations or habitat occupied before the conservation activities occurred, and therefore would not result in impacts relative to baseline conditions.

The Good Neighbor Policy could provide incidental take permit coverage for willing participants on an "opt-in" basis. At the start of habitat restoration, DWR would notify eligible landowners about the policy and would give them the option of providing a report assessing the biological resources on their property or allowing DWR biologists to survey their property. The assessment of biological resources would document baseline conditions, and incidental take related to increased property use by covered species would be covered. The Good Neighbor Policy needs of the HCP/2081 permit should be coordinated with the fish and wildlife resource agencies to determine the best way to meet the needs of land owners/managers and those of the species.

7.3.13 MONITORING AND ADAPTIVE MANAGEMENT

Monitoring is a mandatory element of all HCPs (see 50 CFR 17.22, 17.32, and 222.307). It is also required to document compliance with the terms and conditions of a 2081 permit. Monitoring is necessary to fully document ESA/CESA compliance and effectiveness. Through the monitoring program for the LFR HCP/2081 permit, monitoring results would be evaluated periodically to assess compliance with plan implementation mechanisms, determine the level of take resulting from implementation of covered activities, assess whether biological goals and objectives are being met, and provide feedback information for an adaptive management strategy. Chapter 8, "Tracking and Monitoring," describes how monitoring would be implemented and conceptually describes how a compliance tracking database and data repository would be established and managed. An efficient and cost-effective monitoring approach would be developed to minimize the complexity of this monitoring while still supporting conservation and flood management goals.

Adaptive management is a required element of HCP monitoring. This element of the LFR HCP would be important for evaluating the efficacy of management actions and incorporating new information into plan implementation. Adaptive management is a decision-making process that allows for flexible management by adjusting actions in response to information from monitoring. This experimental approach uses monitoring data to update, revise, and adjust hypotheses and conceptual models of the managed system.

7.3.14 CHANGED/UNFORESEEN CIRCUMSTANCES AND ASSURANCES

The LFR HCP would describe how plan participants, NMFS and USFWS would address "changed circumstances"—changes in circumstances that can reasonably be anticipated and planned for by plan developers and USFWS and NMFS (50 CFR 17.3). For example, these changed circumstances could include listing or delisting of species, wildfire, drought or catastrophic flooding, or invasions by nonnative species. For each changed circumstance, the LFR HCP would describe a planned response and explain how implementation would

be modified as necessary to avoid, minimize, or mitigate the effects of the changed circumstances on covered species. Funding would also need to be available to allow for appropriate responses to changed circumstances.

"Unforeseen circumstances" are defined by the No Surprises Rule (50 CFR 17) as changes in circumstances, affecting a species or geographic area covered by an HCP, that could not reasonably have been anticipated by plan developers and USFWS at the time of the plan's negotiation and development, and that would result in a substantial and adverse change in status of the covered species (50 CFR 17.3). For the purposes of the LFR HCP, changes not already described as changed circumstances and that would substantially alter the status of a covered species would be considered unforeseen circumstances.

The LFR HCP would expressly incorporate the permit assurances set forth in the No Surprises Rule adopted by USFWS and published in the *Federal Register* on February 23, 1998 (50 CFR 17). If the USFWS were to make a finding of unforeseen circumstances during HCP implementation, DWR to the extent practicable would work cooperatively with NMFS and USFWS to adaptively manage implementation of the HCP to address the unforeseen circumstances.

7.3.15 Modifications to the Habitat Conservation Plan

The LFR HCP and associated permits may be modified in accordance with existing regulations. Plan participants, NMFS, or USFWS may request modifications. The HCP would describe two categories of possible changes: minor revisions and amendments. Minor revisions and amendments would be processed in accordance with all applicable legal requirements—namely, the ESA, NEPA, and other applicable regulations. Each category of change would be defined, and the process to be followed in implementing such changes would be described.

7.3.16 Funding

Before CDFW can issue 2081 permit findings, the applicant must ensure that funding is adequate to carry out conservation actions identified in the plan. NMFS and USFWS also need funding assurances in perpetuity to complete the NEPA and HCP processes. Costs associated with implementing the HCP/2081 permit include the following expenses:

- Administration and training
- Conservation components of multi-benefit flood management projects as enhancements or mitigation
- Projects focused on providing conservation benefits as enhancements
- Avoidance and minimization measures
- Long-term maintenance, monitoring, response to changed circumstances and adaptive management, and reporting
- Remedial actions for changed circumstances

In LFR HCP/2081 permit annual reports, DWR would provide available financial information that documents the availability of financial resources for the following year, and would confirm the State's ability to fulfill its obligations.

7.3.17 ALTERNATIVES TO TAKE

The ESA requires that Section 10 permit applicants specify in HCPs what alternatives to the taking of federally listed threatened and endangered species were considered and the reasons that implementing those alternatives is not proposed. No similar requirement exists for CESA 2081 compliance. The LFR HCP would describe, for each covered species, what actions were considered as alternatives to take and the reasons that those alternatives were not selected. Alternatives to take encompass both actions that would avoid take altogether and actions that would reduce take below levels predicted to result from implementation of the HCP (USFWS and NMFS 1998). With implementation of enhancement actions, the baseline population status of listed species would be improved; therefore the alternatives analysis should be conducted in this context

7.4 OTHER FEDERAL PROGRAMMATIC PERMITS

Appendix O provides background information about the roles and responsibilities of federal agencies that might need to issue permits for the proposed activities covered in the LFRCMP. The appendix also provides further details about the regulatory mechanisms that the permitting agencies could use to provide programmatic authorizations for the LFRCMP.

7.4.1 U.S. ARMY CORPS OF ENGINEERS—CLEAN WATER ACT SECTION 404 AND RIVERS AND HARBORS ACT SECTION 10

USACE could develop an RGP for the LFRCMP under the authority of CWA Section 404 (Title 33, Section 1344 of the U.S. Code [33 USC 1344]) and Rivers and Harbors Act Section 10 (33 USC 403). The RGP would be developed in accordance with provisions of the USACE Regulatory Program (33 CFR 323.2[h]) for proposed activities within the LFR corridor that are substantially similar in nature and cause only minimal individual and cumulative environmental impacts. Overall RGPs expedite the USACE permitting process by avoiding the need to obtain separate permits on a project-by-project basis.

To qualify for authorization under an RGP permit, applicants must meet the general and special conditions established for that RGP. RGPs typically require project-by-project notification to USACE. An RGP would be issued only after USACE ensures compliance with its regulations at 33 CFR 325, and only for those activities that are substantially similar in nature and cause only minimal individual and cumulative environmental impacts.

When developing an RGP for LFRCMP activities and determining whether this programmatic permit would be warranted, USACE would first consider how frequently an RGP could be used. As discussed in Appendix O, only a limited number of Section 404 and Section 10 permits have been issued for activities on the LFR over the last several years. Relatively few maintenance activities described in Appendix L would require a USACE permit, but several of the flood-management and ecosystem-enhancement management actions could require such permitting.

For the proposed actions described in Chapter 6, project-specific details need to be developed describing the extent of activities that would occur below the ordinary high-water mark (the limit of USACE's LFR jurisdiction), and explaining what portion of the activities occurring below the ordinary high-water mark would be regulated under either CWA Section 404 or Rivers and Harbors Act Section 10. However, the following proposed floodway- and ecosystem/habitat–enhancement management actions might require a Section 404 or Section 10 permit:

- FMA-4—Improve Drainage of Waterside Levee Borrow Channels at Abbott Lake and O'Connor Lakes
- FMA-5—Improve Levee Borrow Channel Drainage on Lake of the Woods, and Shorten Pump Plant 2 Drainage Ditch
- EMA-1—Restore Intermittent Flow to Old Feather River Channel at Eliza Bend
- EMA-2—Restore 500 Acres of Riparian and Upland Habitat in the Feather River Setback Area
- EMA-3—Distribute Overbank Flows in Swales and Revegetate the Northern Feather River Setback Floodplain
- EMA-4—Enlarge Existing Swale to Improve Drainage in Southern Feather River Setback Floodplain; Plant Riparian Forest, Willow Scrub
- EMA-8—Improve Drainage at Abbott Lake and the O'Connor Lakes Unit
- EMA-10—Create an Overbank Swale and Vegetated Bench at O'Connor Lakes
- EMA-11—Create an Inlet Swale to Increase Overbank Flow into and through Lake of the Woods
- EMA-13—Create Shaded Riverine Aquatic Habitat and a Mosaic of Riparian/Upland Habitat at Nelson Slough

If issued, an RGP would be valid for no more than 5 years from the date of issuance, and would remain in effect until it automatically expires or is modified, suspended, or revoked. If the RGP is not modified, suspended, or revoked, following the RGP's expiration, USACE may follow procedures at 33 CFR 325 and evaluate the RGP for reissuance. Compliance with additional regulations such as those identified below would be required by USACE before it makes a decision on whether or not to issue the RGP:

- ESA (compliance to be achieved by developing an HCP, as described above)
- Fish and Wildlife Coordination Act (compliance to be achieved through a Fish and Wildlife Coordination Act report prepared by USFWS and NMFS)
- Magnuson-Stevens Fishery Conservation and Management Act for Essential Fish Habitat (compliance to be achieved at NMFS discretion by incorporating RGP special conditions that require implementing Essential Fish Habitat conservation recommendations provided in the HCP);
- Marine Mammal Protection Act (compliance to be achieved through coordination with NMFS and USFWS during the Section 7 consultation process)
- Migratory Bird Treaty Act (compliance to be achieved through coordination with USFWS during the Section 7 consultation process)
- Section 106 of the NHPA (compliance to be achieved by developing a PA with the State Historic Preservation Officer [SHPO], as described below)

- Section 401 of the CWA (compliance potentially to be achieved by developing a programmatic Section 401 water quality certification with the State Water Resources Control Board [SWRCB] or Central Valley RWQCB, as described below)
- NEPA (compliance to be achieved through USACE preparation of an environmental assessment as part of the RGP process; a finding of no significant impact is anticipated)
- Bald and Golden Eagle Protection Act (compliance to be achieved by coordination with USFWS during the Section 7 consultation process)

Before making a decision about whether or not to issue a RGP, USACE would require DWR to consider and use all reasonable and practical measures to avoid and minimize impacts on aquatic resources. If DWR is unable to avoid or minimize all impacts, USACE may require compensatory mitigation. Compensatory mitigation for impacts on waters of the United States would conform to the minimum mitigation standards set by the HCP, and would be consistent with USACE's mitigation rule (33 CFR 332).

7.4.2 U.S. Army Corps of Engineers—Rivers and Harbors Act Section 14

Activities that alter State Plan of Flood Control facilities require authorization under Section 14 of the Rivers and Harbors Act of 1899 (33 USC 408), referred to as "Section 408." If proposed changes are minor, low-impact alterations, then the commander of USACE's Sacramento District has the delegated authority to approve the change. To qualify, the project must not change the authorized structural geometry or hydraulic capacity, and not have impacts on the system performance.

If there is a minor, low-impact alteration that is not a direct benefit to a flood control structure (for example, a pipeline or bridge crossing), these may be approved in accordance with 33 CFR 208.10 through submittal of an encroachment permit application to the CVFPB. (Encroachment permits are submitted for review to the USACE Sacramento District, and the district can recommend permit conditions.)

Activities that would result in major modifications (i.e., levee raisings, extensions, realignments, and permanent degradations) require authorization at USACE Headquarters under Section 408.

