APPENDIX L

Lower Feather River Corridor Management Plan
Flood Facility Maintenance Plan

APPENDIX L FLOODWAY MAINTENANCE PLAN FOR THE LOWER FEATHER RIVER CORRIDOR MANAGEMENT PLAN STUDY AREA

The California Department of Water Resources (DWR) Division of Flood Management is responsible for providing flood protection to safeguard life and property in the *Lower Feather River Corridor Management Plan* (LFRCMP) study area. To fulfill this responsibility, the Division of Flood Management maintains floodways and flood control facilities, supervises and encourages preventive floodplain management practices, and cooperates with Local Maintaining Agencies in flood control maintenance and planning. The purpose of this Floodway Maintenance Plan is to describe current floodway maintenance activities conducted in the LFRCMP study area by DWR and Local Maintaining Agencies, and to recommend future maintenance and monitoring tasks.

This plan encompasses the following sections:

- Section L.1 describes existing floodway capacity; provides an overview of current and historical flood risks; discusses existing flood operations, management responsibilities, and jurisdictions; and describes routine, ongoing maintenance activities occurring within the LFRCMP study area.
- Section L.2 describes proposed future maintenance and monitoring activities that would likely be needed if the actions described in LFRCMP Chapter 6, "Proposed Management Actions," were to be implemented. These proposed future activities would be needed to maintain floodway capacity and the ecological benefits derived from implementing the ecosystem management actions.
- Section L.3 offers recommendations for integrating invasive-weed management into current and future floodway maintenance activities.
- Section L.4 lists the references cited in this Floodway Maintenance Plan.

L.1 CURRENT FLOOD OPERATIONS AND MAINTENANCE

L.1.1 FLOODWAY CAPACITY

Through Title 33 of the Code of Federal Regulations, the U.S. Army Corps of Engineers (USACE) was commissioned to establish operations and maintenance (O&M) rules, regulations, and standards for flood control, which apply to State Plan of Flood Control (SPFC) projects. Title 23 of the California Code of Regulations (the California Water Code) incorporates these rules, regulations, and standards and requires the Central Valley Flood Protection Board (CVFPB) and DWR to enforce them. DWR inspects SPFC facilities and reports its findings to the CVFPB. In turn, the CVFPB provides assurances to the federal government that the maintenance actions for the facilities are fulfilling the USACE maintenance requirements.

The State of California currently operates SPFC facilities and manages floodway capacity in the LFRCMP study area based on the 1957 design flow water-surface profile rather than on flows from O&M manuals (DWR 2010a). Floodway capacity depends on a variety of factors: levee spacing, height, design, and integrity; channel bathymetry and floodplain topography; and vegetation and topographic roughness. In the LFRCMP study area,

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

The existing floodway of the Lower Feather River 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 coefficient "n" values) than grasslands or other low-growing or sparse vegetative cover; 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 surveyed 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) (2011a). Chapter 5 and Appendix F, "Lower Feather River Corridor Management Plan Hydraulic Analysis—Baseline Model Documentation," and Appendix H, *"Lower Feather River Corridor Management Plan Geomorphic and Ecological Modeling,"* 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, cross channel spacing, and integrity also contribute substantially to floodway capacity. As a result of numerous levee improvement projects implemented during the past decade, a 200-year level of flood protection is incrementally being achieved throughout 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 2010b). 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 2010b). However, levees in the western and southeastern portions of the study area, in Sutter County, currently provide less flood protection (Sutter County 2010a).

L.1.2 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 2009). 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, some level of flood risk continues to occur in the study area and regional vicinity.

USACE has implemented major upgrades to segments of the Feather River east-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 Feather River east 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 southern 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 using dredge tailings to provide some flood protection to southern 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 2013).

TRLIA has 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. 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.

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).

L.1.3 MAINTAINING AGENCIES

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, State of California), DWR, and local governments or agencies such as TRLIA, RD 784, RD 1001, LD 1, Linda County Water District, Yuba City, the City of Marysville, and Sutter County. In general, DWR has responsibility for maintaining the floodway, and the Local Maintaining Agencies are responsible for maintaining the levees. Those state and local entities with responsibility for flood management in the LFRCMP study area are described below.

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 CVFPB). The SSJDD, which is under the management and control of the CVFPB, 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:

- LD 1 of Sutter County 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.
- 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 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 Maintenance Yard of DWR's Maintenance Area 3 and the Local Maintaining Agencies conduct management activities to maintain the conveyance channels between levees and the levees 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, as well as 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 TRLIA's grant funding agreement for the property ownership acquisition funds requires eventual fee title transfer to the State of California (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 federal 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 federal 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 the 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 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 also maintains the west levee along the Abbott Lake Unit of the Feather River Wildlife Area (FRWA) and private orchard land east of the west levee from RM 21.5 to the Star Bend setback area.

L.1.4 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 SPFC. 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 L-1). Additionally, numerous 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. Routine maintenance and project-level repairs of larger scope are subject to California Environmental Quality Act 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 federally authorized 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 Floodway Maintenance Plan, 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 2011a) (Exhibit L-2):

- 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 Maintaining Agencies maintain all remaining levee reaches (Exhibit L-1). Specifically, the DWR Sutter Maintenance Yard is responsible for maintaining all river channels 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 west (right) 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 2010a).

Several agencies are responsible for O&M of distinct units of land and levees in the study area (Table L-1):

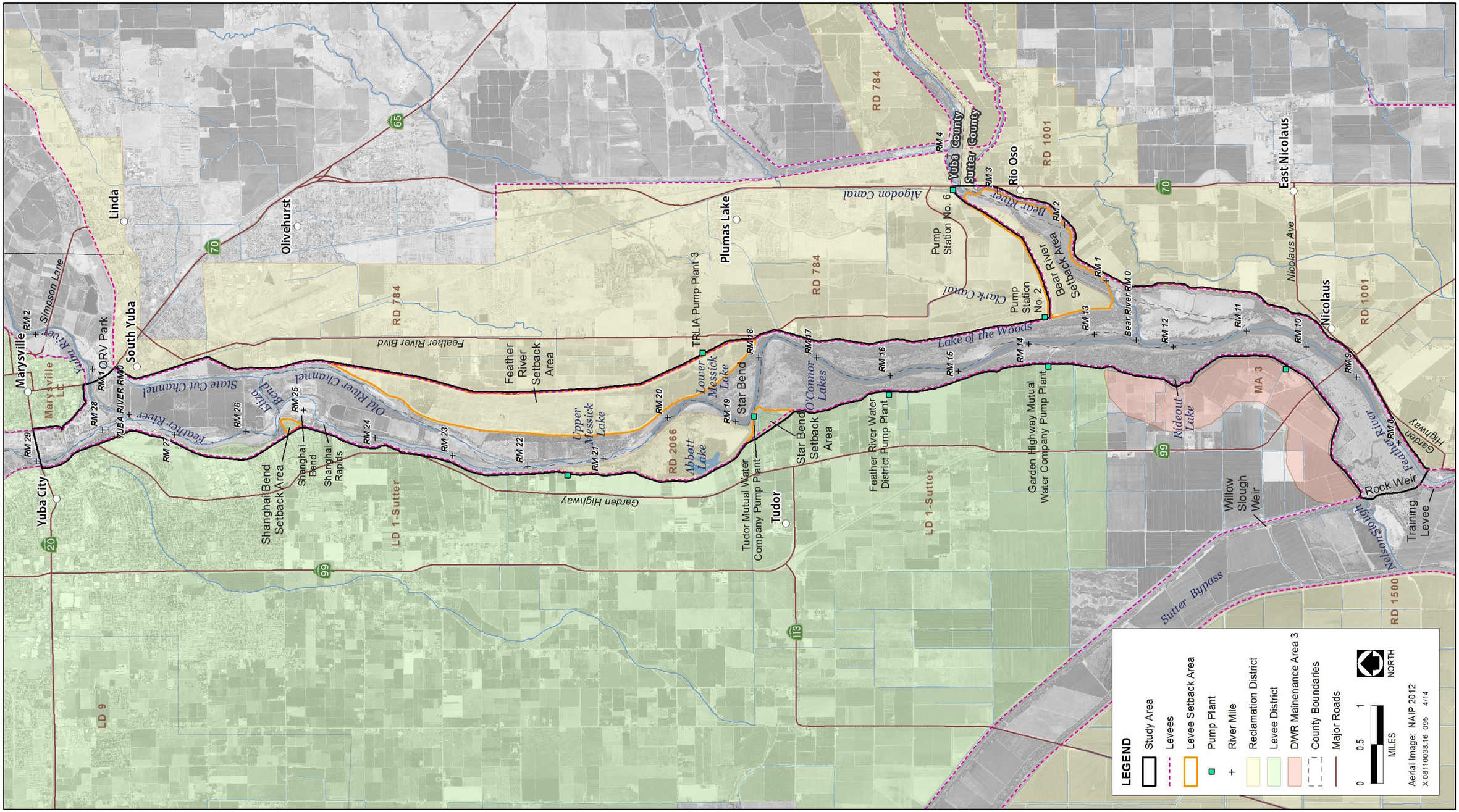
- LD 1 maintains levees along the right (west) bank of the Lower Feather River in Sutter County from north of Yuba City to approximately 5 miles north of the confluence with the Sutter Bypass; the lowermost 5 miles of the right-bank levees are maintained by the State (Maintenance Area 3).

