Public Workshop (10/1-2/12)
Bay-Delta Workshop 2
Deadline: 9/14/12 by 12 noon

American Rivers
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RECEIVED
9-14-12
SWRCB Clerk

John Cain
2150 Allston Way, Suite 320
Berkeley, CA 94704

Jeanine Townsend
Clerk to the Board
State Water Resources Control Board
P.O. Box 100
Sacramento, California 95812
RE: Bay-Delta Workshop 2: Bay-Delta Fishery Resources

Dear Ms. Townsend:

American Rivers is providing comments in response to the State Water Resources Control Board's ("Board's") notice dated June 22, 2012, in which the Board presented the schedule for a series of workshops on particular topics associated with its review and potential revision of the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan). This letter addresses the topics to be discussed in the second workshop, Bay-Delta Fishery Resources (focused on pelagic fishes and salmonids), and responds to the two questions the Board posed in the June 22, 2012 notice. For the purposes of making our comments more useful to the Board, we have addressed the Board's two questions in reverse order. We address the Boards second question on scientific uncertainty and adaptive management first, and then address the question regarding what additional technical information the board should consider.

We also include some recommendations for consideration as the Board undertakes modification of the Bay-Delta Plan. Our comments build on previous American Rivers input on the Board's review of the Bay-Delta Plan (provide citation).

Question two: How should the State Water Board address scientific uncertainty and changing circumstances, including climate change, invasive species, and other issues? Specifically, what kind of adaptive management and collaboration (short, medium, and long-term), monitoring and special studies programs should the State Water Board consider related to Bay-Delta fisheries as part of this update to the Bay-Delta Plan?

1. The board should take action to facilitate flow and non-flow measures where there is relatively little scientific uncertainty. While scientific uncertainty on many issues is an understandable impediment to management action, the Board should not let scientific dispute about some issues impede action on matters where there is relatively little uncertainty. Adaptive Management is a strategy for managing the risk associated with

uncertainty, but the very best risk management strategy is to implement management strategies with certain benefits.

There is high certainty and clear and compelling evidence documented in numerous, peer-reviewed scientific articles that inundated floodplain habitat is very beneficial to Chinook salmon, Sacramento splittail, and other public trust resources (American Rivers et al. 2010).

There is also reason to believe that inundated floodplain habitat may be an important component of food web productivity, a potentially important variable effecting pelagic species such as Delta smelt. Dr. Kimmerer's comments and presentation in workshop #1 indicate that food web subsidies from upstream of the low salinity zone may be important for providing food resources to pelagic fish in the low salinity zone. If so, floodplain inundation may benefit not only salmon and splittail, but also pelagic species that utilize the low salinity zone. The same may be true for tidal marsh restoration, but there is a higher level of uncertainty regarding whether tidal marsh restoration would benefit salmon and splittail.

Floodplain inundation will also likely generate large phytoplankton blooms which could increase turbidity. Turbidity is a measure of the clarity of the water and can be influenced not only by the presence of suspended sediment, but also by the presence of biological particulates such as phytoplankton. The benefits and functions of biologically induced turbidity for pelagic fish as received very little attention to date.

2. Scientific certainty in a highly complex ecosystem is not the correct standard of evidence, and is not a realistically achievable standard of evidence, for making changes in the water management regulations of the Bay-Delta watershed, particularly when public trust resources are at risk of irreversible damage or extinction. It is not realistic to anticipate statistical certainty in an ecosystem as complex as the Delta. There are simply too many confounding variables. In most cases, it is not possible to control research experiments for all of the independent variables. In many cases where some control is possible, it could take years or even decades to generate statistically irrefutable information without intentional changes in flows designed to accelerate completion of adaptive management research.

   Rather, the precautionary principle using the preponderance of evidence is the proper standard. Where several patterns, data points, and lines of evidence indicate that a Board action will benefit species on the verge of extinction, the board should take action, particularly where the underlying mechanism is partly or fully understood.

3. The board should consider the following criteria when deciding which measures to implement in the face of scientific uncertainty:
   - Magnitude of impact
   - Breadth of impact
   - Certainty of benefit

- Risk of undesirable and irreversible ecological impacts
- Reversibility: measures that are reversible are relatively low risk.
- Learning richness
- Time required to demonstrate outcomes

Increasing floodplain inundation, particularly by notching the Freemont weir or modifying floodplain configuration is a measure that scores very high on the criteria above. Floodplain restoration in the Yolo Bypass is the only measure evaluated through the BDCP which has a high certainty, high magnitude impact. The breadth of impact is large, because inundated floodplain habitat could have large impacts on the pelagic food web. There are some risks associated with mercury methylation and impacts to avian and terrestrial species, but any negative impact associated with opening a gate in the Freemont Weir could be entirely reversed (or managed) by closing the gate in the Freemont Weir (at certain times to reduce negative outcomes). Research regarding food web and turbidity benefits would provide an important learning opportunity for evaluating whether physical habitat restoration can yield benefits for pelagic species.

Similarly, increasing Delta flows at the right time is likely to have a high magnitude and breadth of impact. Sufficiently increasing Delta outflows will provide high certainty floodplain inundation benefits. Scientific certainty regarding the benefits of increased outflows in the absence of floodplain inundation may not be as high as certainty associated with floodplain inundation, but there is a very strong body of evidence that suggests it would benefit numerous species (TBI et al. 2010 and 2012). While there may be economic costs for junior water right users, there are little to no ecological risks. And lastly, increased flows are totally reversible if future data shows that the ecological benefits do not materialize.

Recommendations regarding question number two:

a) The Board should take actions that will increase the area of frequently inundated floodplain habitat in the Delta.
b) In combination with recommendation (a) above, the Board should require adaptive management research on the question of whether floodplain inundation in the Delta or upstream would provide food web resources or turbidity benefits for pelagic species and whether these benefits would create a population level effect.
c) The Board should utilize the precautionary principle and preponderance of evidence approach to prevent irreversible harm to public trust resources.
d) The Board should utilize the decision making criteria described in the comments above to guide decisions in the face of scientific uncertainty.

Question one: What additional scientific and technical information should the State Water Board consider to inform potential changes to the Bay-Delta Plan relating to Bay-Delta Fishery resources, and specifically pelagic fishes and salmonids that was not addressed in the 2009 Staff Report and the 2010 Delta Flow Criteria Report? For large reports or documents, what pages or chapters should be considered? What is the level of scientific certainty or uncertainty regarding the foregoing information? What changes to the Bay-Delta Plan should the State Water Board consider based on the above information to address existing circumstances and changing circumstances such as climate change and BDCP?

American Rivers has focused our comments on technical information pertaining to the subject of creating inundated floodplain habitat. Inundated habitat could either be created by changing flow regimes into the Delta or by implementing a physical solution to create more inundated habitat (levee set-backs, notching Fremont Weir) at existing instream flow levels. The technical analysis and information discussed below demonstrate that a physical solution alone is not sufficient to benefit salmon and other species dependent on frequent floodplain inundation. This is particularly true on the Feather River and the Lower San Joaquin where current flows are insufficient to inundate floodplain habitat. In these cases, increases in instream flows into the Delta during the spring months are necessary to create inundated floodplain habitat for salmon.

American Rivers recommends that the Board consider several recent technical analyses regarding the hydrologic connectivity of floodplains under existing and potential hydrology.

1. The Central Valley Flood Protection Plan (DWR, 2012) and associated technical appendices: The CVFPP calls for significantly expanding floodways and floodplains in the Delta through an expansion of the Yolo Bypass and creation of a new bypass parallel to Paradise Cut in the southern Delta. The plan also calls for modifying fish passage at all bypasses to better provide fish habitat for both upstream and downstream migrants. These expanded and modified bypasses could significantly improve conditions for salmon and other species, but only if flows are adequate to provide inundated floodplain habitat at the frequency required to provide population level benefits.

2. The Floodplain Inundation Potential (FIP) analysis conducted as an appendix to the flood plan (CVFPP, Attachment 9E): This analysis shows that levee removal from large areas of the levee protected floodplains would not result in sufficient frequency of inundated habitat to benefit salmon. Flows on the Feather River below Oroville Reservoir and the San Joaquin River in the Delta are insufficient to create inundated floodplain habitat in the critical spring months even if levees are fully removed. As discussed below, the lack of sufficient flows on the Feather River is caused by export/inflow regulations in the Delta. This new analysis validates previous testimony and information presented by American Rivers (American Rivers et al. 2010), which shows that lack of sufficient flows on the Feather River is caused by export/inflow regulations guiding Delta water management operations (figure 1). The perversion of Delta flows by the e/i ratio is also documented in the comments presented by Tom Cannon in workshop #1.

   The frequency of floodplain inundation during late winter and spring in the Delta and upstream can be increased both by changing flow release from reservoirs and also by making physical changes in the channel and floodway (grading, levee setbacks, notching weirs, and intentionally raising the channel invert in strategic locations) that would cause inundation at lower flows. This "physical solution" could increase the frequency of inundation at a lower water cost.

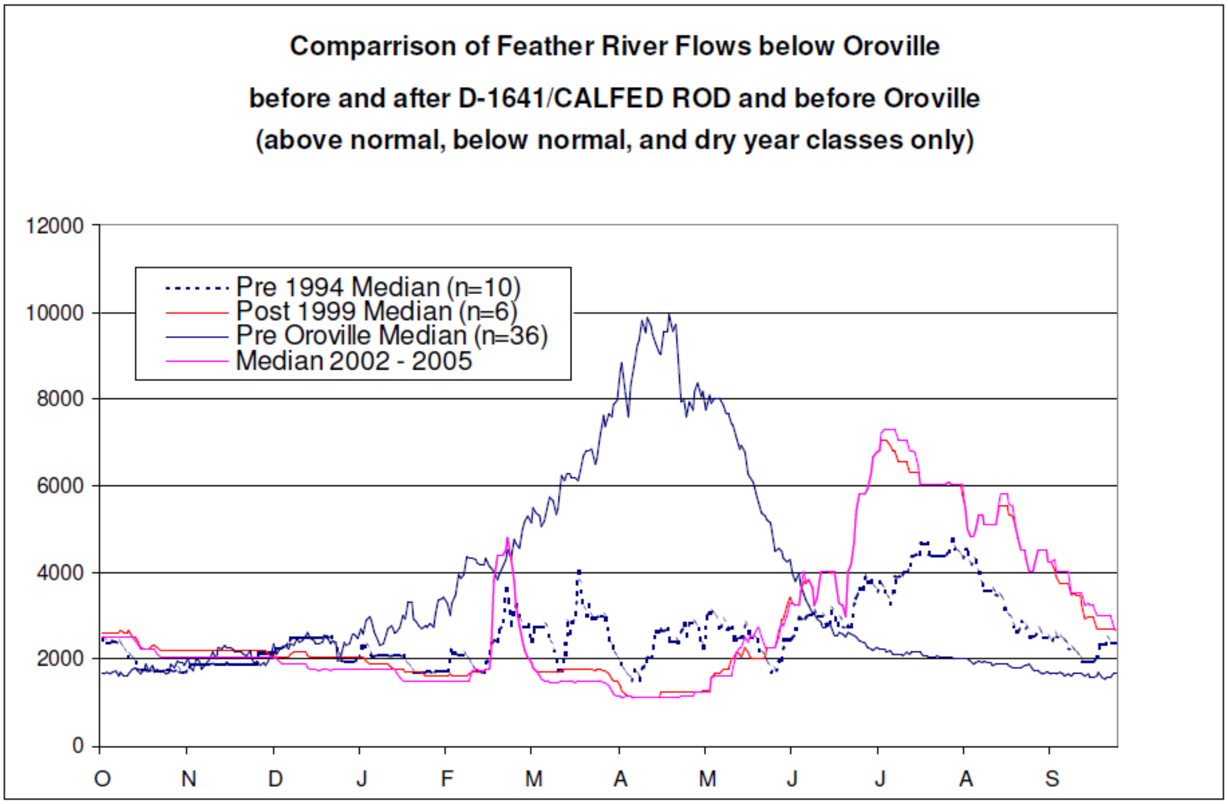

Figure 1: Influence of the Sacramento-San Joaquin Delta Regulations on Feather River Hydrograph. The blue line depicts pre-Oroville median flows and approximates the natural flow regime. In 1995 the Water Quality Control Plan tightened restrictions on the timing of Delta diversions. The pre-1994 hydrograph compared to the post-1999 hydrograph illustrates how the hydrograph shifted spring flows to summer releases to optimize water diversions with the Delta export/inflow requirements.

3. South Delta Habitat Working Group report on opportunities for floodplain and habitat restoration in the South Delta (BDCP, Attachment E.A to Appendix 5.E): this planning study shows that restoration of large areas of floodplain habitat in the South Delta, particularly between Vernalis and Mossdale, could have significant benefits for San Joaquin river salmon, splittail, and other species. The benefits of floodplain restoration, however, would be significantly limited without changes in in-stream flows. The flow regime of the San Joaquin River is so altered that setting-back levees to restore habitat does not provide significant inundated floodplain habitat in most years. As discussed above, physical modifications to the channel and floodplain could offer a “physical solution” that would reduce the amount of water necessary to inundate floodplains.

4. BDCP Effects Analysis regarding the impacts of diversions on salmonids and other fish migrating from the American, Yuba, and Feather Rivers, as well at Butte Creek. Fisheries from these drainages that enter the Sacramento downstream of Fremont Weir will not benefit from notching of Fremont Weir and creation of inundated floodplain habitat in the

Yolo Bypass as proposed by BDCP. Levee setbacks or other efforts to create floodplain habitat downstream of the American River could provide benefits to fish runs from the lower Sacramento and Feather River tributaries, but BDCP has not yet identified any specific plans for such floodplain restoration.

Recommendations regarding question number one:

a) Require increased flows during the late winter and early spring on upstream rivers (particularly the Feather and San Joaquin) to increase the frequency of floodplain inundation.
b) Facilitate changes in water rights, if any, that may be necessary to allow for the diversion of water onto floodplains, particularly in the Yolo Bypass.
c) Require reservoir operators to evaluate opportunities that could increase the frequency of floodplain inundation. These evaluations should consider how best to optimize reservoir releases with physical modifications to the channel and floodway to maximize the amount of inundated floodplain habitat associated with pulse flow releases from upstream reservoirs into the Delta.
d) Request that the Bay Delta Conservation Plan EIR/EIS evaluate alternatives that employ a proportionate unimpaired flow approach or otherwise mimic natural flow patterns for the purpose of increasing the frequency of floodplain inundation.
e) The Board should closely examine how BDCP will effect salmonid populations that enter the mainstem of the Sacramento River downstream of Freemont weir and request that BDCP consider floodplain restoration measures on the Sacramento River downstream of Fremont weir to offset the impacts of the proposed new diversion intakes on these populations.

Thank you for this opportunity to provide written comments. I have attached a list of references and submitted the new document referenced above in form requested by the Board. American Rivers looks forward to the upcoming workshops. If you have any questions about our comments or about the material attached, please contact me at (510) 388-8930.

Sincerely,

John Cain
Conservation Director
Bay-Delta and Flood Management

References Cited

American Rivers, The Bay Institute, Environmental Defense Fund, Natural Heritage Institute, Natural Resources Defense Council, The Nature Conservancy [AR et al. 2010 exhibit 1] Written Testimony of John Cain, Dr. Jeff Opperman, and Dr. Mark Tompkins Before the State Water Resources Control Board, Exhibit 1

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California Department of Water Resources and the Central Valley Flood Protection Plan, June 2012. The Central Valley Flood Protection Plan ; Attachment 9F: Floodplain Restoration Opportunity Analysis. http://www.water.ca.gov/cvfmp/docs/2012CVFPP_Att9F_June.pdf

Bay Delta Conservation Plan Attachment E.A to Appendix 5.E 'BDCP South Delta Habitat and Flood Corridor Planning, Corridor Description and Assessment Document'. September 10, 2012. Draft documents included in American Rivers comments for workshop #2 as S_Delta_Hab_Cord and S_Delta_Hab_Pres.

Bay Delta Conservation Plan: South Delta Working Group Presentation, February 17, 2012. http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Handout_for_South_Delta_Habitat_Working_Group_mtg_2-17-12.sflb.ashx

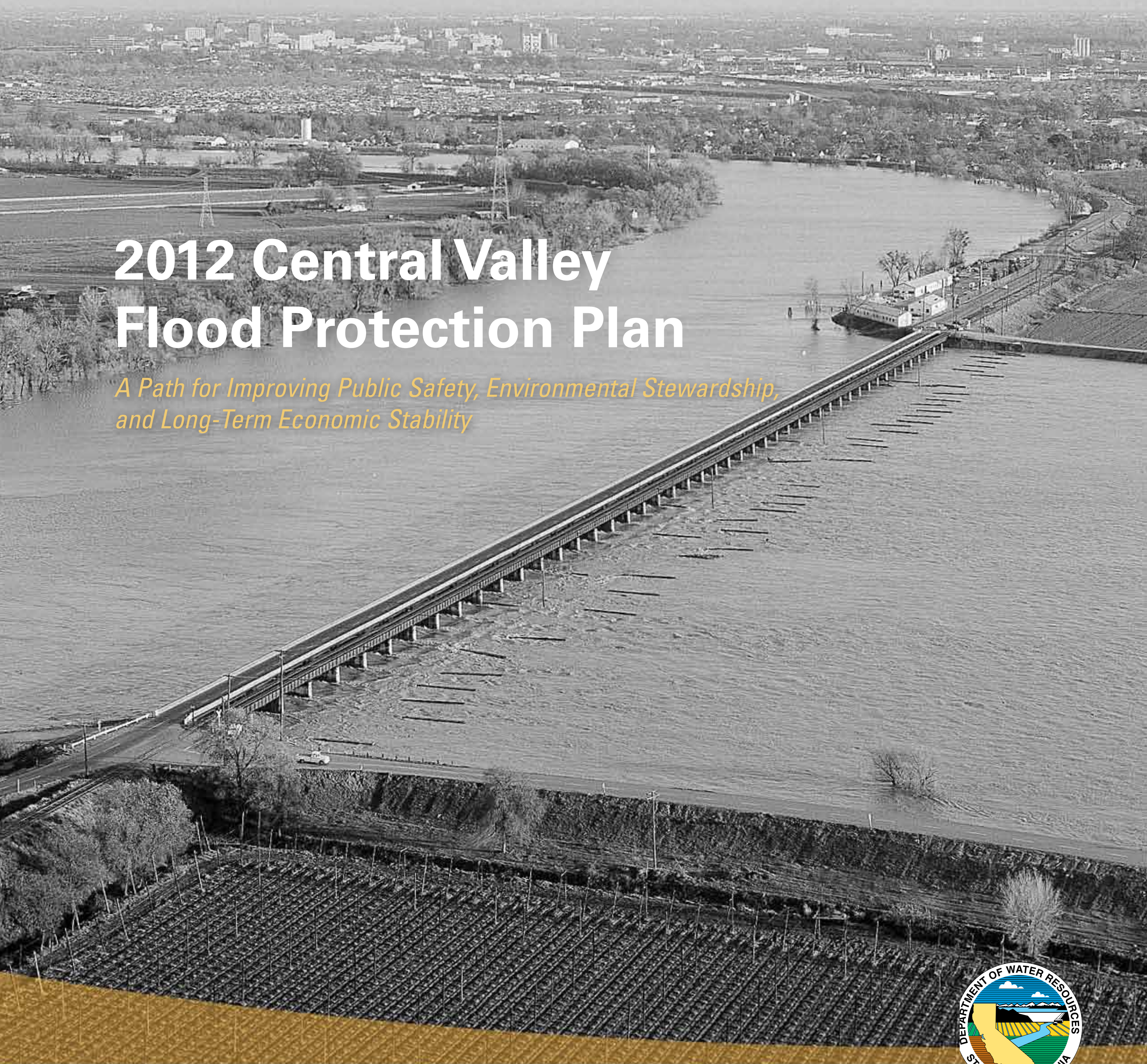
The Bay Institute, Natural Resources Defense Council, American Rivers, Natural Heritage Institute. [TBI et al. 2010 exhibits 1-4]. 2010. Written Testimony of Jonathan Rosenfield, Christina Swanson, John Cain, et al. Before the State Water Resources Control Board, Exhibits 1-4, summary, and closing comments. Available at: http://www.bay.org/publications/flow-criteria-for-the-delta-ecosystem

The Bay Institute, Natural Resources Defense Council, American Rivers, Natural Heritage Institute. [TBI et al. 2012]. Additional Scientific Information, Recommended Changes to the Bay-Delta Water Quality Control Plan, and Recommendations to Address Scientific Uncertainty and Changing Circumstances - Workshop 1: Ecosystem Changes and the Low Salinity Zone Prepared by: Jonathan Rosenfield, Ph.D.

CENTRAL VALLEY
FLOOD MANAGEMENT
PLANNING PROGRAM

FloodSAFE
CALIFORNIA

June 2012



2012 Central Valley Flood Protection Plan

A Path for Improving Public Safety, Environmental Stewardship, and Long-Term Economic Stability

DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA

PUBLIC SAFETY ENVIRONMENTAL STEWARDSHIP ECONOMIC STABILITY

Cover Photo: Sacramento Weir (December 23, 1964), DWR Photo Lab

The Sacramento Weir and Bypass discharges excess flows from the Sacramento River (on the left) into the Yolo Bypass (not shown).
The 1964-65 water year was marked by one of the most disastrous floods in California's history.

2012 Central Valley Flood Protection Plan

June 2012

This document was prepared for submission to the
Central Valley Flood Protection Board
Pursuant to the California Central Valley
Flood Protection Act of 2008

by

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Foreword

More than one million Californians live and work in the floodplains of the Sacramento-San Joaquin Valley where flood risks are among the highest in the nation. In response to this threat to people, property and the environment, the Central Valley Flood Protection Act of 2008 directed the Department of Water Resources (DWR) to prepare the Central Valley Flood Protection Plan (CVFPP) for Central Valley Flood Protection Board adoption. The CVFPP is the most comprehensive flood management planning effort ever undertaken in California, addressing flood risks in an integrated manner while concurrently improving ecosystem functions, operations and maintenance practices, and institutional support for flood management.

In preparing the CVFPP, DWR examined a range of potential approaches for improving flood management. The recommended approach – known as the State Systemwide Investment Approach (SSIA) – sets forth a strategy for responsibly meeting the State's objectives to improve public safety, ecosystem conditions, and economic sustainability, while recognizing the financial challenges facing local, State, and federal governments today. Under this approach, California will prioritize investments in flood risk reduction projects and programs that incorporate ecosystem restoration and multi-benefit projects, without precluding future actions, such as those presented in the Enhance Flood System Capacity Approach, should additional State and federal funding become available.

The SSIA outlines a sustainable flood management strategy that will support California's vital agricultural economy, maintain agricultural land uses, limit growth in undeveloped floodplains, and provide policies, programs, and incentives to encourage wise long-term floodplain management. The SSIA includes significant capital investments to strengthen levees that protect existing urban areas and small communities, prioritizing improvements to the 1,600-mile levee system included in the State Plan of Flood Control. The SSIA also will help improve system resiliency in the face of climate change by expanding flood conveyance capacities, coordinating reservoir operations, and restoring floodplains.

In the coming years, DWR will continue to work collaboratively with local, State, and federal agencies, environmental interests, and other parties to develop regional flood management plans and focus investments on expanding flood bypasses to lower flood risks in flood prone areas. In addition, DWR will continue to refine the CVFPP as projects and policies evolve, additional information is gathered, elements are implemented, and funding becomes available.

With the support and cooperation of partnering and permitting agencies, property owners, interest groups, and the public at large, DWR is committed to making real improvements every year — including stronger levees, enhanced flood capacity, a healthier ecosystem, improved preparations for and responses to flood emergencies, greater resiliency, and leaner, more efficient operations. With California's first-ever CVFPP, we have a path for improving public safety, environmental stewardship, and long-term economic stability.

Mark W. Cowin, *Director*

A Framework for Flood Risk Reduction

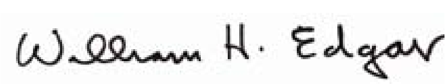
On behalf of the Central Valley Flood Protection Board (Board) I am pleased to announce that the 2012 Central Valley Flood Protection Plan (CVFPP) was adopted by the Board on June 29, 2012, prior to the date required in Water Code 9612(b). The CVFPP, as modified by Board Resolution 2012-25, meets the legislative requirements outlined in the Central Valley Flood Protection Act of 2008.

The Board appreciates the efforts of the Department of Water Resources (DWR) to prepare and deliver the CVFPP to the Board prior to the January 1, 2012 legislative deadline, and congratulates DWR for their work to produce the first comprehensive framework for system-wide flood management and flood risk reduction in the Sacramento and San Joaquin River Basins.

The Board conducted an extensive public review and comment process over the past six months, and would like to thank the many stakeholders and public representing agricultural, city and county, conservation, environmental, flood control, landowner, recreation and water supply interests who provided valuable comments, letters of support, constructive criticism, and detailed reviews of the proposed CVFPP. The adopted CVFPP is not just a State government plan, but one which considers the views, goals, and hearts of the people of California living, working and contributing to the quality of life in our Central Valley.

Implementation of the 2012 CVFPP, and development of future five-year updates, will require ongoing cooperation and collaboration between the Board, DWR, our stakeholders, and the public to construct effective improvements to our flood control infrastructure with measureable reductions in levels of residual flood risk to our urban areas, small communities, and rural agricultural lands.

Since its creation as The Reclamation Board in 1911 to its rebirth as the Central Valley Flood Protection Board in 2008 through today, the Board has cooperated with DWR, the U.S. Army Corps of Engineers, numerous federal, State and local agencies, and non-government organizations to control flooding along the Sacramento and San Joaquin Rivers and their tributaries, to cooperatively establish, plan, construct, operate, and maintain flood control works, and to maintain the integrity of existing flood risk reduction infrastructure and designated floodways in the Central Valley. The Board is committed to providing an ongoing public forum for the development, integration and implementation of regional and systemwide planning efforts, and construction of eventual project improvements to reduce flood risk, preserve rural agriculture, protect and restore our environment, maximize federal and State cost-sharing, and to seek needed regulatory reform and reduced insurance rates for rural and small communities located in the Federal Emergency Management Agency (FEMA) floodplain. We look forward to continuing and expanding our partnerships with our stakeholders and the public.



William H. Edgar, *President*

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Appendix A:

Central Valley Flood Protection Board Adoption Resolution 2012-25, Amending and Adopting the 2012 Central Valley Flood Protection Plan, June 2012

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1.0 RESPONDING TO THE NEED FOR IMPROVED FLOOD MANAGEMENT IN THE CENTRAL VALLEY

1.1 What is the Central Valley Flood Protection Plan?

The Central Valley Flood Protection Plan (CVFPP) is a critical document to guide California's participation (and influence federal and local participation) in managing flood risk along the Sacramento River and San Joaquin River systems. The CVFPP proposes a systemwide investment approach for sustainable, integrated flood management in areas currently protected by facilities of the State Plan of Flood Control (SPFC). The CVFPP will be updated every five years, with each update providing support for subsequent policy, program, and project implementation.

The State of California (State) conducted planning and investigations for the 2012 CVFPP from 2009 through 2011, representing the most comprehensive flood evaluations for the Central Valley. Following the anticipated adoption of the CVFPP in 2012 by the Central Valley Flood Protection Board (Board), preparation of regional- and State-level financing plans will guide investments in the range of $14 billion to $17 billion during the next 20 to 25 years. These financing plans are critical to CVFPP implementation, given the uncertainty in State, federal, and local agency budgets and cost-sharing capabilities. Figure 1-1 shows the progression of flood planning, financial planning, and project implementation leading to the 2017 update of the CVFPP and beyond.

Implementation of some elements included in the CVFPP began in January 2007 when bond funding provided a down payment towards SPFC improvements outlined in the CVFPP. On-the-ground construction has begun to solve some key levee problems, and management of the system has improved. With adoption of the CVFPP, the pace of implementation should significantly increase.

WHY A FLOOD RISK REDUCTION PROGRAM IS NEEDED IN THE CENTRAL VALLEY

- Existing level of flood protection – among lowest for metropolitan areas in the Nation
- State Plan of Flood Control urban levees – about half do not meet current engineering criteria
- State Plan of Flood Control nonurban levees – about 60 percent have relatively high potential for failure
- Population at risk – about 1 million in floodplains
- Assets at risk – about $70 billion
- Lands within Federal Emergency Management Agency 100-year (1% annual chance of occurrence) floodplain – 1.2 million acres
- Cumulative flood damages in 1983, 1986, 1995, and 1997 – well in excess of $3 billion (2011 cost level)
- Flood in 1997:
  - *All Central Valley counties declared disaster areas*
  - *Over 120,000 people evacuated*
  - *Over 9,000 homes destroyed*
  - *Many businesses flooded*
  - *Thousands of acres of agricultural land flooded*
  - *Over $1 billion (2011 price level) in direct flood damages*
- Potential economic losses – disruption in local, regional, and State economies
- Ecosystem – riparian habitat and key species in crisis
- Operations and maintenance – flood risk reductions actions and ecosystem needs not often in harmony

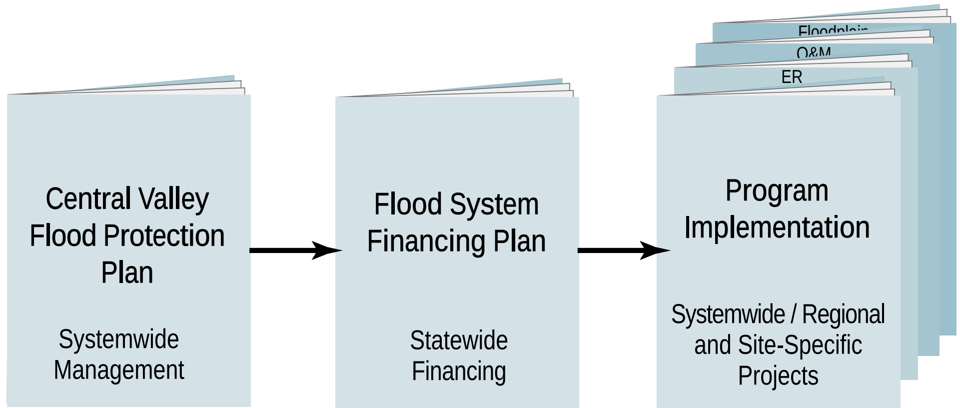


Figure 1-1. Rollout of Future Programs

During the next five years (2012 to 2017), flood managers will continue to build infrastructure improvements that upgrade levees in high risk urban areas and will begin other flood management improvements. Subsequent infrastructure improvements will be based on results of detailed feasibility studies that consider improvements for high risk urban areas, small communities, rural-agricultural areas, and more complicated systemwide facilities, such as bypass expansions. Integral to these improvements will be the inclusion of environmental considerations in all phases of flood management planning and implementation.

1.2 Setting and Historical Context

Floods have had devastating effects on life and property in the Central Valley and on the economic prosperity of the State of California. The most recent significant floods in the Central Valley, which occurred in 1986 and 1997, together caused over $1 billion in damage[1] (U.S. Army Corps of Engineers [USACE], 1997). Despite the protection provided by the current flood management system, residual flood risk in the Central Valley remains among the highest in the country. Currently, even small flood events with a 5 % annual chance of exceedence can stress parts of the flood system.

The Central Valley of California is a broad, gently sloping valley that drains into the largest estuary on the West Coast, the Sacramento-San Joaquin Delta (Delta). Lower-lying lands along the valley’s two major rivers, the Sacramento River and the San Joaquin River, were floodplains that were regularly inundated for long periods during large, seasonal flood events before reclamation. The valley is bounded on the west by the Coast Range, on the north by the Cascade Range, and on the east by the Sierra Nevada Range. The most devastating floods are caused by warm Pacific storms that sweep in from the west or southwest, picking up moisture over thousands of miles of ocean, causing torrential rains when intercepted by the mountains surrounding the Central Valley.

1 *Sacramento and San Joaquin River Basins, California Post-Flood Assessment* (USACE, 1999).

1862 Flooding in Sacramento

Catastrophic floods in the Central Valley have been documented since the mid-1800s. Hydraulic mining in the Sierra Nevada Mountains in the late 1800s sent large amounts of sediment downstream, choking the channels of rivers such as the Yuba River, Feather River, and American River and increasing flooding by raising channel beds above their natural levels and surrounding lands.

In response to frequent flood events and the challenges posed by the huge and recurring sediment loads created by hydraulic mining, the current flood management system has evolved through an incremental learning and construction process (Figure 1-2). SPFC facilities have been constructed through the individual and combined efforts of local, State, and federal agencies. The facilities were constructed with materials at hand over many decades, to evolving design standards and construction techniques. As a result, these facilities provide varying levels of protection, depending on when and how they were constructed and upgraded. Construction of these facilities has also resulted in loss of floodplain habitats and marshes.

The process was originally driven by the need to defend the developing valley floor against periodic floods while maintaining navigable channels for commerce. Over time, with development of the railroads in the late 1800s and early 1900s, and the highway system since then, river navigation has become less economically important. However, the importance of Central Valley rivers and floodplains as conduits for municipal, industrial, and agricultural water supply, fisheries and wildlife habitat, and recreation has increased as a result of population growth and environmental degradation in the State.

The Central Valley flood management system includes levees along the major rivers and streams of the valley floor and around the islands of the Delta, a major bypass system for the Sacramento River and its tributaries, several bypass segments along the San Joaquin River, and reservoirs on almost all major rivers and streams draining to the Central Valley.

Levee construction and improvement began in about 1850 and continues to this day. The Sacramento River bypass system was federally authorized in 1917. It includes a system of flood relief structures and weirs that release Sacramento River flows into the bypass system when flows exceed downstream channel capacity at five locations, from the latitude of Chico to Sacramento (see Section 1.2.1). At the latitude of Sacramento, the Yolo Bypass carries 80 percent or more of floodflows southward to the Delta.

Construction of Yolo Bypass Levee

Significant Flood Management Events

1849	California Gold Rush
1850	Federal Arkansas Act giving away “California Swamplands”
1850	California Statehood
1861	State Flood Control Act
	Reclamation District Act
1883	Federal Anti-Debris Act ends hydraulic mining
1911	State Reclamation Board created
1933	Central Valley Project authorized
2003	Paterno Decision
2005	DWR Flood Warning White Paper
2006	Propositions 1E and 84 passed
2007	Flood Management Reform Legislation

Sacramento River Basin

1850	First levee built in Sacramento
1917	Sacramento River Flood Control Project authorized
1944	Shasta Dam was built
1955	Folsom Dam was built
1967	Oroville Dam was built
1969	New Bullards Bar Dam was built

San Joaquin River Basin

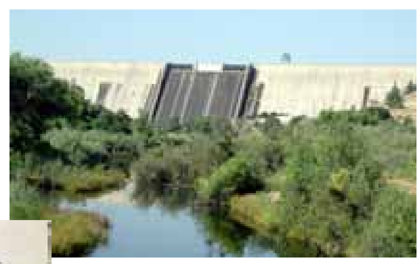
1944	Lower San Joaquin River and Tributaries Project
1949	Friant Dam completed
1955	Bypasses and levees authorized on San Joaquin River above Merced River
1963	Camanche Dam was built
1964	New Hogan Dam was built
1967	New Exchequer Dam was built
1971	New Don Pedro Dam was built
1978	New Melones Dam was built
1993	Redbank/Fancher Creeks Project


1849 Sutter’s Mill


1862 Flood in Sacramento


1955 Folsom Dam built


1997 Flood in Central Valley


1949 Friant Dam built


1907 Flood in Stockton

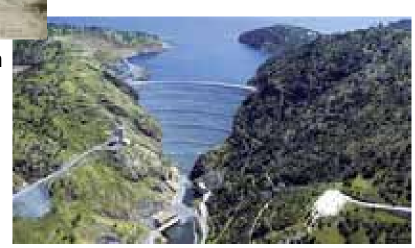

1978 New Melones Dam built

Figure 1-2. Chronology of Flood Management-Related Actions in Central Valley

Nearly 150 reservoirs have been constructed on streams draining to the Central Valley since 1850 by a variety of public agencies, including utilities, water districts, the USACE, the U.S. Department of the Interior, Bureau of Reclamation (Reclamation), and the California Department of Water Resources (DWR). Of these, ten major multipurpose reservoirs play a critically important role in moderating Central Valley flood inflows[2]:

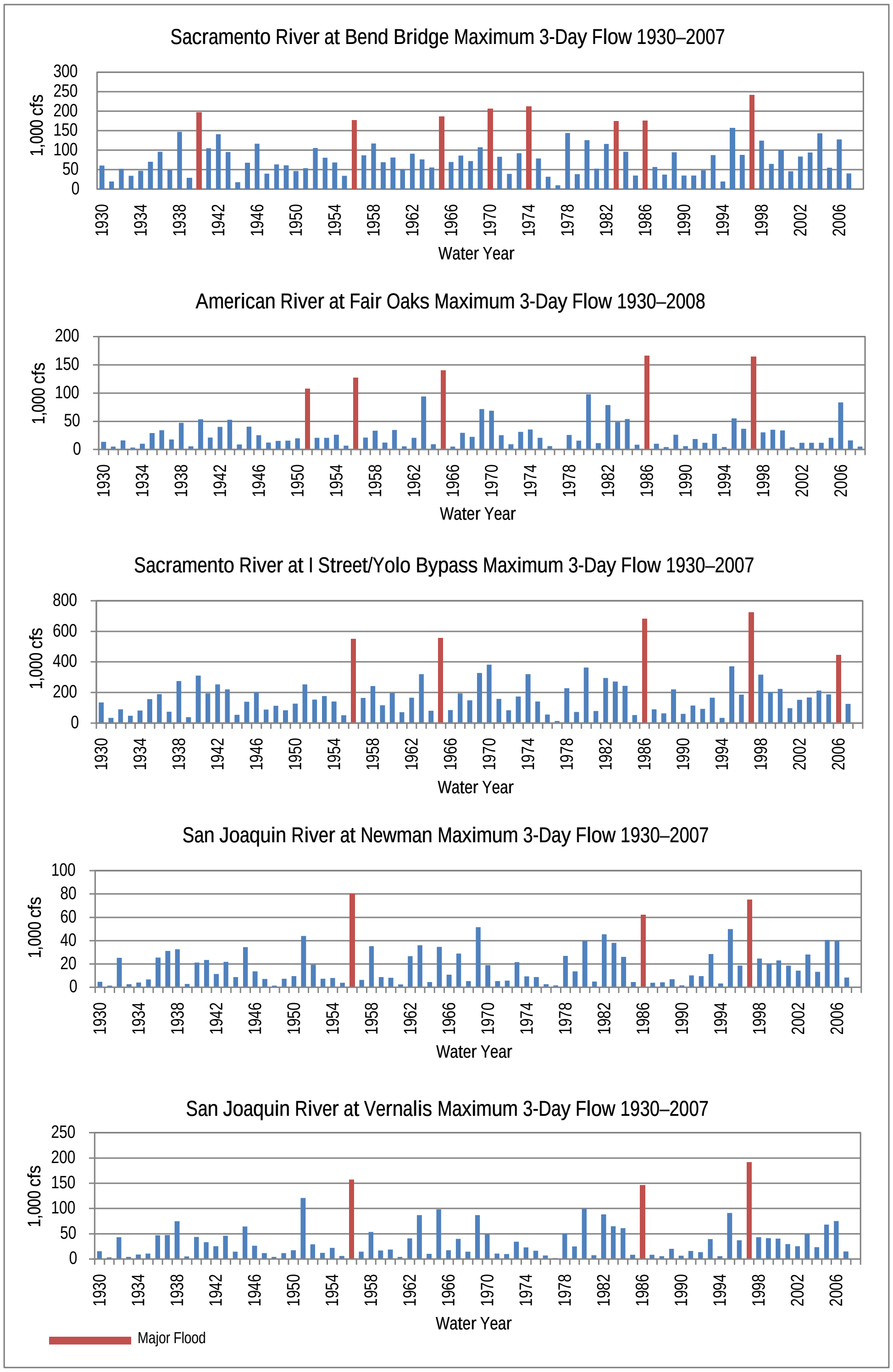
- Shasta Lake on the Sacramento River
- Lake Oroville on the Feather River
- New Bullards Bar Reservoir on the Yuba River
- Folsom Dam on the American River
- Camanche Reservoir on the Mokelumne River
- New Hogan Reservoir on the Calaveras River
- New Melones Reservoir on the Stanislaus River
- New Don Pedro Reservoir on the Tuolumne River
- Lake McClure on the Merced River
- Millerton Lake on the San Joaquin River

These reservoirs are operated in accordance with flood control rules established by USACE. In general, the flood control rules require that during the flood season, a portion of the storage space in the lake is reserved for capturing floodflow peaks and releasing them gradually so that downstream channel capacity is not overwhelmed. In some reservoirs, the required flood control space is adjusted in proportion to the seasonal precipitation, soil moisture, and snowpack. This space is drained as quickly as feasible after each flood peak to be ready for the next floodflow peak. The rules are tuned to the particular runoff characteristics of each river basin.

During major flood events, there is close coordination between State, federal, and local agencies to forecast weather and runoff conditions, manage and coordinate flood releases from the reservoir system, patrol and floodfight along the levee and bypass system, and operate the weirs, drainage pumps, and other flood control structures. These activities are important in preparing for and coordinating responses to damaging flood events. The effort required varies significantly from basin to basin due to differences in river flows, shown in Figure 1-3. The figure displays historical maximum three-day floodflows in the Sacramento and San Joaquin River basins. Instead of using instantaneous peak flows, maximum three-day flows were selected to provide more consistent comparisons of the highest flood flows each year due to the large basin size and reservoir regulation of floods.

2 Note: The rivers draining into the Tulare Lake Basin, including the Kings River, Kaweah River, Tule River, and Kern River, are not considered to be part of the Sacramento-San Joaquin River System, but Kings River drains northward during very wet years, such as 1968 – 1969, 1982 – 1983 and 2005 – 2006.

USACE has played a key role in plan formulation, design, construction, inspection, and floodfighting in the Central Valley since the late 1800s. USACE is responsible for the maintenance of navigation, management of hydraulic mining debris, and the construction and operation of many of the large multipurpose reservoirs that moderate flows into the Central Valley. USACE continues to be responsible for implementing most federally authorized flood control projects, in partnership with State and local agencies.



Key: cfs = cubic feet per second

Figure 1-3. Sacramento and San Joaquin Rivers Hydrographs

1.2.1 Definition of State Plan of Flood Control

The SPFC represents a portion of the Central Valley flood management system for which the State has special responsibilities, as defined in the California Water Code (Figure 1-4, Figure 1-5, and Table 1-1). It is defined as follows:

> *"…the state and federal flood control works, lands, programs, plans, policies, conditions, and mode of maintenance and operations of the Sacramento River Flood Control Project described in Section 8350, and of flood control projects in the Sacramento River and San Joaquin River watersheds authorized pursuant to Article 2 (commencing with Section 12648) of Chapter 2 of Part 6 of Division 6 for which the board or the department has provided the assurances of nonfederal cooperation to the United States, and those facilities identified in Section 8361." – California Water Code Section 9110 (f)*

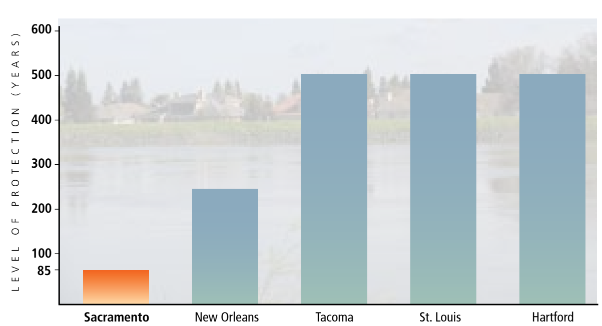
The ***State Plan of Flood Control Descriptive Document*** (DWR, 2010) provides a detailed inventory and description of the levees, weirs, bypass channels, pumps, dams, and other structures included in the SPFC.

1.3 Assets Protected by State Plan of Flood Control

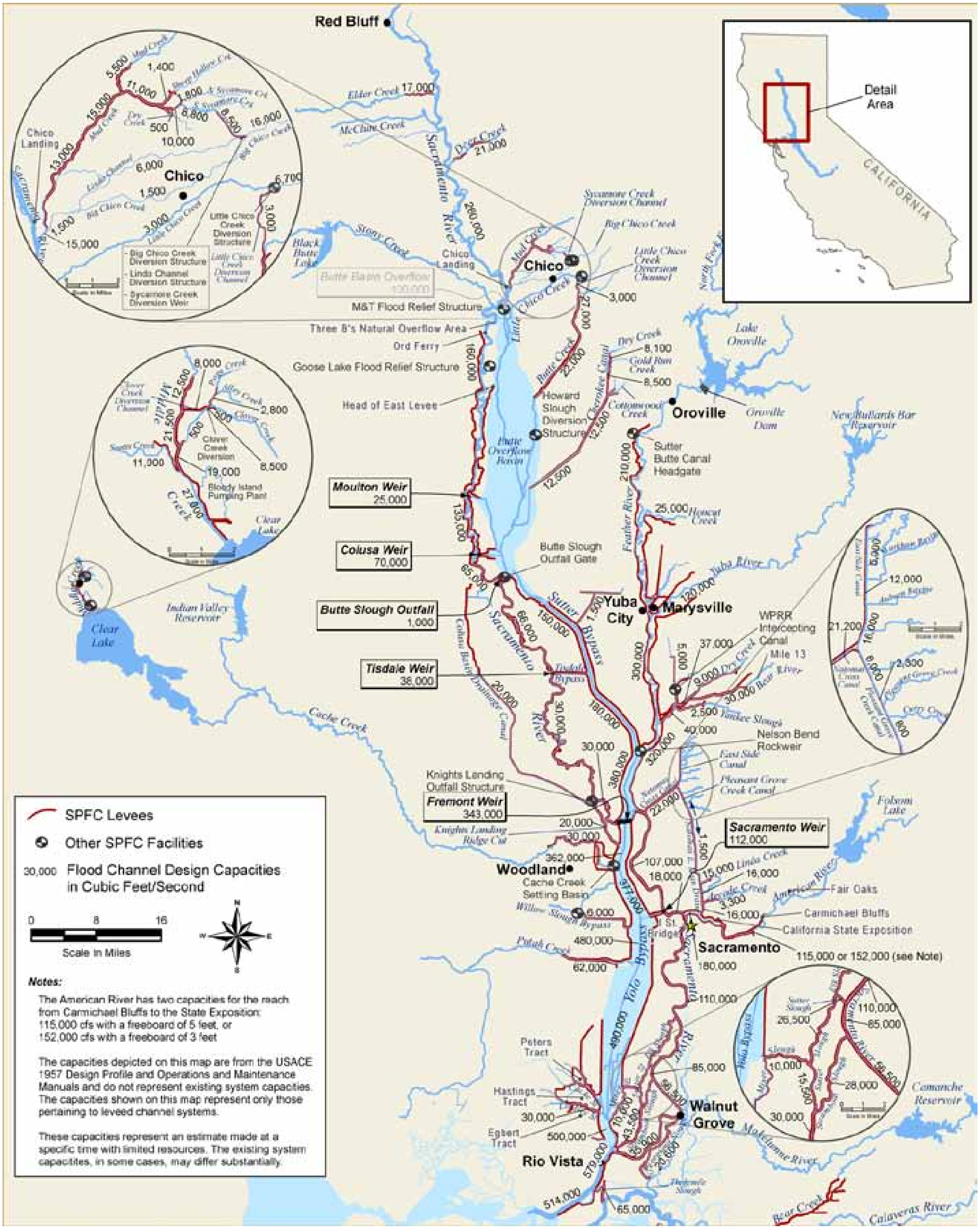
Over the last century, the Central Valley has experienced intensive development to meet the needs of a growing population. A complex water supply and flood risk management system supports and protects a vibrant agricultural economy, several cities, and numerous small communities. The SPFC protects a population of over one million people, major freeways, railroads, airports, water supply systems, utilities, and other infrastructure of statewide importance, including $69 billion in assets (includes structural and content value and estimated annual crop production values) (Figure 1-6). Many of the more than 500 species of native plants and wildlife found in the Central Valley rely to some extent on habitat existing within the SPFC.

1.4 Current Problems and Future Trends Facing State Plan of Flood Control

Much of the Central Valley levee system was built over many years using the sands, silts, clays, and soils, including organic soils that were conveniently available, often poorly compacted over permeable foundations. The system was designed to contain the record floods of the early twentieth century with the aim of fostering development of an agriculturally oriented economy and promoting public safety. The subsequent construction of a series of multipurpose reservoirs with substantial

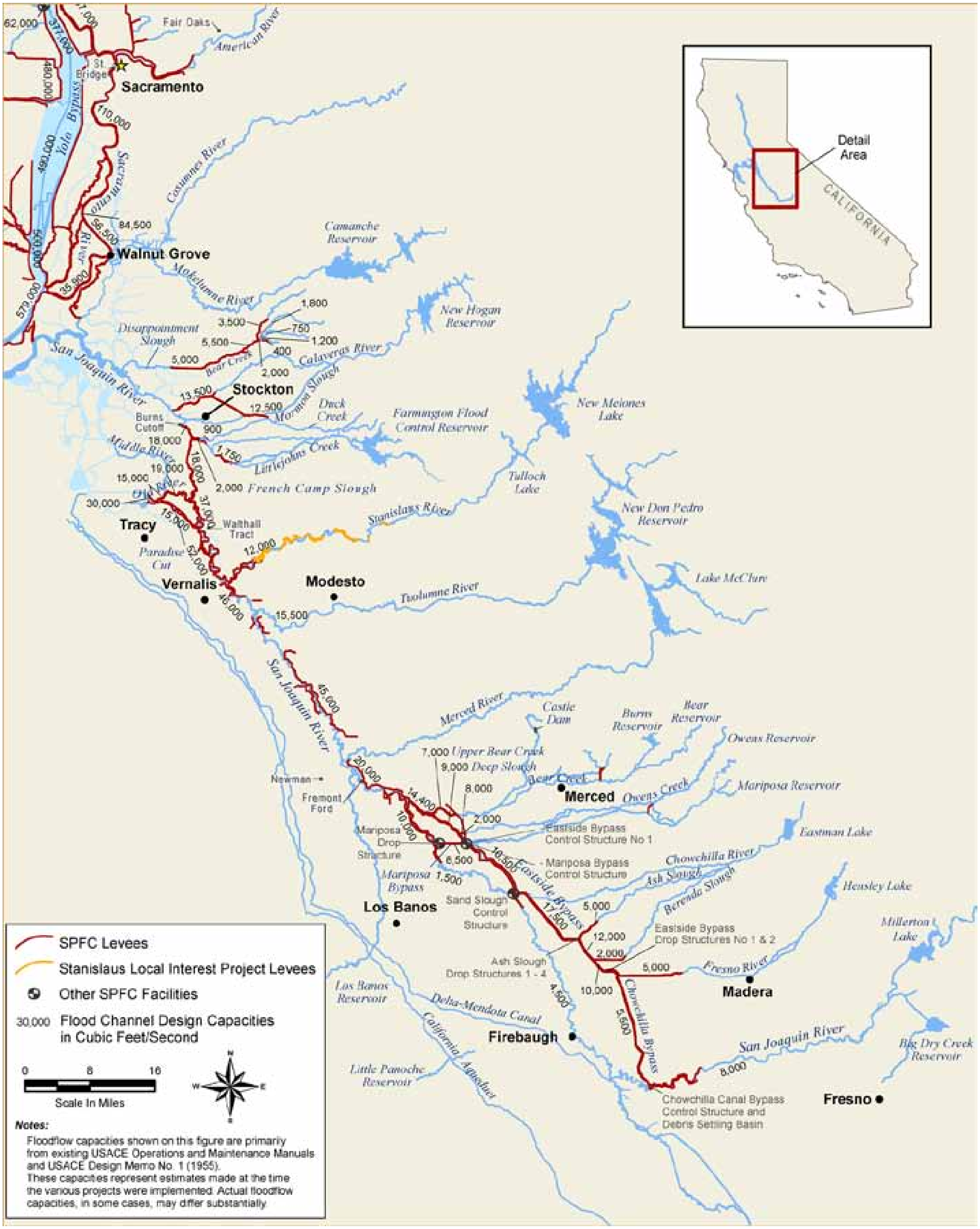


Level of Flood Protection for Selected Major River Cities in the United States



Key: cfs = cubic feet per second SPFC = State Plan of Flood Control USACE = U.S. Army Corps of Engineers

Figure 1-4. State Plan of Flood Control Facilities, Sacramento River Basin



Key: SPFC = State Plan of Flood Control USACE = U.S. Army Corps of Engineers

Figure 1-5. State Plan of Flood Control Facilities, San Joaquin River Basin

Table 1-1. Overview of State Plan of Flood Control

FEATURE AND DESCRIPTION AS OF 2010
Project Works
• Approximately 1,600 miles of levees • Two flood relief structures and one natural overflow area spilling floodwaters from the Sacramento River into the Butte Basin • Four fixed weirs (Moulton, Colusa, Tisdale, Fremont) and one operable weir (Sacramento) spilling floodwaters from the Sacramento River into the Butte Basin, Sutter Bypass, and Yolo Bypass • Four dams • Five control structures directing flow in bypass channels along the San Joaquin River • Seven major pumping plants • Channels • Bypasses and sediment basins • Environmental mitigation areas • Associated facilities, such as bank protection, stream gages, and drainage facilities
Lands
• Fee title, easements, and land use agreements • Approximately 18,000 parcels
Operations and Maintenance
• Two standard operations and maintenance manuals • 118 unit-specific operations and maintenance manuals • Maintenance by State and local maintaining agencies
Conditions
• Assurances of Cooperation (as specified in Memorandums of Agreement, the California Water Code, and agreements) • Flood Control Regulations, Section 208.10, 33 Code of Federal Regulations • Requirements of standard and unit-specific operations and maintenance manuals • Design profiles (e.g., 1955 and 1957)
Programs and Plans
• Historical documents and processes • As-constructed drawings • Oversight and management • Ongoing programs and plans

flood control capability significantly augmented the capacity of the flood management system and contributed greatly to the State's economic development and public safety objectives. These reservoirs constituted the principal response to the mid-century recognition that extreme floods that were much larger than those that guided design of the levee system were reasonably foreseeable.

The latter half of the twentieth century has been marked by a growing awareness of the effects of the levee system and the multipurpose reservoirs on the environmental health of the Central Valley's rivers and streams and their associated seasonal wetland and riparian habitats. The reduction of these habitats to accommodate the levee system and the reservoirs has impacted the populations of salmon, steelhead, sturgeon, Swainson's hawks, bank swallows, giant garter snakes, and many other wildlife species in the Central Valley. As a result, preservation and enhancement of the valley's remaining wetland and riparian habitat has become an increasingly important consideration in the design, construction, operations, and maintenance of the flood management system.

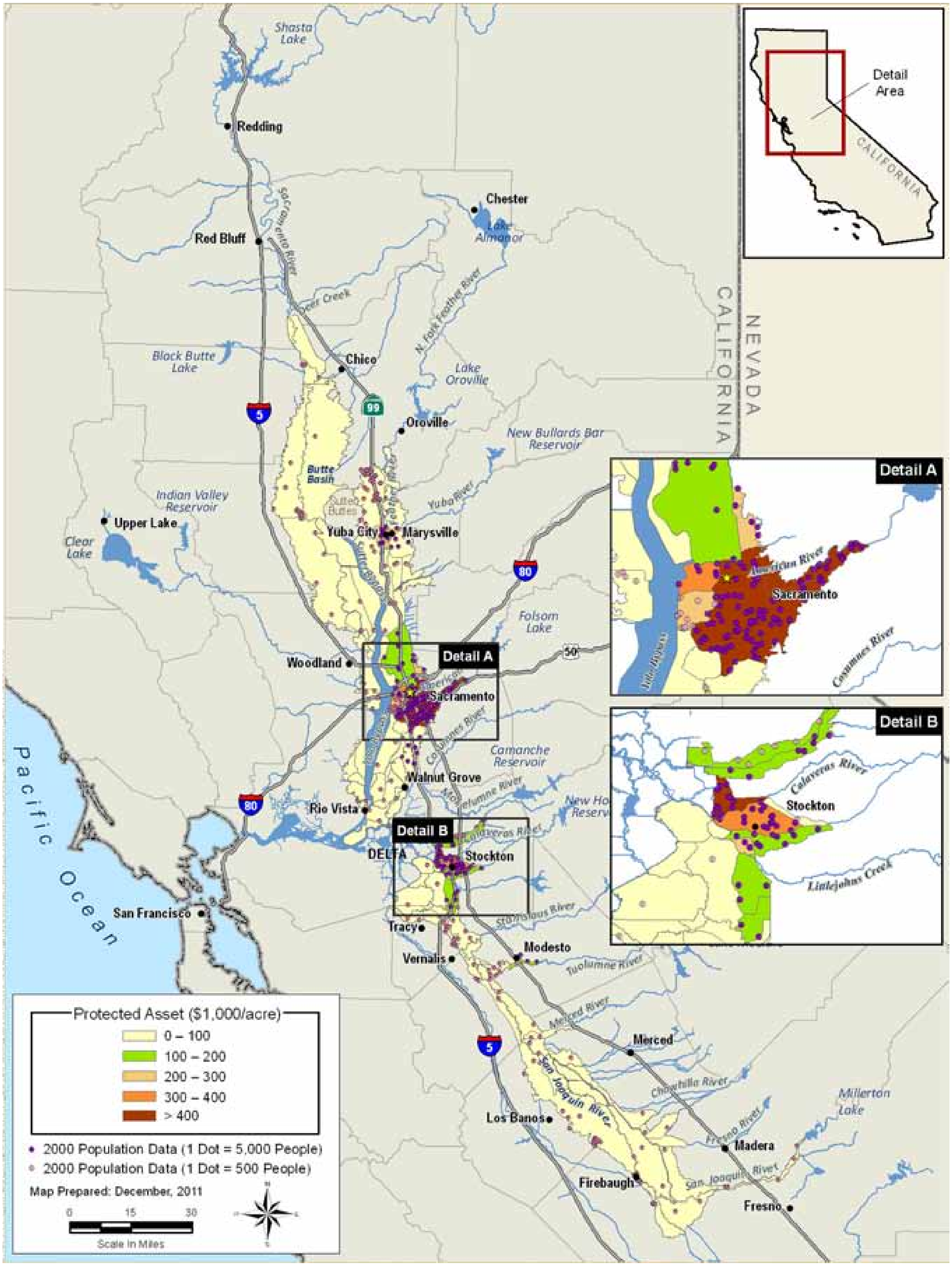


Figure 1-6. Geographic Distribution of Assets and Population Protected by State Plan of Flood Control Facilities

Although the SPFC has prevented billions of dollars in flood damages since its construction, a better understanding of the risk assessment and engineering standards has made it clear that some SFPC facilities face an unacceptably high chance of failure. This, combined with continued urbanization in the floodplains, has increased the estimated level of flood risk. While the chance and frequency of flooding have decreased since construction of SPFC facilities and other multipurpose reservoirs, the damages that would occur if a levee were to fail in one of the urban areas are much greater, resulting in a net long-term increase in cumulative damages if no action is taken to improve the flood management system and limit further development in these areas.

UNDERSTANDING FLOOD RISK

As used in this report, flood risk is the product of the chance of flooding multiplied by the consequences. Thus, flood risk increases with storm frequency and severity, as well as with floodplain development. The potential for flooding is often underrated and misunderstood. For this reason, not enough focus is placed on flood preparedness. An ongoing challenge is to fully inform floodplain residents and businesses of the importance of understanding and preparing for flooding, especially in levee-protected areas.

The overall physical condition of SPFC levees is summarized in Figure 1-7. To simplify representation of levee conditions, the figure includes Urban Levee Evaluations and Non-Urban Levee Evaluations results that are not directly comparable because different evaluation methodologies were used for each project. The figure is intended to show broadly which levee reaches are of relatively higher, medium, and lower concern, based on physical conditions of the levees. Levees shown as purple (higher concern) on the map generally display more performance problems than those shown in green (lower concern). Results do not reflect economic or life safety consequences of flooding, which are key factors in planning system repairs and improvements.

Including the overall condition of SPFC levees shown in Figure 1-7, an overview of the condition of urban levees, nonurban levees, channels, and flood control structures of the SPFC is as follows:

- Approximately half of about 300 miles of SPFC urban levees evaluated do not meet current engineering design criteria[3] at the design water surface elevation.
- Approximately 60 percent of about 1,230 miles of SPFC nonurban levees evaluated have a high potential for failure at the assessment water surface elevation[4]. Nonurban levees were evaluated based on systematic, consistent, repeatable analyses that correlated geotechnical data with levee performance history, not relative to any current design criteria[5].

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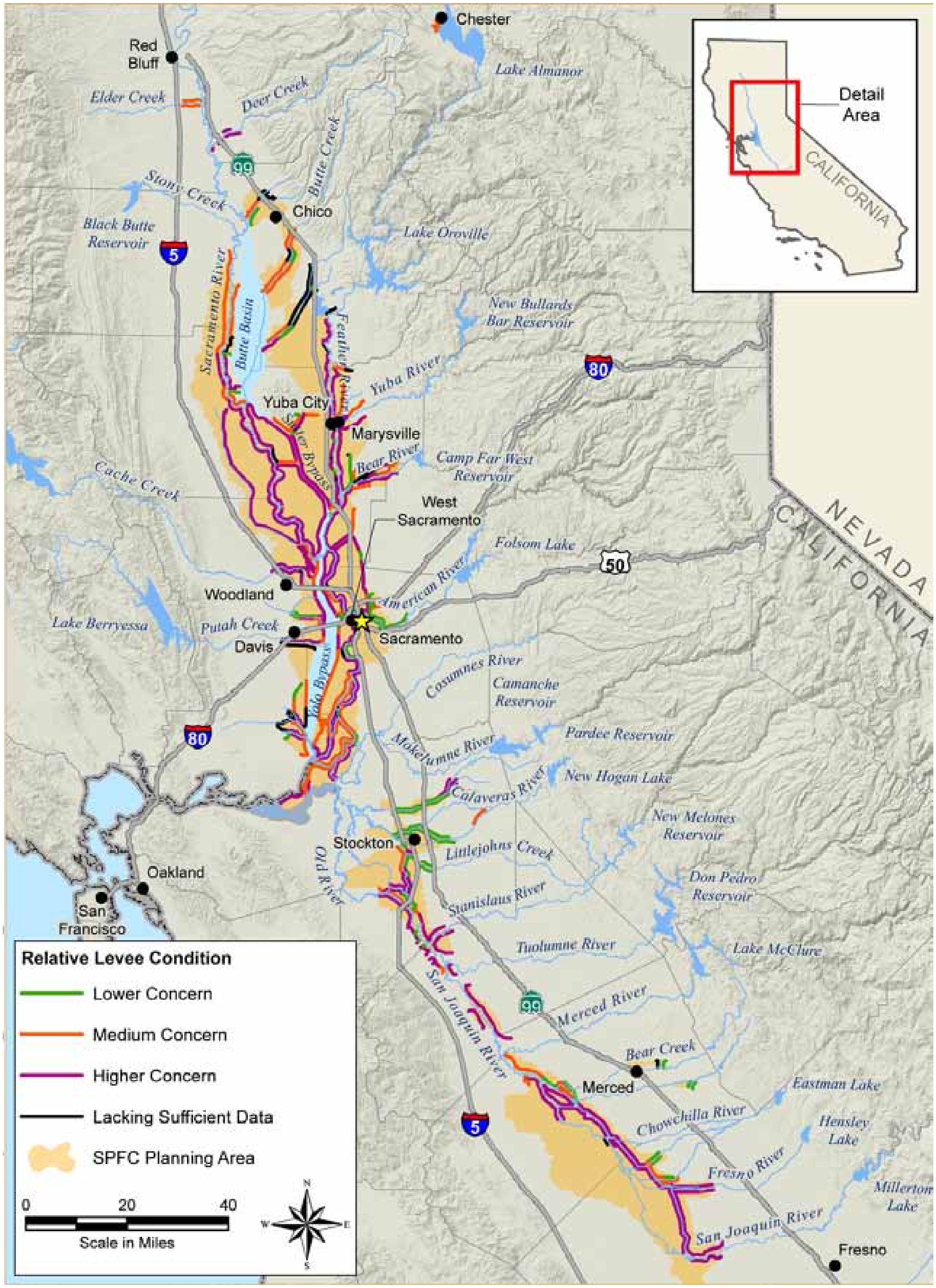
3 The design criteria used were based on *the Design and Construction of Levees Engineering Manual 1110-2-1913* (USACE, 2000) and *Interim Levee Design Criteria for Urban and Urbanizing Areas in the Sacramento Valley*, Version 4 (DWR, 2010).

4 Where available, 1955/57 design water surface elevations were used as the assessment water surface elevations. In the absence of 1955/57 design water surface elevations, the assessment water surface elevations were based on freeboard requirements for each levee segment (i.e., generally 3 feet below the levee crest).

5 This approach was selected because the extent of the Non-Urban Levee Evaluations Project is significantly greater than that of the Urban Levee Evaluations Project, making it difficult to conduct the same level of field explorations and geotechnical data collection performed for Urban Levee Evaluations levees.



Key: SPFC = State Plan of Flood Control

Figure 1-7. Summary of Physical Levee Conditions Based on Levee Evaluations Program Results

- Approximately half of the 1,016 miles of channels evaluated in the SPFC have a potentially inadequate capacity to convey design flows, and require additional evaluation to confirm conditions.
- None of the 32 hydraulic structures or 11 pumping plants inspected by DWR for the SPFC were rated "Unacceptable" during the 2009 inspections; however, many are approaching the end of their design life. Of the 10 SPFC bridges inspected by DWR in 2009, 2 were in need of repairs.

MANAGING FLOODS VERSUS MANAGING FLOOD RISK

Managing floods means building and operating facilities such as dams, weirs, levees, and pump stations to safely store and convey flood flows within designated channels to reduce the chance of flooding. Such improvements can greatly reduce, but not entirely eliminate, the flood risk. Often, floodplains are subsequently developed because of the perception that the chance of flooding has been eliminated. As a result, the overall flood risk can (paradoxically) increase following construction of flood control facilities.

Flood risk is the combined effect of the chance of flooding and the property that would be damaged if flooded. Managing flood risk means either reducing the chance of flooding or the population and property exposed to flooding, or doing a combination of both. Thus, managing flood risk can include flood control facilities, as well as limiting floodplain development, elevating structures above flood elevations, creating natural flood storage and groundwater recharge areas, and using flood risk notification, flood insurance, and flood preparedness.

The regional and system improvements considered in the CVFPP are intended to address a number of potential physical threats to the existing flood management system. These threats are described in the ***Flood Control System Status Report*** (DWR, 2011). For levees in the system, threats include problems associated with geometry, seepage, structural instability, erosion, settlement, penetrations, vegetation, rodent damage, and encroachments. For channels of the system, threats include inadequacies in overall conveyance capacity. For necessary flood management structures such as weirs, pumping plants, and bridges, threats primarily include inadequate hydraulic capacities. The Board continues to address encroachments on a site-by-site basis.

The physical and cultural landscape of the Central Valley has changed dramatically since the flood management system was initially constructed. Population growth and economic development behind levees have increased flood risk. In many areas, development has outpaced the ability of flood managers to implement structural and nonstructural solutions needed to control flood damages. Among floodplain residents, flood risk is often poorly understood. Flood risk management tools such as flood insurance and disaster preparedness are often underused.

Development behind levees is often incompatible with periodic flooding, to the detriment of public safety and floodplain ecosystems, unless special measures, such as elevating or floodproofing buildings, are implemented to limit damages.

Riverine habitats and ecosystem functions have been degraded over time through changes in land use, construction of dams and levees, water pollution, and other causes. The geographic extent, quality, and connectivity of native habitats along Central Valley rivers have all declined. Today, less than 4 percent of the historical riparian forests that lined valley streams remain, with a significant portion of this forest growing on, or close to, levees of the SPFC.

The historical practice of constructing SPFC levees close to the river channels to induce sediment scour has, in many cases, interfered with the natural stream meandering process. Where meandering channels begin to erode SPFC levee slopes, erosion protection is required to protect the integrity of the system. The result has been the placement of several hundred miles of rock revetment protecting about 30 percent of SPFC stream banks and waterside levee slopes. Stream banks require costly, ongoing maintenance and repairs. The Sacramento River Bank Protection Project has provided the authority and mechanism for placing the majority of rock revetment along SPFC facilities.

Typical Rock Revetment Along Sacramento River

Faced with limited funding, increasing regulatory constraints, and changing expectations for the multiple uses of the flood management system, it is increasingly difficult for State and local agencies to maintain levees and channels. This has jeopardized eligibility for federal levee rehabilitation funds under Public Law 84-99, administered by USACE, and levee accreditation under the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program.

A recent change in the USACE approach towards woody levee vegetation also poses new challenges for those who operate and maintain the existing system of levees. Since the levee system failures along the Gulf Coast caused by Hurricane Katrina in 2005, USACE has taken the position that no woody vegetation should be tolerated on or near federal project levees and, through a series of administrative actions, has moved to promulgate and enforce this approach. For the California Central Valley, woody vegetation is of great ecological and aesthetic value and would be extremely costly to remove. Consequently, the State, local maintaining agencies, and environmental groups have been working with USACE to encourage development of a flexible levee vegetation management approach that would achieve public safety goals without sacrificing environmental quality and misallocating scarce public funds. (This issue is discussed in greater detail in Section 3 with regard to retention of Public Law 84-99 Disaster Recovery eligibility, in Section 4 with regard to management vegetation on the levees, and at length in Attachment 2 – Conservation Framework).

Operations and maintenance and repairs of the flood management system are difficult to execute and often deferred for many reasons. These include original system designs that do not meet existing engineering standards, inadequate funding, encroachments, inconsistent levee maintenance practices among maintaining agencies, and challenges in complying with a variety of State and federal environmental permitting and mitigation requirements.

Responsibilities for flood management and land use decisions in the Sacramento-San Joaquin Valley are dispersed among many agencies, and flood risk is often poorly understood among the floodplain residents. Land use decisions, such as those involv-

"100-Year Flood" is a shorthand expression for a flood that has a 1 in 100 chance of being exceeded in any given year. This may also be expressed as the 1% annual chance of exceedence flood, or "1% annual chance flood" for short. Similarly, a 200-year flood has a 1 in 200 (or 0.5%) chance of being exceeded in any given year.

ing development in floodplains, are typically made at the local level by counties and cities. Local jurisdictions often have economic incentives to support and encourage such development. On the other hand, when levees fail, resulting in flood damages and loss of life, the costs associated with floodfighting, rescue, recovery, and rehabilitation are shared by local, State, and federal agencies.

Overlapping jurisdictions across various federal and State agencies involved in flood management can lead to inconsistent policies and regulations. Coordinating activities within this fragmented jurisdictional landscape can be challenging, particularly for local entities.

Population increase and distribution will likely drive changes in land use patterns, potentially increasing the population at risk from flooding and possibly further reducing existing agricultural land and wildlife habitat. Continued urban development within major floodplains will also make future changes to the footprint of the flood management system progressively more costly, and increase consequences and risks (life safety and damages) when the flood management system is overwhelmed. Two factors are likely to slow this process in the future. First, FEMA's flood risk map digitizing and risk reassessment efforts will result in remapping of much of the SPFC-protected areas with less than 100-year (1% annual chance) flood protection. As a result, development in these areas will be more expensive, difficult to insure, and subject to flood-proofing or elevation requirements. The passage of Senate Bill 5[6] has set an even higher threshold for urban areas by requiring that they ultimately be provided with at least 200-year (0.5% annual chance) flood protection as a condition for further development.

Climate change is expected to reduce snowpack coverage in the Sierra

Climate change will lead to a greater fraction of seasonal precipitation occurring as rain rather than snow and sea levels will rise. These trends appear to be already established and, if they continue as expected, they will put increasing stress on California's flood management system. Floodplain risk assessments and development constraints will likely be adjusted accordingly. For example, the 100-year and 200-year (1% and 0.5% annual chance) flood events, calculated based on historical flood events may become larger for many watersheds, with long-term effects on National Flood Insurance Program map ratings, flood insurance costs, floodplain development, and the economic viability of floodplain communities. In addition, as the moderating effects of snowpack on runoff decrease, there will be a need for more water supply storage, putting greater pressure on California's multipurpose flood control reservoirs. Increased temperatures and altered runoff patterns also directly impact the health of California's natural ecosystems and habitats.

6 2007 Senate Bill No. 5, Machado. Flood management.

In some portions of the Central Valley, levees are subsiding because of several causes, including groundwater extraction, natural gas extraction, and the gradual compression or oxidation of weak, organic, or clay foundation soils. Project levees in the Delta, in the Knights Landing area of Yolo County, and in other areas, have subsided up to several feet over the past century. Such subsidence decreases the flood-carrying capacity, and sometimes the structural integrity, of these levees.

Over the past 40 years, State and federal environmental laws and regulations have been developed to reduce environmental impacts of human activities, such as those related to endangered species, fisheries, wetlands, and water quality. While progress has been made in achieving the goal of reducing environmental impacts of human activities, more can be achieved in terms of reducing impacts, and restoring some of what has been lost. One challenge is that these laws and regulations have added to the complexity, cost, and time required to plan, design, construct, operate, and repair portions of the flood management system. Future flood management practices will need to continue to adapt to current and new environmental regulations.

Collaboration between flood system managers and resource and regulatory agencies will be critically important in developing approaches that support long-term integrated management of the flood management system that serves public safety and environmental needs. This type of collaboration, which is discussed below, has been occurring. While not an exhaustive list, following are some of the challenges to address that will improve the ability to manage the system for multiple benefits:

- Addressing the needs of special-status species while also providing for the needs of multiple species that may use the habitat in the flood management system.
- Existing laws set relatively short time limits for some environmental permits given that flood management systems need to be managed in perpetuity.
- The process for developing management agreements for flood control projects under the multitude of federal and State environmental laws can be costly and complex and, in some cases, has been the responsibility of the project proponent, even when the actions provide multiple benefits. Increased partnering and leveraging of multiple funding sources will expand the opportunities for implementing multi-benefit projects.
- Work windows for species protection can challenge flood system managers in completing required annual maintenance. If habitat is improved and increased in and near the flood system, an intended outcome is increases in population sizes and, potentially, populations of new species using restored areas, which could increase limitations on maintainers and thereby increase flood risks. Refining work windows that meet the needs for species protection and flood activities, both of which can be very constrained by seasonal events and conditions, will support integrated management of the flood system.
- Improving habitat in ways that reduce, or at least do not substantially increase, needs for maintenance of flood facilities will be important. Additional long-term funding may be needed where such improvements substantially increase maintenance needs.