Currently no mechanism is available to achieve programmatic Section 408 compliance. Authorizations must be sought from either USACE district commanders or Headquarters' Chief of Engineers on an individual project basis. Only two flood management actions potentially affecting levees (FMA-7—Set Back Corner Levee at Constriction from RM 7.7 to 7.4, and FMA-8—Reevaluate and Realign Portions or All of Sutter Bypass Hook Levee) are proposed in Chapter 6, and no programmatic compliance with Section 14 is proposed here.

7.5 OTHER STATE PROGRAMMATIC PERMITS

Appendix O provides background information about the roles and responsibilities of State agencies that might need to issue permits for the proposed activities covered in the LFRCMP. The appendix also describes the regulatory mechanisms that could be used by the permitting agencies to provide programmatic authorizations for the LFRCMP.

7.5.1 CEQA COMPLIANCE

A certified CEQA document is required before any of the following State permits will be issued:

- Section 401 water quality certification by the appropriate RWQCB or the SWRCB
- Streambed alteration agreement by CDFW
- 2081 incidental take permit from CDFW
- Master lease from the State Lands Commission
- National Pollutant Discharge Elimination System (NPDES) permit or waiver from the RWQCB

Therefore, programmatic permitting for LFR proposed actions would be greatly facilitated by preparing CEQA documents that provide well-substantiated impact analyses and clearly defined and implementable avoidance, minimization, and mitigation measures.

As designated lead agency, DWR would determine and prepare the appropriate CEQA document that would identify the project's scope and probable environmental impacts of proposed activities covered by the permits listed above. The CEQA document also would identify the aggregate and cumulative impact of these activities, to the extent that these impacts can be defined and are not speculative.

In addition to providing CEQA compliance for the State permits listed above, the CEQA document would provide a means to integrate management of cultural resources required by NHPA Section 106. Furthermore, it would address potential program-level impacts on State-listed species, water quality, and lands within the jurisdiction of the State Lands Commission.

7.5.2 CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE—LAKE AND STREAMBED ALTERATION PROGRAM

Section 1600 of the California Fish and Game Code requires that CDFW be notified before a project would substantially obstruct or divert natural flows of State waters; substantially change or use materials from a bed, bank, or channel; or deposit materials into a river, stream, or lake. If CDFW determines that the activity may substantially adversely affect fish and wildlife resources, a lake or streambed alteration agreement (LSAA) must be prepared. The LSAA includes reasonable conditions necessary to protect those resources and must comply with CEQA.

CDFW and DWR signed a streambed alteration agreement (SAA) for routine maintenance of flood control projects by the DWR Sacramento and Sutter maintenance yards. This SAA, the DWR Routine Maintenance Streambed Alteration Agreement (RMSAA), became effective on January 6, 2011 (DFG 2011). The 2011 DWR RMSAA is a type of SAA that outlines a project-specific approval process in which DWR provides detailed notification to CDFW before conducting routine maintenance. This notification allows CDFW to review DWR's proposed maintenance work to ensure that the work fits within the parameters and covered activities of the RMSAA and its CEQA Notice of Exemption and confirm that the work would not adversely affect fish and wildlife resources. Additionally, DWR submits an annual report to CDFW, summarizing the work completed that year.

CDFW does not issue MOUs or memoranda of agreement in place of SAAs, and routine-maintenance agreements are typically issued only for routine reoccurring maintenance activities with appropriate CEQA compliance.

CDFW could authorize LFR HCP/2081 permit projects under a master lake and streambed alteration agreement (Master LSAA) between CDFW and DWR or the CVFPB. This Master LSAA would cover routine maintenance projects (e.g., floodway management, maintenance) and proposed floodway- and ecosystem-enhancement management actions as described in Chapter 6.

Based on conditions identified in the Master LSAA, sub-notifications would have to be filed for each project or type of project (e.g., routine maintenance, floodway management project, ecosystem enhancement project).

Under the Master LSAA, CDFW would maintain authority over the LSAA process and would be notified of new proposed projects under the agreement. The Master LSAA sub-notification process would allow CDFW to determine whether each proposed project could be authorized under the Master LSAA and the master or project-specific CEQA document. Avoidance and minimization measures would be incorporated into the authorization based on the Master LSAA and/or CEQA document applicable to each project, based on the species and sensitive resources that may be present. These avoidance and minimization measures would be consistent with those identified in the LFR HCP/CESA permit. The Master LSAA would cover both reoccurring maintenance activities and new flood management and ecosystem enhancement actions that are included as a part of the original notification package; the Master LSAA may not cover all activities. A Master LSAA could be used to increase the efficiency of the process for complying with Section 1600 of the California Fish and Game Code.

The Master LSAA would be issued for a 10-year period or possibly longer; the specific term of the Master LSAA would be developed in consultation with CDFW. Issuing the Master LSAA would require certification of CEQA compliance. CDFW would be a responsible agency under CEQA; in acting on issuance of the Master LSAA, CDFW would rely on the CEQA compliance document for the associated HCP/2081 permit to ensure the document adequately analyzed the impacts and provided avoidance, minimization and mitigation measures to allow CDFW to issue the LSAA and prepare its CEQA findings.

7.5.3 STATE HISTORIC PRESERVATION OFFICER—NATIONAL HISTORIC PRESERVATION ACT SECTION 106

This section summarizes the regulatory mechanisms that would provide a programmatic, efficient process for implementing the activities described in the LFRCMP to comply with Section 106 of the NHPA.

For actions included as covered activities in the LFR HCP/2081 permit, USACE would initiate consultation with SHPO to determine whether a PA would be executed to comply with Section 106 using the process defined in 36 CFR 800.14. This process allows deferred identification and management of cultural resources under an agreement document (36 CFR 800.4[b][2]).

The PA can programmatically identify the types of activities that will and will not be subject to further Section 106 review. This screening mechanism can release numerous minimal activities from Section 106 requirements and allow certain types of activities to proceed in an expedited fashion. The PA also can stipulate abbreviated consultation periods, reduced reporting requirements, and other necessary processes that would be faster and more

efficient than under the standard Section 106 process. The requirements of the PA may also be integrated into CEQA mitigation to coordinate CEQA and NEPA compliance.

On execution (signing and approval) of the PA by the consulting parties, Section 106 compliance is deemed complete for the purpose of permits and authorizations that depend on the Section 106 process (36 CFR 800.14[b][2][iii]). Therefore, execution of the PA would satisfy Section 106 sufficiently to allow USACE to determine whether or not to issue a Section 404 and/or a Section 10 permit for a project. It also would allow DWR and USACE to defer identification and management of historic properties until specific sites require maintenance or habitat restoration.

The PA would provide a process for performing an inventory of cultural resources at maintenance and restoration sites as they are identified, evaluating those resources, and resolving adverse effects on significant resources (historic properties). The Native American Heritage Commission, local Native American tribes, and the interested public (such as local historic preservation organizations) would be consulted to assist with cultural resources inventories and development of the PA. DWR would facilitate coordination with other federal agencies providing permits and authorizations for the project so that the PA would provide a unified Section 106 compliance framework for the project. The PA would be valid for 5 years, and could be renewed at the discretion of USACE and the SHPO concurrent with renewal of the Section 404 permit and/or Section 10 permit.

7.5.4 Central Valley Regional Water Quality Control Board—Clean Water Act Section 401

Applicants seeking a federal permit under Section 404 of the CWA must also obtain a water quality certification from the appropriate RWQCB, in accordance with Section 401 of the CWA. In California, the U.S. Environmental Protection Agency (EPA) has delegated authority to the RWQCBs to issue Section 401 water quality certifications. Section 401 certification of the RGP would provide another level of efficiency for the LFRCMP. However, if the RGP were to not be certified under Section 401, each floodway management and restoration project carried out under the RGP would require separate Section 401 certification before project activities could begin.

The SWRCB or the Central Valley RWQCB could develop a programmatic Section 401 water quality certification concurrently with USACE's RGP process to authorize activities covered by the LFR HCP/2081 permit under Section 401. Certification of USACE's RGP would provide another level of efficiency for flood management activities. The SWRCB or the Central Valley RWQCB would be a responsible agency under CEQA; the RWQCB would rely on the CEQA compliance document to prepare and issue its own findings regarding the activities covered by the HCP/2081 permit, and to decide whether or not to issue a water quality certification. The programmatic certification would be effective for 5 years, and could be renewed at the discretion of the Central Valley RWQCB concurrently with renewal of the RGP.

7.5.5 Central Valley Regional Water Quality Control Board—Clean Water Act Section 402

CWA Section 402 prohibits certain discharges of stormwater containing pollutants, except in compliance with an NPDES permit (33 USC 1311, 1342[p]; also referred to as CWA Sections 301 and 402[p]). The CWA authorized EPA to delegate NPDES permit program authority to state governments, enabling states to perform many of the

permitting, administrative, and enforcement aspects of the NPDES program. In California, the SWRCB has been authorized to implement the NPDES program, with EPA retaining oversight responsibilities.

California's NPDES program requires projects that disturb 1 acre or more of soil, or that disturb less than 1 acre but are part of a larger common plan of development that in total disturbs 1 acre or more, to obtain coverage under the State's general permit for discharges of stormwater associated with construction activity, known as the Construction General Permit. (The Construction General Permit is SWRCB Order No. 2009-0009-DWQ NPDES General Permit No. CAS000002, Waste Discharge Requirements for Discharges of Storm Water Runoff Associated with Construction and Land Disturbance Activities.) Construction activity subject to the Construction General Permit includes clearing, grading, and disturbances to the ground such as stockpiling or excavation.

Based on requirements of the Construction General Permit, if grading for routine maintenance or for proposed floodway- or ecosystem-enhancement management actions would exceed 1 acre, a notice of intent (NOI) must be filed. As discussed in Appendix O, Central Valley RWQCB staff members said that they could consider approving a "generic" SWPPP for the LFRCMP to expedite the Construction General Permit authorization process for routine maintenance under the plan, and for other proposed projects (Raley, pers. comm., 2010; Muhl, pers. comm., 2009).

Using this approach, DWR could develop a generic SWPPP with standardized best management practices for all routine maintenance, floodway management, and restoration projects. A draft version of the SWPPP would be submitted to the Central Valley RWQCB for comment. Once the RWQCB determined that the generic document met SWPPP requirements, the generic SWPPP could be submitted on a project-by-project basis with a project-specific NOI and check for the required NPDES permit filing fee. Central Valley RWQCB staff members indicated that in such cases, they generally would be able to turn around a notice of applicability to use the Construction General Permit in approximately 10 days from receipt of the NOI.

8 IMPLEMENTATION, TRACKING, AND MONITORING

This chapter describes the roles, responsibilities, and timeline for implementation of actions described in Chapter 6 of this *Lower Feather River Corridor Management Plan* (LFRCMP). In addition, this chapter discusses a conceptual process for tracking, storing, and disseminating information on ecosystem/habitat restoration and flood management projects. It also discusses permit compliance tracking and reporting for routine maintenance activities, including the process for making updates, implementing adaptive management, and maintaining agency input. A discussion of potential funding sources for these activities concludes this chapter.

8.1 ROLES AND RESPONSIBILITIES AND TIMELINE

DWR would oversee implementation of actions described in the LFRCMP over which it has jurisdiction, such as ongoing routine floodway maintenance, some flood management projects, and restoration and ecosystem improvement projects related to programmatic permitting. DWR would also monitor and report on implementation of the LRFCMP undertaken by other parties, and would support the adaptive management process described below. A 30-year timeline is proposed for implementing the LFRCMP management actions proposed in Chapter 6, and for developing and implementing the permitting strategy described in Chapter 7.