- The Marysville Levee Commission maintains levees along the right (north) bank of the Yuba River near Marysville (DWR 2010a).

- 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 2010a). RD 784 also maintains drainage facilities and pumping stations associated with these levees (TRLIA 2010a) and portions of the Feather River setback area (TRLIA 2010b).

- 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 2010b).

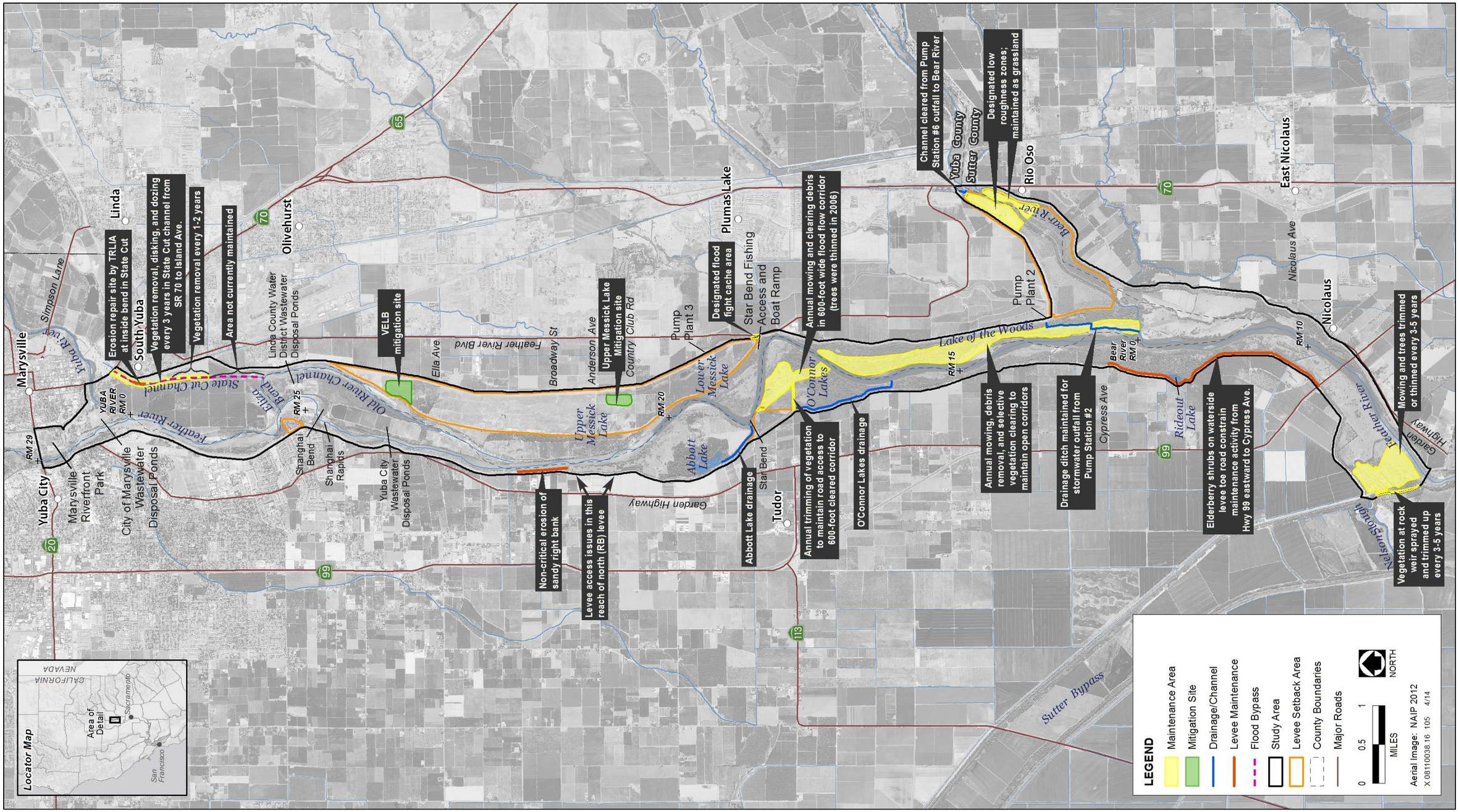
- RD 1001 maintains the remaining levees along the left (south) bank of the Bear River and the left (east) bank of the Feather River from the Bear River to the Sutter Bypass, and continuing southward along the Feather and Sacramento rivers to the Natomas Cross Canal (DWR 2010c).



Source: AECOM 2012, SWQCB 2007, DWR 2003

Exhibit L-1

Flood Control Facilities and Maintenance Jurisdictions in the LFRCMP Study Area



Source: DFG 2011; data compiled by AECOM in 2012

Exhibit L-2

Floodway Maintenance Activities in the LFRCMP Study Area

Table L-1
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 study area to the north boundary of MA 3	*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 1955e)
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 the Feather River setback area, and portions of the land on the east side of the Feather River west 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 2010b).
Marysville Levee Commission	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: River Partners 2006; TRLIA 2010b; USACE 1955b, 1955c, 1955d, 1955e, 1955f, 1955g

O&M work for the flood control system is conducted in accordance with Title 23 of the California Code of Regulations (DWR 2010a). 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 and Lake of the Woods) 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 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 firebreaks
- Repairing bridges and culverts
- Conducting minor geotechnical sampling
- Completing 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 FRWA.
- 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.

Based on a GIS analysis of land ownership, approximately 15% of the study area is under direct CDFW jurisdiction (e.g., FRWA), and some waterways, floodplains, and associated riparian habitat in the study area also fall under CDFW Fish and Game Code1600 jurisdiction for lake and streambed alteration agreements.. 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 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 L-2 summarizes the floodway maintenance activities in each unit of the FRWA.

Table L-2
Current Floodway Maintenance in Management Units of the Feather River Wildlife Area

FRWA Units	Responsible Agencies	Additional Maintenance Details
Lake of the Woods	CDFW	Retention of 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 (USFWS 2005)
		Removal of nonnative vegetation and occasional use of herbicides in cleared areas to assist with ongoing maintenance of these areas (USFWS 2005)
	DWR	Easement held by DWR to disk large swaths through the unit to maintain flood-carrying capacity through the site
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	
	DWR	Vegetation clearing and stacking, and burning of debris to maintain flood-carrying capacity throughout the site
Star Bend	CDFW	
	DWR	Vegetation management practices for enlarged floodplain of approximately 49.5 acres, including valley elderberry longhorn beetle mitigation/enhancement, future mitigation/enhancement site, and plantings to protect cultural resource area (DWR 2011a)
Nelson Slough	CDFW	Retention of a fringe of dense cottonwood forest along the west bank and levee as a protective buffer from wave wash (DWR 2010c)
		Maintenance of open areas by sheep grazing through an agreement between CDFW and a local rancher (DWR 2010c)
	DWR	Additional mowing and vegetation clearing
Shanghai Bend	CDFW	Management by Sutter County until 2005; current administration and management of this unit being determined by CDFW (formerly California Department of Fish and

Table L-2 Current Floodway Maintenance in Management Units of the Feather River Wildlife Area
Game) (DWR 2010c)
Sources: DWR 2010c, 2011a; USFWS 2005

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). Roads within the Feather River setback area are maintained by TRLIA or DWR, except within the elderberry mitigation area, where RD 784 maintains the roads (Fordice, pers. comm., 2014). RD784 has voluntarily assisted with road maintenance elsewhere in the setback area but has no legal responsibility to do so (Fordice pers. comm 2014). 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 2008) 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.
- 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).
- Remove debris, vegetation, or beaver dams from the floodplain swale and adjacent floodplain.

- Conduct multiple mowing events and targeted herbicide treatment as needed.
- Conduct remedial maintenance activities, as needed (e.g., replanting, weed control, and 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 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 firebreak along the north property boundary, and controlling invasive weeds when feasible. Volunteers from the Sacramento Audubon Society are responsible for this maintenance.

L.2 FUTURE MAINTENANCE AND MONITORING

This section describes future floodway maintenance activities proposed by LFRCMP Appendix M, "Lower Feather River Corridor Management Plan Conceptual Restoration Plan," and Management Actions described in Chapter 4. These activities are either new responsibilities or modifications of existing routine maintenance activities under the proposed LFRCMP. The new and modified activities are to be performed primarily by personnel from the Sutter Maintenance Yard, located in DWR Maintenance Area 3, and have been recommended for these reasons:

- The results of hydraulic and sediment transport modeling have demonstrated a need to renew or increase maintenance activity in specific areas (e.g., lower State Cut).
- The flood hydraulic modeling results demonstrated that maintenance activity in specific areas (e.g., lower Lake of the Woods) is no longer necessary.
- Flood hydraulic modeling and the LFRCMP conceptual plan established maximum thresholds for vegetation roughness in potential future mitigation and restoration areas (see Exhibit L-3); therefore, vegetation roughness in these areas (e.g., the middle and northern portions of the Feather River setback [FRS] area) must be monitored and maintained for consistency with LFRCMP plans.

Most existing routine floodway maintenance activities conducted by personnel from DWR's Sutter Maintenance Yard are appropriate for future conditions described in the LFRCMP and should continue. Some existing activities should be replaced by the new or modified maintenance and monitoring activities described below for five reaches of the Lower Feather River corridor. Table L-3 identifies the future new and modified floodway maintenance activities described below, and Exhibit L-4 shows their locations; Appendix C provides large-scale aerial photos of the five reaches.