- Regulatory coverage under the federal Endangered Species Act and the California Endangered Species Act will be needed for a broad range of flood system management activities. Flood management, resource, and regulatory agencies will need to continue to work together to apply the most appropriate mechanisms for given areas and types of work from the variety of tools available (e.g., Habitat Conservation Plans, Incidental Take authorizations, Safe Harbor Agreements).

Effective interagency collaboration to address some of the issues noted above, and others, has been occurring. One example of this is the Interagency Flood Management Collaborative Program. Started in 2005 at the request of DWR and including local, State, and federal flood control, regulatory, and resource agencies, this program was instrumental in accelerating the 29 critical Central Valley levee repairs ordered by Governor Arnold Schwarzenegger in early 2006. This program also helped create and is supporting development of the Small Erosion Repair Program and the Corridor Management Strategy (both discussed in more detail in Attachment 2 – Conservation Framework), and continually provides technical support and assistance to the Division of Flood Management in the programs and projects it implements. The activities and successes reflect the program's underlying commitment that effective flood system management and healthy ecosystems can both be supported in the ongoing effort to protect public safety.

Land ownership underlying the facilities of the SPFC is a patchwork of private and public parcels. A variety of easements cover many private parcels and these easements have been established for a variety of different and often site-specific purposes. The types and terms of these easements relate to, for example, periodic flooding, conservation of agricultural land, and habitat restoration. This patchwork of land ownership and easement terms both constrains and complicates the potential for providing flood or environmental improvements over areas greater than individual parcels.

Impacts of modifications to facilities and environmental restoration on adjacent properties must also be carefully considered and mitigated, where feasible. For example, where wildlife habitat is proposed in proximity to existing agricultural lands, the impacts of plowing, spraying, and harvesting of agricultural lands on nearby wildlife habitat and, conversely, the impacts of protected species on agricultural lands, must both be carefully addressed to successfully implement long-term environmental enhancement projects.

There are several important connections between flood management and water quality. Most importantly, floods are capable of mobilizing enormous sediment loads and their contaminants, carrying them downstream, and then sorting and redepositing them. Many of the streams of the Sierra and the Coast Range have large amounts of mercury, mainly due to its use in capturing gold from sluice boxes during the Gold Rush, and also due to erosion from natural deposits. Mercury poses major obstacles to sediment management and ecosystem restoration where it occurs in large concentrations, such as in Cache Creek and the Cache Creek Settling Basin.

When levees fail, the inundation of homes, farms, businesses, and industries often results in the release and dispersion of highly toxic chemicals, which can have far reaching health and economic effects. All of these water quality concerns will continue to affect flood management programs by requiring that contaminants and toxics be addressed in the planning, design, construction, and maintenance phases of flood management projects, most likely intensifying in the future.

Major capital improvement and routine maintenance of the flood management system are primarily dependent on public funding generated by State, federal, and local sources. Flood risk management programs must compete with numerous other pressing funding needs such as education, transportation, health, and welfare. Major infusions of funding for flood risk management have historically followed major floods, when public attention is focused on the catastrophic damages they cause. For example, Propositions 1E and 84[7], with a combined bond funding capability of $4.9 billion, were approved by California voters little more than a year after Hurricane Katrina flooded and destroyed much of New Orleans, killing over 1,200 people. However, flood risk reduction programs and infrastructure need steady, long-term funding to achieve and sustain the requisite level of protection. Governments at all levels struggling with heavy debt burdens, recession-damped revenue projections, and rising construction costs all add uncertainty for fully funding the flood risk management programs and projects described in this report.

1.4.1 Future of State Plan of Flood Control Without Comprehensive Action

In the absence of the CVFPP, current trends would likely continue. Among the most notable trends are the following:

- FEMA's ongoing flood risk mapping program, conducted in coordination with State and local communities, will remap the floodplains protected by the SPFC with less than 100-year (1% annual chance) flood protection. This will impose significant long-term burdens on farms, homeowners, and businesses in these areas, including higher flood insurance premiums and limitations on repairing, reconstructing, and expanding structures.
- The existing partnership among the federal government, the State, and local entities for implementing flood risk reduction projects will continue. Current federal regulations strongly favor flood management projects in urban areas. Primarily in order to demonstrate a federal interest, flood damage reduction benefits of a project must exceed project costs. In other words, the benefit-to-cost ratio must be greater than one. To be recommended for funding in the President's budget, a more robust benefit-to-cost ratio is generally required. Although each of these projects is implemented taking into consideration its effects on the system as a whole, this process is by its very nature a piece-meal approach. These regulations also do not take into account the long-term

7 Proposition 1E = Disaster Preparedness and Flood Prevention Bond Act of 2006; Proposition 84 = Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006.

benefit of integrating environmental restoration projects, thus undervaluing the importance of rural projects. The historical federal/State/local partnership has created a dichotomous system in which urban areas have a much higher level of protection than rural-agricultural areas and receive the majority of available funding. Since the passage of Propositions 1E and 84, the State has taken a stronger leadership role in the project delivery process, including project formulation, design, and advancing of funds to cover much of what traditionally has been the federal cost share, with the hope of obtaining credit against future State cost-sharing obligations.

- System maintenance will continue to be challenged by the need to complete annual maintenance activities such as mowing grass, trimming trees and brush, filling burrows, clearing sediment, and restoring patrol roads while at the same time minimizing impacts on migrating fish, nesting birds, and hibernating snakes. The result is a combination of rapidly rising costs, shortening maintenance windows, high mitigation costs, and uncertainty.
- Without improved approaches to improve the effectiveness and efficiency of the environmental regulatory process, the complexity of meeting the variety of environmental regulations may continue to result in project delays and costs and inadequate environmental improvements. Continued collaboration at local, State, and federal levels will be important in navigating regulatory complexities and crafting approaches that will support the shift to long-term integrated management of the system that serves both public safety and environmental needs.

SOME IMPORTANT TERMS USED IN THE CENTRAL VALLEY FLOOD PROTECTION PLAN

Integrated Flood Management. This is an approach for addressing flood risk that recognizes the interconnection of flood management actions within broader water resources management and land use planning; the value of coordinating across geographic and agency boundaries; the need to evaluate opportunities and potential impacts from a system perspective; and the importance of environmental stewardship and sustainability.

Sustainable. A project is considered "sustainable" when it is socially, environmentally, and financially feasible for an enduring period. For the CVFPP, a sustainable project will also have flexibility to adapt to potential future changes such as climate change.

Systemwide. Evaluations on a "systemwide" basis consider how all the parts of the river basin and flood protection facilities interrelate in the movement of floodflows from rim reservoirs through the Delta. In other words, the evaluations consider the workings of the entire system rather than more traditional approaches that may only evaluate short reaches of levee along a river.

1.5 State's Interest in Integrated Flood Management

The CVFPP is drafted with careful consideration of the well-represented interests of involved local, State, and federal agencies, and special interest, nongovernmental organizations. The CVFPP also takes into consideration the interests of the State as a whole, which are typically not represented by any special interest group, in promoting the wise stewardship of public funds and natural resources.

The State has a fundamental interest in promoting the health and safety of its people, robust and sustainable economic growth, and a healthy ecosystem.

Specific to flood management, the State has a responsibility for, and primary interest in, building and maintaining flood management facilities along the Sacramento and San Joaquin rivers and their tributaries to preserve the welfare of the residents and landowners within reclaimed overflow basins in the Central Valley (California Water Code Sections 8532 – 8533). This responsibility is inextricably linked to the State's obligation to comply with environmental laws, policies, and directives. As the agency primarily charged with this dual responsibility, DWR has played a leadership role in developing environmentally sound project designs and maintenance practices. Therefore, environmental enhancements are fully integrated into formulation of the flood management approaches presented in the CVFPP.

The State is also responsible for responding to emergencies and public threats; thus, it is in the State's interest to invest funds proactively to avoid and mitigate for known risks to reduce costly emergency response and recovery.

1.6 Formulation of 2012 Central Valley Flood Protection Plan

The 2012 CVFPP is built on the foundation of Central Valley flood risk management efforts dating back to 1850, as documented in the previous sections. In 2006, DWR consolidated and coordinated its various flood risk management programs under the FloodSAFE California (FloodSAFE) initiative, which incorporates emergency preparedness, flood operations, flood risk reduction and ecosystem restoration projects, flood project maintenance, and comprehensive, systemwide assessment and planning to deliver improved flood protection as quickly and efficiently as possible.

This long-term planning document will address the flood management challenges discussed in the previous section as part of a sustainable, integrated flood management approach. The CVFPP is a descriptive document. It is not a systemwide feasibility study of sufficient detail to support project-specific actions such as authorizing legislation, design, and construction. It is intended to provide a foundation for prioritizing Central Valley flood risk reduction and ecosystem restoration investments, including feasibility studies on appropriate scales – from valleywide to project-specific.

The CVFPP was prepared in coordination with local flood management agencies, the Board, USACE, FEMA, and Reclamation. It is supported by data, analyses, and findings from related FloodSAFE efforts. These include the ***State Plan of Flood Control Descriptive Document,*** the ***Flood Control System Status Report***, and the ***CVFPP Final Program Environmental Impact Report***, being prepared in parallel with the CVFPP and documented in interim products and reference documents (Figure 1-8).

CENTRAL VALLEY FLOOD PROTECTION ACT OF 2008

California Water Code Section 9603 (a) "The Central Valley Flood Protection Plan shall be a descriptive document, and neither the plan nor anything in this part shall be construed to expand the liability of the state for the operation or maintenance of any flood management facility beyond the scope of the State Plan of Flood Control, except as specifically determined by the board pursuant to Section 9611. Neither the development nor the adoption of the Central Valley Flood Protection Plan shall be construed to constitute any commitment by the state to provide, to continue to provide, or to maintain at, or to increase flood protection to, any particular level."

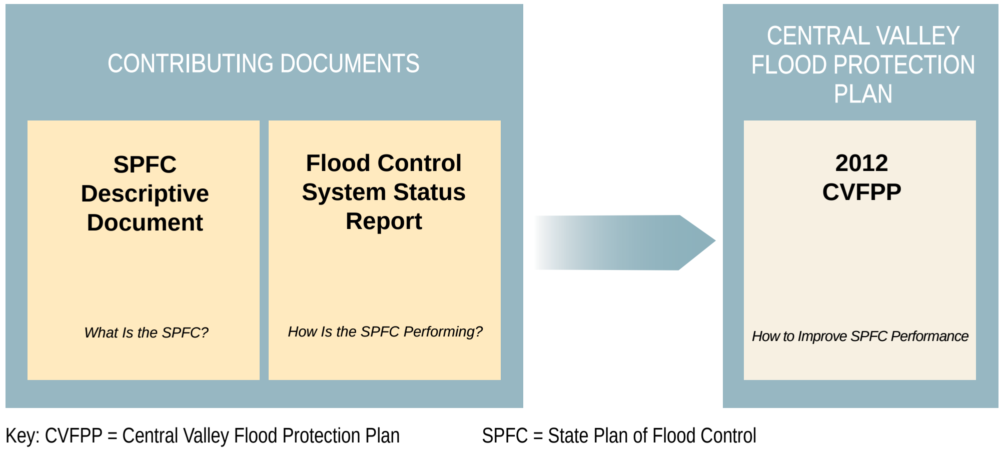


Figure 1-8. Contributing Documents

Collectively, this body of work fulfills the intent and requirements of the Central Valley Flood Protection Act of 2008, embedded in Senate Bill 5 and codified in Sections 9600 through 9625 of the California Water Code. Detailed specifications for the plan formulation process and its contents are provided for reference in Attachment 1 – Legislative Reference.

In accordance with the requirements of the act, the Board is expected to adopt the CVFPP on or about July 1, 2012. The CVFPP will subsequently be updated every five years by DWR and submitted to the Board for adoption.

The 2012 CVFPP focuses on improving integrated flood management and flood risk reduction for areas protected by facilities of the SPFC (Figure 1-9). While the CVFPP focuses on the areas protected by SPFC facilities, the flood emergency response and operations and management of facilities in tributary watersheds that influence SPFC-protected areas are also considered.

The CVFPP recognizes the connection of flood management actions to water resources management, land use planning, environmental stewardship, and long-term economic, environmental, and social sustainability. Integrated flood management also recognizes the importance of evaluating opportunities and potential impacts from a systemwide perspective, and the importance of coordinating across geographic and agency boundaries to treat entire hydrologic units.

The CVFPP provides an opportunity to mitigate some of the negative effects of current trends while promoting wise investments of federal, State, and local funds, as in the following examples:

- The CVFPP will emphasize wise floodplain management, which, in concert with FEMA's National Flood Insurance Program, will limit excessive floodplain development and promote continued sustainability of the current rural-agricultural economy and small communities.
- Investments in levees and other flood protection infrastructure will be considered on a systemwide basis. It is likely that urban communities, with the greatest concentrations of population and damageable property, will continue

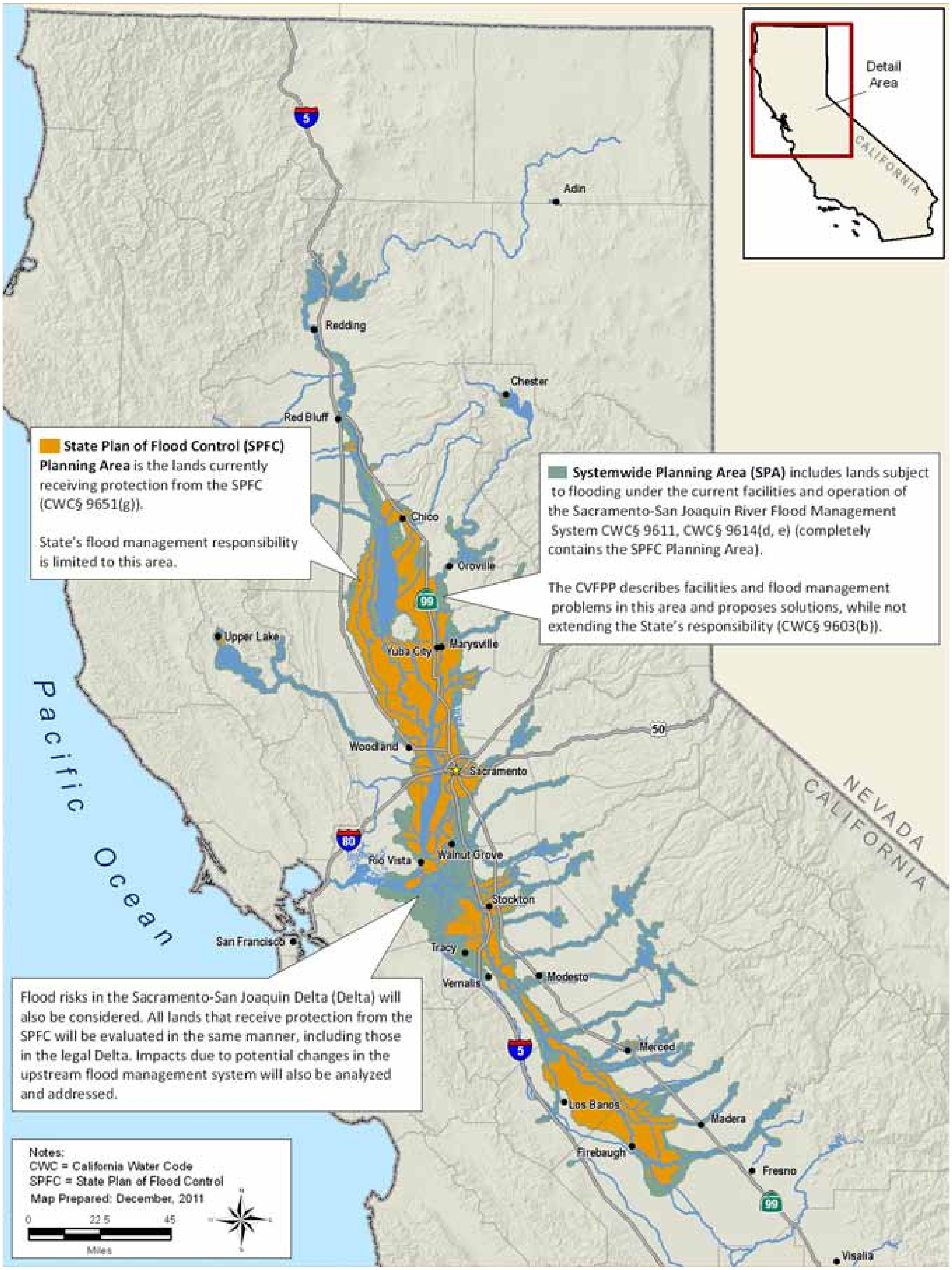


Figure 1-9. Geographic Scope of Central Valley Flood Protection Plan

to receive the greatest share of available federal and State funds. However, the CVFPP gives careful attention to fixing known weaknesses in the rural-agricultural levee system and also protecting small communities. Because rural-agricultural areas are less developed, the State is interested in seeing more nonstructural improvements, as these often can have lower long-term annual operations and maintenance costs and greater system benefits. With this in mind, the CVFPP provides a framework for a much broader benefit analysis than the traditional approach, which relies almost entirely on the benefit-to-cost ratio and net economic development indicators to guide investments. The CVFPP considers potential system improvements, such as expanded bypasses and associated ecosystem enhancements, which are beyond the sponsorship capabilities of even the most robust local agencies.

- The CVFPP proposes to take an integrated system approach to maintenance and ecosystem restoration. In practice, this means an approach that promotes implementation of a future flood management system footprint that provides additional habitat area to help support recovery of listed species and other State conservation goals while reducing flood risk by reducing long-term maintenance needs.
- The CVFPP focuses on implementation and considers the sequential phasing of incremental elements of the programs. This approach relies on development of a firm technical foundation to inform implementation actions in future CVFPP phases, with an initial focus on the most urgent flood management system needs. It also supports development of a sound funding strategy to pursue effective, long-term flood management in the Central Valley.

1.6.1 Outreach Activities Informing Central Valley Flood Protection Plan

DWR initiated an extensive communications and engagement process for the 2012 CVFPP by reaching out to partnering agencies, interested parties, and the public, allowing them to share and solicit information and offer input and recommendations. The intent was to facilitate open communication and provide opportunities to participate in CVFPP development in a variety of ways, depending on interest and availability.

A comprehensive, multiphase, public engagement planning process was essential in developing the CVFPP. Figure 1-10 depicts the phases and major components of the engagement process. In addition, all public engagement activities are detailed in Attachment 5 – Engagement Record.

CENTRAL VALLEY FLOOD PROTECTION ACT OF 2008

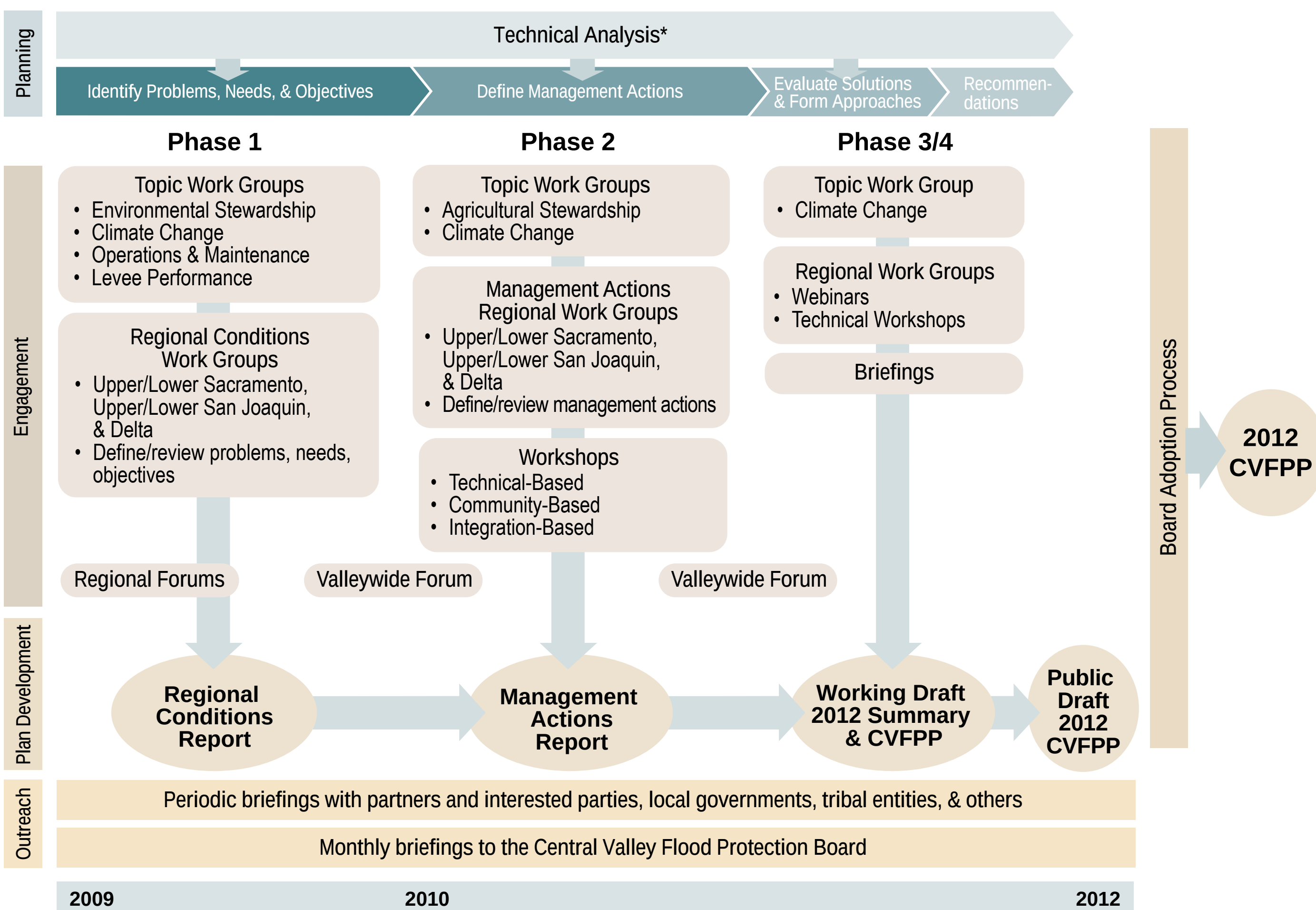
California Water Code Section 9615. "For the purposes of preparing the plan, the department shall collaborate with the United States Army Corps of Engineers and the owners and operators of flood management facilities."

Throughout the planning process, many different venues promoted open and transparent communication about important integrated flood management issues and provided partners and interested parties with opportunities to participate in CVFPP development. DWR staff also communicated and met with many local maintaining agencies to solicit feedback on levee performance issues and confirm preliminary results of DWR levee assessments (for both urban and nonurban levee evaluations). Using this information, DWR, USACE, the Board, and their partners worked together to characterize problems and future trends, shape and define goals and planning principles, formulate management actions, and evaluate possible solutions for integrated flood management. These efforts will also be vital to implementation of the CVFPP.

ENGAGING CALIFORNIA'S TRIBAL COMMUNITIES IN FLOOD MANAGEMENT IMPROVEMENTS

The State respects the perspectives and opinions held by California's Tribal communities. To that end, the CVFPP communication and engagement approach included regular communication with Tribal representatives, and utilized the California Water Plan Tribal Communications Committee to share and receive information relevant to the CVFPP.

It will be important and necessary for local, regional, State, and federal government agencies to collaborate with Tribal governments during the planning and implementation of flood management actions. The local implementation approach will help ensure that historical and valued Tribal lands are respected and considered as planning for flood management improvements continues.



* ***State Plan of Flood Control Descriptive Document*** and ***Flood Control System Status Report*** inform technical analysis

KEY: Board = Central Valley Flood Protection Board   CVFPP = Central Valley Flood Protection Plan

Figure 1-10. Communication and Engagement Process

COMMUNICATION AND ENGAGEMENT IN PLAN DEVELOPMENT

DWR has gone through considerable effort in getting stakeholder feedback and informing a variety of groups and individuals across the CVFPP planning area. Subjects have been as varied as the interest groups themselves. With nearly 300 meetings and more than 40 publications, in addition to a Web site and webinars, the CVFPP has focused on including interested parties and the public.

Initial meetings with organizations and individuals, January and February 2009

- 113 meetings with individuals and organizations across the planning area

Regional and Valleywide forums, June 2009, 2010, and December 2010

- 7 Forums in various areas valleywide

Work groups covering regional conditions and management actions, August 2009 – November 2010

- 55 meetings with stakeholder participation across the planning area

Special Topic work groups and subcommittees, August 2009 – November 2011

- 36 meetings covering a variety of subjects and attended by a variety of stakeholders

Workshops on Flood Management Actions and levee design criteria, July 2010 – September 2011

- 20 workshops focusing on technical issues

Briefings to and coordination with local government, Legislature, interest groups, work groups, and media, January 2010 – May 2011

- 46 briefings on specific subjects of concern and general information to individual groups

Tribe and tribal organization briefings, October 2009 – February 2011

- 17 briefings for various Tribes and Tribal organizations on a variety of subjects

Numerous newsletters, fact sheets, flyers, posters, and reports were distributed to stakeholders via e-mail and in meetings and workshops from May 2009 to the present on a variety of flood topics, including technical and environmental work associated with the CVFPP.

1.6.2 Central Valley Flood Protection Plan Goals

Primary Goal

- **Improve Flood Risk Management** – Reduce the chance of flooding, and damages once flooding occurs, and improve public safety, preparedness, and emergency response through the following:
    - » *Identifying, recommending, and implementing structural and nonstructural projects and actions that benefit lands currently receiving protection from facilities of the SPFC.*
    - » *Formulating standards, criteria, and guidelines to facilitate implementation of structural and nonstructural actions for protecting urban areas and other lands of the Sacramento and San Joaquin river basins and the Delta.*

Supporting Goals

- **Improve Operations and Maintenance** – Reduce systemwide maintenance and repair requirements by modifying the flood management systems in ways that are compatible with natural processes, and adjust, coordinate, and streamline regulatory and institutional standards, funding, and practices for operations and maintenance, including significant repairs.

- **Promote Ecosystem Functions** – Integrate the recovery and restoration of key physical processes, self-sustaining ecological functions, native habitats, and species into flood management system improvements.
- **Improve Institutional Support** – Develop stable institutional structures, coordination protocols, and financial frameworks that enable effective and adaptive integrated flood management (designs, operations and maintenance, permitting, preparedness, response, recovery, and land use and development planning).
- **Promote Multi-Benefit Projects** – Describe flood management projects and actions that also contribute to broader integrated water management objectives identified through other programs.

CVFPP Goals, described above, provide guidance for the formulation of its specific policies and physical elements. The goals also capture guidance and objectives provided in the authorizing legislation (California Water Code Section 9616), summarized in the sidebar.

1.6.3 Plan Formulation Process

Plan formulation for the 2012 CVFPP was a multistep process. First, DWR, the Board, and participants in the outreach process worked together to define flood risks and related problems in the Central Valley and articulate the CVFPP Goals. Basic principles to guide how the plan was to be developed and implemented were also collaboratively developed.

A wide range of individual management actions were identified as possible ways to address the goals and planning principles. Management actions are individual tactics or strategies, including physical improvements and policy changes, that address the CVFPP Goals while adhering to the planning principles.

The California Central Valley Flood Protection Act of 2008 (Senate Bill 5) defined objectives, codified in California Water Code Section 9616, for reducing the risk of flooding in the Central Valley. Per California Water Code Section 9616, the CVFPP is to describe both structural and nonstructural means for improving the performance and eliminating the deficiencies of levees, weirs, bypasses, and other SPFC facilities. Wherever feasible, these actions should meet multiple objectives, including the following:

- Reduce the risk to human life, health, and safety from flooding, including protection of public safety infrastructure.
- Expand the capacity of the flood management system in the Sacramento-San Joaquin Valley to either reduce floodflows or convey floodwaters away from urban areas.
- Link the flood protection system with the water supply system.
- Reduce flood risks in currently nonurbanized areas.
- Increase the engagement of local agencies willing to participate in improving flood protection, ensuring a better connection between State flood protection decisions and local land use decisions.
- Improve flood protection for urban areas to the urban level of flood protection.
- Promote natural dynamic hydrologic and geomorphic processes.
- Reduce damage from flooding.
- Increase and improve the quantity, diversity, and connectivity of riparian, wetland, floodplain, and shaded riverine aquatic habitats, including the agricultural and ecological values of these lands.
- Minimize flood management system operations and maintenance requirements.
- Promote the recovery and stability of native species' populations and overall biotic community diversity.
- Identify opportunities and incentives for expanding or increasing use of floodway corridors.
- Provide a feasible, comprehensive, and long-term financing plan for implementing the CVFPP.
- Identify opportunities for reservoir reoperation in conjunction with groundwater flood storage.

Given the large geographic scope and range of perspectives affecting flood management solutions in the Central Valley, thousands of potential solutions could have been formed by combining the management actions in different ways. Instead, the management actions were combined to create a manageable range of flood management approaches. Evaluation of these preliminary approaches identified trade-offs between benefits, costs, and other decision making factors, and identified the most promising elements of each approach.

Computer models were used to evaluate the hydrologic and hydraulic performance of the flood management system, comparing the existing system to preliminary approaches with various combinations of levee improvements, expanded bypasses, and additional reservoir storage. These models simulated storm precipitation, runoff, reservoir operations, and flows moving downstream through the system to the Delta. The models took into account levee heights and physical condition, weir spills, levee failures, and other dynamic processes that can occur during major floods. The output from these hydrologic and hydraulic models was used in additional models to estimate expected annual flood damages in the protected floodplains.

This suite of computer models made it possible to evaluate flood system performance and the potential systemwide effects (both benefits and impacts) of various improvements in terms of flows, velocities, and stages.

Costs of capital improvements and programs were also evaluated on a reconnaissance level for the purpose of comparing preliminary approaches. Cost estimates used in this report were based on 2011 dollars. More detailed cost evaluations, taking into account financing costs, inflation, and implementation time, will be developed as part of a Financing Plan for the CVFPP and during subsequent feasibility study analyses.

Section 2 discusses the preliminary approaches and summarizes how each approach meets the legislative objectives and goals of the CVFPP. The State Systemwide Investment Approach (SSIA), described in Section 3, was formulated after evaluation of the preliminary approaches and determining that the most reasonable and cost-effective approach to reducing flood risks, while addressing other key goals, was to combine key elements from each of the three preliminary approaches.

1.6.4 Central Valley Flood Protection Plan Implementation

The CVFPP will guide State, federal, and local actions for improving flood management in areas currently protected by facilities of the SPFC. The CVFPP addresses the unique responsibilities of the State, as they relate to the SPFC.

The 2007 flood legislation requires cities and counties in the Sacramento-San Joaquin Valley to incorporate information from the CVFPP into local land use plans and projects after the CVFPP is adopted. Subsequently, cities and counties will also be required to make findings related to the urban level of flood protection (California Government Code Sections 65865.5, 65962, and 66474.5).

COORDINATION WITH OTHER PROGRAMS AND PROJECTS

DWR will continue to coordinate with other flood management and ecosystem enhancement work during CVFPP implementation. Following are a few key examples:

Statewide Flood Management Planning Program. The comprehensive Statewide Flood Management Planning Program is assessing flood risk statewide to inform development of the State's flood management policies and investment decisions over the next 15 – 20 years. This is a program complementary to the CVFPP that focuses on areas outside the SPFC, including the Delta.

Delta Stewardship Council's Delta Plan. The Delta Plan is driven by coequal goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place. The plan also includes policies and recommendations to reduce risk to people, property, and State interests in the Delta.

Bay Delta Conservation Plan. When complete, the Bay Delta Conservation Plan will provide the basis for issuing of endangered species permits for operation of State and federal water projects. The plan would be implemented over the next 50 years. The heart of the Bay Delta Conservation Plan is a long-term conservation strategy that sets forth actions needed for a healthy Delta and making modifications to the conveyance of the State and federal water projects. Ecosystem enhancement activities may extend into areas protected by the SPFC (e.g., the Yolo Bypass); therefore, those activities are incorporated into the CVFPP.

Coordination with Other Flood Management and Ecosystem Restoration Programs. DWR will continue coordination with other programs to improve synergy among various flood management and environmental restoration investments, including programs such as the San Joaquin River Restoration and Fish Passage Improvement projects.

Other Ongoing Activities. DWR will continue to coordinate with many other ongoing activities within the watersheds of the Sacramento River and San Joaquin River basins. Many of the ongoing flood protection improvements have been incorporated into the SSIA and are expected to eventually become part of the SPFC. DWR will coordinate CVFPP activities with the Integrated Regional Water Management Plans, California Water Plan Updates, and other activities to integrate flood management in these programs.

Future updates to the 2012 CVFPP will incorporate new and revised information and also review and realign goals and actions as specific projects are implemented and conditions in the Central Valley evolve. Additional activities, such as local and regional studies, federal feasibility studies, and environmental compliance evaluations, will occur to support implementation of physical elements or features of the CVFPP.

Section 4 describes the framework for formulating the implementation and financing strategy for the CVFPP. DWR recognizes that funding provided by Propositions 1E and 84 will not be sufficient to realize all of the improvements to flood management in the Central Valley envisioned over time. The 2012 CVFPP includes a financing strategy to support implementation; however, a detailed implementation schedule and financing plan will be prepared after the CVFPP is adopted.

In mutual recognition of the importance of close collaboration and coordination on Central Valley flood risk reduction measures, USACE, DWR, and the Board are conducting a parallel planning process, the Central Valley Integrated Flood Management Study (CVIFMS), with a scheduled completion date of 2017. It is anticipated that CVIFMS will make recommendations leading to Congressional authorization and federal participation in future flood risk reduction projects, including the CVFPP.

1.6.5 2012 Central Valley Flood Protection Plan Organization

The CVFPP is organized as follows:

- **Section 1 – Responding to the Need for Improved Flood Management in the Central Valley** presents historical flood context, existing and future flood management problems, and an overview of the 2012 CVFPP plan formulation process, including next steps.
- **Section 2 – Preliminary Approaches** discusses actions considered during the planning process for further policy development and investment approach formulation.
- **Section 3 – State Systemwide Investment Approach** details SSIA policy directives, systemwide and regional elements, and anticipated outcomes and costs.
- **Section 4 – Implementing and Managing the State Systemwide Investment Approach** discusses the projects, programs, and actions that will be needed to implement the CVFPP.
- **Appendix A** includes Board Adoption Resolution 2012-25, amending and adopting the 2012 CVFPP.
- **Attachment 1 – Legislative Reference** outlines legislative requirements fulfilled by the 2012 CVFPP and the supporting analyses and documentation.
- **Attachment 2 – Conservation Framework** describes how environmental stewardship is integrated into flood management activities, directs the reader to relevant environmental elements in the CVFPP, and provides additional detail on environmental planning elements.
- **Attachment 3 – Documents Incorporated by Reference** summarizes documents incorporated by reference in the 2012 CVFPP that may also fulfill other legislative requirements.
- **Attachment 4 – Glossary** defines key terms used in the CVFPP.
- **Attachment 5 – Engagement Record** catalogues and describes the approaches and accomplishments of communication and engagement activities to support and complement technical planning processes implemented through the CVFPP and other related FloodSAFE programs and studies.
- **Attachment 6 – Contributing Authors and Work Group Members List** indexes those who provided substantive comments on and/or content for development of each of the CVFPP documents as well as members of each of the CVFPP work groups.

- **Attachment 7 – Plan Formulation Report** describes the plan formulation process for the 2012 CVFPP.
- **Attachment 8 – Technical Analysis Summary Report** describes the technical analyses completed for the 2012 CVFPP.
- **Attachment 9 – Supporting Documentation for Conservation Framework** describes the technical analysis approach, tools, and data supporting development of the Conservation Framework.

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2.0 PRELIMINARY APPROACHES

Development of the CVFPP included formulation and evaluation of three significantly different preliminary approaches to address the CVFPP Goals. The preliminary approaches were primarily used to explore different potential physical changes to the existing flood management system and to assist in highlighting the need for policy or other management actions. Evaluation of these preliminary approaches displayed information on differences in costs, benefits, and overall effectiveness for use in preparing a preferred approach – the State Systemwide Investment Approach (SSIA).

This section describes formulation and evaluation of the three preliminary approaches and resulting basic considerations used in developing the SSIA, described in detail in Section 3.

2.1 Management Actions

Given the large geographic area covered by the existing flood protection system in the Central Valley, and the resources and problems being addressed, a wide range of different management actions can be considered for inclusion in the CVFPP. Each action represents a discrete feature or process to contribute to one or more of the goals described in Section 1. Through a collaborative process, more than 90 individual management actions were identified and grouped into the following categories:

- Additional floodplain and reservoir storage
- Storage operations
- Flood protection system modifications
- Operations and maintenance
- Ecosystem functions
- Floodplain management
- Disaster preparedness and flood warning
- Floodfighting, emergency response, and flood recovery
- Policy and regulations
- Permitting
- Finance and revenue

The management actions generally encompass broad tactics or strategies, rather than location-specific projects, and vary in their level of detail. They range from physical and operational improvements to the flood management system to residual risk management and overall program implementation considerations.

No single management action can achieve all of the CVFPP goals. Each management action is an individual building block that may be used with other management actions for flood risk reduction on systemwide and regional scales, and for managing residual risk. Each preliminary approach provides a different overall strategy towards flood management that affects which management actions are included.

2.2 Purposes of Preliminary Approaches

DWR formulated and evaluated three preliminary approaches to inform flood management policy development and explore the potential accomplishments of different combinations of physical investments in the flood management system. The preliminary approaches highlight different ways to focus future flood management investments and contribute to the CVFPP Goals in different ways, both in magnitude and geographic scope.

CENTRAL VALLEY OF FLOOD PROTECTION ACT OF 2008

California Water Code Section 9614

"The Plan shall include…

(g) An evaluation of the structural improvements and repairs necessary to bring each of the facilities of the State Plan of Flood Control to within its design standard. The evaluation shall include a prioritized list of recommended actions necessary to bring each facility not identified in subdivision (h) to within its design standard."

CENTRAL VALLEY OF FLOOD PROTECTION ACT OF 2008

California Water Code Section 9614

"The Plan shall include…

(i) A description of both structural and nonstructural methods for providing an urban level of flood protection to current urban areas. The description shall also include a list of recommended next steps to improve urban flood protection."

An urban area means the same as set forth in Section 5096.805 (k) of the California Public Resources Code.

The three preliminary approaches are as follows:

- **Achieve State Plan of Flood Control Design Flow Capacity.** This approach focuses on improving existing SPFC facilities so that they can convey their design flows with a high degree of reliability based on current engineering criteria. Levee improvements would be made regardless of the areas the levees protect. This approach provides little opportunity to incorporate benefits beyond flood management.
- **Protect High Risk Communities.** This approach evaluates improvements to levees to protect life safety and property for high risk population centers, including urban and small communities. Levees in rural-agricultural areas would remain in their existing configurations. This approach provides minor opportunities to incorporate benefits beyond flood management.
- **Enhance Flood System Capacity.** This approach would seek opportunities to achieve multiple benefits through enhanced flood system storage and conveyance capacity, to protect high risk communities, and to fix levees in place in rural-agricultural areas. This approach combines the features of the above two approaches and provides more room within flood conveyance channels to lower flood stages throughout most of the system, with additional features and functions for ecosystem restoration and enhancements.

These preliminary approaches are not alternatives from which a single, superior alternative can be selected. Rather, these approaches display a range of potential physical and operational flood management actions and allow exploration of potential trade-offs in benefits, costs, and other factors, including corresponding needs for residual risk management actions and necessary policy directives. The three preliminary approaches are intended to bracket the potential range of future flood management in the Central Valley and address flood problems in fundamentally different ways, not to achieve the CVFPP Goals to the same degree. Information provided through evaluations allowed DWR to select the better performing characteristics and avoid the poorer performing characteristics of each preliminary approach to assemble the SSIA.

To effectively evaluate the preliminary approaches, DWR used available technical tools to judge how changes to SPFC facilities would affect systemwide performance while also reducing flood damages, protecting public safety, and restoring degraded ecosystems. As part of this approach evaluation, DWR developed key quantitative indicators. Indicators used to assess the performance of the preliminary approaches include changes to riverine and Delta flood stages, structure and content damages, crop flood loss damages and associated business income losses, and potential for life loss.

Findings from evaluation of the three preliminary approaches, combined with necessary systemwide policies, informed development of the SSIA as the State's proposal for balanced, sustainable flood management in the Central Valley. Parts of the physical actions contained in the three preliminary approaches, along with insight on policies and guidance, were combined to form the SSIA.

Although policies are not specifically identified in a separate policy section of this report, policies are imbedded in duties of the management programs and in the initiatives outlined in Section 4. In addition, policy statements are within the description of management actions in Section 3.

2.3 Preliminary Approach: Achieve State Plan of Flood Control Design Flow Capacity

This approach focuses on reconstructing SPFC facilities to meet current engineering criteria without making major changes to the footprint or operation of those facilities. Engineering risk assessment, design, and construction methods have greatly evolved since the original construction of the SPFC facilities. The system was largely constructed based on geometric criteria using available soil materials without extensive investigation of foundation conditions. Subsequent construction of a series of multipurpose reservoirs benefited the SPFC facilities by reducing peak floodflows. Nevertheless, the majority of the SPFC levees are not capable of carrying their design flows with the degree of reliability based on current engineering criteria because of problems with levee and foundation reliability. In addition, portions of the levee system have experienced erosion damage.

This approach was formulated to address legislation that required DWR to consider structural actions necessary to reconstruct SPFC facilities to their design standard (California Water Code Section 9614 (g)). This approach also addresses requests from stakeholders to consider reconstructing the existing flood management system in place, or without major modification to facility locations. This approach does not consider improving SPFC facilities to carry floodflows greater than project design flows, nor other enhancements (e.g., to levee height, width, footprint). Also, this approach does not seek a specific level of protection in any area.

2.3.1 Major Components

This approach includes major remedial actions to address medium and high threats to facilities of the SPFC. These threats are identified and described in the ***Flood Control System Status Report***. Remedial actions include major reconstruction of SPFC facilities. Medium and high threat factors are those judged to pose the most significant potential threat to SPFC facility integrity. These factors include inadequate levee freeboard, inadequate levee geometry, structural instability, and excessive seepage, as well as inadequate channel capacity to convey design flows.

To address these threats, this approach includes remediation of about 170 miles of urban SPFC levees and 1,400 miles of nonurban SPFC levees. This approach includes remediation of non-SPFC urban levees, as it is recognized that some non-SPFC levees can affect flooding within the SPFC Planning Area. Figure 2-1 illustrates the general location of levees for which some kind of SPFC levee remediation would be needed.

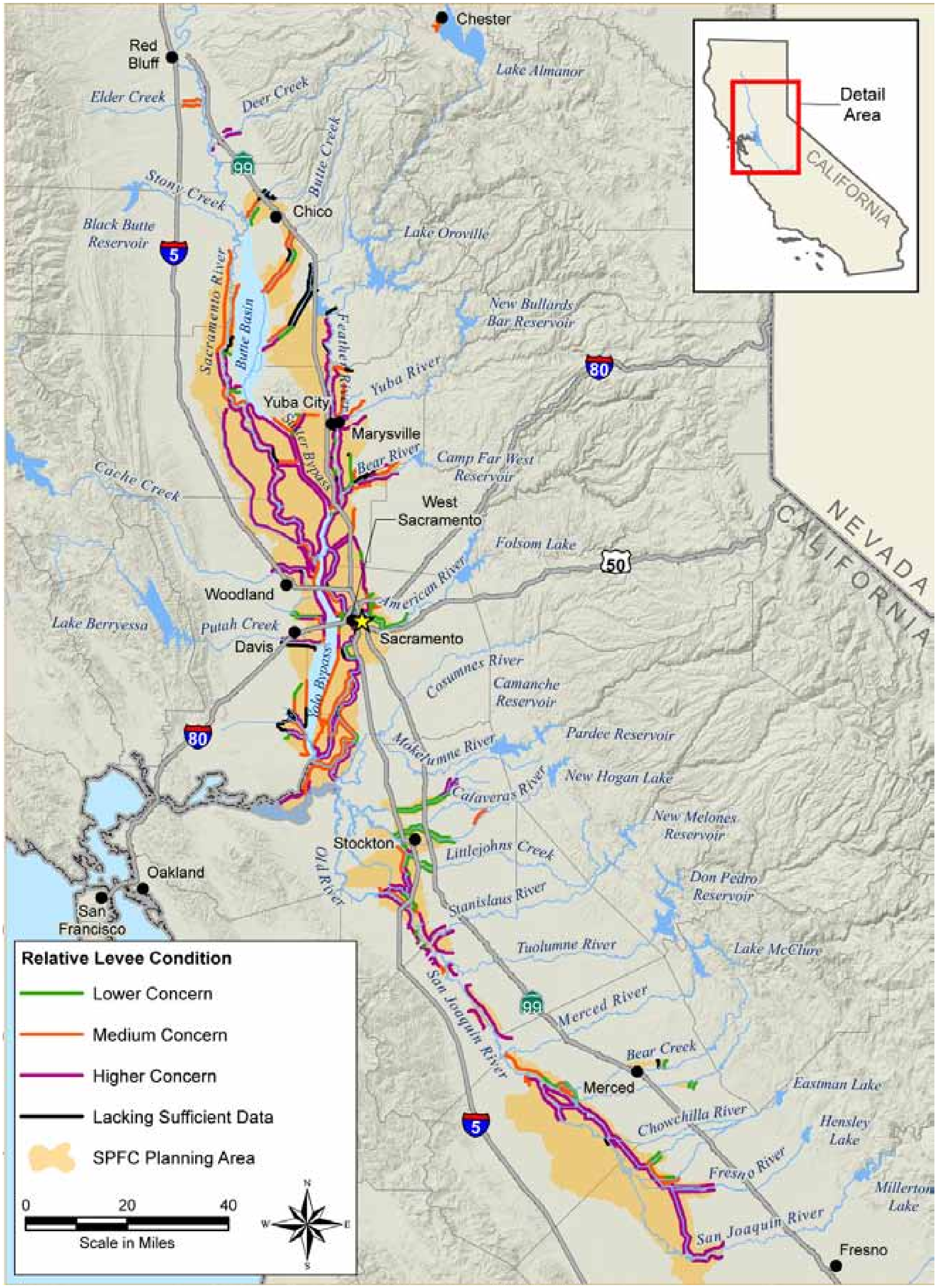
The primary objective of these remedial actions is to improve the levee system to convey SPFC design flows with a high degree of reliability, based on current engineering design and construction criteria. Levees shown as purple in Figure 2-1 ("higher concern") or orange ("medium concern") generally display more performance problems than those shown in green ("lower concern"). This approach would address all concerns shown in Figure 2-1.

Remedial actions would primarily include modifications of levees in their current locations, as follows:

- SPFC levees would be modified or reconstructed to address identified adverse geotechnical conditions to provide a high reliability of accommodating design flows.
- Levee height would be increased to achieve design freeboard, where needed, to accommodate the design water surface elevation.

Remedial actions would include different types of stability and seepage berms, cutoff walls, rock slope protection, increased levee height and/or geometry, and replacement levees needed for the system to convey design flows.

Operations of existing weirs, bypasses, and other structures within the flood management system would generally continue as under current conditions. Some short-term changes in reservoir operations (see Section 3) would be made in anticipation of, and during, flood events.



Key: SPFC = State Plan of Flood Control

Figure 2-1. Levee Conditions Considered in Achieve State Plan of Flood Control Design Flow Capacity Approach

2.3.2 Initial Assessment

Based on an initial assessment, the Achieve SPFC Design Flow Capacity Approach is estimated to cost approximately $19 billion to $23 billion and take 30 to 35 years to implement. This approach would provide an approximate 43 percent reduction in annual flood damages compared to current conditions.

This approach would improve the reliability of SPFC facilities compared with existing conditions. Since the original designs did not consider geotechnical and other risk factors addressed by current engineering criteria, reconstruction would significantly improve reliability of the levee system and the level of protection provided by the SPFC over that of existing conditions. However, the level of protection would be highly variable throughout the system and not linked to the land uses at risk within the floodplain.

ACHIEVE SPFC DESIGN FLOW CAPACITY APPROACH

- Reconstruction of approximately 1,600 miles of levee.
- Reconstruction of levees in their current footprint to safely pass design flows would contain more floodflows within channels, thus increasing peak floodflows and stages throughout the system.
- Reduction of approximately 47 percent in annual flood damage estimates includes structure values and contents and crops.
- Estimated capital costs are higher for the Sacramento River Basin because of the greater number of levees in the basin.

In many locations, levee reconstruction would result in increased peak flows and stages compared with current conditions because of the reduction in levee failures. Consequently, this approach would only partially address the primary CVFPP goal of improving flood risk management.

Investments in SPFC reconstruction would initially reduce SPFC operations and maintenance costs. However, the long-term cost to maintain the system would remain high (similar to current conditions) because reconstruction alone would not address chronic erosion, sedimentation, and other geomorphic conditions inherent to the current system configuration. This approach would only partially contribute to the goal of improving operations and maintenance.

Because the footprint and operation of an SPFC facility would remain largely unchanged under this approach, opportunities to integrate ecosystem restoration and enhancement would be limited and would not contribute to improved ecosystem functions on a systemwide scale. Therefore, existing conflicts between environmental stewardship and levee maintenance practices would continue to hamper the improvement of ecosystem conditions and public safety. There would also be few opportunities to incorporate new groundwater recharge or other water-related benefits. Consequently, this approach would contribute in only a minor way to the supporting goals of promoting ecosystem functions and multi-benefit projects.

2.4 Preliminary Approach: Protect High Risk Communities

This approach focuses primarily on physical improvements to facilities of the SPFC to address the highest threats to public safety and property. These threats predominate in densely populated areas, including urban areas and small communities subject to deep or rapid flooding.

2.4.1 Major Components

This approach includes a variety of physical actions to reduce the chances of flooding in urban areas and small communities where substantial threats to public safety exist from flooding from major rivers and tributaries with SPFC facilities. This approach does not include improvements that may be needed to address interior drainage or other local sources of flooding. Also, this approach includes improvements to non-SPFC levees that protect some urban areas.

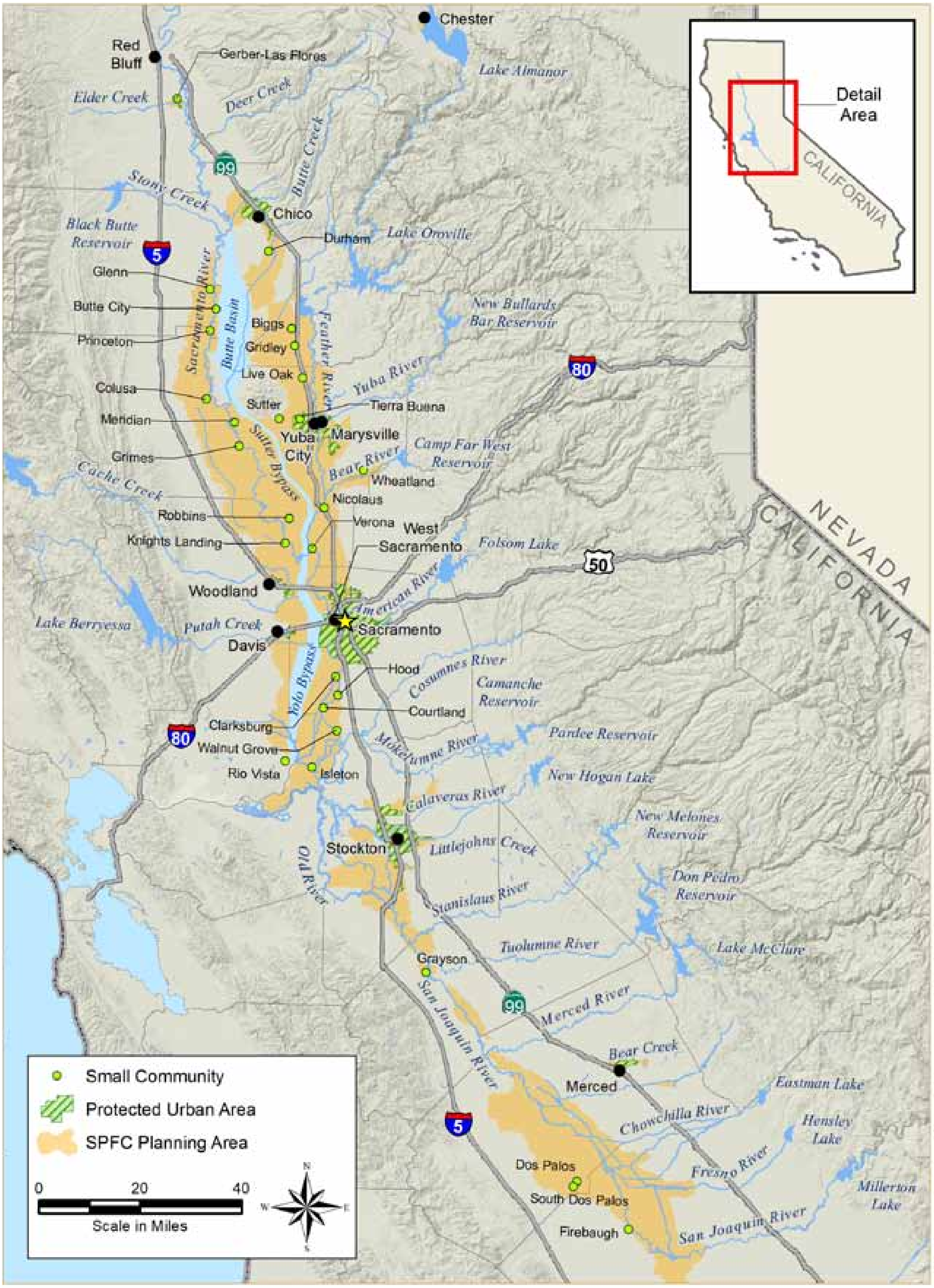
DWR assessed flood threat levels based on the population at risk, population density, flood frequency, flood depth, and proximity to river or tributary flood sources. This approach focused on reducing flooding from major rivers and waterways associated with the SPFC; flooding from small drainages, local sources, and interior storm drainage were not included in the formulation of this approach.

Figure 2-2 shows the urban areas and small communities considered in the Protect High Risk Communities Approach.

Urban areas in the floodplain (with populations greater than 10,000) are considered to have high threat levels because of the potentially significant public safety consequences of floods occurring in these densely populated areas within the SPFC Planning Area. In general, this approach considered structural options for protecting small communities.

The targeted level of flood protection and the types of flood management improvements considered for urban areas and small communities are summarized below:

- Urban areas would achieve protection from a 200-year (0.5% annual chance) flood event, consistent with the urban level of flood protection requirement. This would be accomplished via structural repairs, reconstruction, or improvements to about 160 miles of urban SPFC levees and about 120 miles of urban non-SPFC levees to protect a population of about 1 million. This includes work for Chico, Yuba City, Marysville, Sacramento, West Sacramento, Woodland and Davis, Stockton, and Merced. Repairs and improvements would typically be implemented within current facility footprints (in-place fixes) because of the proximity of existing de-velopment and infrastructure.
- Small communities would achieve protection from a 100-year (1% annual chance) flood event, corresponding to the existing federal standard for developed areas. This would be accomplished primarily via structural repairs or reconstruction of existing nearby SPFC levees. Construction of new training levees, ring levees, or floodwalls immediately adjacent to the communities may also be required. The total length of levee improvement and construction of new levees is approximately 120 miles to protect a population of about 47,000. The targeted level of protection for small communities is considered for planning purposes only, and does not represent a State requirement or target. A total of 27 small communities were included in this approach. Some of these small communities adjacent to existing urban areas may achieve a 100-year level of flood protection or higher as a result of improvements for the adjacent urban areas.



Key: SPFC = State Plan of Flood Control

Figure 2-2. Urban Areas and Small Communities Included in Protect High Risk Communities Approach

Weirs, bypasses, and other control structures would remain unchanged. Some short-term changes in reservoir operations (see Section 3) would be made in anticipation of, and during, flood events.

2.4.2 Initial Assessment

Based on an initial assessment, the Protect High Risk Communities Approach is estimated to cost between approximately $9 billion to $11 billion and take 15 to 20 years to implement. This approach would provide an approximate 63 percent reduction in annual flood damages compared to current conditions.

The potential for loss of life and economic damages in urban areas, which would achieve an urban level of flood protection, would be reduced substantially. Improved flood protection for small communities would also reduce the potential for loss of life and economic damages, while preserving the important resources these communities provide to surrounding rural-agricultural areas. However, levels of protection elsewhere in the valley, particularly rural-agricultural areas, would generally not improve. Consequently, this approach only partially addresses the primary goal of improving flood risk management. Because of the limited extent of levee improvements, relatively minor changes in peak floodflows and stages would occur systemwide.

Although limited, this approach would include the opportunity to improve operations and maintenance of SPFC facilities in the vicinity of a number of urban areas and small communities, including provisions for local erosion monitoring and problem corrections. However, the long-term cost to maintain the system would remain high (similar to current conditions) because this approach would not address chronic erosion, sedimentation, and other geomorphic conditions associated with the majority of rural SPFC facilities. Consequently, this approach would only partially contribute to the goal of improving operations and maintenance.

There would be some opportunities to integrate environmental features into small community and urban area protection actions, including the construction of waterside berms or incorporation of native vegetation or habitat. However, because these opportunities would largely be site-specific, and because the footprint and operation of the SPFC facilities would remain largely unchanged, this approach would not significantly contribute to the restoration of ecosystem functions. Also, there would be few opportunities to incorporate groundwater recharge or other water-related benefits. Consequently, this approach would contribute in only a minor way to the supporting goals of promoting ecosystem functions and multi-benefit projects.

PROTECT HIGH RISK COMMUNITIES APPROACH

- Levee improvements limited to urban areas and small communities, resulting in minimal change to how the system functions and to peak floodflows and stages.
- Significant improvement in public safety over existing conditions.
- Reduction of approximately 63 percent in annual flood damage estimates includes structure values and contents and crops.
- Estimated capital costs for improving SPFC facilities to achieve urban level of protection and for protection of small communities are higher for the Sacramento River Basin because of the greater magnitude of population at risk.

2.5 Preliminary Approach: Enhance Flood System Capacity

This approach focuses on enhancing flood system storage and conveyance capacity to achieve multiple benefits. This approach incorporates all elements included in the prior two approaches to reduce flood risks in urban areas and small communities and at least restore SPFC system capacity in rural areas. Flood system capacity enhancements would be designed on a systemwide scale to integrate multiple benefits, including environmental restoration and water supply reliability.

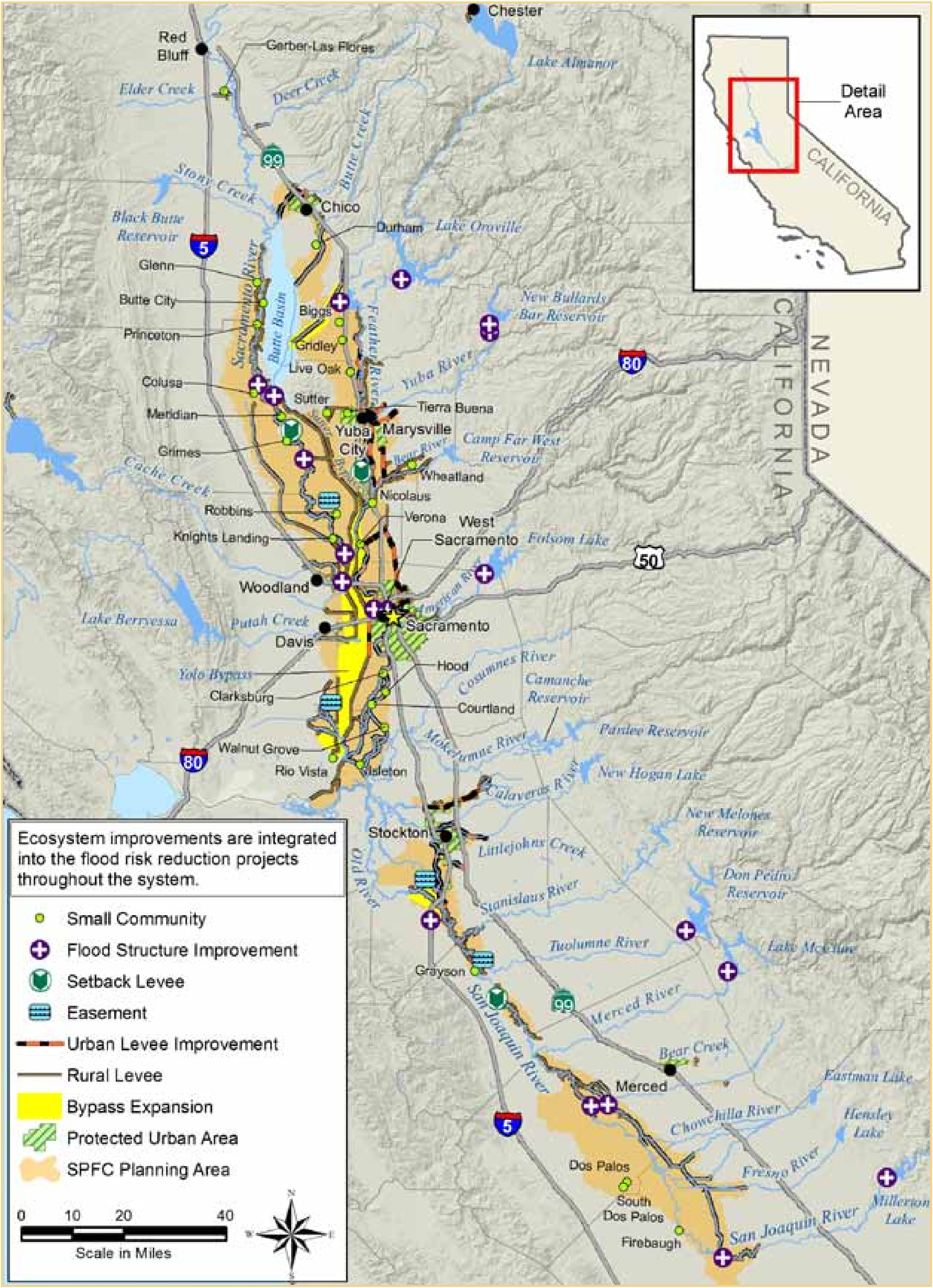
2.5.1 Major Components

This approach includes modifying the existing footprint and function of the flood management system primarily to increase the overall conveyance capacity and floodwater storage, and to provide opportunities for ecosystem restoration and water resources benefits. This approach also protects high risk communities and fixes levees in place in rural-agricultural areas to achieve design flow capacity. This approach does not include improvements that may be needed to address interior drainage or other local sources of flooding. Also, this approach includes improvements to non-SPFC levees that protect some urban areas.

In general, flood system capacity can be increased through widening floodways and bypasses, setting back levees away from the active river channel, and increasing floodwater storage. Floodwater storage can be increased through a combination of operational changes to existing reservoirs, new reservoir storage, and modified or new floodplain storage. Widening floodways and setting back levees along some reaches of major rivers and tributaries also provides significant opportunities to restore native habitat quantity, quality, and connectivity and to restore natural processes necessary to support healthy ecosystems.

In addition to the elements included in the prior two approaches, major elements of the Enhance Flood System Capacity Approach are shown in Figure 2-3 and include the following:

- The existing bypass system in the Sacramento River Basin – including the Sutter and Yolo bypasses and associated inflow weirs – forms the central backbone of the Sacramento River Flood Control Project, forming a corridor for conveying floodflows to the Delta. This approach would increase the capacity of the existing bypass system to enhance its efficiency and ability to convey large flood events. Initial analyses indicate that the following combination of features could effectively enhance the performance of the existing bypass system:
    - » *Widening the Sutter Bypass by up to 1,000 feet to increase its capacity by 50,000 cubic feet per second*
    - » *Widening the Colusa Weir and Bypass and the Tisdale Weir and Bypass by up to 1,000 feet*



Key: SPFC = State Plan of Flood Control

Figure 2-3. Ecosystem Improvement and Restoration Projects are Integrated into Risk Reduction Projects Throughout the System

  - *Widening the Fremont Weir by about one mile, and widening portions of the Yolo Bypass to increase its capacity by 40,000 cubic feet per second*
  - *Widening the Sacramento Weir and Bypass by about 1,000 feet*

- This approach also includes a potential new bypass to divert flows from the Feather River downstream from Oroville Dam along the alignment of Cherokee Canal into Butte Basin. Initial analyses indicate that a bypass with a capacity of 32,000 cubic feet per second could reduce peak flood elevations along the Feather River and help convey floodflows into the existing bypass system.
- In the lower portion of the San Joaquin River Basin, this approach includes a new bypass to divert flows from the San Joaquin River into the south Delta. Preliminary analyses indicate that a new bypass at Paradise Cut, or in its vicinity, with a capacity of about 4,000 cubic feet per second could effectively reduce peak flood stage along the San Joaquin River in the Stockton metropolitan area.
- This approach includes floodway widening along smaller sections of some rivers by setting back SPFC levees as follows:
  - *Along the right bank of the Feather River (below the Bear River confluence) to allow opportunities for ecosystem restoration and to provide continuity with the Sutter Bypass*
  - *Along intermittent sections of the Sacramento River upstream from the Tisdale Weir to provide a more continuous corridor for environmental restoration and to address levee conditions*
  - *Along the San Joaquin River between the Merced and Stanislaus rivers*
- This approach includes modification to the reservoir release schedule and flood storage allocation at Oroville Dam and Reservoir (equivalent to an additional 200,000 acre-feet of flood storage), and coordinated operation with New Bullards Bar Reservoir, to reduce flood stages on the Feather River during a 200-year (0.5% annual chance) flood event. Also, in the San Joaquin River Basin, the State would partner with interested reservoir operators to increase the flood storage allocation at New Don Pedro, Friant, and New Exchequer dams by about 400,000 acre-feet to effectively manage the 100-year (1% annual chance) flood event at these reservoirs. These features help manage the timing and magnitude of peak floodflows before they enter the Sacramento and San Joaquin rivers.
- This approach includes approximately 200,000 acre-feet of transitory storage in the floodplains of the Sacramento River Basin and approximately 100,000 acre-feet of transitory storage in the floodplains of the San Joaquin River Basin. Floodplain storage effectively works with bypass and floodway expansion to attenuate flood peaks and provide opportunities for conservation of agricultural lands and native floodplain habitats.

2.5.2 Initial Assessment

Based on an initial assessment, the Enhance Flood System Capacity Approach is estimated to cost between approximately $32 billion to $41 billion and would take 35 to 40 years to implement. This approach would provide an approximate 80 percent reduction in annual flood damages compared to current conditions.

The expansion of system storage and conveyance capacity would reduce peak flood stages throughout the system. This would result in increased levels of flood protection throughout the system, although levels would continue to vary from location to location. Urban areas would achieve an urban level of flood protection, or higher, through the combination of conveyance, storage improvements, and in-place levee improvements. Flood damages would be significantly reduced to various degrees throughout the system. Accordingly, this approach would address the primary goal of improving flood risk management, although at a high cost.

This approach would provide opportunities to address chronic erosion, geomorphic conditions, and levee foundation conditions that make operations and maintenance of the current system costly and unsustainable. Hence, this approach would significantly address the supporting goal of improving operations and maintenance.

This approach would also provide opportunities to restore native habitats (including aquatic, riparian, and floodplain habitats) and improve the quality and connectivity of environmental resources within the flood management system. In addition, there would be opportunities to improve (1) water supply reliability through multipurpose reservoir storage projects, (2) conjunctive management of groundwater and surface water resources, and (3) groundwater recharge within floodplain storage areas. Accordingly, this approach would address the supporting goals of promoting ecosystem functions and multi-benefit projects.

ENHANCE FLOOD SYSTEM CAPACITY APPROACH

- Expansion of storage and conveyance capacity to attenuate flood peaks, resulting in reduced peak flood stages throughout the system. However, peak floodflows may increase locally in certain reaches as a result of the proposed expansion of bypasses.
- Reduction of approximately 80 percent in annual flood damage estimates includes structure values and contents and crops.
- Higher estimated capital costs for the Sacramento River Basin because of the greater number of levees, and magnitude of assets and population at risk.
- Enlarging the area within the levees, providing more room for floods and habitat and promoting natural hydrologic and geomorphic processes.

2.6 Comparison of Preliminary Approaches

To illustrate the potential tradeoffs among benefits, costs, and other factors relevant to formulation of the SSIA, the three preliminary approaches are compared according to their effectiveness in contributing to the CVFPP Goals and other performance measures.

The following sections show comparisons among the three approaches. These comparisons assisted DWR in selecting superior elements of each preliminary approach when assembling the SSIA.

2.6.1 Major Elements

Table 2-1 shows major elements of the three preliminary approaches. The first two approaches differ significantly regarding improving SPFC facilities. The third approach includes all of the elements of the first two approaches plus many additional elements.

Table 2-1. Major Elements of Preliminary Approaches

FLOOD MANAGEMENT ELEMENT	PROJECT LOCATION OR REQUIRED COMPONENTS	ACHIEVE SPFC DESIGN FLOW CAPACITY	PROTECT HIGH RISK COMMUNITIES	ENHANCE FLOOD SYSTEM CAPACITY
Bypasses				
New Bypass Construction and Existing Bypass Expansion	• Feather River Bypass • Sutter Bypass Expansion • Yolo Bypass Expansion • Sacramento Bypass Expansion • Lower San Joaquin River Bypass (Paradise Cut) Components potentially include land acquisition, levee improvements, and new levee construction			YES
Reservoir Storage and Operations				
Forecast-Coordinated Operations/ Forecast- Based Operations	Fifteen reservoirs with Sacramento River Basin and San Joaquin River Basin	YES	YES	YES
Reservoir Storage/Enlarge Flood Pool	• Oroville • New Bullards Bar • New Don Pedro • McClure • Friant			YES[1]
Easements	• Sacramento River Basin – 200,000 acre-feet • San Joaquin River Basin – 100,000 acre-feet			YES
Flood Structure Improvements				
Major Structures	• Intake structure for Feather River Bypass • Butte Basin small weir structures • Upgrade and modification of Colusa and Tisdale weirs • Sacramento Weir widening and automation • Gate structures and/or weir at Paradise Cut • Upgrade of structures in Upper San Joaquin Bypasses • Low-level reservoir outlets at New Bullards Bar Dam • Fremont Weir widening and improvement • Other pumping plants and small weirs			YES
System Erosion and Bypass Sediment Removal Project	• Cache Creek Settling Basin sediment management • Sacramento System Sediment Remediation Downstream from Weirs			YES

Table 2-1. Major Elements of Preliminary Approaches (cont'd.)

FLOOD MANAGEMENT ELEMENT	PROJECT LOCATION OR REQUIRED COMPONENTS	ACHIEVE SPFC DESIGN FLOW CAPACITY	PROTECT HIGH RISK COMMUNITIES	ENHANCE FLOOD SYSTEM CAPACITY
Urban Improvements				
Target 200-Year Level of Protection	Selected projects developed by local agencies, State, federal partners		YES	YES
Target SPFC Design Capacity	Urban Levee Evaluations Project results	YES[2]		
Non-SPFC Urban Levee Improvements	Includes approximately 120 miles of non-SPFC levees that are closely associated with SPFC urban levees. Performance of these non-SPFC levees may affect the performance of SPFC levees	YES	YES	YES
Small Community Improvements				
Target 100-Year Level of Protection	Small communities protected by the SPFC		YES[3]	YES[3]
Target Design Capacity	Non-Urban Levee Evaluations Project results	YES[2]		YES[2]
Rural-Agricultural Improvements				
Site-Specific Rural-Agricultural Improvements	Based on levee inspections and other identified critical levee integrity needs			
Target Design Capacity	Non-Urban Levee Evaluations Project results	YES[2]		YES
Ecosystem Restoration				
Fish Passage Improvements	• Tisdale Bypass and Colusa Bypass fish passage • Fremont Weir fish passage improvements • Deer Creek			YES
Ecosystem Restoration and Enhancement	For areas within new or expanded bypasses, contributing to or incorporated with flood risk reduction projects			YES
River Meandering and Other Ecosystem Restoration Activities	At selected levee setback locations in Sacramento and San Joaquin river basins			YES

Notes:
[1] All approaches include Folsom Dam Raise, as authorized.
[2] Actual level of protection varies by location.
[3] Includes all small communities within the SPFC Planning Area.
Key:
SPFC = State Plan of Flood Control
State = State of California

Residual Risk Management

In addition to the major physical elements shown above, each approach would require different levels of ongoing annual management of residual risk. Emergency response, flood system operations and maintenance, and floodplain risk management depend on the configuration and reliability of the physical features included in the system. Table 2-2 shows residual risk management for each of the three preliminary approaches. Each column shows the residual risk management actions included for a preliminary approach. The scale of the risk management actions vary among the approaches. For example, the Protect High Risk Communities Approach would

Table 2-2. Residual Risk Management

FLOOD MANAGEMENT ELEMENT	PROJECT LOCATION OR REQUIRED COMPONENTS	ACHIEVE SPFC DESIGN FLOW CAPACITY	PROTECT HIGH RISK COMMUNITIES	ENHANCE FLOOD SYSTEM CAPACITY
Enhanced Flood Emergency Response	All-weather roads on levee crowns	(included in rural levee repairs)	(no rural levee repairs)	(included in rural levee repairs)
	Flood information collection and sharing	YES (small)	YES (large)	YES (small)
	Local flood emergency response planning	YES	YES	YES
	Forecasting and notification		YES	
	Rural post-flood recovery assistance program		YES (large)	
Enhanced Operations and Maintenance	Identify and repair after-event erosion	YES (small)	YES (large)	YES (small)
	Develop and implement enhanced O&M programs and regional O&M organizations	YES	YES	YES
	Sacramento channel and levee management, and bank protection	YES	YES	YES
Floodplain Management	Raising and waterproofing structures and building berms	YES[1]	YES[1]	YES[1]
	Purchasing and relocating homes in floodplains	YES[1]	YES[1]	YES[1]
	Land use and floodplain management	YES	YES	YES

Note:
[1] Ongoing FEMA programs, implementation based on available funding and conformance with federal criteria

Key:
FEMA = Federal Emergency Management Agency
O&M = operations and maintenance
SPFC = State Plan of Flood Control

RESIDUAL RISK MANAGEMENT

Even with the realization of major physical improvements to the flood management system, the risk of flooding can never be completely eliminated. Unanticipated facility failures or extreme flood events may cause flooding. This remaining flood threat is called "residual risk."