8.2 TRACKING AND DATA DISSEMINATION

DWR would serve as the clearinghouse for LFRCMP information and would use the conceptual process described below to compile, store, and share information on the status of ecosystem and habitat restoration projects, flood management improvement projects, and maintenance activities. This process would also provide a forum for sharing updated hydrological analyses using the models developed as part of the LFRCMP, as well as any new model development and analyses.

The implementation tracking and data dissemination approach described here would be integrated with similar efforts for the Central Valley Flood Protection Plan (CVFPP) (DWR 2011) and the *Central Valley Flood System Conservation Strategy* (Conservation Strategy), as described in the CVFPP Conservation Framework (DWR 2012). Consistent with the Conservation Strategy approach, implementation tracking and data dissemination for the LFRCMP would serve the following purposes:

- Document compliance with the terms and conditions of grants, agreements, permits, and other authorizations.
- Track the effects of maintenance activities.
- Offer a forum that allows agency and public review of the implementation of LFRCMP management actions and related permits.
- Provide information to support adaptive management decisions.

These four purposes would be fulfilled by implementation of a tracking and data sharing system that would consist of two main data repositories with numerous related queries, reports, and data views to facilitate reporting, information sharing, and adaptive management.

DWR is developing these data repositories specifically for the CVFPP and associated Conservation Strategy, and would include the LFRCMP data in the repositories. Each data repository would be designed and maintained to provide quality assurance and quality control of data, and for ease of access and use for evaluations. It would be accessible through the Internet, and graphic user interfaces would allow users to query the data and generate a variety of reports based on those queries.

8.2.1 PROJECT DATA REPOSITORY

Data related to LFRCMP flood management and ecosystem improvement projects and associated permits would be maintained in a project data repository. The project data repository would contain information about the planning, design, funding, environmental review, and permitting of projects implemented to further the goals of the LFRCMP and to contribute to fulfilling CVFPP goals. In addition to project attributes, this data repository could contain links to available project documents (e.g., digital copies of environmental documents and regulatory permits) and links to relevant geospatial datasets.

This data repository is currently under development, and is likely to rely on a system using Microsoft Access (MS Access). The MS Access database would provide a starting point for the project data repository; ultimately, the database could be enhanced to store additional project information and moved to a different database platform to facilitate shared network access and multiple concurrent users, and to improve stability, reliability, and functionality.

Three specific data views, in the form of customizable queries and reports, would be created to facilitate review and interaction with data stored in the project data repository. For example, similar to the HabiTrak (CDFW 2013) database used by some regional HCPs and Natural Community Conservation Plans, the project data repository may be queried to tabulate effects by habitat type, time period, and geographic unit Together these three data views would allow for review of the implementation of LFRCMP projects and associated permits.

Each data view proposed for the project tracking database is briefly described below.

- *Project Information View*. The project information view would facilitate input, updates, and review of attribute information for all LFRCMP projects, including project name, sponsor, location (with links to geographic information systems), links to electronic copies of project documents, contact information, and similar project-related information.

- *Compliance Tracking View*. The compliance tracking view would facilitate input and updates to and review of avoidance and minimization measures and the provision of compensatory mitigation, as required by environmental permits issued for LFRCMP projects. It could also be used to allocate mitigation credits from LFRCMP projects to specific CVFPP projects and maintain a “balance sheet” of total available mitigation credits, by mitigation credit type. The source of the data would be the compliance documentation for LFRCMP activities covered by programmatic permits. In addition, the compliance tracking view could keep track of management actions that supply surplus habitat enhancements that could be applied elsewhere in the Feather River Conservation Planning Area to offset anticipated impacts of flood system construction or maintenance. This documentation (i.e., scanned copies) would reside in the project data repository as described above under “Project Information View.”

- *Effects Tracking View*. The effects tracking view would facilitate input and updates to and review of the effects of LRCMP projects on ecosystem processes and habitats, as well as species and habitat covered by the project permits. These effects include both adverse and beneficial effects. The units for most effects would be acreages or linear distances (e.g., acreage of riparian habitat or linear feet of shaded riverine aquatic habitat). Beneficial effects (e.g., the creation of habitat) would be dynamically linked to the ecosystem data repository (described below). Because adverse and beneficial effects cannot always be adequately captured using spatial data alone, DWR would work with resource agencies to develop additional metrics to fully document the effects of LFRCMP actions.

8.2.2 ECOSYSTEM DATA REPOSITORY

The ecosystem data repository would document the systemwide status of ecosystem processes, habitats, and species. It would be linked to the project data repository such that LFRCMP projects that would have a net positive effect on ecosystem processes (e.g., by restoring riparian habitat or increasing shaded riverine aquatic habitat) would automatically propagate into the ecosystem data repository to update the current status (e.g., acreage or linear feet) of habitats, species, or ecosystem processes. Where appropriate, data would be spatially referenced to facilitate spatially explicit queries and comparisons (e.g., acreage of riparian habitat within the Feather River Conservation Planning Area). It would also accommodate storage of ecosystem data and metrics that do not have a spatial component (e.g., improvements in riparian habitat conditions caused by control of invasive weeds). The ecosystem data repository would have a single view, described below.

The ecosystem data repository would distinguish and track separately those areas within the LFRCMP study area that are devoted to mitigation for project-specific impacts from areas where proposed management actions would generally contribute to the overall improvement of baseline habitat conditions. Mitigation for project impacts would only offset those impacts to maintain a “no-net loss” status quo, but conservation, restoration and enhancement actions not specifically dedicated to project mitigation would be credited as contributing to enhanced conditions with habitat values substantially increased above baseline.

- *Ecosystem Status View*. The ecosystem status view would facilitate input and updates to and review of data characterizing the status and trend of ecosystem processes, species, and habitats. Through this view, it would be possible to incorporate ecosystem data that were not specifically related to an LFRCMP action, and thus not automatically propagated into this data repository from the project data repository. It would also be possible to calculate a variety of ecosystem performance metrics that could be used to assess the contributions of LFRCMP projects to the Conservation Strategy’s goals, and to assess changes in specific ecosystem metrics over time. The ecosystem status view would also facilitate comparison of baseline habitat conditions with enhanced habitat conditions.

8.3 PERMIT COMPLIANCE TRACKING AND REPORTING FOR ROUTINE MAINTENANCE

One of DWR’s goals for the LFRCMP is to establish an efficient, cost-effective approach for monitoring and reporting compliance with permits described in Chapter 7. This goal is particularly important for the permits needed to perform the routine floodway maintenance activities described in Appendix L. Some year-to-year variation occurs in implementing routine maintenance, depending on factors such as major flood events or

availability of funding. In general, however, the locations and ongoing activities associated with maintenance within the LFRCMP study area are highly predictable, and therefore lend themselves to a programmatic and simplified approach for tracking and reporting.

Monitoring and reporting routine maintenance would be facilitated by the fact that most activities occur within well-defined locations in the LFRCMP study area. Appendix L describes the maintenance "envelopes" in which current maintenance occurs, and where future maintenance would be needed if certain management actions described in Chapter 6 were implemented. It also discusses the kinds of activities that occur in the maintenance envelopes and their frequency, and the acreages of various cover types present in the envelopes. The maintenance envelopes conservatively encompass a larger area than is typically maintained each year. The activities generally maintain a steady-state condition for the cover types within the envelopes (as described in Appendix L, these cover types are composed mostly of ruderal lands and annual grassland) and a corresponding steady-state condition in the associated habitat values and ecosystem functions.

The tracking and annual reporting system for routine maintenance would not require detailed bookkeeping for all maintenance activities conducted within the maintenance envelopes. It would instead focus on verification, through an easy-to-implement process (e.g., review of aerial photography), that maintenance activities were restricted to the boundaries of the envelopes. The reporting would also include documentation that activities were restricted to those described in the permit conditions, and that other permit conditions, including avoidance and minimization measures, were implemented as required.

The Verification Request Form and annual reporting described in DWR's Routine Maintenance Streambed Alteration Agreement (DFG 2011) provides an example of a simple reporting system that could be implemented to track and monitor routine maintenance activities in the LFRCMP study area. DWR's newly developed Small Erosion Repair Program (SERP) could also provide a model for the tracking and reporting process. SERP is a collaborative interagency effort developed to create a streamlined regulatory review and authorization process to facilitate annual repairs of small erosion sites on levees within the Sacramento River Flood Control Project area. In developing this pilot program, DWR worked closely with permitting agencies to create notification requirements and reporting standards for SERP activities. Unlike the ongoing, repetitive maintenance activities in the LFRCMP study area, SERP repairs are one-time projects (levee repairs). Therefore, a simplified version of the SERP reporting system would be appropriate for the LFRCMP's routine maintenance activities. The collaborative process developed by DWR and the permitting agencies was successful in creating a workable tracking and reporting system and could provide a model for permitting routine maintenance activities in the LFRCMP study area.

With implementation of proposed LFRCMP management actions (for example, Flood Management Action 6, "Cease Vegetation Clearing from River Mile [RM] 13.5 to RM 12.5 at Lake of the Woods," and Flood Management Action 9, "Incorporate Invasive Plant Control Best Management Practices into Routine Maintenance"), the composite, overall habitat functions and values of lands routinely managed by DWR and other local maintaining agencies would experience a net increase compared to existing, baseline habitat values. This increase in habitat values and functions would contribute to the incremental habitat improvements required as part of the Conservation Strategy, to achieve target levels of enhancement throughout the Feather River Conservation Planning Area. This net increase in values would be accounted for and tracked as part of the implementation tracking and data dissemination system described above in Section 8.3.

8.4 UPDATES, ADAPTIVE MANAGEMENT, AND AGENCY INPUT

Updates to the LFRCMP would be integrated with the CVFPP update process, which is scheduled to occur every 5 years (DWR 2011). Input would be sought from the appropriate partner agencies, such as the U.S. Army Corps of Engineers (USACE), CDFW, NMFS, USFWS, the Central Valley Water Quality Control Board, the Central Valley Flood Protection Board, and local maintaining agencies, and from other stakeholders.

Revisions would rely on information compiled in the project and ecosystem data repositories described above, and would build on previous versions of the LFRCMP. Updates would likely include a description of changes to physical conditions in the LFRCMP study area since the baseline conditions were described; changes in approaches, projects, and programs; and results of relevant new technical studies. These technical studies could include revised modeling efforts to assess changes in flood hydraulics and geomorphic trends, using models developed for the LFRCMP. The hydraulic model for the 100-year and 200-year flood analysis (see Appendix F) and the hydrodynamic and sediment-transport model (see Appendix H) are the two models that were developed and used to evaluate the effects of implementing potential LFRCMP management actions. These models are currently kept in DWR's Library of Models.

An adaptive management approach would be applied to LFRCMP decision making during plan updates and after implementation of management actions. The adaptive management approach allows managers to address the uncertainty that is always present when they make decisions that affect flood risk and riverine ecosystems, thereby providing a structured process to make decisions and take actions based on monitoring results. These actions may include changes to flood management actions, including operations and maintenance, or implementation of additional ecosystem and habitat enhancement actions. Chapter 7, "Permitting Strategy," describes the adaptive management approach that would be used during development of programmatic permits for the LFRCMP.