Table L-3
New and Modified Floodway Maintenance Activities in the LFRCMP Study Area

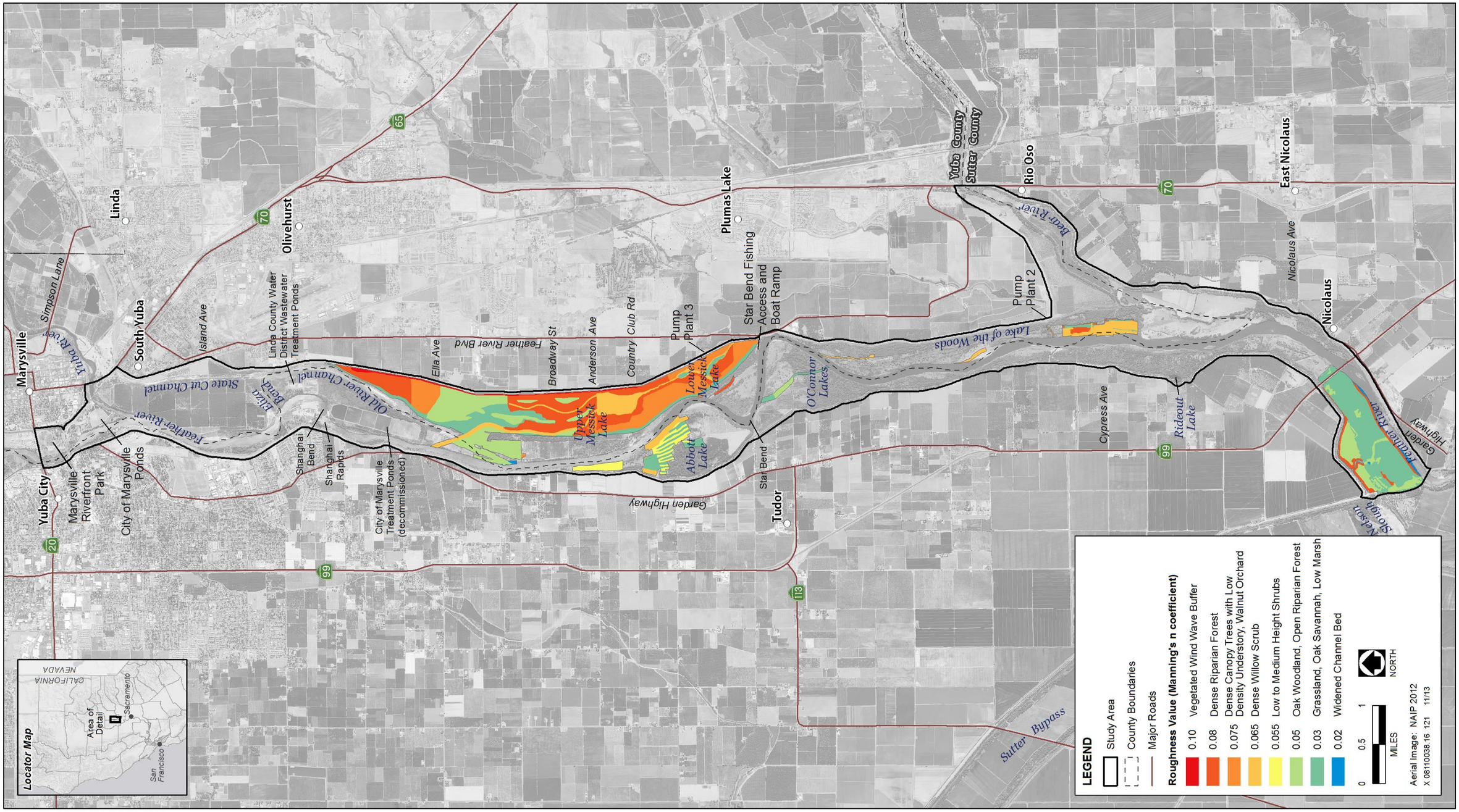
Maintenance Site[a]	Aerial Photo[b]	RM	Location	Maintain	Monitor	Notes	New	Mod.
M12	C-1	7.5 to 9.5	Nelson Slough Unit		Future vegetation roughness/plans	Keep roughness below threshold/grassland		X
M10	C-2	2.5 to 3.5	Bear River setback area		Future vegetation roughness	Keep roughness below threshold/grassland		X
M11	C-2	12.5 to 13.5	Lake of the Woods Unit	Refrain from vegetation removal on 1 mile	No need to monitor	River floodway is much wider by Bear River setback levee project	X	
M6, M8	C-3	17.5 to 21.5	Abbott Lake, Star Bend, and O'Connor Lakes units		Future vegetation roughness/plans	Keep roughness below threshold values based on LFRCMP concept plan		X
M9	C-3	16 to 17.5	O'Connor Lakes Unit	Improve drainage of waterside levee toe drains		Support LD 1 and CDFW to modify and manage drain system	X	
M7	C-3 & C-4	18.8 to 19.3	Abbott Lake Unit	Improve drainage of waterside levee toe drains		Support LD 1, RD 2066, and CDFW to modify and manage drain system	X	
M4 & M5	C-4	20.5 to 24.2	FRS area and other TRLIA-owned land		Future vegetation roughness/plans	Keep roughness below threshold values based on concept plan	X	
M3	C-4	23.3	FRS West Diversion Swale	Manage sedimentation at inlet to West Diversion Swale	West Diversion Swale inlet sill elevation	Inlet sill design elevation is 36.8 feet NGVD	X	
M5	C-4	–	Messick Lake drainage swale	Remove debris to ensure drainage of Upper Messick Lake	Debris blocking channel, impairing drain	Enlarged channel between Upper and Lower Messick lakes	X	
M4 & M5	C-4	–	FRS area and other TRLIA-owned land		Future plans and footprint of spoils ridges	Ensure that ridges are linear and parallel to flood flow	X	
M1	C-5	–	Upper State Cut channel	Skim sediment mounds, fill scour depressions	Sediment at inlet sill to bypass and in channel	Yuba River/UPRR Bridge to Island Avenue crossing		X
M2	C-5	–	Lower State Cut channel	Skim sediment mounds, fill scour depressions	Sediment and scour in bypass	Island Avenue crossing to Eliza Bend/Old Feather River	X	
	C-5	24.6 to 25	Shanghai Rapids breach and Modesto Formation		Trends in breach expansion and channel incision	Future breach enlargement could cause upstream channel incision	X	

Notes: Mod. = modified; NGVD = National Geodetic Vertical Datum

[a] Maintenance Site # shown on Exhibit L-4. Maintenance and Monitoring Activity Areas

[b] Aerial Photo # = large scale aerial photos and vegetation maps C-1 -- C-5 in Appendix C of LFRCMP