DWR manages residual risk through programs governed by DWR's existing organization for FloodSAFE implementation. These programs are responsible for specialized work in the following:

- Flood emergency response
- Flood operations and maintenance
- Floodplain risk management

Areas protected by levees that receive major improvements will generally require lower levels of residual risk management compared with levees that are not improved.

require a "large" effort to identify and repair after-event erosion because rural levees are not improved with this approach. The Enhance Flood System Capacity Approach would require a "small" effort since all levees are improved and many are set back from the rivers. See Section 4 for more discussion of residual risk management.

Costs and Time to Implement

The estimated costs and time to implement the preliminary approaches are shown in Table 2-3.

Cost estimates in the table are for initial costs to implement physical on-the-ground improvements and ongoing annual costs over 25 years to manage the residual risk for each approach. These estimates are based on 2011 dollars and will differ in the future. Because the approaches are not complete alternatives, the cost estimates are likely low, but suitable for comparison of the preliminary approaches. In addition, actual implementation costs would likely be higher than the estimates because of inflation and the length of time needed to implement the work. The cost estimates allow for planning studies, design, and permitting. The estimates also include costs for ecosystem mitigation for the first two preliminary approaches. For the Enhance Flood System Capacity Approach, the goal in integrating ecosystem restoration and enhancement is to achieve overall habitat improvement, thereby reducing or eliminating the need to mitigate for most ecosystem impacts. However, depending on the timing of improvements and implementation, some ecosystem mitigation may be required.

Table 2-3. Estimated Cost of Approaches

PRELIMINARY APPROACH	LOW COST ($ BILLION)		HIGH COST ($ BILLION)	IMPLEMENTATION (YEARS)
Achieve SPFC Design Flow Capacity	19	to	23	30 – 35
Protect High Risk Communities	9	to	11	15 – 20
Enhance Flood System Capacity	32	to	41	35 – 40

Key:
SPFC = State Plan of Flood Control

The estimates of time to implement are based on experience with past flood projects, but with assumptions of more efficient execution of planning and design, engaged federal and local partners, streamlined permitting, and timely funding. In the past, many flood protection projects have remained in the feasibility study phase for a decade or more. Large, complicated projects have often taken several decades to progress from initial concept to completion. Maintaining focus to complete projects in a timely manner is often difficult, especially given changing commitments from State, federal, and local partners over long periods of time.

Peak Flow and Stage Changes

The three preliminary approaches result in different peak flows and stages. Hydrologic and hydraulic modeling for the three preliminary approaches provides estimates of peak flow and stage compared to current conditions (No Project) at key SPFC locations. Modeling considers levee condition and probability of levee failures, which influence floodwater surface elevations. Figure 2-4 shows peak 100-year (1% annual chance) floodflows at several of these locations within the Sacramento River Basin for current conditions (No Project) and the three preliminary approaches. The figure also shows the corresponding peak stage change for each preliminary approach compared to current conditions.

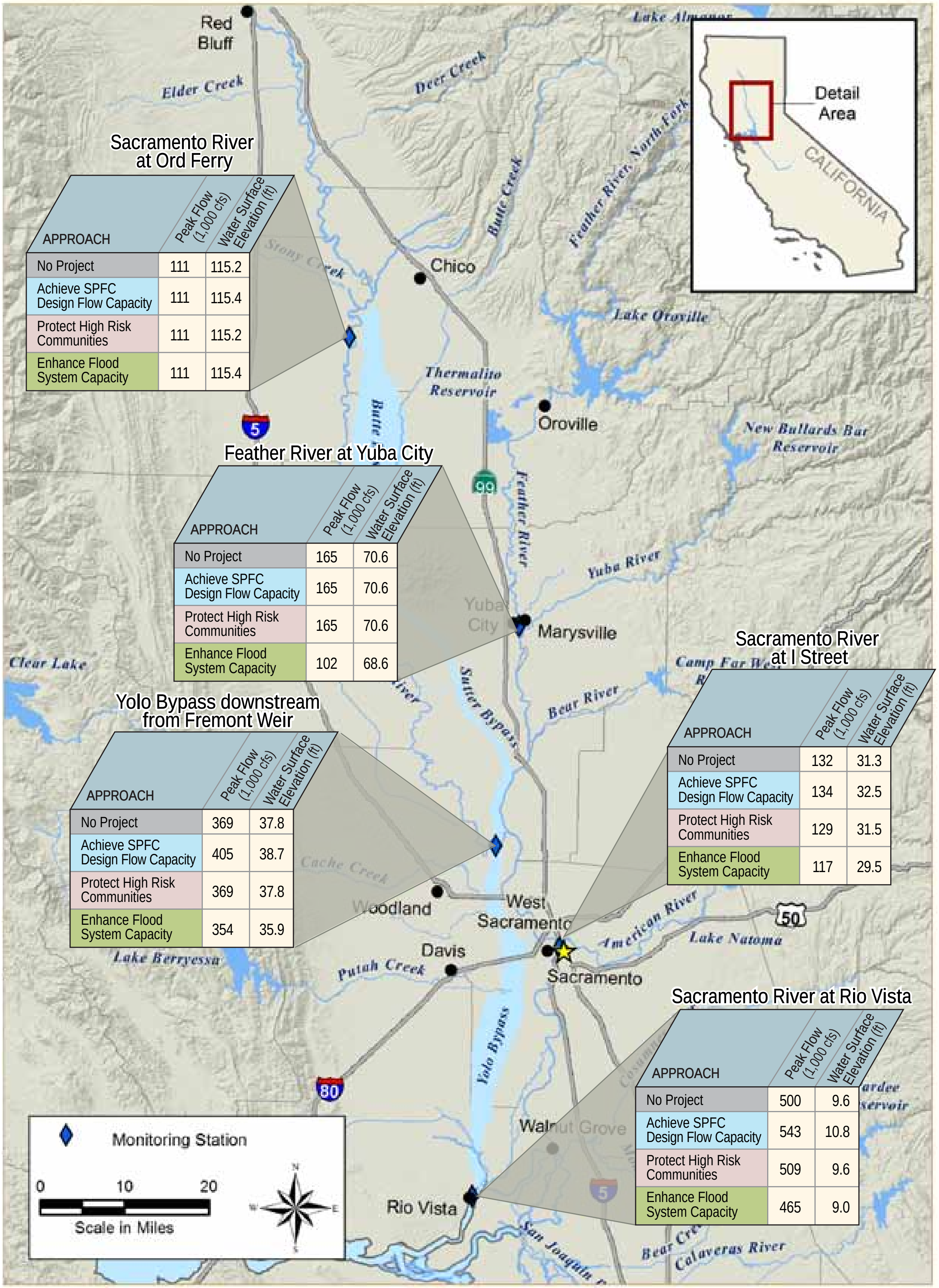
Figure 2-5 shows peak 100-year (1% annual chance) floodflows at several of these locations within the San Joaquin River Basin for current conditions and the three preliminary approaches. The figure also shows the corresponding peak stage for each preliminary approach compared to current conditions.

In general, the Achieve SPFC Design Flow Capacity Approach results in higher river stages than for existing conditions (No Project) because levee rehabilitation occurs in place and levee failures are reduced. A separate detailed analysis beyond the scope of the CVFPP would be needed to identify whether any increased river stage would cause a significant hydraulic impact. The Protect High Risk Communities Approach results in relatively little stage change compared with existing conditions because levee improvements are focused in small areas, and much of the levee system remains in its current condition. The Enhance Flood System Capacity Approach generally provides for lower flood stages, except in the upper San Joaquin River Basin Bypass, because flood peaks are lowered by storage, and bypasses provide wider flow areas that reduce stages.

Performance in Meeting Goals

Table 2-4 compares the relative contributions of the preliminary approaches to the CVFPP primary goal of improving flood risk management. Contributions to the primary goal are described in terms of level of flood protection, public safety, and economic damages.

Table 2-5 compares the relative contributions of the preliminary approaches to the CVFPP supporting goals of Improve Operations and Maintenance, Promote Ecosystem Functions, and Promote Multi-Benefit Projects. Table 2-5 also assesses the relative completeness of the preliminary approaches described as the ability to meet the various objectives described in the authorizing legislation.



Sacramento River at Ord Ferry

APPROACH	Peak Flow (1,000 cfs)	Water Surface Elevation (ft)
No Project	111	115.2
Achieve SPFC Design Flow Capacity	111	115.4
Protect High Risk Communities	111	115.2
Enhance Flood System Capacity	111	115.4

Feather River at Yuba City

APPROACH	Peak Flow (1,000 cfs)	Water Surface Elevation (ft)
No Project	165	70.6
Achieve SPFC Design Flow Capacity	165	70.6
Protect High Risk Communities	165	70.6
Enhance Flood System Capacity	102	68.6

Yolo Bypass downstream from Fremont Weir

APPROACH	Peak Flow (1,000 cfs)	Water Surface Elevation (ft)
No Project	369	37.8
Achieve SPFC Design Flow Capacity	405	38.7
Protect High Risk Communities	369	37.8
Enhance Flood System Capacity	354	35.9

Sacramento River at I Street

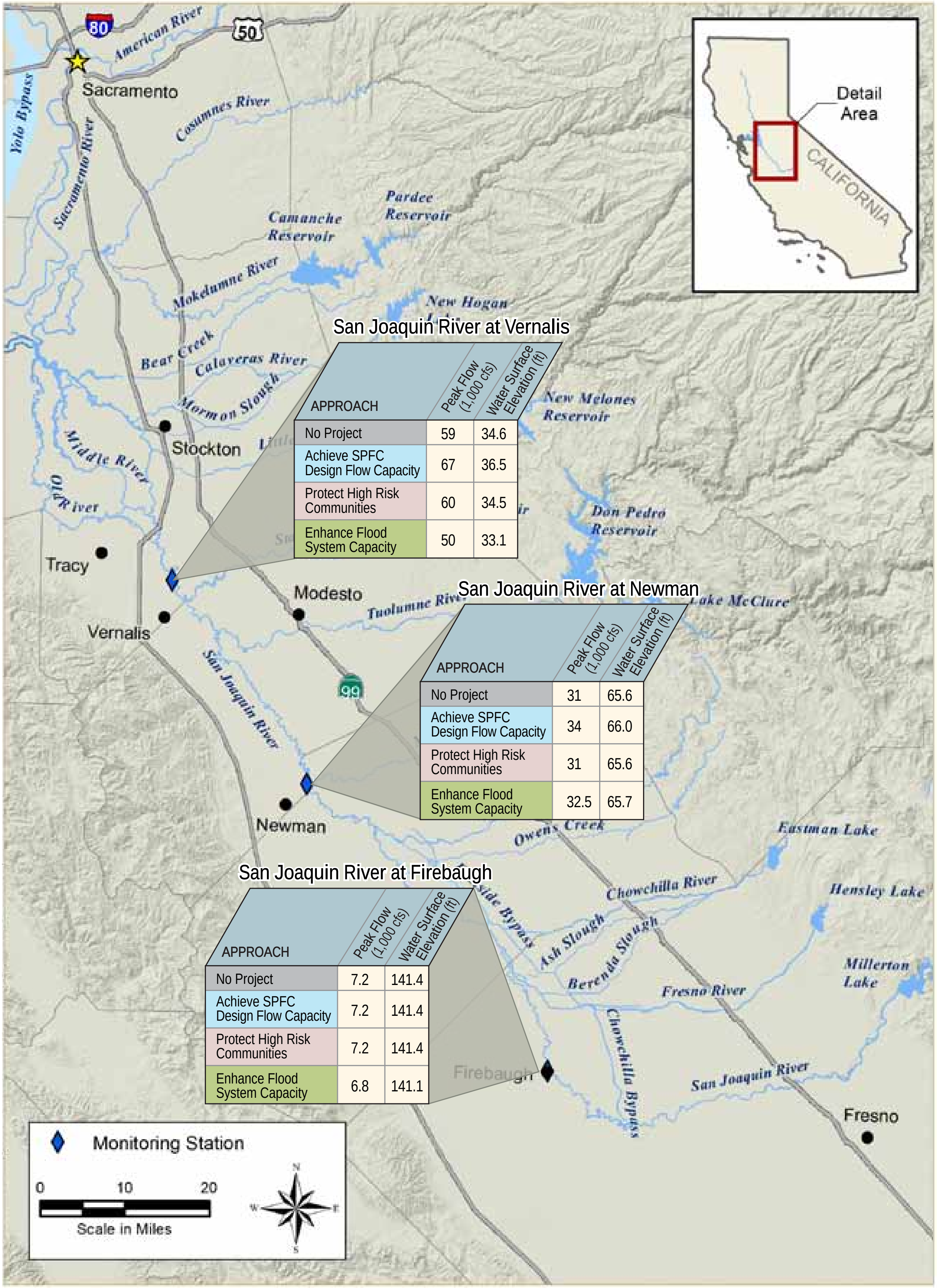
APPROACH	Peak Flow (1,000 cfs)	Water Surface Elevation (ft)
No Project	132	31.3
Achieve SPFC Design Flow Capacity	134	32.5
Protect High Risk Communities	129	31.5
Enhance Flood System Capacity	117	29.5

Sacramento River at Rio Vista

APPROACH	Peak Flow (1,000 cfs)	Water Surface Elevation (ft)
No Project	500	9.6
Achieve SPFC Design Flow Capacity	543	10.8
Protect High Risk Communities	509	9.6
Enhance Flood System Capacity	465	9.0

Note: Location of peak flow and water surface elevation estimates for 100-Year storm event at selected monitoring locations in the Sacramento River Basin.
Key: cfs = cubic feet per second ft = feet SPFC = State Plan of Flood Control

Figure 2-4. Simulated Peak Flow and Stage Changes in Sacramento River Basin for 100-year Storm Events



San Joaquin River at Vernalis

APPROACH	Peak Flow (1,000 cfs)	Water Surface Elevation (ft)
No Project	59	34.6
Achieve SPFC Design Flow Capacity	67	36.5
Protect High Risk Communities	60	34.5
Enhance Flood System Capacity	50	33.1

San Joaquin River at Newman

APPROACH	Peak Flow (1,000 cfs)	Water Surface Elevation (ft)
No Project	31	65.6
Achieve SPFC Design Flow Capacity	34	66.0
Protect High Risk Communities	31	65.6
Enhance Flood System Capacity	32.5	65.7

San Joaquin River at Firebaugh

APPROACH	Peak Flow (1,000 cfs)	Water Surface Elevation (ft)
No Project	7.2	141.4
Achieve SPFC Design Flow Capacity	7.2	141.4
Protect High Risk Communities	7.2	141.4
Enhance Flood System Capacity	6.8	141.1

Note: Location of peak flow and water surface elevation estimates for 100-Year storm event at selected monitoring locations in the San Joaquin River Basin.

Key: cfs = cubic feet per second   ft = feet   SPFC = State Plan of Flood Control

Figure 2-5. Simulated Peak Flow and Stage Changes in San Joaquin River Basin for 100-year Storm Events

Table 2-4. Relative Comparison of Preliminary Approach Contributions to Central Valley Flood Protection Plan Primary Goal

METRIC	EXISTING SYSTEM (NO PROJECT)	PRELIMINARY APPROACHES		
		ACHIEVE SPFC DESIGN FLOW CAPACITY	PROTECT HIGH RISK COMMUNITIES	ENHANCE FLOOD SYSTEM CAPACITY
Contributions to Primary Goal – Improve Flood Risk Management				
– Level of Flood Protection	Varies throughout system • Most urban areas do not have urban level of flood protection • Protection to rural-agricultural areas and small communities varies widely	Varies throughout system • Substantial improvement in rural-agricultural areas and partial improvement in urban areas • SPFC facilities reliably pass design flow capacities • Levels of flood protection associated with SPFC design flow capacities vary throughout the system	High in urban areas and small communities, varies elsewhere • Urban areas achieve 200-year flood protection • Small communities achieve 100-year flood protection	Overall higher protection, but varies throughout system • Urban areas achieve 200-year flood protection • Small communities achieve 100-year flood protection • Overall increased levels of flood protection throughout system
– Public Safety (focused on population at risk)	Varies throughout system • Public safety threat is high for many communities, particularly those in deep floodplains • **79% of population with less than 100-year protection**	Some improvement • Improvement in urban areas • Improvement in some small communities protected by SPFC facilities • **46% of population with less than 100-year protection**	Highest improvement • Substantial improvement in urban areas • Improvement in small communities • **6% of population with less than 100-year protection**	Improvement varies • Improvement in urban areas • Improvement in small communities and rural-agricultural areas • **5% of population with less than 100-year protection**
– Economic Damages[1]	Very high potential for damages • Economic damages, particularly in urban areas, are very high • $329 million/year in EAD	Reduction in rural-agricultural area damages • Substantial reduction throughout rural areas; some reduction in urban areas • 43% reduction in total EAD	Reduction in urban and small community damages • Substantial reduction due to focus on protecting urban areas and small communities • 63% reduction in total EAD	Reduction in urban and rural-agricultural area damages • Substantial reduction due to increased storage and conveyance • 80% reduction in total EAD

Note:
[1] Structure and content values used parcel data from the 2010 June ParcelQuest with an October 2010 price index. Parcel data were updated based on information (including depreciation, construction quality, construction class, occupancy type, etc.) in reconnaissance-level field surveys collected from summer 2010 to summer 2011.
Crop data acreages were from the May 2010 DWR GIS land use datasheet. Crop damage unit costs were originated from the *Sacramento and San Joaquin River Basins Comprehensive Study* (USACE, 2002) and were adjusted to an October 2010 price index. Expected annual damages include structure and content, crop, and business income loss.

Key:
DWR = California Department of Water Resources
EAD = expected annual damages
GIS = geographic information system
SPFC = State Plan of Flood Control
USACE = U.S. Army Corps of Engineers

Table 2-5. Comparison of Preliminary Approach Contributions to Central Valley Flood Protection Plan Supporting Goals and Completeness

GOAL/METRIC	EXISTING SYSTEM (NO PROJECT)	PRELIMINARY APPROACHES		
		ACHIEVE SPFC DESIGN FLOW CAPACITY	PROTECT HIGH RISK COMMUNITIES	ENHANCE FLOOD SYSTEM CAPACITY
Contributions to Supporting Goals				
Improve Operations and Maintenance	Ongoing and long-term O&M requirements remain very high	Initial decrease in O&M costs, but remain high long-term • SPFC reconstruction would initially decrease O&M requirements • Long-term O&M costs would remain high because of potential conflicts with natural geomorphic process	Increase in long-term O&M requirements • Potential cost increase due to the construction of approximately 120 miles of new levees to protect small communities	Decrease in long-term O&M requirements • Decrease in long-term costs due to modifications that make the system more compatible with natural geomorphic processes and facilitate vegetation management and removal of facilities
Promote Ecosystem Functions	Limited opportunities for ecosystem restoration • Native habitat may be integrated into SPFC facility repair projects, primarily through mitigation	Limited opportunities for ecosystem restoration • Limited opportunities to integrate ecosystem restoration into in-place repairs to SPFC facilities	Limited opportunities for ecosystem restoration • Limited opportunities to integrate restoration into in-place repairs in urban areas, and new facilities protecting small communities	Substantial opportunities for ecosystem restoration • Floodplain expansion improves ecosystem functions, fish passage, and the quantity, quality, and diversity of habitats
Promote Multi-Benefit Projects	Limited opportunities for multi-benefit projects • Limited opportunities to integrate other benefits into repairs to SPFC facilities	Limited opportunities for multi-benefit projects • Limited opportunities to integrate other benefits into repairs to SPFC facilities	Limited opportunities for multi-benefit projects • Limited opportunities to integrate other benefits into repairs, improvements, and new levees	Enhanced opportunities for multi-benefit projects • Increased opportunities to integrate water quality, groundwater recharge, recreation, power, and other benefits
Completeness (ability to meet legislative objectives)				
Ability to Meet Objectives in Flood Legislation	Do not meet • Varied level of protection throughout the system and high potential for risks to public safety and economic damages	Partially meets • Limited contributions to environmental and water supply objectives; does not achieve high level of urban flood protection	Partially meets • Limited contributions to environmental and water supply objectives	Mostly meets • Contributes to all objectives, but at highest cost and with substantial impacts to existing land uses (potentially low acceptability)

Key:
O&M = operations and maintenance
SPFC = State Plan of Flood Control

Sustainability

Table 2-6 compares the sustainability aspects of the preliminary approaches. Sustainability relates to the overall financial, environmental, social, and climate change adaptability aspects of the flood management system under a given approach.

Table 2-6. Relative Comparison of Preliminary Approach Sustainability

METRIC	EXISTING SYSTEM (NO PROJECT)	PRELIMINARY APPROACHES		
		ACHIEVE SPFC DESIGN FLOW CAPACITY	PROTECT HIGH RISK COMMUNITIES	ENHANCE FLOOD SYSTEM CAPACITY[1]
Sustainability (financial, environmental, and social)				
Social	• Significant risk to public safety and high economic consequences of flooding	• Chance for redirected growth outside floodplain from where currently planned due to extensive levee improvements in nonurban areas • Some land use impacts due to acquisition/easements to accommodate SPFC reconstruction	• Some potential to encourage new development in floodplains within and adjacent to urban area and small community improvements	• Considerable impacts to existing land uses due to floodway expansion • Some potential to encourage new development in floodplains due to improved level of flood protection
Climate Change Adaptability	• Low system resiliency (i.e., ability to adapt to climate change)	• Does not improve flood system resiliency	• Does not improve flood system resiliency	• Improves flood system resiliency by enhancing storage and conveyance

Key:
SPFC = State Plan of Flood Control

Qualitative Comparison

Considering evaluation information available for the preliminary approaches, including information shown on the preceding pages, DWR prepared a qualitative comparison to show broad differences in potential performance of the approaches. Figure 2-6 shows estimated relative performance for each preliminary approach. For example, an open circle indicates the lowest performance and a full circle indicates the highest performance.

PERFORMANCE CATEGORY	ACHIEVE SPFC DESIGN FLOW CAPACITY	PROTECT HIGH RISK COMMUNITIES	ENHANCE FLOOD SYSTEM CAPACITY
Flood Risk Reduction Benefit	Moderate	Moderate-High	High
Level of Flood Protection	Low-Moderate	Moderate	High
Life Safety	Low-Moderate	Moderate-High	Moderate-High
Reduction in Economic Damages	Moderate	Moderate-High	Moderate-High
Regional Economics	Moderate	Moderate-High	High
Integration and Sustainability	Low	Low-Moderate	High
Promote Ecosystem Functions	Low	Low	High
Promote Multi-Benefit Projects	Low	Low-Moderate	High
Sustainable Land Uses	Low	Low-Moderate	High
Cost	$$$	$$	$$$
Capital Costs	$$$	$	$$$$
Operations & Maintenance	$$	$$$$	$

BENEFIT KEY

- Low
- Low-Moderate
- Moderate
- Moderate-High
- High

COST KEY

- $ Low-Moderate
- $$ Moderate
- $$$ Moderate-High
- $$$$ High

Key: SPFC = State Plan of Flood Control

Figure 2-6. Performance Comparison for Preliminary Approaches

Another view of the relative performance of the three preliminary approaches is shown in Figure 2-7. The figure shows estimated performance in terms of secondary benefits (supporting goals from Section 1) against the performance for the primary goal of flood risk reduction. For example, the Achieve SPFC Design Flow Capacity Approach and the Protect High Risk Communities Approach perform similarly for secondary benefits, but the Protect High Risk Communities Approach performs better for flood risk reduction. The figure also plots the size of the approaches (circles) in proportion to their estimated costs.

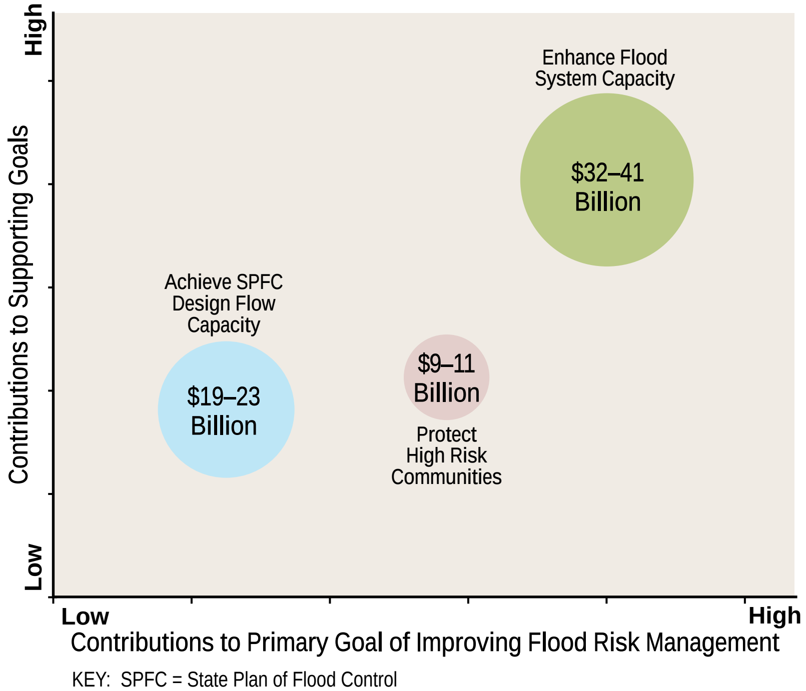
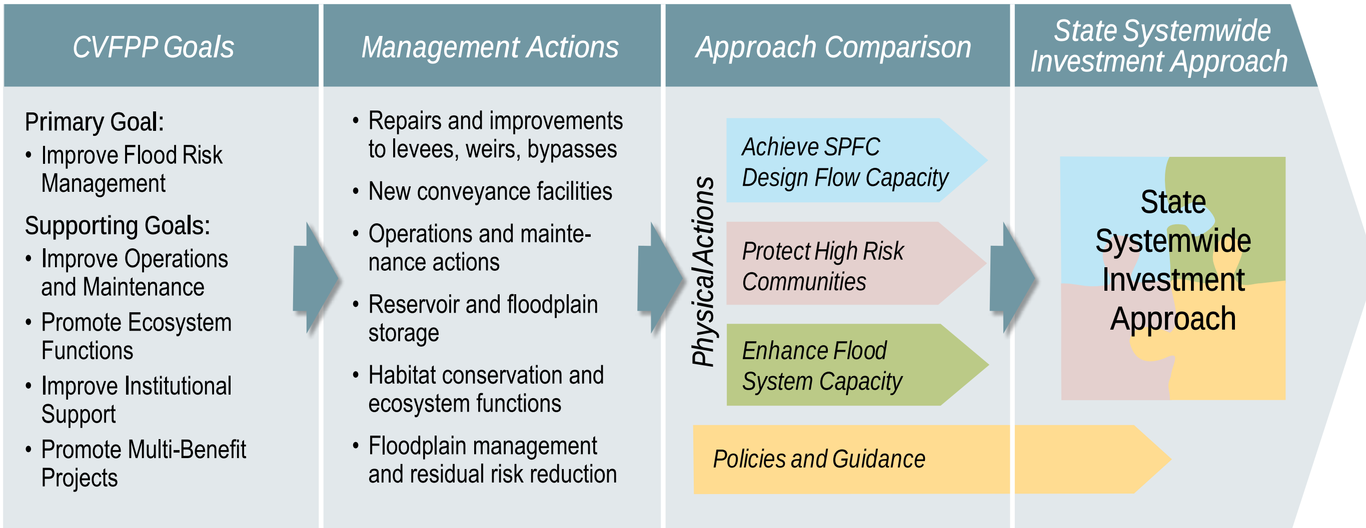


Figure 2-7. Relative Cost and Performance of Three Preliminary Approaches

2.7 Preferred Approach — Meeting Central Valley Flood Protection Plan Goals

Based on relative comparisons of the three preliminary approaches, the Enhance Flood System Capacity Approach best meets and exceeds the CVFPP Goals, but requires the highest level of investment and significant institutional changes. As shown in Tables 2-5 and 2-6, among the three preliminary approaches the Enhance Flood System Capacity Approach is the only approach that substantially improves resiliency to climate change while meeting the objectives delineated in the authorizing legislation in the highest degree. However, each approach highlights opportunities to achieve the goals in different ways, to different degrees, and at different costs. The Enhance Flood System Capacity Approach has a substantially high capital cost, but lower levee operations and maintenance costs compared to the other approaches. The Protect High Risk Communities Approach is the least costly approach, and would result in substantial reduction in flood risks to urban areas and small communities.

Figure 2-8 shows a schematic of the process to assemble the SSIA. CVFPP Goals show what needs to be accomplished to solve problems with the SPFC and address existing challenges to managing the complex flood protection system. Management actions are the building blocks that are used in various ways to develop the preliminary approaches. Comparison of the preliminary approaches helps articulate the trade-offs among various physical actions and also helps develop policies and guidance for the SSIA.



KEY: CVFPP = Central Valley Flood Protection Plan SPFC = State Plan of Flood Control

Figure 2-8. Formulation and Comparison of Approaches to Flood Management in Central Valley

Examination of the performance of preliminary approaches highlights the need to develop a State flood management strategy that combines the strengths of each of the three preliminary approaches into a single approach – the SSIA. The examination considered five distinguishing characteristics that are important from a State investment perspective: (1) life safety, (2) vibrant agricultural economy, (3) reduction in economic losses, (4) ecosystem restoration and enhancements, and (5) cost to implement.

The three preliminary approaches presented above contributed to these characteristics in different degrees. For example, the Achieve SPFC Design Flow Capacity Approach would provide protection for rural-agricultural areas, with less emphasis on an urban level of flood protection and ecosystem benefits. The Protect High Risk Communities Approach would achieve 200-year (0.5% annual chance) urban protection and associated life safety benefits, but would not contribute to rural-agricultural flood risk reduction. The Enhance Flood System Capacity Approach would provide multiple benefits, but at a high cost. The SSIA also incorporates evolving State policies and guidance on a number of issues important to effective flood management in the Central Valley.

The SSIA begins with the Protect High Risk Communities Approach, but encompasses aspects of each of the preliminary approaches, to balance achievement of the CVFPP Goals from a systemwide perspective. The SSIA would also improve rural-agricultural levees, where feasible. Some rural-agricultural levees would be integrated into system improvements (bypasses) presented in the Enhance Flood System Capacity Approach. As configured, the SSIA is rooted in the vision for the CVFPP and is designed for efficient conveyance of floodflows from existing watershed reservoirs through the Delta. The SSIA has many beneficial features that were included in the three preliminary approaches and the cost and time to implement would be more reasonable.

Following are additional observations on the performance of the preliminary approaches that contributed to formulation of the SSIA.

Achieve SPFC Design Flow Capacity – Improving the existing flood management system to meet current engineering criteria within its existing footprint:

- Is very expensive considering that it primarily addresses the Improve Flood Risk Management goal and does little for supporting goals, especially for promoting multi-benefit projects
- Level of flood protection is significantly improved throughout the system, but is spatially highly variable
- Would increase the population receiving at least a 100-year (1% annual chance) level of flood protection from about 21 percent to about 54 percent compared with existing conditions
- May initially improve operations and maintenance conditions, but long-term benefits are questionable
- Does little to improve ecosystem functions
- May increase flood risks (residential development) in rural-agricultural areas
- Would create significant increases in downstream flood stages over existing conditions by reducing the chance of levee failures upstream
- Would reduce potential flood damages by about 47 percent compared to existing conditions
- Need for residual risk management would be reduced from existing conditions

Protect High Risk Communities – Improving levees in urban areas and small communities:

- Protects, with the least investment, the majority of the population
- Does little to address supporting goals of improving operations and maintenance and promoting ecosystem functions
- Would do little to contribute to adaptive flood management
- Urban areas would achieve 200-year (0.5% annual chance) level of flood protection
- Small communities within the area protected by facilities of the SPFC would achieve 100-year (1% annual chance) of flood protection
- Would increase the population receiving at least a 100-year (1% annual chance) level of flood protection from about 21 percent to about 94 percent compared with existing conditions
- Level of flood protection for rural-agricultural areas would remain unchanged
- Relatively few increases in downstream flood stages from upstream improvements

- Would reduce potential flood damages by about 63 percent compared to existing conditions
- Need for residual risk management would be the highest among the preliminary approaches

Enhance Flood System Capacity – Improving urban, small communities, and rural-agricultural levees along with expanded flow capacity:

- Is by far the most expensive approach
- Significantly meets all CVFPP Goals
- Urban areas would likely exceed 200-year (0.5% annual chance) level of flood protection
- Many small communities would likely exceed 100-year (1% annual chance) level of flood protection
- Most areas, including rural-agricultural areas, would benefit from lower flood stages, improved levee conditions, and improved levees constructed for bypass expansion
- Would reduce potential flood damages by about 80 percent compared to existing conditions
- Would increase the population receiving at least a 100-year (1% annual chance) level of flood protection from about 21 percent to about 95 percent compared with existing conditions
- Need for residual risk management would be the lowest among the preliminary approaches
- Includes significant ecosystem features and multipurpose projects

2.8 Key Implications for State Systemwide Investment Approach

Evaluation and comparison of the preliminary approaches highlighted various findings and implications that informed preparation of the SSIA, described in more detail in Section 3. Key implications are summarized below:

- Levels of flood protection should be commensurate with risk within the floodplains.
- Investments should not result in increased flood risk.
- Investments should promote actions that increase system flexibility and the ability to accommodate and attenuate large flood peaks.
- High operations and maintenance costs are driven in part by the current footprint of the levee system, which in many locations is at odds with natural geomorphic processes.
- To fully realize efficient and sustainable operations and maintenance over the long term, the State should consider changes to institutional arrangements, practices, and funding.

- A comprehensive SSIA should develop and implement policies and programs that help manage residual risks that remain after improvement projects are implemented.
- Systemwide and regional (urban areas, small communities, and rural-agricultural areas) elements representing proposed flood management system improvements both have roles in the SSIA.
- Central Valley cities and counties that wish to continue to develop in urban areas are required to achieve an urban level of flood protection (200-year flood), defined in California Government Code Section 65007(l) and California Water Code Section 9602(i). The State supports achieving an urban level of flood protection, at a minimum, for all existing urban and urbanizing areas in the Systemwide Planning Area. Where feasible, the State supports consideration of higher levels of flood protection, particularly for existing urban and adjacent urbanizing areas in deep floodplains (greater than 3 feet of flooding during a 200-year flood).
- From a systemwide perspective, it is in the State's interest to support the continued viability of small communities within the Systemwide Planning Area to preserve cultural and historical continuity and important social, economic, and public services to rural-agricultural populations, agricultural enterprises, and commercial operations.
- New development in nonurbanized areas, including small communities, must meet the national FEMA standard of flood protection, per California Government Code Sections 65865.5, 65962, and 66474.5. This corresponds to the minimum level of flood protection (100-year flood) required to remove or exclude an area or community from a Special Flood Hazard Area (SFHA) as defined by FEMA.
- Many rural-agricultural areas would benefit from systemwide elements of the SSIA, which provides direct flood risk reduction benefits by lowering flood stages and more efficiently moving floods through the system.
- While the State supports improving rural-agricultural flood protection to foster and support economic viability, it should be done in a way that minimizes the potential for being growth inducing.

KEY ELEMENTS OF STATE SYSTEMWIDE INVESTMENT APPROACH

The vision of an integrated systemwide and sustainable flood management plan for the Central Valley is to develop a flood management system that provides for the following:

- Minimum of 200-year level of protection for urban communities protected by facilities of the SPFC
- Lower peak flood stage through much of the system, especially for the Feather, lower Sacramento, and lower San Joaquin rivers
- 100-year level of protection for small communities, where feasible
- Proactive floodplain management, including a program to floodproof and/or relocate structures in the floodplains where building ring levees and other flood structures is not feasible
- Enhancing rural-agricultural area flood protection by repairing known localized problems that cause the highest risk of exposure and by restoring all-weather roads on levee crests
- Leveraging flood system improvements to create habitat through levee setbacks, waterside planting berms, and extension and expansion of bypass systems and to connect riparian habitat from the Delta to Butte Basin and Oroville and to the San Joaquin River
- Connecting fishery habitat from the Delta to Yolo and Sutter bypasses and to Butte Creek
- Supporting policies, implementation programs, and financing strategy

- The State supports corridor management planning approaches to develop integrated, multi-benefit projects.
- State and local-proposed changes and reforms to FEMA's National Flood Insurance Program are expected to promote a vibrant agricultural economy in the rural-agricultural areas that do not have protection from a 100-year flood.
- The State supports implementing integrated projects to achieve multiple benefits, including environmental conservation and restoration, agricultural conservation, water supply and quality, and related benefits.
- Recognizing the benefits to both public safety and the ecosystem, the State has a great interest in integrated environmental stewardship and flood management to leverage investments and associated benefits.
- All levels of project planning and development need to consider opportunities to integrate ecosystem enhancements with flood damage reduction projects.
- The State should encourage programs that provide incentives for including ecosystem improvements and other multi-benefits to projects, as outlined in California Water Code Section 12585.7.

3.0 STATE SYSTEMWIDE INVESTMENT APPROACH

The State Systemwide Investment Approach (SSIA) reflects the State's strategy for modernizing the SPFC to address current challenges and affordably meet the CVFPP Goals described in Section 1. The preliminary approaches, described in Section 2, suggested a broad range of physical and institutional flood damage reduction actions to improve public safety and achieve economic, environmental, and social sustainability. The SSIA is an assembly of the most promising, affordable, and timely elements of the three preliminary approaches.

The State Systemwide Investment Approach provides guidance for future State participation in projects and programs for integrated flood management in the Central Valley.

Physical elements for the SSIA are organized into regional and system elements:

- **Urban, small community, and rural-agricultural improvements** – These are physical actions or projects to achieve local and regional benefits.
- **System improvements** – These are projects and modifications to the SPFC that provide cross-regional benefits, improving the overall function and performance of the SPFC, and are generally large system improvements, such as bypass expansions. The State will provide leadership in developing and implementing these components.

The regional and system elements require detailed analyses to refine how elements may complement each other and to develop appropriate justification for future selection of on-the-ground projects. The SSIA reflects a broad vision for SPFC modernization; therefore, element refinements, additions, and deletions can be expected as a result of future feasibility studies.

Section 2 introduced elements of the SSIA. The following sections provide a more detailed description of the SSIA, its estimated cost, residual risk management needs, and a preliminary presentation of expected performance. Section 4 describes how the SSIA is expected to be implemented and managed over the next several decades.

3.1 Major Physical Improvements in Sacramento and San Joaquin River Basins

Existing SPFC facilities in the Sacramento River Basin are much more extensive and protect larger populations and assets than SPFC facilities in the San Joaquin River Basin. In addition, peak floodflows from the Sacramento River Basin can be about 10 times higher than those from the San Joaquin River Basin. Therefore, physical improvements included in the SSIA are more extensive within the

Sacramento River Basin than within the San Joaquin River Basin. Table 3-1 shows important characteristics of the Sacramento and San Joaquin river basins.

Table 3-1. Key Characteristics of Sacramento and San Joaquin River Basins

CHARACTERISTICS	SACRAMENTO RIVER BASIN	SAN JOAQUIN RIVER BASIN
Land Area Within 500-Year (0.2% annual chance) Floodplain (acres)	**1,217,883**	**697,465**
Population at risk[1] (people)	*762,000*	*312,000*
Replacement value of assets at risk ($ millions)	*53,000*	*16,000*
Total SPFC Levees (miles)	**1,054**	**448**
SPFC Levees with identified threat factors[2] (miles)	*852*	*354*
Total Potential 2-Year (50% annual chance) Floodplains (acres)	**235,000**	**85,000**
Currently connected to river (acres)	*93,000*	*26,000*
Currently connected and in native/natural habitat (acres)	*50,000*	*19,000*
Total Reservoir Capacity[3] Tributary to Area (thousand acre-feet)	**10,477**	**7,100**
Reserved Flood Storage Space	*3,066*	*1,881*

Notes:

[1] Estimated population (from 2000 U.S. Census data) within 500-year floodplain.

[2] Source: *Flood Control System Status Report* (DWR, 2011). Includes Urban Levee Evaluations Project classifications "Marginal" and "Does Not Meet Criteria," and Non-Urban Levee Evaluations Project categories B (Moderate) and C (Low).

[3] Only includes reservoirs with dedicated flood storage space.

Key:
SPFC = State Plan of Flood Control

CENTRAL VALLEY FLOOD PROTECTION PLAN OF 2008

California Water Code Section 9614. "The Plan shall include…

(i) A description of both structural and nonstructural methods for providing an urban level of flood protection to current urban areas where an urban area means the same as set forth in subdivision (k) of Section 5096.805 of the Public Resources Code. The description shall also include a list of recommended next steps to improve urban flood protection."

Major physical (capital improvement) elements included in the SSIA are shown in Table 3-2 and in the schematics in Figures 3-1 and 3-2 for the Sacramento and San Joaquin river basins. The following sections provide more description of urban, small community, rural-agricultural, and system improvements.

3.2 Urban Flood Protection

Consistent with legislation passed in 2007, the SSIA proposes improvements to urban (populations greater than 10,000) levees to achieve protection from the 200-year (0.5% annual chance) flood, at a minimum. With some exceptions, existing SPFC levees in urban areas are often located immediately adjacent to houses and business, leaving few opportunities for setting levees back or making improvements that enlarge levee footprints. Therefore, reconstruction of existing urban levees is generally the method for increasing flood protection. The State is already supporting many SPFC urban levee improvement projects through its Early Implementation Program grants program and other FloodSAFE efforts, including some setback levees.

Table 3-2. Major Physical and Operational Elements of Preliminary Approaches and State Systemwide Investment Approach

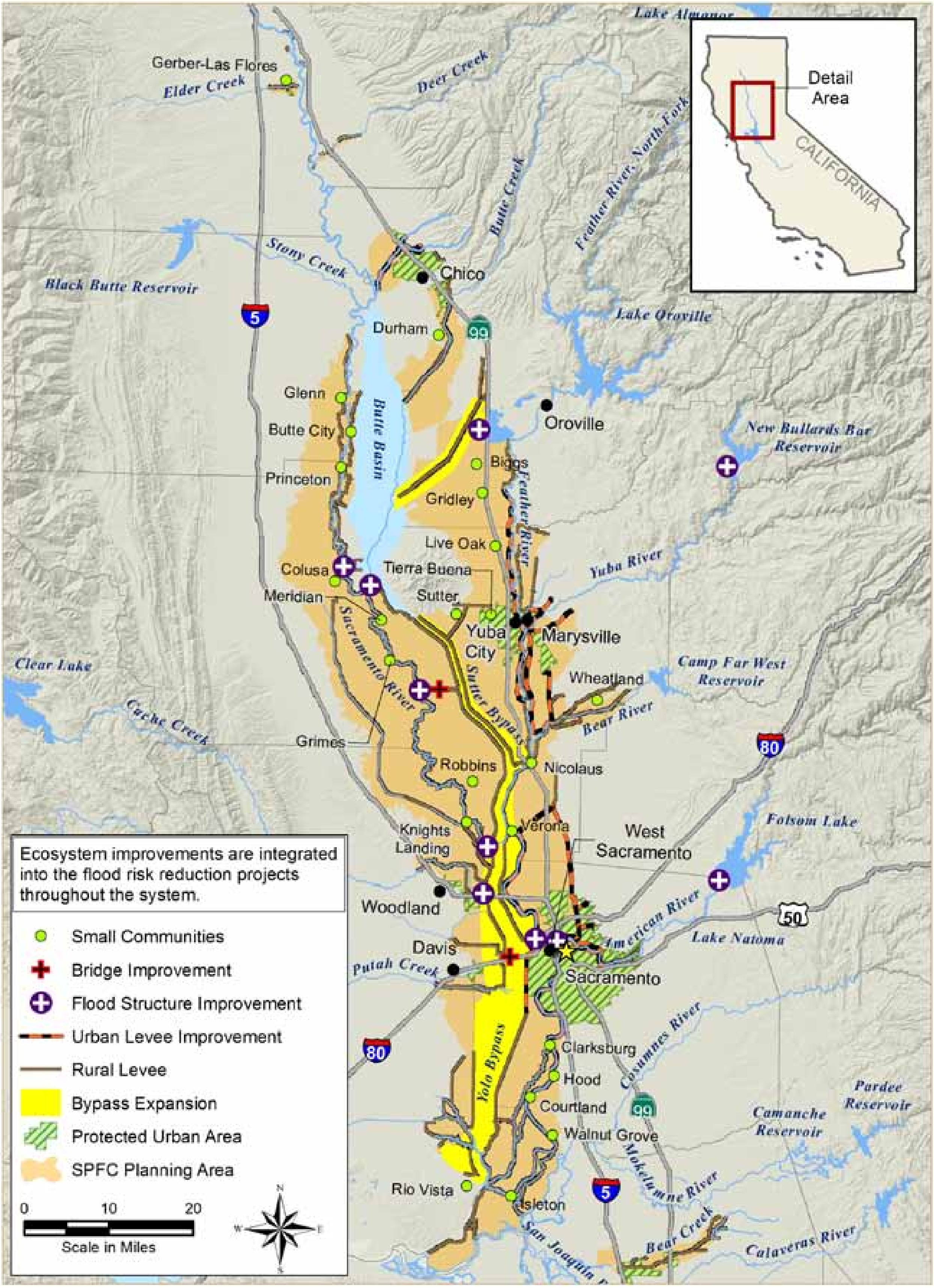
FLOOD MANAGEMENT ELEMENT	PROJECT LOCATION OR REQUIRED COMPONENTS	ACHIEVE SPFC DESIGN FLOW CAPACITY	PROTECT HIGH RISK COMMUNITIES	ENHANCE FLOOD SYSTEM CAPACITY		STATE SYSTEMWIDE INVESTMENT APPROACH
Bypasses						
New Bypass Construction and Existing Bypass Expansion	• Feather River Bypass • Sutter Bypass expansion • Yolo Bypass expansion • Sacramento Bypass expansion • Lower San Joaquin River Bypass (Paradise Cut) Components potentially include land acquisition, conservation easements, levee improvements, new levee construction			YES	→	YES
Reservoir Storage and Operations						
Forecast-Coordinated Operations/Forecast-Based Operations	Fifteen reservoirs within Sacramento River Basin and San Joaquin River Basin	YES	YES	YES		YES
Reservoir Storage/Enlarge Flood Pool[1]	• Oroville • New Bullards Bar • Don Pedro • McClure • Friant			YES	→	
Easements	• Sacramento River Basin – 200,000 acre-feet • San Joaquin River Basin – 100,000 acre-feet			YES		
Flood Structure Improvements						
Major Structures	• Intake structure for new Feather River Bypass • Butte Basin small weir structures • Upgrade and modification of Colusa and Tisdale weirs • Sacramento Weir widening and automation • Gate structures and/ or weir at Paradise Cut • Upgrade of structures in Upper San Joaquin bypasses • Low level reservoir outlets at New Bullards Bar Dam • Fremont Weir widening and improvement • Other pumping plants and small weirs			YES	→	YES
System Erosion and Bypass Sediment Removal Project	• Cache Creek Settling Basin sediment management • Sacramento system sediment remediation downstream from weirs			YES		YES
Urban Improvements						
Target 200-Year Level of Protection	Selected projects developed by local agencies, State, federal partners		YES	YES	→	YES
Target SPFC Design Capacity	Urban Levee Evaluations Project results	YES[2]				

Table 3-2. Major Physical and Operational Elements of Preliminary Approaches and State Systemwide Investment Approach (cont'd.)

FLOOD MANAGEMENT ELEMENT	PROJECT LOCATION OR REQUIRED COMPONENTS	ACHIEVE SPFC DESIGN FLOW CAPACITY	PROTECT HIGH RISK COMMUNITIES	ENHANCE FLOOD SYSTEM CAPACITY		STATE SYSTEMWIDE INVESTMENT APPROACH
Non-SPFC Urban Levee Improvements	Includes approximately 120 miles of non-SPFC levees that are closely associated with SPFC urban levees. Performance of these non-SPFC levees may affect the performance of SPFC levees.	YES	YES	YES		YES
Small Community Improvements						
Target 100-Year Level of Protection	Small communities protected by the SPFC		YES[3]	YES[3]	→	YES[4]
Target Design Capacity	Non-Urban Levee Evaluations Project results	YES[2]		YES[2]		
Rural-Agricultural Improvements						
Site-Specific Rural-Agricultural Improvements	Based on levee inspections and other identified critical levee integrity needs				→	YES
Target Design Capacity	Non-Urban Levee Evaluations Project results	YES[2]		YES[2]		
Ecosystem Restoration						
Fish Passage Improvements	• Tisdale Bypass and Colusa Bypass fish passage • Fremont Weir fish passage improvements • Deer Creek			YES	→	YES
Ecosystem Restoration and Enhancement	For areas within new or expanded bypasses, contributing to or incorporated with flood risk reduction projects			YES		YES
River Meandering and Other Ecosystem Restoration Activities	At selected levee setback locations in Sacramento and San Joaquin river basins			YES		YES (at select locations)

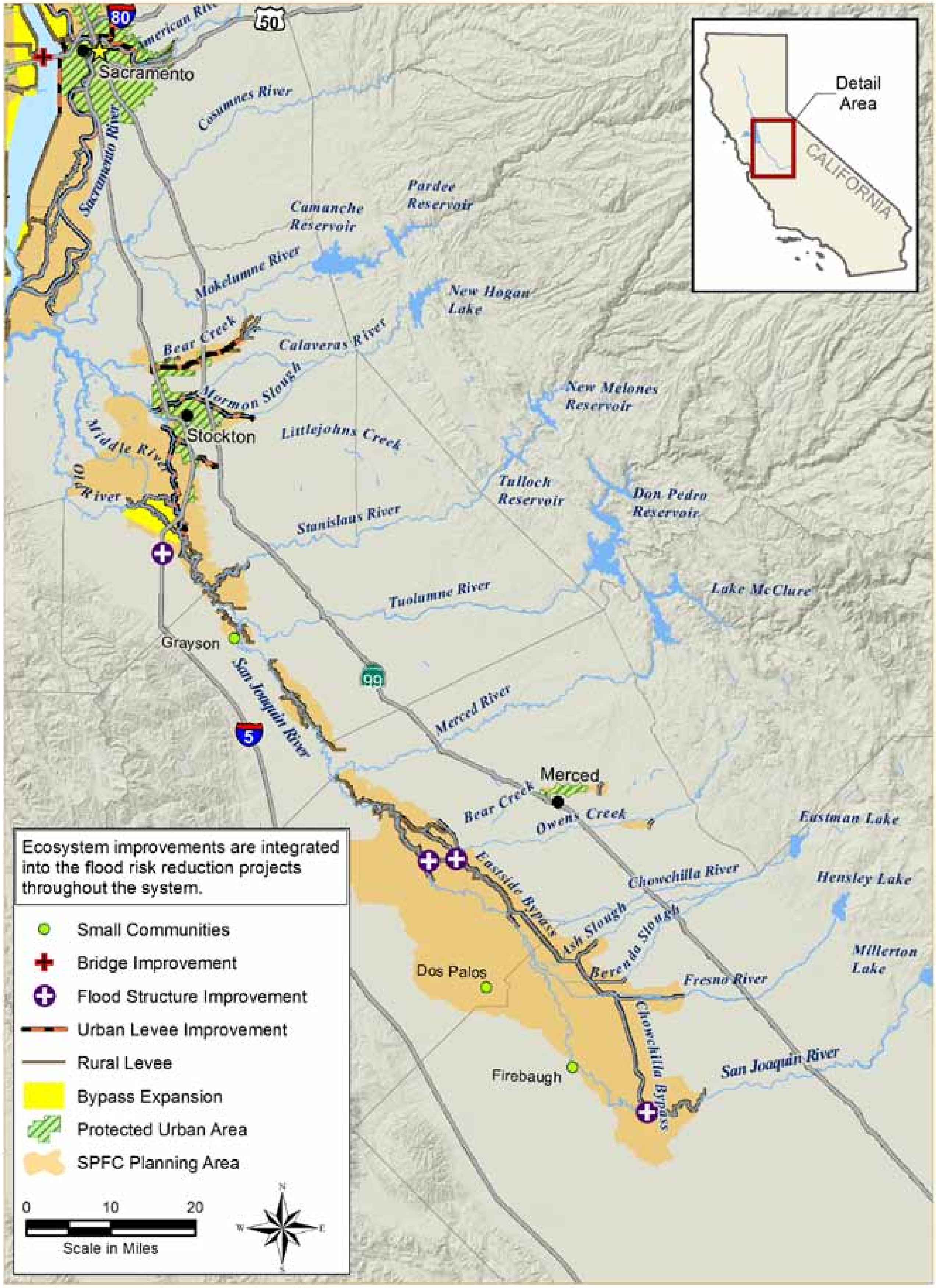
Notes:
[1] All preliminary approaches and State Systemwide Investment Approach include Folsom Dam Raise, as Congress authorized.
[2] Actual level of protection varies by location.
[3] Includes all small communities within the SPFC Planning Area.
[4] Includes selected small communities within the SPFC Planning Area.

Key:
SPFC = State Plan of Flood Control
State = State of California



Key: SPFC = State Plan of Flood Control

Figure 3-1. State Systemwide Investment Approach – Sacramento River Basin Major Capital Improvements under Consideration



Key: SPFC = State Plan of Flood Control

Figure 3-2. State Systemwide Investment Approach – San Joaquin River Basin Major Capital Improvements under Consideration

Improvements to urban levees or floodwalls should follow DWR's ***Urban Levee Design Criteria***, at a minimum. The State strongly supports consideration of features that offer greater system resilience, such as levees that can withstand overtopping without catastrophic breaching. Another example is to build compartmentalized floodplains (the use of secondary levees, berms, or elevated roadways within protected areas to reduce the geographic extent of flooding when a failure occurs).

Levee projects in urban areas should consider setbacks, to the extent feasible, based on the level of existing development and the potential benefits. These projects should also preserve and/or restore, at minimum, shaded riparian habitat corridors along the waterside toe of levees. Other improvements will consider incorporating ecosystem preservation, restoration, and enhancements in project designs. Urban improvements should also be implemented and maintained consistent with the State's vegetation management approach (see Section 4.2 and Attachment 2 – Conservation Framework).

LEVEE RESILIENCY

Reducing the risk of catastrophic system failure is an important aspect of flood risk reduction. Levee breaches increase flood losses and recovery costs, and lengthen the time needed to rebuild. USACE estimates that at least half of the direct losses from Hurricane Katrina may have been averted, had catastrophic breaching not occurred (Building a Stronger Corps: A Snapshot of How the Corps is Applying Lessons Learned from Katrina (USACE, 2009)). Designing facilities to withstand overtopping and incorporating resiliency into overall system design not only help to reduce flood losses, but also provide flexibility to accommodate changing climate conditions, floodplain uses, and technical standards.

In addition to urban area levees, other system and regional elements included in the CVFPP, such as reservoir operational changes and new or expanded bypasses, have the potential to contribute to achieving an urban level of flood protection. These elements could potentially reduce the need for urban area levee improvements, and/or provide additional system flexibility and resiliency in accommodating hydrologic uncertainty, including climate change.

The CVFPP does not include improvements that may be needed to address interior drainage or other local sources of flooding. The State could pursue improvements to non-SPFC levees (see Section 3.6) that protect some urban areas even though the State has no responsibility over these levees at this time. The decision to add these levees to the SPFC would require Board action. Alternatively, the State may choose to participate in funding levee reconstruction or improvements, if found to be feasible.

DWR will evaluate and participate in projects (in-place and with setbacks, if appropriate) that contribute to achieving an urban level of flood protection through reconstructing, rehabilitating, or improving SPFC facilities for the following urban areas in the Central Valley:

- **City of Chico** – Improvements include reconstruction of existing SPFC urban levees bordering the City of Chico to provide protection from flooding along local tributaries.

- **Yuba City and City of Marysville** – Improvements for this metropolitan area and adjacent existing urbanizing corridor (along Highway 99 north of Yuba City, and along Highway 70 within and south of Marysville) include the following:
    - » *Continue work to reconstruct and/or improve SPFC levees to urban design criteria along the Feather and Yuba rivers immediately adjacent to Marysville, consistent with ongoing local efforts. The State is supporting ongoing work to achieve an urban level of flood protection for the City of Marysville as part of the Yuba Basin Project. This project encompasses four phases of levee improvements and other actions, with an ultimate goal of protecting Marysville from a 250-year (0.4% annual chance) flood event.*
    - » *Continue to work with Sutter Butte Flood Control Agency to develop and implement projects to achieve an urban level of flood protection for Yuba City and adjacent existing urbanizing areas. This includes reconstructing and/or improving SPFC levees to urban design criteria along the right bank of the Feather River, adjacent to and upstream from Yuba City, as part of the Feather River West Levee Project.*
- **Sacramento Metropolitan Area** – Improvements for this area include the following:
    - » *Reconstruct and/or improve SPFC levees protecting urban areas along the Sacramento and American rivers to urban design criteria, as needed, to complete ongoing urban flood protection improvements within Sacramento County (includes the Laguna portion of Elk Grove). The State has supported the Sacramento Area Flood Control Agency's urban flood protection projects through cost sharing and grant funding under the FloodSAFE Early Implementation Program. Completed work that supports the SSIA includes levee improvements along the American River under the American River Watershed Common Features Project, and elements of the South Sacramento County Streams Project. Ongoing work includes levee improvements under the Natomas Levee Improvement Program and construction of an auxiliary spillway at Folsom Dam as part of the Folsom Dam Joint Federal Project.*
    - » *Reconstruct and/or improve SPFC levees to complete ongoing urban protection improvements for the City of West Sacramento. The State has supported urban levee improvements by the West Sacramento Area Flood Control Agency through the FloodSAFE Early Implementation Program grants program. Locally planned work, for potential State participation, includes levee reconstruction and raising, cutoff walls, setback levees, and erosion protection features.*

Levee Improvements in Natomas

   - *Evaluate the potential benefits of widening, automation, and operational changes to the Sacramento Weir and Bypass for the purpose of reducing peak flood stage along the Sacramento and American rivers, in combination with expansion of the Yolo Bypass (described later under System Improvements). Weir automation and other improvements have the potential to improve operational safety and flexibility.*

- **Cities of Woodland and Davis** – Continued participation in the Lower Cache Creek, Yolo County Woodland Area Feasibility Study, which considers modifications to the Cache Creek Settling Basin and other facilities to determine their feasibility and contribution toward achieving urban and rural-agricultural flood improvement in the area. Also evaluate the Cache Creek Settling Basin to identify a long-term program for managing sediment and mercury to maintain the flood conveyance capacity of the Yolo Bypass.

- **City of Merced** – Continued support of the Merced County Streams Project, which is contributing to improving flood protection for the City of Merced.

- **Stockton Metropolitan Area** – Improvements for this area include the following:
   - *Improve SPFC levees along the San Joaquin River and tributary channels.*
   - *Evaluate the potential benefits of and State interest in local floodgates and control structures, as they relate to facilities of the SPFC in and around Stockton, and contribute to achieving an urban level of flood protection.*

- **Other Areas** – For urban areas also protected by non-SPFC levees, the State may evaluate its interest in participating in levee improvements under other State programs.

3.3 Small Community Flood Protection

Many small communities in the SPFC Planning Area are expected to receive increased flood protection through implementation of system elements and improvements focused on adjacent urban areas, although some of these improvements may take many years to implement. The State will evaluate investments to preserve small community development opportunities without providing urban level of protection. However, some small communities adjacent to existing urban areas may achieve a 100-year level of flood protection or higher as a result of improvements for the adjacent urban areas. Additional State investments in small community protection will be prioritized based on relative community flood threat levels, considering factors such as population, likelihood of flooding, proximity to flooding source, and depth of flooding. Other factors considered in prioritizing small community flood improvements include financial feasibility and achievement of the CVFPP Goals with respect to integrating multiple benefits.

In general, the State will consider the following structural and nonstructural options for protecting small communities in the SPFC Planning Area from a 100-year (1% annual chance) flood:

- Protecting small communities "in-place" using ring levees, training levees, or floodwalls when improvements do not exceed a certain predetermined cost threshold. For planning purposes for the SSIA, DWR used a preliminary cost threshold of $100,000 per house protected, an approximate value for elevating or flood proofing a house. When estimated costs exceed the threshold, nonstructural means for flood protection will be considered. DWR will further evaluate this threshold during future studies.
- Reconstructing or making improvements to adjacent SPFC levees.
- Implementing nonstructural improvements, such as raising/elevating structures, flood proofing, willing seller purchases, and/or relocating structures, when the in-place improvements described above are not feasible.

In some cases, small communities may achieve flood protection as part of adjacent urban area improvements.

Based on planning level estimates, 15 small communities would receive 100-year (1% annual chance) flood protection from about 80 miles of levee improvements or new levee construction. A new levee is one constructed from the ground up, not a levee that has been repaired in place. Another five small communities would receive 100-year (1% annual chance) flood protection, at minimum, through implementation of urban and system improvements included in the SSIA. Seven small communities would receive flood protection through floodplain management actions such as flood proofing or raising structures.

Improvements to small communities should also be implemented and maintained consistent with the State's vegetation management approach (Attachment 2 – Conservation Framework). Other improvements will consider incorporating ecosystem preservation, restoration, and enhancements in project designs.

3.4 Rural-Agricultural Area Flood Protection

Rural-agricultural area levee improvements included in the SSIA are not as extensive as for urban areas and small communities, reflecting the lower levels of development within these floodplains.

3.4.1 State Plan of Flood Control Levees

The State recognizes that federal engineering guidance and design standards may result in cost-prohibitive levee repairs for many rural-agricultural areas. The State will work with rural-agricultural communities to develop applicable rural levee critera repair for SPFC levees (see Section 4). The State will also evaluate investments to preserve rural-agricultural activities that discourage incompatible development, and encourage compatible development, within floodplains.

The State's participation in rural-agricultural SPFC facility reconstruction projects may also require inclusion of nonstructural measures to manage risks in adjacent floodplains, such as purchasing agricultural conservation easements from willing landowners, where consistent with local land use plans. In addition to improving flood management, project designs will consider restoring shaded riparian aquatic habitat, wetlands, or other habitat. This includes protection and enhancement of existing healthy ecological communities, in addition to the enhancement/restoration of degraded ecosystem services and functions. Flood risk reduction projects in rural-agricultural areas that can achieve multiple resource benefits will be preferable to single purpose projects, and are likely to be encouraged through enhanced State and federal cost-sharing.

In general, the State will consider the following rural-agricultural flood protection options, with a focus on integrated projects that achieve multiple benefits:

- SPFC levee improvements in rural-agricultural areas will focus on maintaining levee crown elevations and providing all-weather access roads to facilitate inspection and floodfighting.
- Levee improvements, including setbacks, may be used to resolve known performance problems (such as erosion, boils, slumps/slides, and cracks). Projects will be evaluated that reconstruct rural SPFC levees to address identified threat factors, particularly in combination with small community protection, where economically feasible.
- Agricultural conservation easements that preserve agriculture and prevent urban development in current agricultural areas may be purchased, when consistent with local land use plans and in cooperation with willing landowners.

The State, in consultation with local entities, will prioritize available funding among all-weather roads and other important investments, addressing the greatest need first.

3.4.2 Hydraulic Structure Upgrades

In addition to hydraulic structures mentioned as part of urban and system improvements, existing hydraulic structures in the upper San Joaquin River Basin need to be upgraded because of facility age or operational problems. In some cases, gates do not operate properly, new automation is needed, or the structures are otherwise deteriorated.

3.4.3 Local Non-State Plan of Flood Control Levees

During future feasibility studies, the State will evaluate projects to maintain the function of local levees (not part of the SPFC) if they contribute to the effective operations and maintenance of the SPFC. The State may be able to participate through existing programs on feasible projects.

3.4.4 Removal of State Plan of Flood Control Facilities

The State will evaluate potentially removing (physically or administratively) facilities of the SPFC in rural areas, including rock revetment, levees, and other facilities, consistent with criteria presented in Section 4. Removing small portions of the SPFC that are no longer functioning would reduce the State's responsibility and costs for operations and maintenance. Facilities that may be evaluated for potential removal from the SPFC include the following:

- A two-mile long segment of the Feather River right-bank levee, upstream from the Thermalito Afterbay, which was replaced by an embankment constructed to create Thermalito Afterbay (on its southeast side).
- Approximately seven miles of levee included in the Lower San Joaquin River and Tributaries Project, which is currently being physically breached and removed. This effort is part of a nonstructural project modification, under the authority of Public Law 84-99, following damage during the 1997 floods.
- Intermittent SPFC levees along reaches of the San Joaquin River and in the vicinity of the Mariposa Bypass and Deep Slough. If pursued, removal projects should consider integration of wetland, riparian, and floodplain habitat restoration.
- Some existing, intermittent bank protection sites along the Sacramento River between Red Bluff and Chico Landing, now unconnected with the active river channel and believed to no longer provide a flood management function by erosion control.
- Levees and pumping plants from the Middle Creek Project at the west end of Clear Lake, for which removal is currently underway. Facilities removal was authorized by Congress in the Water Resources Development Act of 2007.

Floodflow over the Moulton Weir

3.5 System Improvements

System elements include physical actions or improvements with the potential to provide benefits across large portions of the flood management system, and improve the overall function and performance of the SPFC in managing large floods. These actions enhance the system's overall ability to convey and attenuate flood peaks through expansion of bypass capacity and storage features. System improvements provide flood protection benefits to urban, small community, and rural-agricultural areas by lowering flood stages.

These actions also present significant opportunities to improve ecosystem functions and continuity on a systemwide level. System improvements should also be implemented and maintained consistent with the State's vegetation management approach (see Section 4.2 and Attachment 2 – Conservation Framework).

The following sections describe system elements included in the SSIA.

3.5.1 Weir and Bypass System Expansion

The Sutter and Yolo bypasses, in combination with their appurtenant control features – the Moulton, Colusa, Tisdale, Fremont, and Sacramento weirs/bypasses – function as the central backbone of the Sacramento River Flood Control Project. This weir and bypass system redirects damaging floodflows away from the main channels of the Sacramento, Feather, and American rivers, conveying up to 490,000 cubic feet per second during large flood events. The considerable capacity of the bypass system also slows the movement of floods, effectively attenuating flood peaks and metering flows into the Delta. For initial planning purposes, technical evaluations are based on construction of all bypass expansions and extensions described below.

Bypass expansions would increase the overall capacity of the flood system to convey large flood events. Peak flood stages would be reduced along the Sacramento River and, to a lesser extent, along its tributaries. The lower stages throughout the system benefit flood management in urban, small community, and rural-agricultural areas. Floods from storms centered within different watersheds of the Sacramento River Basin have different characteristics, and bypass system expansion would contribute to greater system flexibility in managing these different flood events.

Improvements would be designed and operated in consideration of ecosystem restoration features and benefits, including conservation and restoration of aquatic and floodplain habitats and continued compatible agricultural land uses within the bypass. Improvements may include contouring and channelizing to facilitate proper draining and to lessen the possibility of entraining fish. Contouring may also increase the frequency of floodplain activation in places to promote wetland and riparian habitat success. When consistent with local land use plans, and in cooperation with willing landowners, the State will consider purchasing agricultural conservation easements adjacent to the Sutter and Yolo bypasses to preserve agriculture and prevent urban land uses.

Sutter Bypass Expansion

Future studies to refine specific project elements related to bypass expansion should consider increasing the capacity of the Sutter Bypass to convey large flood events. Expansion would likely require building a new levee for about 15 miles along one side of the bypass to widen the bypass for increased flow capacity. Although the required width of the bypass has not been determined, DWR used a 1,000-foot increase in the bypass width for planning purposes. The evaluations for planning purposes were initially based on 75 percent of the new width allocated to agricultural use and 25 percent allocated to habitat restoration.

Modifications to the Colusa and Tisdale weirs and the Butte Basin overflow areas from the Sacramento River will be considered as part of the expansion. The expansion may require rebuilding some SPFC facilities, such as weirs and pumping stations.

Yolo Bypass Expansion

Future studies to refine specific project elements related to bypass expansion should consider the following:

- Lengthening and/or lowering the Fremont Weir and incorporating features to facilitate fish passage through the upper bypass and at the weir.
- Increasing capacity in the upper portion of the Yolo Bypass (upstream from the Sacramento Bypass) by setting back levees and/or purchasing easements.
- As described under Section 3.2, evaluate the Cache Creek Settling Basin to identify a long-term program for managing sediment and mercury to sustain the flood conveyance capacity of the Yolo Bypass.
- Expanding the lower end of the Yolo Bypass upstream from Rio Vista by setting back levees.

About 42 miles of new levee could potentially be required to expand the Yolo Bypass.

Sacramento Bypass Expansion

As part of urban elements to reduce flood risks to the Sacramento/West Sacramento metropolitan area, future studies to refine specific project elements related to bypass expansion (also described under Section 3.2) will consider the following:

- Widening the Sacramento Weir
- Automating the weir or eliminating gates
- Widening the Sacramento Bypass by constructing about two miles of new levee
- Making operational changes to the Sacramento Weir and Bypass, as necessary

3.5.2 New Bypasses

Two new bypasses are included in the SSIA. While they would primarily provide benefits to the urban areas of Yuba City/Marysville and Stockton, they are described here with other system improvements because of their complexity and long lead time for construction.

Feather River Bypass

Evaluate the feasibility of constructing a new bypass from the Feather River to the Butte Basin to further contribute to improving overall urban, small community, and rural-agricultural flood protection in the planning area. The new bypass would require construction of about 16 miles of new levee on one side of the Cherokee Canal. A new bypass would have the potential to reduce flood stages by as much as one foot at Yuba City and Marysville during a 100-year (1% annual chance) flood. A new bypass would also provide greater system resiliency in accommodating future hydrologic changes in the planning area, including those due to climate change, and would be a relief path when Feather River flows are greater than 200-year (0.5% annual chance). The State will consider findings of ongoing studies by local entities when evaluating the potential system benefits of the bypass.

Lower San Joaquin Bypass

Evaluate the construction of a new bypass in the south Delta (expansion of Paradise Cut and/or other south Delta waterways), primarily for the purpose of reducing peak flood stages in the Stockton area. A south Delta bypass would include habitat components. A gate structure or weir at Paradise Cut will be considered as part of the project. The new bypass would require construction of about eight miles of new levee. In combination with the bypass, the State will consider purchasing easements in the south Delta from willing sellers to provide floodwater storage and reduce peak flood stages along the San Joaquin River.

3.5.3 Flood System Structures

Several flood system structures will require rehabilitation, rebuilding, or modifications. These structures are primarily associated with the bypass expansions and new bypasses described above. Flood structures and related actions include the following:

- Intake structure for the new Feather River Bypass
- Butte Basin small weir structures
- Upgrade and modification of Colusa and Tisdale weirs
- Modifications to bridges to reduce or eliminate flow constrictions
- Sacramento Weir widening and automation or elimination of gates
- Gate structures and/or weir for new Lower San Joaquin Bypass
- Low-level reservoir outlet at New Bullards Bar Dam to facilitate changes in reservoir operations
- Other pumping plants and small weirs, such as those associated with the Sutter Bypass

In addition, opportunities to expand fish passage at SPFC structures will be considered.

3.5.4 Flood Storage

Preliminary systemwide analyses have identified potential benefits and opportunities for reservoir flood storage and operational changes for flood management in the Sacramento River and San Joaquin river basins.

Flood storage may reduce the need for some types of downstream actions, such as levee improvements, and can offset the hydraulic effects of system improvements on downstream reaches. Additional flood storage can also provide greater flexibility in accommodating future hydrologic changes, including climate change, and provide greater system resiliency (similar to that provided by freeboard on levees) in the face of changing downstream conditions.

New Reservoir Storage

The only new surface water storage included in the SSIA is the Folsom Dam Raise, which is already authorized. During future feasibility studies, the State may consider partnering with other willing agencies on expanding existing reservoir storage.

Transitory Storage

The SSIA has not identified specific floodplain transitory storage, but may consider such storage on a willing-seller basis where consistent with local land use plans, all affected land owners support such storage, and the new flood storage area can be safely isolated from adjacent areas (easements or fee title).

3.5.5 Conjunctive Use and Groundwater Recharge

Capturing and using floodflows for groundwater recharge has been considered as a component of integrated flood and water management for the SSIA. Conjunctive water management through use of floodwater for recharge has been practiced for many years, especially in the San Joaquin Valley. The State supports programs that use flood flows for groundwater recharge to improve water management throughout California. However, the State also recognizes the limitations of direct groundwater recharge in lowering flood stage and reducing flood risks, especially in the Sacramento River Basin. These limitations are due to inadequate groundwater storage capacity, except in the American River Basin, and low recharge rates in comparison with large floodflows. More substantial recharge capacities cannot be achieved without significant investments in off-stream recharge facilities or regional infrastructure to facilitate in-lieu recharge, such as those North of the American River in the Sacramento metropolitan area. Consistently, these facilities are developed by local agencies with emphases on water supply purposes. Considering these limitations, the SSIA provides opportunities for in-channel groundwater recharge and, although not recommending any specific recharge projects at this time, encourages exploring recharge opportunities in the San Joaquin River Basin, especially for capturing a portion of high flows from snowmelt, where feasible.

3.5.6 Operational Changes

Operational changes to SPFC facilities can benefit both flood risk reduction and the ecosystem. Initial concepts for operational changes are described below for existing reservoirs and bypasses.

Coordinated Reservoir Operations

Most major reservoirs in the Central Valley have been designed and built to meet multiple purposes, including water supply, recreation, and flood control. These multipurpose reservoirs have defined water conservation space for capturing winter and spring runoff for water supply purposes, and designated flood control space to capture, manage floodflows to reduce flood releases downstream.

The Forecast-Coordinated Operations (F-CO) Program seeks to coordinate flood releases from the reservoirs located in various tributaries of a major river to optimize the use of downstream channel capacity, the use of total available flood storage space in the system, and eventually to reduce overall peak floodflows downstream from these reservoirs. The management process and partnerships, formed during early development of the F-CO Program, contribute significantly to enhanced coordination of reservoir operations during flood events.

Implementing Forecast-Based Operations (F-BO) of Central Valley reservoirs is the next logical step in advancing the F-CO Program. The intended F-BO would involve the use of improved long-term runoff forecasting and operating within the parameters of an existing flood control diagram. Proactive reservoir management through the use of more flexible flood control diagrams would require extensive studies of the most feasible diagrams, environmental documentation for changing reservoir operations, and Congressional approval for new dynamic flood control diagrams. The SSIA includes implementation of both F-CO and F-BO for all reservoirs in the Central Valley.