The LFRCMP Work Group has been DWR's forum for stakeholder participation in development of the LFRCMP, but future input from resource agencies, flood managers, and other stakeholders would likely be integrated with the Conservation Strategy's ongoing efforts and the Interagency Advisory Committee (IAC). The IAC was established by DWR during preparation of the Conservation Framework to promote a strong working relationship with resource agencies, and to provide guidance on development and content of the Conservation Strategy and associated environmental regulatory compliance. Participants include the Central Valley Flood Protection Board, USACE, U.S. Fish and Wildlife Service, California Department of Fish and Wildlife, National Marine Fisheries Service, and State Water Resources Control Board. Development and implementation of the Conservation Strategy would require continued input from the IAC or an equivalent interagency group. Input from resource agencies and other stakeholders on development of programmatic permitting for the LFRCMP would be integrated with the Conservation Strategy work of the IAC, as well as the Regional Planning/System-Wide Coordinating Committee (Coordinating Committee).

To achieve the multiple benefits of management actions proposed in the LFRCMP, and to incorporate these management actions with other regional and systemwide efforts, the coordination should also be aligned with the locally led Regional Flood Management Planning and the State-led Basin-Wide Feasibility Studies. The Regional Flood Management Planning effort focuses on developing projects and strategies to address local and regional flood management needs. The Basin-Wide Feasibility Studies seek to develop long-term improvements that

provide cross-regional benefits and improve overall flood system function flexibility and resiliency. These two planning efforts integrate conservation into flood management actions to provide multiple benefits. The CVFPB and DWR formed the Coordinating Committee to facilitate integration of the Conservation Strategy, Regional Flood Management Planning and Basin-Wide Feasibility Study efforts. Coordinating Committee participants include representatives from agencies also participating in the IAC, along with local agency representatives, environmental NGO representatives, and other interested stakeholders.

8.4.1 FUNDING SOURCES

Funding would be needed to implement the LFRCMP management actions, update information and models, conduct ongoing maintenance and land management, and for long-term monitoring, reporting, and adaptive management. Funding assurances for these activities is a required element of some permit conditions, such as for a 2081 permit under CESA. Currently no funding has been identified for implementing proposed LFRMP management actions.

Funding sources would vary according to the type of project or program, beneficiaries, availability of funds, urgency, and other factors. Funding is likely to involve a mix of federal, State, and local funds, and cost sharing among these parties would change depending on project objectives and agency interests. Flood management and associated ecosystem improvement projects within the State Plan of Flood Control (SPFC) have historically been funded by federal, State, local, and nongovernmental funds. Since 2000, the State has authorized $19.6 billion in water-related general obligation bonds, and these bonds often contain provisions for conservation-related purposes (NMFS 2009). Implementation of the CVFPP is anticipated to require an investment of $14 billion to $17 billion, shared by federal, State, and local agencies (DWR 2012).

Through Proposition 1E, the Disaster Preparedness and Flood Prevention Bond Act of 2006, and Proposition 84, the Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006, the State has provided approximately $5 billion for flood management activities, of which $3 billion are allocated for implementing the CVFPP. An additional $11 billion to $14 billion will be needed during the next 20 years from federal, State, and local sources (DWR 2011), although the amount of funding, timing, and sources are currently unknown. Another State bond measure will likely be required to augment federal and local agency funding because Proposition IE funding will expire in 2017.

The federal government is likely to have greater interest in sharing the cost of implementing flood management projects that produce benefits for multiple project objectives (e.g., flood risk management and ecosystem restoration). For those projects in which the federal government has an interest, cost-sharing between State and federal flood management agencies is established in State and federal law. USACE's *Trade-Off Analysis Planning and Procedures Guidebook* (USACE 2002) contains details about the types of projects for which USACE shares costs, and lays out a framework explaining how to allocate those costs to different project objectives.

For those flood management projects in the Central Valley for which a federal interest is not established, project costs are generally allocated among the State and local partners based on cost-sharing formulas. For example, in accordance with legislation enacted in 2007 (Assembly Bill 5, Chapter 366, Section 26 [California Water Code, Section 9625]), DWR developed cost-sharing formulas for the Early Implementation Projects program. The cost-sharing formulas used funds made available by Proposition 1E and Proposition 84, which funded numerous flood management projects in advance of adoption of the 2012 CVFPP.

DWR recently released guidelines for the Flood System Repair Project (FSRP), authorized under Proposition 1E and Proposition 84, that describe how DWR intends to fund projects for repair, rehabilitation, reconstruction, or replacement of levees, weirs, bypasses, channels, and other facilities of the SPFC (DWR 2013). To ensure that funds are spent in accordance with Proposition 1E requirements and are consistent with the State System-Wide Investment Approach detailed in the CVFPP (DWR 2011), the FSRP incorporates prioritizing funded projects to focus on repair of performance problems that are critical or serious, or that may impede flood fight capabilities. The FSRP also provides for proactive repairs that lead to sustainable operations and maintenance practices. The FSRP also supports the goals of the Conservation Framework (DWR 2012) by incorporating habitat enhancement components with avoidance of environmental impacts; by mitigating impacts on-site, or nearby for unavoidable impacts; and coordinating with identified restoration projects as necessary to ensure that selected repair sites are consistent with the State Systemwide Investment Approach and minimize foreclosing future environmental enhancement opportunities. FSRP cost-sharing provisions encourage local maintaining agencies to participate in habitat improvements and in corridor management and multi-benefit projects.

The State has also used Proposition 1E funding to strategically initiate projects that integrate ecological benefits into physical improvements to the flood system. This funding can be applied to projects that evaluate, repair, reconstruct, or replace SPFC facilities; projects that improve or add to the SPFC to improve flood protection for urban areas; or related costs of relocating infrastructure or mitigating environmental impacts. For these projects, the State generally collaborates and shares costs with other funders—typically federal agencies, local maintaining agencies, other State agencies, or other public agencies. These projects target actions that provide benefits complementing or supporting those of the other CVFPP actions. Projects are evaluated and funded in accordance with the State's guidelines, based on the significance of the projects' ecological benefits, technical and political feasibility, and cost reasonableness/cost-sharing opportunity.

The potential to provide multiple benefits and support from diverse interests is also an important consideration in securing funding for proposed projects. The guiding strategy for reducing flood risk in the 2012 CVFPP is based on the State Systemwide Investment Approach (SSIA), a multi-benefit and integrated flood management approach (DWR 2011). Multi-benefit projects will likely be given priority in future State-funded grant opportunities. A formal definition of multi-benefit projects has not been established, but generally, multi-benefit projects are those that support multiple public values, such as public safety, environmental stewardship, water reliability and quality, agricultural sustainability and recreation. Well defined multi-benefit projects have the advantage of being able to access different types of funding sources.

8.4.2 FUNDING FOR MAINTENANCE

Implementation of the SSIA requires efficient and sustainable long-term operations and maintenance practices. However, funding for operations and maintenance within the flood management system has been insufficient to keep pace with the rising cost of routine maintenance (see Chapter 4 of the CVFPP [DWR 2011] for a more detailed discussion). Activities identified in the CVFPP to improve SSIA implementation and funding include reforming roles and responsibilities; formalizing criteria by which maintenance practices, procedures, and inspections are performed and reported; and implementing strategies to adequately and reliably fund routine maintenance activities and permitting. Some of the proposed activities will likely involve legislative action, new institutional arrangements involving local maintaining agencies, modifications to existing State programs, and additional revenue generation (DWR 2011).

Maintaining the biological values of restoration sites also requires a funding source to fulfill commitments to manage and protect those sites in perpetuity; endowments are the typical mechanism used to support this required long-term management. Income generated by endowments covers the costs of management tasks such as invasive species control programs, fence maintenance, signage, fire management, monitoring and reporting, adaptive management, and administrative expenses such as personnel, accounting, legal support, and insurance.

Some funding sources, including bonds such as Proposition 1E, have funding restrictions and are not eligible to be used for endowments or to directly fund routine maintenance. These restricted funds can only be used for bond program management, project planning and permitting, and project implementation. Some past bond acts have included language that allows establishment of maintenance endowment funds equal to 20 percent of the purchase price of the property. However, in some circumstances this would prove to be too limiting because some restoration projects occur on property which is already owned, donated, or purchased at a token price (e.g. $1). Future infrastructure bonds that allow funds to be applied to mechanisms supporting long-term operations and maintenance of investments (such as habitat enhancement and constructed improvements) with a dollar amount based on the value of those improvements could provide an additional revenue source. Changes to these bond restrictions would provide an additional revenue source for the stewardship of restoration lands and maintenance of the flood management system.

DWR and other parties, including TRLIA, have been seeking creative solutions to the problem of securing long-term maintenance funding mechanisms to maintain state-created mitigation and restoration areas (Brunner, pers. comm., 2014). Revenues generated by agricultural leases within the LFRCMP study area could provide DWR with a funding source to cover long-term maintenance costs of these lands. However, lease revenues from State-owned property must go directly into the General Fund rather than specifically to management of LFRCMP restoration areas because DWR lacks the discretion to use them for another purpose. A legislative solution to this problem could be pursued to allow DWR discretion to use lease revenues for long-term operational and maintenance expenses of lands in the LFRCMP study area.

Additional options for generating income for maintenance of lands in the corridor could include sale of materials mined from the floodway, such as sand or fill, or grazing leases. The CDFW has successfully issued permits for Excess Vegetation Disposal at Fremont Weir and other locations. These permits are an important tool for achieving species and habitat management goals on CDFW lands (Holley, pers. comm., 2014). The permits are issued by CDFW to remove non-native vegetation and promote growth of forbs and forage to support deer and other wildlife, and they have the added benefit of providing income that can be used for management and maintenance.

9 REFERENCES

9.1 INTRODUCTION

California Department of Water Resources. 2010a (September 21). *Department of Water Resources Policy Paper: Environmental Stewardship.* Final. Sacramento, CA. Available: http://www.waterplan.water.ca.gov/docs/news/EnvironmentalStewardshipPolicy2010.pdf. Accessed October 16, 2013.

———. 2011 (December). *2012 Central Valley Flood Protection Plan: A Path for Improving Public Safety, Environmental Stewardship, and Long-Term Economic Stability*. Public Draft. Sacramento, CA.

———. 2012 (January). *Central Valley Flood Protection Plan: A Path for Improving Public Safety, Environmental Stewardship, and Long-Term Economic Stability.* Attachment 2: Conservation Framework. Public Draft. Sacramento, CA.

———. 2014 (May 19). *Feather River Region Regional Flood Management Plan*. Administrative Draft. Sacramento, CA.

DWR. *See* California Department of Water Resources.

9.2 FACTORS AFFECTING DEVELOPMENT OF THE LOWER FEATHER RIVER CORRIDOR MANAGEMENT PLAN

None.

9.3 EXISTING CORRIDOR CONDITIONS

Atkins. 2011. *Final Olivehurst Public Utilities District 2010 Urban Water Management Plan*. Roseville, CA.

Bank Swallow Technical Advisory Committee. 2013. Bank Swallow (Riparia riparia) Conservation Strategy for the Sacramento River Watershed, California. Version 1.0. Available: www.sacramentoriver.org/bans/.

BANS TAC. See Bank Swallow Technical Advisory Committee.

California Department of Fish and Game. 1988. *Lower Feather River Complex (Abbott Lakes Ecological Reserve, O'Connor Lakes Ecological Reserve, Lake of the Woods Wildlife Area) Operations and Maintenance Plan*: *Final Report, Volume I.* Rancho Cordova, CA.

———. 2006. *Memorandum of Understanding between the Department of Fish and Game and the Division of Flood Management of the Department of Water Resources for Maintenance of Flood Control Projects in the Sacramento River and Feather River Wildlife Areas.* Effective May 23, 2006.