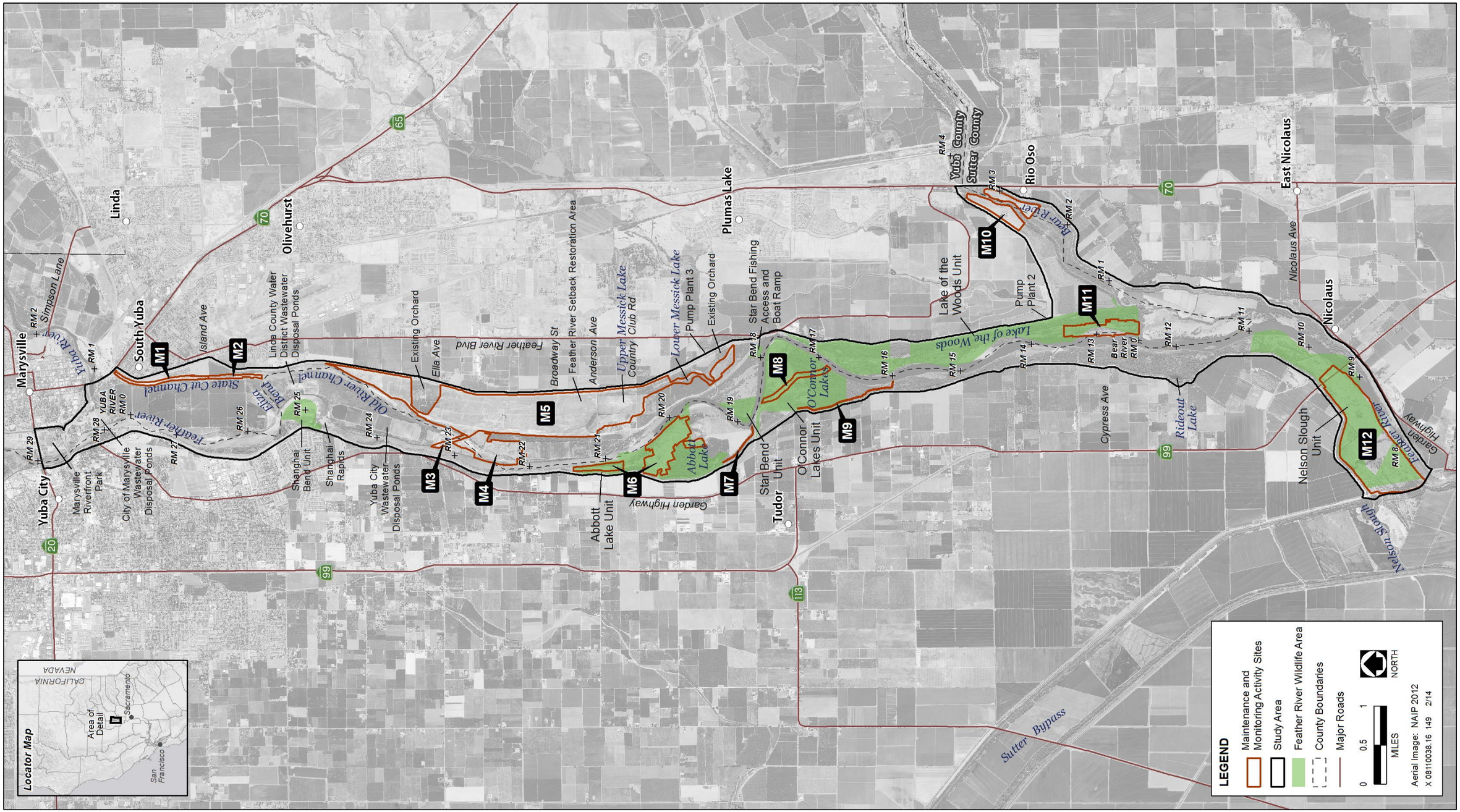
Source: Data compiled by AECOM in 2014



Source: AECOM 2013, CBEC 2013

Exhibit L-3

Modeled Roughness Values for Proposed Revegetation Areas, May 2013



Source: AECOM 2013, CBEC 2013

Exhibit L-4

Maintenance and Monitoring Activity Sites

L.2.1 NELSON SLOUGH TO BOBELAINE AUDUBON SANCTUARY (RM 7.5 TO RM 12)

This reach encompasses the confluence of the Lower Feather River with the Sutter Bypass, the Nelson Slough Unit of the FRWA, the southern portions of Bobelaine Audubon Sanctuary, and Scheiber Ranch near Nicolaus (Exhibit L-4, Site M12). See Appendix C-1 for the corresponding aerial photo and Vegetation Map 1.

Future floodway maintenance responsibilities in this reach of the LFRCMP study area are limited to annual monitoring of planned or future mitigation and restoration areas within the Nelson Slough Unit. The purpose of monitoring is to assess vegetation changes in this area and determine whether maintenance is needed to ensure that roughness levels throughout the floodplain are consistent with the distribution and pattern of maximum-roughness thresholds as shown in the LFRCMP conceptual plan for this area. Most of the floodplain should remain as grassland, although scattered oak trees and small tree clusters are acceptable, consistent with the level of oak savanna/grassland cover proposed for this reach (n=0.030). The north side of the Nelson Slough Unit is within a "hydraulic shadow" zone of ineffective flow, a wedge-shaped area between projecting bends in the levee alignment. Because the floodway is wider here, and because of the hydraulic shadow effect, the floodway in this area can be converted to a higher roughness vegetation type, and planted as valley oak woodland (n=0.050).

L.2.2 BEAR RIVER TO LAKE OF THE WOODS (RM 12 TO RM 16)

This reach encompasses the northern portions of Bobelaine Audubon Sanctuary and Scheiber Ranch, the southern and central portions of the Lake of the Woods Unit of the FRWA, the Bear River setback area, and the confluence with the Bear River (Exhibit L-4, Sites M10 and M11). See Appendix C-2 for the corresponding aerial photo and Vegetation Map 2.

The only future floodway maintenance responsibilities in the Bear River setback area would be limited to monitoring the existing mitigation and restoration areas regularly to ensure that the low-roughness zone at the upstream (east) portion is maintained as native perennial grassland (Exhibit L-4, Site M10) with widely scattered valley oak trees. Volunteer stands of riparian vegetation such as willows and cottonwood, or exotic invasive plants such as blackberry and false bamboo, should not be allowed to establish within the grassland areas. Volunteer riparian or invasive plants that appear should be removed promptly when these plants are small and more manageable at a reduced maintenance cost.

DWR's Sutter Maintenance Yard should continue its current, ongoing routine vegetation management, including periodic removal of dense vegetation in the Lake of the Woods Unit, in coordination with CDFW's local refuge managers. Ongoing vegetation management and removal should continue between the upstream (north) end of Lake of the Woods (RM 17) and RM 13.5. However, hydraulic modeling described in Chapter 5, "Hydraulic, Hydrologic, and Sediment Transport Modeling of Potential Future Conditions," demonstrates that higher vegetation roughness in this portion of the corridor no longer affects floodway capacity because the Bear River setback project widened both the Bear and Feather River floodways in this area. Therefore, vegetation monitoring, management, and removal are no longer necessary in the lower 1 mile (RM 13.5 to RM 12.5) of the Lake of the Woods Unit.

L.2.3 NORTHERN LAKE OF THE WOODS TO ABBOTT LAKE (RM 15.5 TO RM 20)

This reach encompasses the northern portion of the Lake of the Woods Unit of the FRWA, the O'Connor Lakes Unit, the Star Bend levee setback area, the Star Bend Unit, the southern and central portions of the Abbott Lake Unit, and the southern end of Feather River setback levee area (Exhibit L-4, Sites M6, M7, M8, and M9). See Appendix C-3 for the corresponding aerial photo and Vegetation Map 3.

The primary future floodway maintenance responsibilities in this reach include annual monitoring of existing, planned, and future mitigation and restoration areas within the Abbott Lake (Exhibit L-4, Site M8), Star Bend, and O'Connor Lakes (Exhibit L-4, Site M6) units of the FRWA (including the west levee at the Star Bend levee setback area). The goal of the monitoring is to ensure that all sites are managed to be consistent with the distribution and pattern of maximum-roughness thresholds (Exhibit L-3), as represented in the LFRCMP's conceptual restoration plan (Appendix M) and flood hydraulic modeling (Chapter 5, Appendix G).

The designated 400-foot-wide corridor in the O'Connor Lakes Unit (Exhibit L-4, Site M8) should continue to be maintained as a low-roughness zone where scattered trees are limbed up and understory vegetation is restricted to mostly volunteer grassland (Exhibit L-3). This management approach is similar to that used to maintain a natural oak savanna and grassland vegetation type (n=0.030). The managed corridor within an otherwise dense riparian forest varies from 300 to 500 feet wide and measures 2,500 feet long from north to south.

The proposed excavated overbank flow swales in the O'Connor Lakes, Star Bend, and upper Lake of the Woods units would enhance the natural ecological functions of the floodplain topography, and would not require maintenance activities by DWR's Sutter Maintenance Yard even if future local occurrences of scour, organic debris, or sediment deposition were to occur. In the northern portion of O'Connor Lakes, the proposed excavated bench should be monitored at least every other year to ensure that the vegetation roughness remains generally low. The proposed vegetation types for this area, primarily native grassland or low-density valley oak savanna/grassland vegetation types (n=0.030) would achieve this low vegetation roughness.

Proposed improvements to the drainage system along the waterside of the east levee (Exhibit L-4, Sites M7 and M9) could be undertaken a cooperative effort between LD 1, RD 2066, and the CDFW managers of the FRWA. Improving drainage and lowering the waterside levee toe drain would improve levee stability and reduce the deleterious effects of semiaquatic borrowing mammals (beaver and muskrats) on levee integrity. Damage to the westside levee by beavers and muskrats has occurred primarily in locations where these perennial toe drains are adjacent to the waterside levee slope, are surrounded by riparian vegetation, and provide corridors of permanent open water connecting with natural lakes and the river. These combined elements are ideal habitat conditions that encourage beavers to form dams along levee toe drains and burrow to create dens in lower levee slopes. Supporting local efforts to improve seasonal drainage on waterside toe drains in these locations would minimize the risk of levee damage from burrowing mammals, and would improve water quality by lessening eutrophic conditions caused by a lack of seasonal water flushing.

L.2.4 NORTHERN ABBOTT LAKE TO YUBA CITY WASTEWATER DISPOSAL PONDS (RM 20 TO RM 24)

This reach encompasses the northern portion of the Abbott Lake Unit of the FRWA, the Marysville-Yuba Mitigation Area, most of the Feather River setback levee area (including Messick Lake and the valley elderberry

longhorn beetle mitigation areas), the Yuba City Wastewater Disposal Ponds, and the Old Feather River channel (Exhibit L-4, Sites M3, M4, M5 and M6). See Appendix C-4 for the corresponding aerial photo and Vegetation Map 4.

The primary future floodway maintenance responsibilities in this reach include monitoring existing and future mitigation and restoration areas for the FRS and adjacent TRLIA-owned mitigation and restoration areas. The goal of such monitoring is to ensure that all of these areas are designed and managed to be consistent with the distribution and pattern of maximum-roughness thresholds (Exhibit L-3) and topographic modifications (Exhibit L-5, Exhibit L-4 Sites M3, M4, and M5), as represented in the LFRCMP's conceptual restoration plan (Appendix M) and flood hydraulic modeling (Chapter 5, Appendix G).