Water Flowing from Sacramento River to Yolo Bypass Through Sacramento Weir and Bypass

As part of early FloodSAFE implementation, operators at Lake Oroville and New Bullards Bar Reservoir have begun coordinating flood operations to better manage downstream flows on the Yuba and Feather rivers. The coordinated operation of New Bullards Bar Reservoir with Lake Oroville will require construction of an outlet to accommodate early releases of floodflows from New Bullards Bar Dam; preliminary evaluations indicate that a new outlet with a capacity of about 20,000 cubic feet per second should be considered.

In addition, DWR will consider willing partnerships with other reservoir operators to accomplish F-BO and overall F-CO program objectives.

Weir and Bypass Operational Changes

The State proposes to investigate modifying the function and operation of weirs that spill floodwater to the bypasses in the Sacramento River Basin. The concept is to physically lower crests of overflow weirs and modify operations so that bypasses carry flows earlier and for longer durations during high river stages. These changes would reduce river stages and flood risks along main rivers. Depending on timing, duration, and a host of related hydraulic factors, the more frequently activated floodplain in the bypasses would potentially provide a more productive rearing habitat for juvenile salmonids and other native fish and may provide riparian habitat.

One potential change in operations is for the Sacramento Weir, which is currently opened when the Sacramento River water surface elevation reaches 27.5 feet at the I Street Bridge. Evaluation may show that opening the weir when the river stage reaches 25 feet provides improvements in both flood management and ecosystem function. Similarly, the crest of the Fremont Weir may be lowered or other modifications made to provide flow to the Yolo Bypass below its current spill stage. Other structures that would be subject to assessment and potential operational modifications include Moulton, Colusa, Tisdale, and Paradise Cut weirs.

Evaluations would also need to consider the extent of potential impacts from more frequent and longer durations of flooding in the bypasses. For example, some levees along the bypasses may not be as durable as levees along the main rivers – levee reliability could be lowered by longer duration wetting. Longer duration flooding of the bypasses would increase the duration of levee patrols. Also, extending the duration of bypass flooding could interfere with ongoing agricultural practices.

3.5.7 Features to Mitigate Potential Flood Stage Increases

Since future feasibility studies are needed to refine the SSIA, the ultimate configuration of facilities will likely vary from those presented in the SSIA. Only at that time will the State know the potential magnitude and extent of hydraulic impacts from planned improvements, if any, within the system. Cost estimates for the SSIA include an allowance for features to mitigate significant hydraulic impacts caused by project implementation.

A number of mitigation features may be used, depending on the hydraulic impacts throughout the system and downstream from SPFC facilities. Mitigation features may include the following:

- Levee enhancements for affected areas
- New surface storage partnerships with willing reservoir operators
- New transitory storage
- Modification of project designs to limit stage increases
- Other features that appear promising during feasibility studies

3.6 Non-State Plan of Flood Control Levees

Approximately 420 miles of private non-SPFC levees are closely associated with SPFC levees. Non-SPFC levees are those (1) that abut SPFC levees, (2) whose performance may affect the performance of SPFC levees, or (3) that provide flood risk reduction benefits to areas also being protected by SPFC features.

3.6.1 Non-State Plan of Flood Control Urban Levees

A total of about 120 miles of non-SPFC urban levees work in conjunction with SPFC levees to provide protection to urban areas within the SPFC Planning Area. Table 3-3 shows the distribution of non-SPFC levees for the various urban areas. Figure 3-3 shows the locations of these non-SPFC urban levees.

To achieve 200-year (0.5% annual chance) flood protection, improvements to both SPFC and non-SPFC levees will be needed. DWR has estimated that improving these non-SPFC urban levees to achieve this level of protection would cost approximately $1.2 billion in 2011 dollars. This cost is included in the SSIA costs.

Table 3-3. Non-State Plan of Flood Control Urban Levees

URBAN AREA	NON-SPFC LEVEES (miles)
Chico	0
Yuba City	0
Marysville	0
Sacramento	24
West Sacramento	30
Woodland	1
Davis	0
Stockton	65
Merced	0
Total	120

Key:
SPFC = State Plan of Flood Control

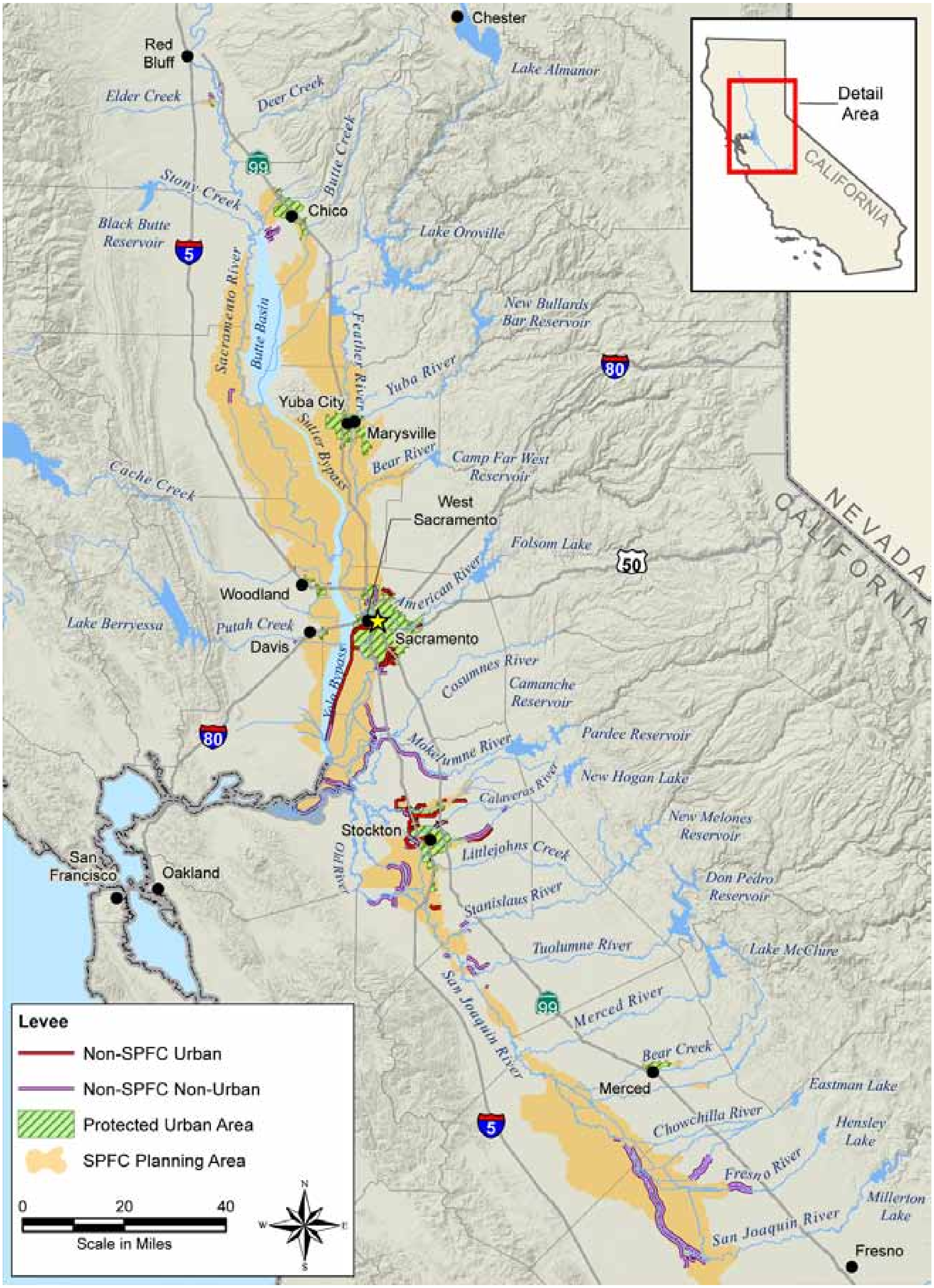
The State recognizes that for an urban area protected jointly by both SPFC and non-SPFC levees, the legislated requirement for an urban level of flood protection (200-year or 0.5% annual chance flood) requires improvement to both types of facilities. The Board may choose to treat some or all these non-SPFC levees in a similar manner to SPFC urban levees for State participation in levee improvements, and potentially add them to the SPFC. Alternatively, if the Board chooses not to add these levees to the SPFC, the State will consider participation in improvements to these levees under other State programs.

In addition, completed and ongoing Early Implementation Projects initiated since bond funding became available in 2007 will likely be added to the SPFC when final documentation is complete.

3.6.2 Non-SPFC Nonurban Levees

About 300 miles of non-SPFC nonurban levees work in conjunction with SPFC levees in rural areas. Most of these levees are along the upper San Joaquin River. Figure 3-3 shows the locations of non-SPFC nonurban levees that protect portions of the SPFC Planning Area. Non-SPFC Delta levees are not included since they do not protect the SPFC Planning Area.

Improving these levees to the same level as SPFC rural levees would cost about $300 million. This cost is not included in the costs for the SSIA. Portions of these non-SPFC nonurban levees may be candidates for being added to the SPFC after preparation of regional plans and feasibility studies (see Section 4), but DWR has not included them as part of the SSIA.



Key: SPFC = State Plan of Flood Control

Figure 3-3. Non-State Plan of Flood Control Levees Protecting Portions of State Plan of Flood Control Planning Area

3.7 Integrating Ecosystem Restoration Opportunities with Flood Risk Reduction Projects

While flood risk reduction (public safety) remains the primary goal of the CVFPP, early integration of other important resource management goals into the plan formulation process remains a premise of integrated flood management. Those supporting goals, along with the legislative objectives, are described in Section 1.6.2. This will help improve overall flood project delivery and may broaden public support for flood projects.

In taking an integrated flood management approach, the intent of the SSIA is to make progress on improving ecological conditions on a systemwide basis, using integrated policies, programs, and projects. This approach builds upon and advances on-going efforts and successes to incorporate environmental benefits into flood management projects. Integrating environmental stewardship early into policy and project planning, development, and implementation will help move beyond traditional project-by-project compensatory mitigation. This approach also creates the opportunity to develop flood management projects that may be more sustainable and cost-effective, and can provide ecological benefits while protecting public safety. Under the SSIA, ecosystem restoration opportunities are integral parts of system improvements, as well as urban, small community, and rural-agricultural area flood protection projects.

CENTRAL VALLEY FLOOD PROTECTION ACT OF 2008

California Water Code Section 9614.

"The Plan shall include…

(j) A description of structural and nonstructural means for enabling or improving Systemwide riverine ecosystem function, including, but not limited to, establishment of riparian habitat and seasonal inundation of available flood plains where feasible."

California Water Code Section 9616.

"The Plan shall meet…multiple objectives…including…

(7) Promote natural dynamic hydrologic and geomorphic processes.

(9) Increase and improve the quantity, diversity, and connectivity of riparian, wetland, flood plain, and shaded riverine aquatic habitats, including the agricultural and ecological values of these lands.

(11) Promote the recovery and stability of native species populations and overall biotic community diversity."

Attachment 2 to the CVFPP, the Conservation Framework, provides a preview of a long-term Central Valley Flood System Conservation Strategy (Conservation Strategy) that DWR is developing to support the 2017 update of the CVFPP. The Conservation Framework focuses on promoting ecosystem functions and multi-benefit projects in the context of integrated flood management for near-term implementation. The Conservation Framework provides an overview of the floodway ecosystem conditions and trends and key conservation goals that further clarify the CVFPP's ecosystem goal. The Conservation Framework also identifies opportunities for integrated flood management projects that can, in addition to improving public safety, enhance riparian habitats, provide connectivity of habitats, restore riparian corridors, improve fish passage, and reconnect the river and floodplain.

The long-term Conservation Strategy will be consistent with the Conservation Framework and provide a comprehensive, long-term approach for the State to achieve the objectives of the Central Valley Flood Protection Act and the

FloodSAFE and CVFPP goals. Flood protection projects that are integrated with environmental restoration components have the potential to increase federal and State cost-sharing for flood management projects and make improvements more affordable for local entities.

Consistent with the Conservation Framework, ecosystem restoration and enhancement opportunities of the SSIA include the following:

- **Regional improvements (urban, small community, and rural-agricultural areas)** – Flood protection projects will preserve important shaded riparian aquatic habitat along riverbanks and help restore the regional continuity/connectivity of such habitats. Planning and designs for flood risk reduction projects will consider opportunities to enhance ecosystem functions.
- **System improvements** – DWR, through its multiple programs, will continue to work on integrated flood management projects within the Systemwide Planning Area, and will evaluate and initiate other projects that benefit the SPFC. Sutter and Yolo bypass expansions (described previously) may increase the overall area of floodplain that would support wetland habitats.
- **Fish passage improvements** – Improve fish passage at SPFC weirs, bypasses, and other flood management facilities undergoing modification or rehabilitation to improve access to upstream aquatic habitat and facilitate natural flow routing. Possible candidates for fish passage improvements include the following:
  - » *Big Chico Creek system*
  - » *Tisdale and Colusa weirs*
  - » *Cache Creek Settling Basin*
  - » *Fremont Weir*
  - » *Yolo Bypass*
  - » *Willow Slough Weir in Yolo Bypass*
  - » *Sacramento Weir*
  - » *Sand Slough Control Structure*

DWR's goal in integrating ecosystem restoration and enhancement is to achieve overall habitat improvement, thereby reducing, or eliminating the need to mitigate for most ecosystem impacts. However, depending on the timing of improvements and implementation, some ecosystem mitigation may be required.

3.8 Climate Change Adaption Strategy

As mentioned in Section 1, climate change is likely to generate more extreme floods in the future. Development of flood hydrology that accounts for the potential effects of climate change is a complicated and time-consuming exercise that must account for many uncertainties. DWR, in partnership with the USACE, is in the process of developing new hydrology that includes the effects of climate change, but that hydrology will not be ready for use in system evaluation until late 2012. Therefore, the new hydrology will be most useful in technical evaluations leading to the 2017 update of the CVFPP.

Even though climate change hydrology was not yet available, development of the SSIA included allowances for potentially higher flows due to climate change. Providing wider bypasses to lower floodwater surface elevations would increase flow-carrying capacity and flexibility to deal with higher flood flows that may occur because of climate change. Changes in reservoir operations from F-CO and F-BO can provide flexibility and adaptability to changes in extreme flood events. In addition, the SSIA includes the potential for the State to participate with others in reservoir expansion projects and in obtaining rights for floodplain transitory storage from willing landowners. These and other strategies to address the effects of climate change will be further evaluated for the 2017 update of the CVFPP.

The effects of sea level rise are important in the Sacramento-San Joaquin Delta, portions of which are protected by SPFC facilities. Sea level rise will affect levees within the Delta and for some distance upstream along the rivers. The estimated average sea level rise is currently under the review of the National Research Council. For the 2012 CVFPP, high tide conditions during the 1997 flood were used as the boundary conditions for hydraulic analysis and could be considered an initial, surrogate condition under climate change. This tide was about two feet higher than would normally be expected on the basis of solar and lunar gravitational forces that create tides. DWR will continue to coordinate with other DWR programs, Delta Stewardship Council's Delta Plan, and ongoing USACE feasibility studies to collectively address how sea level rise could contribute to potential estuary flooding in the Delta.

CLIMATE CHANGE

Climate change impacts for extreme events, such as flooding and droughts, will result not from changes in averages, but from changes in local extremes. DWR initiated a study to investigate a new approach to assessing impacts based on climate change indices more suitable for flood events – "Atmospheric Rivers." Preliminary findings are promising for:

- Assessing climate change impacts on flood management and to communities receiving flood protection
- Identifying prudent system improvements that are resilient in climate change conditions

DWR intends to continue methodology development and application for the 2017 CVFPP Update.

For the 2017 CVFPP update, improved sea level rise information will be used. DWR will develop approaches for addressing sea level rise that may vary depending on the expected range and rate of sea level rise. For example, these approaches may vary from abandoning some facilities to raising and strengthening affected levees. Some affected areas may be transformed to ecosystem uses. Other management approaches may be considered, as supported by technical analysis during the preparation of regional plans and feasibility studies.

DWR is developing a new methodology for estimating the impacts of climate change on flood hydrology. Typical climate change impact assessments for long-term water supply needs consider likely changes in average temperature and precipitation. However, climate change impacts on extreme events, such as floods, will not result from changes in averages, but from changes in local extremes. Therefore, DWR collaborated with the National Oceanic and Atmospheric Administration, U.S. Geological Survey, USACE, and Reclamation in developing a new methodology based on the intensity of "Atmospheric Rivers," which are fast-moving, concentrated streams of water vapor that can release heavy rains. Since the moisture source of water vapors is often the ocean southwest of the Hawaiian Islands, these storm events are often referred to as Pineapple Expresses.

Since available climate change information does not present probabilistic characteristics, DWR is working on the concept of prudent decision making that focuses on investments that could accommodate a broader range of climate change scenarios rather than optimizing investments within a few selective scenarios. The resulting Threshold Analysis Approach was applied to the Yuba-Feather system in a proof-of-concept pilot study. The results of the pilot study suggest that under the F-CO, New Bullards Bar Dam on the Yuba River has inadequate capacity to help respond to climate change, as compared to Oroville Dam on the Feather River, because of limited regulating capacities. This information provides guidance for the overall investment strategy for modifications such as enlarged outlets at New Bullards Bar Dam. DWR intends to fully develop the Threshold Analysis Approach for the 2017 Update with new Central Valley hydrology and improved Atmospheric River indices.

In summary, improved climate change information will allow more detailed evaluation of potential climate change impacts on the SPFC and refinement of approaches to manage higher floodflows and sea levels during preparation of regional plans and feasibility studies.

3.9 Considerations for Sacramento-San Joaquin Delta

Land uses in the Delta outside the SPFC Planning Area are primarily rural and dominated by agriculture and open space, with several dispersed small communities. Flood management facilities primarily include levees, which often protect lands at or below sea level. Flood management responsibilities in Delta areas outside the SPFC Planning Area reside with a variety of local agencies, supported by the State's Delta Special Flood Projects Program and Delta Levees Maintenance Subventions Program.

Restoration of ecosystem functions and aquatic habitats in the Delta have been, and continue to be, the focus of various State, federal, and local efforts, in addition to water supply and flood management planning. Major efforts include the Delta Stewardship Council's Delta Plan, the Delta Protection Commission's Economic Sustainability Plan, the Bay Delta Conservation Plan, and the Delta Habitat Conservation and Conveyance Program.

The CVFPP supports a financially and environmentally sustainable Delta. Depending on which elements of the SSIA are eventually implemented in upstream regions, there is a potential for hydraulic impacts in the Delta. The SSIA includes management actions (see Section 3.5.7), and a cost allowance, to lessen or mitigate these impacts compared with current conditions.

The State will continue to support Delta flood management improvements outside the SPFC Planning Area through existing programs and in coordination with ongoing multiagency Delta planning efforts. Existing programs include the Statewide

Flood Management Planning Program, Delta Levees Maintenance Subventions Program, Delta Special Flood Control Projects program, emergency planning and response support, and other residual risk management programs and support provided by the State.

3.10 U.S. Army Corps of Engineers Levee Vegetation Policy and Public Law 84-99 Eligibility

The USACE levee vegetation management policy affects implementation of the SSIA and its ability to maintain eligibility for federal Public Law 84-99 rehabilitation assistance in the event of flooding. The following provides context for the USACE policy and the State's resultant levee vegetation management strategy described in Section 4. A more detailed description of the levee vegetation management issue can be found in Attachment 2 – Conservation Framework.

3.10.1 U.S. Army Corps of Engineers Levee Vegetation Policy

In April 2007, USACE released a draft white paper, ***Treatment of Vegetation within Local Flood Damage Reduction Systems***, which clarified its nationwide policy regarding the removal of wild growth, trees, and other encroachments as a prerequisite for Public Law 84-99 eligibility. The USACE policy requires removal of all woody vegetation from levee slopes and toe areas. This policy is not consistent with the USACE "vegetation variance letter" dated August 3, 1949, which revised the Standard O&M Agreement to include the following text: "Brush and small trees may be retained on the waterward slope where desirable for the prevention of erosion and wave wash. Where practicable, measures shall be taken to retard bank erosion by the planting of willows or other suitable growth on areas riverward of the levees." The 2007 policy is also not consistent with the long-standing USACE practice of protecting trees while performing levee repairs on Central Valley levees, and requiring new tree planting in its levee designs, where feasible.

USACE has proposed the new levee vegetation policy to improve levee integrity and reduce flood risk. The ***Flood Control System Status Report*** includes DWR's assessment of the safety risks associated with trees and shrubs on, and adjacent to, levees. The report concludes that properly trimmed and spaced levee vegetation poses a low threat to levee integrity in comparison with other risk factors, and can help stabilize soils and reduce nearshore flow velocities. DWR does not believe that the presence of properly maintained woody vegetation on "legacy levees" constitutes a degree of risk that necessarily requires removing vegetation or constructing engineered works to address the perceived risk. Instead, DWR believes such "legacy levee vegetation" needs to be considered in a balanced recognition of its role to the ecosystem and to the levee's integrity.

A preliminary assessment by DWR has also concluded that the complete removal of existing woody vegetation along the 1,600-mile legacy Central Valley levee system would be enormously expensive, would divert investments away from more critical threats to levee integrity, and would be environmentally devastating. Recent USACE research regarding the risks associated with trees on levees found that trees can slightly increase or decrease levee safety, depending on their location on the levee slope. While concluding that more research is needed, the research did not characterize levee vegetation as a major risk factor.

In the spirit of cooperation, DWR, USACE, local maintaining agencies, and key federal and State resources agencies, have been engaged in California Levees Roundtable discussions since August 2007. Early discussions regarding ways to address USACE's levee vegetation policy led to the ***California's Central Valley Flood System Improvement Framework*** (Framework Agreement), dated February 27, 2009. The Framework Agreement allows Central Valley levees to retain acceptable maintenance ratings and Public Law 84-99 rehabilitation eligibility as long as levee trees and shrubs are properly trimmed and spaced to allow for visibility, inspection vehicles, and flood-fight access. The Framework Agreement states that "…the eligibility criteria will be reconsidered based on the contents of the CVFPP."

Erosion along the Sacramento River

While the California Levees Roundtable discussions were underway, USACE issued Engineering Technical Letter (ETL) 1110-2-571, which finalized its ***Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures*** (April 10, 2009). These guidelines essentially established a woody vegetation-free zone on all levees and the adjoining ground within 15 feet of the levee on both sides, and are at odds with DWR's independent assessment described above. As an implementation directive for the ETL, USACE subsequently issued a draft Policy Guidance Letter (PGL), ***Variance from Vegetation Standards for Levees and Floodwalls*** (February 9, 2010). Congress, through the Water Resources Development Act of 1996, Section 202 (g), had mandated that USACE "address regional variations in levee management and resource needs" – but the February 2010 draft PGL did not address regional variations.

Before and following release of the draft PGL, DWR has recommended that USACE formulate a variance process that is workable on a systemwide scale, such as might be required for the Central Valley flood management system. DWR has recommended that such a variance process should allow for consideration of the geotechnical, hydraulic, environmental, and economic factors that DWR believes are important in formulating and prioritizing levee repairs and improvements. Because the February 2010 draft PGL was not workable from DWR's perspective, in May 2011, DWR proposed an alternative variance procedure for USACE consideration. Although USACE has stated their procedural inability to work individually with California (or collectively with several non-federal entities) to collaboratively develop a variance policy that recognizes and accommodates regional differences, DWR remains hopeful that USACE will issue a final vegetation variance PGL that will complement and be consistent with the CVFPP.

It is important to note that the large-scale removal of levee vegetation runs at odds with State and federal environmental requirements. State and federal resource agencies find that the ETL itself, and the potential impacts of widespread vegetation removal due to strict enforcement of that regulation, pose a major threat to fish and wildlife species, including protected species, and to their recovery. Similarly, local agencies are concerned about negative impacts to public safety from ETL compliance due to redirection of limited financial resources to lower priority risks. For this reason, widespread vegetation removal is unlikely to be a feasible management action for many of California's levees.

A further complication is the question of shared responsibility for activities to address woody vegetation. The USACE ETL and associated February 2010 draft PGL do not recognize that legacy levee vegetation exists for a wide variety of reasons (in many cases, because USACE itself placed the vegetation or encouraged its placement or retention), and instead treats all legacy levee vegetation as if it were "deferred maintenance" and solely a nonfederal responsibility. Consequently, USACE asserts through the ETL and draft PGL that all of the administrative and financial burdens for ETL compliance, or for obtaining a variance, should be placed on its nonfederal partners. The State continues to encourage USACE to accept shared responsibility for addressing levee vegetation issues, as appropriate – which would also facilitate USACE plan formulation as a partner in cost-shared flood risk reduction projects.

It is important to note that DWR's purpose in advocating for shared responsibility is not to commit federal funds toward the enormous cost of removing vegetation to achieve ETL compliance. Rather, DWR is advocating that such inordinate costs be avoided by having USACE partner with DWR and local agencies in addressing legacy levee vegetation issues, jointly considering the environmental and risk reduction implications of vegetation remediation within the context of prudent expenditure of limited public funds. DWR will continue to confer with USACE on plan formulation concepts that recognize shared responsibility for addressing vegetation issues (in parallel with traditional levee risk factors) within a systemwide risk-informed context that is intended to enable critical cost-shared flood system improvements to move forward.

A critical limitation of the USACE ETL is that it is written strictly in terms of new levee construction. It does not recognize and address the unique engineering and environmental attributes presented by well-established "legacy vegetation" as an integral aspect of many SPFC levees. While the CVFPP proposes to adhere to USACE vegetation policy for new levee construction, compatibility of the CVFPP levee vegetation management strategy with implementation of USACE national vegetation policy for "legacy levee vegetation" needs flexibility to recognize and accommodate regional differences – which could be achieved through a collaboratively developed variance policy that provides such regional flexibility.

3.10.2 Economics of Public Law 84-99 Eligibility for Rural-Agricultural Levees

Noncompliance with USACE vegetation policy may result in Public Law 84-99 ineligibility for rural-agricultural levees. However, compliance with the policy is costly and generally is not affordable for rural-agricultural maintaining agencies, nor is it practicable. Although the Public Law 84-99 Rehabilitation and Inspection Program can be helpful to nonfederal sponsors in rehabilitating damaged levees after a flood, its usefulness is limited in the Central Valley for the following reasons:

- Funding for Public Law 84-99 rehabilitation assistance is generally very limited. Public Law 84-99 rehabilitation assistance for significant damage repairs usually requires a special appropriation by Congress.
- There is no mechanism to obtain reimbursement or credit when a nonfederal sponsor performs the repairs, or pays USACE to perform the repairs.
- Increasingly stringent USACE maintenance requirements, especially for encroachments and vegetation, can be difficult to meet and are unaffordable.
- Rehabilitation projects need to be economically justified with a benefit-to-cost ratio of 1.0 or greater to justify federal involvement. In rural-agricultural areas of the Sacramento and San Joaquin river basins, this requirement can be difficult to achieve.

From a nonfederal perspective, the most critical concerns about implementing the USACE vegetation policy are the environmental impacts, the cost to comply with the policy, and the misallocation of scarce public funds for system improvement.

Based on USACE expenditures under Public Law 84-99 for declared flood events in 1995, 1997, 1998, and 2006, the preliminary estimate of annualized assistance of levee rehabilitation is approximately $30 million. This estimate is significantly influenced by the $120 million in assistance provided by USACE following the 1997 flood event – an amount not likely to be duplicated based on subsequent changes in USACE policy, such as their levee vegetation policy.

In April 2010, DWR developed a ***Fiscal Impact Report of the U.S. Army Corps of Engineers' Vegetation Management Standards and Vegetation Variance Policy for Levees and Flood Walls***. This report includes the cost estimates of applying the ETL to the 116 critical levee repairs performed from 2006 through 2008 and the cost estimate of applying the ETL to the entire 1,600 miles of project levee system by extrapolation. The estimated order of magnitude cost to comply with the USACE policy ranged from $6.5 billion to $7.5 billion. Annualizing this cost of compliance (over a 50-year project life at 6 percent) would yield an annual cost of over $400 million, more than ten times the $30 million annual assistance estimated above.

Therefore, the State interest is to follow the vegetation management strategy presented in Section 4. The local maintaining agencies may choose to comply with the USACE vegetation policy to maintain Public Law 84-99 eligibility; however, it would be very challenging for rural-agricultural maintaining agencies because of cost of compliance for eligibility. This is evident by the results of fall 2011 USACE periodic inspections, 39 of 116 local maintaining agencies have lost eligibility for

Public Law 84-99 rehabilitation assistance for reasons other than vegetation. In addition, removal of levee systems from "active status" under Public Law 84-99 based on noncompliant vegetation would be unfortunate and unnecessary. USACE Engineering Regulation 500-1-1 protects the federal government from bearing any of the cost of any levee rehabilitation work associated with "deferred or deficient maintenance." Thus, to protect the federal investment in SPFC levees, USACE would be justified in retaining "active status" for SPFC levee systems with noncompliant vegetation, assigning to the nonfederal partner any rehabilitation costs attributable to such vegetation.

3.11 Residual Risk Management

As elements of the SSIA are constructed over time, residual flood risk within the Central Valley should decrease. However, the potential for flooding in the Central Valley will always pose risks to life and property, particularly in areas of deep or rapid flooding. Table 3-4 illustrates estimated residual risk management needs for the SSIA. These can be compared with the residual risk needs estimated for the preliminary approaches in Table 2-2.

Table 3-4. Residual Risk Management for State Systemwide Investment Approach

FLOOD MANAGEMENT ELEMENT	PROJECT LOCATION OR REQUIRED COMPONENTS	INCLUDED IN SSIA IMPLEMENTATION
Enhanced Flood Emergency Response	All-weather roads on levee crown	YES
	Flood information collection and sharing	YES
	Local flood emergency response planning	YES
	Forecasting and notification	YES
	Rural post-flood recovery assistance program	YES (small)
Enhanced Operations and Maintenance	Identify and repair after-event erosion	YES
	Developing and implementing enhanced O&M programs and regional O&M organizations	YES
	Sacramento channel and levee management, and bank protection	YES
Floodplain Management	Raising and waterproofing structures and building berms	YES (large)
	Purchasing and relocating homes in floodplains	YES (large)
	Land use and floodplain management	YES
	Agricultural conservation easements	YES

Key:
Large = relatively high level of work to implement
O&M = operations and maintenance
Small = relatively low level of work to implement
SSIA = State Systemwide Investment Approach

Consequently, investments in residual risk management must continue, both during and after implementation of the SSIA. Policies and programs related to residual risk management are described in more detail in Section 4.

3.12 Estimated Cost of State Systemwide Investment Approach

Table 3-5 summarizes the preliminary estimate of costs for the SSIA, assuming all elements are ultimately completed. Estimates include costs for capital improvements and 25 years of ongoing annual work to maintain the system. Estimated costs are in 2011 dollars. Actual costs will vary from those in Table 3-5 because of a wide range of factors, including project justification by feasibility studies, project configuration, implementation time, future economic and contractor bidding conditions, and many others.

Specific project features ultimately implemented for the SSIA will depend on a host of factors. These factors include detailed project feasibility studies; designs and costs; environmental benefits and impacts; interaction with other local projects and system improvements; local, federal, and State agency participation in project implementation; and changing physical, institutional, and economic conditions.

The table also includes SPFC flood management investments that have already been expended or committed during the 2007 to 2011 period. Since passage of the 2007 flood legislation directing preparation of the CVFPP, the State has made substantial progress in reducing flood risks within the Central Valley by investing bond funds from Propositions 84 and 1E. These efforts encompass urban levee improvements, emergency repair projects, physical and operational changes to flood management reservoirs, emergency response planning, and improvements to operations and maintenance, emergency response, and floodplain management. These accomplishments over the past five years represent significant progress in achieving the CVFPP Goals.

The estimated amounts in Table 3-5 are total combined investments for State, federal, and local agencies. Section 4 provides further detail on cost-sharing proportions, and expenditures prior to adoption of the CVFPP. Consistent with traditional cost-sharing for flood management projects, DWR

STATE INVESTMENTS IN STATE PLAN OF FLOOD CONTROL FLOOD MANAGEMENT, 2007 – 2011

Flood Emergency Response

- Emergency exercises
- New water gaging
- Forecast-Coordinated Operations for Yuba/Feather
- Rock stockpiles in the Delta

Operations and Maintenance

- Over 220 levee sites repaired
- Sediment removal from bypasses
- Rehabilitation of 7 flood structures

Floodplain Management

- Approved building code amendment for single-family residential occupancy
- 300,000 flood risk notifications annually, since 2009
- Mapping of Central Valley Levee Flood Protection Zones

Capital Improvements

- 15 ongoing or completed projects

Assessments and Engineering

- 9,000 square miles of topographic data
- Urban and nonurban levee evaluations
- State Plan of Flood Control Descriptive Document
- Flood Control System Status Report
- CVFPP development
- Coordination with USACE on many ongoing evaluations

Ecosystem

- See Section 4 for ecosystem accomplishments

Table 3-5. Estimated Costs of State Systemwide Investment Approach ($ millions)

REGION	SYSTEM IMPROVEMENTS Low High	URBAN IMPROVEMENTS Low High	RURAL-AGRICULTURAL IMPROVEMENTS Low High	RESIDUAL RISK MANAGEMENT Low High	TOTAL COST Low High
1 – Upper Sacramento	$109 - $180	$120 - $144	$154 - $168	$95 - $114	$480 - $610
2 – Mid-Sacramento	$234 - $340	$0 - $0	$360 - $379	$261 - $333	$860 - $1,050
3 – Feather River	$1,695 - $2,139	$891 - $1,048	$282 - $289	$170 - $212	$3,040 - $3,690
4 – Lower Sacramento	$1,627 - $1,962	$3,549 - $4,283	$77 - $88	$138 - $169	$5,390 - $6,500
5 – Delta North[1]	$754 - $924	$144 - $192	$604 - $634	$266 - $311	$1,770 - $2,060
6 – Delta South[1]	$427 - $549	$0 - $0	$47 - $52	$110 - $135	$580 - $740
7 – Lower San Joaquin	$7 - $8	$626 - $809	$17 - $19	$82 - $97	$730 - $930
8 – Mid-San Joaquin	$60 - $102	$0 - $0	$48 - $55	$81 - $96	$190 - $250
9 – Upper San Joaquin	$229 - $297	$166 - $199	$183 - $189	$308 - $396	$890 - $1,080
TOTAL	$5,140 to $6,500	$5,500 to $6,680	$1,770 to $1,870	$1,510 to $1,860	$13,920 to $16,910

Notes:
[1]SPFC Facility costs only
Costs in $ millions. All estimates in 2011 dollars.

Key:
SPFC = State Plan of Flood Control

estimates that the State's share of costs included in Table 3-5 will be $6,400 million to $7,700 million, including already expended or committed investments, if all elements of the SSIA are ultimately constructed. Section 4 also shows cost estimates over a more certain time period of 10 years that will allow near-term projects to be constructed as longer term projects are under additional evaluation.

3.13 Performance of State Systemwide Investment Approach

Based on the evaluations, the SSIA could effectively improve management of flood risk for urban, small community, and rural-agricultural areas given differing population, assets at risk, and other State interests. The SSIA reflects a cost-justifiable approach to effectively meet the legislation requirements and the CVFPP Goals, and provides a road-map for more detailed studies and designs leading to site-specific capital improvements.

The following sections summarize the additional performance benefits that could be achieved through implementing the SSIA. The following sections compare the performance of the SSIA to current conditions for several key parameters: changes in flood stage, sustainability, contributions to the CVFPP Goals, and relative efficiency. For analysis purposes, the current or No Project condition represents conditions consistent with the Notice of Preparation for the PEIR. It is also important to note that Early Implementation Projects and other FloodSAFE initiatives implemented since bond funding became available in 2007, which are considered part of the SSIA, have already provided benefits.

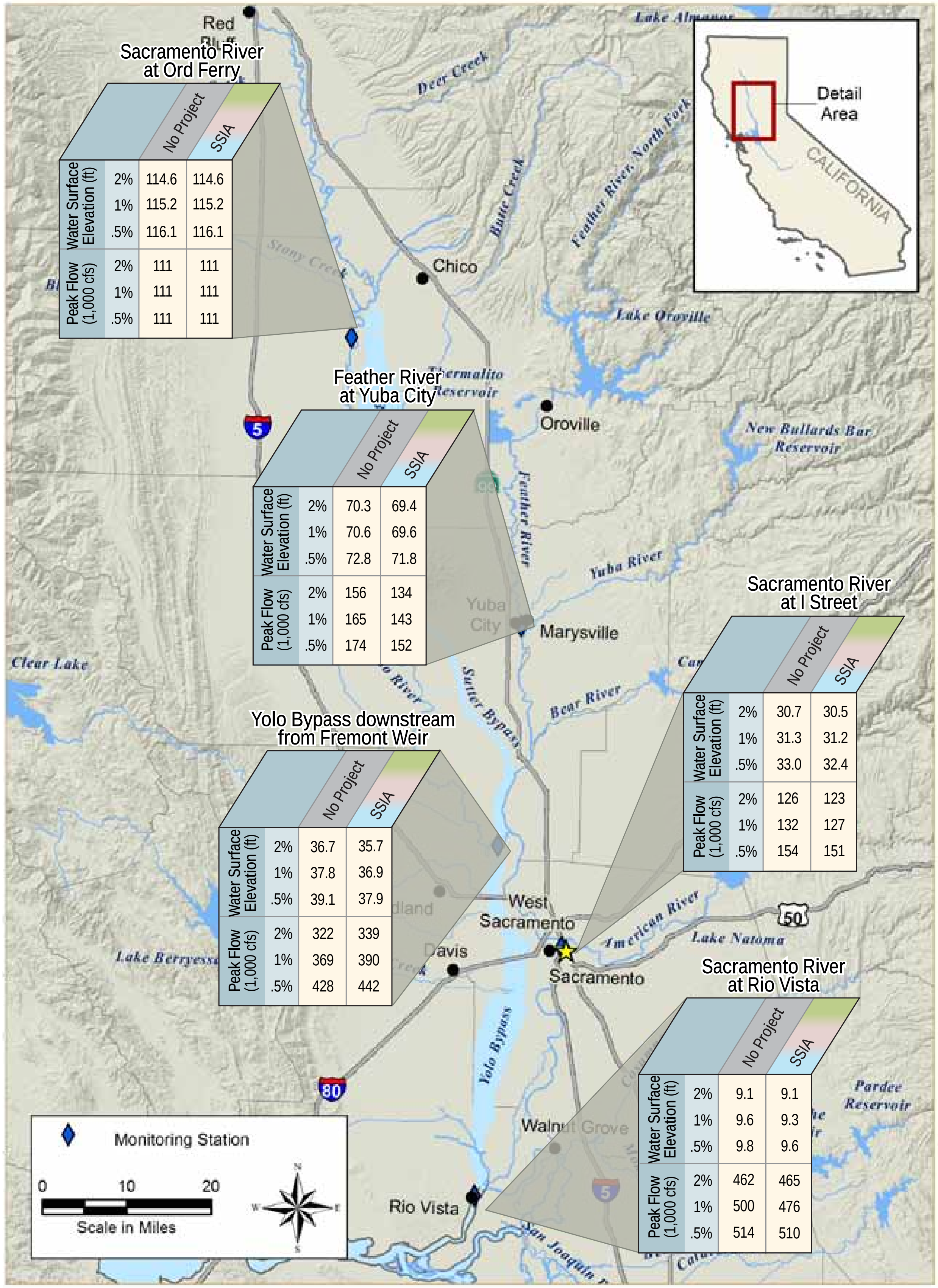
3.13.1 Stage Changes

STATE SYSTEMWIDE INVESTMENT APPROACH STAGE PERFORMANCE

Although peak floodflows may increase locally (over current conditions) in certain reaches, expansion of conveyance capacity proposed by the SSIA would result in reduced peak flood stages throughout the system.

Figures 3-4 and 3-5 illustrate performance of the SSIA with respect to systemwide peak floodwater surface elevations (stages) compared to current conditions. In most areas along the rivers in the Sacramento River Basin, stages are lower than current conditions because of the proposed bypass expansions. Flood stages in the San Joaquin River Basin would not change much with respect current conditions because large bypass expansions were not included, except near the Delta. Flood stages entering the Delta may be higher by a few tenths of a foot. If stage changes result in significant hydraulic impacts, features to mitigate the impacts may be used.

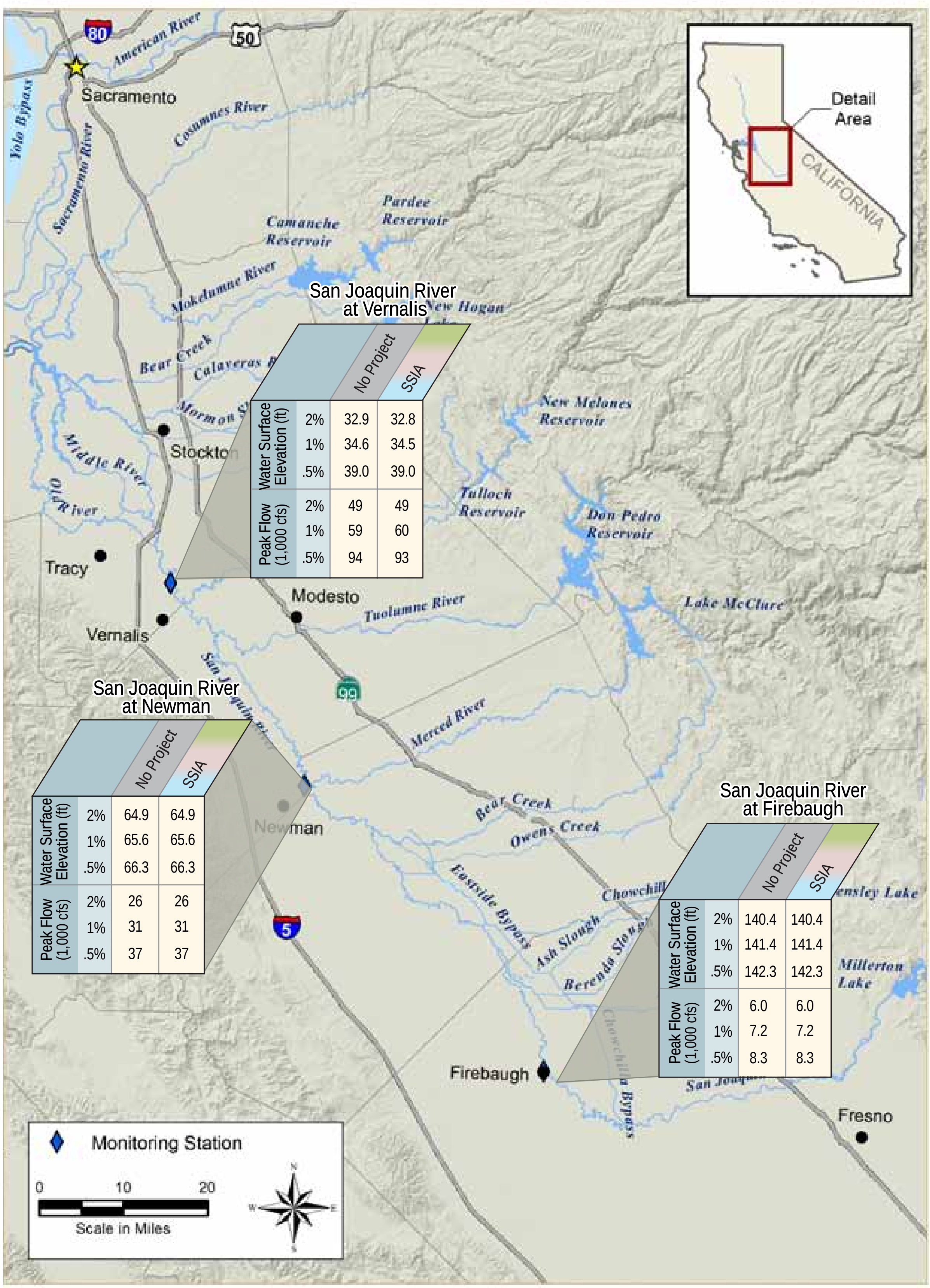
Sequencing improvements along the river corridors may cause temporary water stage impacts and or hydraulic impacts. Sequencing improvements from downstream to upstream may eliminate these temporary impacts, but may not be practical considering the wide range of improvements that need to be made.



Note: Figure presents peak flow and water surface elevation estimates for various frequency flood events (represented as percent chance exceedence, e.g., 1%) at selected monitoring locations in the Sacramento River Basin.

Key: cfs = cubic feet per second ft = feet SSIA = State Systemwide Investment Approach

Figure 3-4. Changes in Peak Floodflows and Stages – No Project Versus State Systemwide Investment Approach for Various Storm Events – Sacramento River Basin



Note: Figure presents peak flow and water surface elevation estimates for various frequency flood events (represented as percent chance exceedence, e.g., 1%) at selected monitoring locations in the San Joaquin River Basin.

Key: cfs = cubic feet per second ft = feet SSIA = State Systemwide Investment Approach

Figure 3-5. Changes in Peak Floodflows and Stages – No Project Versus State Systemwide Investment Approach for Various Storm Events – San Joaquin River Basin

3.13.2 Sustainability

Table 3-6 summarizes the financial, environmental, and social sustainability aspects of the SSIA compared with current conditions.

Table 3-6. Summary of State Systemwide Investment Approach Sustainability Compared with No Project

	NO PROJECT	STATE SYSTEMWIDE INVESTMENT APPROACH
Overall Sustainability	Low	Medium
Financial	Very high ongoing and long-term annual costs	Very high upfront and lower long-term annual costs.
Environmental	Limited opportunities to improve habitat connectivity, quality, quantity, and biodiversity	Enhanced opportunities to improve habitat connectivity, quality, quantity, and biodiversity.
Social	Varied level of protection throughout the system Significant potential for public safety and economic consequences of flooding	Seeks flood protection comparable with assets being protected. Limits cumulative growth of flood risks to State's people and infrastructure due to system improvements. Reduces reliance on compensatory mitigation for project implementation and regular operations and maintenance due to implementation of systemwide conservation strategy. Rebalances institutional arrangement for operations and maintenance responsibilities.
Climate Change Adaptability	Low system resiliency (ability to adapt)	Conveyance improves flood system resiliency by lowering stages, which improves ability to adapt to climate change.

Key:
State = State of California

3.13.3 Central Valley Flood Protection Plan Goals

Table 3-7 summarizes contributions of the SSIA to the five CVFPP Goals, compared with No Project.

3.13.4 Relative Efficiency

DWR prepared a qualitative comparison to show broad differences in potential performance of the preliminary approaches and the SSIA. Figure 3-6 shows these qualitative comparisons of performance for the SSIA with the three preliminary approaches. These comparisons are the same as shown in Figure 2-6, but with the addition of the SSIA.

Another view of the relative performance of the three preliminary approaches and SSIA is shown in Figure 3-7. The figure shows preliminary cost estimates and estimated performance in terms of the relative contributions of each approach to the primary and supporting goals of the CVFPP.

Table 3-7. Summary of Contributions of State Systemwide Investment Approach to Central Valley Flood Protection Plan Goals Compared with No Project

GOAL OR METRIC	NO PROJECT	STATE SYSTEMWIDE INVESTMENT APPROACH
Contributions to Primary Goal – Improve Flood Risk Management		
– Level of Flood Protection	Varies throughout system • Most urban areas do not have 200-year level of flood protection • Protection to rural-agricultural areas and small communities varies widely	Overall higher protection consistent with assets being protected • Urban areas achieve protection from a 200-year flood, and for small communities achieve protection from a 100-year flood • Overall increased levels of flood protection throughout the system reflecting improved capacity to manage flood peaks
– Life Safety (focused on populations at risk)	Varies throughout system • Public safety threat is high for many communities, particularly those in deep floodplains	Improvement varies • Substantial improvement in urban areas • Improvement in small communities varies
– Economic Damages	$329 million in expected annual damages • Economic damages, particularly in urban areas, are very high	Reduction of 66 percent in expected annual damages • Substantial reduction in damages in urban areas, small communities, and rural areas
Contributions to Supporting Goals		
Improve Operations and Maintenance	Very high current costs • Ongoing and long-term O&M costs are very high relative to other approaches	Decrease in long-term O&M requirements • Decrease in long-term costs due to O&M reforms (clarified roles and responsibilities, consistent standards, and revenue generation improvements) and physical modification to reduce geomorphic stressors
Promote Ecosystem Functions	Limited opportunities for ecosystem benefit • Native habitat may be integrated into SPFC repair projects, primarily through mitigation	Enhanced opportunities for systemwide ecosystem benefit • Floodway expansion provides substantial opportunity to improve ecosystem functions, fish passage, and the quantity, quality, and diversity of natural habitats
Improve Institutional Support	• **Continued dispersion of responsibilities and roles** for flood management in the Central Valley among many agencies with varying functions and priorities	• **Improve flood management functions** through changes and/or clarifications in current State policy directives, legislated authority and responsibilities, and partnerships with federal and local partners
Promote Multi-Benefit Projects	• **Limited opportunities** to integrate other benefits into repairs to SPFC facilities	• **Enhanced opportunities** to integrate water quality, groundwater recharge, recreation, power, and other benefits
Ability to Meet Legislative Objectives (Completeness)		
Ability to Meet Objectives in Flood Legislation	Does not meet • Varied level of protection throughout the system and high potential for public safety and economic damages	Addresses all objectives • Contributes to all objectives with proposed system and regional elements, and supporting implementation policies and programs

Key:
O&M = operations and maintenance
SPFC = State Plan of Flood Control
State = State of California

PERFORMANCE CATEGORY	ACHIEVE SPFC DESIGN FLOW CAPACITY	PROTECT HIGH RISK COMMUNITIES	ENHANCE FLOOD SYSTEM CAPACITY	STATE SYSTEMWIDE INVESTMENT APPROACH
Flood Risk Reduction Benefit	Moderate	Moderate-High	High	Moderate-High
Level of Flood Protection	Low-Moderate	Moderate	High	Moderate-High
Life Safety	Low-Moderate	Moderate-High	Moderate-High	Moderate-High
Reduction in Economic Damages	Moderate	Moderate-High	Moderate-High	Moderate-High
Regional Economics	Moderate	Moderate-High	High	Moderate-High
Integration and Sustainability	Low	Low-Moderate	High	Moderate-High
Promote Ecosystem Functions	Low	Low	High	Moderate
Promote Multi-Benefit Projects	Low	Low-Moderate	High	Moderate-High
Sustainable Land Uses	Low	Low-Moderate	High	High
Cost	$$$	$$	$$$	$$
Capital Costs	$$$	$	$$$$	$$
Operations & Maintenance	$$	$$$$	$	$$

BENEFIT KEY

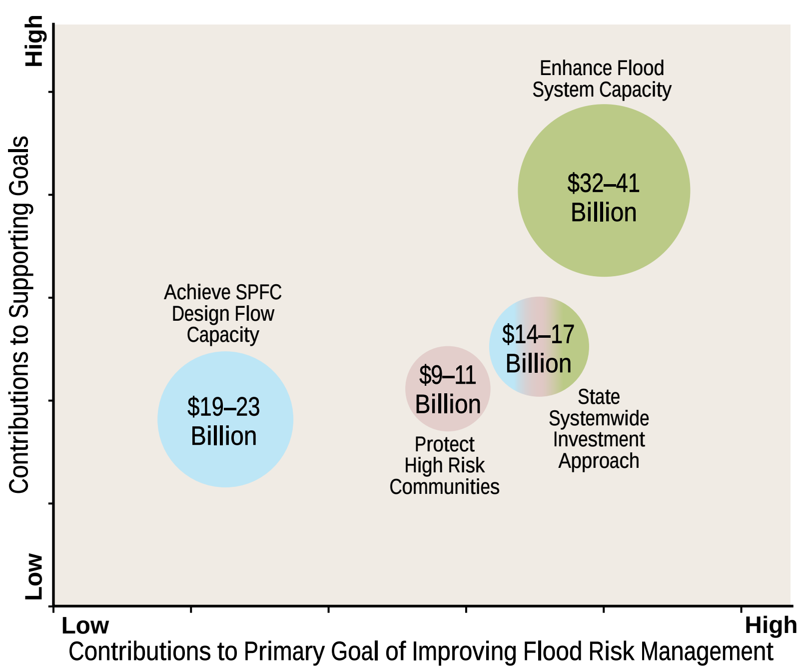
- Low
- Low-Moderate
- Moderate
- Moderate-High
- High

COST KEY

- $ Low-Moderate
- $$ Moderate
- $$$ Moderate-High
- $$$$ High

Key: SPFC = State Plan of Flood Control

Figure 3-6. Performance Comparison for All Approaches



KEY: SPFC = State Plan of Flood Control

Figure 3-7. Relative Comparison of State Systemwide Investment Approach and Preliminary Approach Efficiency

3.14 State Systemwide Investment Approach Benefits

The SSIA, as a multi-benefit and integrated flood management approach, has many direct and indirect benefits to the Central Valley, State, and nation. This section summarizes the benefits of the SSIA.

Benefits assessed include reduced economic damages, benefits to local and regional economies, improved public health and safety, ecosystem restoration, open space and recreation, increased flood system resiliency and climate change adaptability, water management, and reduced long-term flood system management costs. Some of these benefits are presented quantitatively and some qualitatively, because some of the benefits could not be calculated at this time. These benefits will be further refined and documented during the feasibility study process scheduled to be initiated upon adoption of the CVFPP by the Board.

3.14.1 Reduced Economic Flood Damages

The USACE Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) model was used to estimate the flood risk reduction benefits of the SSIA. Expected annual flood damages were computed over the array of potential floods, from small to extremely large, compared with the no project condition. The flood damage estimates consider the following:

- Residential, commercial, industrial, and governmental structure and contents damage
- Agricultural/crop losses
- Business production losses

Results of the modeling indicate an overall reduction in total expected annual damages of about 66 percent, with specific reductions in damages and losses as follows:

- Structure and contents flood damages would be reduced by 73 percent
- Crop damages due to flooding would be reduced by 6 percent
- Business production losses would be reduced by 71 percent

3.14.2 Benefits to Local and Regional Economies

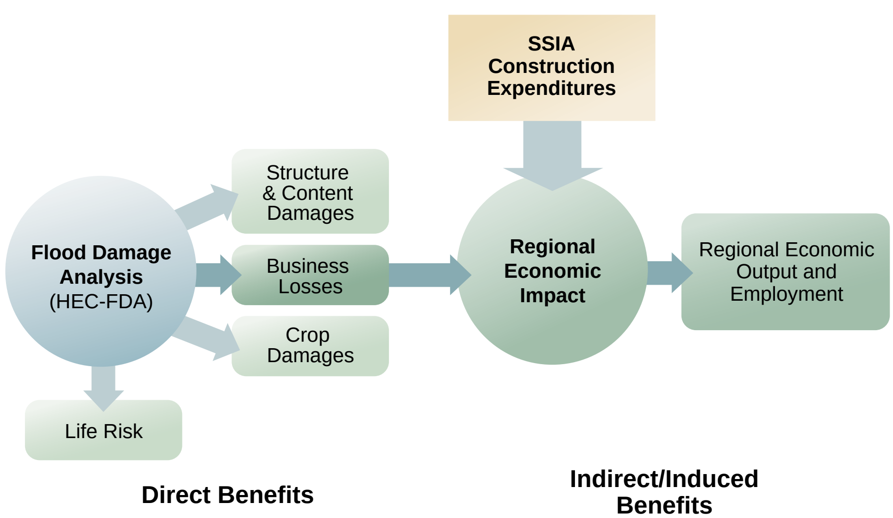
Reduction in flood damages is only one aspect of the potential economic benefits of the SSIA. As illustrated in Figure 3-8, flood risk reduction improvements can also provide both direct and indirect benefits to local, regional, and State economies.

Implementation of the SSIA would contribute to local and regional economic activities, as described below:

- **Increased benefits to regional economies** – Implementing the SSIA would directly and indirectly benefit local and regional economies and support continued economic development in the valley. Implementation of the plan would reduce the potential for lost agricultural, commercial, and industrial production/income, and secondary "ripple" effects, as a result of a flood.

Construction activities related to SSIA implementation could be expected to boost economic output over the coming decades by as much as $900 million, and avoided business losses due to flooding could increase long-term economic output by over $100 million. The potential for flood-induced industry relocation or failure to recover to preflood levels would also be reduced. In addition, construction projects resulting from implementation of the SSIA would be expected to boost regional short-term employment and employment incomes, and increase regional economic output. Construction activities in support of SSIA implementation could be expected to generate as many as 6,500 jobs annually over the coming decades, while reduced business losses from flooding could be expected to boost long-term employment. These employment economic benefits would also enhance the revenues of local governments through increased income and sales taxes.

- **Enhanced agricultural sustainability** – Central Valley agriculture is a critical sector of the State economy that provides and supports reliable, affordable food and fiber production, both domestically and on a global scale. Agricultural and associated processing industries and services also account for a considerable portion of local employment. Flood management improvements would reduce direct crop damages. Improved flood protection would result in an increased ability to obtain favorable crop insurance coverage and rates. Similarly, improved protection would also increase the ability to obtain agricultural loans with favorable terms. As a result, flood management improvement has the potential to contribute to improved agricultural sustainability. Over 90 percent of the citizens in rural-agricultural areas and small communities within the SPFC Planning Area could receive additional flood protection by levee improvement measures, flood proofing, and relocation opportunities presented in the SSIA.



Key: HEC-FDA = U.S. Army Corps of Engineers Hydrologic Engineering Centers Flood Damage Analysis
SSIA = State Systemwide Investment Approach

Figure 3-8. Components of Economic Analysis

- **Reduced disruption of public services** – In addition to reducing physical damages to structures and infrastructure, flood management improvements would reduce potential disruption of critical public services needed to maintain the health, safety, and welfare of the population. These critical functions include emergency services, transportation, health care, education, and public utilities (water and wastewater, electricity, natural gas, and communications). Interruption of these services and functions would greatly affect socioeconomic conditions in the region and its economic and industrial diversity. The CVFPP has not quantitatively assessed the loss of critical public services, but has estimated the number of critical facilities *exposed* to flood hazards.

3.14.3 Improved Public Health and Safety

A primary objective of the SSIA is to protect the citizens living and working in the floodplains of the Central Valley.

- **Reduced potential for injuries and loss of life** – When fully implemented, the SSIA would significantly reduce the potential for flooding in urban areas and other population centers, thereby reducing the direct threats posed by flooding to public safety, including the potential for injury or loss of life. Implementation of the SSIA would result in an increase in the population receiving at least a 100-year (1% annual chance) level of flood protection from the current 21 percent to over 90 percent. Additional reductions in the potential for loss of life would be achieved as a result of nonstructural flood mitigation, such as improved flood emergency response, operations and maintenance, and floodplain management measures.

  HEC-FDA was used to estimate life risk indicators and inform the decision-making process. However, these values are NOT forecasts of deaths expected to occur from flood events, to be used for emergency planning or other purposes. Instead, these values are informative indices of life risk, providing a metric for assessing the reduction in life risk attributable to the SSIA. Based on the analysis, the SSIA was shown to reduce life risk by about 49 percent compared with current conditions.

  The economic and life safety benefits for the SSIA described above do not include benefits attributable to projects that were recently completed or are currently under construction. Therefore, the overall benefits of the SSIA described herein are considerably underestimated.

- **Reduced release of hazardous materials during floods** – Floods can cause a release of hazardous materials resulting in increased threats to public health and safety. Hazardous materials and contaminants may exist in floodplains, including feed lots, fuel tanks, septic systems, water and wastewater treatment facilities, landfills, illegal dumping, and other sources. Improved flood management under the SSIA would contribute to reducing public exposure to hazardous materials released during floods and improve water quality.

3.14.4 Ecosystem Restoration Benefits

Ecosystem restoration is fully integrated with the flood risk reduction components of the SSIA. Major restoration benefits of the SSIA include the following:

- Floodways would be expanded and extended to improve the flow carrying capacity of the channels, and the lands acquired for the expansion would be used for habitat restoration and environmentally-friendly agricultural activities. Over 10,000 acres of new habitats would be created within the flood management system. In addition, over 25,000 acres of land would be leased for growing grains, corn, and other habitat-compatible crops. Flood management system improvements would provide opportunities for improving ecosystem function and increasing habitat extent, quantity, quality, and connectivity from the Delta to the upper Sacramento River. Expanded floodways would create space for river meandering, sediment erosion and deposition, natural ecosystem disturbance processes, and a healthy diversity of riverine habitat.
- The SSIA would improve fish passage at flood diversions, flashboard dams, and flood management structures. This includes connecting fishery habitat from the Delta to the Yolo and Sutter bypasses and to the Butte Basin. These actions would assist in increasing and improving habitat connectivity and promoting the recovery of anadromous fish populations.
- Changes in flood control facility operations, including directing flows more frequently and for longer durations over weirs and into bypasses, levee setbacks, and other similar measures planned under the SSIA, would enhance riverine processes and improve the overall health of the ecosystem.

Overall, these restoration activities would contribute to improving habitat connectivity along the flood management system, would provide for migration of fish to spawning areas in the watershed, and would enhance riverine processes.

3.14.5 Open Space and Recreational Opportunities

The State's interest in public health and sustainable economic growth are well supported by the quality of life benefits of nature-based recreation and the economic vitality provided by environmental tourism revenues. The potential for recreational use of the flood control system has long been recognized. In 1929, when the flood control system was under construction, noted landscape architect Frederick Law Olmstead Jr. recommended that a system of recreation lands be preserved within the leveed floodplains along the lower Sacramento River and other waterways.

The SSIA includes floodplain reconnection and floodway expansion, which would improve ecosystem functions, fish passage, and the quantity, quality, and diversity of natural habitats, all of which contribute to increasing opportunities for recreation and ecotourism, as well as augmenting the aesthetic values of those areas. Expansion of habitat areas provides fishing, hunting, and wildlife viewing opportunities. Recreation-related spending associated with increased use by visitors can be an important contributor to local and regional economies.

3.14.6 Increasing Flood System Resiliency and Climate Change Adaptability

Climate change is expected to result in more precipitation in the form of rainfall, more frequent flooding, and higher peak flows. Expansion and extension of the bypass system under the SSIA would reduce peak flood stages throughout the system, increasing the flood carrying capacity of channels and, hence, add flexibility to manage extreme flood events and future climate change effects.

3.14.7 Water Management Benefits

The SSIA, as an integrated flood and water management program, would provide opportunities for improved water management in many ways. While estimates of water management benefits will be quantified for the 2017 CVFPP, DWR expects that the average annual water management benefits of the SSIA may approach a few hundred thousand acre-feet compared to No Project. SSIA elements that could contribute to improved water management include reservoir operations and increases in channel groundwater recharge due to expansion and extension of the bypass system.

- **Reservoir operation** – The F-CO program (see Section 3.5.8) is designed to modify operation of reservoirs in a way that will improve flood management and also provide opportunities for more aggressive refilling of reservoirs during dry years. Such operations could increase water supplies within reservoirs, especially in dry years when the water supply system is most stressed. Water supply benefits from F-BO would vary depending on current reservoir operation manual requirements, watershed hydrology, flexibility in reservoir operation (i.e., adequate release capacity), quality of reservoir inflow forecasts, etc. Therefore, a case-by-case study of flood management reservoirs will be needed to adequately define and quantify the potential benefits of reservoir F-BO.
- **Groundwater recharge** – Groundwater aquifers are naturally recharged through various processes, including percolation of precipitation and infiltration of water from lakes, canals, irrigation and in-channel groundwater recharge. Implementation of the SSIA includes expansion and extension of the bypass system and levee setbacks. These actions would expand flood system lands by an additional 35,000 to 40,000 acres, which would be flooded during high water and contribute to in-channel and floodplain groundwater recharge.

3.14.8 Reduced Long-Term Flood System Management Costs

Although not quantified for the 2012 CVFPP, the SSIA was developed to reduce the overall, long-term costs associated with flood management in the Central Valley. This includes the following:

- Reduced long-term emergency response and recovery needs
- Reduced long-term operations and maintenance costs
- Efficiency through regional approaches to permitting and regulatory needs

3.15 Land Use

SPFC improvements under the SSIA provide for higher levels of flood protection for existing land uses without taking actions that may encourage changes to those uses. Elements of the SSIA have been carefully formulated to reduce flood risk in the area protected by SPFC facilities while avoiding land use changes that promote growth in deep floodplains and increase State flood hazard liabilities. Improved flood protection with the SSIA enhances the likelihood that activities associated with each existing land use will continue to thrive.

Following is a summary of land use conditions under the SSIA:

- **Urban Land Use** – Urban and urbanizing areas within the SPFC Planning Area would achieve a minimum of 200-year (0.5% annual chance) flood protection, as specified by legislation. Legislation requires each city and county within the Sacramento-San Joaquin Valley to amend its general plan to include data, analysis, goals, and policies for protection of lives and property, and related feasible implementation measures. DWR will make data, analysis, and information gathered for the CVFPP available to local agencies for inclusion in their amended general plans. In addition, these local entities are required to amend their zoning ordinances to be consistent with their general plans. As a result, urban development would continue based on sound planning; however, the SSIA does not promote urban development in floodplains beyond existing urban/urbanizing areas.
- **Small Community Land Use** – The SSIA supports the continued viability of small communities within the SPFC Planning Area to preserve cultural and historical continuity and important social, economic, and public services to rural-agricultural populations, agricultural enterprises, and commercial operations. Under the SSIA, several small communities within the SPFC Planning Area would achieve 100-year (1% annual chance) flood protection through structural means such as ring levees, where feasible. This would preserve small community development opportunities within specific boundaries without encouraging broader urban development. However, some small communities adjacent to existing urban areas may achieve a 100-year level of flood protection or higher as a result of improvements for the adjacent urban areas. For other small communities where structural improvements are not feasible, the SSIA proposes nonstructural means such as flood proofing and elevating structures to support continued small communities land use, providing feasible flood protection in a way that is not growth-inducing.

EFFECTS OF STATE SYSTEMWIDE INVESTMENT APPROACH IMPLEMENTATION ON LAND USE

Preliminary analyses indicate that with implementation of the SSIA it is expected that:

- 100 percent of existing urban areas protected by SPFC facilities attain 200-year level of flood protection
- About 20 of the small communities in the SPFC Planning Area (from a total of 27) will attain 100-year level of flood protection, at a minimum. The rest of the small communities are expected to get flood protection through nonstructural means, including raising, flood proofing, and relocation of structures
- About 90 percent of residents in small communities within the SPFC Planning Area will receive at least 100-year flood protection
- In rural areas, the level of flood protection will increase slightly; in the Sacramento River Basin, rural areas receiving a 25-year or higher level of protection would increase by about 6 percent, while the San Joaquin River Basin will increase slightly
- About 10,000 acres of agricultural lands would be converted to environmental habitat restoration within the expansion of the bypass systems

- **Rural-Agricultural Area Land Use** – The SSIA includes improvements for rural-agricultural flood protection, but excludes participation in flood projects to achieve 100-year (1% annual chance) flood protection that would be growth-inducing and, thus, increase potential flood risks. The SSIA includes many elements to preserve rural-agricultural viability, such as purchase of conservation easements to preserve agriculture and prevent urban development, when consistent with local land use planning and in cooperation with willing landowners. Because expansion of floodways would be primarily in rural-agricultural areas, some loss of agricultural land would occur. However, based on preliminary planning, 75 percent of additional land needed for bypass expansion would continue to be farmed. The remaining 25 percent that would be subject to more frequent flooding would be converted to ecosystem uses.

  The State will work with FEMA's National Flood Insurance Program to promote the continued sustainable rural-agricultural economy and to examine opportunities to provide affordable flood insurance for low risk agricultural and farming structures in the floodplain.

- **Ecosystem/Open Space Land Use** – Opportunities for ecosystem and open space land use would increase within the footprint of the flood management system facilities, especially through expansion of bypasses and select areas where setback levees for multiple benefits prove feasible. This net increase in habitat area should contribute to flood risk reduction and ecosystem restoration and enhancement, while providing for open space and recreational opportunities in rural areas.

  Setback levees along some reaches of the main rivers may increase habitat area. These setbacks are likely to be most feasible in reaches where there are known levee conditions that would be difficult to correct with fix-in-place methods, operations and maintenance problems exist, channel hydraulic performance would be significantly improved, regional flood risk reduction benefits would be realized, and/or there is an opportunity for uniquely valuable ecosystem restoration.

LIMITING GROWTH IN CENTRAL VALLEY FLOODPLAINS

SSIA improvements are designed to discourage growth in rural floodplains with the intention of reducing flood risks. The State does not promote flood management improvements that would induce growth in rural areas.

Urban flood risk reductions under the SSIA will be limited to areas protected by facilities of the State Plan of Flood Control.

Agricultural conservation measures proposed by the SSIA are also designed to limit conversion of agricultural land to urban uses, and to preserve the robust agricultural economy of the Central Valley.

Feather River Setback Levee was Constructed for Multiple Benefits Including Improved Flow Conditions

4.0 IMPLEMENTING AND MANAGING THE STATE SYSTEMWIDE INVESTMENT APPROACH

Section 3 outlined the integrated set of on-the-ground projects that comprise the State Systemwide Investment Approach (SSIA). Section 4 describes how DWR will implement the SSIA, including the development of feasibility studies, funding strategies, and implementation challenges.

The SSIA is a broad plan for flood system improvements and additional work is needed to refine its individual elements. Some elements have already been implemented (since 2007), others will be accomplished before the first update of the CVFPP in 2017, and many will require additional time to fully develop and implement. Ongoing planning studies, engineering, feasibility studies, designs, funding, and partnering are required to better define, and incrementally fund and implement, these elements over the next 20 to 25 years.

In general, DWR will continue to prioritize its implementation efforts on the most significant flood risks. However, some critical elements could take longer to implement because of complexity, local and federal interest, and funding that will be made available incrementally over the next few decades. While implementation must occur incrementally, the accumulated outcome will be a sustainable flood management system.

This section describes DWR programs and strategy for implementing and managing the SSIA over time, planning level cost estimates, and funding strategies and partnership among federal, State, and local agencies needed to implement the SSIA. Each of the programs below will have an implementation plan with details of program activities and priorities.

4.1 Flood Management Programs

SSIA implementation requires a wide range of actions for developing, constructing, and managing improvements to the SPFC. This work will be organized into several programs, established and led by DWR and implemented in coordination with local, State, and federal partnering agencies. These programs are governed by DWR's existing FloodSAFE organization. Each program is responsible for specialized implementation of different portions of the SSIA; together, they cover all work required for implementation and management.

DWR's major flood management programs are as follows:

- Flood Emergency Response Program
- Flood System Operations and Maintenance Program

- Floodplain Risk Management Program
- Flood System Assessment, Engineering, Feasibility, and Permitting Program
- Flood Risk Reduction Projects Program

The first three programs are responsible for residual risk management. The fourth program is responsible for conducting the feasibility evaluations and design, engineering, and other activities necessary for implementation. The last program is responsible for working with partnering agencies to implement on-the-ground projects that are included in the SSIA.

The following sections describe these programs and related key policies.

ENVIRONMENTAL JUSTICE

California's low socio-economic status residents are often the most vulnerable to the impacts of natural disasters due to the location and quality of housing, lack of resources to relocate, barriers to transportation, or other factors. Consequently, reducing the risk of flooding, and improving flood emergency response are both very relevant to low socio-economic status populations.

It will be important and necessary for local and regional agencies to incorporate environmental justice principals into regional flood management plans and flood emergency response and recovery activities.

4.1.1 Flood Emergency Response Program

The responsibility of the Flood Emergency Response Program is to prepare for floods, effectively respond to flood events, and quickly recover when flooding occurs. The SSIA supports enhanced emergency response, particularly for rural-agricultural areas where physical improvements are not anticipated to be as extensive as in more populated areas. Program enhancements include providing flood hazard information, real-time flood data, more frequent and timely flood forecasts, and state-of-the-art flood emergency information dissemination. In addition, the SSIA includes a State cost-shared program for improving levee crowns to provide all-weather access roads that allow agencies to quickly respond to flood emergencies. This is a one-time State-local cost-shared program. The program also provides real-time flood information to assist local agencies in deciding whether and how to conduct flood emergency response and evacuation actions for the public.

Reservoir flood operations during major flood events play a role in reducing downstream flood peaks. Coordinated operation of reservoirs to help manage the timing of their individual flood peaks, thereby minimizing cumulative downstream flood peaks, is a major element of the process.

Similarly, coordinated flood operations among local maintaining agencies, cities and counties, the California Emergency Management Agency, the State-Federal Flood Operation Center, and USACE are critically important in managing and fighting floods, and saving lives and properties.

The Flood Emergency Response Program will make flood management system information easily accessible to entities involved in flood management. Through the California Data Exchange Center, the State intends to provide access to collected flood management and related maps, data, and materials (including as-builts, operations and maintenance manuals, levee logs, permits, channel capacities, easements, real-time flood data and forecasts, and flood models). In addition, through the State-Federal Flood Operations Center, DWR will continue to provide flood fight assistance in the field in the form of technical assistance, flood emergency response teams, and materials when the local resources are exhausted.

To quickly respond to flood emergencies, the State proposes to provide all-weather access roads on levee crowns

DWR supports establishing a program to assist local agencies in preparing flood emergency response plans and developing appropriate regional communications tools and processes for emergency response operations. An important consideration in flood emergency preparation is the availability of strategically-located resources for flood fight activities. Local maintaining agencies, as the first responders, have the responsibility for stockpiling flood fight materials for timely response to flood threats before other flood fight assistance becomes available. In addition, without impacting necessary action to protect public safety during an emergency, response planning should consider opportunities to avoid and minimize ecosystem impacts.

4.1.2 Flood System Operations and Maintenance Program

The Flood System Operations and Maintenance Program includes work to keep specific flood management facilities (as defined in the California Water Code) in good, serviceable condition so that facilities continue to function as designed. Program activities include channel maintenance (hydraulic assessments, sediment removal, channel clearing, and vegetation management); erosion and levee repairs; levee inspection, evaluation, and maintenance; and repair and replacement of hydraulic structures.