———. 2009. Data from 2009 survey for Swainson's hawk conducted by the California Department of Fish and Game, including nests found, selected survey blocks, and discovered nests. Data provided to Susan Sanders of AECOM (in shapefiles and a .kml file) by Kelley Barker, Staff Environmental Scientist,

California Department of Fish and Game Region 2 Liaison to Department of Water Resources, Rancho Cordova, CA, on September 26, 2011.

———. 2011 (January 6). *Streambed Alteration Agreement between the California Department of Fish and Game and the Division of Flood Management of the Department of Water Resources for Routine Maintenance of Flood Control Projects by the Sacramento and Sutter Maintenance Yards.* Routine Maintenance Streambed Alteration Agreement. Notification No. 1600-2010-0108-R2.

———. 2012a. Feather River Wildlife Area—Sutter & Yuba Counties. Available: http://www.dfg.ca.gov/lands/wa/region2/featherriver.html. Accessed January 15, 2012.

———. 2012b. Public Use Guidelines. City of Marysville. Available: http://www.marysville.ca.us/city_services.asp?did=37. Accessed January 16, 2012.

California Department of Fish and Wildlife. 2013. California Natural Diversity Database Info. Available: http://www.dfg.ca.gov/biogeodata/cnddb/cnddb_info.asp. Accessed October 22, 2013.

California Department of Water Resources. 1997. *Final Report of the Flood Emergency Action Team*. Chapter VII. Flood Control System Improvements. Available: http://www.water.ca.gov/historicaldocs/irwm/feat-1997/fcsib1a.html. Accessed March 2, 2012.

———. 2007 (May). *California Central Valley Unimpaired Flow Data, Fourth Edition*. Draft. Delta Office. Sacramento, CA. Available: http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/docs/sjrf_spprtinfo/dwr_2007a.pdf. Accessed March 13, 2012.

———. 2008. *Management of the California State Water Project*. Bulletin 132-07. Sacramento, CA.

———. 2010a (July). Improved Levee System in Yuba County to Receive Federal Accreditation. *FloodSAFE Focus* 1(2):1.

———. 2010b (January). *Draft State Plan of Flood Control Descriptive Document*. Central Valley Flood Management Planning Program. FloodSAFE California. Available: http://www.water.ca.gov/cvfmp/docs/DRAFT_SPFC_Descriptive_Doc_20100115.pdf. Accessed January 3, 2012.

———. 2010c (May 27). *Lower Feather River Corridor Management Plan*. O&M Funding Subcommittee Notes.

———. 2010d (March). *2012 Central Valley Flood Protection Plan Regional Conditions Report—A Working Document.* Sacramento, CA.

———. 2011a. *Report of Activities of the Department of Water Resources*. Presented before the Central Valley Flood Protection Board on April 22, 2011.

———. 2011b. Levee Repair—Repair Projects. Available: http://www.water.ca.gov/levees/projects/. Last updated November 29, 2011. Accessed January 4, 2012.

———. 2011c (February 11). *Biological Resources in the Lower Feather River Corridor*. Sacramento, CA. Letter memorandum to Earl Nelson and Tony Danna of the California Department of Water Resources, Division of Flood Management. Prepared by AECOM, Sacramento, CA.

DWR 2011d. *Staff Report for Meeting of the Central Valley Flood Protection Board, January 28, 2011, for approval of the Vegetation Monitoring Plan of Feather River Floodplain Adjacent to Unit No. 144 Levee System* as an addendum to the Supplement to Standard Operation and Maintenance Manual. Sacramento, CA.

———. 2013. Flood Management: Small Erosion Repairs. Available: http://www.water.ca.gov/floodmgmt/fmo/msb/smallerosionrepairs.cfm. Last updated March 20, 2013. Accessed October 10, 2013.

California Native Plant Society. 2013. Inventory of Rare and Endangered Plants (online edition, v8-01a). Sacramento, CA. Available: http://cnps.rareplants.cnps.org. Accessed October 22, 2013.

California State University at Chico. 2011. *Vegetation—Medium Scale Central Valley Riparian Vegetation and Land Use, 2011*. Chico, CA.

cbec. 2011 (December 5). *Geomorphic Assessment of the Feather River from RM 6.9 to RM 12.5*. Technical memorandum.

CDFW. *See* California Department of Fish and Wildlife.

Central Valley Regional Water Quality Control Board. 2011. Time Schedule Order R5-2011-0056. Rancho Cordova, CA.

Central Valley RWQCB. *See* Central Valley Regional Water Quality Control Board.

City of Marysville. 2012. City of Marysville Web site. Available: http://www.marysville.ca.us/city_services.asp?did=37. Accessed January 16, 2012.

City of Yuba City. 2007 (April 17). City of Yuba City Staff Report. Available: http://www.yubacity.net/documents/Agendas/2007/041707Council/041707AgendaItem22.pdf. Accessed January 16, 2012. Cleveland, Stan. Sutter County Supervisor, District 2, Yuba City, CA. January 12, 2012—telephone conversation with Abby Rizzo and Helen Swagerty of River Partners regarding the recreation opportunities and sedimentation issues within the Lower Feather River Corridor Management Plan project area.

CNPS. *See* California Native Plant Society.

Dacus, Larry, P.E., Project Manager, MBK Engineers, Sacramento, CA. January 16, 2012—telephone conversation with Abby Rizzo of River Partners regarding the agricultural leases in the Feather River setback area.

DFG. *See* California Department of Fish and Game.

DWR. *See* California Department of Water Resources.

GEI Consultants. 2005. *Bear River Setback Levee Design Report.* Volume 1 of 4. Sacramento, CA.

———. 2009. *Feather River Levee Repair Project Levee Segments 1 & 3, Addendum to Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project Unit No. 145—Part No. 1*. Sacramento, CA.

Geographic Information Center. 2008. Riparian Habitat Mapping in Central Valley, California. Geographical Information Center, California State University, Chico. Available: http://www.gic.csuchico.edu/Veg_sac.html. Accessed November 1, 2011.

Gnusti, Jacyln, P.E. Authorized agent for City of Yuba City Public Works Department, Moffatt & Nichol, Sacramento, CA. February 1, 2012—letter to Len Marino, Central Valley Flood Protection Board, Sacramento, CA.

Hickman, J. D. (ed.). 2013. *The Jepson Manual, Higher Plants of California.* Berkeley: University of California Press.

Holland, R. 1986. *Preliminary Descriptions of the Terrestrial Natural Communities of California*. Unpublished document. Sacramento: California Department of Fish and Game, Natural Heritage Division.

ICF. *See* ICF International.

ICF International. 2013 (June). *Feather River West Levee Project 408 Permission Environmental Impact Statement.* Final. (ICF 00852.10.) Sacramento, CA. Prepared for U.S. Army Corps of Engineers, Sacramento, CA.

James, L. A., M. B. Singer, S. Ghoshal, and M. Megison. 2009. Historical Channel Changes in the Lower Yuba and Feather Rivers, California: Long-term Effects of Contrasting River-management Strategies. In *Management and Restoration of Fluvial Systems with Broad Historical Changes and Human Impacts*, ed. L. A. James, S. L Rathburn, and G. R. Whittecar, 57–81. Geological Society of America Special Paper 451.

Jones & Stokes. 2006. *Habitat Mitigation and Monitoring Plan for the Feather-Bear-WPIC Levee*. Sacramento, CA.

Kennedy/Jenks Consultants. 2010. *South Yuba County Regional Wastewater Feasibility Study*. Rancho Cordova, CA.

LD 1. *See* Levee District 1 of Sutter County.

Levee District 1 of Sutter County. 2012. Star Bend Set-back Levee. Available: http://www.leveedistrict1.com/projects.html. Accessed March 1, 2012.

MBK. *See* MBK Engineers.

MBK Engineers. 2010. *Addendum to the Supplement to the Standard Operation and Maintenance Manual for Unit No. 145—Part 1*. Sacramento, CA.

———. 2011a (December 8). *Lower Feather River Corridor Management Plan Hydraulic Analysis*. *Baseline Model Documentation.* Draft. Sacramento, CA.

———. 2011b (October). Preliminary Analysis of the Yuba River South Training Wall. Sacramento, CA.

Moffatt & Nichol. 2012 (February 1). Emergency Letter of Authorization Request, Yuba City Outfall. Prepared for Central Valley Flood Protection Board.

Moyle, P. B. 2002. *Inland Fishes of California.* Berkeley: University of California Press.

Neubert, David. Yuba City resident and agribusiness consultant at DCN Associates, Yuba City, CA. September 6, 2011—telephone conversation with Abby Rizzo of River Partners regarding recreational opportunities along the Lower Feather River and waste water treatment ponds.

———. 2010. *Sutter County General Plan Draft Environmental Impact Report*. Sacramento, CA.

Quad Consultants. 1994. *Yuba County General Plan*. Volume I: Environmental Settings and Background. Sacramento, CA.

RD 784. *See* Reclamation District 784.

Reclamation. *See* U.S. Bureau of Reclamation.

Reclamation District 784. 2012. Reclamation District 784 Web site. Available: http://www.rd784.org. Accessed March 19, 2012.

River Partners. 2005. *Riparian Restoration Plan for Bear River Setback Levee Project*. *Yuba County, California.* Issued for approval. Chico, CA.

———. 2006 (August 1). *Operations and Maintenance Plan for Riparian and Upland Habitats and Mitigation Features of the Bear River Setback Levee Project.* Chico, CA. Prepared for Bookman-Edmonston/GEI Consultants, EDAW, and Three Rivers Levee Improvement Authority.

———. 2009. *Conceptual Land Management Plan for the Feather River Setback Levee Project*. Chico, CA.

———. 2011a. *2011 End of Season Report for the Feather River Setback Mitigation Project*. Chico, CA.

———. 2011b. *Final Report for the Feather River Setback Levee Project, Valley Elderberry Longhorn Beetle Mitigation Area.* Chico, CA.

———. 2011c. *2011 Mitigation and Monitoring Report for the Bear River Setback Levee Restoration Project.* Chico, CA.

———. 2011d. Riparian Plant Community Classification. Available: http://www.riverpartners.org/resources/riparian-ecology/veg-wildlife-habitat/communities-classification/. Accessed October 10, 2011.

Robertson-Bryan, Inc. 2011 (April). *Garden Bar Reservoir Studies Water Supply Simulation.* Technical memorandum prepared for RMC Water and Environment, Inc. Elk Grove, CA.

RRM Design Group. 2002. *Feather River Parkway Strategic Plan*. San Luis Obispo, CA.

Sacks, B. N., H. U. Wittmer, and M. J. Statham. 2010. *The Native Sacramento Valley Red Fox*. Report to the California Department of Fish and Game, Sacramento, CA.

SACOG. *See* Sacramento Area Council of Governments.

Sacramento Area Council of Governments. 2011. *Draft Environmental Impact Report for the Draft Metropolitan Transportation Plan/Sustainable Community Strategies for 2035*. Sacramento, CA.

Schmoldt, Don. President. Audubon Society, Sacramento Chapter, Sacramento, CA. January 11, 2012—telephone conversation with Heyo Tjarks of River Partners regarding operations and management of the Bobelaine Audubon Reserve.

Singer, M. B., R. Aalto, and L. A. James. 2008 (August 1). Status of the Lower Sacramento Valley Flood-Control System within the Context of its Natural Geomorphic Setting. *Natural Hazards Review* 9(3).