A secondary but associated responsibility is to ensure that TRLIA maintains major FRS internal access roads in good condition so that levee- and floodway-inspection personnel from DWR's Sutter Maintenance Yard have internal access to the floodway (Exhibit L-4, Site M5), including access to TRLIA- and State-owned land west of the FRS area boundary on the east side of the Feather River (Exhibit L-4, Site M4). Major roads and levee access points, shown in Exhibit L-6, include internal north-south routes (Old Levee Road and the eastside levee toe road), east-west routes (Ella Avenue and Country Club Road), and eastside levee waterside access ramps at Ella Avenue, Broadway, and Anderson, Country Club, and Rich roads. The north-south route of Moore Avenue passes through leased commercial orchards and a mitigation site on both TRLIA and State-owned land parcels. All these roads need to be maintained for floodway and levee inspection and maintenance.

Future deposition and debris that may accumulate in the proposed West Diversion Swale (Exhibits L-4, Site M3, Exhibit L-5) would not affect floodway capacity or flood stage because excavating the swale would remove material and would substantially lower existing topography (Appendix G). Some degree of scour, deposition, and debris accumulation within the proposed swales is anticipated as part of natural geomorphic processes and would not require remedial maintenance for floodway protection (Appendix G). However, excessive sediment accumulation at the sill of the inlet to the diversion swale at RM 23, on the left bank, would diminish the ecological benefits of more frequent inundation and through-flow across the FRS floodplain. The inlet sill elevation should be inspected after major flood events to determine whether periodically removing sediment at this location is justified to maintain the intended diversion frequency from higher stages in Feather River. Sill design elevation at the inlet is 36.8 feet National Geodetic Vertical Datum (NGVD).

At the proposed Messick Lake Drainage Swale between Upper and Lower Messick Lakes (Exhibit L-4, Site M5, Exhibit L-5), deposition and debris that may accumulate in the enlarged and deepened channel also would not affect floodway capacity or flood stage (Appendix G). However, debris accumulation in the drainage channel should be monitored to ensure that more frequent backwater inundation of the upper FRS floodplain is not impaired. Inspections should also be conducted at Upper Messick Lake to confirm that it drains completely after flood recession to prevent fish entrapment and poor water quality conditions in the Upper Messick Lake basin and lowered floodplain. If inspections reveal blockages at the outlet of the Upper Messick Lake basin and drainage pathways of the upper FRS floodplain, accumulated debris should be cleared.

Maintenance of proposed diversion and drainage swales within and west of the FRS area would be the responsibility of the current landowner and land manager, TRLIA, unless and until all or portions of these lands are turned over to State ownership under future interagency management agreements.

Proposed spoils ridges (high-ground refugia) within the FRS area (Exhibit L-5) would not require vegetation maintenance. These areas are considered the maximum potential area of relocation of excavated material on-site, and should not exceed the combined footprint as presented and modeled in the LFRCMP.

Also important are the linear form and orientation to the direction of flood flow as simulated under the LFRCMP. Should some of the proposed excavated features of the concept plan not be implemented, or if future secondary uses of excavated material are identified for use off-site to reduce the overall costs of grading work for habitat creation, there would be a corresponding, proportional reduction of the volume and combined footprint of spoils ridges. Future erosion of windward portions of the spoils ridges may occur during prolonged high flood stage, but this is considered a natural process and does not require remedial maintenance. Vegetation growing on spoils ridges within FRS (Exhibits L-3 and L-5) would not require vegetation maintenance because the flood hydraulic model assumed relatively high roughness values. This assumption of high roughness values is conservative because the tops of ridges would have generally arid growing conditions and would be unlikely to support dense vegetation. Furthermore, top elevations for most of the ridges would be near or above the 100-year flood stage water surface elevation.

L.2.5 SHANGHAI BEND TO YUBA RIVER AND MARYSVILLE (RM 24 TO RM 29)

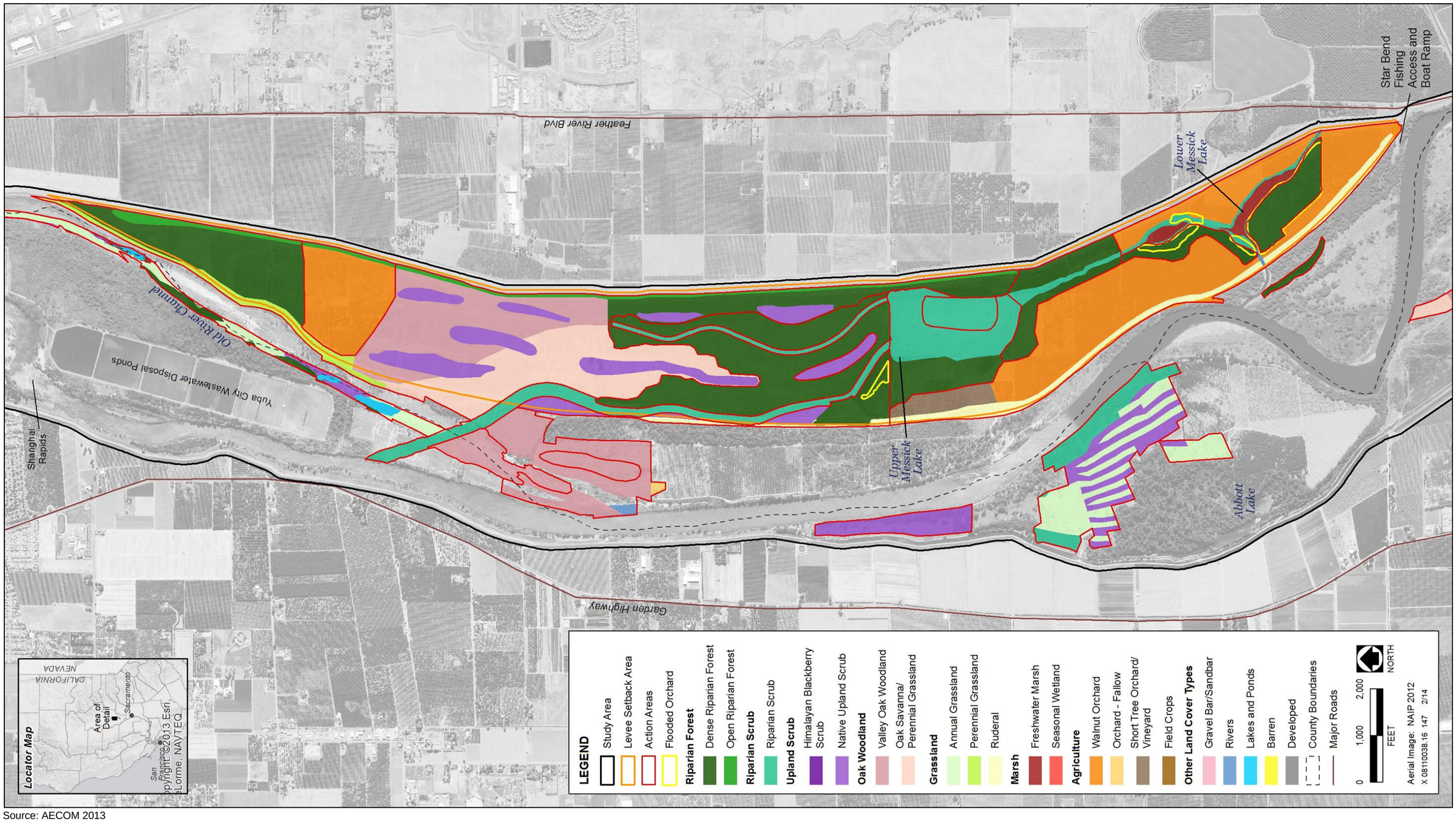
This reach encompasses the north end of the Yuba City Wastewater Treatment Ponds, Shanghai Rapids, the Shanghai Bend Unit, Eliza Bend, the Old Feather River and State Cut channels, the Yuba River confluence, and the City of Marysville and Linda County Water District wastewater treatment ponds (Exhibit L-4, Sites M1 and M2). See Appendix C-5 for the corresponding aerial photo and Vegetation Map 5.

As described below, the primary areas of future floodway maintenance responsibilities in this reach of the LFRCMP study area include Upper and Lower State Cut, and monitoring channel changes at and upstream of the Shanghai Rapids breach chute.