Currently, operations and maintenance responsibilities within the flood management system are fragmented and often confusing. Funding has been insufficient to keep pace with the rising cost of routine maintenance. Implementation of the SSIA requires efficient and sustainable long-term operations and maintenance practices through the following:

- Reforming roles and responsibilities
- Formalizing criteria by which maintenance practices, procedures, and inspections are performed and reported
- Implementing strategies to adequately and reliably fund routine activities and streamline permitting

Some of the proposed activities will likely involve legislative action, new institutional arrangements involving local maintaining agencies, modifications to existing State programs, and additional revenue generation.

The SSIA includes enhancements to the current operations and maintenance of the flood management system, as described in the following sections.

Consolidation of State's Role and Responsibility

The State supports consolidation of operations and maintenance responsibilities, where appropriate, for the purpose of improving efficiency and maintaining critical flood system functions.

- The State will work with local maintaining agencies to examine opportunities and local agency support for legislative action that would allow DWR to assume full operations and maintenance responsibility for the Sacramento River bypass system (Sutter and Yolo bypasses, in combination with their appurtenant control features – the Moulton, Colusa, Tisdale, Fremont, and Sacramento weirs/bypasses, and proposed new bypasses, when constructed) to support proper function during flooding conditions. DWR will require State funding augmentation before accepting this additional responsibility. The bypass system is a central element of the Sacramento River Flood Control Project, conveying the majority of floodflows. The State currently has responsibility for maintaining a portion of these facilities under the California Water Code.
- The State supports working with local maintaining agencies and, with their support, developing a coordinated partnership program to conduct regular erosion repairs on the waterside of the Sacramento River and the San Joaquin River levee systems to promote efficient and timely repairs. The State already has significant responsibility for maintaining certain channels and a portion of certain levees under the California Water Code. Local agencies would be expected to contribute a cost-share component, fee, or equivalent, in exchange for the State's service recognizing that because of different statutory responsibilities for the Sacramento and San Joaquin systems, the cost-share would likely be different.

Standardization of Operations and Maintenance Practices

The State supports implementing more comprehensive and enhanced operations and maintenance standards for SPFC facilities. This would include formalizing criteria and guidance for operations and maintenance practices and procedures, such as best management practices to facilitate efficient maintenance and environmental compliance. The guidance would provide a common basis for State inspection and reporting activities, which serve as the basis for evaluating State funding and assistance eligibility.

The State will take the lead role in training local agencies to implement enhanced operations and maintenance standards and guidelines. Furthermore, the State has a continued interest in enforcing maintenance area formation per California Water Code Section 12878, where appropriate, in rare cases when local agencies consistently fail to meet routine maintenance expectations.

Consolidation of Roles and Responsibilities of Local Agencies

The State has an interest in encouraging local agencies, especially in rural-agricultural areas, to form regional maintenance authorities to enhance their ability to collectively perform their operations and maintenance responsibilities. The State prefers voluntary formation of joint power authorities, similar to those established in urban areas, with possible State-sponsored incentives.

FLOOD SYSTEM OPERATIONS AND MAINTENANCE AND ENVIRONMENTAL STEWARDSHIP

Over the years, the Flood System Operations and Maintenance Program has made significant steps in incorporating environmental stewardship into its operations. Some of these steps include the following:

- Enhanced interagency collaboration to efficiently integrate public safety and environmental stewardship objectives.
- Routine maintenance agreement with Department of Fish and Game to minimize environmental impacts associated with routine flood control project operations and maintenance.
- Initiated Corridor Management planning on the Feather River to protect public safety in a manner that also enhances the environment.
- Integrated environmental specialists in project design and development.
- Increased environmental training of maintenance staff and cross pollination of information between engineers, geology staff, and environmental scientists.
- Increased coordination with local stream groups in development of channel management actions.
- Developed and implemented a levee vegetation management strategy as an alternative to USACE vegetation removal policy. Managed vegetation research to improve understanding of public safety implications of the vegetation on the levees.
- Increased utilization of native species in restoration activities.
- Implemented selective vegetation management to support habitat enhancement.
- Integrated habitat enhancement into major rehabilitation projects.
- Implemented enhanced invasive species removal and control.
- Worked on fish passage improvements structures along important migration corridors.
- Adopted scheduling of maintenance activities to avoid sensitive time periods for species.
- Worked in partnership with other agencies to create habitat.
- Changed channel vegetation management from dozing and disking to mowing and expanded channel grazing program.
- Implemented equipment retrofits for improved air quality.
- Increased recycling of waste product and initiated chipping of wood debris for co-generation fuel as opposed to burning on site.
- Purchased specialized equipment to minimize environmental disturbance during maintenance activities.
- Expanded use of hand crews in areas containing sensitive environmental resources.
- Utilization of carefully selected herbicides and rodenticides to minimize impacts to nontargeted species.
- Rehabilitated Maintenance Yard buildings for energy efficiencies.
- Implemented landscape water use efficiency improvements at maintenance yards.

4.1.3 Floodplain Risk Management Program

The Floodplain Risk Management Program strives to reduce the consequences of riverine flooding in the Central Valley. A major focus of this work is the delineation and evaluation of floodplains to assist local decision makers with their near-term and long-term land use planning efforts.

The State promotes an enhanced floodplain management program, especially in rural-agricultural areas, through the following:

- The State will actively engage FEMA to help provide grants to local agencies and citizens for applicable risk mitigation actions, including property acquisition, structure demolition, and relocation; and floodproofing and elevating residential and nonresidential structures.
- Senate Bill 5, and related legislation passed in 2007, established various floodplain management requirements for cities and counties related to local land use planning. The State will collaborate with local planning agencies and provide information used to develop the CVFPP to help them integrate these data into their local land use planning. The State will also encourage local planning agencies to actively participate in development of regional flood management plans, which will help to reduce flood risk for local jurisdictions and comply with the provisions of Senate Bill 5.
- The State supports efforts to reform the National Flood Insurance Program that would result in more equitable implementation while reflecting corresponding flood risks. Nationally-supported flood insurance premiums and payouts should be commensurate with demonstrated flood risk for a structure or area to encourage sound floodplain management at the State, local, and personal levels. Structures that sustain flood losses outside FEMA Special Flood Hazard Areas should be evaluated and their flood insurance premiums adjusted based on their full risk of flooding. In addition, to sustain agricultural communities and support the natural and beneficial functions of floodplains, FEMA should consider establishing a flood zone for agriculturally-based communities to allow replacement or reinvestment development in the floodplain for existing structures. The State will work with FEMA to consider a special, lower rate structure that reflects actual flood risks for agricultural buildings in rural-agricultural areas located in Special Flood Hazard Areas.

4.1.4 Flood System Risk Assessment, Engineering, Feasibility, and Permitting Program

Risk Assessment, Engineering, and Feasibility Evaluations

Risk assessments and engineering are performed under this program that support ongoing planning, feasibility evaluations, and refinement of the SSIA. The program looks beyond individual projects to plan the manner in which all flood management facilities, operations, habitat and ecosystem restoration, and other practices work together as a system to protect life and property and enhance the ecosystem.

The program will support development of site-specific improvements. Feasibility studies and updates to the CVFPP will be prepared under this program. This program will also perform flood system engineering and modeling assessments of existing facility conditions for use in identifying areas needing improvements. In addition, the program will develop and maintain hydrologic, hydraulic, geotechnical, economic, and other models and relationships, providing the foundation of information necessary for developing site-specific and systemwide projects. In support of the CVFPP, this program will prepare two basin-wide feasibility studies, in partnership with USACE, as described in Section 4.4.4.

Role of USACE in Flood Risk Reduction Projects

The majority of Central Valley flood management facilities, and nearly all SPFC facilities, are part of the State-federal flood protection system. Any modifications or additions to, or deletions from, an existing federal flood management project require federal participation and approval through USACE and Congress. Major improvements or modifications to the SPFC will require a federal feasibility study. Feasibility-scope investigations are a critical and integral part of federal involvement in new water resources projects or modification to existing federal projects. Feasibility reports and subsequent documentation are used by federal decision makers and Congress to authorize new projects or project modifications and appropriate funds.

USACE, in partnership with the State and other local interests, is currently conducting a number of feasibility studies in the Central Valley. After feasibility studies are completed and successfully processed, it is anticipated that, in accordance with their findings and recommendations, the studies will lead to Congressional authorization and appropriation. Federal feasibility studies are an element of the State Flood Risk Reduction Projects Program. DWR and the Board are actively coordinating with USACE on these feasibility studies. Additional information concerning federal feasibility investigations is presented in Section 4.4.3.

Integrated Flood System Improvements and Permitting

DWR has initiated integrated flood management programs that could also facilitate permitting processes for implementing flood risk reduction programs and operations and maintenance of the flood management system in the Central Valley. Below are descriptions of major programs to achieve the goal of implementing multiobjective projects while facilitating programmatic permitting for flood management activities. Upon adoption of the CVFPP, these programs could inform DWR and partnering agencies in developing the Conservation Strategy that promotes implementation of integrated multiobjective projects while reducing or eliminating the need for mitigation, facilitating project permitting and reducing the costs and the time needed to acquire required permits.

Conservation Planning

This program coordinates the development and implementation of system and regional approaches for improving ecosystems associated with the flood management system. An initial Conservation Framework, included as Attachment 2, will provide environmental guidance for integrated flood project planning until the more detailed Conservation Strategy is completed in time to guide development of the

2017 CVFPP. The Conservation Strategy described below integrates measures to mitigate potential impacts to environmental resources resulting from improvements to the SPFC, along with other ecosystem restoration activities implemented within the SFPC footprint.

APPROACHES TO ENVIRONMENTAL COMPLIANCE AND ENHANCEMENTS

Through development of the Conservation Framework and future Conservation Strategy, DWR is evaluating systemwide and regional permitting approaches that will bring efficiencies to the approval processes for project construction and operations and maintenance activities. These permitting approaches are being informed through analyses of restoration opportunities to help prioritize restoration as mitigation investments.

DWR, through development of the future Conservation Strategy, is evaluating systemwide and regional permitting approaches that will bring efficiencies to the approval processes for project construction and operations and maintenance activities. The Conservation Framework provides an overview of floodway ecosystem conditions and trends, key conservation goals that further clarify the CVFPP supporting goal of promoting ecosystem functions, and the ways flood management improvements can be accomplished to improve both public safety and environmental conditions. The future Conservation Strategy will be consistent with the Conservation Framework and provide a comprehensive, long-term approach for the State to achieve the objectives of the Central Valley Flood Protection Act, FloodSAFE, and CVFPP Goals.

Corridor Management Strategy

The Corridor Management Strategy involves developing a vision, strategy, and plan (Corridor Management Plan (CMP)) for managing river corridors that integrate flood risk management, improved ecosystem function, and water management over a long-term planning horizon (greater than 30 years). A CMP includes a strategy for managing flood protection facilities, conveyance channels, floodplains, and associated uplands; a maintenance plan; and a restoration plan. A CMP also identifies policies for compatible land uses, such as agriculture and recreation, within the corridor. In addition to addressing habitat restoration and flood facility maintenance, CMPs are a foundation for securing programmatic regulatory agency approvals for ongoing maintenance activities and routine habitat restoration. CMPs rely on coordination, collaboration, and cooperative working relationships with interested parties and stakeholders, including State, federal, and local agencies, nongovernmental organizations, maintenance districts, agricultural interests, and landowners. The State has initiated development of a CMP for a 20-mile-long reach of the lower Feather River (from Yuba City to the Sutter Bypass). CMPs will be a key method for working with agricultural communities, in particular, in a coordinated approach to implementing the Conservation Strategy.

CMP strategies are a means of restructuring existing flood management practices and policies implemented within a given management area to benefit and enhance the environment without compromising actions required by practices and policies. CMPs effectively support the development and implementation of the CVFPP – an integrated flood management plan to reduce flood risk, promote ecosystem function, and create a more sustainable flood management system that allows for ongoing operations and maintenance activities.

Flood Corridor Program

The Flood Corridor Program is a unique local assistance program focused on providing nonstructural flood risk reduction integrated with natural resource and agricultural land protection. The Flood Corridor Program is implementing multiobjective projects that create and restore natural floodways, reconnecting streams and rivers to their historic floodplains, where feasible, and using other nonstructural approaches such as constructing levee setbacks, creating detention basins, and removing structures from flood-prone areas. The integrated approach helps DWR and the State achieve public goals of making communities safe from flooding while restoring important wildlife habitat and protecting farmland.

The above programs and CMP approach will collectively help implement the elements of the SSIA. As shown in Figure 4-1, each program contributes to system improvements, urban improvements, small community improvements, and rural-agricultural area improvements. System improvements will also provide additional flow capacity and flood system flexibility to accommodate climate change and large flood events (over 200-year events).

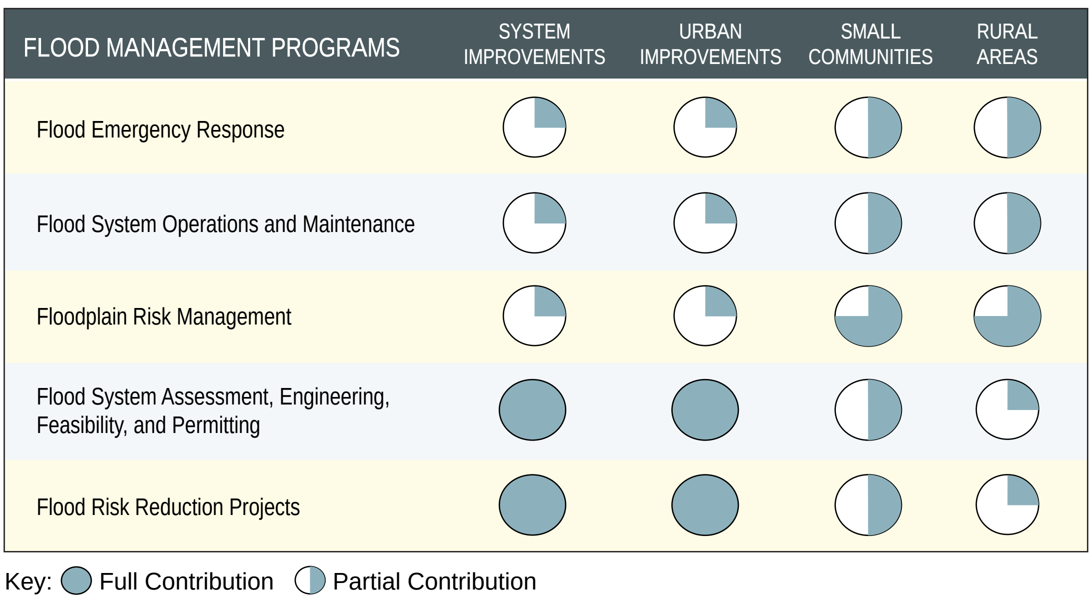


Figure 4-1. Flood Management Programs and Their Relative Contributions to State Systemwide Investment Approach Implementation

Rural-Agricultural Area Flood Management

The State will help coordinate activities needed to improve flood management in rural-agricultural areas. Over 90 percent of the Central Valley's levee-protected floodplains are rural-agricultural in character, with levees providing limited flood protection to over 60,000 people.

The approximately 1,200-mile-long State-federal levee system protecting rural-agricultural areas was constructed to a geometry standard using available soil materials with the intent to pass design flows with adequate freeboard. In recent years, it has become clear that a large portion of the rural-agricultural levee system does not meet current levee engineering performance standards because of inadequate cross sections, geotechnical weaknesses, erosion, encroachments, penetrations, or other concerns. It is also clear that the combined resources of local agencies, the State, and the federal government will not be sufficient to improve the levees protecting rural-agricultural areas to meet the current 100-year level of flood protection performance standards. The CVFPP recognizes these realities, but also notes that it is important to improve flood protection for rural-agricultural areas, to the extent feasible, on a prioritized basis.

Historically, the highly variable and largely unknown geotechnical characteristics of rural-agricultural levees were addressed through inspections, flood fighting during flood events, and periodic repairs. The accepted practice has been to conduct regular inspections during flood events to identify areas of weakness (such as erosion sites, boils, sloughs, fallen trees, and cracks), followed by vigorous flood fights and post-flood repairs wherever these weaknesses appeared. Therefore, it is fundamentally important to provide access for inspection and flood fighting activities via all-weather roadways on levee crowns and, where possible, on the landside levee toes. The program will invest in rural-agricultural area levees, addressing the greatest risk factors first.

Upon adoption of the CVFPP, the State will work with the local maintaining agencies to develop local and regional flood management plans for repairs and improvements to rural-agricultural levee systems. These plans will identify actions to improve public safety and reduce flood damages in a cost-effective manner, with financial support from the State, when feasible. The local flood management plans will prioritize improvements within rural-agricultural basins, with an emphasis on past performance and life safety.

The State supports developing rural levee repair criteria for rural-agricultural areas, in coordination with local and regional flood management agencies. While Urban Levee Design Criteria should be applied when the consequences of failure may result in significant loss of life or billions of dollars in damages in an urban area, implementing levee improvements or repairs to meet this standard requires an enormous financial investment that is difficult to justify in rural-agricultural areas.

The State supports cost-sharing of the following rural-agricultural flood management improvements, subject to availability of funds and where feasible to:

- Providing opportunities to improve reaches of levee where a failure would result in rapid, deep flooding of a small community.
- Providing opportunities to improve reaches of levee that protect critical infrastructure of statewide importance.
- Addressing known, localized performance problems or levees that have experienced distress during past flood events, prioritized based on flood risk.
- Improving access for flood emergency response and flood fighting by providing all-weather access roads on levee crowns, with associated ramps and turnouts.
- Improving visibility and accessibility by removing or modifying encroachments, where necessary.

- Preparing and implementing economically feasible local or regional flood management plans. Benefits could include reduced flood damages, improved life safety, protection of critical infrastructure, and ecosystem restoration.
- Repairing rural-agricultural erosion sites identified by the latest inspection, on a priority basis (most critical first).
- Developing rural levee repair criteria, in coordination with local and regional flood management agencies.

The State may help local agencies identify feasible projects, prepare financial plans, and develop cost-sharing arrangements to implement feasible flood management improvements in rural-agricultural areas.

The State also proposes reducing small community flood risks by improving levees protecting small communities and/or constructing new levees and flood walls (see Section 3). In many small communities, structural improvements will not be economically feasible and other management actions may be implemented, including working with FEMA to provide assistance for floodproofing homes and structures or relocating structures from deep floodplains. In addition, the State will work with FEMA to evaluate the feasibility of a program to provide post-flood recovery assistance to rural-agricultural areas (See Section 4.1.3).

Erosion along the Sacramento River in January 2002

4.1.5 Flood Risk Reduction Projects Program

The Flood Risk Reduction Projects Program works to develop on-the-ground projects (see Section 3) that are compatible with and support the CVFPP Goals. In addition to improvement of existing facilities and implementation of new projects, some existing flood protection facilities may be removed or modified under this program if the facilities no longer support system performance (see Section 4.3). State investments in system improvements may be through direct investment in new or improved facilities or through grant programs. System improvements will generally be implemented through a partnership program and cost-sharing among DWR, local agencies, the Board, and USACE, as the interests of agencies in the improvements are identified.

Three major implementation programs are required to develop and construct on-the-ground projects: System Improvements, High Risk Area Flood Risk Reductions, and Small Community Flood Risk Reductions programs. In addition, all levels of project funding, planning, design, and development will consider opportunities to integrate ecosystem enhancements with flood damage reduction projects.

The following is a summary of each implementation program for the Flood Risk Reduction Projects Program.

System Improvements

This program will coordinate development of more complicated system projects, such as system reservoir operations, expansion and extension of flood bypasses, new bypasses, flood system structures, and ecosystem enhancements (including fish and wildlife habitat enhancement and fish passage improvements). System improvements will provide operational flexibility during major flood events by lowering peak flood stages throughout the system, redirecting devastating floodflows away from urban areas, creating open space, and providing integration of ecosystem enhancement and flood risk reduction. Specific actions under this program include the following:

- Acquiring land and establishing easements
- Improving existing levees in urban areas and construction of new setback levees, where feasible
- Developing and extending riparian corridors and environmental restoration
- Implementing fish passage improvements and fish and wildlife habitat connectivity
- Upgrading flood control structures and removing sediment from bypass system weirs, gates, and channels
- Coordinating reservoir operations during major floods and establishing dynamic flood control diagrams, where feasible

Participation and partnership in this program by USACE will be critical for implementing large-scale systemwide projects. The State and local project sponsors would be responsible for any lands, easements, rights-of-way, and relocations. An important element of system improvements is the Conservation Strategy, discussed in Section 4.1.4.

High Risk Area Flood Risk Reductions

This program will coordinate development of regional flood damage reduction projects for urban areas to achieve an urban level of flood protection (protection from a 200-year flood). This program replaces the Early Implementation Program that DWR managed during the first phase of FloodSAFE. Many local agencies, including Reclamation District 784, the City of Marysville, Sutter Butte Flood Control Agency, and those in the Sacramento, West Sacramento, and Stockton areas, have been working diligently toward achieving the goal of providing 200-year protection. This program will be implemented in partnership with local agencies and USACE, with close coordination and cooperation among program participants.

APPROACH TO URBAN FLOOD RISK REDUCTION

The SSIA outlines improvements to SPFC facilities to achieve 200-year flood protection for existing urban and adjacent urbanizing areas. Some urban areas receive protection from SPFC levees and local, non-SPFC levees. The State would assist local agencies in improving these pertinent non-SPFC levees to achieve an urban level of flood protection, but without accepting any responsibility for those levees as they may remain non-SPFC facilities.

Small Community Flood Risk Reductions

This program will coordinate the development of local flood damage reduction projects for small communities. This program may include State-led improvements to SPFC facilities or provide support for locally sponsored projects. The program activities may include achieving 100-year flood protection by constructing new ring levees around small communities and improvement of existing levees and floodwalls where feasible. Some small communities adjacent to existing urban areas may achieve a 100-year level of flood protection or higher as a result of improvement for the adjacent urban areas. In addition to feasible structural improvements (see Section 3), previously discussed small communities may be considered for non-structural flood risk reduction, such as flood-proofing, raising structures, and relocation of structures. This program will be implemented in partnership with local agencies, FEMA, and USACE, with close coordination and cooperation among program participants.

4.2 Levee Vegetation Management Strategy

Levee vegetation management practices and procedures are an important component of the Flood System Operations and Maintenance Program, and of numerous ongoing and proposed flood risk reduction projects. Through management actions set forth in the CVFPP, and the associated Conservation Framework, the State will implement a flexible and adaptive integrated vegetation management strategy that meets public safety goals and protects and enhances sensitive habitats within the Central Valley. Implementation of the State's approach to levee vegetation management will be adaptive and responsive to (1) the results of ongoing and future research, and (2) knowledge gained from levee performance during high water events.

The State recognizes that woody vegetation on levees must be appropriately managed. The State's levee vegetation management strategy is focused on improving public safety by providing for levee integrity, visibility, and accessibility for inspections, maintenance and flood fight operations; at the same time, it protects important and critical environmental resources. While the strategy has a particular focus on protecting and enhancing the remaining shaded riverine aquatic habitat associated with the SPFC, it also addresses long-term quality and connectivity of habitat within the full flood management corridor.

Levee failure mechanisms (or risk factors), such as under-seepage, through-seepage, slope and structural instability, erosion, and deep rodent burrows, indisputably have negative impacts on levee integrity and public safety. Legacy levee vegetation does not fall into such a grouping of unequivocal failure mechanisms. Given that USACE Engineer Research and Development Center's research report (July, 2011) has shown that woody vegetation has the potential to increase or reduce risk, depending on a variety of factors, DWR believes it is appropriate to characterize woody vegetation as only a "potential risk factor" that should be considered in relation to the unequivocal risk factors. One of the findings of the ***Flood Control System Status Report*** (2011) is that levee vegetation is a low threat to levee integrity in comparison with other risk factors; this is consistent with the fact that, with many levee failures in California, none have been attributed to vegetation.

From a flood threat perspective, lower waterside slope vegetation rarely presents an unacceptable threat to levee integrity. However, lower waterside slope vegetation more typically provides beneficial functions, such as slowing near shore water velocities and holding soil in place to reduce erosion. Dense riparian brush provides the greatest erosion protection and least levee safety threat. Larger woody vegetation helps stabilize levees through extensive root systems. In consideration of the relatively low potential threat to public safety and high habitat value for State- and federally-listed species, the State will, in coordination with State and federal resource agencies:

- Allow retention of vegetation on the lower waterside levee slope (below the vegetation management zone)
- Protect existing lower waterside levee slope vegetation on State-maintained levees, and encourage a similar practice for projects and maintenance activities by local entities
- Allow development of appropriate vegetation on the lower waterside levee slope and near the waterside levee toe

For the systemwide scale of the CVFPP, it is not practical to assess each levee segment individually to determine relative risk factors and to prioritize integrated system improvements. An expectation of "site by site" or "tree by tree" assessments would create an unreasonable administrative burden for project proponents and agency staff of all project partners. However, through routine inspections, levees will be inspected multiple times each year for a wide variety of potential problems, including trees that may pose an unacceptable threat to levee integrity, or which create a visibility problem within the vegetation management zone.

This strategy affords levee maintaining agencies with flexibility and encourages them to retain existing trees and other woody vegetation. Because of the importance of these critical vegetation resources, it is anticipated that implementing this vegetation strategy will result in retaining, in the near-term, the vast majority of existing trees and other woody vegetation that provide important and critical habitat. In the long-term, it is anticipated that the vast majority of trees and other woody vegetation on the lower waterside levee slope would be left to continue to grow with appropriate management.

A chronology of past and ongoing interaction with USACE regarding implementation of USACE levee vegetation policy and Public Law 84-99 rehabilitation eligibility is provided in Section 3; a summary of the CVFPP levee vegetation management strategy is described below, and the full text of that strategy is included in Attachment 2 – Conservation Framework. Specific vegetation management procedures will be dependent on whether a levee is (1) a new or legacy

ADAPTIVE LEVEE VEGETATION MANAGEMENT

Implementation of the State's strategy for levee vegetation management will be adaptive and responsive to (1) the results of ongoing and future research, and (2) knowledge gained from levee performance during high water events. The strategies outlined below for the lower waterside slope and for the vegetation management zone provide a path forward for CVFPP implementation.

Lower Waterside Slope

In order to sustain critical habitat, the CVFPP levee management strategy retains lower waterside vegetation (below the vegetation management zone). Vegetation would be removed (in coordination with resource agencies) only when it presents an unacceptable threat.

Vegetation Management Zone: Life Cycle Management (LCM)

LCM addresses "visibility and accessibility" criteria while progressing gradually (over many decades) towards the current USACE vegetation policy goal of eventually eliminating woody vegetation from the "vegetation management zone" on the landside slope, crown, and upper waterside slope of levees.

LCM addresses resource agency objectives to protect and improve riparian habitat by largely preserving in the near-term existing vegetation within the vegetation management zone that does not impair visibility and accessibility, while developing additional habitat under the Conservation Strategy to offset gradual die-off of existing trees and the removal of trees that pose an unacceptable threat to levee integrity. For the long-term, it is anticipated that continued scientific research, potential system modifications, and evolving vegetation policy will support preservation and restoration of sustainable riparian habitat within the levee system.

levee, and (2) directly adjacent to the river or set back from the channel. Revisions to the following procedures may be considered in future 5-year updates to the CVFPP. The following summarizes the current vegetation management strategy:

- The State proposes adherence to USACE guidance for new levee construction, which typically would be new setback, bypass, or ring levees located away from the river channel.
- Vegetation present on the system, except for the lower waterside slope, will be trimmed to provide for visibility and access, as originally defined in the Framework Agreement, signed February 27, 2009 by participants of the California Levees Roundtable. It is important to note that the vegetation that was introduced, allowed, required as mitigation, or endorsed by a previous USACE action as necessary to comply with environmental requirements, and/or was present when the levee system was transferred from USACE to a nonfederal sponsor, will not be removed (unless changed conditions cause such vegetation to pose an unacceptable threat or it creates a visibility problem within the vegetation management zone).
- Vegetation present on the system will be evaluated, based on accepted engineering practice, and as part of the routine operations and maintenance responsibilities of DWR and other levee maintaining agencies, trees and other woody vegetation will be monitored to identify changed conditions that could pose an unacceptable threat. DWR will develop and incorporate vegetation criteria into its inspection checklist to guide identification of potential threats, as the science becomes available. Any vegetation that has been evaluated and found to present an unacceptable threat will be removed in coordination with the resource agencies.
- DWR will implement, and will advise local maintainers in their implementation of an adaptive vegetation management strategy. This strategy will include a long-term vegetation life-cycle management plan, which will allow existing trees and other woody vegetation of a certain size to live out their normal life cycles, but will result in the gradual elimination of trees and other woody vegetation from the vegetation management zone though the removal of immature (less than 4 inches) trees and immature woody vegetation. Throughout their lives and after their deaths, these trees and other woody vegetation will be periodically evaluated and, if found to pose an unacceptable threat to levee integrity would be removed in coordination with the resource agencies.
- Implementation of the life-cycle management plan will result in the gradual loss of important terrestrial and upper waterside riparian habitat throughout the State-federal project levee system. However, the CVFPP's vegetation management strategy includes the early establishment of riparian forest corridors that will result in a net gain of this habitat. The Conservation Framework includes a tree planting program, which will be more fully defined in the Conservation Strategy, to ensure that the quantity and quality of the riparian corridors of the Central Valley are maintained and enhanced over time. A monitoring plan will also be included in the Conservation Strategy.

- The CVFPP also calls for encouraging and supporting research on the risks and benefits of trees on levee performance, and techniques for concurrently achieving flood risk reduction and environmental quality goals. State and local agency-sponsored research, along with USACE-sponsored research, are addressing information gaps surrounding levee performance through applied research and an ongoing synthesis of historical information. Findings of these research programs are informing current policy development, and will continue to do so for future CVFPP updates. In addition, further research will follow up on recent research into the effects of woody vegetation on levees, and address other data gaps. DWR and its partnering agencies will incorporate new information into evolving policies and practices.

4.2.1 Long-Term Compatibility of State Levee Vegetation Management Strategy and U.S. Army Corps of Engineers Vegetation Policy

As described in the foregoing, removing lower waterside levee slope vegetation is a very low priority and would generally not be justified until high levee risk factors (as documented in the ***Flood Control System Status Report*** (2011)) are addressed. However, compatibility between the State levee vegetation management strategy and USACE vegetation policy is potentially achievable when framed in the following context:

> *Through long-term implementation of life-cycle vegetation management on the landside slope, crown, and upper waterside slope of SPFC levees, the CVFPP levee vegetation management strategy will gradually (over a period of decades) result in levees clear of woody vegetation, consistent with USACE vegetation policy, except for lower waterside vegetation – which is mostly the same part of the levee where USACE has indicated that variances can be appropriate.*

DWR believes that the best path toward State-USACE vegetation policy compatibility is through a sufficiently flexible systemwide variance process consistent with the above levee vegetation management strategy that can supplement, if necessary, the existing vegetation variance for lower waterside slope vegetation (per USACE letter dated August 3, 1949). Removal of woody vegetation on the lower water side that does not pose an unacceptable threat to levee integrity will be deferred indefinitely to allow for development of new information, tools, and techniques that can expand future options for mutually acceptable treatment of lower waterside vegetation.

4.3 Removal and Addition of State Plan of Flood Control Facilities

As the SSIA is implemented, some features of the SPFC may prove to be obsolete and slated for removal, while other features may be added. The following provides guidance for physical and administrative removal and addition of SPFC facilities.

4.3.1 State Plan of Flood Control Facilities Removal

Over the years, some of the facilities included in the SPFC have ceased to exist, have failed to achieve their original design objectives, have deteriorated to the point of becoming nonfunctioning, or otherwise have become a detriment to the existing system. Accordingly, in some cases, it is in the public interest for the State to formally remove these facilities from the SPFC. Removal of a facility from the SPFC may consist of physical and administrative actions, or only administrative actions. Physical removal of any facility is subject to a case-by-case evaluation. To be considered for removal from the SPFC, candidate facilities need to meet one or more of the following criteria:

- Physical removal of the SPFC facility would result in improving the flood management system
- Removal of the SPFC facility is in the mutual interest of the State and the local maintaining agency
- Physical removal of the facility has already been initiated or completed

For facilities to be removed from the SPFC, it must be demonstrated that such action would not cause unacceptable impacts to other flood management features, protected people or property, or to nonflood management purposes. If removal of a specific facility would cause potential undesirable or unacceptable effects to flood management or to other purposes, mitigation measures would be implemented to offset such potential adverse effects before the facility is removed. Facilities recommended to be removed from the SPFC are listed and discussed in Section 3.4.4.

CENTRAL VALLEY FLOOD PROTECTION ACT OF 2008

California Water Code Section 9614 (h)
"The evaluation shall include a list of facilities recommended to be removed from the State Plan of Flood Control. For each facility recommended for removal, the evaluation shall identify both of the following:

(1) The reasons for proposing the removal of the facility from the State Plan of Flood Control.

(2) Any additional recommended actions associated with removing the facility from the State Plan of Flood Control."

4.3.2 State Plan of Flood Control Facilities Addition

Ongoing State-federal projects in the Sacramento and San Joaquin river basins are expected to become part of the SPFC after completion, and turned over to the State and local maintaining agencies. Also, while some projects completed through the Early Implementation Projects Program and Section 221 of the Flood Control Act of 1970 are not currently part of the SPFC, they may become part of the SPFC in the future after undergoing the appropriate processes.

Generally, the traditional way for facilities to become part of the SPFC is by completion of the following processes:

- USACE prepares a Chief of Engineers Report to recommend to Congress that federal participation in a project be authorized and that completed works be incorporated into the federal project. Congress passes and the President signs legislation for the project, usually as part of a periodic Water Resources Development Act.
- The State Legislature passes and the Governor signs legislation authorizing State participation in the project, incorporating specific language referencing federal authorization.

CENTRAL VALLEY FLOOD PROTECTION ACT OF 2008

California Water Code Section 9611.

"The Sacramento-San Joaquin River Flood Management System comprises all of the following:

(a) The facilities of the State Plan of Flood Control as that plan may be amended pursuant to this part.

(b) Any existing dam, levee, or other flood management facility that is not part of the State Plan of Flood Control if the board determines, upon recommendation of the department, that the facility does one or more of the following:

(1) Provides significant systemwide benefits for managing flood risks within the Sacramento-San Joaquin Valley.

(2) Protects urban areas within the Sacramento-San Joaquin Valley.

(c) Upon completion of the Central Valley Flood Protection Plan pursuant to this part, the department may identify and propose to the board additional structural and nonstructural facilities that may become facilities of the State Plan of Flood Control, consistent with the Central Valley Flood Protection Plan. The board may add those facilities to the State Plan of Flood Control based on a determination showing how the facility accomplishes the purposes identified in subdivision (b).

(d) For the purposes of subdivision (c), facilities that may become facilities of the State Plan of Flood Control include bypasses, floodway corridors, flood plain storage, or other projects that expand the capacity of the flood protection system in the Sacramento-San Joaquin Valley to provide flood protection."

- The project is constructed. After construction is complete, the project finishes the closeout phase. USACE prepares an Operation and Maintenance Manual for the project unit.
- USACE and the Board execute a standard agreement transferring responsibility for operations, maintenance, repair, and rehabilitation to the State.
- The Board and appropriate local maintaining agency or DWR execute a standard agreement, further transferring these responsibilities to the maintaining agency.
- In addition, the Central Valley Flood Protection Act of 2008 authorizes the Board to add facilities to the SPFC directly. Such facilities would need to meet other legal requirements, including, but not limited, to the lol California Environmental Quality Act, Water Resources Law of 1945, and Flood Control Law of 1946.

4.4 Refining Flood System Investments

While the CVFPP establishes an overall vision for Central Valley flood risk management, detailed feasibility studies are needed to further refine and define specific improvements that support the CVFPP Goals. Two proposed State feasibility studies for the Sacramento and San Joaquin river basins will focus on defining a systemwide set of flood management improvements to the SPFC, beginning with the physical elements included in the SSIA. Elements can be expected to be refined and modified based on those two feasibility studies. This is especially true for larger system elements that require more studies and feasibility evaluations to better understand their costs and benefits and to reduce the level of uncertainty. The feasibility studies are also needed for federal project appropriation.

To prepare the State feasibility studies, the State will first work with local agencies to prepare regional flood management plans. These plans (see Section 4.4.1) will include assessment of levees in each levee Flood Protection Zone (FPZ), will identify reasonable and feasible solutions to remedy the areas needing repair, and will include a regional financial framework. The State will use the regional plans as foundational information and will integrate the plans with system improvement feasibility analyses to prepare the two basin-wide feasibility studies. These feasibility studies will be prepared in coordination with USACE and in conjunction with its CVIFMS.

Figure 4-2 is a schematic presentation of the process outlined above, showing the interconnection of regional flood management plans, State basin-wide feasibility studies, and USACE CVIFMS. The majority of flood risk reduction project implementation will occur as a result of the State basin-wide feasibility studies. However, implementation of some projects will continue while the feasibility studies are prepared.

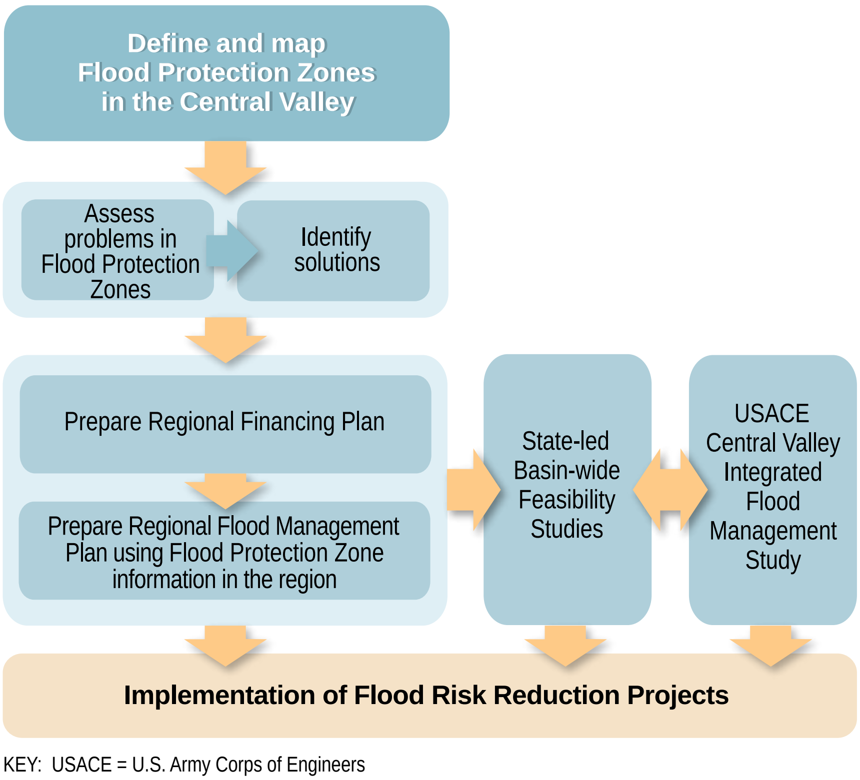


Figure 4-2. Planning and Implementing Flood Risk Reduction Projects

The section below further discusses the regional flood management plans, State basin-wide feasibility studies, and USACE CVIFMS.

4.4.1 Regional Flood Management Plans

To document site-specific flood system improvement needs and to involve local agencies in developing local investment strategies, the State will work with local entities and engage other interested stakeholders to define local flood system improvements that support the SSIA. This work will be site-specific for individual river reaches and likely begin with each FPZ within the potential implementation regions. FPZs are the smallest planning unit for gathering and organizing data and evaluating the costs and benefits of proposed flood management actions as they relate to overall systemwide improvements. Flood protection needs within the FPZs of an implementation region will be aggregated into regional flood management needs that, in turn, will be used to formulate regional projects/programs and associated feasibility analyses.

CENTRAL VALLEY FLOOD PROTECTION ACT OF 2008

California Water Code Section 8201
"(a) A local agency may prepare a local plan of flood protection in accordance with this chapter.…

(d) Plans prepared pursuant to this chapter, within the Sacramento-San Joaquin Valley as defined by Section 9602, shall be consistent with the Central Valley Flood Protection Plan pursuant to Section 9612."

The regional plans will be prepared with participation of local maintaining agencies, regional flood management agencies, counties and cities within the region, and agricultural and environmental interests. The role of counties and cities in the planning process is important because they are required to update their general plans to incorporate information used to prepare the regional plans. DWR will participate in the planning process, will provide any available information, and may provide financial assistance for preparing the regional plans, if funds are available.

Based on analyses conducted for selected projects in a region, a regional financing strategy will also be prepared and will identify potential federal, State, and local cost-sharing. The cost-sharing formula may differ based on the nature of the flood risk reduction needs of and systemwide benefits achieved in each region. The regional analyses will be combined with the regional financing plan to form a regional flood management plan. To implement SPFC improvements from a systemwide perspective, evaluations will consider monetary and nonmonetary benefits on a regional basis, to be updated as system improvements are defined over time.

The State and its partners will need to develop benefit-cost analyses by focusing on different project purposes in various reaches of the system. For example, in urban areas the focus would likely be on flood risk reduction, while in rural-agricultural areas the focus would be on flood risk reduction supported by floodplain management and improved ecosystem function and sustainability. The State proposes to provide a greater cost-share at the local level for environmentally beneficial projects, such as setback levees. The State will allow local rural entities to cover their cost-shares with in-kind services, agricultural conservation easements, and other compatible elements.

Development of regional flood management plans and formulation of specific capital improvement projects will continue after completion of the 2012 CVFPP. This plan development process will coordinate with other overlapping planning efforts by identifying common goals and pursuing opportunities to collaborate and reduce potential conflicts with these other efforts. The information gathered for the regional flood management plans will be used to help develop the State basin-wide feasibility studies scheduled for completion by 2017.

A review of areas protected by facilities of the SPFC initially identifies regions with varying characteristics (see Figure 4-3). Ultimately, more or fewer regions may be used, depending on organization and preferences of local entities.

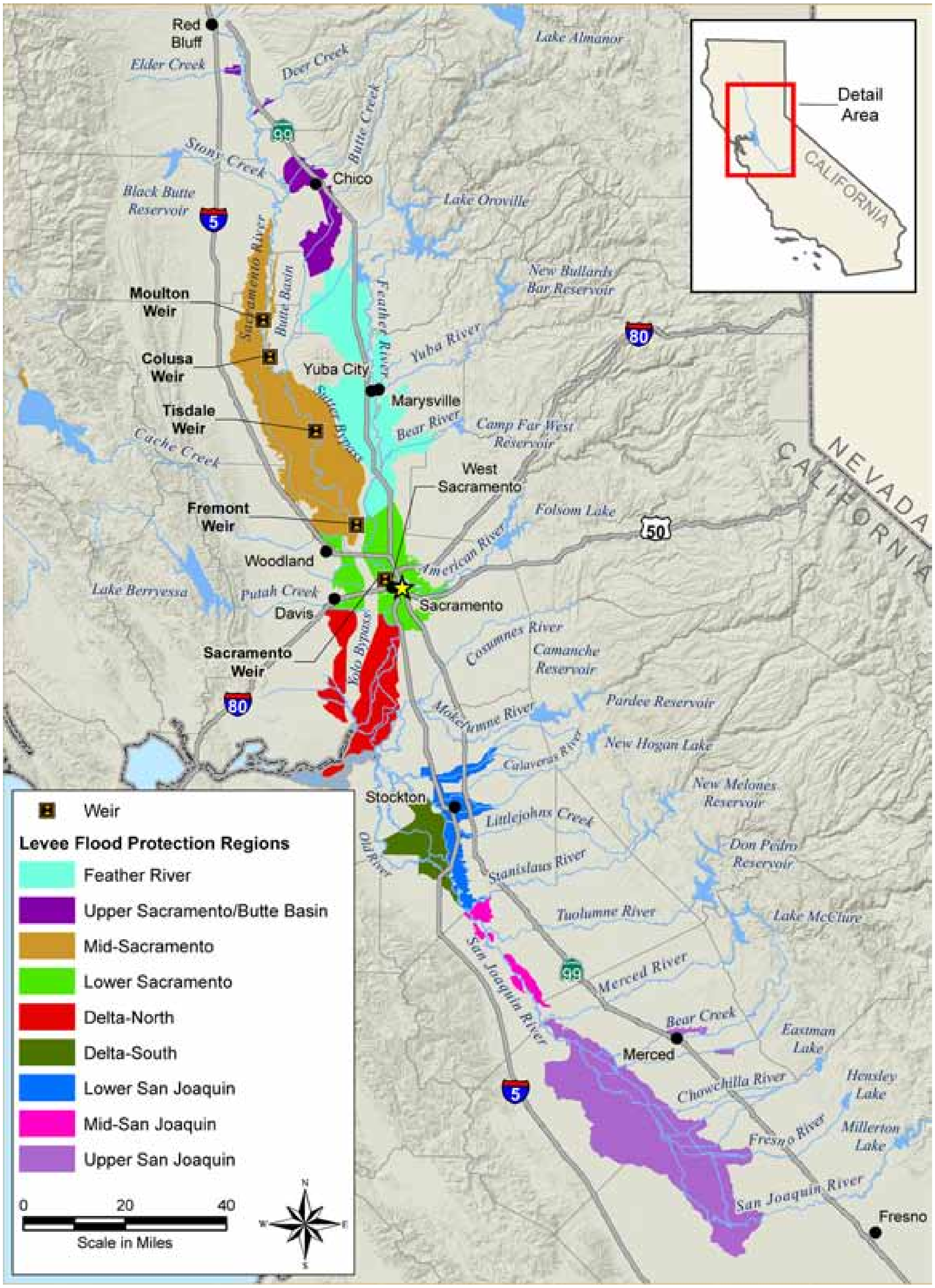


Figure 4-3. Central Valley Flood Protection Plan Implementation Regions based on Flood Protection Zones

4.4.2 Assisting Local Agencies in Land Use Planning

The Central Valley Flood Protection Act requires each city and county within the Sacramento- San Joaquin Valley to amend its general plan to include flood-related information gathered for and presented in the CVFPP, within 24 months of the Board adopting the CVFPP. To assist local agencies in complying with the law, DWR will prepare the following information and make it available to local agencies:

- Information gathered and used in the CVFPP.
- Maps and geographic information system (GIS) data used to generate maps in the CVFPP and related documents.
- Levee inspection data and completed geotechnical assessment results of SPFC facilities and related non-SPFC facilities, where data are available.
- Water surface elevations for 100-year and 200-year flood events.
- 100-year and 200-year inundation maps of the areas protected by the facilities of the SPFC.
- Criteria for demonstrating an urban level of flood protection, including urban levee design criteria.

> **CENTRAL VALLEY FLOOD PROTECTION ACT OF 2008**
>
> California Government Code 65302.9
> "(a) Within 24 months of the adoption of the Central Valley Flood Protection Plan by the Central Valley Flood Protection Board pursuant to Section 9612 of the Water Code, each city and county within the Sacramento-San Joaquin Valley, shall amend its General Plan…
>
> (b) To assist each city or county in complying with this section, the Central Valley Flood Protection Board, the Department of Water Resources, and local flood agencies shall collaborate with cities or counties by providing them with information and other technical assistance."

The information listed above will be made available, subject to availability of funds, to local agencies upon request. DWR has prioritized its work so that information needed for urban areas is developed first and shared with local agencies. The State proposes a planning process in which local agencies, with assistance from DWR, will work together to prepare regional flood management plans (see Section 4.4.1). The local land use agencies are encouraged to actively participate in development of the regional flood management plans. Participation of the agencies in regional planning combined with specific information listed in this section will help local land use agencies to update their general plans and any zoning considerations, as required by the law.

4.4.3 Central Valley Integrated Flood Management Study

The USACE CVIFMS is a feasibility study to evaluate flood management improvements in the Central Valley from a federal perspective, and to provide a framework for authorizing and implementing flood risk reduction projects in the Central Valley. When completed, this feasibility study will ultimately be used to determine the federal interest in implementing elements of the CVFPP and identifying nonfederal responsibilities regarding changes to the SPFC. Through the CVIFMS, USACE is reviewing documents and providing technical and policy level input, joint data, information, and analytical tools for the CVFPP. The CVIFMS would integrate information and findings from the two State basin-wide feasibility studies; USACE is conducting the CVIFMS, in partnership with DWR and the

> **CENTRAL VALLEY FLOOD PROTECTION ACT OF 2008**
>
> California Water Code Section 9615.
> "For the purpose of preparing the plan, the department shall collaborate with the United States Army Corps of Engineers…"

Board, under existing federal authorization for the ***Sacramento-San Joaquin River Basins Comprehensive Study*** (USACE, 2002).

From a federal perspective, potential changes to existing facilities of the SPFC should show a positive impact on the facilities, the people the facilities protect, and the purposes of the facilities. Therefore, it is important to the State to work closely with USACE to further analytically define and refine elements of the SSIA, and to evaluate potential flood management, ecosystem restoration, and other related project benefits to justify a strong federal interest in the SSIA. The State will continue to work closely with USACE to examine opportunities to fully integrate processes and analyses needed for preparing the State basin-wide feasibility studies with the CVIFMS.

4.4.4 State Basin-Wide Feasibility Studies

As mentioned above, and as part of SSIA implementation, the State will initiate two basin-wide feasibility studies. The primary purposes of these State-led feasibility studies are to (1) develop a Locally Preferred Plan for consideration by USACE in formulating and selecting a recommended plan and pursuing federal authorization, (2) prepare environmental compliance evaluations, and (3) establish the State's role in project implementation. A benefit of these State-led feasibility studies is that the State can effectively contribute to, and help accelerate, the federal feasibility study; if USACE is not able to move forward with implementation, the State would be poised to do so.

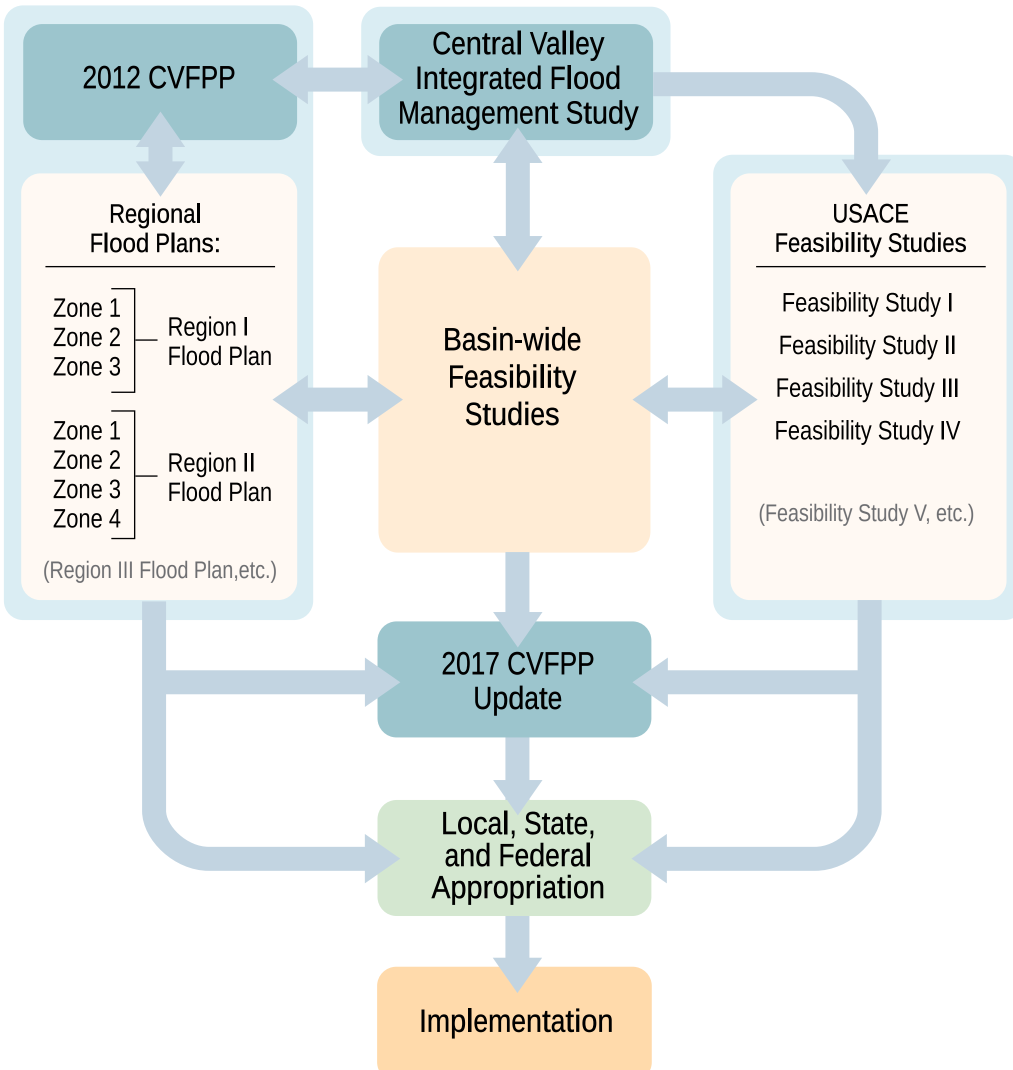
FEASIBILITY STUDY COORDINATION

As part of CVFPP implementation and development of the 2017 update, the State will continue to coordinate and engage with federal partners on the State basin-wide feasibility studies, the CVIFMS, and other related efforts.

History suggests that federal studies can be accomplished in a more efficient manner when there is (1) strong nonfederal sponsor understanding of the federal project implementation process, (2) active nonfederal leadership and direction, and (3) a well-developed Locally Preferred Plan for use in the process.

The State feasibility studies will examine the options and elements included in the 2012 CVFPP to determine study feasibility and refine study features/characteristics. The State feasibility studies will be accomplished in close coordination and partnership with USACE; the CVIFMS, in particular, will follow the federal milestone system, and will comply with the ***Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*** (Water Resources Council, 1983). It is anticipated that the State feasibility studies will establish a complete, well-developed Locally Preferred Plan in the context of a federal feasibility study, and provide a solid foundation for initiation of federal studies, as appropriate. Engagement with federal partners would occur throughout the State feasibility studies period. State planning and technical analyses will employ approaches consistent with federal practices, such that information can be efficiently used in corresponding federal feasibility studies. Under this condition, it is fully anticipated that the corresponding federal studies would incorporate information developed by the State basin-wide feasibility studies, including the Locally Preferred Plan.

The State-led feasibility studies will integrate information presented in regional flood management plans prepared by local agencies, and information, analyses, and evaluations conducted as part of federal feasibility studies and the CVIFMS, as shown in Figure 4-4. Upon adoption of the CVFPP, DWR intends to work closely with the USACE Sacramento District to further examine opportunities for fully integrating the basin-wide feasibility studies with CVIFMS.



KEY:
CVFPP = Central Valley Flood Protection Plan
USACE = U.S. Army Corps of Engineers

Figure 4-4. Preparing Basin-Wide Feasibility Studies Leading to Implementation

4.4.5 Program Coordination, Communication, and Integration

Development and implementation of the CVFPP requires continued coordination, communication, and integration with other flood and water management and ecosystem enhancement programs in the planning area. These programs include, but are not limited to, other State and federal efforts such as the San Joaquin River Restoration Program, Bay-Delta Conservation Plan, Delta Stewardship Council Delta Plan, Delta Protection Commission Economic Sustainability Plan, Statewide Flood Management Planning Program, USACE CVIFMS, and other programs. The State has a strong interest in coordinating and, when feasible, achieving integration of flood risk management with water supply reliability enhancement, environmental restoration, and other multiresource benefits.

Effective integration across resource categories and planning efforts means that all of the programs and projects, when implemented, work together to achieve the key goals of the various programs in a cost-effective and appropriately prioritized sequence, and do not cancel intended benefits. It is recognized, however, that effective integration of planning among many programs for multiple benefits is a significant challenge. Carrying that integration across multiple major planning efforts is difficult and complex. The sheer complexity of the various planning processes, as well as gaps in understanding of how they may work together; make it difficult to define effective and integrated fixes at a systemwide level. Contributing to the integration challenge are competition for available funding and the competing priorities of involved agencies and interest groups with different views and measures of what constitutes success.

With these challenges in mind, it is also recognized that coordination, communication, and integration across a number of programs and projects also present opportunities for collaboration, minimizing duplication, reducing costs, and identifying other opportunities. The State recommends taking the following steps (as well as other similar steps) to achieve, to a large extent, integration and implement projects and programs in a coordinated fashion:

- The integration of flood management with other resource management activities is best achieved during project planning and on-the-ground activities. In executing the CVFPP, the State proposes to work with local agencies to prepare regional flood management plans. Preparation of the regional plans will include examining opportunities for integrating of flood management with water management and ecosystem restoration and to coordinate with other agencies' relevant activities in the region.
- At the high level planning, the flood management activities are incorporated and tied with the broad environmental enhancement activities in the CVFPP. In addition, through reservoir operation activities (F-CO and F-BO) flood and water management activities are also integrated.
- During preparation of systemwide feasibility studies and project implementation, standardized, well-documented analytical tools will be employed to evaluate performance with regard to key resource categories. For example, DWR is working with the State Water Project, Yuba County Water Agency, USACE, and National Weather Service-River Forecast Center to develop F-CO for Lake Oroville and New Bullards Bar. The reservoir operation model developed for the F-CO can be enhanced and also used for water operations, hence integrating flood and water operations of the reservoirs.

- The State supports investing in "no-regrets" programs and actions that clearly enhance system resiliency, integrate programs and resources, and preserve flexibility for future generations. Actions that fall into this category may include the following:
  - » *Acquisition of agricultural conservation easements where compatible with local land use plans (especially in deep floodplains adjacent to existing flood conveyance channels).*
  - » *Expansion of existing river and bypass channels through levee setbacks, creation of new flood bypass channels, and development of wildlife and fisheries habitats in the bypass system, creating open space and integrating with recreation activities.*
  - » *Isolation, stabilization, or removal of mercury and other heavy metals, polychlorinated biphenyls, and other long-lasting ecosystem contaminants within the State flood management system to improve channel conveyance and water quality and fishery habitat.*
  - » *Development of new maintenance practices and institutional frameworks, such as corridor management planning and the Conservation Strategy, to facilitate long-term integrated management of the system that effectively serves public safety, water management, and ecosystem needs.*
- At the feasibility study level for specific projects, reasonable opportunities will be carefully evaluated for integrating multiple objectives into project design. During feasibility studies, DWR and its implementation partnering agencies will conduct system impact analyses for all significant resources categories, and will consult with all interested agencies and stakeholders before finalizing projects for execution.
- At the systemwide level, major implementation activities will continue to be coordinated with other ongoing programs in the planning area.

4.4.6 Process for Updating the Central Valley Flood Protection Plan

Updates to the CVFPP will be prepared by DWR and its partner agencies (including USACE, the Board, and local agencies) every five years. Following adoption of this initial CVFPP by the Board in mid-2012, work will continue toward the first update of the CVFPP, due in 2017. Work required for the first, and each subsequent, update will generally follow the five-year cycle shown in Figure 4-5.

Each update will build on the previous CVFPP and will describe accomplishments since the prior version; will identify results of subsequent technical analyses; will highlight changes in approaches, projects, and programs; and will describe near-term implementation of projects (or components of longer-term projects) that can be expected to be completed before the next update. Therefore, level of detail is expected to increase from version to version as feasibility studies and implementation progress. Because of the five-year update cycle, the CVFPP will be a living document that adapts to progress, changing conditions, new information, and available funding.

Development of the Financing Plan for the CVFPP will be the major deliverable in the first year (portions of 2012 and 2013) following adoption of the 2012 CVFPP.

The 2017 update of the CVFPP will be reviewed by the Board for overall consistency with the adopted 2012 CVFPP, and the cycle will be repeated for the 2022 update. The 2017 CVFPP update will be prepared in close coordination with USACE.

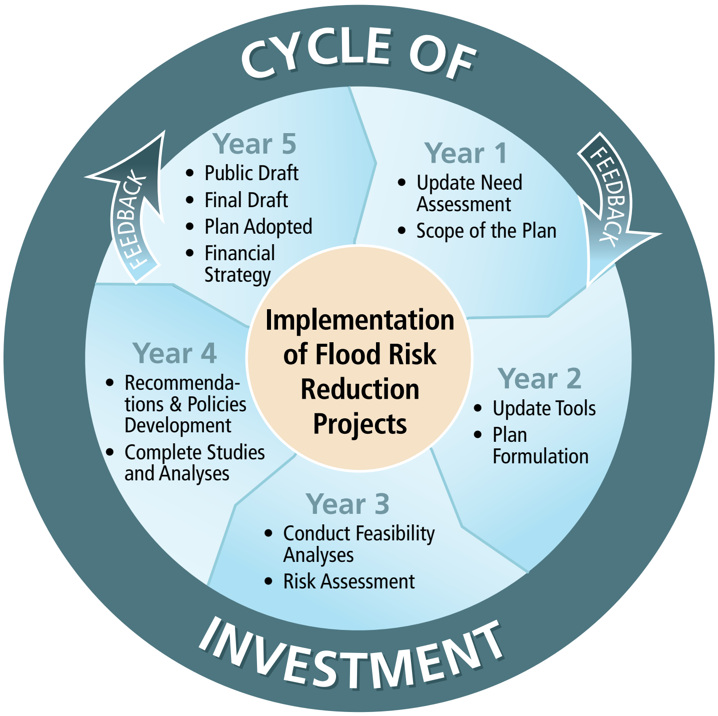


Figure 4-5. Five-Year Cycle for Investment and Central Valley Flood Protection Plan

4.5 2007 – 2011 Accomplishments and Near-Term Priority Actions (2012 through 2017)

4.5.1 Accomplishments

Since the passage of Propositions 1E and 84 in November 2006, DWR has been working with USACE and local agencies to improve flood management within areas protected by facilities of the SPFC. These accomplishments are considered part of the SSIA. Major accomplishments to date are summarized below.

Flood Emergency Response

- Conducted 15 flood emergency exercises, including the Golden Guardian Statewide Flood Exercise
- Added about 50 flood forecasting and water supply gaging sites
- Developed a Flood Emergency Response Information System
- Developed F-CO program for Yuba-Feather River

The Golden Guardian Statewide Flood Exercise Series was first implemented in 2004 and has become a statewide exercise series conducted to coordinate flood emergency preparation, response, and recovery by local, State, and federal governmental entities and private sector and volunteer organizations. The goal of the Golden Guardian Exercise Series is to build on the lessons learned from this and subsequent exercises, as well as real-world events. Golden Guardian is currently the largest statewide flood emergency exercise program of its kind in the country.

The Golden Guardian 2011 Full-Scale Exercise was conducted in May 2011 and was based on a major past California flood. The exercise focused on California's strategy in preparing for and responding to a catastrophic flood in the inland region of the State. Over 5,000 local, regional, State, and federal responders participated in various events throughout the three-day exercise.

The Golden Guardian 2013 exercise will be based on a major Bay Area earthquake, providing an opportunity to assess emergency operations plans as they relate to potential effects on the flood management system in the Sacramento-San Joaquin Delta.

- Updated hydrology for Central Valley streams
- Stockpiled 240,000 tons of rocks in the Delta for emergency response
- Enhanced environmental integration in emergency response activities, including an emergency response exercise with environmental resource and regulatory agencies

Flood System Operations and Maintenance

- Repaired over 120 critical levee erosion sites
- Proactively repaired over 220 levee sites
- Removed three million cubic yards of sediment from the bypasses
- Rehabilitated seven flood system structures
- Developed and began implementing, in partnership with resource and regulatory agencies, environmental initiatives, including the Corridor Management Strategy and Small Erosion Repair Program
- Initiated and coordinated the Interagency Flood Management Collaborative Program

Floodplain Management

- Prepared voluntary flood-related Building Standards Code (California Code of Regulations, Title 24, Parts 2 and 2.5) for single-family residential occupancy groups R-3 and R-3.1 for adoption by cities and counties
- Sent flood risk notification letters to 300,000 affected property owners in the Central Valley in 2010 and 2011
- Mapped Central Valley Levee Flood Protection Zones

Flood Risk Assessment, Engineering and Feasibility, and Permitting

- Collected topographic data and light detection and ranging (or LiDAR) data for 9,000 square miles along the flood system
- Conducted engineering and geotechnical evaluations for urban and nonurban levees
- Developed a comprehensive medium-scale GIS data set of riparian vegetation for the Central Valley
- Assessed major fish passage barriers within the Systemwide Planning Area

- Evaluated potential floodplain restoration opportunity areas throughout the Systemwide Planning Area
- Developed a statewide policy framework and approach for Regional Advance Mitigation Planning (RAMP)
- Catalogued and summarized conservation objectives from 30 conservation planning efforts that overlap the Systemwide Planning Area
- Prepared the public draft Conservation Framework
- Implemented 12 Flood Corridor Program projects in the Central Valley, providing over 4,000 acres of habitat conservation and over 500 acres of agricultural land conservation
- Prepared the ***State Plan of Flood Control Descriptive Document***, 2010
- Prepared the ***Flood Control System Status Report***, 2011
- Prepared the Public Draft 2012 CVFPP

Geotechnical improvements to levees in the Pocket Area of Sacramento

Capital Improvement Projects

DWR, USACE, and local agencies have been working on capital improvement projects to upgrade the State-federal flood management system in the Central Valley, including the following areas:

- American River Common Features Project, to provide an urban level of flood protection to the following areas:
  - » *American River downstream from Folsom Dam*
  - » *Sacramento River downstream from the American River*
  - » *Natomas Basin*
- Folsom Dam Modifications (as part of the Folsom Dam Joint Federal Project)
- Marysville Ring Levee Improvement Project
- Mid-Valley Area Levee Reconstruction Project
- South Sacramento Streams Project
- Three Rivers Levee Improvement Authority, Feather River Levee Improvement Project, Yuba County
- Three Rivers Levee Improvement Authority, Upper Yuba River Levee Improvement Project, Yuba County
- Levee District 1, Star Bend levee setback on the Feather River, Sutter County

- Reclamation District 2103, Bear River North Levee Rehabilitation Project, Sutter, Yuba and Placer counties
- Reclamation District 17, 100-Year Seepage Area Project, San Joaquin River, San Joaquin County
- West Sacramento Area Flood Control Agency, Capital Outlay, City of West Sacramento
- Repair of two Yolo Bypass east bank levee slips in West Sacramento (underway)

DWR has also been working with USACE, the Board, and local agencies to evaluate the potential feasibility of the following projects and efforts in the Central Valley. These activities will continue through the next phase of implementation (2012 to 2017) to the extent feasible. The State will work with USACE and local agencies to incorporate ecosystem restoration in these feasibility studies:

- American River Common Features General Reevaluation Report
- Lower San Joaquin River Feasibility Study, investigating actions to achieve a 200-year level flood protection and opportunities for floodplain restoration, recreational enhancements, and ecosystem restoration for the City of Stockton and surrounding areas
- Merced County Streams Group investigation, evaluating options to increase the level of flood protection from a 50-year event to 200-year event within the Merced urban area
- Sutter Basin Feasibility Study, improving flood protection for communities in Sutter- Butte Basin
- West Sacramento General Reevaluation Report, providing a minimum 200-year level of protection for the City of West Sacramento
- West Stanislaus County-Orestimba Creek Feasibility Study, evaluating feasible flood protection alternatives for the City of Newman and surrounding area
- Woodland/Lower Cache Creek Feasibility Study
- Yuba Basin Project General Reevaluation Report, increasing the level of flood protection for the Yuba River Basin communities of Marysville, Linda, Olivehurst, and Arboga
- Mid-Valley Area Levee Reconstruction Project
- South Sacramento County Streams Project study, increasing flood protection for the urbanized area of South Sacramento County

CENTRAL VALLEY FLOOD PROTECTION ACT OF 2008

California Water Code Section 9616 (b)
"The plan shall include a prioritized list of recommended actions to reduce flood risks and meet the objectives described in subdivision (a)."

4.5.2 Near-Term Priority Actions

Between adoption of the 2012 CVFPP and its first update in 2017, priority actions include the following (organized by flood management programs):

Flood Emergency Response Program

- Develop improved flood forecasting and notifications for rural-agricultural areas of the Central Valley, and provide assistance to local agencies in preparing for and responding to flood emergencies
- Invest in additional monitoring gages and forecasting points to facilitate timely and accurate dissemination of flood information, particularly for rural-agricultural areas subject to more frequent flooding
- To the extent funding is available, propose a State grant program to assist rural local agencies throughout the Central Valley preparing flood emergency responses plans for their jurisdictions, and to develop appropriate regional communication tools and processes for flood emergency response operations
- Continue implementation of F-CO of reservoirs and initiate F-BO programs, where feasible
- Provide flood system information to local flood emergency responders
- Formalize procedures for enhanced inspection and maintenance

Flood System Operations and Maintenance Program/ Rural Agricultural Areas

- Work with rural-agricultural communities to develop rural levee repair criteria
- Repair erosion sites throughout the flood system that were identified by the 2011 inspection program, before these sites further degrade the integrity of the flood control system and require costly repair
- Repair known and documented critical problems, prioritized based on flood risks
- Provide all-weather access roads on levee crowns for quick response to flood emergencies
- Implement rural levee projects that are consistent with the SSIA, are ready to proceed, and are shown to be feasible

Floodplain Risk Management Program

- Prepare new flood hazard identification and notification information for rural-agricultural community planners and local officials using updated hydrology and hydraulic studies
- Work with FEMA to actively engage the agency in floodplain management in the Central Valley, including funding for floodproofing homes and structures in floodplains, relocating structures and homes from deep floodplains, and developing a special insurance program for structures located in floodplains that play a major role in promoting the vibrant agricultural economy in rural areas of the Central Valley

Flood System Risk Assessment, Engineering, Feasibility, and Permitting

- Launch a major effort to coordinate FloodSAFE activities with all levels of USACE, and with Congress to refine USACE feasibility study processes under the two State basin-wide feasibility studies, for the purpose of facilitating timely federal cost-sharing of flood management projects in the Central Valley
- Perform two basin-wide feasibility studies: one for the Sacramento River Basin and one for the San Joaquin River Basin
- Initiate feasibility studies and designs for ecosystem projects that are consistent with the SSIA, are ready to proceed, and are shown to be feasible, such as the Fremont Weir fish passage project
- Complete the Conservation Strategy
- Develop a comprehensive fine-scale GIS dataset of riparian vegetation for the Central Valley
- On completion of the State basin-wide feasibility studies and refinement of the projects, prepare a long-term implementation plan for presentation in the 2017 CVFPP
- Complete the Financing Plan for the CVFPP in 2013
- Prepare the 2017 update of the CVFPP, identifying flood management improvements to be made in the subsequent five-year cycle
- Continue engagement with partners and stakeholders
- Evaluate the feasibility of initiating a program to provide post-flood recovery assistance to rural-agricultural areas
- Develop a regional assessment for RAMP
- Provide programmatic permitting for operations and maintenance of the flood management system

DWR will continue working with local agencies to implement flood management activities

Flood Risk Reductions Projects Program

- Continue to design and construct projects that are consistent with the SSIA, are ready to proceed, and are shown to be feasible, such as levee improvements for high-risk existing urban and adjacent urbanizing areas
- Implement small community projects that are consistent with the SSIA, are ready to proceed, and are shown to be feasible
- Acquire lands, rights-of-way, and easements to implement systemwide projects, including extending and expanding the bypass system and ecosystem restoration components, as soon as studies to further refine the locations of the lands to be acquired are completed
- Work with local agencies to implement rural-agricultural area flood management activities that are consistent with the SSIA, ready to proceed, and are shown to be feasible
- Work with local agencies and USACE in completing regional flood management plans with USACE to prepare basin-wide feasibility studies
- New Bullards Bar Outlet Modifications Project

PLANNING LEVEL COST ESTIMATES

Cost estimates presented in the plan are only conceptual and not intended for use for a specific project. Actual implementation costs will likely be higher than estimates in the 2012 CVFPP because of future price increases and the incremental nature of plan implementation.

4.6 Estimated Costs and Time to Implement

Section 3 presented cost information for the SSIA. Discussion in this section focuses on the investment and implementation schedule for the SSIA.

4.6.1 State Systemwide Investment Approach Cost Estimates

Table 4-1 summarizes costs to implement various elements of the SSIA.

Table 4-1. State Systemwide Investment Approach Cost Estimates by Element

ELEMENT	LOW ESTIMATE ($ Millions)		HIGH ESTIMATE ($ Millions)
System Improvements	$5,140	to	$6,500
Urban Improvements	$5,500	to	$6,700
Rural-Agricultural Improvements	$1,080	to	$1,180
Small Community Improvements	$690	to	$690
Residual Risk Management	$1,510	to	$1,860
Total	$13,920	to	$16,910

Table 4-2. State Systemwide Investment Approach Cost Estimates by Region

REGION	LOW ESTIMATE ($ Millions)		HIGH ESTIMATE ($ Millions)
1 - Upper Sacramento Region	$480	to	$610
2 - Mid-Sacramento Region	$860	to	$1,050
3 - Feather River Region	$3,040	to	$3,690
4 - Lower Sacramento Region	$5,390	to	$6,500
5 - Delta North Region	$1,770	to	$2,060
6 - Delta South Region	$580	to	$740
7 - Lower San Joaquin Region	$730	to	$930
8 - Mid - San Joaquin Region	$190	to	$250
9 - Upper San Joaquin Region	$890	to	$1,080
Total	$13,920	to	$16,910

These costs are planning level estimates; they are based on 2011 price levels and will differ in the future. The estimated distribution of costs among implementation regions is shown in Table 4-2.

The total cost of the SSIA is estimated to be between $14 billion and $17 billion. As shown in Figure 4-6, the SSIA invests approximately equally in urban flood protection and system improvements; this will promote opportunities for flood system operational flexibility, ecosystem enhancement, open space, and expansion of the flood-carrying capacity of the Central Valley flood management system.