Sommer, T. R., M. L. Nobriga, W. C. Harrell, W. Batham, and W. J. Kimmerer. 2001. Floodplain Rearing of Juvenile Chinook Salmon: Evidence of Enhanced Growth and Survival. *Canadian Journal of Fisheries and Aquatic Sciences* 58:325–333.

Sommer, T. R., W. C. Harrell, M. L. Nobriga, and R. Kurth. 2003. Floodplain as Habitat for Native Fish: Lessons from California's Yolo Bypass. In *California Riparian Systems: Processes and Floodplain Management, Ecology, and Restoration*, 2001 Riparian Habitat and Floodplains Conference Proceedings, ed. P.M. Faber, 81–87. Sacramento, CA: Riparian Habitat Joint Venture.

Sommer, T. R., W. C. Harrell, R. Kurth, F. Feyrer, S. C. Zeug, and G. O'Leary. 2004. Ecological Patterns of Early Life Stages of Fishes in a Large River-Floodplain of the San Francisco Estuary. *American Fisheries Society Symposium* 39:111–123.

Stoll Engineering. 2009. *Feather River Parkway Opportunities for Public Access.* Redding, CA. Prepared for River Partners.

Sutter County. 2010a (February 19). *Lower Feather River HUC/Honcut Creek Watershed: Existing Conditions Assessment.* Prepared by Foothill Associates with funding from the California Bay-Delta Program. Prepared for Sutter County Resource Conservation District. Available: http://www.scrcd.org/projects/lfr.htm.

———. 2010b (September). *Sutter County General Plan Draft Environmental Impact Report*. State Clearinghouse No. 2010032074. Yuba City, CA. Prepared by PBS&J. Hydrology and Water Quality section. Available: http://www.co.sutter.ca.us/doc/government/depts/cs/ps/gp/gp_documents.

———. 2010c. *Sutter County General Plan Update*. Yuba City, CA. Available: http://www.co.sutter.ca.us/doc/government/depts/cs/ps/gp/gp_home. Accessed January 15, 2012.

———. 2011. *Sutter County 2010 Crop Report*. Yuba City, CA.

Sutter County Local Agency Formation Commission. 2011a. *Reclamation Districts 70, 777, 1001, 1500, 1660, and 2056 Municipal Service Review and Sphere of Influence Update, LAFCO-11-015*. Yuba City, CA.

———. 2011b. *Levee District 1 Municipal Service Review and Sphere of Influence Update, LAFCO-11-013.* Yuba City, CA.

Sutter LAFCO. *See* Sutter County Local Agency Formation Commission.

Three Rivers Levee Improvement Authority. 2006. *Draft Environmental Impact Report for the Feather River Levee Repair Project*. Marysville, CA. Prepared by EDAW, Sacramento, CA.

———. 2008a (January 11). *The Feather River Levee Setback: Assessment of Potential Geomorphic Effects*. Marysville, CA. Prepared by Philip Williams and Associates, Ltd.

———. 2008b. *Messick Lake and Floodplain Drainage Swale Mitigation Areas: Long-term Operations and Maintenance Plan.* Marysville, CA.

———. 2009a (February 6). *Initial Study/Proposed Mitigated Negative Declaration Feather River Erosion Site 2 Repair Project.* Marysville, CA. Prepared by EDAW, Sacramento, CA.

———. 2009b (December 21). *Land Management Plan for the Feather River Setback Levee Project*. *Yuba County, California.* Marysville, CA. Prepared by River Partners.

———. 2010a. Feather River Levee Improvement Projects. Segment 2: Setback Levee. Available: http://www.featherriversetbacklevee.com/PUCseg2.html. Accessed January 4, 2012.

———. 2010b (June 15). Memorandum from TRLIA Executive Director, Paul Brunner, to the Three Rivers Levee Improvement Authority Board of Directors. Subject: FY 2010/11 TRLIA Benefit Assessment District Revenues and FY 2010/11 RD784 Levee Maintenance Budget.

———. 2010c (July 26). *Feather River Setback Area and Adjacent Lands Interim Operation and Management Plan*. Marysville, CA.

———. 2011 (April). *Three Rivers Flood Corridor Project, Feather River, Yuba County. Flood Protection Corridor Program Grant Application 2011.* Prepared for Earl Nelson, Program Manager, Flood Corridor Program, California Department of Water Resources, Sacramento, CA.

———. 2012. Bear River Levee Improvements: Bear River Setback Levee—Phase 2 (2005/2006). Available: http://www.featherriversetbacklevee.com/BearRiver.html. Accessed March 2, 2012.

———. 2013a (April 13). *TRLIA Three Rivers Flood Corridor Project.* Application to the California Department of Water Resource's Flood Protection Corridor Program.

———. 2013b. Yuba Goldfields Flood Protection Feasibility Study: Initial Report. Prepared by MBK Engineers, ENGEO Inc. CBEC ECO engineers, and AECOM, Sacramento, CA.

TRLIA. *See* Three Rivers Levee Improvement Authority.

USACE. *See* U.S. Army Corps of Engineers.

U.S. Army Corps of Engineers. 1955a. *Standard Operation and Maintenance Manual, Sacramento River Flood Control Project*. Sacramento, CA.

———. 1955b. *Supplement to the Standard Operation and Maintenance Manual Sacramento River Flood Control Project: Unit No. 145—Part No. 1.* Sacramento, CA.

———. 1955c. *Supplement to the Standard Operation and Maintenance Manual Sacramento River Flood Control Project: Unit No. 141—Part No. 1.* Sacramento, CA.

———. 1955d. *Supplement to the Standard Operation and Maintenance Manual Sacramento River Flood Control Project: Unit No. 141—Part No. 2.* Sacramento, CA.

———. 1955e. *Supplement to the Standard Operation and Maintenance Manual Sacramento River Flood Control Project: Unit No. 144.* Sacramento, CA.

———. 1955f. *Supplement to the Standard Operation and Maintenance Manual Sacramento River Flood Control Project: Unit No. 143.* Sacramento, CA. U.S. Bureau of Reclamation (Reclamation). 2010 (May 11). *Draft Feather Water District Water Management Plan 2008 Criteria.* Available: http://www.usbr.gov/mp/watershare/wcplans/2011/Feather%20River%20WMP%206-3-11.pdf. Accessed January 16, 2012.

U.S. Fish and Wildlife Service. 1998. *Draft Recovery Plan for the Least Bell's Vireo*. Portland, OR.

———. 2005 (September 9). *Intra-Agency Formal Consultation on the Memorandum of Understanding between the U.S. Fish and Wildlife Service, California Department of Fish and Game, and California Department of Parks and Recreation for Riparian Restoration and Management in Glenn, Tehama, Butte, and Colusa Counties, California.* 1-1-05-F-0016. Sacramento, CA: Sacramento Fish and Wildlife Office.

———. 2013. USFWS Species List Generator. Available: http://www.fws.gov/sacramento/ES_Species/Lists/es_species_lists-overview.htm. Accessed October 22, 2013.

USFWS. *See* U.S. Fish and Wildlife Service.

Water Engineering & Technology, Inc. 1991. *Geomorphic Analysis and Bank Protection Alternative Report for Sacramento River (RM (0-78), Feather River (RM 28-61), Yuba River (RM 0-11), Bear River (RM 0-17), American River (RM 0-23), and Portions of Three Mil, Steamboat, Sutter, Miner, Georgian, Elk, and Cache Soughs.* Prepared for the Sacramento District, U.S. Army Corps of Engineers, Contract DACW05-88-D-0044.

WET. *See* Water Engineering & Technology, Inc.

Willis, A. D., J. R. Lund, E. S. Townsley, and B. A. Faber. 2011. Climate Change and Flood Operations in the Sacramento Basin, California. *San Francisco Estuary and Watershed Science* 9(2):1–18.

Yuba County. 2009. *Infrastructure, Public Facilities, and Public Services: General Plan Update Background Report*. Marysville, CA.

———. 2010. Assessors' parcel numbers, boundaries, and owner name for Yuba County. Obtained from Katie Atkinson and Doris Rogers, Yuba County Assessor's Office.

———. 2011a (May). *Final Yuba County 2030 General Plan Environmental Impact Report*. State Clearinghouse No. 2010062054. Prepared by AECOM, Sacramento, CA. Available: http://www.yubavision2030.org/EIR.aspx. Accessed October 10, 2011.

———. 2011b. *Yuba County 2030 General Plan*. Adopted June 7, 2011. Marysville, CA. Prepared by AECOM, Sacramento, CA.

Yuba County Department of Agriculture. 2011. *Yuba County Agricultural Crop Report for 2010.* Marysville, CA.

Yuba County Local Agency Formation Commission. 2008 (July 24). *Yuba County Municipal Services Review.* Prepared by Burr Consulting. Available: http://www.burrconsulting.com/Yuba_Countywide_Final_MSR.htm. Accessed January 13, 2012.

Yuba LAFCO. *See* Yuba County Local Agency Formation Commission.

9.4 MANAGEMENT GOALS, CHALLENGES, AND OPPORTUNITIES

Bank Swallow Technical Advisory Committee. 2013. *Bank Swallow (*Riparia riparia*) Conservation Strategy for the Sacramento River Watershed, California*. Version 1.0. Available: www.sacramentoriver.org/bans/.

BANS TAC. *See* Bank Swallow Technical Advisory Committee.

Barker, Kelley. Senior Environmental Scientist (Specialist), California Department of Fish and Wildlife, North Central Region, Rancho Cordova, CA. January 22, 2014 – e-mail communication to Susan Sanders, AECOM, regarding CDFW feedback on LFRCMP proposed management actions.

Bayoumi, A., and M. A. Meguid. 2011. Wildlife and Safety of Earthen Structures: A Review. *Journal of Failure Analysis and Prevention* 11(4):295–319.

Bossard, C. C., J. M. Randall, and M. C. Hoshovsky (eds.). 2000. *Invasive Plants of California Wildlands*. Berkeley: University of California Press.

California Department of Water Resources. 2008 (October). *Managing an Uncertain Future. Climate Change Adaptation Strategies for California's Water.* Sacramento, CA. Available: http://www.water.ca.gov/climatechange/docs/ClimateChangeWhitePaper.pdf. Accessed November 9, 2013.

———. 2010 (May 25). *Important Considerations for the Central Valley Flood Protection Plan Related to Sacramento–San Joaquin Valley Agriculture*. Draft. Central Valley Flood Management Planning Program, FloodSAFE California.

Cal-IPC. *See* California Invasive Plant Council.

California Invasive Plant Council. 2011. The Impact of Invasive Plants. Available: http://www.cal-ipc.org/ip/definitions/impact.php. Accessed March 15, 2011.

California State Lands Commission. 2010. About the California State Lands Commission. Available: http://www.slc.ca.gov/About_The_CSLC/About_The_CSLC_Home_Page.html#FAQs. Accessed June 17, 2014.

City of Yuba City. 2004 (April 8). Yuba City General Plan. Adopted in Resolution #04-049, April 8, 2004. Available: http://www.yubacity.net/planning/general-plan.htm. Accessed October 8, 2013.

DWR. *See* California Department of Water Resources.

Fordice, Steve. General Manager. Reclamation District 784, Arboga, CA. February 24, 2012—telephone conversation with Heyo Tjarks of River Partners regarding unauthorized off-road vehicle use.

Hagar, J. C. 1999. Influence of Riparian Buffer Width on Bird Assemblages in Western Oregon. *Journal of Wildlife Management* 63:484–496.