UPPER STATE CUT (YUBA RIVER OVERFLOW TO ISLAND AVE CROSSING)

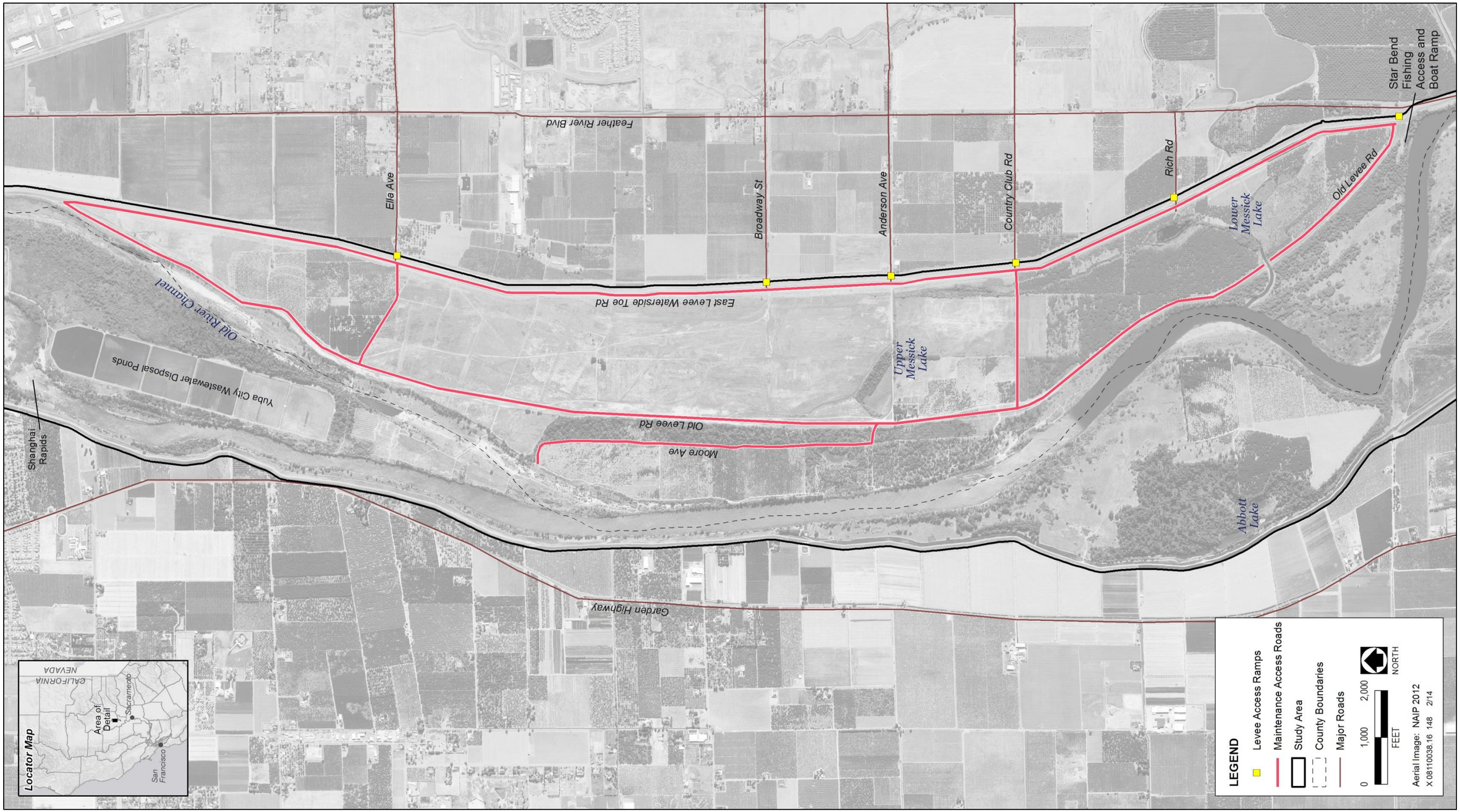
Personnel from DWR's Sutter Maintenance Yard have typically removed accumulated sediment and cleared vegetation from the Upper State Cut flood bypass an average of every 2–3 years to maintain bypass conveyance capacity. This routine maintenance activity should continue to maintain floodway bypass capacity (Appendix G).

To maintain the ecological benefits of actions proposed in Chapter 6, the inlet sill elevation at the upstream end of State Cut near the Union Pacific Railroad Bridge, and the overall bypass bed gradient, should be evaluated after major flood events to ensure that deposition at the inlet elevation does not exceed bypass design (Exhibit L-4, Site M1). In addition, postflood maintenance should include inspection and maintenance of a bed-level gradient and width of the bypass channel to maintain a uniform sediment transport capacity, and to minimize future locations of deposition and scour. The results of sediment transport modeling (Appendix H) indicate the potential for scour depths of 2–6 feet for 0.66 mile below the Union Pacific Railroad Bridge during a 100-year flood hydrograph, and sediment deposition of 1–5 feet farther downstream to Island Avenue and along the flanks of the scoured upper segment. However, lesser flood events with more shallow, lower velocity flow in the bypass may result in periodic accumulation of sediment at both the upstream and downstream segments of Upper State Cut, including the critical elevation of the overflow sill.



Source: AECOM 2013

Exhibit L-5 **Lower Feather River Corridor: Feather River Setback Area - Future Vegetation, Swales, and Fill Ridges**



Source: AECOM 2013

Exhibit L-6

Major Roads and Levee Access Points in the LFRCMP Study Area

Installing sediment chains and graduated posts, or using other on-site elevation reference methods, would allow for efficient and frequent observations of bed-level changes in the bypass to calibrate the State Cut channel's maintenance needs.

LOWER STATE CUT (ISLAND AVENUE CROSSING TO ELIZA BEND CONVERGENCE)

Personnel from DWR's Sutter Maintenance Yard have not conducted routine maintenance activities in Lower State Cut in recent years (Hull, pers. comm., 2011). The bypass channel is split into two parallel channels by a sparsely vegetated, 2,500-foot-long ridge of sandy sediment down the center of the bypass. Approximately 30 medium to large trees are growing on the deposition ridge, but the understory is mostly ruderal nonnative grassland and blackberry scrub. The split channel and sediment ridge reduces bypass conveyance capacity, especially considering the low gradient of State Cut and the potential for future deposition in Lower State Cut as indicated by the results of sediment transport modeling (Appendix H). Maintenance activity in Upper State Cut should be extended southward to include periodic removal of sediment and vegetation in Lower State Cut to gradually restore a more uniform bypass capacity and flow-line gradient (Exhibit L-4, Site M2).

An alternative to complete ridge removal is incremental widening of one side of the split channel over several maintenance cycles, and retention of some of the existing mature oaks on mounds. DWR has successfully implemented a similar long-term maintenance practice at the upper end of the Yolo Bypass below Fremont Weir. Some of the sediment skimmed from Upper and Lower State Cut can be used to fill in localized scour holes and unauthorized sand pits near the confluence of the bypass with Eliza Bend/Old Feather River.

SHANGHAI RAPIDS BREACH INCISION

Floodway capacity maintenance is not required in the main river channel and floodway at Shanghai Rapids. The primary future maintenance need is to monitor trends in channel incision that may be caused by the expansion and deepening of the breach chute that is actively eroding the Modesto Formation (Exhibit L-7). The erosion-resistant Modesto Formation acts as a grade control feature in this part of the Feather River. The results of sediment transport modeling and geomorphic analysis of breach chute expansion indicate a long-term trend of westward channel migration within Shanghai Bend, and bed-level incision upstream of Shanghai Rapids to the Yuba River confluence. These channel dynamics could cause bank and bed erosion near levees or bridges in the general vicinity of RM 27 and RM 28.5. DWR should conduct periodic bathymetric sampling of changes in bed level upstream of Shanghai Rapids, and low-flow observations of the changes at the exposed Modesto Formation breach chute and the secondary cutoff channel forming across the bar at Shanghai Bend.

Source: Google Earth May 2, 2013

Exhibit L-7. Breach Chute across Modesto Formation at Shanghai Rapids, LFRCMP Study Area

L.3 INVASIVE WEED MANAGEMENT

L.3.1 BACKGROUND

Invasive plant species degrade habitat quality, alter ecosystem processes, and can alter channel morphology by retaining sediments and increasing the channel's hydraulic roughness, thereby restricting flows and reducing flood conveyance (Bossard et al. 2000). Species with shallow root systems, such as giant reed (*Arundo donax*) and red sesbania (*Sesbania punicea)*, promote bank undercutting, collapse, and erosion (Bossard et al. 2000).

Nonnative invasive species such as giant reed, tree-of-heaven (*Ailanthus altissima*), black locust (*Robinia pseudoacacia*), perennial pepperweed (*Lepidium latifolium*), eucalyptus (*Eucalyptus* spp.), star thistle (*Centaurea solstitialis*), and Himalayan blackberry (*Rubus armeniacus*) 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 LFRCMP study area. Riparian tree species have a low tolerance of wildfire and may not recover naturally after a hot fire in an understory of giant reed. All of these invasive species can alter the structure, function, and composition of plant communities in riparian and adjacent habitats, and they compete with and displace native vegetation in the LFRCMP study area. They also generally provide low-quality wildlife habitat.

Incorporating invasive plant control in routine maintenance activities would improve floodway capacity and would provide ecosystem benefits. Specifically, invasive weed control in the LFRCMP should focus on controlling established nonnative species such as Himalayan blackberry, black locust, tree-of-heaven, giant reed, eucalyptus, and perennial pepperweed, and preventing introduction of new, highly invasive plants such as red sesbania, tamarisk (*Tamarix ramosissima*), and fig (*Ficus carica*). 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 integrating the best management practices (BMPs) described below with LFRCMP maintenance activities. These invasive plant control BMPs could also be applied to maintenance activities on CDFW and FRS area lands. The BMPs recommended below are consistent with those currently being developed for the *Central Valley Flood Protection Plan Conservation Strategy*, as described in the Central Valley Flood Protection Plan Conservation Framework (DWR 2012).

L.3.2 CURRENT INVASIVE SPECIES MANAGEMENT

DWR conducts invasive species management during general O&M of the flood control facilities. Current practices at the Sutter Maintenance Yard reflect requirements for maintenance work authorized in the RMSAA between DWR and CDFW (DFG 2011), which identifies conditions that limit when, where, and how vegetation may be removed. Operations in the maintenance yards are conducted in close coordination with CDFW as required by the RMSAA. DWR uses chemical and physical tools to manage vegetation. Physical methods include manual removal using hand tools, mechanical methods (mowing, disking, dragging, grading), burning, and grazing. Many of these methods are used in concert to reach the ultimate goal of clearing the vegetation. These methods are applied on the levee slopes, on the levee crown, and adjacent to and in the channel. Typically, with

the exception of management to control invasive species, 15-foot-wide vegetated zones extending along both banks of the low-flow channels are left intact.