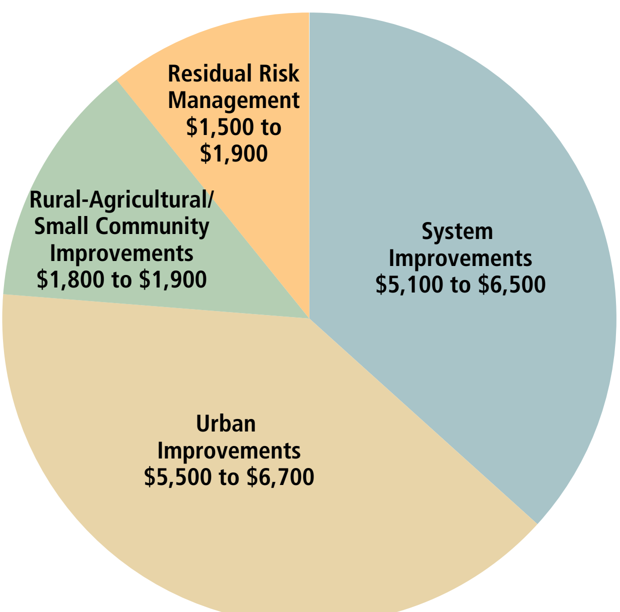


Figure 4-6. State Systemwide Investment Approach Investments by Element ($ millions)

Over 23 percent of the total investment will be for the combination of rural-agricultural areas, small communities, and residual risk management, primarily designed to improve flood risk reduction in rural-agricultural areas. More than one third (38 percent) of estimated costs are for the Lower Sacramento Region, where flood risks and potential threats to lives and economic losses are of the greatest concern.

Full implementation of the SSIA will take 20 to 25 years. As shown in Section 4.5, implementation has already begun for some features of the SSIA through programs such as the Early Implementation Projects Program, which began in 2007. Additional physical improvements will begin in the next cycle of investment (2012 through 2017) and some will be completed beyond 2017. A consideration in formulating the SSIA has been the time that would be required to implement the approach. It is estimated that most features of the SSIA could be implemented in the next 15 to 20 years, assuming State and federal funding will be available in a timely manner.

4.6.2 Implementation Phasing

Some elements of the SSIA are more complicated and will take longer to develop and implement than others. Phasing of system improvements will help accommodate the timing of project planning, design, land acquisition, partnering, etc., as well as funding availability. Implementation phasing is not, however, intended to expedite implementation of some SSIA elements at the expense of other elements. Progress will be made with implementation of all elements during each phase of program implementation. Each five-year CVFPP update will refine implementation for subsequent phases.

- **Phase I** will generally occur within five years (2012 to 2017) of CVFPP adoption. DWR will begin working on priority improvements, such as improved flood forecasting and emergency response, land use planning initiatives, enhanced operations and maintenance practices, and flood risk reduction projects. Physical on-the-ground improvements will focus on continued efforts to improve flood risk reduction in urban areas, develop small community and rural flood risk reduction projects, repair erosion sites, and implement ecosystem improvements, where feasible. The Conservation Strategy will be developed, and feasibility evaluations and land acquisitions for expansion of the bypasses will be initiated. A more detailed list of activities for Phase I is presented in Section 4.5.
- **Phase II** will include broad flood system improvements with an emphasis on improving the operational flexibility of the flood management system. Work will include F-BO of reservoirs and construction of levee setbacks. Work on modifying flood control structures, such as weirs, gates, and pumping plants, will be undertaken to further add flexibility to flood system operations. Work to reduce flood risks in urban areas, rural-agricultural areas, and small communities will continue. Design and construction of levee setbacks and bypasses will be initiated. Improvements for rural-agricultural areas will also be initiated, where feasible.
- **Phase III** will include completing system improvements with an emphasis on reducing peak flood stages throughout large areas of the system. Many Phase III activities require a much longer period of planning and design preparation. Although these activities will be initiated in early phases, during Phase III, implementation of major system improvement elements, such as expansion of bypasses, construction of new bypasses, and implementation of the Conservation Strategy, will be completed.

Each phase of implementation will generally require the reevaluation of components of the SSIA, including prioritizing policies, programs, and project elements that provide the greatest benefit to public safety, environmental quality, and California's economy. Work on all phases will occur at the same time, but the emphasis changes. For example, emphasis during the first five years will be on foundation improvements. During the following five years, the emphasis will be on implementing improvements in Phase II, with emphasis on increasing flood system flexibility. Prioritizing investments in facilities will also be based on population and assets at risk.

Phased implementation recognizes that some projects are more complicated and require more time to complete, and that the need for some projects is more immediate than for others. Phased implementation also allows time for incremental funding and for CVFPP updates to incorporate improved understanding of the flood system over time. Each five-year update of the CVFPP will track ongoing and completed projects and programs and refine subsequent implementation actions.

As implementation phasing continues and elements of the SSIA are completed, the benefit-cost ratio of remaining elements may decrease; this is because project elements with higher benefit-cost ratios will likely be implemented earlier. It is important to recognize that the SSIA is an integrated approach to flood management, and that each element contributes to the overall goals of the CVFPP and should be holistically implemented. Accordingly, federal and State representatives will need to work together to quickly develop and gain approval for a "program" implementation process that accommodates incremental implementation of project elements toward the overall flood risk reduction and ecosystem restoration goals of the SSIA.

4.7 Financing Strategy for Implementing State Systemwide Investment Approach

CENTRAL VALLEY FLOOD PROTECTION ACT OF 2008

California Water Code Section 9616 (a)
"The plan shall…
(13) Provide a feasible, comprehensive, and long-term financing plan for implementing the plan."

The CVFPP includes a flood risk reduction financing strategy founded on the following:

- Flood management is a shared responsibility among federal, State, and local agencies, with the cost of improvement shared by all partners
- Interest and ability of the partnering agencies to participate and fund the projects
- Broad evaluation of system benefits
- Strong interest in achieving greater flood system reliability and sustainability
- Commitment to improve system operations and maintenance
- Need to continue to manage residual risk
- Commitment to conservation and enhancement of environmental quality, especially remnant riparian vegetation that grows in channels and on levees of Central Valley rivers and streams

Implementation of the CVFPP began in January 2007 when bond funding became available. Since that time, DWR has invested in prudent Central Valley flood risk reduction projects and programs in advance of the CVFPP. For example, improvements in maintenance, emergency response, and repair of critically eroding levees, floodplain delineation, levee investigations, and upgraded levees for urban areas were important investments, integral to the SSIA, that could be made while the CVFPP was being prepared. The strategy for investing in projects that are ready to move forward, are feasible, and are considered to be consistent with the CVFPP Goals will continue during the next five years while detailed, basin-wide feasibility studies are completed. Implementation is based on phasing – prioritizing funding for the most critical actions, while setting the foundation for flood system improvement and developing more detailed feasibility studies to support the SSIA.

The Central Valley Flood Protection Act of 2008 requires DWR to prepare a Financing Plan for the CVFPP. Following adoption of the CVFPP in 2012, DWR will prepare a framework for financing projects at a regional level. DWR will use the information gathered from preparation of the framework to prepare the Financing Plan for the CVFPP that will guide investment in flood risk management in the Central Valley during the next 20 years. The Financing Plan will be available in 2013, after adoption of 2012 CVFPP. The Financing Plan is critical to implementation, given the uncertainty in State, federal, and local agency budgets and cost-sharing capabilities.

The following sections describe preparation of near-term and long-term financing plans for the CVFPP.

4.7.1 Funding for State Systemwide Investment Approach Implementation

A mix of federal, State, and local funds will be needed to implement the SSIA. Funding sources will vary according to the type of project or program, beneficiaries, availability of funds, urgency, and other factors. Cost-sharing among State, federal, and local agencies may also change depending on project objectives and agency interests. A legislative requirement for Proposition 1E funds is to maximize, to the extent feasible, federal and local cost-sharing in flood management projects. Cost-sharing rules are governed by federal and State laws, regulations, and policies, which continue to evolve over time. The geographic extent and magnitude of project benefits must be evaluated to identify potential beneficiaries on a regional or systemwide scale. The intent of the CVFPP is to support equitable distribution of project costs among beneficiaries, encourage projects that provide benefits outside their immediate locales, and help achieve added flexibility in the SPFC. The State proposes to place a priority on funding and providing a greater cost-share for flood management improvement projects that provide multiple benefits.

California Water Code Section 12585.7 identifies the State cost-share of nonfederal capital costs for flood management projects. The State normally pays 50 percent of the nonfederal cost-share, but will pay up to 20 percent more (for a maximum of 70 percent of the nonfederal cost-share) if the project makes significant contributions to other objectives, including the following:

- Enhancement, protection, and restoration of endangered species and riparian, aquatic, or other important habitats
- Open space
- Recreational opportunities
- Flood control for communities with median household income less than 120 percent of the poverty level
- Flood control for State transportation infrastructure or water supply facilities

Table 4-1 shows the funding required to implement various elements of the SSIA, and the specific flood management programs established to successfully implement the SSIA elements. Table 4-3 presents planning estimates for an equitable distribution of expenditures among State, federal, and local agencies over time. This distribution is based on a traditional cost-sharing formula, assuming local and federal interest in some of the SSIA elements, and recognizing that State, federal, and local agency interests may vary depending on the type of investment and results of feasibility studies. For example, Table 4-3 is based on local agencies having an interest in investing in their respective urban areas and small communities to reduce flood risks, while they may not be fully interested in investing in system improvement components of the SSIA. Similarly, USACE may have an interest in investing in urban flood risk reduction while its interest in system improvement components may be limited to specific actions such as ecosystem restoration. The State has an interest in implementing a robust flood emergency response program and expects to fund most of the flood emergency response activities proposed for implementation (some local cost-sharing may be required). Cost-sharing for implementation of the SSIA will be refined during feasibility studies and project implementation as additional project-level information is gathered and the interests of the partnering agencies in elements of the

SSIA are identified. In general, a cost-sharing arrangement among State, federal, and local agencies will be needed to implement the projects.

It is expected that FEMA will play an active role in, and provide funding assistance for, floodplain management activities formulated in the SSIA, including floodproofing of rural-agricultural homes and structures, and relocating rural homes from deep floodplains.

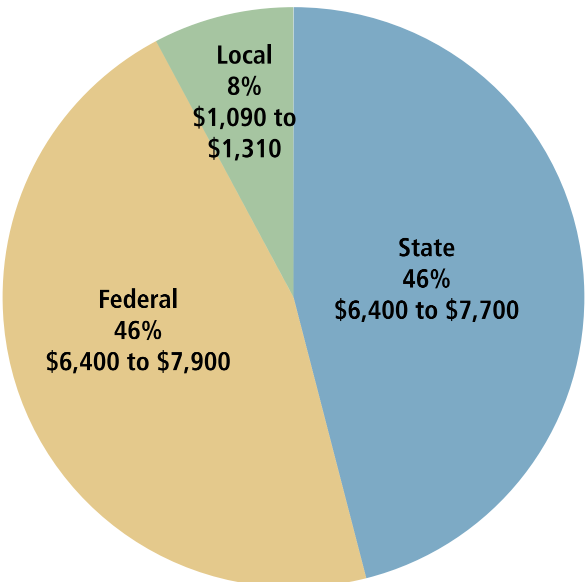


Figure 4-7. State Systemwide Investment Approach Potential Cost-Sharing by Agency (% and $ millions)

STATE SYSTEMWIDE INVESTMENT APPROACH IMPLEMENTATION

The State will need to present a General Obligation Bond Law to voters to provide an additional $4 to $5 billion to cover the remaining State's share of investment in the flood reduction projects outlined in SSIA.

Figure 4-7 illustrates the potential allocation of SSIA costs to State, federal, and local interests. Federal cost-sharing for capital improvements will be based on results of feasibility studies, and cost-sharing amounts will vary depending on the mix of purposes included in a project. For example, the federal cost-share for ecosystem restoration projects can be as much as 50 to 65 percent for urban flood risk reduction projects. Costs that do not qualify for federal cost-sharing include lands, easements, relocations, operations and maintenance, and other costs that must be paid by nonfederal sponsors. Water supply, recreation, or other benefits included in flood risk reduction projects can further modify federal cost-sharing. State cost-sharing of the nonfederal costs also depends on the mix of project purposes. Adequate funding from local agencies may require creation of assessment districts to implement capital improvements or to support effective, efficient, and improved system operations and maintenance.

4.7.2 Financing of Central Valley Flood Protection Plan (through 2017 and beyond)

The State may have to rely more heavily on State bond funding to finance flood risk reduction projects until more federal funding becomes available. Propositions 84 and 1E provided $4.9 billion for flood risk reduction in California, of which $3.0 to $3.3 billion could be used for flood risk reduction in areas protected by facilities of the SPFC. The remaining bond funding was allocated to statewide flood risk reduction (including the Statewide Subventions Program, Stormwater Management Program, and flood risk reduction in the Delta). The State has already invested $1.6 billion over the last five years. Additionally, $1.5 billion to $1.7 billion of bond funding are already authorized and available for implementing flood risk reduction projects associated with the SPFC. It is estimated that local agencies, through assessments, will provide their share of the cost of about $0.5 billion from 2012 through 2017. DWR needs to work closely with USACE and Congress to obtain at least $1 billion in appropriations through 2017. The combination of State, federal, and local funding sources could provide about $3 billion for the next phase of implementation, until more robust federal financing is available.

Table 4-3. State Systemwide Investment Approach Range of Investments over Time ($ millions)

FLOOD MANAGEMENT PROGRAMS		FLOOD EMERGENCY RESPONSE	FLOOD SYSTEM OPERATIONS AND MAINTENANCE	FLOODPLAIN RISK MANAGEMENT	FLOOD SYSTEM ASSESSMENT, ENGINEERING, FEASIBILITY, AND PERMITTING	FLOOD RISK REDUCTION PROJECTS	TOTAL
		Low to High	Low to High	Low to High	Low to High	Low to High	Low to High
2007–2011	State	$64	$180	$99	$257	$1,032	$1,632
	Federal[1]	–	–	–	$160	$620	$780
	Local	–	–	–	$40	$450	$490
	Subtotal	*$64*	*$180*	*$99*	*$457*	*$2,102*	*$2,902*
2012–2017	State	$130 to $140	$30 to $60	$30 to $40	$170 to $200	$1,140 to $1,300	$1,500 to $1,730
	Federal	–	$20 to $40	$70 to $90	$230 to $270	$1,190 to $1,340	$1,500 to $1,740
	Local	–	$10 to $10	–	$50 to $60	$140 to $220	$190 to $290
	Subtotal	*$130 to $140*	*$60 to $110*	*$100 to $130*	*$450 to $530*	*$2,470 to $2,860*	*$3,210 to $3,770*
2018 and Beyond	State	$290 to $310	$20 to $50	$60 to $120	$270 to $420	$2,630 to $3,440	$3,270 to $4,340
	Federal	–	$130 to $160	$340 to $450	$590 to $740	$3,090 to $4,020	$4,150 to $5,370
	Local	–	$50 to $60	–	$120 to $150	$230 to $320	$410 to $530
	Subtotal	*$290 to $310*	*$200 to $270*	*$400 to $570*	*$980 to $1,310*	*$5,950 to $7,780*	*$7,830 to $10,240*
Total	State	$480 to $510	$230 to $290	$190 to $260	$700 to $880	$4,800 to $5,770	$6,400 to $7,700
	Federal	–	$150 to $200	$410 to $540	$980 to $1,170	$4,900 to $5,980	$6,430 to $7,890
	Local	–	$60 to $70	–	$210 to $250	$820 to $990	$1,090 to $1,310
	Subtotal	*$480 to $510*	*$440 to $560*	*$600 to $800*	*$1,890 to $2,300*	*$10,520 to $12,740*	*$13,920 to $16,910*

[1] Federal and local project cost-shares for 2007 – to 2011 were estimated.

Key:
State = State of California

Table 4-4. State Investments over Time ($ millions)

FLOOD MANAGEMENT PROGRAMS	2007 – 11	2012 – 2017	2018 AND BEYOND	TOTAL
Flood Emergency Response	$64	$130 to $140	$290 to $310	$480 to $510
Flood System Operations and Maintenance	$180	$30 to $60	$20 to $50	$230 to $290
Floodplain Risk Management	$99	$30 to $40	$60 to $120	$190 to $260
Flood System Assessment, Engineering, Feasibility, and Permitting	$257	$170 to $200	$270 to $420	$700 to $880
Flood Risk Reduction Projects	$1,032	$1,140 to $1,300	$2,630 to $3,440	$4,800 to $5,770
System Improvement Costs	*$350*	*$495 to $565*	*$1,155 to $1,610*	*$1,995 to $2,525*
Urban Improvement Costs	*$550*	*$545 to $620*	*$445 to $730*	*$1,535 to $1,900*
Rural-Agricultural Area and Small Community Improvement Costs	*$132*	*$105 to $120*	*$1,040 to $1,095*	*$1,275 to $1,345*
Total	$1,632	$1,500 to $1,730	$3,270 to $4,340	$6,400 to $7,700

Beyond 2017, an additional $8 billion to $10 billion will be needed for implementing the SSIA (See Table 4-3). Table 4-4 summarizes the State's share of investments to implement the SSIA, ranging from $6.4 to $7.7 billion. Considering that the State already has authorized bond funding of over $3.0 to $3.3 billion to implement the SSIA, an additional bond measure will be needed to cover the remaining $4 to $5 billion of the State's share.

During the next five years (2013 through 2017), the State must work diligently with its federal and local partners and the Legislature to overcome several challenges that influence investment in flood risk reduction projects:

- Limited State, federal, and local funding for cost-sharing
- Changing regulations
- Resource intensive and time consuming federal feasibility study processes
- Need to fund ongoing implementation programs in addition to new capital projects

These challenges are further discussed in the next sections.

4.8 Central Valley Flood Protection Plan Approvals and Partner Roles and Responsibilities

DWR and the Board are the State lead agencies for implementing the SSIA and preparing the five-year CVFPP updates. It is the intent of the State that all major flood management programs and projects in the Central Valley be planned and implemented consistent with the vision, overall goals, and provisions of the evolving CVFPP. Ensuring consistency between the CVFPP and its program elements and projects over time will be the responsibility of the State through the continued partnership of DWR and the Board.

DWR will also work closely with USACE and the Board in developing the federal CVIFMS and the two State basin-wide feasibility studies. In addition, the State is partnering with USACE on a number of regional feasibility and post-authorization scope-change investigations aimed at further modifying the flood management system. Findings and recommendations from these regional investigations will be included in the two State feasibility studies. Future modifications to the SPFC originating frookaym the CVFPP will primarily be identified through the two State feasibility studies.

Flood system improvement requires a coordinated partnership of federal, State, and local agencies. DWR will continue its tradition of working closely with federal and local partners to improve flood protection in the Central Valley.

4.9 Implementation Challenges and Uncertainties

Many challenges and uncertainties arise during the implementation of any large-scale program. These can include funding availability; federal and state government budgetary issues; future economic activities and inflation; and changes to federal programs, policies, and permitting.

Potential challenges and uncertainties are briefly described below:

- **Funding availability** – Implementation of SSIA will require an investment of $14 billion to $17 billion, shared by federal, State, and local agencies. Through Propositions 84 and 1E, the State has provided approximately $5 billion for flood management activities, of which $3.0 billion are allocated for implementing the SSIA. An additional $11 to $14 billion will be needed during the next 20 years from federal, State, and local sources. It is anticipated that another State bond measure will be required to augment federal and local agency funding. The amount of funding available from these sources and timing of the funding are unknown at this time.
- **Federal, State, and local agencies budgetary issues** – Flood management in California is a shared responsibility among federal, State, and local agencies. These agencies face daunting challenges in balancing their budgets. Shortfalls in State and local agency budgets and the federal deficit are issues of great concern in planning for implementation of a program that solely relies on cost-sharing from various level of government funding.
- **Economic activities** – Cost estimates presented in the CVFPP are based on 2011 level costs and, therefore, do not reflect future costs of implementation. Future costs and corresponding funding needs are, among other factors, dependent on future inflation rates and the time needed to implement the SSIA. Economic activities also influence competition and bidding conditions among the contractors who would build the future improvements to the SPFC.

- **Federal programs, policies, and permitting** – Many federal programs, policies, and permitting processes administered by USACE affect implementation of flood risk reduction programs. The following summarizes the potential impacts of USACE policies and programs on implementation of the SSIA:
  - » ***Section 408*** *– Under Section 408 of the Rivers and Harbors Act of 1899, the Secretary of the Army has the authority to regulate all significant modifications to a USACE civil works project. To issue a Section 408 permit, the Secretary must determine that a modification will not impair the usefulness of a federal project and will not be injurious to the public interest. Thus, such modifications, when approved, will be subject to requirements established by USACE related to acceptable design criteria and all associated environmental constraints. Since 2006, USACE has developed new, stringent guidance for Section 408 permitting authority, which has resulted in significant cost and schedule impacts on recent projects.*
  - » ***Section 104 Credit*** *– In May 2011, the Assistant Secretary of the Army for Civil Works (ASA-CW) declared that USACE will no longer accept Section 104 credit applications. The ASA-CW indicated that more recent crediting language included in the Water Resources Development Act of 2007 was a more modern tool. Furthermore, the change would address a USACE concern that Section 104 credit letters, because they can be issued early in the federal project implementation process, can encourage nonfederal sponsors to distort the federal project formulation process and pursue a credit that may be unlikely to materialize. Specifically, USACE intends to use Section 221 of the Flood Control Act of 1970, as amended by Section 2003 of Water Resources Development Act of 2007, which under current guidance requires completion of a federal decision document (USACE Chief of Engineers Report) for a proposed project before to approval for credit. This USACE guidance policy is likely to have a chilling effect on local efforts to expedite urgently needed flood risk reduction projects, which will ultimately affect schedules for project execution in the Central Valley.*
  - » ***Levee Vegetation Policy*** *– The current USACE levee vegetation policy has impacted progress in implementing flood risk reduction projects during the last three years, as sponsors have attempted to comply with those requirements. The State believes that strict compliance with the policy would be cost-prohibitive, disastrous for the ecosystem, and detrimental to public safety because it redirects funding from more critical problems unless a workable systemwide variance process is established by USACE.*
  - » ***Feasibility Studies*** *– The current USACE feasibility study process is a time-consuming and expensive way of implementing fragment-*

ed projects, and is inconsistent with the reality that many systemwide projects have multiple sponsors, each with its own requirements. In the case of the SSIA, there is an opportunity for USACE to work with the State to demonstrate federal interest in improving flood protection through a systemwide approach. This approach has the potential to benefit State, federal, and local interests.

» ***Reservoir Operations*** *– Revisions to reservoir Water Control Manuals will require USACE participation and/or review, as well as appropriate environmental documentation. Changes to federal projects will require action by Congress.*

» ***Technical challenges*** *– Many technical challenges also lie ahead. Better understanding of climate change and development of the appropriate adaptive strategy to address it, adequate technical information for project decision making, and other similar issues should be resolved over time as regional and basin-wide feasibility evaluations move forward.*

These issues can add considerably to costs, uncertainty, and time needed for project implementation. FloodSAFE and other State officials plan to actively engage USACE and Congress to resolve these issues to support future implementation of the SSIA.

Many flood management challenges lie ahead and require diligent collaboration and effective partnerships to be overcome. The CVFPP reflects the State's effort to take a balanced approach to achieving the objectives established in the Central Valley Flood Protection Act of 2008 as well as the primary and supporting goals defined in the initial phase of CVFPP formulation.

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5.0 ACRONYMS AND ABBREVIATIONS

ASA-CW................................Assistant Secretary of the Army for Civil Works
Board ....Central Valley Flood Protection Board
cfs..cubic feet per second
CMP......................................Corridor Management Plan
Conservation Strategy ....Central Valley Flood System Conservation Strategy
CVFPP..................................Central Valley Flood Protection Plan
CVIFMS ....Central Valley Integrated Flood Management Study
Delta ....Sacramento-San Joaquin Delta
DWR ....California Department of Water Resources
EAD ....expected annual damages
ETL ....Engineering Technical Letter
F-BO......................................Forecast-Based Operations
F-CO......................................Forecast-Coordinated Operations
FEMA....................................Federal Emergency Management Agency
FloodSAFE ....FloodSAFE California
FPZ ....Flood Protection Zone
Framework Agreement..........California's Central Valley Flood System Improvement Framework Agreement
ft ....feet
GIS.......................................geographic information system
HEC-FDA..............................USACE Hydrologic Engineering Centers Flood Damage Analysis
LCM.....................................Life Cycle Management
PGL......................................Policy Guidance Letter
Proposition 1E ....Disaster Preparedness and Flood Prevention Bond Act of 2006
Proposition 84........................Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006
RAMP ....Regional Advance Mitigation Planning
Reclamation ..........................U.S. Department of the Interior, Bureau of Reclamation
SPA ....Systemwide Planning Area
SPFC....................................State Plan of Flood Control
SSIA......................................State Systemwide Investment Approach
State ....State of California
USACE .................................U.S. Army Corps of Engineers

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APPENDIX A:

Central Valley Flood Protection Board Adoption Resolution 2012-25, Amending and Adopting the 2012 Central Valley Flood Protection Plan, June 2012

STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
CENTRAL VALLEY FLOOD PROTECTION BOARD
PROPOSED RESOLUTION NO. 2012-25
PROVIDING THE BOARD'S VISION FOR AND
ADOPTION OF THE 2012 CENTRAL VALLEY FLOOD PROTECTION PLAN
AND PROVIDING A FRAMEWORK FOR INTERPRETATION AND
IMPLEMENTATION OF THE PLAN
JUNE 2012

HISTORY:

A. WHEREAS, The history of the Sacramento Valley flood system is chronicled by Robert Kelley in *Battling the Inland Sea*. The earliest levees in the Sacramento River basin were originally constructed by landowners to prevent the flooding of swamp and overflow areas in order to convert these lands to agricultural use. These levees failed repeatedly, in part due to channel aggradation from hydraulic mining debris. In response, levees were strengthened and raised close to the main channel to concentrate floodwaters in order to scour mining debris from river channels for both navigation and flood control. As early as the 1860's however, a Colusa newspaper publisher named Will S. Greene argued that it was not possible to contain entire floods in a single channel between the levees and instead advocated for a bypass system to safely accommodate large flood flows. In a report to the State legislature in 1880, William Hammond Hall, the first State Engineer, also recognized that large floods could not be contained within a single channel between the levees and argued that "floods will occasionally come which must be allowed to spread" into bypasses and flood basins; and

B. WHEREAS, The prevailing view from about 1870 to about 1905 was that Sacramento River floodwaters could be contained between the Sacramento River levees. The State's Dabney Commission Report of 1905 proposed continued use of the Sacramento River as the main "single channel" conveyance, but also proposed that water be allowed to flood out of the river onto agricultural lands when flood flows were too high. The Dabney Commission was based on a flood flow of about 250,000 cubic feet per second (cfs) near Rio Vista. The Dabney Commission Report was never adopted however; and

C. WHEREAS, Recently installed river gages indicated that the floods of 1907 and 1909 each produced a flow of about 600,000 cfs which was far in excess of the flow that could be contained by the Sacramento River levees; and

D. WHEREAS, The U.S. Army Corps of Engineers' (USACE) Jackson Plan of 1910 was based on the 1907 and 1909 floods with peak flows of about 600,000 cfs and recommended a coordinated river and bypass system, as had been promoted by Colusa resident Will S. Green. The purposes were to (1) allow conversion of valley swamp and overflow lands to agriculture; (2) improve commercial navigation, and (3) maintain river velocities sufficient to transport soil, sand, and rock that were being washed down into valley rivers as a result of hydraulic gold mining in the Sierra Nevada. In 1917 Congress authorized the Jackson Plan as the Sacramento River Flood Control Project (SRFCP). The levees were typically constructed of material dredged from the river bottom and shaped into a specified geometry, which resulted in relatively inexpensive, but unreliable levees; and

E. WHEREAS, The Jackson Plan has worked well to reduce the frequency and damage associated with flooding. Construction of reservoirs with flood control storage in the second half of the 20th Century increased the ability of the system to accommodate flood flows larger than originally envisioned. Although the Jackson Plan was perceived as a success by early 20th Century landowners it does not meet society's expectations today; and

F. WHEREAS, Flood management in the San Joaquin Valley began with the construction of levees to reclaim fertile tule lands and to protect against out-of-bank flows; and

G. WHEREAS, The Flood Control Act of 1944 authorized the Lower San Joaquin River and Tributaries Project. The project included constructing levees on the San Joaquin River downstream of the Merced River, Stanislaus River, Old River, Paradise Cut, and Camp Slough. Construction began on the Lower San Joaquin River and Tributaries Project in 1956. This project included construction of New Hogan Dam on the Calaveras River, New Melones Dam on the Stanislaus River, and Don Pedro Dam on the Tuolumne River. New Melones Dam was later reauthorized for construction under the Flood Control Act of 1962. The Chowchilla and Eastside Bypasses were constructed by the State as part of the Lower San Joaquin River Flood Control Project; and

H. WHEREAS, The Flood Control Act of 1944 also authorized construction of Isabella (Kern River), Success (Tule River), Terminus (Kaweah River), and Pine Flat (Kings River) dams in the Tulare Lake Basin. Following major flooding in 1955 construction of levees and bypasses on the San Joaquin River upstream of the Merced River was authorized. From 1962 to 1963 Congress authorized construction of Buchanan Dam on the Chowchilla River and Hidden Dam on the Fresno River, and authorized federal participation in the cost of New Exchequer Dam on the Merced River. In addition to flood protection all of these reservoirs provide water supply for irrigation uses and, in some cases, hydropower generation. The 2008 legislation as described below that required preparation of the Central Valley Flood Protection Plan (CVFPP) did not include the Tulare Lake Basin as a part of the CVFPP. Significant flood flows are diverted from the Kings River to the San Joaquin River at Mendota Pool during large flood events; and

I. WHEREAS, Several smaller flood management projects have been developed in the Sierra Nevada foothills on San Joaquin River tributaries. These projects generally consist of dry dams constructed to protect downstream metropolitan areas and nearby agricultural lands. The Merced County Stream Group Project was constructed to restrict flood flows on several streams to non-damaging levels from the foothill line to the City of Merced. Farmington Dam on Little Johns Creek provides flood protection for intensely developed agricultural lands below the dam, the City of Stockton, and the rural towns of Farmington and French Camp; and

J. WHEREAS, The very large 1986 and 1997 storms pushed the total flood system – levees, bypasses and reservoirs – to maximum capacity. Some levees failed and areas were flooded. In 1997 some reaches of the Sacramento and San Joaquin systems were pushed beyond their capacity resulting in numerous levee breaks and substantial flooding. If the flood control reservoirs had not been built the peak flow at the mouth of the Sacramento River is estimated to have been about one million cfs, and there would likely have been many more levee breaks and widespread flooding; and

K.WHEREAS, In 1911 the Legislature created the Reclamation Board. The Reclamation Board was given regulatory authority over the Sacramento Valley's local levee maintaining agencies with the objectives of (1) assuring a logical, integrated system for controlling flooding along the Sacramento and San Joaquin Rivers and their tributaries in cooperation with the USACE, (2) cooperating with various agencies in planning, constructing, operating, and maintaining flood control works, and (3) maintaining the integrity of the flood control system and designated floodways. In 1913 the Reclamation Board was given regulatory authority over the San Joaquin Valley's local levee maintaining agencies. In 2007 the Legislature restructured the Reclamation Board and renamed it as the "Central Valley Flood Protection Board."

FLOOD RISK:

L. WHEREAS, The primary flood management challenges facing the Sacramento and San Joaquin River Basins are (1) insufficient levee integrity and insufficient capacity to handle large rain floods in the Sacramento Basin, (2) insufficient levee integrity and insufficient capacity to handle large rain floods and prolonged snowmelt runoff events in the San Joaquin Basin and (3) urban developments in deep floodplains, because damages and potential life loss from inundation would be so large.

M. WHEREAS, Flood risks in the Central Valley are among the highest in the nation, putting the people of California and their economic livelihoods at risk (CWC § 9601); and

AGRICULTURE:

N. WHEREAS, Agriculture in the Sacramento and San Joaquin River Basins provides substantial economic and societal benefits to the region, the nation, and the world, providing vast quantities of food and fiber. Many specialty crops produced in these Basins are grown only in a few other places in the world. Agriculture provides substantial open space and habitat. This agricultural economy needs to be protected whenever possible; and

DEGRADATION OF HABITATS:

O. WHEREAS, Riverine habitats and ecosystem functions along Central Valley rivers have been degraded over time. Upstream reservoirs further altered the natural hydrology, and levees constructed adjacent to the active channel hydraulically severed millions of acres of floodplain habitat from rivers that were essential for fish and wildlife now actively protected under State and federal law. Roughly four percent of the historical riparian forests that once lined valley streams remain today. Much of this remaining habitat is growing on, within, or close to facilities of the State Plan of Flood Control (SPFC); and

LEVEE REQUIREMENTS:

P. WHEREAS, In response to this and other flood-related threats to people, property, and the environment, the Legislature enacted legislation requiring that new development approved by cities and counties within flood hazard zones in the Sacramento-San Joaquin Valley must be supported by a finding related to the urban level of flood protection for land use actions in the urban and urbanizing areas, and the Federal Emergency Management Agency standard of flood protection for land use actions in non-urbanized areas. The urban level of flood protection is defined as the level of protection that is necessary to withstand flooding that has a 1-in-200 chance of occurring in any given year using criteria consistent with, or developed by, DWR. After 2025, for urban and urbanizing areas protected by SPFC levees, cities and counties must find that the new development is protected to at least the urban level of flood protection.

While the Legislature did not require a specific level of flood protection for non-urban areas, the SSIA includes the use of structural means to achieve 100-year flood protection for some small communities within the SPFC Planning Area and non-structural means to support continued small community land use for other small communities.

FUNDING AND LEGISLATIVE ACTS:

Q. WHEREAS, In 2006 the people of California approved Proposition 84, the Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006 (Section 1, Division 43 PRC) which authorized $800,000,000 for flood control projects; and

R. WHEREAS, In 2006 the people of California approved Proposition 1E, the Disaster Preparedness and Flood Prevention Bond Act of 2006 (Statutes of 2006, Chapter 33, AB 140), authorizing approximately $4.09 billion to be invested in flood and related water management improvements; and

S. WHEREAS, The Central Valley Flood Protection Act of 2008 (Statutes of 2007, Chapter 364, SB5) (2008 Act) was enacted, directing the Department of Water Resources (DWR) to prepare a proposed Central Valley Flood Protection Plan (proposed CVFPP) by January 1, 2012, and directs the Central Valley Flood Protection Board (Board) to adopt a final CVFPP (adopted CVFPP) by July 1, 2012 (CWC § 9612(b)).

Further, the 2008 Act declares that the Board shall hold at least two hearings to receive comments on the proposed CVFPP, and that the Board shall accept written comments on the proposed CVFPP (CWC § 9612(c)).

Further, the 2008 Act declares that the Board may make changes to the proposed CVFPP to resolve issues raised in the hearings or to respond to comments received by the Board, and that the Board shall publish its proposed changes to the proposed CVFPP at least two weeks before adopting the CVFPP (CWC § 9612(d)).

Further, the 2008 Act declares that the adopted CVFPP shall be updated in subsequent years ending in 2 and 7 (CWC § 9612(e)); and

T. WHEREAS, The 2008 Act declares that the adopted CVFPP shall be a descriptive document reflecting a systemwide approach to protecting the lands currently protected from flooding by existing facilities of the SPFC.

Further, The adopted CVFPP shall provide a description of: (a) both structural and nonstructural means for improving the performance and elimination of deficiencies of levees, weirs, bypasses, and facilities, including facilities of the SPFC; while accomplishing other multiple benefits; (b) probable impacts of projected climate change, projected land use patterns, and other potential flood management challenges on the ability of the system to provide adequate levels of flood protection; (c) both structural and nonstructural methods for providing an urban level of flood protection to current urban areas and a list of recommended next steps to improve urban flood protection; and (d) structural and nonstructural means for enabling or improving systemwide riverine ecosystem function including, but not limited to, establishment of riparian habitat and seasonal inundation of available flood plains where feasible.

Further, The adopted CVFPP shall provide an evaluation of structural improvements and repairs necessary to bring each of the facilities of the SPFC to within its design standard. The evaluation shall include a prioritized list of recommended actions necessary to bring each facility not identified in CWC § 9614(h) to within its design standard; and include a list of facilities recommended to be removed from the SPFC, including the reasoning for and any recommended actions associated with removal; and

U. WHEREAS, The 2008 Act declares that the adopted CVFPP shall not be construed to expand the liability of the State for the operation or maintenance of any flood management facility beyond the scope of the SPFC and that neither the development nor the adoption of the CVFPP shall be construed to constitute any commitment by the State to provide, to continue to provide, or to maintain at, or to increase flood protection to, any particular level (CWC § 9603(a)); and

V. WHEREAS, In addition to the 2008 Act, the 2007 flood legislation consists of AB 162, AB 70, AB 2140, and AB156 to strengthen the link between local land use decisions and regional flood management; and specified that requirements vary depending on location within California, the Sacramento-San Joaquin Valley, and the Sacramento-San Joaquin Drainage District; and

CENTRAL VALLEY FLOOD PROTECTION PLAN:

W. WHEREAS, DWR released its proposed CVFPP (entitled "2012 Central Valley Flood Protection Plan" published in December 2011). DWR's proposed CVFPP is a general framework or roadmap, rather than an engineering proposal for specific construction. Given the complexity and scope of the CVFPP it will take additional time for DWR to size and finalize the engineering and hydrologic aspects of the CVFPP, and

X. WHEREAS, In developing the proposed CVFPP, DWR identified a primary goal and four supporting goals. The primary goal is to improve flood risk management, which means to reduce the chance of flooding, damages once flooding occurs, and improve public safety, preparedness, and emergency response, through identifying, recommending, and implementing structural and non-structural projects and actions that benefit lands currently receiving protection from facilities of the SPFC; and formulating standards, criteria, and guidelines to facilitate implementation of structural and nonstructural actions for protecting urban areas and other lands of the Sacramento and San Joaquin River Basins and the Delta. The supporting goals are: (1) improve operations and maintenance; (2) promote ecosystem functions; (3) improve institutional support; and (4) promote multi-benefit projects; and

Y. WHEREAS, As described in Section 1.6 of the proposed CVFPP, the plan formulation was a multi-step process and was prepared in coordination with local flood management agencies, the Board, federal agencies (i.e., USACE, U.S. Fish and Wildlife Service, FEMA, National Marine Fisheries Service, etc.), local and tribal governments, owners and operators, partners, stakeholders and interest groups, and the general public (*see* Volume I, Attachment 5); and

Z. WHEREAS, In developing the proposed CVFPP, DWR formulated and evaluated three preliminary approaches highlighting different ways to focus future flood management investments and address CVFPP goals. These approaches were: (1) Achieve State Plan of Flood Control Design Flow Capacity; (2) Protect High Risk Communities; and (3) Enhance Flood System Capacity (*see* Section 2 of the proposed CVFPP); and

AA. WHEREAS, DWR developed and recommends adoption of the State Systemwide Investment Approach (SSIA), an approach that draws from the strengths of each of the preliminary approaches (*see* Section 3 of the proposed CVFPP); and

BB. WHEREAS, DWR's proposed CVFPP includes (a) levee and other regional flood risk reduction improvements; and (b) increased system capacity such as expanding existing bypasses, modifying some bypass weirs, reoperating reservoir storage and operations, and modifying Folsom Dam; and

CC. WHEREAS, The proposed CVFPP would provide the following benefits: a) Levee improvements would lower the likelihood of flooding areas protected by levees; b) Increased system capacity, such as expanded bypasses or reservoir reoperation would provide flood benefits to both urban and rural areas by (1) lowering the water surface elevation of floodwater against levees, recognizing that water pressure is a main driver for several levee failure mechanisms, and (2) by providing additional capacity to handle larger floods; c) With levee improvements and the increased system capacity in a very large flood, there will be a greater likelihood of containing the floodwaters within the system rather than having levees fail, resulting in uncontrolled flooding of urban and rural lands. In smaller floods the elevation of floodwater against the levees would be lower, which would reduce the likelihood of urban and rural levee failures; and

VEGETATION MANAGEMENT POLICY:

DD. WHEREAS, Many of the levees along rivers in the Sacramento and San Joaquin River Basins were constructed close to the rivers in order to maintain high velocities to scour out rock, sand, and dirt settling in the rivers. Many of these levees have woody vegetation on or near the levee. In some cases, this was incorporated into the design of the levee project while in others, maintenance practices have resulted in woody vegetation being left to grow on the levee; and

EE. WHEREAS, Rivers in California provide many public purposes including recreation, fisheries and fishing, habitat, esthetics, State and local parks, etc. Because many of the levees are very close to the rivers, the levee vegetation has become integral and essential to these valuable public purposes, and

FF. WHEREAS, The USACE has always had policies limiting vegetation on certain levees, those vegetation-prohibition policies have not been consistently enforced, and the USACE itself has, at times, planted such vegetation. Recently the USACE has issued an engineering technical letter (ETL) specifying standards that no woody vegetation may remain on federal-State levees or be within fifteen (15) feet of the levee toe on either side of the levee. The cost of complying with these standards would be substantial. If a levee does not meet the standards, flood-damaged levees would not be eligible for federal rehabilitation (Public Law 84-99) assistance. The USACE is currently requiring compliance with the standards in projects that it sponsors, provides assistance for, or approves under Code of Federal Regulations Section 408. It has also required compliance with the ETL for modifications of project levees in the CVFPP planning area; and

GG. WHEREAS, Many different interests, including DWR and the Board, have objected to the adoption and implementation of the USACE standards. The proposed CVFPP outlines a different levee-vegetation management strategy for these “close to the river” levees in the Sacramento and San Joaquin River Basins. DWR’s vegetation management strategy would allow some of the existing woody vegetation to remain. This proposed interim management strategy would be implemented while scientific studies progress to determine whether vegetation removal or attrition are necessary for public safety considerations, appropriate, and the best use of limited funds; and

PUBLIC MEETINGS AND HEARINGS:

HH. WHEREAS, At the direction of the Board its staff engaged in a review of: (1) the technical analyses conducted by DWR in the development of the proposed CVFPP; and (2) the proposed CVFPP Conservation Framework that describes how environmental stewardship is integrated into flood management activities; and

II. WHEREAS, DWR presented and highlighted key elements of the proposed CVFPP to the Board at its monthly meeting on January 27, 2012, at which time the Board also described its process for reviewing the technical documents and accepting public comments. The Board solicited recommendations of focus topics for Board review of the proposed CVFPP at its monthly meeting on February 24, 2012; and

JJ. WHEREAS, DWR, as lead agency under the CEQA, PRC § 21000 *et seq*. and pursuant to a lead agency agreement, prepared a Draft Program Environmental Impact Report (DPEIR) on the CVFPP, (State Clearinghouse (SCH) No. 2010102044, March 6, 2012). The 45-day public review period ended on April 20, 2012. DWR presented the DPEIR to the Board at its monthly meeting on March 23, 2012; and

KK. WHEREAS, The Board, as a responsible CEQA agency in the preparation of the DPEIR, held four joint public hearings with DWR on April 5th (Sacramento), 6th (Marysville), 9th (Stockton) and 11th (Woodland) to accept comments on the draft PEIR, hear further public comments on the proposed CVFPP, hear a report by Board staff on their technical review of the proposed CVFPP, documents incorporated by reference, and attachments; and

LL. WHEREAS, The public comments fell into five general categories: (1) project definition; (2) system and local improvements; (3) participation by stakeholders; (4) implementation; and (5) secondary but related issues. Public comments were focused on the following key issues:

a) Inclusion of bypass expansions and new bypasses in the proposed CVFPP, including the potential Sutter Bypass expansion, Yolo Bypass expansion, a new Feather to Butte Bypass, and a Paradise Cut Bypass. Certain maps, such as those depicted on Figures 3-1 and 3-2 in the proposed CVFPP, show potential bypass enlargements. These enlargements are conceptual in nature as presented in the proposed CVFPP and the Figures do not reflect actual alignments.

b) Agricultural land conversion and potential effects of the proposed CVFPP on agricultural lands and production, including the sustainability of rural-agricultural economies.

c) Levels of flood protection targeted in the proposed CVFPP for urban and non-urban areas, including potential effects on local maintaining agency operations and maintenance responsibilities, eligibility for emergency repair funding, federal funding for rural improvements, and the need for rural levee repair and improvement standards.

d) New urban level of flood protection requirements for cities and counties that come into effect upon CVFPP adoption, including information and criteria needed for local cities and counties to make findings.

e) Maintenance, repair and rehabilitation of existing flood management system facilities, versus construction of new facilities.

f) Integration of water supply, ecosystem restoration, recreation, and other benefits into flood management system improvements, including the need for objectives to measure the success of integration and concern for potential land use and public safety implications.

g) Desire for a vision statement summarizing the overall intent of the adopted CVFPP and the SSIA.

h) Formulation and selection of the SSIA, including rationale for and cost-effectiveness of the approach.

i) The potentially high cost of the SSIA including financing, federal cost-sharing, and the local ability to pay for improvements.

j) Suggestions that new reservoir flood storage should be included in the SSIA.

k) Consideration of the Sacramento-San Joaquin Delta (Delta) in the proposed CVFPP, including the potential for hydraulic impacts to the Delta and flood protection for Delta lands not protected by SPFC facilities.

l) Need for policies or guidance addressing the potential hydraulic impacts of the proposed CVFPP, including impacts associated with repairing existing SPFC.

m) Level of engagement in proposed CVFPP development of stakeholders, including land owners and other interested parties, and how these stakeholders will be engaged following adoption of the CVFPP.

n) Proposal for and timing of post-adoption activities (such as regional planning and basinwide feasibility studies), including the role of the USACE in these activities and coordination with other, ongoing projects and programs in the Central Valley.

o) Use and prioritization of available and future funds to implement the adopted CVFPP, including allocation to achieve public safety goals in both urban and non-urban areas, and consideration of economic feasibility.

p) The need for increased flexibility for small communities and rural-agricultural areas in complying with FEMA’s standards applicable to special flood hazard areas; and

MM. WHEREAS, During the public hearings Board staff reported its findings regarding the completeness and adequacy of DWR's technical analysis, including its conclusion that DWR applied well established standards of engineering and scientific practice in the preparation of the proposed CVFPP; and

NN. WHEREAS, The Board held a public workshop with DWR on April 20, 2012 to discuss key issues raised by the public, to consider how these issues might be addressed in the adopted CVFPP, and to discuss the proposed structure of an adoption package; and

OO. WHEREAS, The Board held its regular monthly Board meeting on April 27, 2012 and received a summary report from Board staff on public comments received to date, received a report from DWR on the Regional Planning Process, and publicly discussed the proposed adoption package; and

PP. WHEREAS, The Board publicly discussed the adoption package to seek further public comments at various meetings, including: a special Board meeting on May 11, 2012; the Board's regular monthly meeting on May 25, 2012 (continued on June 1 and June 8, 2012); and a special Board meeting on June 15, 2012 to authorize the proposed CVFPP adoption package, and to post the adoption package on the Board's public web site for a two-week period per CWC § 9612(d); and

QQ. WHEREAS, DWR, as lead agency and pursuant to a lead agency agreement, prepared a Final Program Environmental Impact Report (FPEIR) (SCH No. 2010102044, June 2012), certified the FPEIR and CEQA findings, mitigation measures, a Mitigation Monitoring or Reporting Program (MMRP), and a Statement of Overriding Considerations pursuant to CEQA and the CEQA Guidelines (incorporated herein by reference) on June 28, 2012, and intends to file a Notice of Determination with the State Clearinghouse. The DPEIR and FPEIR are incorporated herein by reference and available at the Board or DWR offices; and

RR. WHEREAS, the FPEIR serves as the basis for program-level CEQA compliance for all discretionary actions by other State and local agencies necessary to implement the CVFPP. Adoption of the CVFPP by the Board is a programmatic discretionary action that can rely on the program-level FPEIR. Consistent with the provisions of the CEQA Guidelines Section 15152(d), State or local agency discretionary actions on future projects shall be based upon the FPEIR together with additional project-level environmental analysis and public comment for such projects not examined in detail in the FPEIR.

SS. WHEREAS, The Board reviewed the findings of its staff, documents and correspondence in its file, and environmental documents prepared by DWR.

NOW,THEREFORE, BE IT RESOLVED THAT:

1. RESOLVED, That the above recitals are true and correct.

GOALS:

2. RESOLVED, That the Board hereby adopts the primary goal and four supporting goals, as described in Whereas X, for the CVFPP previously proposed by DWR and by this resolution the Board is also adopting a specific vision for the CVFPP that is consistent with those goals and the Board's goals of: (1) managing flood risk along the Sacramento and San Joaquin Rivers and their tributaries in cooperation with the USACE; (2) cooperating with various agencies of the federal, State and local governments in establishing, planning, constructing, operating, and maintaining flood control works; (3) and maintaining the integrity of the existing flood control system and designated floodways through the Board's regulatory authority by issuing permits for encroachments.

VISION STATEMENT:

3. RESOLVED, That the Board's vision for the CVFPP is to:|

(a) Have as first priority the protection of life and property by reducing both the probability and consequences of flooding.

(b) Protect life and property in urban and rural areas by assuring that the existing system is properly maintained and managed.

(c) Protect life and property in urban and rural areas by improving reliability and expanding the capacity of the existing system to provide a margin of safety in the event of larger flood events.

(d) Cooperate with various federal, State, and local agencies and stakeholders to manage flood risk.

(e) Restore ecosystem function to promote the recovery and stability of native species and overall biotic diversity and provide for recreation.

(f) Promote economic sustainability in urban, rural, and agricultural areas.

(g) Improve long-term system resiliency to address uncertainties such as the effects of climate change, other changes in hydrology, or uncertain geotechnical conditions.

TECHNICAL FINDINGS:

4. RESOLVED, That the Board finds that the adopted CVFPP meets the requirements and intent of the 2008 Act.

5. RESOLVED, That the Board finds that DWR, in preparing the proposed CVFPP, applied well-established standards of engineering practice, and utilized best available scientific data and methodologies to evaluate a range of conceptual, preliminary approaches including modifying existing SPFC facilities to achieve their design standards, focusing flood system improvements on protecting public safety and populations at risk, and enhancing overall flood system capacity and ecosystem functions.

6. RESOLVED, That the Board finds that the SSIA identified the most promising elements of each of the three preliminary approaches.

7. RESOLVED, That the Board finds that SSIA helps achieve the Board's vision for flood management in a balanced manner through responsible investment of public funds, commensurate with flood risks, in projects that integrate multiple benefits, where feasible, in proactive SPFC maintenance and residual risk management, and through wise management of floodplains protected by the SPFC.

8. RESOLVED, That the Board finds that the USACE is often an essential partner for flood protection repairs and improvements for the communities in the Sacramento and San Joaquin River Basins.

9. RESOLVED, That the Board finds that the adopted CVFPP will be used as a long-term planning document acting as the framework for: (1) regional plans to be prepared by local agencies and stakeholders under a DWR-sponsored process; (2) systemwide improvement plans to be prepared by DWR, with stakeholder input, in consideration of regional plans; and (3) other local, regional, and basinwide plans to be prepared by USACE and / or DWR. The adopted CVFPP does not authorize or approve any site-specific ground-disturbing actions or construction activities.

10. RESOLVED, That the Board finds that in addition to local benefits, existing and expanded bypasses provide systemwide benefits. Therefore, systemwide flood control beneficiaries should contribute to the cost of providing systemwide benefits including but not limited to bypass modifications and maintenance. The Board also believes that to the extent that bypass modifications are considered prior to the adoption of the 2017 CVFPP, such modifications should focus first on the furthest downstream bypasses on the systems, such as the Yolo and proposed Paradise Cut Bypasses.

AMENDMENTS AND ADOPTION:

11. RESOLVED, That the Board, in consideration of public comment, amends and adopts the proposed CVFPP, including the documents listed in Resolved 24, based on the following framework that will guide implementation of the adopted CVFPP:

(a) The Board will exercise its authority and jurisdiction in partnership with DWR to conduct post-adoption planning and implementation, and provide a public forum for activities related to the adopted CVFPP including participating with DWR in regional planning, basinwide and project-specific feasibility studies, project-level environmental compliance to refine adopted CVFPP elements and physical features; enforcing maintenance requirements and other applicable permitted conditions; issuing permits; acquiring lands and easements; executing cost-sharing agreements; and other activities needed to update and implement the adopted CVFPP.

(b) Future processes and activities will occur which will continue to ensure meaningful public and stakeholder participation as the reconnaissance-level proposals expressed in the adopted CVFPP are further studied at regional and basinwide levels of detail to determine whether or not they will improve flood management, and are feasible and fundable. The use of different lists of stakeholders in this Resolution is not intended to present the exclusive list of stakeholders who may be interested in a particular issue, and the ordering of the list is not intended to indicate that one stakeholder group is more significant than another.

(c) The Board intends to provide a forum, through the establishment of one or more advisory committees or other group pursuant to CWC § 9612(f), to discuss guidelines that prioritize and implement flood risk reduction projects and programs, consistent with the adopted CVFPP, using remaining funding from Propositions 84 and 1E and any further sources of funding identified.

(d) The Board will designate an advisory committee or other group to develop specific, measurable, achievable, results oriented and time-bound conservation objectives for consideration by the Board for possible inclusion in the adopted CVFPP and the Conservation Strategy.

(e) DWR anticipates completing a draft Central Valley Flood System Conservation Strategy not later than 2014, expanding on the Conservation Framework attached to the adopted CVFPP, to describe long-term, systemwide conservation objectives and covered actions associated with the flood management system.

(f) Pursuant to CWC § 9620(c), DWR will prepare a recommended schedule and funding plan in 2013 to implement the recommendations of the adopted CVFPP, and DWR, by December 31, 2012, will brief the Board as to how it intends to collaborate with local, State and federal agencies on the development of the recommended schedule and funding plan.

(g) DWR intends to provide funding, to be cost shared by local agencies, to implement urban, small community, and rural levee repairs and improvements consistent with the adopted CVFPP.

(h) The Board will create an advisory committee, or other appropriate group, working with DWR, local maintaining agencies, interested stakeholders, and the USACE to develop rural levee repair and improvement criteria, to be applied to planned or emergency work. The Board intends for the advisory committee or group to produce draft criteria to be available by July 1, 2013.

(i) The Board should, consistent with the CVFPP, seek to preserve rural agricultural landscapes, minimize the loss of agricultural production by using agriculture to achieve habitat values, i.e. "working landscapes", and minimize the impacts to adjacent landowners from construction of flood system improvements that include newly created habitat.

The Board recognizes that mitigation of the impacts of newly established or expanded bypasses and habitat areas on agriculture is a concern to the agricultural community, but also recognizes that the issue of mitigating for effects presents complex questions of both law and policy. The current policy of the Natural Resources Agency to examine the issue on a case-by-case basis. However, this policy is now evolving as agencies consider the effects of large-scale infrastructure projects on habitat and farmland. The Board encourages DWR to consider mitigation on a case-by-case basis.

(j) DWR, in coordination with the Board, USACE, local agencies and the public will initiate State-led basinwide feasibility studies for the Sacramento and San Joaquin River Basins (in time to inform the 2017 CVFPP update) to evaluate and refine the conceptual system improvement elements described in the adopted CVFPP, including bypass expansions and new bypasses, and evaluate appropriate regional plan elements at the system-wide level. These are likely to include the formation of one or more working groups to identify potential implementation challenges and solutions, potential effects on local and regional land uses and economies, and specific multi-benefit objectives for system elements.

(k) In accordance with the authority and jurisdiction of the Board to approve or deny any flood risk reduction project affecting any facility of the SPFC, the Board will review project-specific implementation actions, and associated environmental review and compliance documents, as appropriate, developed through post-adoption planning activities associated with the adopted CVFPP.

(l) In conducting post-adoption implementation activities associated with the adopted CVFPP, DWR will work with the Board on other ongoing projects and programs in the Central Valley to identify mutual objectives, complementary project elements, and improve the efficiency of outreach and engagement with stakeholders and the public.

(m) Wherever feasible, improvements to the SPFC should be implemented in accordance with CWC § 9616 and provide for multiple benefits through projects designed to improve public safety while achieving other benefits, such as restoration of ecosystem functions and habitats within the flood management system.

(n) DWR will continue to make investments in new data, analysis tools, and systemwide benefit policies to support refinement of the physical elements of the adopted CVFPP, and assess the feasibility of project-specific implementation actions and local planning efforts.

(o) DWR will conduct additional analyses to evaluate the effects of climate change and the effectiveness of various flood system improvements proposed in the SSIA to accommodate future changes in hydrology and sea level rise, for use in the basinwide feasibility studies.

(p) The proposed CVFPP includes the Folsom Dam Joint Federal Project, the Folsom Dam Water Control Manual Update Project, the Folsom Dam Raise Project, the Yuba-Feather Rivers Joint Project for Forecast Coordinated Operations (FCO), and FCO for other reservoirs. These projects will have the effect of increasing and / or improving the use of the reservoir storage space for flood management. In addition to these projects, DWR will: (1) consider reservoir reoperations, expansions or modifications, including those proposed by local or regional entities; and (2) continue to consider flood management as an objective of its ongoing multi-benefit surface storage investigations and systemwide reoperation studies. Should these related DWR efforts identify flood management as a component of a feasible reservoir storage project, such project may be proposed for implementation under the adopted CVFPP and / or may be reflected in future updates to the adopted CVFPP.

(q) DWR will continue to provide guidance, criteria, data, analyses and technical support to assist cities and counties in making findings related to the urban level of flood protection and related land use planning requirements that come into effect upon adoption of the CVFPP to assist them to meet their statutory deadlines. The Board encourages DWR to provide preliminary 100- and 200-year floodplain mapping of areas protected by SPFC facilities to cities and counties by July 1, 2013 to allow cities and counties to meet their statutory deadlines.

(r) Studies and analyses that result from implementation of the adopted CVFPP will be included in the 2017 update of the CVFPP and will be shared with the USACE to be considered in its Central Valley Integrated Flood Management Study scheduled for release at the same time, consistent with the State's goal to maximize federal and local cost sharing.

(s) DWR will sponsor regional flood management planning efforts which will develop regional plans that present stakeholder perspectives of flood management priorities for each region, the results of which will be coordinated between regions and integrated into or consistent with the basinwide plans. Regional planning should create a role for all interested stakeholders including representatives from agricultural, city and county, conservation, environmental, landowner, and water supply interests as well as the flood control agencies and organizations. The Board will provide a link on its website at http://cvfpb.water.ca.gov to a location on DWR's website for announcements and documentation on the regional planning process.

(t) The Board intends to: (1) participate in each regions' planning process by providing a representative for each region who can participate in regional meetings and act as a liaison between the regional planning process and the Board; and (2) hold hearings to allow the Board to evaluate the content of the different regional plans, consider the interplay of the various regional plans, consider the coordination and integration of the regional plans with and into the basinwide feasibility studies, and provide a public forum for stakeholder comments. The Board will engage in the development and integration of the regional and basinwide plans in a manner consistent with this Resolution.

(u) Regional planning efforts should include a focus on managing the river corridors covered by the CVFPP to reduce flood risk and promote ecosystem functions, and should build on the existing river corridor management efforts, including those efforts in the Sacramento and San Joaquin River basins which have had some success.

(v) The Board desires to support viable, cost effective and locally supported repair and improvement projects, but may not support projects that physically interfere with systemwide improvements developed consistent with the adopted CVFPP.

(w) The Board will partner with State and local agencies to work with FEMA and Congress to seek needed regulatory reform and reduced insurance rates for rural and small communities located in the FEMA floodplain to assure continued economically viable agricultural operations.

(x) The Board intends, in cooperation with DWR, to reach out to State and federal agencies and departments to facilitate coordination between the CVFPP and other major water and conservation-related programs in the Sacramento and San Joaquin River Systems.

(y) For those deliverables and processes set forth in items (a) through (x) above, it is understood that DWR shall provide quarterly reports to the Board regarding schedules and progress.

12. RESOLVED, That the Board will consider whether to adopt as part of the CVFPP the Draft Urban Level of Flood Protection Criteria (ULOP) and the Urban Levee Design Criteria (ULDC) six-months after their public release, not earlier than November 14, 2012. The Board will not adopt the ULOP and ULDC as part of the CVFPP until participating with a group of representatives from cities, counties, DWR staff and other stakeholders, in an effort to resolve concerns, guide implementation, and incorporate any changes necessitated through legislation to the ULOP and ULDC.

13. RESOLVED, That the Board may adopt interim updates to the adopted CVFPP consistent with the requirements of CEQA.

14. RESOLVED, That the Board, in accordance with its authority and jurisdiction, will review and provide comments on proposed amendments to the safety elements of general plans within the Sacramento and San Joaquin Drainage District relating to: (1) uses of land and policies in areas subject to flooding; and (2) methods and strategies for flood risk reduction and protection pursuant to CGC § 65302(g) (Statutes of 2007, Chapter 369, AB 162).

15. RESOLVED, That nothing in the proposed CVFPP and appendices, nor any referenced policies or guidelines, is intended to change the Board's practice for the evaluation of hydraulic impacts. Under this practice the Board has consistently found that no adverse hydraulic impacts are associated with levee strengthening projects that do not change the alignment or height of the levee, or the cross section of the channel and overflow area.

16. RESOLVED, That DWR, in coordination with the Board, USACE, and other stakeholders, intends to develop appropriate policies or guidance for the consideration of potential temporary or permanent hydraulic impacts associated with incremental implementation of projects consistent with the adopted CVFPP.

17. RESOLVED, That urban, small community, and rural areas that desire to reduce their flood risk may pursue levee alterations or other improvements and other changes when not inconsistent with the adopted CVFPP.

18. RESOLVED, That the adopted CVFPP shall be updated by DWR in 2017 and considered for adoption by the Board at that time, and every five years thereafter, in subsequent years ending in 2 and 7, documenting progress made in refining and implementing the CVFPP.

19. RESOLVED, That DWR shall update the Flood Control System Status Report in 2016, and in subsequent years ending in 1 and 6 to help inform future CVFPP updates.

20. RESOLVED, That DWR shall update the State Plan of Flood Control Descriptive Document as necessary by agreement between the Board and DWR as facilities are added to or removed from the SPFC.

21. RESOLVED, That to the extent that changes in law or administrative rules affect implementation of the adopted CVFPP, the adopted CVFPP will be implemented consistent with such changed laws and administrative rules.

22. RESOLVED, That the new USACE levee vegetation standards would require removal of all woody vegetation, the larger roots of woody vegetation, forbs, and non-perennial grasses.

Instead of serving multiple public purposes such as recreation and esthetics, the levees would, under the USACE standard, become single-purpose flood control facilities.

A number of California Congressional members have introduced bipartisan legislation to ask the USACE to further study its levee vegetation policy. In addition, the State's Department of Fish and Game and other organizations have filed separate litigation against the USACE regarding lack of compliance with the federal Endangered Species Act and the National Environmental Policy Act.

Management of vegetation on Central Valley levees is at the heart of the disagreement between the USACE vegetation policy and resource agency recovery efforts for river corridors. At a minimum, USACE should have completed an Environmental Impact Statement, consulted with the United States Fish and Wildlife Service and other relevant state and federal agencies in developing its nationwide levee vegetation removal policy. Further USACE should coordinate with California agencies in the development of an appropriate approach to the management of levee vegetation in California's Central Valley.

DWR has developed an alternate levee vegetation management strategy, as proposed in the CVFPP and the Conservation Framework.

This Resolution amends and approves the proposed CVFPP levee vegetation management strategy as an interim strategy. The objectives of the strategy are to provide for levee safety and to protect the other important public purposes served by vegetation on the levees.

The Board adopts the levee vegetation management strategy in Section 4.2 of the CVFPP with the following changes: (1) not to implement the new USACE vegetation policy and implementation procedures that significantly compromise the multi-purpose uses provided by the river system in California, including environmental protection, recreation, aesthetics, and other broad public benefits, (2) would allow, by exception woody vegetation on and near levees if appropriate and consistent with public safety needs, and (3) would allow woody vegetation on the lower portion of the waterside of new levees that are not setback from the river if appropriate and consistent with public safety needs.

In summary, the levee vegetation management strategy would (1) not implement the USACE's levee vegetation policy; (2) not allow woody vegetation on or near new setback levees away from the river and that do not contribute to the multiple purposes served by rivers, (3) permanently allow woody vegetation on the lower portion of the waterside of existing or new levees that are not set back from the river, (4) temporarily allow other existing woody vegetation to remain on and near the rest of the levees until the end of the natural life of the existing woody vegetation, (5) require that woody vegetation be managed to assure visibility and accessibility: visibility for inspection of levee status and accessibility for maintenance, repair, and flood-fighting, and (6) would allow, by exception, woody vegetation on and near levees if appropriate and consistent with public safety needs.

DWR and the Board will work with the State Department of Fish and Game, the State Department of Parks and Recreation, appropriate federal agencies, local maintaining agencies, and other stakeholders to further develop a more comprehensive State levee vegetation management strategy in light of ongoing scientific research, the state of engineering practice, subsequent review, litigation, or legislation.

If the USACE levee vegetation policy becomes non-operative, the Board also intends to revisit the adopted CVFPP interim levee vegetation management strategy.

23. RESOLVED, The Board has serious concerns that the proposed Feather River Bypass (including the enlargement of the Cherokee Canal) (a) could have adverse, unmitigated hydraulic effects on downstream landowners, and (b) is unlikely to be found economically justifiable. In addition, the Board is aware of existing flood-carrying capacity limitations in the Cherokee Canal attributed to its original design, further diminished by channel vegetation and sediment management challenges, possibly compromising critical flood protection at the local level. Therefore, the proposed Feather River Bypass is removed from the CVFPP. The Board thus advises DWR to: (1) consider improving the Canal to its original design capacity; (2) consider alternatives to expansion of the Canal, with alternatives evaluated on an equal footing, and (3) if DWR concludes that expansion is necessary it will fully and carefully evaluate the hydraulic and environmental effects and associated benefits, all with considered public input. This bypass may be brought forward in the 2017 update of the CVFPP.

CAVEATS:

24. RESOLVED, That the following caveats are included:

a) It is expected that appropriate flood risk reduction projects will continue to be implemented during post-adoption regional and basinwide planning efforts.

b) Given the uncertainty of federal funding and approval in the current economic climate, other mechanisms may need to be utilized to make timely and cost-effective flood risk reduction improvements.

c) In an area with a willing and able local agency, that agency can carry out basinwide improvements consistent with the adopted CVFPP.

d) Evaluation of the implications of climate change should be consistent with current science, but it should be recognized that climate change will likely continue beyond 2100.

e) It is recognized that implementation of specific projects and programs is dependent on funding.

f) The proposed CVFPP is a planning document and it is intended to guide subsequent studies, planning, public outreach, environmental review, and decision-making processes relating to individual projects and program elements. Nothing in the proposed CVFPP, this Resolution, or in other actions taken by the Board to adopt the CVFPP represents a commitment to later carry out or approve any such projects and program elements, nor does the adoption of the CVFPP foreclose the development of alternatives as part of the environmental review of any such projects and program elements. The implementation of individual projects and program elements shall occur in compliance with all applicable laws and regulations and the terms of this Resolution.

DOCUMENTS INCLUDED IN THE ADOPTED CVFPP:

25. RESOLVED, That the adopted 2012 Central Valley Flood Protection Plan includes the following documents:

a) The contents of this *Resolution 2012-25*;

b) The Public Draft entitled "*2012 Central Valley Flood Protection Plan*" in the form published by DWR in December 2011, as modified by this Resolution 2012-25 and the Errata discussed in 24 (f) below, and including all the structural and environmental components described in the December 2011 document;

c) The *State Plan of Flood Control Descriptive Document* (DWR, November 2010), as modified by this Resolution 2012-25;

d) The *Flood Control System Status Report* (DWR, December 2011), as modified by this Resolution 2012-25;

e) The following attachments to the Public Draft of the 2012 CVFPP, as modified by this Resolution 2012-25 and the Errata discussed below:

1. Volume I, Attachment 1, *Legislative Reference* (DWR, June 2012);
2. Volume I, Attachment 2, *Conservation Framework* (DWR, June 2012);
3. Volume I, Attachment 3, *Documents Incorporated by Reference* (DWR, June 2012) [1];
4. Volume I, Attachment 4, *Glossary* (DWR, June 2012);
5. Volume I, Attachment 5, *Engagement Record* (DWR, June 2012);
6. Volume I, Attachment 6, *Contributing Authors and Work Group Members List* (DWR, June 2012)

f) *Errata to the Public Draft 2012 Central Valley Flood Protection Plan and Volume 1, Attachments 1-6* (DWR, June 2012, which modifies the Public Draft of the CVFPP and Volume 1, Attachments 1-6.

g) *Public Comment Record* (Board, June 2012) commencing January 1, 2012 through May 4, 2012.

[1] Volume 1, Attachment 3 provides a summary of four documents that are either linked with the proposed CVFPP through legislative requirements or related management policies that adoption of the CVFPP will trigger, but not the documents themselves. These documents are the *State Plan of Flood Control Descriptive Document (DWR, 2010), Flood Control System Status Report (DWR, 2011), Draft Urban Level of Flood Protection Criteria (DWR, 2012) and Urban Levee Design Criteria, (DWR, 2012).*

26. RESOLVED, Not withstanding Section 1.6.5 of the proposed CVFPP as changed by the Errata discussed in 25 (a) and (f) above, that the adopted 2012 Central Valley Flood Protection Plan does not include any portion of Attachments 7, 8 or 9 contained in Volumes II, III, IV and V of the Public Draft of the CVFPP.

CEQA FINDINGS:

27. RESOLVED, That the Board, as a responsible agency, has independently reviewed the analyses in the DPEIR (SCH No. 2010102044, March 2012) and the FPEIR (SCH No. 2010102044, June 2012) which includes the DWR Lead Agency findings, MMRP, Findings of Fact, and Statement of Overriding Considerations on the proposed CVFPP, and has reached its own conclusions.

28. RESOLVED, That the Board, after consideration of the DPEIR (SCH No. 2010102044, March 2012) and the FPEIR (SCH No. 2010102044, June 2012) and DWR Lead Agency findings, adopts the project description, MMRP, analysis and findings which are relevant to the CVFPP.

29. Findings regarding Significant Impacts. Pursuant to CEQA Guidelines sections 15096(h) and 15091, the Board determines that the DWR Lead Agency Findings and Statement of Overriding Considerations, incorporated herein by reference, identify potential impacts of the CVFPP to the Central Valley's flood management system, before and after mitigation. Having reviewed the FPEIR and DWR findings, the Board makes its findings as follows:

a. Findings regarding Significant Impacts and Potentially Significant Impacts that can be reduced to Less Than Significant.

The Board finds that the CVFPP may have significant, avoidable impacts, as more fully described in the FPEIR and the DWR findings. The FPEIR and DWR Lead Agency findings identify the significant and potentially significant impacts associated with the CVFPP that are reduced to a less-than-significant level by mitigation measures.

As a responsible agency, the Board has responsibility for mitigating or avoiding only the direct or indirect environmental effects of those parts of the CVFPP which it decides to carry out, finance, or approve. The Board confirms that it has reviewed the FPEIR, DWR Lead Agency findings, Statement of Overriding Considerations, and the MMRP, and finds that changes or alterations have been required in, or incorporated into, the MMRP which substantially lessen such impacts. The mitigation measures are within the responsibility of another agency, DWR. The Board has confirmed that DWR has adopted and committed to implementation of the measures identified therein. Each of those mitigation measures applicable to those portions of the project which the Board will fund or approve is made a condition of the Board's approval. The Board agrees and confirms that there are no additional feasible mitigation measures within its powers that would substantially lessen or avoid any significant effect the CVFPP would have on the environment.

b. Findings Regarding Significant and Unavoidable Impacts.

The Board finds that the CVFPP may have significant, unavoidable impacts, as more fully described in the FPEIR and the DWR findings. Mitigation has been adopted for each of these potential impacts, although it does not reduce the impacts to less than significant. The Board finds that changes or alterations have been required in, or incorporated into, the MMRP which substantially lessens such impacts, as set forth more fully in the DWR findings.

The mitigation measures are within the responsibility of another agency, DWR. The Board has confirmed that DWR has adopted and committed to implementation of the measures identified therein. Each of those mitigation measures applicable to those portions of the project which the Board will fund or approve is made a condition of the Board's approval. The Board agrees and confirms that there are no additional feasible mitigation measures within its powers that would substantially lessen or avoid any significant effect the CVFPP would have on the environment. The Board also finds that the specific economic, legal, social, technological or other benefits of the project outweigh the unavoidable adverse environmental effects, as discussed in more detail below in the Board's Statement of Overriding Considerations.

30. Statement of Overriding Considerations. Pursuant to CEQA Guidelines sections 15096(h) and 15093, the Board has balanced the economic, social, technological and other benefits described in the CVFPP against its significant and unavoidable impacts. The Board finds that the benefits of the CVFPP outweigh these impacts and they may, therefore, be considered "acceptable."

The Board finds that there is an immediate need to protect the people and property at risk in the CVFPP area. The CVFPP will protect a population of over one million people, major freeways, railroads, airports, water supply systems, utilities, and other infrastructure of statewide importance, including $69 billion in assets (includes structural and content value and estimated annual crop production values). The California Central Valley consists of deep floodplains where, depending on the circumstances, flood depths could reach life-threatening levels. The health and safety benefits of the CVFPP, which would significantly reduce the risk of an uncontrolled flood in the California Central Valley that would result in a catastrophic loss of property and threat to residents, outweigh the remaining unavoidable significant impacts.

31. RESOLVED, The Board directs the Executive Officer to take the necessary actions to prepare and file a Notice of Determination pursuant to CEQA for the Central Valley Flood Protection Plan, Final Program Environmental Impact Report (SCH No. 2010102044).

CUSTODIAN OF RECORD:

The custodian of the CEQA record for the Board is its Executive Officer, Jay Punia, at the Board offices at 3310 El Camino Avenue, Room 151, Sacramento, California 95821.

This resolution shall constitute the written decision of the Board in the matter of adopting the 2012 CVFPP.