Heath, S., and G. Ballard. 2003. Patterns of Breeding Songbird Diversity and Occurrence in Riparian Habitats of the Eastern Sierra Nevada. In *California Riparian Systems: Processes and Floodplain Management, Ecology, and Restoration, Riparian Habitat and Floodplains Conference*, ed. P. M. Faber. Sacramento, CA: Riparian Habitat Joint Venture.

Hupp, C. R., and W. R. Osterkamp. 1996. Riparian Vegetation and Fluvial Geomorphic Processes. *Geomorphology* 14:277–295.

ICF International. 2013 (June). *Feather River West Levee Project 408 Permission Environmental Impact Statement.* Final. (ICF 00852.10.) Sacramento, CA. Prepared for U.S. Army Corps of Engineers, Sacramento, CA.

Johannesson, H., and G. Parker. 1989. Linear Theory of River Meanders. In *River Meandering*, eds. S. Ikeda and G. Parker, 181–214. Washington, DC: American Geophysical Union.

Junk, W. J., P. B. Bayley, and R. E. Sparks. 1989. The Flood Pulse Concept in River-Floodplain Systems. In *Proceedings of the International Large River Symposium*, ed. D. P. Dodge, 110–127. Canadian Special Publication of Fisheries and Aquatic Sciences 106. Cited in The Nature Conservancy 2007.

Knopf, F. L., R. R. Johnson, R. Rich, F. B. Samson, and R. C. Szaro. 1988. Conservation of Riparian Ecosystems in the United States. *Wilson Bulletin* 100: 272-284.

Larsen, Eric. Associate Research Scientist, Department of Environmental Design, University of California, Davis, CA. November 27, 2012—meeting with California Department of Water Resources (Adam Henderson, John Johannis, Ray McDowell, Ron Melcer, Ron Unger, and Kip Young), cbec (Chris Bowles, Chris Campbell, and John Stofleth), and AECOM (Steve Chainey and Susan Sanders) at cbec offices in West Sacramento, CA, to discuss modeling results assessing the Lower Feather River's meander migration potential.

Laymon, S. A., and M. Halterman. 1987. Can the Western Subspecies of the Yellow-Billed Cuckoo Be Saved from Extinction? *Western Birds* 18:19–25.

Leopold, L., M. Wolman, and J. Miller. 1964. *Fluvial Processes in Geomorphology*. San Francisco: W. H. Freeman Company.

Lytle, D. A., and N. L. Poff. 2004. Adaptation to Natural Flow Regimes. *Trends in Ecology & Evolution* 19:94–100.

Moyle, P. B., and D. White. 2002 (January). *Effects of Screening Diversions on Fish Populations in the Central Valley: What Do We Know?* A report for the Science Board, CALFED Ecosystem Restoration Program. University of California, Davis.

Naiman, R. J., H. Decamps, and M. Pollock. 1993. The Role of Riparian Corridors in Maintaining Regional Biodiversity. *Ecological Applications* 3:209–212.

Placer County Planning Department. 2005. Setback Recommendations to Conserve Riparian Areas and Streams in Western Placer County. Prepared by Jones & Stokes, Sacramento, CA, in cooperation with Point Reyes Bird Observatory, Petaluma, CA.

Philip Williams and Associates. 2005. *The Bear River Levee Setback Design: Assessments of Potential Geomorphic Effects.* Prepared for BE/GEI and Three Rivers Levee Improvement Authority.

PWA. *See* Philip Williams and Associates.

RHJV. *See* Riparian Habitat Joint Venture.

Riparian Habitat Joint Venture. 2004. *The Riparian Bird Conservation Plan: A Strategy for Reversing the Decline of Riparian Associated Birds in California*. Version 2.0. Stinson Beach, CA: PRBO Conservation Science.

Rosenberg, D., B. Noon, and E. Meslow. 1997. Biological Corridors: Form, Function, and Efficacy. *Bioscience* 47:677–687.

Scott, M. L., J. M. Friedman, and G. T. Auble. 1996. Fluvial Process and the Establishment of Bottomland Trees. *Geomorphology* 14:327–339.

Singer, M. B., R. Aalto, and L. A. James. 2008 (August 1). Status of the Lower Sacramento Valley Flood-Control System within the Context of its Natural Geomorphic Setting. *Natural Hazards Review* 9(3).

Sommer, T., W. C. Harrell, M. L. Nobriga, R. Brown, P. B. Moyle, W. J. Kimmerer, and L. Schemel. 2001. California's Yolo Bypass: Evidence that Flood Control Can Be Compatible with Fisheries, Wetlands, Wildlife, and Agriculture. *Fisheries* 26(8):6–16.

Sommer, T. R., W. C. Harrell, M. L. Nobriga, and R. Kurth. 2003. Floodplain as Habitat for Native Fish: Lessons from California's Yolo Bypass. In *California Riparian Systems: Processes and Floodplain Management, Ecology, and Restoration, Riparian Habitat and Floodplains Conference*, ed. P. M. Faber. Sacramento, CA: Riparian Habitat Joint Venture.

Staudinger, M. D., N. B. Grimm, A. Staudt, S. L. Carter, F. S. Chapin, P. Kareiva, M. Ruckelshaus, and B. A. Stein. 2012. *Impacts of Climate Change on Biodiversity, Ecosystems, and Ecosystem Services: Technical Input to the 2013 National Climate Assessment.* Cooperative Report to the 2013 National Climate Assessment.

Three Rivers Levee Improvement Authority. 2011 (April). *Three Rivers Flood Corridor Project, Feather River, Yuba County. Flood Protection Corridor Program Grant Application 2011*. Marysville, CA. Prepared for Earl Nelson, Program Manager, Flood Corridor Program, California Department of Water Resources, Sacramento, CA.

The Nature Conservancy (TNC). 2007 (November). *Linking Biological Responses to River Processes: Implications for Conservation and Management of the Sacramento River—A Focal Species Approach*. Chico, CA.

TNC. *See* The Nature Conservancy.

TRLIA. *See* Three Rivers Levee Improvement Authority.

U.S. Forest Service. 1989. *A Proposed Habitat Management Plan for Yellow-Billed Cuckoos in California.* General Technical Report PSW–110. Washington, DC.

USFS. *See* U.S. Forest Service.

Ward, J. V., K. Tockner, U. Uehlinger, and F. Malard. 2001. Understanding Natural Patterns and Processes in River Corridors as the Basis for Effective River Restoration. *Regulated Rivers: Research and Management* 17:311–323.

Yuba County. 2011. Letter of support for Three Rivers Levee Improvement Authority Feather River Floodway Corridor restoration project. Marysville, CA.

9.5 HYDRAULIC, HYDROLOGIC, AND SEDIMENT TRANSPORT MODELING OF POTENTIAL FUTURE CONDITIONS

Ayres. *See* Ayres Associates.

Ayres Associates. 1997. *Yuba River Basin, California Project: Geomorphic, Sediment Engineering and Channel Stability Analysis.* Prepared for U.S. Army Corps of Engineers Sacramento District, Contract No. DACW005-92-C-0077.

———. 2003. *Final Report—Topographic and Hydrographic Surveys of the Feather River System for the Sacramento and San Joaquin River Basins Comprehensive Study, California*.

California Department of Water Resources. 2011 (February 11). *Biological Resources in the Lower Feather River Corridor.* Sacramento, CA. Letter memorandum to Earl Nelson and Tony Danna of the California Department of Water Resources Division of Flood Management. Prepared by AECOM, Sacramento, CA.

California State University at Chico. 2011. *Vegetation—Medium Scale Central Valley Riparian Vegetation and Land Use, 2011*. Chico, CA.

cbec. *See* cbec eco engineering.

cbec eco engineering. 2011. (December 5). *Geomorphic Assessment of the Feather River from RM 6.9 to RM 12.5*. West Sacramento, CA. Technical memorandum prepared for AECOM.

———. 2012. (October 15). *Shanghai Rapids Field Data Collection*. West Sacramento, CA. Technical memorandum prepared for AECOM.

———. 2013a. (October). *Lower Feather River Corridor Management Plan Geomorphic and Ecological Modeling*. West Sacramento, CA. Prepared for California Department of Water Resources, Contract No. 4600008120, and AECOM.

———. 2013b. (March 7). *Flood Hydrograph Modifications and Floodplain Activation Flood Update Technical Memorandum*. West Sacramento, CA. Prepared for AECOM.

CSUC. *See* California State University at Chico.

DWR. *See* California Department of Water Resources.

HJW. *See* HJW Geospatial, Inc.

HJW Geospatial, Inc. 2010. CSURFACE2—Lower Sacramento, Upper Sacramento and Upper Feather River Areas—Datum Conversion Surface Map. HJW Geospatial Pacific Aerial Surveys.

James, L. A., M. B. Singer, G. Ghoshal, and M. Megison. 2009. Historical Channel Changes in the Lower Yuba River and Feather Rivers, California: Long-term Effects of Contrasting River Management Strategies. In *Management and Restoration of Fluvial Systems with Broad Historical Changes and Human Impacts*, eds. L. A. James, L. L. Rathburn, and G. R. Whittecar, 57–81. Geological Society of American Special Paper 451.

MBK. *See* MBK Engineers.

MBK Engineers. 2012a (January 17). *Lower Feather River Corridor Management Plan Hydraulic Analysis—Baseline Model Documentation.* Sacramento, CA.

———. 2012b (July 18). *Lower Feather River Corridor Management Plan Flood Hydraulic Analysis of Future Conditions.* Sacramento, CA.

MEI. *See* Mussetter Engineering.

Moffatt & Nichol. 2012 (February 1). *Emergency Letter of Authorization Request, Yuba City Outfall.* Prepared for Central Valley Flood Protection Board.

Mussetter Engineering. 1999. *Hydraulic Analysis of Levee Realignment Shanghai Bend, Feather River California.* MEI Project No. 98-19. Prepared for U.S. Army Corps of Engineers, Sacramento District.

Nelson, Earl. Chief, Maintenance Environmental Support Branch II, California Department of Water Resources, Sacramento, CA. May 8, 2012—meeting with representatives from California Department of Water Resources, AECOM, cbec, and MBK Engineers to discuss reasons why the Comprehensive Study would not provide accurate input data for determining the Floodplain Activation Flood.

PBI. *See* Peterson Brustad, Inc.

Peterson Brustad, Inc. 2011. *Revised Design Water Surface Profiles for the Feather River West Levee Rehabilitation Technical Memorandum.*

Philip Williams and Associates. 2005. *The Bear River Levee Setback Design: Assessments of Potential Geomorphic Effects.* Prepared for BE/GEI and Three Rivers Levee Improvement Authority.

———. 2006. *The Frequently Activated Floodplain: Quantifying a Remnant Landscape in the Sacramento Valley.* Prepared for University of California at Davis Center for Watershed Sciences.

———. 2008. *The Feather River Levee Setback: Assessment of Potential Geomorphic Effects.* Prepared for BE/GEI and Three Rivers Levee Improvement Authority.

PWA. *See* Philip Williams and Associates.

Three Rivers Levee Improvement Authority. 2011. *Three Rivers Flood Corridor Project Flood Protection Corridor Program Grant Application, Feather River, Yuba County.* Marysville, CA. Prepared for California Department of Water Resources, Sacramento, CA.

TRLIA. *See* Three Rivers Levee Improvement Authority.

USACE. *See* U.S. Army Corps of Engineers.

U.S. Army Corps of Engineers. 2002 (December). *Sacramento and San Joaquin River Basins Comprehensive Study, Technical Studies Documentation.* Appendix B, "Synthetic Hydrology Technical Documentation," and Appendix C, "Reservoir Operations Modeling, Existing Design Operations and Reoperation Analyses." State of California Reclamation Board. Sacramento, CA: Sacramento District.