The frequency of vegetation management for each channel depends primarily on channel capacity. In general, undersized flood channels that have a flow capacity less than or equal to flows expected during a 100-year flood event (i.e., magnitude of flood flows expected to be equaled or exceeded every 100 years on average) require more frequent maintenance to preserve capacity. Oversized channels that have the capacity to convey flows in excess of those expected during a 100-year event require less frequent channel maintenance to preserve capacity of the channel.

HERBICIDES

Herbicide is applied in fall, winter, and early spring as a measure to control weedy annual and broadleaf vegetation. No single herbicide is used more than 2 or 3 consecutive years. Nonselective herbicides are used to maintain bare-ground areas (e.g., levee toe roads, crown roadways, and access points). Broadleaf selective herbicides are used to remove broadleaf weeds from levee slopes. Spot spraying is used for species-specific control and for control of brush and vines that may interfere with access or visibility. All herbicides are applied according to label specifications and by a certified herbicide applicator. The RMSAA defers time restrictions for herbicide application along the levee slopes, channel slopes, and access roads to the California Department of Pesticide Regulation and does not restrict the timing. The RMSAA does dictate timing for herbicide application to control woody and brushy vegetation in channels (July 1 through November 30) and aquatic vegetation (June 1 through March 1).

MANUAL AND MECHANICAL CONTROL OF VEGETATION

On levee slopes, vegetation management conforms to the DWR Vegetation Management Zone Criteria for Standard Levees provided in Appendix G of the CVFPP Conservation Strategy. Generally, trees and shrubs are trimmed up to 5 feet above the ground and thinned to allow access to and visual inspection of the levee slopes, and ground cover that is more than 12 inches high is trimmed, thinned, mowed, burned, dragged, or otherwise removed. Woody stumps are treated with herbicide to prevent regrowth. On the waterside, the top 20 feet of the slope length below the levee hinge point are managed in the same way. Below that point, all vegetation can be left in place.

Manual vegetation control is conducted both on levee slopes and adjacent to the channel. It typically includes selectively trimming, limbing up, or cutting down woody and brushy vegetation. The RMSAA requires that manual vegetation control be performed between August 1 and March 1 to avoid impacts on nesting birds. Work may be requested outside of this work window, but would require a nesting bird survey be completed and approved by CDFW prior to commencement of activities.

Mechanical vegetation management can include dragging or grading, disking or bulldozing, operating a brush hog or similar device, and mowing. The RMSAA requires that dragging or grading of the levee slopes to control vegetation be accomplished between June 1 and March 1. It also authorizes the maintenance yards to control vegetation by strip disking or bulldozing 75- to 100-foot-wide sections in large channels. Any width greater than 100 feet requires additional approval from CDFW. Vegetation removal by mechanical means, such as by using a

brush hog or similar device, is restricted to the period between August 1 and March 1. Mechanical control of aquatic vegetation must be completed between June 1 and March 1.

Mowing typically occurs in late spring and summer on levee slopes that are accessible and not too steep for the mower. Vegetation is mulched and left on-site. The RMSAA allows mowing at any time as long as the mower height is set at 4 inches or higher. Mowing at heights below 4 inches can be conducted only between May 1 and March 1. In addition, mowing in the dry portions of large channels is restricted to the period between August 1 and March 1.

CONTROLLED BURNING

Controlled burns typically are conducted only in rural areas during midsummer (July and August) in coordination with the local air quality management district and CDFW. Burning typically is used along levee slopes to improve visibility. For the maintenance yards, the RMSAA restricts vegetation management by burning to the period between June 1 and March 1. Debris piles can be burned at any time.

LIVESTOCK GRAZING

In Lake of the Woods, sheep and goat grazing is used to manage some densely vegetated areas (USFWS 2005), and open areas in Nelson Slough are maintained by sheep grazing through an agreement between CDFW and a local rancher (DWR 2010c). The RMSAA does not restrict the timing of livestock grazing on levee slopes. In channels, grazing is allowed between July 1 and March 1.

L.3.3 BEST MANAGEMENT PRACTICES FOR INVASIVE WEED CONTROL

BMPs are methods or techniques consistently shown to be the most effective and practical in achieving an objective, such as preventing or reducing invasive plant spread, while making optimal use of resources. BMPs provide a standard way of operating that multiple organizations can use, and they can be improved as new processes or techniques are discovered. Because each situation and organization has different needs, constraints, and resources, proper planning can help to identify areas and species to prioritize when integrating BMPs into management activities. The applicability and effectiveness of BMPs will vary with existing land uses, level of human disturbance, the specific objectives of the BMPs, and the resources available. Factors to consider during planning include management costs, the value of the habitat under consideration, and context of the area being managed. Some BMPs may be implemented using existing resources, whereas others may be implemented only with the allocation of additional resources.

For the purposes of controlling invasive species, BMPs fall into two primary categories: BMPs intended to protect the environment during control efforts and BMPs that result in more effective control of invasive species during a project.

INVASIVE SPECIES CONTROL BMPS

The following invasive-species prevention principles, planning BMPs, and prevention BMPs were selected directly from the California Invasive Plant Council's (Cal-IPC's) *Preventing the Spread of Invasive Plants: Best Management Practices for Land Managers* (Cal-IPC 2012). This publication includes further details and additional applicable prevention BMPs for topics such as travel; tool, equipment, and vehicle cleaning; clothing,

boot, and gear cleaning; project materials; waste disposal; fire and fuel management; and revegetation and landscaping. Additional BMPs on the same and similar topics, as well as aquatic weed prevention and grazing management BMPs, can be found in the U.S. Forest Service's *Guide to Noxious Weed Prevention Practices* (USFS 2001).

General Prevention Principles

The following general prevention principles apply to all projects:

- *Take time to plan*—Proper planning can reduce future maintenance costs by reducing the potential for invasive plant introduction and spread. A good first step is to conduct a preactivity assessment of the project/work area to determine which activities could spread weeds and which BMPs are applicable.
- *Stop movement of invasive plant materials and seeds*—The movement of workers, materials, and equipment can carry weeds between sites. Planning helps to identify potential vectors of spread and eliminate them or reduce their effects.
- *Reduce soil and vegetation disturbance*—Disturbance can allow invasive plants to colonize a new area. When disturbance is unavoidable, managers should conduct follow-up monitoring to ensure early detection of any invasive plants that have been introduced.
- *Maintain desired plant communities*—A healthy plant community with native and desirable species provides resistance to invasive plant establishment.
- *Practice early detection and rapid response*—Early detection and eradication of small populations helps prevent the spread of invasive plants and significantly reduces weed management costs. Regular monitoring increases the chances of success.

Planning Best Management Practices

Planning includes developing schedules, budgets, and strategies and identifying critical control points for carrying out prevention BMPs. Identifying and mapping invasive plants at work sites is critical for evaluating threats. This step helps determine high-risk spots for potential establishment and spread and helps land managers select appropriate prevention practices.

The following BMPs should be considered during project-level planning:

- Evaluate invasive plant risks. Conduct a site assessment for invasive plant infestations and develop a site plan to address those infestations before carrying out field activities:
    - Determine invasive plant prevention and management needs at the onset of activity planning and prioritize treatment.
    - Inspect the work site and adjacent areas and record locations and densities of invasive plants to determine priority areas for implementing prevention BMPs.

- Inspect likely introduction sites, such as roadsides, staging areas, and other disturbed areas. Wet areas may also be especially susceptible.

- Gauge the extent and intensity of the inspection based on the threat of invasive plants to critical habitats, size of the work site, type of activity (ground or vegetation disturbance and degree of disturbance), and adjacent environment.

- Be especially aware of invasive plant species that are not widespread in the work area and that can be controlled using early detection and rapid response. Flag areas infested with invasive plants that are not widespread in the work area. Either avoid disturbance in those areas or identify and isolate contaminated soils during project activities or other disturbance. Isolated contaminated soils should be either placed back in the original location or disposed of appropriately to avoid spreading isolated populations of invasive plants throughout the work site.

- Review internal documentation and consult local groups such as weed management areas (WMAs) and online resources such as Cal-IPC for available maps and information on existing and potential invasive plant infestations on and near work sites.

- Incorporate findings into a database such as Natural Resource Projects Inventory , CalWeedMapper, and project drawings or maps.

► Schedule activities to minimize the potential for introduction and spread of invasive plants:

- Consider the timing of invasive plant control efforts. Determine whether planned efforts should occur before, during, or after the activity based on the plant's life cycle.

- When feasible, schedule land-disturbing activities to occur before invasive plants set seeds to minimize spreading seeds of invasive plants. Keep in mind that seeds may be present in the soil.

- Consider invasive plants' reproductive biology and response to fire when planning prescribed burns.

- Coordinate the timing of maintenance activities and weed control activities when feasible. For example, delay mowing until 2 weeks after herbicide application and delay spraying after mowing until vegetative regrowth has occurred.

- Prioritize reducing invasive plant seed production along roadsides to reduce seed movement by vehicles.