PASSED AND ADOPTED by vote of the Board on June 29, 2012

William H. Edgar
William H. Edgar
President

Jane Dolan
Secretary

Jeremy Arrich, PE
Chief, Central Valley Flood Planning Office
arrich@water.ca.gov

Department of Water Resources
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Sacramento, CA 95821

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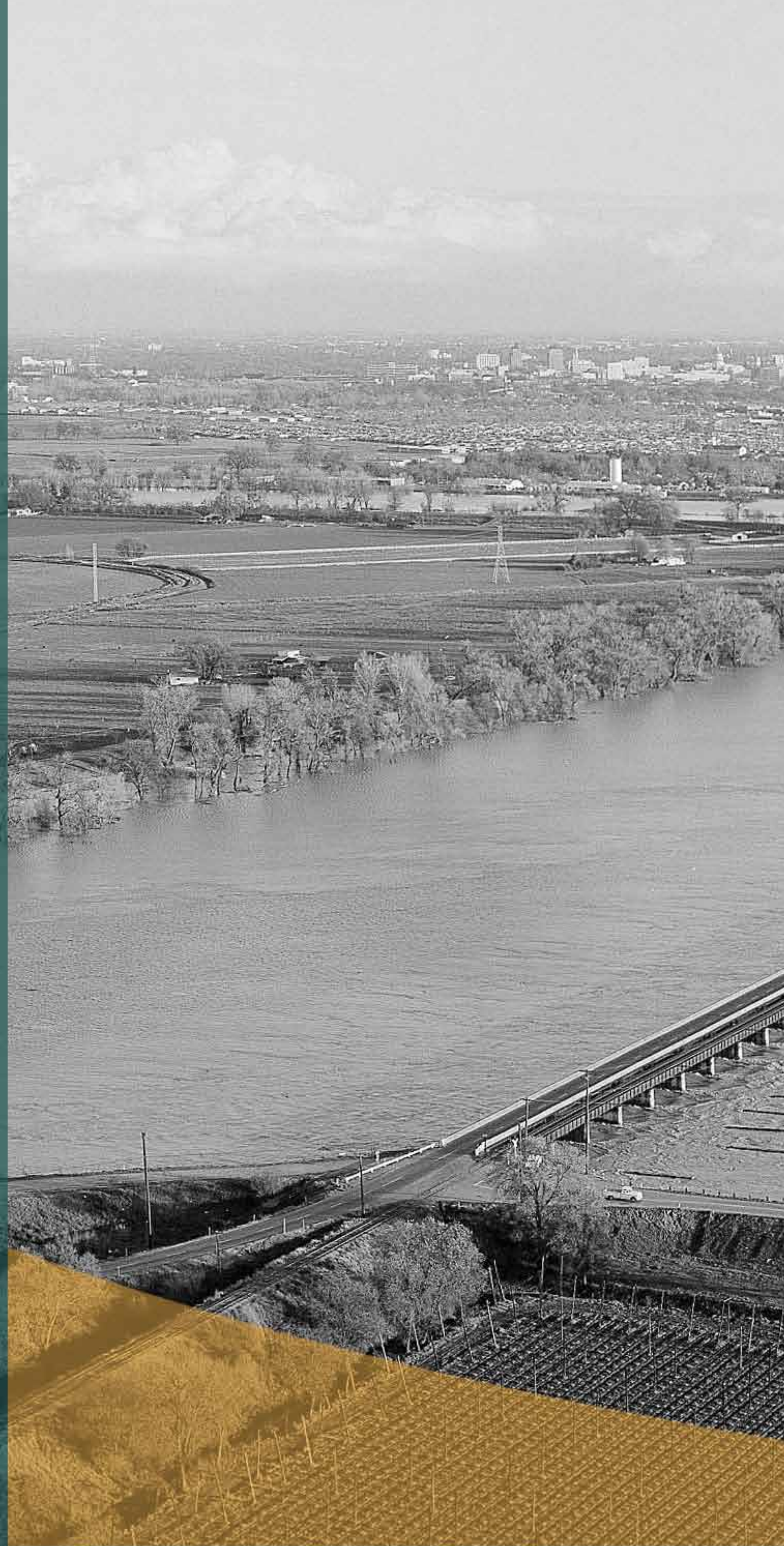


Edmund G. Brown Jr.
Governor
State of California

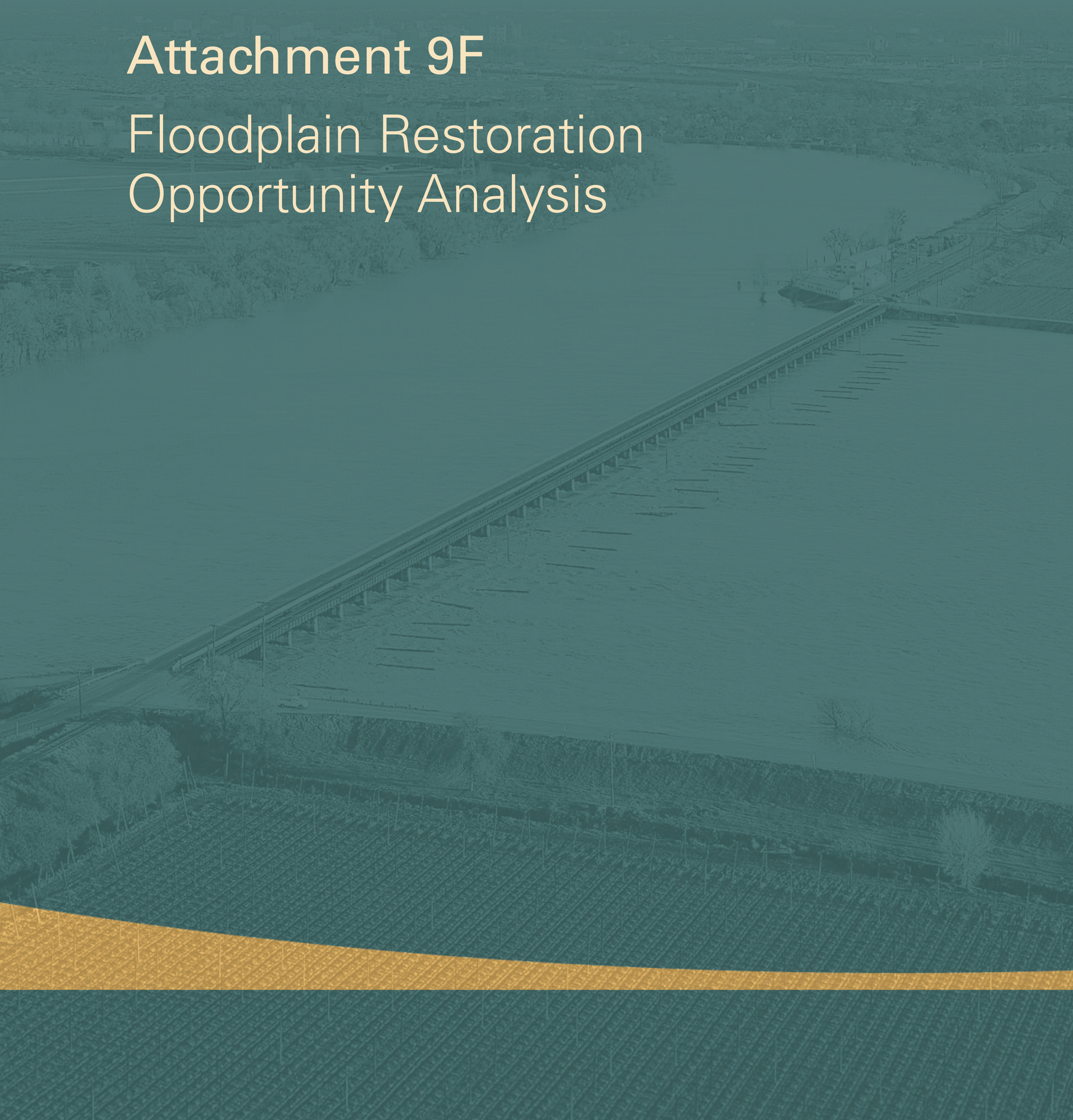
John Laird
Secretary
The California Natural Resources Agency

Mark W. Cowin
Director
Department of Water Resources

Department of Water Resources
The California Natural Resources Agency
State of California

Attachment 9F

Floodplain Restoration Opportunity Analysis



CENTRAL VALLEY FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

2012 Central Valley Flood Protection Plan

Attachment 9F: Floodplain Restoration Opportunity Analysis

June 2012

STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

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1.0 Introduction

This section provides an overview of the attachment and document organization.

1.1 Overview

Ecosystem restoration is a key component of the Central Valley Flood Protection Plan (CVFPP), and actions related to ecosystem restoration have been proposed as part of the CVFPP. This report documents an analysis of the potential for ecosystem restoration of floodplains within the Systemwide Planning Area of the State Plan of Flood Control (SPFC) (Figure 1-1).

To support the identification, development, and implementation of specific restoration actions, a Floodplain Restoration Opportunity Analysis (FROA) was conducted, which is summarized in this report. This FROA identifies areas with greater and/or more extensive potential opportunities for ecological restoration of floodplains. It does so by considering physical suitability; and opportunities and constraints related to existing land cover and land uses, locations and physical condition of levees, locations of other major infrastructure, conservation status of land, and locations that stakeholders are interested in restoring.

To evaluate physical suitability, the concept of floodplain inundation potential (FIP) was applied in a geographic information system (GIS) analysis of corridors along the Sacramento and San Joaquin rivers and their major tributaries. This analysis was selected because of the importance of floodplain inundation for ecosystem functions. To assess physical suitability for restoration actions, the FIP analysis adapted concepts from the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center (USACE-HEC) (USACE-HEC, 2009), the Frequently Activated Floodplain concept of Williams et al. (2009), and the Height Above River (HAR) GIS tool of Dilts et al. (2010). FIP analysis identifies areas of floodplain, both directly connected to the river and disconnected from the river (e.g., behind natural or built levees or other flow obstructions) that could be inundated by particular floodplain flows. The flows evaluated by the FROA included a spring flow sustained for at least 7 days and occurring in 2 out of 3 years (a 77 percent chance event), and 50 and 10 percent chance peak flows.

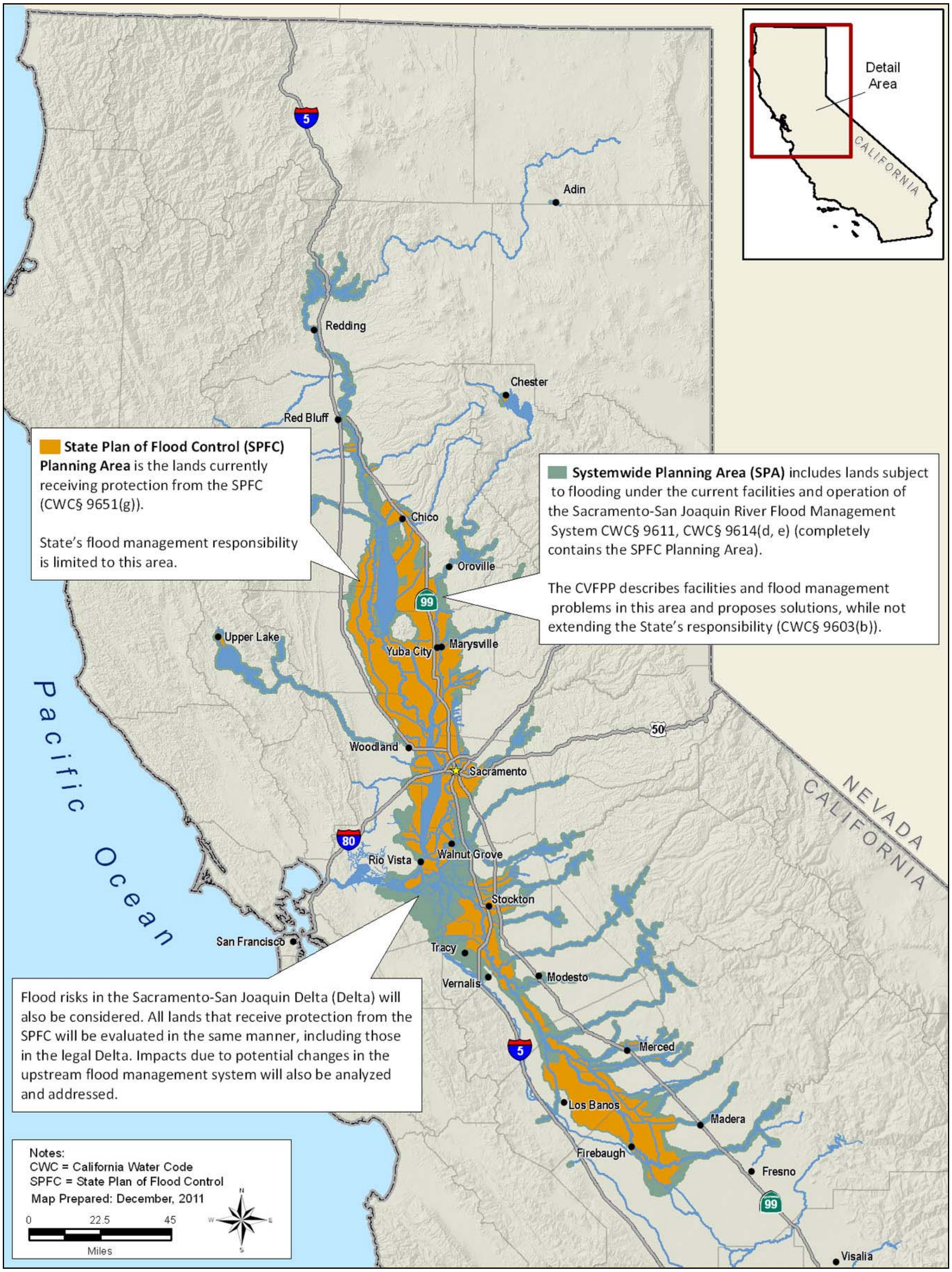

Figure 1-1. Central Valley Flood Protection Plan Planning Area

This analysis adapted existing models and hydrologic data, and thus, the FROA is limited to those reaches of the Sacramento and San Joaquin rivers and their tributaries for which such resources were available. Consequently, the FROA includes the Sacramento River from Woodson Bridge State Recreation Area to Collinsville, the San Joaquin River from Friant Dam to Stockton, the lower Feather River, and the lowermost reaches of other major tributaries of the Sacramento and San Joaquin rivers (i.e., the Bear, Yuba, American, Stanislaus, Tuolumne, and Merced rivers). It does not include smaller tributaries. The Sutter and Yolo bypasses are also included.

For the included river reaches and bypasses, oopportunities and constraints based on existing land use and land cover, major infrastructure locations, and conservation status were determined from existing and available geospatial data for existing wetland and riparian vegetation, Important Farmland (as defined by DOC, 2011), and urban areas; locations of major roads, highways, and railways; and land ownership and management. Four primary categories of existing land use and land cover were considered: developed, irrigated agricultural, open water, and natural; with natural land cover subdivided into wetland, riparian, and upland.

Stakeholder interest in restoration actions was compiled through focused outreach and review of existing reports. Stakeholders were interviewed to document potential ecosystem restoration projects previously identified by various CVFPP stakeholder groups throughout the Systemwide Planning Area. Specific information regarding potential restoration projects identified by stakeholders has been considered confidential. In addition to these interviews, existing reports that identified potential ecosystem restoration opportunities were also reviewed. Projects in reviewed reports that were located within the Systemwide Planning Area and that would provide ecosystem benefits were included with the group of stakeholder-identified projects and areas of interest.

The relationships among areas of physical suitability and opportunities and constraints were used to characterize river reaches and identify reaches with greater and/or more extensive potential opportunities for restoration. Reach boundaries were at junctions with tributaries and other frequently recognized boundaries (e.g., reach boundaries used by the San Joaquin River Restoration Program (SJRRP)).

The results of the FROA are intended to support the subsequent identification, prioritization, and further development of specific restoration opportunities. Through this subsequent planning, specific opportunities would be identified and prioritized on the basis of their potential ecological, flood management, and other benefits (e.g., reduced maintenance and regulatory compliance costs); cost; and regulatory, institutional, technological, and operational feasibility. This process for identifying and prioritizing opportunities would be both part of the continuing development of the overall CVFPP and of the development of species-focused conservation planning and corridor management strategies.

The following report summarizes the methods, results, and recommendations of the FROA.

1.2 Report Organization

The remainder of this attachment is organized into the following sections:

- Section 2.0, Methods
- Section 3.0, Results of the Floodplain Restoration Opportunities Analysis
- Section 4.0, Floodplain Restoration Opportunities: Conclusions and Recommendations
- Section 5.0, References
- Section 6.0, Abbreviations and Acronyms
- Appendix A, Floodplain Inundation and Ecosystem Functions Model Pilot Studies
- Appendix B, Investigation of USGS 10-Meter DEM Accuracy
- Appendix C, CVFED LiDAR Terrain Data Comparisons
- Appendix D, Levee Realignment Methodology
- Appendix E, Synthetic vs. Observed Hydrographs
- Appendix F, HEC-EFM Ecosystem Functional Relationships
- Appendix G, RAS/EFM Analysis FIP-based Mapping

1.3 Acknowledgments

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2.0 Methods

2.1 Overview

This chapter describes the general approach and methods of the FROA, which was based in part on the results and conclusions of two pilot studies conducted on the lower Feather River. The specific method used to determine FIP is described in detail in Appendix A, which provides the methods, results, and conclusions of the two pilot studies conducted on the lower Feather River to evaluate the suitability of FIP (an expanded version of the HAR method) (Dilts et al., 2010) and USACE-HEC-FEM (USACE-HEC, 2009) analyses for use in the FROA.

Traditional approaches for analyzing the inundation characteristics of river channel-floodplain land areas typically involve hydraulic models that rely on one-dimensional cross sections to describe the land surface. In addition to the limitations of cross sections to describe land surfaces, these traditional approaches also generally involve a significant amount of time to develop and use. However, because of the large geographic area covered by the CVFPP and the number of potential ecosystem restoration activities within this region, a computational tool capable of rapidly identifying and quantifying habitat restoration opportunities was desired.

Therefore, for this **planning-level study**, a simplified approach was preferred to understand the spatial extent of floodplain land areas that are connected and disconnected from the river channel for certain flow conditions. The FIP method is a GIS-based approach that does this, requires limited field data, is based on simple concepts, and is computationally efficient (Dilts et al., 2010). The FIP approach uses readily available topographic and hydrologic data sets and GIS analyses to identify floodplains potentially inundated under more frequent, ecologically valuable flow events (e.g., 50 and 10 percent chance events). Thus, GIS layers based on the results of the FIP analysis show floodplains that are connected, or could be more readily reconnected, to the river during specific flow events. **The FIP method is not intended to be a replacement for detailed hydraulic models**; instead, it is considered a viable tool for relatively quickly assessing areas that are physically suitable for restoration.

For the purpose of this work, the “FIP method” is the term used to describe the application of GIS tools provided within the ArcGIS Riparian Topography Toolbox, as described by Dilts et al. (2010). The ArcGIS

Riparian Topography Toolbox is distributed by Environmental Systems Research Institute, Inc. (ESRI) (ESRI, 2011). This GIS software uses digital terrain models and water surface elevations from hydraulic modeling to calculate the relative height of terrain above a water surface and the depth of terrain below a water surface (and thus FIP). It also determines the inundated areas that are connected or disconnected from a river channel by levees or other obstructions for a given flow event.

The Floodplain Inundation Pilot Study on the lower Feather River (Appendix A) evaluated the adaptation of the HAR tool for use in this FIP analysis. It found that the FIP method is a relatively effective way to quickly and easily find features on the land surface that are either above or below a specified water-surface profile. Color ramping of GIS layers of FIP output showing height increments both above the river (i.e., water surface) and below can provide a rapid visualization of the low-lying land areas physically connected to a river channel, or capable of being connected, and the relative depth of these topographic depressions. The results can also be used to guide qualitative assessments of potential levee setback locations. Although the FIP method is not a substitute for detailed hydraulic modeling, it does provide an ability to relatively quickly understand flood characteristics across the floodplain landscape.

The FROA is focused on identifying potential restoration areas based on the ecological functions that could be provided by inundated or potentially inundated floodplains. Initially, the Ecosystem Functions Model (HEC-EFM), developed by the USACE-HEC, was considered as a potential tool for identifying the ecological functions provided by inundated and potentially inundated floodplains. HEC-EFM allows criteria (e.g., timing and duration of inundation) to be defined for eco-hydrologic relationships. By applying these criteria to stage and flow hydrographs produced by the HEC's River Analysis System (HEC-RAS), HEC-EFM identifies specific stages and flows providing specific ecological functions to be identified and visualized.

Consequently, a second pilot study, the HEC-EFM Pilot Study, was conducted along the lower Feather River to evaluate use of the HEC-EFM in the FROA. For this pilot study, criteria were developed for the relationship of cottonwood regeneration and salmonid rearing to flow conditions. These criteria were adapted from a previous application of HEC-EFM to support the Sacramento-San Joaquin Comprehensive Study (Comprehensive Study) (USACE and The Reclamation Board, 2002) and from criteria included as part of the Sacramento River Ecological Flows Tool (SacEFT) (ESSA Technologies, 2009). These functions were selected because of their relationship to lower stage floodplains and the limited extent of these habitat functions throughout the Sacramento and San Joaquin river systems.

The methods, results, and conclusions of this pilot study are provided in Appendix A. The study identified several limitations of HEC-EFM for use in the FROA:

- Constraints on the realism of habitat evaluations: (1) use of a single set of criteria as opposed to a range that distinguishes optimal from suboptimal conditions, (2) lack of coupling of relationships (e.g., cottonwood seedling recruitment depends on suitable conditions for germination in spring followed by minimal inundation during the winter), and (3) the potential for varied relationships between ecological functions and hydrologic conditions among the Sacramento and San Joaquin rivers and their tributaries.

- Lack of functional distinctions among evaluated areas: potential habitat for the ecological functions selected was largely absent, resulting in similar habitat attributes; similar results could occur throughout the Sacramento and San Joaquin river systems,

- Cost of application: the time required to apply the HEC-EFM model would limit analysis to selected reaches of the Sacramento and San Joaquin river system.

Consequently, a more generalized approach was developed for identifying floodplain areas where inundation could provide desired ecological functions: four types of flows were used in conjunction with the FIP method to distinguish floodplain areas that could be physically suitable for providing different types or amounts of multiple ecological functions. This approach is described in the following section.

2.2 Floodplain Restoration Opportunity Analysis Approach

As diagrammed in Figure 2-1, the FROA approach consists of three steps:

- Identify Areas of Physical Suitability.
- Identify Opportunities and Constraints.
- Identify Potential Restoration Opportunities.

The methodology of each of these steps is described in the following sections.

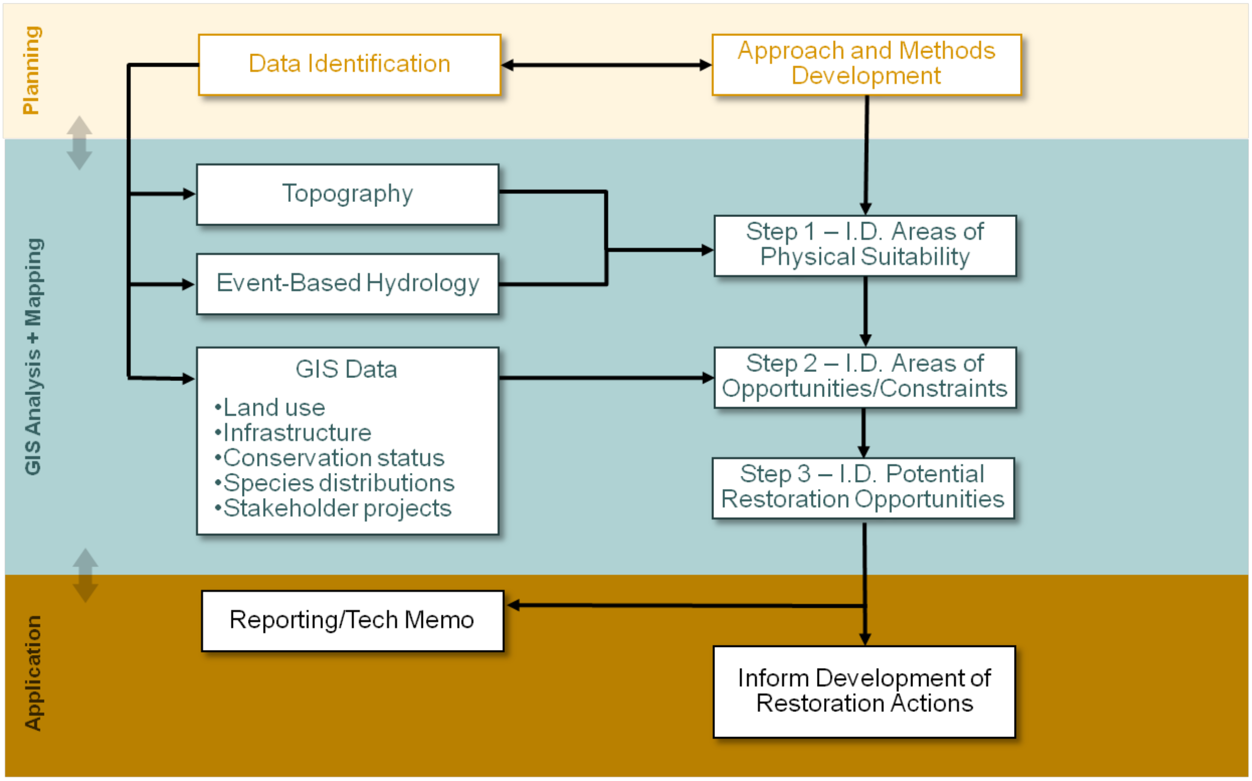

Figure 2-1. FROA Approach

2.2.1 Step 1: Identify Areas of Physical Suitability

To evaluate physical suitability for restoration actions, the FIP method was applied in a GIS analysis of corridors along the Sacramento and San Joaquin rivers and their major tributaries. This analysis was selected because of the importance of floodplain inundation for ecosystem functions, and because, at this planning level of investigation, the FIP method provided a relatively rapid approach for assessing floodplain inundation, as compared to the alternative use of more detailed hydraulic modeling. Furthermore, the pilot project application of the FIP method on the Feather River indicated its feasibility for application to the larger Sacramento and San Joaquin river systems.

The FIP analysis provides a spatial representation of floodplain inundation areas, and depths, relative to a varying water-surface profile. The FIP analysis "projects" a designated water-surface profile laterally from a stream centerline through levees or other obstructions out to a predetermined distance from a river centerline to provide an estimate of floodplain extent and depths if these obstructions were not present. It is acknowledged, however, that the actual water surface resulting from the removal of a levee or other obstruction would differ from that presented in the FIP analysis, but at this planning level the representation of potential floodplain inundation provided by the FIP analysis was deemed acceptable. The analysis was based on the results and conclusions of the pilot projects (Appendix A). It adapted concepts from the USACE HEC-EFM (USACE-HEC, 2009), the Frequently Activated Floodplain concept of Williams et al. (2009), and the HAR GIS tool of Dilts et al. (2010).

Several flows and associated water-surface profiles were evaluated using the FIP analysis, including:

- Water-surface profiles at the time of the CVFED (Central Valley Floodplain Evaluation and Delineation) Light Detection and Ranging (LiDAR) flights in March 2008 representing a low-water baseflow condition; termed the “Baseflow” FIP (most months have greater discharges and higher water surface elevations than March 2008 (e.g., during 1945 – 2010, at Red Bluff, the Sacramento River had a discharge greater than March 2008 in 93 percent of months)). Areas with Baseflow FIP would provide aquatic (riverine or lacustrine) habitats if hydrologically connected to a river.

- Seasonal flows and water-surface profiles derived using HEC-EFM representing a spring flow sustained for at least 7 days and occurring in 2 out of 3 years; termed the “67 percent chance Sustained Spring” FIP. Floodplains experiencing such sustained spring inundation would provide a variety of ecological functions, and greater aquatic foodweb productivity and fish utilization benefits than other floodplains (Williams et al. 2009).

- Peak flows and water-surface profiles associated with the 50 percent chance recurrence intervals; termed “50 percent chance” FIP. Floodplains inundated by these relatively frequent events would regularly sustain fluvial geomorphic processes (such as sediment scour and deposition) and provide inputs to the aquatic ecosystem (e.g., organic matter, including large woody material), among other functions, even where not experiencing sustained spring inundation.

- Peak flows and water-surface profiles associated with the 10 percent chance recurrence interval; termed the “10 percent chance” FIP. Floodplains inundated by these less-frequent events but not by 50 percent chance events would provide ecological functions similar to those inundated by more frequent events, but less frequently.

The analysis of FIP within the Systemwide Planning Area along the Sacramento and San Joaquin rivers and their major tributaries required topographic and hydraulic data. These data and the specific methods of the FIP analysis are described in the following sections.

Topographic Data

Accurate topographic data were required to evaluate FIP for these areas. AECOM completed an evaluation of readily available U.S. Geological Survey (USGS) 10-meter digital elevation models (DEM), and found that the data were not sufficiently detailed for this purpose.

The CVFED program recently mapped topography throughout the Central Valley, using LiDAR. AECOM received the raw LiDAR data files from the CVFED program in the fall of 2010. However, the raw data files were not usable for the Step 3 analysis, and creation of suitable files from the raw data (i.e., a digital terrain model) would duplicate work being completed by CVFED, which is not feasible from a cost or time standpoint.

As a solution to the lack of suitable topographic data, third-party software, Global Mapper, was used with the raw CVFED LiDAR data to create unprocessed digital terrain models. AECOM completed a test conversion of these digital terrain models to ArcGIS format, and found that the resultant topographic surface was usable for the FIP analysis, with minor modification and post-processing.

Hydraulic Data

For the various FIP analyses described above, hydraulic data were required to obtain water-surface profiles, with the exception of the Baseflow FIP analysis, which simply relied upon the water surfaces at the time of the CVFED LiDAR flight.

Hydraulic data for the 67 percent chance Sustained Spring FIP analysis were obtained from an analysis similar to the Feather River HEC-EFM/HEC-RAS pilot study; with a few differences that are noted and in Appendix A. Similar to the pilot study, HEC-EFM was used to query synthetic flow records for the Sacramento and San Joaquin river basins based on an ecosystem function relationship (EFR). The EFR included user-defined criteria such as a season, duration, and frequency. However, while the pilot study involved a HEC-EFM analysis of flow and stage time series produced by unsteady HEC-RAS modeling, findings from the study indicated this was not necessary and the remainder of the FROA effort simply used CalSim-derived synthetic flows that were queried directly by HEC-EFM. Comprehensive Study and Common Features HEC-RAS models were then used in a steady-flow analysis to model the flows identified by HEC-EFM, and the FIP tool was used to map the HEC-RAS water surface elevations (i.e., stages) at model cross-section locations. Major differences between the large-scale HEC-EFM/HEC-RAS analyses and the pilot-study analysis included:

1. Flow Estimation – CalSim-derived synthetic flows were queried directly by HEC-EFM after converting the Excel-based time series flow data to USACE-HEC's Data Storage System (HEC-DSS) format. The flow values were derived from CalSim simulations to capture the flow impacts of recent regulations and projects that are not reflected in the historical record. Daily values were developed from the monthly CalSim values using a pattern matching algorithm based on historical daily flow records. For the pilot study, the flows were used as boundary conditions to an unsteady-flow HEC-RAS model developed by AECOM from the Comprehensive Study and Common Features models, and the flows and stage time series produced by unsteady HEC-RAS were queried using HEC-EFM. It was initially believed that using HEC-RAS would improve the estimate of flows and would also provide useful stage data. Following the pilot study however, it was agreed that this step was unnecessary and potentially misleading, as it could be perceived that using HEC-RAS unsteady flow provided an improvement in the estimate of flow rates. Because of the nature of the CalSim-derived flows, it was agreed that HEC-RAS would not provide any improvement in the estimate of flows (primarily because the flows were originally based on a monthly time step). In addition, the hydrographs produced by unsteady HEC-RAS for areas with strong backwater influence produced significant hysteresis (see HEC-EFM), resulting in large run-times for HEC-EFM and major errors in the resulting HEC-EFM rating curves. Lastly, because the EFR used in the final analysis did not require stage data, the CalSim-derived flows alone were sufficient for completing the HEC-EFM analysis. The consensus decision by the project team was that this approach provided reasonable results consistent with the level of detail provided by the CalSim-derived flows.

2. HEC-RAS Modeling – The Sacramento and San Joaquin river basins were modeled in HEC-RAS as a single basin-wide model (as opposed to subdividing the models into individual rivers). The flow rates selected by HEC-EFM were applied at the nearest river station and a steady-flow analysis was performed. The main purpose of modeling the entire basin as a single model was to provide consistent water surfaces at tributary confluences. A secondary benefit was that the Comprehensive Study and Common Features models were originally developed as basin-wide models and this reduced the level of effort required to subdivide the models. In addition, since the HEC-EFM analysis was performed using the CalSim-derived flows directly, individual Habitat Analysis Areas (HAA) were not needed (see Section 2.3.1 for an explanation of HAAs). Additional details regarding the HEC-RAS modeling include the following:

a. Flow regimes were developed in HEC-EFM for each CalSim-derived node and for those hydrographs developed for tributaries not included in the CalSim-derived flow hydrographs. For the San Joaquin River, flow regimes were based on the restoration flows required by the San Joaquin River Restoration Settlement (as described in Reclamation, 2011). These flow regimes were developed by editing the HEC-EFM data file directly with a text-editor, as opposed to entering them individually in HEC-EFM. Also note that the stage data “required” by HEC-EFM is not necessary if stage results are not desired; thus, the flow hydrograph was used for both the flow and stage data source.

b. Where CalSim-derived flows were unavailable (e.g., Bear River, Yuba River, and Fresno Slough) flow hydrographs were developed by taking the difference between the upstream and downstream CalSim-derived hydrographs. This approach was used in the Lower Feather River Pilot Study and considered to be a reasonable estimate of the tributary flows. At confluences farther upstream on these tributaries (e.g., Union Pacific Interceptor Canal (UPIC), Dry Creek and Bear Creek (upstream from UPIC/Dry Creek)), the same approach could not be used and flows were not available; therefore, these areas were not mapped. For other areas where flows were unavailable, such as flood control bypasses and diversions and sloughs within the northern Sacramento-San Joaquin Delta (Delta), these areas were removed from the HEC-RAS models and not mapped.

c. The vertical datum of each model was not revised and was left in National Geodetic Vertical Datum of 1929 (NGVD 29). The stages output from the GIS extension to the HEC’s River Analysis System (HEC-GeoRAS) and used during the FIP were adjusted to North American Vertical Datum 1988 (NAVD 88) using the same approach as was used for the conversion of the 50 percent and 10 percent chance stages.

d. The Sacramento and San Joaquin models were converted to HEC-RAS 4.1.0 to simplify the export of results to HEC-GeoRAS and ArcGIS.

e. The Sacramento River upstream from River Mile (RM) 143.24 was taken from the Sacramento Comprehensive Study model and added to the Sacramento River basin-wide Common Features model. The Common Features model did not include the Sacramento River upstream from RM 143.24. The Comprehensive Study river stations were revised to match the Common Features model by subtracting 0.8812 mile.

f. The Mean Tidal Level (MTL) at the Port Chicago tide gage was used for a constant downstream stage boundary condition for the Sacramento and San Joaquin rivers. This approach was discussed by the project team and considered reasonable. Tidal data were obtained from the National Oceanic and Atmospheric Administration (NOAA) Center for Operational Oceanographic Products and Services (NOAA, 2011). The gage's MTL datum and NAVD datum values and the NGVD-to-NAVD conversion factor were applied, as follows:

   MTL(NGVD) = (MTL – NAVD) – (NAVD NGVD Conversion Factor)

   MTL(NGVD) = (6.56 – 2.89) – (2.613205)

   MTL(NGVD) = 1.0558 feet

g. The existing HEC-RAS model cross sections were not updated because the official DWR review of the new CVFED Task Order 20 LiDAR-derived DEMs was not complete at the time of this work.

h. Additional consideration was given to whether alternative analyses of sustained spring flows should be performed using either a higher/lower frequency, extended duration, or different season. It was agreed that the 67 percent chance relationship used for this study was the best suited to identifying potential habitat areas and was consistent with past work by others.

Hydraulic data (flows and stages) for the 50 percent chance and 10 percent chance recurrence interval FIP analyses were derived directly from the Comprehensive Study UNET models. Each pair of flow and stage values represents a discrete reach within the Sacramento and San Joaquin river systems.

An important point to clarify is the difference between the 50 percent chance and 10 percent chance recurrence interval FIP analyses versus the 67 percent chance Sustained Spring FIP analysis. The 50 percent chance and 10 percent chance water-surface profile elevations (stages) used for the FIP analysis correspond to peak flow conditions derived from a statistical flood frequency analysis of a series of maximum annual flows. The stages developed for the 67 percent chance Sustained Spring FIP analysis, while corresponding to a 67 percent chance frequency, are limited to those events that occur between March 15 and May 15 and for no less than 7 days. As a result, the 67 percent chance Sustained Spring events are significantly smaller flow events than the 50 percent chance and 10 percent chance events and may correspond to non-storm conditions. For example, 67 percent chance Sustained Spring FIP on the lower American River and Sacramento River downstream from the American River correspond to flows of approximately 2,900 to 3,100 cubic feet per second (cfs) and 21,000 cfs, respectively, which are less than mean monthly winter flows. The 67 percent chance Sustained Spring FIP analysis primarily identifies potential habitat during spring (e.g., salmonid rearing habitat), while the 50 percent chance and 10 percent chance provides information about more general inundated floodplain habitat attributes.

FIP Analysis

The FIP analysis methodology established during the Feather River pilot study was applied to the remainder of the Sacramento and San Joaquin river systems. All aspects of this approach remained the same except that the CVFED pre-processed LiDAR and breakline data, which were used in the pilot study, were not available for the remainder of the Systemwide Planning Area study area. Therefore, the analysis used the unprocessed digital terrain models developed with the Global Mapper software.

Based on the results of this analysis, in combination with the data regarding opportunities and constraints described in Section 2.4.2 below, reaches were identified with greater and/or more extensive potential opportunities for restoration, as described below in Section 2.4.3.

2.2.2 Step 2: Identify Opportunities and Constraints

The identification of other opportunities and constraints besides physical suitability relied on readily available geospatial data layers, except for information on the location of existing interest in restoration, which was compiled from stakeholders for this analysis.

As part of the CVFPP planning process, existing datasets potentially of use in development of the CVFPP and related documents and appendices were reviewed (AECOM, 2010a). The intent of this review was to document those readily available and public-domain geospatial datasets that would be used for the CVFPP, subject to a defined set of selection rules. Included among these rules were the following:

- Data had to be freely available on the Internet or available from a CVFPP participant (i.e., DWR, MWH, or AECOM).
- Data had to cover the entirety of the study area, or as much of the area as possible.

- Where a choice between data currency and data detail (i.e., spatial resolution) was available, more current data were preferred over more detailed data unless it was felt that enhanced data resolution (either spatial or attribute) was essential.

Data collected to help identify areas with opportunities and/or constraints, subject to these rules, are described below.

- **Agricultural and Natural Land Use/Land Cover –** Land use/land cover data were compiled for Important Farmland (as defined by DOC, 2011) from the California Department of Conservation's Farmland Mapping and Monitoring Program (DOC, 2008) and wetlands and riparian vegetation (DWR, 2012).

- **Urban Areas –** These data were developed by DWR (2010a) using data provided by the California Department of Conservation's Farmland Mapping and Monitoring Program.

- **Major Infrastructure –** Major infrastructure consisted of data showing the locations of major roads and highways (U.S. Census Bureau, 2007), railways (Caltrans, 2009), and levees and levee condition (developed by DWR during the CVFPP planning process, and under development by DWR's Urban and Non-Urban Levee Evaluation projects).

- **Terrestrial Sensitive Species Occurrences –** Occurrences of terrestrial sensitive species, meaning species considered to be threatened, endangered, rare, fully protected, or species with similar status that are tracked by the California Department of Fish and Game (DFG) in the California Natural Diversity Database (CNDDB). The January 2011 version of the database (DFG, 2011) was used for this analysis.

- **Salmonid Spawning Reaches –** Reaches of rivers known to support spawning of fall-late-fall-run, winter-run, and spring-run Chinook salmon (*Oncorhynchus tshawytscha*), as well as Central Valley steelhead (*Oncorhynchus mykiss)*, were mapped from the CalFish abundance database (DFG, 2005).

- **Conservation Status –** Locations of preserved and protected habitat were based on the California protected areas database (GreenInfo Network, 2010).

Because of the nature of these data and known data gaps, limitations, or inaccuracies, these data were not considered to conclusively indicate areas that would be more suitable for ecological restoration relative to other areas. For example, the CNDDB only records positive sightings of species based on field surveys. It does not document the actual distribution of species, because additional populations of species tracked by CNDDB may be found in areas that have not been surveyed. This does not indicate that these data have no value in identifying potential ecosystem restoration opportunities, but it does underscore the inherent limitations of these data for use in evaluations of potential ecosystem restoration sites, particularly without considering the physical suitability of potential sites and other applicable data.

In addition to these selected geospatial datasets, information on existing interest in restoring particular areas was compiled from stakeholders. Focused outreach was conducted throughout the study area to document potential ecosystem restoration projects previously identified by various CVFPP stakeholders. Meetings were held with the stakeholder groups listed below.

- The Nature Conservancy (Northern Central Valley, California Water Program, San Joaquin Valley Project)
- American Rivers
- DWR Northern Regional Office
- DWR South Central Regional Office
- River Partners
- San Joaquin River Conservancy
- DFG (Central Region)
- U.S. Department of the Interior, Bureau of Reclamation (SJRRP)
- San Joaquin River Parkway and Conservation Trust
- Natural Resources Defense Council
- NewFields River Basin Services, LLC
- ESA PWA, Inc.

Owing to time constraints, not all potential ecosystem restoration stakeholders in the study area were interviewed.

Each interview consisted of a facilitated discussion, lead by DWR staff, to solicit stakeholder input on previously identified ecosystem restoration projects. Specific information provided by stakeholders regarding their planned projects has been treated as confidential. For each identified project, stakeholders were asked to provide the following information:

- Location of the potential project site, along with geospatial data depicting the project footprint, if available
- Project purpose, including ecosystem functions targeted for restoration
- Specific restoration activities proposed for the project, including a formal restoration plan, if available
- Current biological and physical conditions on the site, including an existing conditions report, if available
- Name and contact information for the project proponent
- Funding sources for the project
- Sources of the information described above

In addition to stakeholder interviews, existing reports that identified potential ecosystem restoration opportunities were also reviewed. These included the Sutter Basin Feasibility Study (USACE, 2010) and the Final Database of Potential Multi-Objective Flood Damage Reduction Actions (CBDA, 2004). Projects located within the study area and that would provide ecosystem benefits were included with the group of stakeholder-identified projects.

As previously described, these areas will be considered as potential restoration opportunities in the identification of reaches to be analyzed in more detail.

2.2.3 Step 3: Evaluate Potential for Restoration

The potential for restoration was determined by evaluating relationships among physically suitable areas and the locations of opportunities and constraints. This evaluation was based on the review and combination of geospatial data layers with ESRI’s ArcGIS software. Through it, reaches with greater and/or more extensive potential opportunities for restoration were identified.

The Sacramento and San Joaquin river systems were subdivided into 29 reaches. Boundaries between reaches were located at discontinuities in river or floodplain morphology, and/or to major junctions with tributaries, bypasses, or canals. In the upper Sacramento and San Joaquin river basins, reaches correspond to those established by the Sacramento River Conservation Area Forum and the SJRRP, respectively.

For each reach, four combinations of physically suitable conditions and suitable land use/land cover representing different restoration opportunities were mapped and their acreages tabulated:

- Nonurban floodplain with 67 percent chance Sustained Spring Flow or 50 percent chance FIP hydrologically connected to the river with riparian vegetation
- Nonurban floodplain with 67 percent chance Sustained Spring Flow or 50 percent chance FIP hydrologically connected to the river without riparian vegetation
- Nonurban floodplain with 67 percent chance Sustained Spring Flow FIP hydrologically disconnected from the river
- Nonurban floodplain with 50 percent chance FIP hydrologically disconnected from the river

Additional information regarding the location and extent of opportunities and constraints was also compiled for each reach.

3.0 Results of Floodplain Restoration Opportunities Analysis

For river reaches and bypasses included in the FROA, results are summarized in narrative descriptions, tables, and maps. FROA includes the Sacramento River from Woodson Bridge State Recreation Area to Collinsville, the San Joaquin River from Friant Dam to Stockton, the lower Feather River, and the lowermost reaches of other major tributaries of the Sacramento and San Joaquin rivers (i.e., the Bear, Yuba, American, Stanislaus, Tuolumne, and Merced rivers). It does not include smaller tributaries. The Sutter and Yolo bypasses are also included.

Narrative descriptions of reaches are provided in Sections 3.1 through 3.5. Maps and tables are provided in Section 3.6. Maps and tables are provided in a separate section to facilitate ease of use, particularly for comparisons of multiple maps.

In the reach descriptions, information is provided for the approximately 2-mile-wide corridors modeled along each river (with the exception of the Yolo Bypass where a 14,000-foot-wide corridor was modeled to account for levees that are set more than 2 miles apart). This information includes physical conditions (FIP and hydrologic connectivity), land use/land cover, infrastructure, conservation status, and occurrences of sensitive species.

Information in the narrative descriptions was primarily derived from the data sources displayed on the maps in this chapter, and previously described in Section 2.4. In addition, some supporting information from the following sources was also incorporated:

- Status and Trends of the Riparian and Riverine Ecosystems of the Systemwide Planning Area (DWR, 2011);
- State Plan of Flood Control Descriptive Document (DWR, 2010b);
- California Natural Diversity Database (DFG, 2011);

- Sacramento River Conservation Area Forum Handbook (Sacramento River Conservation Area Forum, 2003); and
- Draft Program Environmental Impact Statement/Environmental Impact Report San Joaquin River Restoration Program (Reclamation, 2011).

Several terms are used repeatedly in describing the reaches. “Corridor” refers to the extent of the modeled area, which generally extends approximately 1 mile from the river’s centerline. “Connected” and “disconnected” refer to hydrologic connection to the river during a 50 percent chance event (i.e., connected areas would be inundated during a 50 percent chance event). Also, throughout this text, 67 percent chance Sustained Spring FIP refers to a floodplain area 1 foot or more above the water surface of a 67 percent chance spring flow sustained for at least 7 days, but at a lower elevation than the 50 percent chance water surface. Similarly, 50 percent chance FIP refers to floodplain areas 1 foot or more above the 50 percent chance water surface and below the water surface of the 10 percent chance flow. As described in Appendix A, Section 2.9, the process used to estimate water surface elevations resulted in elevations that varied within 1 foot of true elevations. Figure 3-1 illustrates the relationship between these different water surfaces and the elevation zones corresponding to areas with a different FIP.

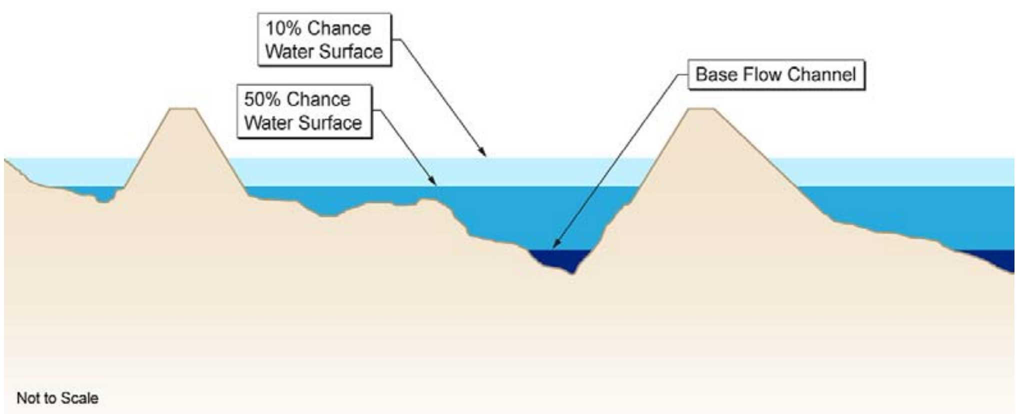

Figure 3-1. Hypothetical Cross Section with Boundary Water Surfaces of FIP Categories

3.1 Sacramento River Reach Descriptions

3.1.1 Woodson Bridge State Recreation Area to Chico Landing

From Woodson Bridge State Recreation Area (SRA) to Chico Landing, the Sacramento River actively meanders through the valley floor along much of this reach. (The majority of the banks along this reach are natural (i.e., without revetment) (DWR, 2011).) The active channel is fairly wide in some stretches and the river splits into multiple forks at many different locations, creating gravel islands, often with riparian vegetation. Historic bends in the river are visible throughout this reach and are remainders of historical channel locations with the riparian corridor and oxbow lakes still present in many locations.

In this reach, the corridor along the river is relatively evenly distributed among areas with 50 percent chance, 10 percent chance, and greater than 10 percent chance FIP. Most areas with 50 percent chance FIP are connected to the river. Only a small percentage of the floodplain has Below Baseflow FIP, and there are almost no areas with 67 percent chance Sustained Spring FIP.

Nearly 25 percent of the corridor along this reach of the Sacramento River has been conserved. Conserved areas include portions of the Sacramento River National Wildlife Refuge, Sacramento River Wildlife Area, Butte Sink Wildlife Management Area, and Bidwell-Sacramento River State Park; the Woodson Bridge SRA; Merrill's Landing Wildlife Area; Westermann, Brattan, Kaplan, and Verschagin preserves; and Bureau of Land Management-managed land.

Natural vegetation covers one-third of the corridor along this reach, and riparian/wetland vegetation approximately an eighth of the corridor. Riparian and wetland-associated sensitive species documented along this reach include Sacramento anthicid beetle (*Anthicus sacramento*), Valley elderberry longhorn beetle (VELB) (*Desmocerus californicus dimorphus*), Swainson's hawk (*Buteo swainsoni*), colonies of bank swallow (*Riparia riparia*), yellow-billed cuckoo (*Coccyzus americanus*), western red bat (*Lasiurus blossevilli*), and western mastiff bat (*Eumops perotis*). This reach also provides habitat for several sensitive fish: foraging adult green sturgeon (*Acipenser medirostris*); migrating, holding, and rearing steelhead and winter- and fall-/late-fall-run Chinook salmon; and migrating and rearing spring-run Chinook salmon.

Developed land uses occupy only a very small portion of the corridor along this reach (less than 2 percent), primarily in the vicinity of Hamilton City.

Other than levees, there is very little major infrastructure along this reach of the Sacramento River except between RM 196 and 197, where State Route (SR) 32, a natural gas pipeline, and an electrical transmission line cross the river.

Along this reach, several nonproject levees (i.e., levees that are not part of the SPFC) protect portions of both banks. This reach does not have project levees.

Stakeholders identified potential restoration opportunities along this reach of the Sacramento River.

3.1.2 Chico Landing to Colusa

From Chico Landing to Colusa, the Sacramento River actively meanders through the valley floor, actively eroding banks, producing oxbows and meander scrolls on the floodplain along much of this reach. (The majority of the banks along this reach are natural (i.e., without revetment) (DWR, 2011).) In this reach, it also historically overflowed into floodbasins. Currently, during flood flows, water from the Sacramento River enters the Butte Basin at the 3Bs natural overflow, the M&T and Goose Lake flood relief structures, and at Moulton and Colusa weirs.

In this reach, more than two-thirds of the corridor along the river has 50 percent chance FIP, and more than half of this area is connected to the river. Only a very small area has 67 percent chance Sustained Spring FIP.

Natural vegetation covers more than one-third of the corridor along this reach, and riparian/wetland vegetation approximately an eighth of the corridor. Riparian and wetland-associated sensitive species documented along this reach include woolly rose-mallow (*Hibiscus lasiocarpus* var. *occidentalis*), several beetles (Antioch Dunes anthicid beetle (*Anthicus antiochensis*), Sacramento anthicid beetle, Sacramento Valley tiger beetle (*Cicindela hirticollis abrupta*), VELB), giant garter snake (*Thamniopsis gigas*), colonies of bank swallow, Swainson's hawk, colonies of tricolored blackbirds (*Agelaius tricolor*), yellow-billed cuckoo, western mastiff bat, and western red bat. This reach also provides habitat for several sensitive fish including foraging adult green sturgeon; migrating, holding, and rearing steelhead and winter- and fall-/late-fall-run Chinook salmon; and migrating and rearing spring-run Chinook salmon.

Nearly 15 percent of the corridor along this reach of the Sacramento River has been conserved. Conserved areas along this reach include portions of the Sacramento River National Wildlife Refuge, Bidwell-Sacramento River State Park, Sacramento River Wildlife Area, and Butte Sink Wildlife

Management Area; the Colusa Bypass Wildlife Area; and the Hartley Island, Jensen, and Cannell preserves.

Developed land uses occupy only a small portion of the corridor along this reach (only about 1 percent), primarily at Colusa. Other than levees, there is little major infrastructure along this reach of the Sacramento River. Natural gas pipelines cross near RMs 184, 174, and 162. SR 162 crosses the river near RM 166, and natural gas pipelines and electrical transmission lines are along the river corridor at several hundred to several thousand feet from the river.

At Ord Ferry on the west bank and 7.5 miles downstream from Ord Ferry on the east bank, SPFC levees border the river downstream along this reach, but are often as far as 1 mile apart. The physical condition of these levees is of medium concern, except for a 10- to 12-mile-long stretch upstream from Colusa where levee physical condition is of higher concern. Upstream from these SPFC levees are several nonproject levees on portions of the reach.

Stakeholders identified potential restoration opportunities along this reach of the Sacramento River.

3.1.3 Colusa to Verona

The general character of the Sacramento River changes downstream from Colusa from a dynamic and active meandering channel to a confined, narrow channel generally restricted from migration along the majority of its length. (DWR, 2011). While levees exist along portions of the river upstream from Colusa, levees are located much closer to the river edge as the river continues south to the Delta. The channel width is fairly uniform and river bends are static as a result of confinement by levees.

From Colusa to Verona, more than half of the corridor along the river has 50 percent chance FIP, but only a small portion of this area remains connected to the river. There also are large areas with Below Base Flow FIP. Most of these areas represent historical floodbasins that are disconnected from the river. Along this reach, about 10 percent of evaluated floodplain has a 67 percent chance Sustained Spring FIP, almost all of which is disconnected from the river.

Natural vegetation covers approximately one-eighth of the corridor along this reach, and riparian/wetland vegetation covers about 3 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include woolly rose-mallow, Sacramento tiger beetle, VELB, giant garter snake, colonies of bank swallows, Swainson’s hawk, colonies of tricolored blackbirds, yellow-billed cuckoo, and western red bat. This reach also provides habitat for several sensitive fish, including Sacramento splittail (*pogonichthys macrolepidotus*), foraging adult green sturgeon; migrating, holding, and rearing steelhead and winter- and fall-/late-fall-run Chinook salmon; and migrating and rearing spring-run Chinook salmon.

Along this reach of the Sacramento River, very little of the land has been conserved (about 1 percent of the corridor). Conserved areas along this reach of the Sacramento River include the Rohleder Preserve, Collins Eddy Wildlife Area, and the Fremont Weir Wildlife Area.

Developed land uses occupy only a small portion of the corridor along this reach (only about 2 percent), primarily in the vicinity of Colusa. However, there is more major infrastructure along this reach of the Sacramento River than along upstream reaches. The Colusa Highway crosses the river between RMs 134 and 133, and SR 113 crosses near RM 90. Natural gas pipelines cross the river near RMs 140, 127, 126; and electrical transmission lines cross the river near RMs 134, 121, 92, 86, and 80. Also, major roads, natural gas pipelines, and electrical transmission lines are located within 1 mile of the river at a number of locations.

There are SPFC levees along both river banks in this reach. The physical condition of these levees is of higher concern, except for several miles of levee east of the river downstream from Colusa.

Stakeholders identified potential restoration opportunities along this reach of the Sacramento River.

3.1.4 Verona to American River

From Verona to the American River, about two-thirds of the corridor along the river has 50 percent chance FIP and about a quarter has 67 percent chance Sustained Spring FIP. Almost all of this floodplain is disconnected from the river.

Natural vegetation covers more than 20 percent of the corridor along this reach, but riparian/wetland vegetation only covers about 3 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include woolly rose-mallow, VELB, giant garter snake, western pond turtle, rookeries of wading birds, colonies of tricolored blackbird, and Swainson’s hawk. This reach also provides habitat for several sensitive fish, including Sacramento splittail, foraging adult green sturgeon; migrating, holding, and rearing steelhead and winter- and fall-/late-fall-run Chinook salmon; and migrating and rearing spring-run Chinook salmon.

Less than 10 percent of the corridor along this reach of the Sacramento River has been conserved. Conserved areas along this reach include Elkhorn Regional County Park, Sacramento Bypass Wildlife Area, several Natomas Basin Conservancy reserves, and Discovery Park at the downstream end of the American River Parkway.

Developed land uses only occupy about 15 percent of the corridor along this reach. However, at the southern end of this reach, where the river enters Sacramento and West Sacramento, developed land uses occupy most of the 2-mile-wide corridor. Along this reach of the Sacramento River, Interstate (I)-5 crosses the river near RM 71 and crosses the American River at its junction with the Sacramento, and I-80 crosses the river near RM 63. Natural gas pipelines cross near RMs 67 and 64, and an electrical transmission line crosses near RM 63. In addition to major infrastructure facilities crossing the river, the Sacramento International Airport is within 2 miles of this reach of the river, and consequently is an important constraint on the restoration of habitat.

There are SPFC levees along both banks. The physical condition of these levees varies from lower concern where sections of the Natomas levees have recently been improved and medium concern for approximately 3.5 miles of the west levee south of the I-5 crossing, to higher concern elsewhere.

Stakeholders identified potential restoration opportunities along this reach of the Sacramento River.

3.1.5 American River to Freeport

From the American River to Freeport, about 20 percent of the corridor along the river has Below Baseflow FIP, nearly 30 percent has 67 percent chance Sustained Spring FIP, and more than 40 percent has 50 percent chance FIP. This FIP distribution reflects the varied landforms along this reach that include historical floodbasins and natural levees along the river channel. Almost all of this floodplain is disconnected from the river. In this tidally influenced reach, the Sacramento River enters the legal Delta.

Natural vegetation covers nearly 20 percent of the corridor along this reach, but riparian/wetland vegetation only covers about 1 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include Sanford’s arrowhead (*Sagittaria sanfordii*), VELB, and Swainson’s hawk. This reach also provides habitat for several sensitive fish, including Sacramento splittail, foraging adult green sturgeon; migrating, holding, and rearing steelhead and winter- and fall-/late-fall-run Chinook salmon; and migrating and rearing spring-run Chinook salmon;

and this reach contains delta smelt (*Hypomesus transpacificus*)-designated critical habitat.

Along this reach of the Sacramento River, only a small amount of land has been conserved (less than 5 percent of the corridor). Conserved areas along this reach are limited to smaller city and county parks and several other public-owned parcels.

Developed land uses occupy nearly two-thirds of the floodplain along this reach. Because this reach of the Sacramento River passes through the city of Sacramento, the corridor along the river has a high density of infrastructure, particularly from RMs 60 to 57. In addition to multiple major road, pipeline, and transmission line crossings, there are a number of Cortese sites (which have hazardous materials issues) and refineries. In addition, Sacramento Executive Airport is within 2 miles of this reach of the river.

There are SPFC levees along both banks of the river. The physical condition of these levees is generally of higher concern, but the physical condition of several sections of the west levee is of lower concern.

Stakeholders identified potential restoration opportunities along this reach of the Sacramento River.

3.1.6 Freeport to Delta Cross Channel

From Freeport to the Delta Cross Channel, approximately 60 percent of the corridor along the river has a Below Baseflow FIP, and of the remainder, most has a 67 percent chance Sustained Spring FIP. This FIP distribution reflects both historical landforms, and historical and ongoing changes to landforms (e.g., subsidence of areas with drained, organic soils). Almost all of this floodplain is isolated from the river. This Delta reach of the Sacramento River is tidally influenced.

Natural vegetation covers nearly 20 percent of the corridor along this reach, and riparian/wetland vegetation covers about 3 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include woolly rose-mallow, Sanford’s arrowhead, several plants characteristic of sloughs and tidal marshes (e.g., Suisun Marsh aster (*Symphyotrichum lentum*), Delta tule pea (*Lathyrus jepsonii*), and Mason’s lilaeopsis (*Lilaeopsis masonii*)) VELB, giant garter snake, western pond turtle (*Emys marmorata*), wading bird rookeries, white-tailed kite (*Elanus leucurus*), and Swainson’s hawk, among others. This reach also provides habitat for several sensitive fish, including Sacramento splittail, delta smelt; foraging adult green sturgeon; migrating, holding, and rearing steelhead and winter- and fall-/late-fall-run Chinook salmon; and migrating and rearing spring-run Chinook salmon.

Less than 10 percent of the corridor along this reach of the Sacramento River has been conserved. Conserved lands include sanitation district and county open space land, Delta Meadows State Park, and a portion of Stone Lakes National Wildlife Refuge.

Along this reach, there are small areas of developed land uses at Cortland and near Walnut Grove, but developed land uses only occupy several percent of the corridor along this reach. Besides levees, there is little major infrastructure along this reach. SR 160 runs along the east bank of the river, and an electrical transmission line crosses the river between RMs 31 and 32.

SPFC levees are along both river banks. In the upstream half of this reach, the physical condition of the levees is generally of higher concern, but in the downstream half of this reach, their physical condition is generally of medium concern.

Stakeholders identified potential restoration opportunities along this reach of the Sacramento River.

3.1.7 Delta Cross Channel to Deep Water Ship Channel

From the Delta Cross Channel to the Deep Water Ship Channel, almost all of the corridor along the river has a Below Baseflow FIP, and is disconnected from the river. This floodplain consists of Delta islands bordered by sloughs, and that have been leveed and drained, and are in agricultural use. Consequently, the organic soils of these islands have been oxidizing and the land surface subsiding. There are only a few hundred acres along this reach with either 67 percent chance Sustained Spring FIP or 50 percent chance FIP, most of which is connected to the river. This Delta reach of the Sacramento River is tidally influenced.

Natural vegetation covers more than 10 percent of the corridor along this reach, but riparian/wetland vegetation only covers about 2 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include woolly rose-mallow, several plants characteristic of sloughs and tidal marshes, Sacramento anthicid beetle, VELB, western pond turtle, Swainson’s hawk, and western red bat. This reach also provides habitat for several sensitive fish: delta smelt; foraging adult green sturgeon; migrating, holding, and rearing steelhead and winter- and fall-/late-fall-run Chinook salmon; and migrating and rearing spring-run Chinook salmon.

Very little of the corridor along this reach of the Sacramento River has been conserved (less than 2 percent of the corridor). Conserved land along this reach is limited to a small area of state land near RM 15.

Along this reach there are small areas of developed land uses at Walnut Grove and Isleton, but developed land uses only account for several percent of the corridor along this reach. SR 160 runs along the river bank, and other major infrastructure includes an electrical transmission line that crosses the river near RM 17, and natural gas pipelines that cross the river near RMs 21, 20, and 15.

SPFC levees are along both river banks. The physical condition of the west levee is of medium concern; the physical condition of the west levee is of medium concern from the Delta Cross Channel to approximately RM 20, and of higher concern from near RM 20 to the junction with the Deep Water Ship Channel.

Stakeholders identified potential restoration opportunities along this reach of the Sacramento River.

3.1.8 Deep Water Ship Channel to Collinsville

From the Deep Water Ship Channel to Collinsville, the corridor along the river consists of Delta islands with a Below Base Flow FIP but disconnected from the river, and an area of uplands downstream from Rio Vista. There are only a few hundred acres along this reach with either 67 percent chance Sustained Spring FIP or 50 percent chance FIP, most of which is disconnected from the river. This Delta reach of the Sacramento River is strongly tidally influenced.

Natural vegetation covers more than two-thirds of the corridor along this reach, but riparian/wetland vegetation only covers about 1 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include woolly rose-mallow, several plants characteristic of sloughs and tidal marshes, Antioch Dunes and Sacramento anthicid beetles, VELB, giant garter snake, Swainson’s hawk, and western red bat. This reach also provides habitat for several sensitive fish, including delta smelt; foraging adult green sturgeon; migrating, holding, and rearing steelhead and winter- and fall-/late-fall-run Chinook salmon; and migrating and rearing spring-run Chinook salmon.

Approximately 5 percent of the corridor along this reach of the Sacramento River has been conserved. Conserved areas along this reach include Brannan Island SRA, Decker Island Wildlife Area, and Lower Sherman Island Wildlife Area.

A small portion of this reach has developed land uses at Rio Vista. In addition to levees, this reach has a high density of other major infrastructure. At Rio Vista, SR 12 crosses the river, as do two natural gas pipelines, and the Rio Vista Municipal Airport is within 1 mile of the river. Also, near the downstream end of this reach, from approximately RMs 7 to 4, nine natural gas pipelines and electrical transmission lines cross the river.

SPFC levees are on the east river bank for the entire length of the reach and on the west bank at RMs 13 to 14 (near Rio Vista). The physical condition of these levees is of higher concern.

Stakeholders did not identify potential restoration opportunities along this reach of the Sacramento River.

3.2 Sacramento River Tributary Reach Descriptions

The lowermost reaches of the Feather, Yuba, Bear, and American rivers were evaluated. These reaches begin approximately 1 mile upstream from the tributary's junction with the Sacramento River because the corridor along the Sacramento River extends 1 mile from the centerline of the Sacramento River.

3.2.1 Feather River – Thermalito Afterbay to Yuba River

Along the Feather River from Thermolito Afterbay to the Yuba River, the floodplain has almost no areas with 67 percent chance Sustained Spring FIP. Areas with 50 percent chance FIP, however, account for more than 40 percent of the corridor along the river, with the remainder evenly divided between 10 percent chance and greater than 10 percent chance FIP. More than two-thirds of areas with 50 percent chance FIP are connected to the river. A series of remnant gravel pit pools/ponds connect to the main channel in this reach. (Connected gravel pits can affect flows and water temperatures, disrupt sediment transport, and provide habitat for nonnative fish that compete with and prey on native species.)

Natural vegetation covers about one-quarter of the corridor along this reach, and riparian/wetland vegetation covers nearly 10 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include VELB, giant garter snake, colonies of bank swallows, western yellow-billed cuckoo, and Swainson's hawk. This reach also provides habitat for several sensitive fish species, including foraging adult green sturgeon; migrating, holding, spawning, and rearing fall-run

Chinook salmon; migrating, holding, and rearing steelhead; and migrating and rearing spring-run Chinook salmon.

More than 10 percent of the corridor along this reach of the Feather River has been conserved. Unlike most other reaches, the majority of conserved area is disconnected from the river. Conserved areas in this reach include the Oroville Wildlife Area and a portion of the Feather River Wildlife Area.

Less than 10 percent of the corridor along this reach has developed land uses, and most of this reach has only small amounts of developed land uses and major infrastructure: three gravel mines are near RMs 58 and 55 to 56, and a low, notched rock dam spans the river near RM 39. However, Yuba City and Marysville are at the downstream end of this reach, and along the river, developed land uses are extensive from about RM 31 to the end of the reach at RM 27. A number of pipelines, roads, and electrical transmission lines cross the river in this area. Also, there is a community airport at Yuba City within 1 mile of the river.

SPFC facilities in this reach include a levee throughout the reach on the west bank, the Sutter-Butte Canal Headgate, a levee extending downstream from Honcutt Creek on the east side of the river, and a ring levee around Marysville. The physical condition of these levees is of higher concern. There are also several nonproject levees.

Stakeholders identified potential restoration opportunities along this reach of the Feather River.

3.2.2 Feather River – Yuba River to Bear River

Between the Yuba and Bear rivers, most of the corridor along the Feather River has 50 percent chance FIP. More than two-thirds of these areas are disconnected from the river. Less than one percent of the corridor along this reach has 67 percent chance Sustained Spring FIP.

Natural vegetation covers nearly one-third of the corridor along this reach, and riparian/wetland vegetation covers approximately 10 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include VELB, giant garter snake, colonies of bank swallows, and Swainson’s hawk. This reach also provides habitat for several sensitive fish species, including foraging adult green sturgeon; migrating, holding, and rearing fall-run Chinook salmon; migrating, holding, and rearing steelhead; and migrating and rearing spring-run Chinook salmon.

Nearly 15 percent of the corridor along this reach of the Feather River has been conserved. A portion of the Feather River Wildlife Area is along this reach.

Developed land uses occupy about 10 percent of the corridor along this reach. The Yuba City and Marysville areas extend along the upstream end of this reach (RMs 24 to 27), and developed land uses are extensive in these areas, an electrical transmission line and a natural gas pipeline cross the river, and a power plant is adjacent to the river. Also, both the Yuba City and Yuba County airports are within 2 miles of the river. However, downstream from the Yuba City and Marysville areas, there is little developed land or major infrastructure except for an electrical transmission line that crosses the river near RM 23 and levees that extend along both banks.

SPFC levees are on both sides of the river and are spaced from about 0.5- to 1-mile apart. The physical condition of most of the west levee is of higher concern; the physical condition of the east bank levee is of lower concern.

Stakeholders identified potential restoration opportunities along this reach of the Feather River.

3.2.3 Feather River – Bear River to Sutter Bypass

From the Bear River to the Sutter Bypass, most of the corridor along the Feather River has 50 percent chance FIP. About two-thirds of these areas are disconnected from the river. Less than one percent of the corridor along this reach has 67 percent chance Sustained Spring FIP.

Natural vegetation covers nearly half of the corridor along this reach, and riparian/wetland vegetation covers approximately 10 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include Antioch Dunes and Sacramento anthicid beetles, VELB, giant garter snake, western pond turtle, colonies of bank swallows, western yellow-billed cuckoo, and Swainson’s hawk. This reach also provides habitat for several sensitive fish, including Sacramento splittail, foraging adult green sturgeon; migrating, holding, and rearing fall-run Chinook salmon; migrating, holding, and rearing steelhead; and migrating and rearing spring-run Chinook salmon.

Nearly 15 percent of the corridor along this reach of the Feather River has been conserved. A portion of the Feather River Wildlife Area is along this reach.

This reach has only a small amount of developed land (less than 2 percent of the corridor), primarily near Nicolaus (near RM 10). SR 99 crosses the river near RM 9, and electrical transmission lines cross the river near RMs 9 and 10.

SPFC levees are on both banks along this reach. The physical condition of these levees is of higher concern except for approximately 2 miles of the north levee (from RM 10 to the junction with the Sutter Bypass).

Stakeholders identified potential restoration opportunities along this reach of the Feather River.

3.2.4 Feather River – Sutter Bypass to Sacramento River

Similar to upstream reaches, from the Sutter Bypass to the Sacramento River, most of the corridor along the Feather River has 50 percent chance FIP. However, this reach has more areas with 67 percent chance Sustained Spring FIP than upstream reaches (12 percent versus 1 percent or less). Connectivity of these areas to the river is also greater along upstream reaches. In this reach, the Feather River has a relatively straight channel located along the eastern edge of the floodway.

Natural vegetation covers more than 20 percent of the corridor along this reach, but riparian/wetland vegetation only covers several percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include Sacramento Valley tiger beetle, giant garter snake, colonies of bank swallows and tricolored blackbirds, and Swainson’s hawk. Along this reach of the Feather River, there are no conserved areas. This reach also provides habitat for several sensitive fish, including Sacramento splittail, foraging adult green sturgeon; migrating, holding, and rearing fall-run Chinook salmon; migrating, holding, and rearing steelhead; and migrating and rearing spring-run Chinook salmon.

This reach has only a small amount of developed land (less than 2 percent of the corridor), and no major infrastructure crosses the river, although an electrical transmission line is located near the east riverbank, where the Garden Highway also is located adjacent to the levee.

SPFC levees are on both river banks along this reach. The physical condition of these levees is of higher concern.

Stakeholders did not identify potential restoration opportunities along this reach of the Feather River.

3.2.5 Yuba River

The lower reach of the Yuba River is a relatively narrow floodplain constrained by nearby terraces and other uplands. Consequently, more than half of the corridor along the river has a greater than 10 percent chance FIP. More than 10 percent of the floodplain corridor had 50 percent chance FIP, about half of which is connected to the river. Very little floodplain had 67 percent chance Sustained Spring FIP. South of the river, a portion of the Yuba Goldfields is within the corridor. This extensive disturbed area contains numerous small water features and patches of riparian vegetation.

Natural vegetation covers approximately 60 percent of the corridor along this reach, but riparian/wetland vegetation only covers about 2 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include VELB, western pond turtle, California black rail (*Laterallus jamaicensis coturniculus*), colonies of tricolored black birds, and Swainson's hawk. This reach also provides habitat for several sensitive fish, including migrating, holding, and rearing steelhead and fall-run Chinook; and migrating and rearing spring-run Chinook.

Approximately 7 percent of the corridor along this reach has been conserved. Conserved areas along this reach of the Yuba River are limited to several Bureau of Land Management-managed parcels (mostly upstream from RM 10) and City of Marysville open space approximately 1 mile upstream from the junction with the Feather River.

Developed land uses occupy less than 10 percent of the corridor along this reach. However, Marysville is at the downstream end of this reach where developed land uses are extensive. Upstream from Marysville, there is little developed land or major infrastructure. From about RM 8 to RM 10 there are two gravel mines and two electrical transmission lines that cross the river, and further upstream is Daguerre Point Dam.

SPFC levees are widely spaced on both sides of the river. There is also a nonproject levee around RMs 6 to 8. The physical condition of segments of these levees varies from lower to higher concern.

Stakeholders identified potential restoration opportunities along this reach of the Yuba River.

3.2.6 Bear River

Along the lowest reach of the Bear River, almost half of the corridor along the river had 67 percent chance Sustained Spring FIP or 50 percent chance FIP. Most of this area (85 percent or more) is disconnected from the river.

Natural vegetation covers nearly one-third of the corridor along this reach, and riparian/wetland vegetation covers several percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include VELB, giant garter snake, western pond turtle, and Swainson's hawk. This reach also provides habitat for migrating, holding, and rearing steelhead; and opportunistic/intermittent migrating, holding, spawning, and rearing for fall-run Chinook salmon.

Only a very small portion of the corridor along this reach of the Bear River has been conserved (approximately 1 percent of the corridor). Conserved areas along this reach are limited to several water district-owned parcels.

Developed land uses occupy less than 5 percent of the corridor along this reach, and are concentrated near Wheatland (near RMs 9 to 11). Major infrastructure includes river crossings by SRs 65 and 70 (near RMs 4 and 10, respectively), and crossings by electrical transmission lines and natural gas pipelines near those major road crossings.

There are SPFC levees on both banks for approximately the first 7 miles of this reach, and the south bank levee continues along Dry Creek. The physical condition of the north levee is of lower concern; the physical condition of the south levee is of higher concern.

Stakeholders did not identify potential restoration opportunities along this reach of the Bear River.

3.2.7 American River

Along the lowest reach of the American River, only about 1 percent of the corridor along the river has 67 percent chance Sustained Spring FIP, and only 14 percent has 50 percent chance FIP. Most of these areas are connected to the river.