———. 2008 (June). *Yuba River Basin Project General Reevaluation Report*. Appendix A, "Synthetic Hydrology & Reservoir Operations Technical Documentation." August 2004, corrected June 2008. Sacramento, CA: Sacramento District.

9.6 PROPOSED MANAGEMENT ACTIONS

Bank Swallow Technical Advisory Committee. 2012 (December). Lower Feather River Corridor Management Area Bank Swallow Monitoring Summary. 4 pp.

———. 2013. Bank Swallow (*Riparia riparia*) Conservation Strategy for the Sacramento River Watershed, California. Version 1.0. www.sacramentoriver.org/bans/.

BANS TAC. *See* Bank Swallow Technical Advisory Committee.

Barker, Kelley. Senior Environmental Scientist (Specialist), California Department of Fish and Wildlife, North Central Region, Rancho Cordova, CA. January 22, 2014 – e-mail communication to Susan Sanders, AECOM, regarding CDFW feedback on LFRCMP proposed management actions.

Bartlett, Tina. Regional Manager. North Central Region, California Department of Fish and Wildlife, Rancho Cordova, CA. October 24, 2011—e-mail communication with Susan Sanders, AECOM, transmitting a 3-page, undated draft memorandum, *Proposed Public Access Improvement Projects Lower Feather River Corridor*.

City of Yuba City. 2004 (April 8). Yuba City General Plan. Adopted Resolution #04-049 April 8, 2004. http://www.yubacity.net/planning/general-plan.htm. Accessed October 8, 2013.

California Department of Fish and Wildlife. 2014 (May 30). Comments on the Draft Lower Feather River Corridor Management Plan. Letter from Tina Bartlett, Regional Manager, California Department of Fish and Wildlife, North Central Region, Rancho Cordova, CA to Earl Nelson, Environmental Program Manager, California Department of Water Resources, Sacramento, CA.

California Department of Water Resources. 2011 (December). *2012 Central Valley Flood Protection Plan: A Path for Improving Public Safety, Environmental Stewardship, and Long-Term Economic Stability.* Public Draft.

———. 2012 (January). *2012 Central Valley Flood Protection Plan*, Attachment 2: Conservation Framework 2012. Public Draft.

CDFW. *See* California Department of Fish and Wildlife.

DWR. *See* California Department of Water Resources.

Neubert, David. Yuba City resident and agribusiness consultant at DCN Associates. Yuba City, CA. September 6, 2011—telephone conversation with Abby Rizzo of River Partners regarding recreational opportunities along the Lower Feather River and wastewater treatment ponds.

River Partners. 2010 (December 16). *Riparian Restoration Plan for the Abbott Lake Unit, Feather River Wildlife Area, Sutter County, CA.* Prepared for California Department of Fish and Game, Wildlife Conservation Board, and Ducks Unlimited. Chico, CA.

Stoll Engineering, Inc. 2009. *Feather River Parkway Opportunities for Public Access*. Redding, CA.

Three Rivers Levee Improvement Authority. 2013 (January 6). *TRLIA Feather River Floodway Corridor Restoration Projec*t. Application to FloodSAFE Environmental Stewardship and Statewide Resources Office.

TRLIA. *See* Three Rivers Levee Improvement Authority.

9.7 PERMITTING STRATEGY

Barker, Kelley. Senior Environmental Scientist. Region 2, California Department of Fish and Game (now California Department of Fish and Wildlife), Sacramento, CA. February 3, 2011—telephone conversation with Lisa Mangione of AECOM regarding potential streambed alteration agreement mechanisms for the *Lower Feather River Corridor Management Plan*.

California Department of Fish and Game. 2002 (August). *Guidance for the NCCP Independent Science Advisory Process.* Sacramento, CA. Available: http://www.dfg.ca.gov/habcon/nccp/science.html. Accessed September 9, 2013.

———. 2006. *Memorandum of Understanding between the Department of Fish and Game and Division of Flood Management of the Department of Water Resources for Maintenance of Flood Control Projects in the Sacramento River and Feather River Wildlife Areas.* Effective May 23, 2006.

———. 2011 (January 6). *Streambed Alteration Agreement between the Department of Fish and Game and the Division of Flood Management of the Department of Water Resources for Routine Maintenance of Flood Control Projects by the Sacramento and Sutter Maintenance Yards.* Routine Maintenance Streambed Alteration Agreement. Notification No. 1600-2010-0108-R2.

California Department of Water Resources. 2012 (January) *Central Valley Flood Protection Plan: A Path for Improving Public Safety, Environmental Stewardship, and Long-Term Economic Stability.* Attachment 2: Conservation Framework. Public Draft. Sacramento, CA.

California Department of Fish and Wildlife. 2014 (May 30). Comments on the Draft Lower Feather River Corridor Management Plan. Letter from Tina Bartlett, Regional Manager, California Department of Fish

and Wildlife, North Central Region, Rancho Cordova, CA to Earl Nelson, Environmental Program Manager, California Department of Water Resources, Sacramento, CA.

CDFW. *See* California Department of Fish and Wildlife.

DFG. *See* California Department of Fish and Game.

DWR. *See* California Department of Water Resources.

McNearney, Leah. Senior Environmental Scientist (Specialist), California Department of Water Resources, FloodSAFE Environmental Stewardship and Statewide Resources Office, Sacramento, CA. October 24, 2013—e-mail communication with Earl Nelson, California Department of Water Resources, regarding DWR's coordination with the Yuba-Sutter Regional Conservation Plan.

Muhl, Richard. Environmental Scientist. Stormwater Unit, Central Valley Regional Water Quality Control Board, Sacramento, CA. December 12, 2009—telephone conversation with Lisa Mangione of AECOM regarding National Pollutant Discharge Elimination System requirements and potential mechanisms for programmatic authorization for the *Lower Feather River Corridor Management Plan*.

Raley, Cliff. Senior Water Regional Control Engineer. Central Valley Regional Water Quality Control Board, Sacramento, CA. December 6, 2010—telephone conversation with Lisa Mangione of AECOM regarding waste discharge requirements and potential mechanisms for programmatic authorization for the *Lower Feather River Corridor Management Plan*.

U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998 (March). *Endangered Species Act Consultation Handbook. Procedures for Conducting Section 7 Consultations and Conferences.* Final Draft. Washington, DC.

USFWS. *See* U.S. Fish and Wildlife Service.

USFWS and NMFS. *See* U.S. Fish and Wildlife Service and National Marine Fisheries Service.

9.8 IMPLEMENTATION, TRACKING, AND MONITORING

Brunner, Paul. Executive Director, Three Rivers Levee Improvement Authority. June 2 and 5, 2014 – e-mail communications with Susan Sanders, AECOM, regarding TRLIA's efforts to use agricultural grazing lease income for maintenance and management.

California Department of Fish and Game. 2011 (January 6). *Streambed Alteration Agreement between the Department of Fish and Game and the Division of Flood Management of the Department of Water Resources for Routine Maintenance of Flood Control Projects by the Sacramento and Sutter Maintenance Yards.* Routine Maintenance Streambed Alteration Agreement. Notification No. 1600-2010-0108-R2.

California Department of Fish and Wildlife. 2013. Habitat Tracking and Reporting (HabiTrak)—About. Available: https://nrm.dfg.ca.gov/habitrak/About.aspx. Accessed November 10, 2013.

California Department of Water Resources. 2011 (December). *2012 Central Valley Flood Protection Plan: A Path for Improving Public Safety, Environmental Stewardship, and Long-Term Economic Stability*. Public Draft. Sacramento, CA.

———. 2012 (January). *Central Valley Flood Protection Plan: A Path for Improving Public Safety, Environmental Stewardship, and Long-Term Economic Stability.* Attachment 2: Conservation Framework. Public Draft. Sacramento, CA.

———. 2013 (July).*Guidelines: Flood System Repair Project Authorized Under the Disaster Preparedness and Flood Prevention Bond Act of 2006 (Proposition 1E), and the Flood Control, River and Coastal Protection Bond Act of 2006 (Proposition 84)*. Sacramento, CA.

CDFW. *See* California Department of Fish and Wildlife.

DFG. *See* California Department of Fish and Game.

DWR. *See* California Department of Water Resources.

Holley, Jason. Wildlife Program Supervisor, California Department of Fish and Wildlife, North Central Region, Rancho Cordova, CA. June 10, 2014 – telephone conversation with Susan Sanders, AECOM, regarding CDFW use of grazing to manage vegetation and generate income.

National Marine Fisheries Service. 2009. (October). *Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead*. Sacramento, CA: Sacramento Protected Resources Division.

NMFS. *See* National Marine Fisheries Service.

USACE. *See* U.S. Army Corps of Engineers.

U.S. Army Corps of Engineers. 2002 (April). *Trade-Off Analysis Planning and Procedures Guidebook*. Alexandria, VA.

10 PREPARERS

10.1 PROJECT LEADER - DWR

Earl Nelson, Program Manager III, HLPCO

10.2 MANAGEMENT OVERSIGHT AND GUIDANCE - DWR

Keith Swanson, Chief, Division of Flood Management
Noel Lerner, Chief, Flood Maintenance Office
Kelly Briggs, Environmental Program Manager I, Chief, FMO/MESB
Terri Gaines, Program Manager II, FESSRO Floodway Ecosystem Sustainability Branch
Stacy Cepello, Program Manager II, FESSRO Floodway Ecosystem Sustainability Branch

10.3 TECHNICAL SUPPORT - DWR

Kip Young, Sr. Environmental Scientist (Specialist), FMO/MES
Karen Hull, Superintendent, FMO Sutter Maintenance Yard
Joel Farias, FMO Sutter Maintenance Yard
John Johannis, Sr. Engineer, FMO
Heydar Massoudi, Sr. Engineer, FMO
Tony Danna, Sr. Environmental Scientist (Specialist), FESSRO/FESB
Ron Unger, Sr. Environmental Scientist (Supervisor), DES
Leah McNearney, Sr. Environmental Scientist (Specialist), FESSRO/FESB
Scott Deal, Sr. Environmental Scientist (Supervisor), FMO/MESB
Scott Kranhold, Sr. Environmental Scientist (Specialist), FMO/MES
Ray McDowell, Program Manager I, FESSRO/FESB
Ron Melcer, Sr. Environmental Scientist (Specialist), FESSRO/FESB
Caitlin Roddy, Environmental Scientist, DES

10.4 TECHNICAL SUPPORT - CONSULTANTS

AECOM

Susan Sanders, Ph.D., Senior Wildlife Biologist
Steve Chainey, Senior Restoration Ecologist
Julie Roth, Wildlife Biologist
Cindy Davis, Wildlife Biologist
Lisa Mangione, Senior Conservation Biologist/Regulatory Specialist
Anne King, Senior Wildlife Biologist

MBK Engineers

Don Trieu, P.E., Principal Engineer
Patrick Ho, P.E., Engineer

cbec, inc., eco engineering

Chris Bowles, Ph.D., P.E., Ecoengineer
Chris Campbell, M.S., Ecohydrologist
John Stofleth, M.S., P.E., Ecoengineer

River Partners

John Carlon, President
Helen Swagerty, Senior Restoration Biologist/Project Manager
Heyo Tjarks, Restoration Biologist
Abby Rizzo, Restoration Biologist

H. T. Harvey & Associates

John Hunter, Ph.D., Associate Plant Ecologist
Debra Bishop, Senior Associate, Restoration Ecologist
Matt Wacker, Senior Ecologist