- Conduct work under conditions that minimize the risk of spread, such as seed absence.

- Avoid working during rain events and high winds. Wet conditions make it easier for seeds to be picked up by a vehicle and spread miles down the road.

- Integrate cleaning BMPs into planning for land management activities:
    - Determine cleaning needs for tools, vehicles, equipment, clothing, boots, and gear in conjunction with each activity and work site. Include these cleaning needs in project plans, and make prior arrangements for any special needs identified.
    - Include cleaning costs in project budgets.
    - Acquire necessary cleaning tools.
    - Designate sites for cleaning vehicles, equipment, clothing, and gear.
    - Identify cleaning facilities (such as car washes) near the work site in the event that cleaning on-site is not an option.
- Prepare work site to limit the introduction and spread of invasive plants:
    - Protect likely introduction sites, such as pull-outs, trailheads, and parking lots, from invasive plant introductions by paving, deep mulching, or planting a dominant noninvasive groundcover.
    - Periodically inspect areas of concentrated use, such as staging areas or parking areas, and keep them free of invasive plants.
    - Treat invasive plants at access roads and staging areas before using them.
    - Control invasive plants in areas adjacent to work sites. This practice prevents seeds or other reproductive plant parts from moving into the work site.
    - If feasible, position activity boundaries to exclude areas infested with invasive plants, or control invasive plants in infested areas before the areas are used. Activity boundaries include staging areas, access roads, and other temporary facilities.
- Provide prevention training to staff members, contractors, and volunteers before starting work:
    - Prior to the start of work, provide training on invasive plants and prevention BMPs to staff members, contractors, and volunteers. Training should address field identification, reproductive biology, and ecological and economic impacts of invasive plants; inspection and cleaning protocols; recording and reporting occurrences; and treatment of infested materials.
    - Provide additional training to supervising staff members and contractors including how to acquire weed-free materials (e.g., seed and erosion control materials) and how to inspect those materials.
    - Ensure that staff members and contractors understand provisions for invasive plant prevention throughout the project site. Invasive plant considerations should be routinely addressed during prebid, preproject, and other meetings, as appropriate.

- Identify and train personnel responsible for inspecting cleaned tools, equipment, and vehicles at facilities and work sites. Require that an inspection form or checklist be used to document items cleaned before they are removed from an infested work site and to document that they remain clean upon arrival at an uninfested work site.

- Provide invasive plant identification guides and prevention BMP and cleaning inspection checklists to staff members, contractors, and volunteers. Provide these resources in other languages when appropriate. Also have these resources available at highly visible locations, such as access points and field stations and work trailers.

- Monitor work sites for invasive plants after land management activities:

  - Carry out the established monitoring plan.

  - Partner with local WMAs, agencies, and organizations to help with monitoring when possible.

  - Train staff members to recognize and report invasive plants as part of ongoing monitoring.

  - Monitor on-site cleaning area; waste disposal area; areas where project materials are stored; access routes; roads and other areas of concentrated use; and areas near salt licks, watering sites, loading/unloading areas, and corrals for animals.

  - Monitor and maintain revegetation and landscaping to ensure long-term establishment of desired plant species.

  - Monitor these sites during multiple growing seasons, especially at times of germination and flowering, for a minimum of 3 years after project completion to ensure that any invasive plants are promptly detected and controlled. If 3 years is insufficient to control invasive plants, continue monitoring and treatment until invasion has been controlled.

  - For ongoing projects, continue to monitor these sites until reasonably certain that invasive plants will not reappear. Plan for follow-up treatments based on presence of invasive plants.

Prevention Best Management Practices

The most cost-effective strategy for dealing with invasive plants is preventing them from becoming established. This is accomplished by preventing the intentional or unintentional introduction of seed or reproductive plant parts of invasive species into an area. Preventing the spread of established invasive plants can reduce future maintenance needs and costs; reduce fire hazards and herbicide use; enhance access and safety; limit landowner liability and maintain good public relations; and protect existing wildlife habitat, endangered species, native plant populations, and beneficial insects (Cal-IPC 2012).

Vegetation Management Best Management Practices

Vegetation management activities may include but are not limited to mowing, manual clearing, trimming, mechanized clearing and trimming, herbicide application, prescribed grazing, and burning. Implementing the following BMPs during vegetation management activities would reduce the spread of invasive plants:

- Manage vegetation with methods to reduce the spread of invasive species and encourage desirable vegetation:
    - Coordinate management of invasive plants and desirable plants.
    - Schedule mowing, clearing, trimming, or grazing of desirable plants for after seed maturation, ensuring that desirable plants grow unrestricted and produce seed.
    - Schedule management of invasive plants at early flowering stage (or well before seed development) to avoid spreading viable invasive plant seeds.
    - Limit mowing and other mechanical control to the minimum needed to control invasive plants. To reduce plant shock and root dieback of desirable plant species, mowing height should not be less than 6 inches. Mowing too low during the growing season increases soil exposure to sun, soil temperatures, and erosion risks and encourages invasive plant growth.
    - Identify conditions under which invasive plants should not be mowed to avoid spreading them. Some invasive plants have the ability to sprout from stem and root fragments. Mowing these plants should be avoided.
    - Before excavating invasive plants from drainage ditches, treat the entire infestation to ensure that the plant parts will not spread to adjacent and downstream areas.
- Retain existing desirable vegetation and canopy:
    - Identify and protect desirable vegetation on-site to increase competition with invasive plants. Desirable vegetation should be noninvasive and suitable for the conditions.
    - Minimize clearing large amounts of vegetation and creating canopy openings. Increased sunlight and bare ground creates suitable habitats for invasive plant germination.
    - Consider the impacts of different types of equipment. Choose equipment that minimizes vegetation disturbance.

Soil Disturbance Best Management Practices

Soil disturbance activities may include but are not limited to contouring, grubbing, moving, removing, excavation, and cutting. Disturbing soil provides an opportunity for invasive plants to establish and spread, to compete with native species, and to colonize new areas. Implementing the following BMPs during soil disturbance activities would reduce the spread of invasive plants:

- Minimize soil disturbance:
    - Retain soil and desirable vegetation in and around the activity area as much as possible to prevent the introduction and spread of invasive plants.
    - Minimize ground disturbance because increased bare ground creates suitable habitat for invasive plant germination.

- Consider the impacts of different types of equipment. Choose equipment that minimizes soil disturbance.
- Minimize the frequency of soil disturbance. If a site has to be cleared of vegetation regularly (such as for brush clearing), consider paving or otherwise protecting the site with weed-free materials (gravel, mulch, decomposed granite), deep mulching, planting noninvasive groundcover, or sealing the bare surface with soil stabilizer.
- Limit the number of roads and access points used, to help minimize soil disturbance and to limit the risk of unintentionally transporting invasive plants into uninfested areas.

► Implement erosion control practices:

- Promptly revegetate and/or mulch disturbed soil after ground-disturbing activities. This will stabilize soils and reduce the likelihood of invasive plant establishment.
- Use weed-free mulch, or plant a native or nonpersistent cover crop as temporary cover during the delay between soil disturbance and revegetation.
- Contain and manage water runoff, which may carry soil, seeds, and plant material. Silt fences installed along perimeters of work sites can aid in preventing the spread of infested materials.

► Manage existing topsoil and excavated material to reduce contamination by invasive plants:

- Plan topsoil management before soil is disturbed. Save local existing topsoil for reuse unless the topsoil and duff material are determined to be contaminated with invasive plants.
- Identify on the project plans where local topsoil on the work site should be removed or excavated, stockpiled, or reapplied.
- When excavating local topsoil and removing duff material, minimize handling of the material to reduce detrimental impacts on soil microorganisms.
- Stockpile local topsoil and duff material in windrows no taller than 10 feet for local topsoil and 5 feet for duff. Implement temporary erosion control measures to reduce the likelihood of invasive plant establishment and loss of material.
- Seed local topsoil stockpiles that will remain in place for more than 6 months with a fast-growing noninvasive native plant species to maintain soil microorganisms. Covering topsoil stockpiles with impermeable barriers such as plastic sheeting may destroy living soil microorganisms.
- Monitor stockpiles of topsoil and duff material regularly because they are highly susceptible to invasion by invasive plants. Determine management needs based on presence of invasive plants.
- Avoid side-casting (piling excavated soil on either side of a trench when clearing a channel) materials infested with invasive plants. Stockpile in one area that can be monitored.

L.3.4 HAZARD ANALYSIS AND CRITICAL CONTROL POINTS

Resource management work may be the pathway to unintentionally spreading unwanted plants to new locations. Transporting equipment such as bulldozers and backhoes and gear such as tools and clothing can provide pathways for the spread of invasive species that could potentially invade new and critical habitat for already endangered species. Hazard Analysis and Critical Control Points (HACCP) is a strategic planning process to prevent contamination. Originally developed by the food industry, this process has been adapted for natural resource work. HACCP comprehensive planning serves to identify unwanted species and the risk of contamination. It focuses on identifying critical control points where invasive species can be removed while documenting the BMPs used to prevent and remove the unwanted species. HACCP planning builds a framework of information to weigh the risks of species spread against management benefits. An HACCP planning manual, supporting documents, forms, and a database of completed HACCP plans with BMPs are available on the HACCP Planning for Natural Resources Management Web site (http://www.haccp-nrm.org/), supported by USFWS.

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