Natural vegetation covers more than 20 percent of the corridor along this reach, and riparian/wetland vegetation covers about 8 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include Sanford's arrowhead, VELB, western pond turtle, wading bird rookeries, colonies of bank swallows, white-tailed kite, and Swainson's hawk. This reach also provides habitat for migrating, holding, and rearing steelhead; and migrating, holding, spawning, and rearing fall-run Chinook salmon.

More than 20 percent of the corridor along this reach of the American River has been conserved. This reach has the largest percentage of conserved area among reaches of the Sacramento and San Joaquin river systems. Conserved areas along this reach of the American River include the American River Parkway and associated county parks.

Because this reach passes through the Sacramento Metropolitan Area, developed land uses occupy more than three-quarters of the land along this reach. There also is a high density of major infrastructure along the river, particularly from RMs 0 to 9. Multiple major roads and railroads, natural gas pipelines, and electrical transmission lines cross the river.

SPFC levees are on both sides of the river for the first 10 miles of this reach and extend further along the north side. The physical condition of these levees is of lower concern, except for the section of the north levee between the river and the Natomas Basin, whose physical condition is of higher concern.

Stakeholders did not identify potential restoration opportunities along this reach of the American River.

3.3 Sutter and Yolo Bypass Descriptions

3.3.1 Sutter Bypass

The Sutter Bypass is a wide flood channel that carries floodwater diverted from the Sacramento River at several weirs north of the Sutter Buttes to the confluence of the Feather and Sacramento rivers, and then on to the Yolo Bypass. From the west, Butte Creek (Butte Slough) enters the bypass. It is inundated in most years by water diverted out of the Sacramento River.

The Sutter Bypass is used mainly for agriculture, and there are only small amounts of natural vegetation. Riparian and wetland-associated sensitive species documented along this reach include woolly rose-mallow, giant garter snake, western pond turtle, California black rail, yellow-headed blackbird (*Xanthocephalus xanthocephalus*), colonies of tricolored blackbirds, and Swainson’s hawk. Sutter National Wildlife Refuge extends throughout this reach of the Sutter Bypass. The Sutter Bypass also provides extremely productive inundated floodplain habitat that exports nutrients and food items to the downstream river system (Sommer et al., 2001). Inundated floodplain also provides rearing habitat for steelhead and Chinook salmon, and spawning habitat for Sacramento splittail.

There is no developed land within the Sutter Bypass, and major infrastructure is limited to just several road crossings (most notably SR 113), several interconnected electrical transmission lines, and two major water supply canals, the West Borrow Canal and East Borrow Canal, which are immediately adjacent to the waterside toes of the western and eastern Sutter Bypass levees, respectively.

The Sutter Bypass levees are project levees whose physical condition is generally of higher concern.

Stakeholders identified potential restoration opportunities in the Sutter Bypass.

3.3.2 Yolo Bypass

To the north and east, the Yolo Bypass is bordered by the natural levees of the Sacramento River and its distributary channels, on the west by the alluvial fans of Putah Creek and Cache Creek, and to the south by the tidal sloughs and islands of the Delta. During flood flows, water enters the Yolo Bypass from the Sacramento River from the north, and Cache Creek, Putah Creek, and Willow Slough from the west; and drains south to the northern Delta. During about 70 percent of years, the bypass is inundated one to several times for 0 to 135 days during May through November (DFG, 2008).

Land cover in the Yolo Bypass consists of a mosaic of agricultural and natural vegetation that includes row crops, seasonal wetlands managed as habitat (primarily for waterfowl), permanent wetlands, and uplands. Riparian and wetland-associated sensitive species documented along this reach include giant garter snake, California black rail, and Swainson’s hawk. Also, as described for the Sutter Bypass, the Yolo Bypass provides extremely productive inundated floodplain habitat that benefit downstream ecosystems and provide rearing habitat for steelhead and Chinook salmon, and spawning habitat for Sacramento splittail. A substantial portion of the bypass is included in the Yolo Bypass Wildlife Area.

There is no developed land in the Yolo Bypass. Infrastructure in and adjacent to the Yolo Bypass includes levees and several major transportation features. The Sacramento Deep Water Ship Channel is east of the bypass. There are a variety of small interior levees and berms constructed for local agricultural development that prevent the inundation of particular areas from tidal fluctuations and small floods. In addition, causeways and bridge crossings of the bypass include I-80, I-5, portions of the abandoned Sacramento North Railroad, and the Southern Pacific Railroad.

The Yolo Bypass is surrounded completely on the east and partially on the west by SPFC levees. The physical condition of these levees is of higher to medium concern.

Stakeholders identified potential restoration opportunities in the Yolo Bypass.

3.4 San Joaquin River Reach Descriptions

3.4.1 Friant Dam to SR 99

Along this reach, the San Joaquin River is confined by bluffs and between the bluffs by low terraces. Consequently, the corridor along the river predominantly has greater than 10 percent chance FIP. Along the river are the pits of active and abandoned aggregate mines. A number of these pits have been captured by (i.e., become connected to) the river. (These captured pits are of conservation concern because of the potential for fish stranding and predation by warm-water fish.)

Natural vegetation covers nearly half of the corridor along this reach, and riparian/wetland vegetation covers about 8 percent of the corridor. Invasive plant species are abundant in this riparian vegetation (e.g., red sesbania (*Sesbania punicea*), blue gum (*Eucalyptus globulus*), and giant reed (*Arundo donax*)). Riparian and wetland-associated sensitive species documented along this reach include VELB and rookeries of wading birds.

More than 15 percent of the corridor along this reach has been conserved. Conserved areas include the San Joaquin River Ecological Reserve, Camp Pashayan Ecological Preserve, and several county parks and land managed by the San Joaquin River Parkway and Conservation Trust.

Developed land uses occupy nearly 30 percent of the corridor along this reach, and are most extensive south of the river. Because of its proximity to Fresno, this reach has major infrastructure throughout, particularly near SR 99, where natural gas pipelines, electrical transmission lines, and a railroad cross the river. Electrical transmission lines also cross the river near RMs 250 and 254, and SR 41 crosses the river near RM 252. In addition, there are a number of historical and several active gravel mines along this reach. Also, Sierra Sky Park Airport is within 1 mile of the river.

In addition to increasing spring–fall river flows, potential restoration actions identified for this reach by the SJRRP include isolating/eliminating selected gravel pits, modifying side channels, controlling invasive species and fish predators, modifying road crossings, and augmenting spawning gravel.

Stakeholders identified potential restoration opportunities along this reach of the San Joaquin River.

3.4.2 SR 99 to Gravelly Ford

From SR 99 to Gravelly Ford, the San Joaquin River is confined between bluffs. At the downstream end of this reach, the bluffs diminish in height and gradually merge with floodplain surfaces. Despite this change, along this entire reach of river, the evaluated corridor primarily has greater than 10 percent chance FIP.

Natural vegetation covers only about one-eighth of the corridor along this reach, and riparian/wetland vegetation covers several percent of the corridor. Riparian and wetland-associated sensitive species have not been documented along this reach in the CNDDB.

Very little of the corridor along this reach has been conserved (less than 1 percent of the corridor). A county park (Skaggs Bridge Park) is the only conserved area along this reach of the San Joaquin River.

Developed land uses occupy less than 1 percent of the corridor along this reach. Except for a natural gas pipeline that is along the length of this reach and crosses the river twice between RMs 238 and 240, there is no major infrastructure along this reach of the San Joaquin River.

In addition to increasing spring–fall river flows, potential restoration actions identified for this reach by the SJRRP include isolating/eliminating selected gravel pits, controlling invasive plant species, and modifying road crossings. Stakeholders also identified potential restoration opportunities along this reach of the San Joaquin River. Stakeholders did not identify potential restoration opportunities along this reach of the San Joaquin River.

3.4.3 Gravelly Ford to Chowchilla Bypass

From Gravelly Ford to Chowchilla Bypass, the San Joaquin River is sand bedded and meandering. Through lateral migration and avulsion the channel actively moves within the levees. The SJRRP is restoring year-round flow to this reach that, because of diversions, has had only seasonal flow. The FIP of the corridor along this reach varies considerably, with about 40 percent having 67 percent chance Sustained Spring or 50 percent chance FIP. Most of these areas are disconnected from the river.

Natural vegetation covers more than 10 percent of the corridor along this reach, and riparian/wetland vegetation covers approximately 5 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include VELB and Swainson’s hawk. There are no conserved areas along this reach of the San Joaquin River.

Developed land uses occupy much less than 1 percent of the corridor along this reach. There is very little major infrastructure along this reach of the San Joaquin River. A natural gas pipeline is within 1,000 feet of the river at RMs 219 to 220.

SPFC levees are along both river banks. The physical condition of these levees is of higher concern.

Stakeholders identified a potential restoration opportunity along this reach of the San Joaquin River.

3.4.4 Chowchilla Bypass to Mendota Dam

From Chowchilla Bypass to Mendota Dam, FIP varies considerably. However, nearly half of the corridor has 67 percent chance Sustained Spring or 50 percent chance FIP. Most of these areas are disconnected from the river.

The backwater of Mendota Pool occupies the lower few miles of this reach. This backwater is an extensive area of open water bordered by riparian and emergent wetland vegetation. The Mendota Pool is formed by Mendota Dam at the confluence of the San Joaquin River and Fresno Slough. The primary source of water to the Mendota Pool is conveyed from the Delta through the Delta-Mendota Canal. Most of the Mendota Pool is less than 10 feet deep, with the deepest areas no more than 20 feet deep and averaging about 400 feet wide. Inflows to and outflows from the pool are balanced so that the pool remains at a relatively constant depth. The pool must remain above 14.5 feet at the Mendota Dam gage for users at the southern end of the pool to be able to draw water.

Along this reach of the San Joaquin River, there are almost no conserved lands. However, the Mendota Wildlife Area is along the James Bypass, at the southern end of the Mendota Pool.

Natural vegetation covers nearly 15 percent of the corridor along this reach, and riparian/wetland vegetation covers about 5 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include Sanford's arrowhead, giant garter snake, western pond turtle, and Swainson's hawk.

Developed land uses occupy only about 1 percent of the corridor along this reach. Although San Mateo Road crosses the river in this reach and a natural gas pipeline repeatedly crosses the river between RMs 203 and 208, Mendota Dam and the diversions associated with Mendota Dam account for most major infrastructure along this reach. Also, there is a community airport at Mendota within 2 miles of the river.

There are nonproject levees on both banks of this reach. There are no project levees along this reach.

The SJRRP includes constructing a bypass channel around Mendota Pool, and setting back levees to create a floodplain between 500 and 3,700 feet wide. It also identifies modifying the San Mateo Road crossing as a potential restoration action. Stakeholders also identified a potential restoration opportunity along this reach of the San Joaquin River.

3.4.5 Mendota Dam to Sack Dam

Along this reach, regulated flows for water deliveries from the Delta-Mendota Canal are conveyed through the San Joaquin River channel to Sack Dam for diversion to Arroyo Canal.

From Mendota Dam to Sack Dam, about two-thirds of the corridor along the river has 50 percent chance FIP, and most of the remainder (mostly located near Firebaugh) has greater than 10 percent chance FIP. Along this reach, nearly 90 percent of areas with 50 percent chance FIP are disconnected from the river.

Natural vegetation covers about an eighth of the corridor along this reach, and riparian/wetland vegetation covers less than 4 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include giant garter snake, western pond turtle, Swainson’s hawk, and western red bat. There is almost no conserved area along this reach of the San Joaquin River.

Developed land uses occupy about 5 percent of the corridor along this reach, and are extensive in the vicinity of Firebaugh on the west bank. Major infrastructure along this reach includes a crossing by Avenue 7 ½; electrical transmission line crossings near RMs 184, 185, and 195; a natural gas pipeline crossing near RM 192; and a gravel mine near RM 188. There is also a community airport at Firebaugh that is within 1 mile of the river.

For most of its length, this reach is bounded on both sides by man-made structures, including irrigation canals and project and nonproject levees. There are no project levees along this reach. At some locations, lands within the floodway are actively used for agricultural production, and are protected by local or interior levees. During the 2006 flood, a number of these parcels were inundated.

The SJRRP has not planned or identified any restoration actions along this reach other than modification of facilities to improve fish passage, and the previously described Mendota Pool Bypass, which would reconnect to the river at the beginning of this reach. Stakeholders, however, identified a potential restoration opportunity along this reach of the San Joaquin River.

3.4.6 Sack Dam to Sand Slough Control Structure

From Sack Dam to the Sand Slough Control Structure, the geomorphology of the San Joaquin River is transitional from the meandering river channel and associated floodplain of upstream reaches to the numerous sloughs and extensive floodbasins downstream. Many sloughs originate in this and the immediately downstream reach of the San Joaquin River.

This reach normally carries only seepage water from Sack Dam and from adjacent agricultural areas. At its downstream end, any water in the channel flows through Sand Slough and into the Eastside Bypass.

Along this reach, the floodway is only about 300 feet wide. Outside of this floodway, the corridor along the river consists predominantly of areas with 50 percent chance FIP, which are disconnected from the river.

Natural vegetation covers about an eighth of the corridor along this reach, but riparian/wetland vegetation covers less than 2 percent of the corridor. Swainson’s hawk has been documented along this reach. There are no conserved lands along this reach of the San Joaquin River.

The floodplain of this reach is almost entirely in agricultural use. It virtually lacks developed land uses and has relatively little major infrastructure: SR 152 crosses the river at RM 173, an electrical transmission line crosses the river at RM 173, and a natural gas pipeline crosses the river near Sack Dam.

Nonproject levees are close to the river along all of this reach except at the northern end, where there are SPFC levees. The physical condition of these project levees is of higher concern.

The SJRRP includes projects to modify Sack Dam (to improve fish passage) and to screen the intake of the Arroyo Canal. Stakeholders did not identify potential restoration opportunities along this reach of the San Joaquin River.

3.4.7 Sand Slough Control Structure to Mariposa Bypass

In this reach, the channel of the San Joaquin River historically was connected to sloughs and floodbasins. Consequently, more than two-thirds of the corridor along the river has 67 percent chance FIP, and most of the remainder has Below Baseflow FIP. This reach has the largest percentage of 67 percent chance FIP among reaches of the San Joaquin and

Sacramento river systems. About 60 percent of these areas are disconnected from the river.

Natural vegetation covers nearly 15 percent of the corridor along this reach, and riparian/wetland vegetation covers approximately 3 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include Delta button-celery (*Eryngium racemosum*), giant garter snake, northern harrier (*Circus cyaneus*), and Swainson's hawk.

More than 5 percent of the corridor along this reach has been conserved. This conserved land is part of the San Luis National Wildlife Refuge.

This reach virtually lacks developed land uses. Other than the Sand Slough Control Structure and the Mariposa Bypass at the ends of this reach, and several levees, this reach also has almost no major infrastructure. SPFC levees are on both banks at the northern end of this reach, and nonproject levees are at two locations farther upstream. The physical condition of the SPFC levees is of higher concern.

The SJRRP includes increasing conveyance in this reach, potentially with setback levees, modifying road crossings, and modifying the San Slough Control Structure to improve fish passage and the San Joaquin River Headgate to allow improve conveyance.

Stakeholders identified potential restoration opportunities along this reach of the San Joaquin River.

3.4.8 Mariposa Bypass to Bear Creek

From the Mariposa Bypass to Bear Creek, the San Joaquin River was historically connected to sloughs and floodbasins. Approximately 90 percent of the corridor along this reach has 50 percent chance FIP. Most of this area is disconnected from the river.

Natural vegetation covers more than 90 percent of the corridor along this reach, and riparian/wetland vegetation covers nearly 15 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include Delta button-celery, northern harrier, and Swainson's hawk.

More than 70 percent of the corridor along this reach of the San Joaquin River has been conserved. Unlike most reaches, the majority of this conserved land is disconnected from the river. Conserved areas along this reach include a portion of the San Luis National Wildlife Refuge.

This reach virtually lacks developed land uses. There is very little major infrastructure along this reach other than an electrical transmission line that crosses the river at RM 142.

SPFC levees are on both banks along this reach. The physical condition of these levees is of higher concern.

Stakeholders identified potential restoration opportunities along this reach of the San Joaquin River.

3.4.9 Bear Creek to Merced River

From Bear Creek to the Merced River, the San Joaquin River has more sinuosity than in upstream reaches; and oxbow, side channel, and remnant channel landforms are present. About half of the corridor along the river has a 50 percent chance FIP, and most of these areas are connected to the river.

Natural vegetation covers more than 70 percent of the corridor along this reach, and riparian/wetland vegetation covers nearly 10 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include Delta button-celery, western pond turtle, colonies of tricolored blackbirds, northern harrier, Swainson’s hawk, western red bat, and pallid bat (*Antrozous pallidus*).

More than 50 percent of this reach of the San Joaquin River has been preserved. Conserved areas along this reach include the North Grasslands Wildlife Area, Great Valley Grasslands State Park, and San Luis National Wildlife Refuge.

Developed land uses occupy only about 2 percent of the corridor along this reach. There is little major infrastructure along this reach: an electrical transmission line is located near the river at RM 116, SR 140 crosses the river near RM 123, and Lander Avenue crosses the river near RM 130.

An SPFC levee is located along the river’s east side, and extends for several miles along the west side. The physical condition of the east levee is of medium concern; the physical condition of the west levee is of higher concern.

Stakeholders identified potential restoration opportunities along this reach of the San Joaquin River.

3.4.10 Merced River to Tuolumne River

Between the Merced and Tuolumne rivers, the San Joaquin River is sinuous and in some areas is actively meandering. The corridor along this reach of the San Joaquin River includes abandoned sloughs, channel portions, and oxbow cutoffs. In this reach, more than half of the corridor along the San Joaquin River has a 10 percent chance or greater than a 10 percent chance FIP. A 50 percent chance FIP accounts for almost 40 percent of the corridor, and about half of these areas are disconnected from the river.

Natural vegetation covers more than 30 percent of the corridor along this reach, and riparian/wetland vegetation covers about 6 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include Delta button-celery, VELB, wading bird rookeries, least Bell's vireo (*Vireo bellii pusillus*), colonies of tricolored blackbirds, Swainson's hawk, pallid bat, and western red bat. This reach also provides habitat for Sacramento splittail; and migrating, holding, and rearing, steelhead and fall-run Chinook salmon.

Only a small portion of the corridor along this reach of the San Joaquin River has been conserved (approximately 5 percent of the corridor). However, there are several conserved areas along this reach, including the West Hilmar Wildlife Area, a portion of the San Joaquin National Wildlife Refuge, and several county and regional parks and open space areas.

Developed land uses occupy about 5 percent of the corridor along this reach. However, major infrastructure is widely dispersed along this reach. Electrical transmission lines cross the river near RMs 85, 87, and 101, and pipelines cross the river near RMs 101 and 107. In addition to these crossings, a wastewater treatment facility is on the east bank at RMs 94 and 93, and an aggregate mine is near RM 107.

SPFC levees are along most of the east bank and portions of the west bank, but neither connects to other SPFC levees upstream or downstream from this reach. The physical condition of these levees is of higher concern, except for a west levee at the junction with the Tuolumne River, whose physical condition is of medium concern. There are several nonproject levees in intervening areas.

Stakeholders identified potential restoration opportunities along this reach of the San Joaquin River.

3.4.11 Tuolumne River to Stanislaus River

The San Joaquin River is actively meandering in portions of this reach, and the river corridor includes floodplain with complex topography, including oxbows, swales, and other products of channel migration. Between the

Tuolumne and Stanislaus rivers, nearly half of the corridor along the San Joaquin River has a 50 percent chance FIP, and most of the remainder has either 10 percent chance or greater than a 10 percent chance FIP. Approximately 60 percent of areas with a 50 percent chance FIP are disconnected from the river.

Natural vegetation covers nearly half of the corridor along this reach, and riparian/wetland vegetation covers more than 10 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include VELB, least Bell's vireo, colonies of tricolored blackbirds, Swainson's hawk, riparian woodrat (*Neotoma fuscipes riparia*), and riparian brush rabbit (*Sylvilagus bachmani riparius*). This reach also provides habitat for migrating, holding, and rearing, steelhead and fall-run Chinook salmon.

More than one-third of the corridor along this reach of the San Joaquin River has been conserved. This conserved land is part of the San Joaquin National Wildlife Refuge.

This reach virtually lacks developed land uses. Along this reach, there is little major infrastructure except for levees: between RM 78 and RM 75, Maze Boulevard, and an electrical transmission line cross the river.

There are SPFC levees on portions of both banks and nonproject levees connecting to and/or inside of the SPFC levees. The physical condition of these levees is of higher concern.

Stakeholders identified potential restoration opportunities along this reach of the San Joaquin River.

3.4.12 Stanislaus River to Stockton

The San Joaquin River is actively migrating in portions of this reach, and the corridor along the river includes floodplains with complex topography and oxbow lakes. From the Stanislaus River to Stockton, about 40 percent of the corridor along the San Joaquin River has a 50 percent chance FIP, and most of the remainder is distributed relatively evenly between areas with Below Base Flow, a 67 percent chance Sustained Spring, and a 10 percent chance FIP. About 90 percent of areas with a 67 percent chance Sustained Spring or 50 percent chance FIP are disconnected from the river. In this tidally influenced reach, the San Joaquin River enters the legal Delta.

Natural vegetation covers approximately 10 percent of the corridor along this reach, and riparian/wetland vegetation covers approximately 2 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include Sanford's arrowhead, Delta button-celery, several plants associated with marshes and sloughs (e.g., slough thistle (*Cirsium crassicaule*)), Suisun song sparrow (*Melospiza melodia maxillaris*), colonies of tricolored blackbirds, Swainson's hawk, riparian woodrat, and riparian brush rabbit. This reach also provides habitat for several sensitive fish species, including foraging adult green sturgeon; and migrating, holding, and rearing steelhead and fall-run Chinook salmon; and this reach contains delta smelt designated critical habitat.

Only a very small portion of the corridor along this reach has been conserved (approximately 1 percent of the corridor). The only conserved area along this reach is a small preserve near Vernalis.

Developed land uses are extensive, occupying more than one-quarter of the corridor along this reach. This reach of the San Joaquin River has a high density of major infrastructure that not only includes major road and railroad, natural gas pipeline, and electrical transmission line crossings, but also aggregate mines and refineries. However, there is no major infrastructure between RMs 43 and 46, RMs 47 and 56, and RMs 61 and 65.

Except for an upstream portion of the west bank, there are SPFC levees on both banks along this reach. The physical condition of these levees is predominantly of higher concern, but there are sections on both banks (that total several miles in length) whose physical condition is of medium or lower concern.

Stakeholders identified a potential restoration opportunity along this reach of the San Joaquin River.

3.5 San Joaquin River Tributary Reach Descriptions

The lowermost reach of the Merced, Tuolumne, and Stanislaus rivers were evaluated. These reaches begin approximately 1 mile upstream from the tributary's junction with the Sacramento River because the corridor along the Sacramento River extends 1 mile from the centerline of the Sacramento River.

3.5.1 Merced River

The lowermost reach of the Merced River has a relatively narrow floodplain constrained by uplands of higher elevation. Consequently, almost three-quarters of the corridor along this reach has a greater than 10 percent chance FIP. Only a very small area of floodplain has a 50 percent chance FIP or a 67 percent chance Sustained Spring FIP, most of which is connected to the river.

Natural vegetation covers nearly 10 percent of the corridor along this reach, and riparian/wetland vegetation covers about 2 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include VELB, Swainson's hawk, pallid bat, and western red bat. This reach also provides habitat for migrating, holding, and rearing, steelhead and fall-run Chinook salmon.

Only a very small portion of the corridor along this reach of the Merced River has been conserved (less than 1 percent of the corridor). Conserved areas along this reach are limited to the George J. Hatfield State Recreation Area and a county park.

Developed land uses occupy about 8 percent of the corridor along this reach. Although dispersed throughout the reach, they are more extensive near Livingston at the upstream end of the reach. Major infrastructure along this reach includes a gravel mine near RM 17, and road crossings by Landers Avenue at RM 12 and SR 99 near RM 21. Additionally, a natural gas pipeline, an oil pipeline, and an electrical transmission line cross the river within this reach.

There also are nonproject levees on the south bank of this reach at several locations, but no project levees.

Stakeholders identified potential restoration opportunities along this reach of the Merced River.

3.5.2 Tuolumne River

Similar to the Merced River, the lowermost reach of the Tuolumne River has a relatively narrow floodplain constrained by uplands of higher elevation. Consequently, nearly 90 percent of the corridor along this reach has a greater than 10 percent chance FIP. Only a very small area of floodplain has a 50 percent chance FIP or a 67 percent chance Sustained Spring FIP, about half of which is connected to the river.

Natural vegetation covers nearly an eighth of the corridor along this reach, and riparian/wetland vegetation covers about 2 percent of the corridor. Riparian and wetland-associated sensitive species documented along this reach include VELB, colonies of tricolored blackbirds, and Swainson's hawk. This reach also provides habitat for migrating, holding, and rearing, steelhead and fall-run Chinook salmon.

Only a small portion of this reach of the Tuolumne River has been conserved (nearly 5 percent of the corridor). Conserved areas along this reach include the Tuolumne River and Ceres River Bluff regional parks.

Developed land uses occupy more than one-third of the corridor along this reach. Although located throughout the reach, developed land uses and major infrastructure are most extensive at Modesto (from RMs 10 to 22).

Major infrastructure is concentrated between approximately RM 13 and RM 22. In that stretch there are major road and railroad, electrical transmission line, and natural gas pipeline crossings. The Modesto City-County Airport is also located within 1 mile of the river in this area.

There are several nonproject levees on portions of each bank along this reach, but no project levees.

Stakeholders identified potential restoration opportunities along this reach of the Tuolumne River.

3.5.3 Stanislaus River

Similar to the Merced and Tuolumne rivers, the lowermost reach of the Stanislaus River has a relatively narrow floodplain constrained by uplands of higher elevation. Consequently, more than half of the corridor along this reach has a greater than 10 percent chance FIP, and most of the remainder has a 10 percent chance FIP. Only a very small area of floodplain has a 50 percent chance FIP or a 67 percent chance Sustained Spring FIP, more than two-thirds of which is disconnected from the river.

Natural vegetation covers more than 15 percent of the corridor along this reach, but riparian/wetland vegetation accounts for about half of that land cover. Riparian and wetland-associated sensitive species documented along this reach include VELB, Swainson’s hawk, riparian woodrat, and riparian brush rabbit. This reach also provides habitat for migrating, holding, and rearing, steelhead and fall-run Chinook salmon.

Nearly 15 percent of the corridor along this reach of the Stanislaus River has been conserved. Conserved areas along this reach of the Stanislaus River include Caswell State Park and San Joaquin National Wildlife Refuge.

Developed land uses occupy about 9 percent of the corridor along this reach. Although some developed land uses are located throughout the reach, they are extensive at Ripon (RMs 12 to 14). Along this reach, there is little major infrastructure besides project and nonproject levees. Natural gas pipelines cross the river near RM 4 and RM 15.

SPFC levees are on both banks for about the first 10 river miles. The physical condition of these project levees is of higher concern. Nonproject levees extend upstream discontinuously along both sides of the river.

Stakeholders identified potential restoration opportunities along this reach of the Stanislaus River.

3.6 Maps and Tables of Results

This section provides a set of maps (Figures 3-2 through 3-26) and tables (Tables 3-1 through 3-12) for 2-mile-wide corridors along (1) Sacramento River reaches, (2) Sacramento River tributary and bypass reaches, (3) upper San Joaquin River reaches, and (4) lower San Joaquin River reaches. Each set includes maps of FIP, land use/land cover, conserved areas, and major infrastructure. Each set also includes a map of nonurban floodplain areas with a 67 percent chance Sustained Spring or a 50 percent chance FIP classified by their connectivity to the river system and their land use/land cover. (Areas with a 67 percent chance Sustained Spring or a 50 percent chance FIP represent those areas with the greatest potential for providing inundated floodplain habitats.) This map represents different types of restoration opportunities. Each set of tables summarizes information displayed on the maps by reach, including FIP and connectivity, and land cover and conservation status for selected areas.

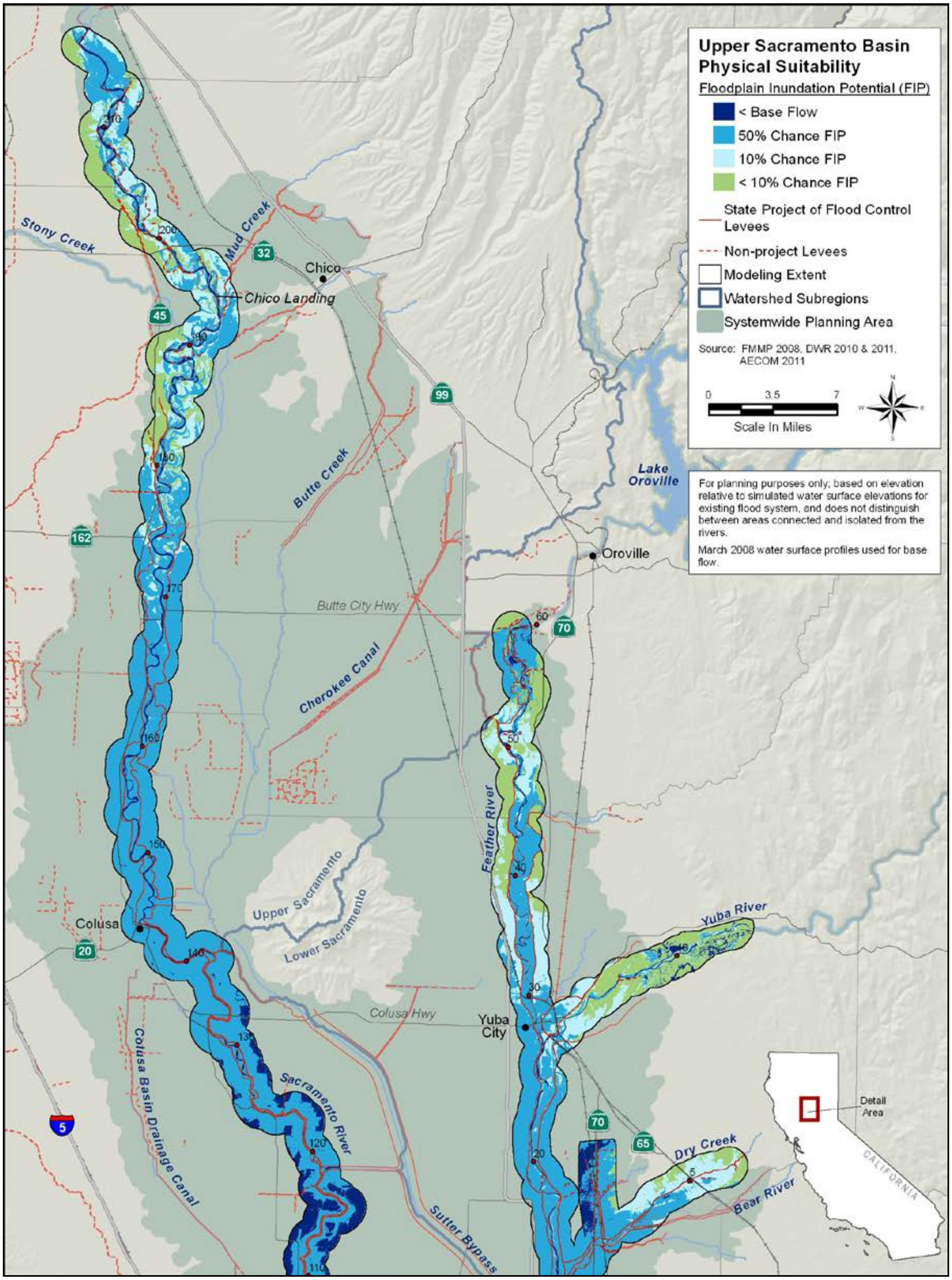

Figure 3-2. Floodplain Inundation Potential of Major River Corridors in the Upper Sacramento Basin

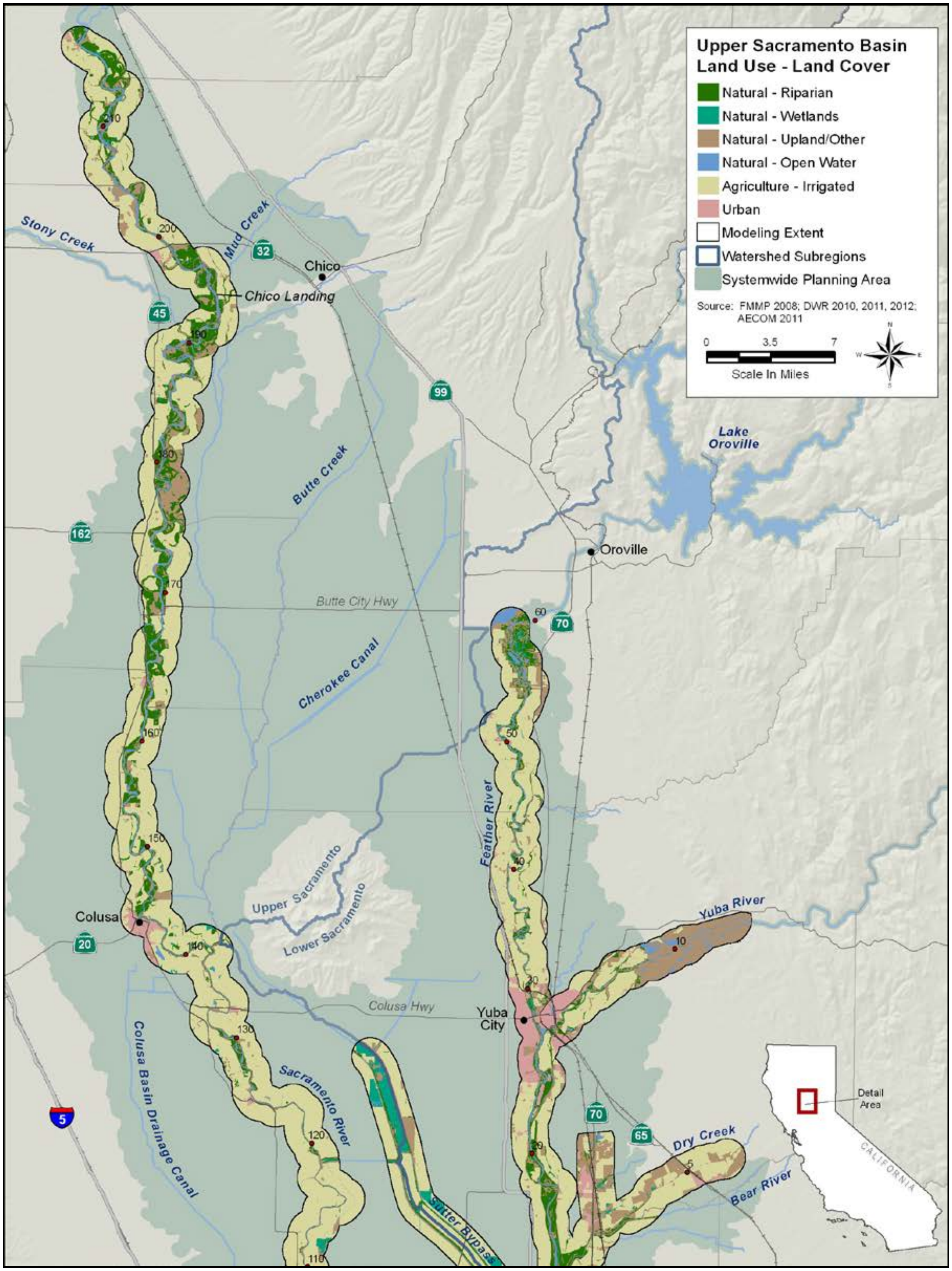

Figure 3-3. Land Use/Land Cover of River Corridors in the Upper Sacramento Basin

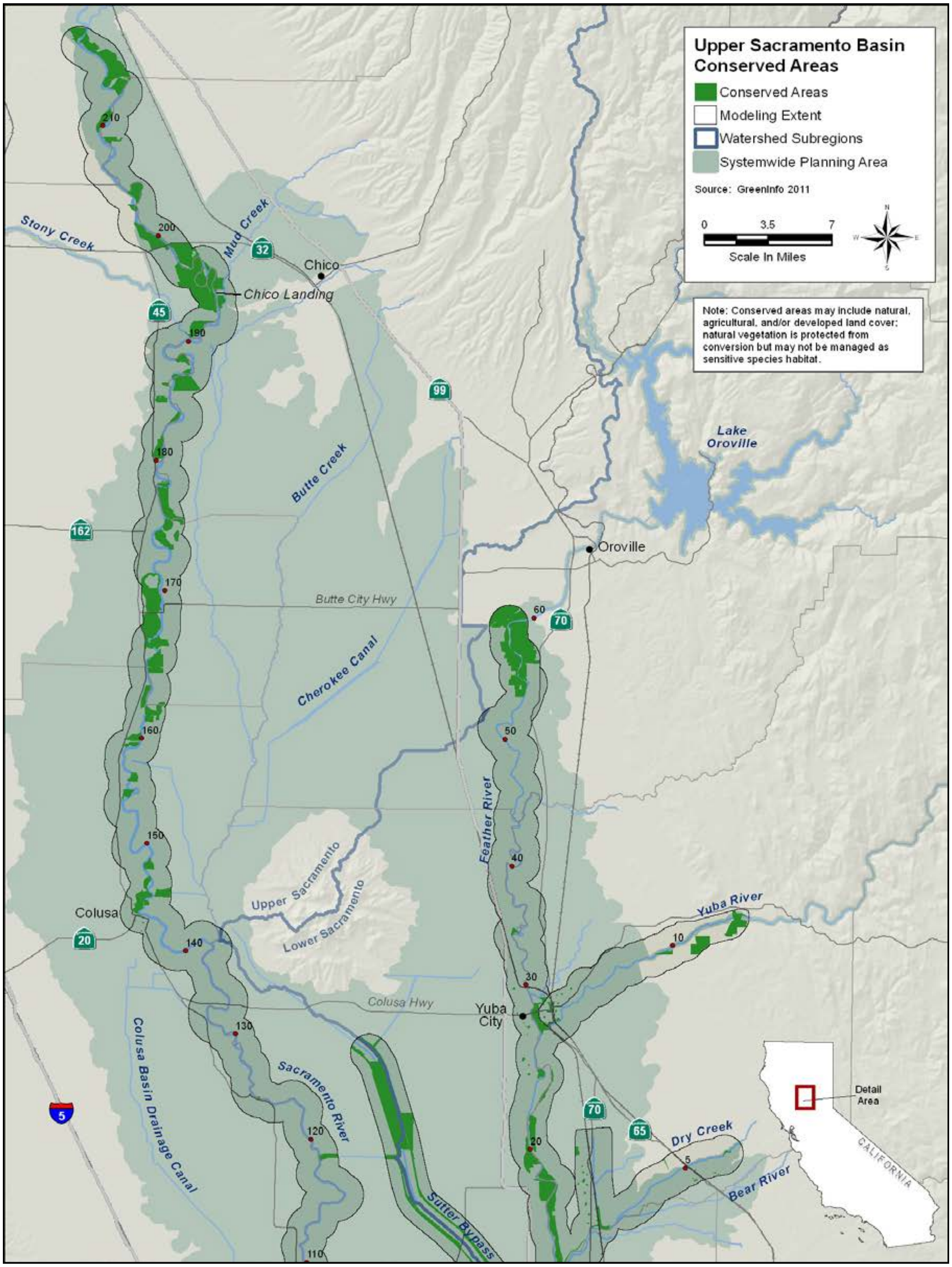

Figure 3-4. Conserved Areas of River Corridors in the Upper Sacramento Basin

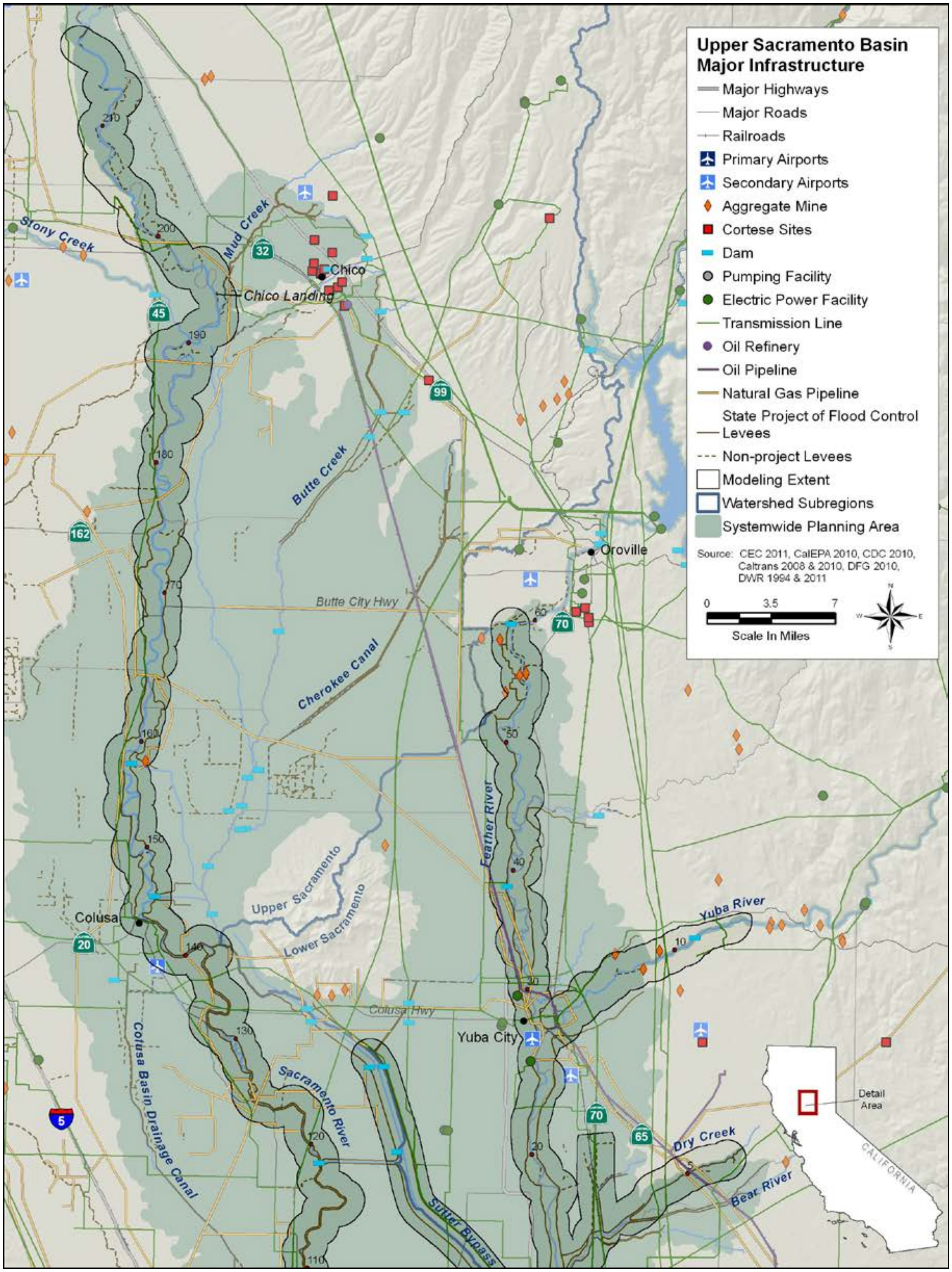

Figure 3-5. Major Infrastructure in River Corridors in the Upper Sacramento Basin

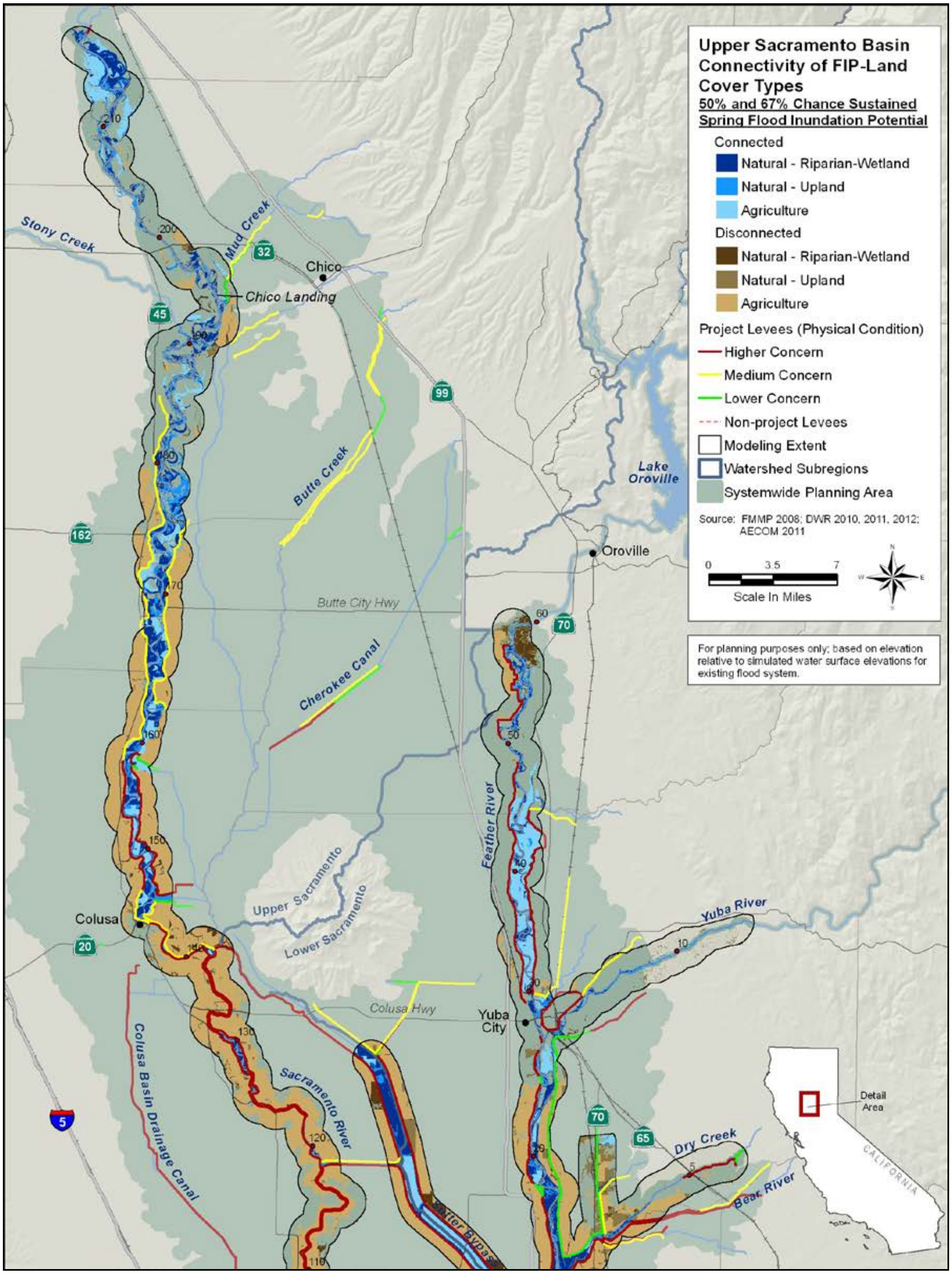

Figure 3-6. Connectivity of FIP-Land Cover Types in the Upper Sacramento Basin

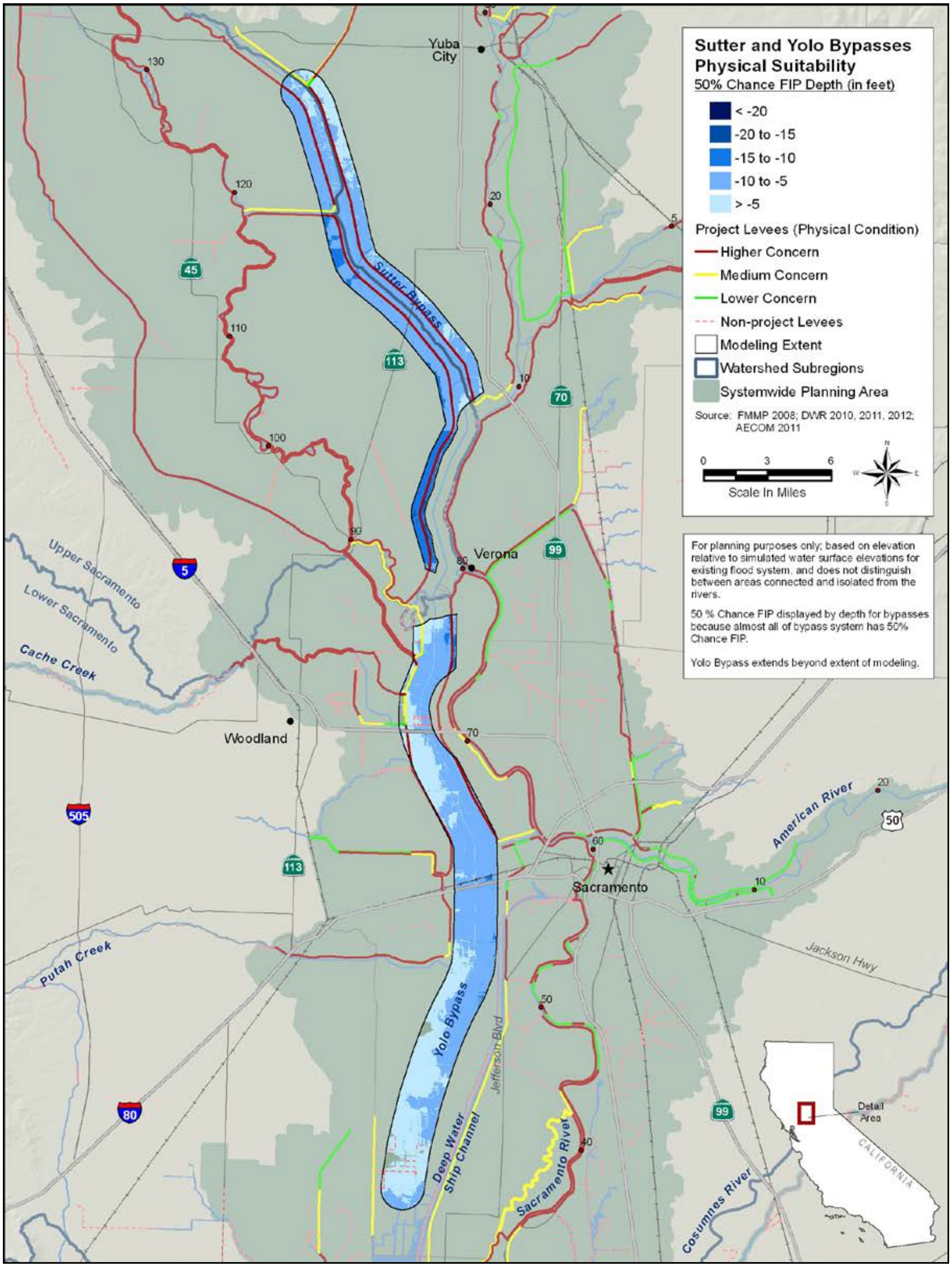

Figure 3-7. Depth of 50 Percent Chance Floodplain Inundation Potential in the Sutter and Yolo Bypasses

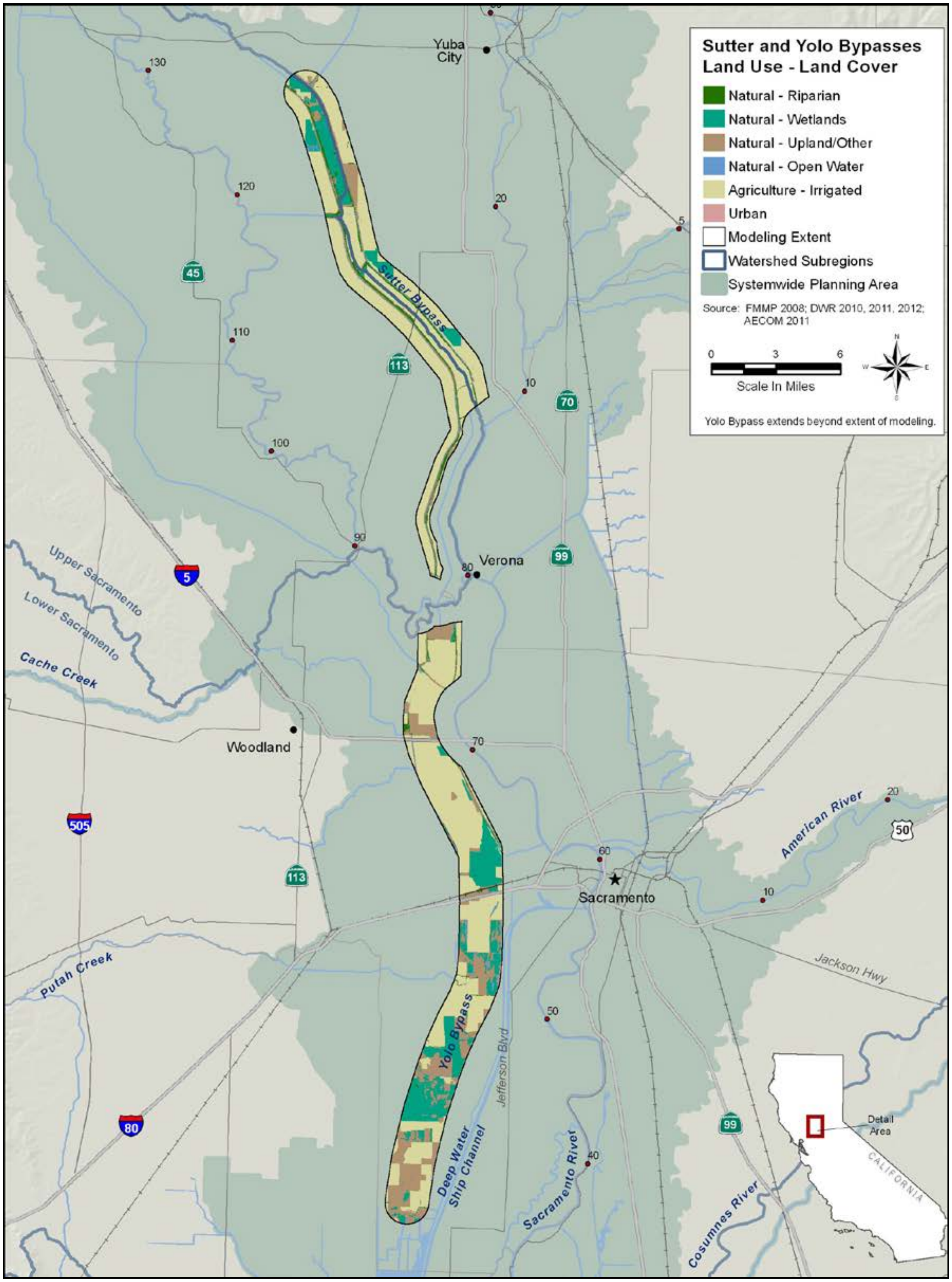

Figure 3-8. Land Use/Land Cover of River Corridors in the Sutter and Yolo Bypasses

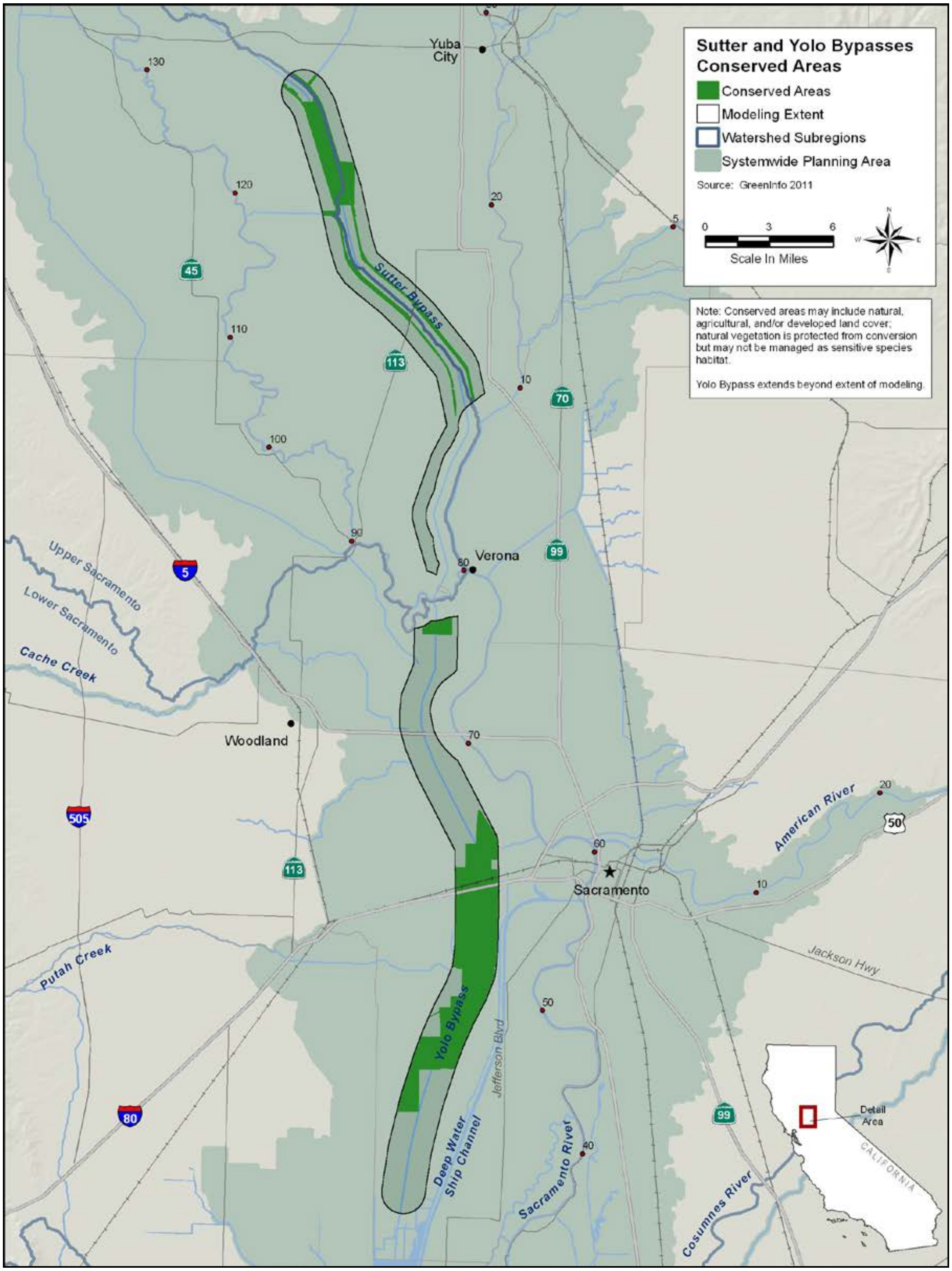

Figure 3-9. Conserved Areas of River Corridors in the Sutter and Yolo Bypasses

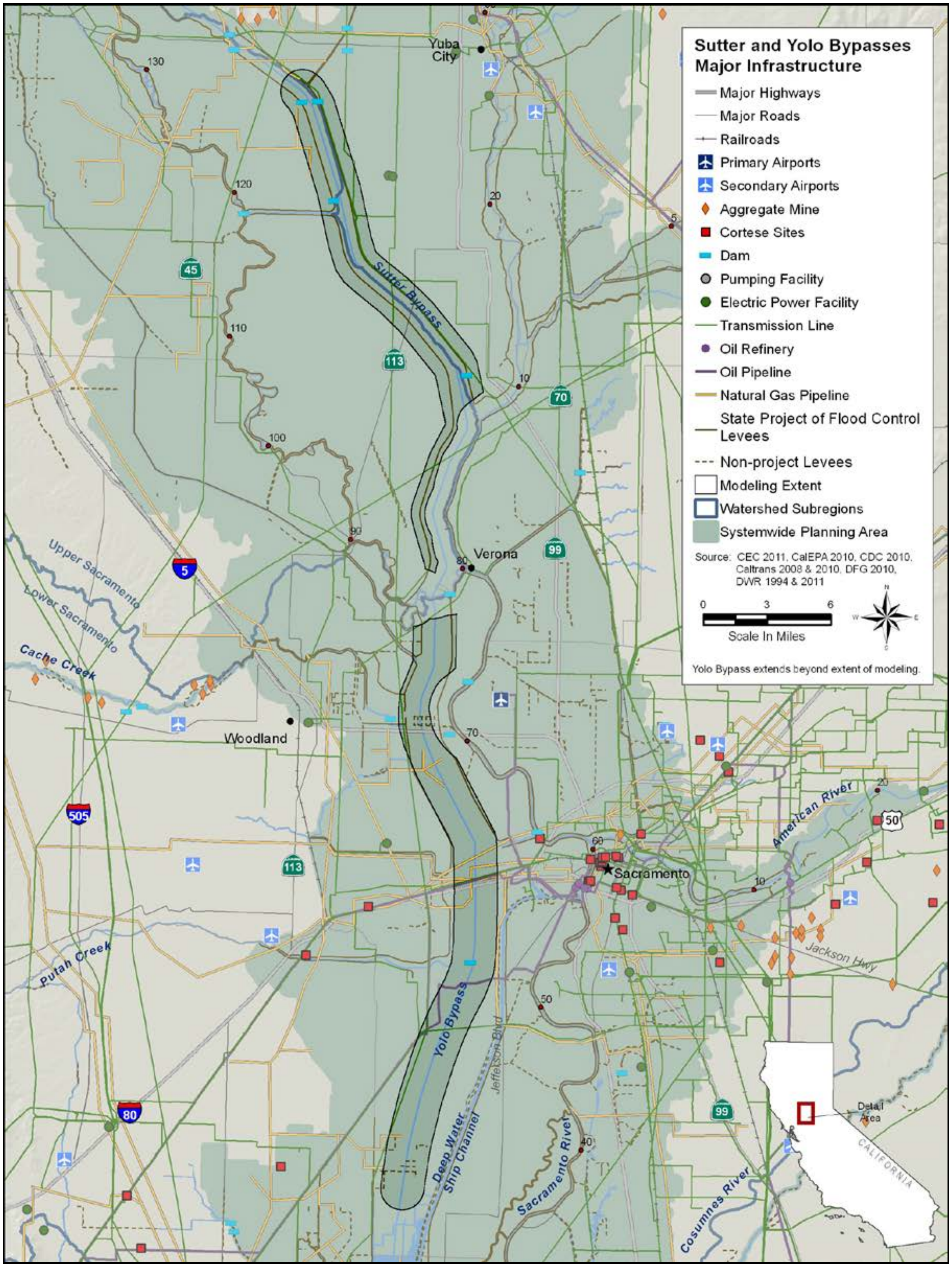

Figure 3-10. Major Infrastructure in River Corridors in the Sutter and Yolo Bypasses

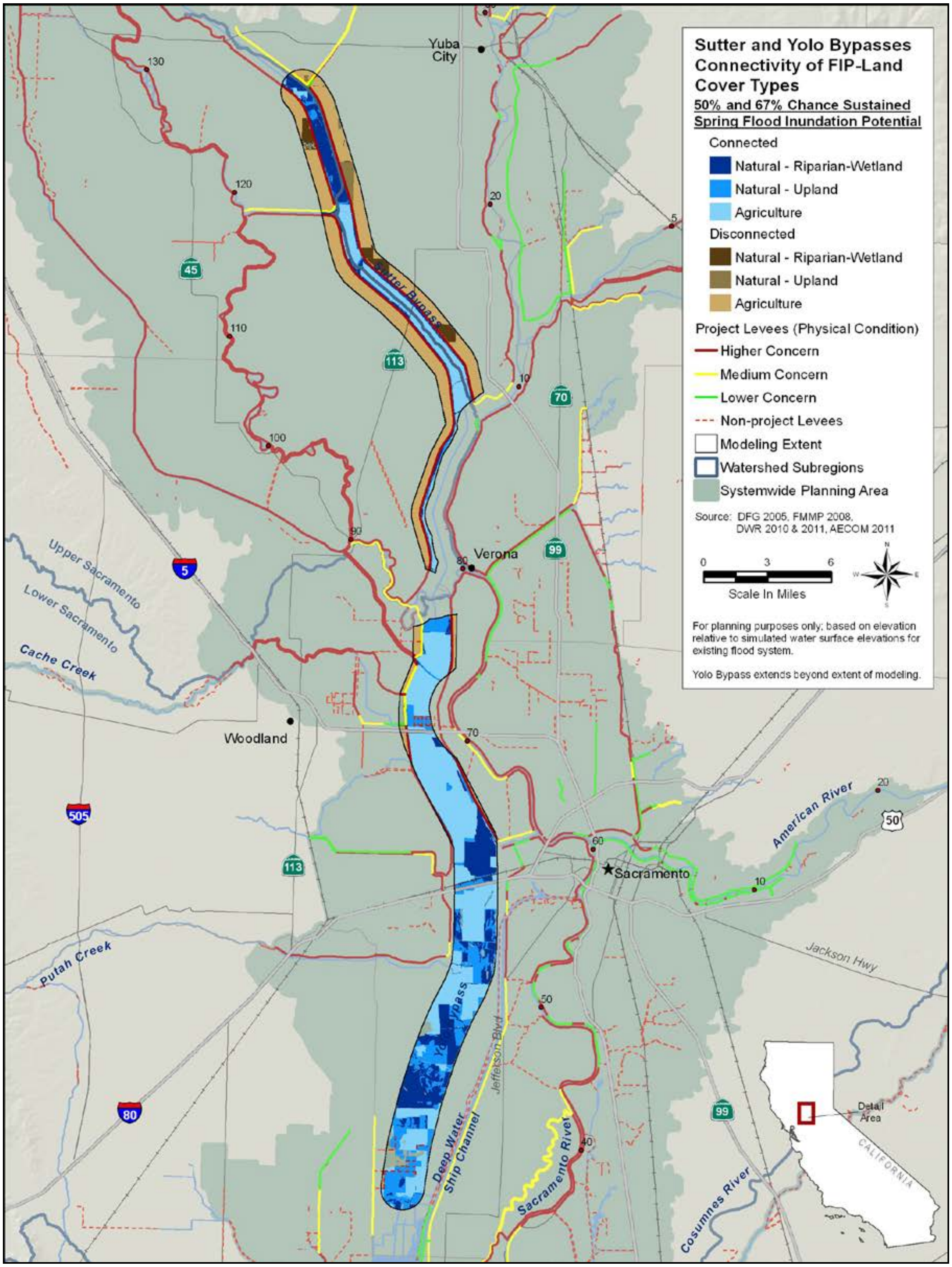

Figure 3-11. Connectivity of FIP-Land Cover Types in the Sutter and Yolo Bypasses

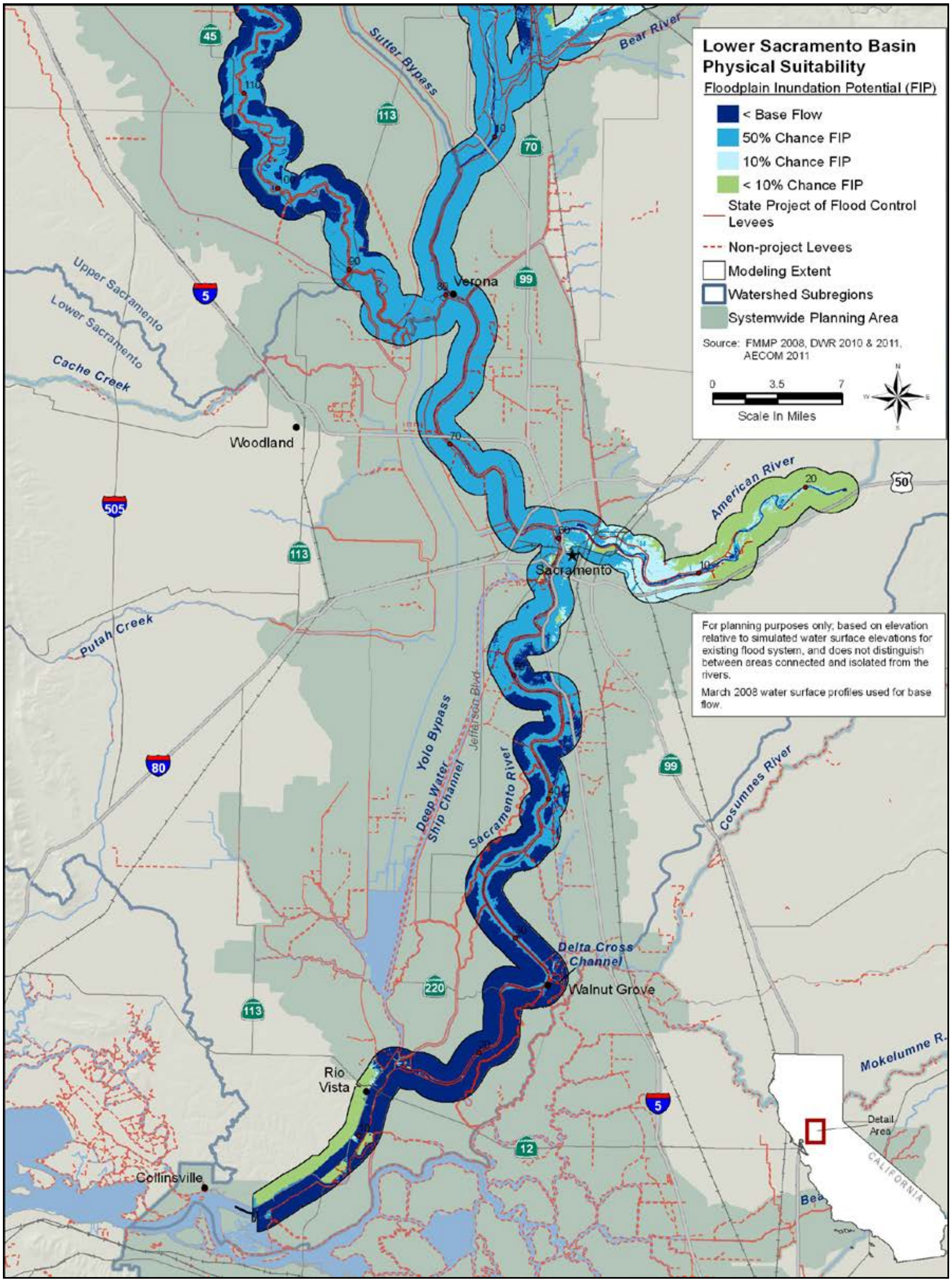

Figure 3-12. Floodplain Inundation Potential of Major River Corridors in the Lower Sacramento Basin

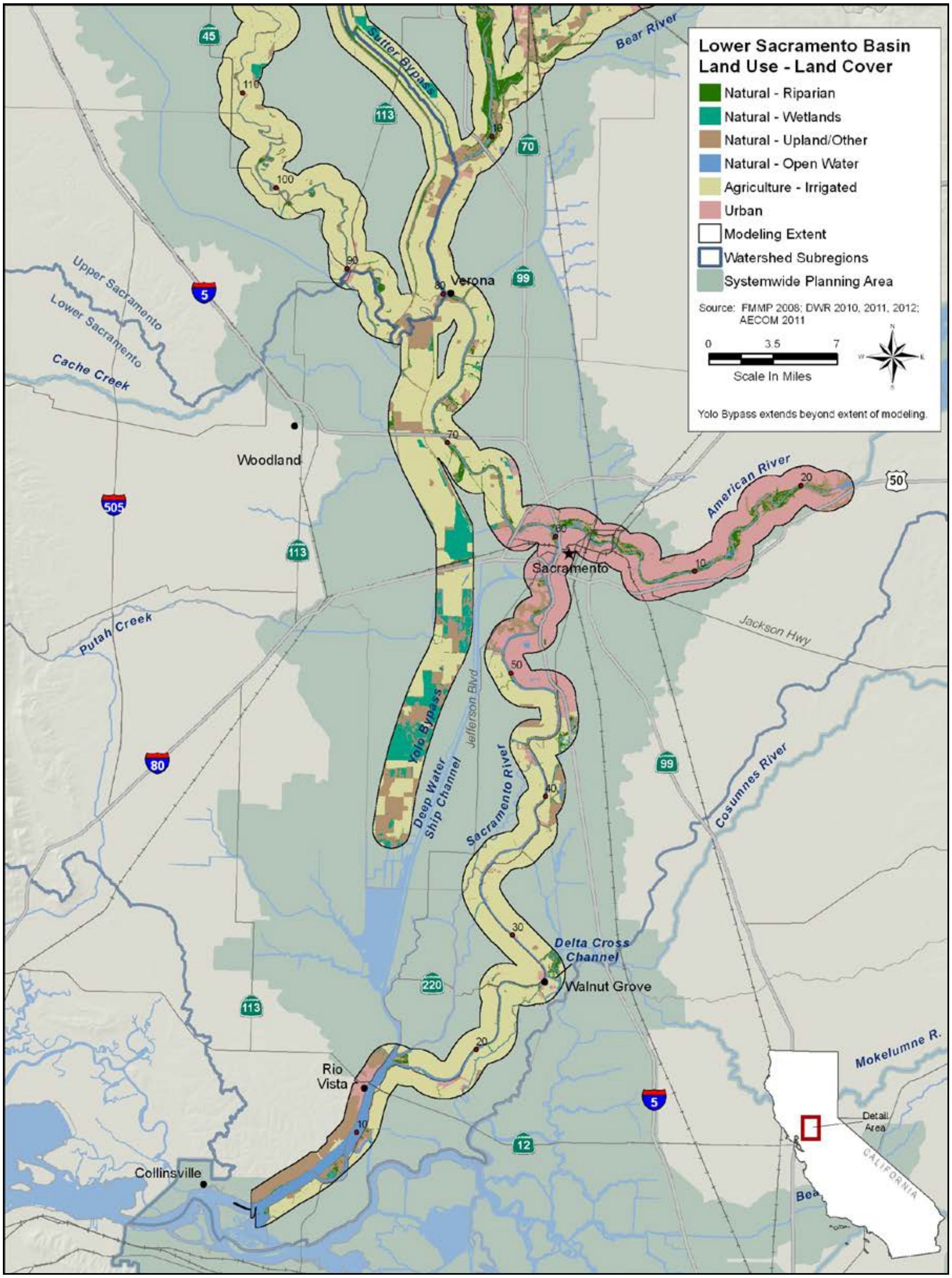

Figure 3-13. Land Use/Land Cover of River Corridors in the Lower Sacramento Basin

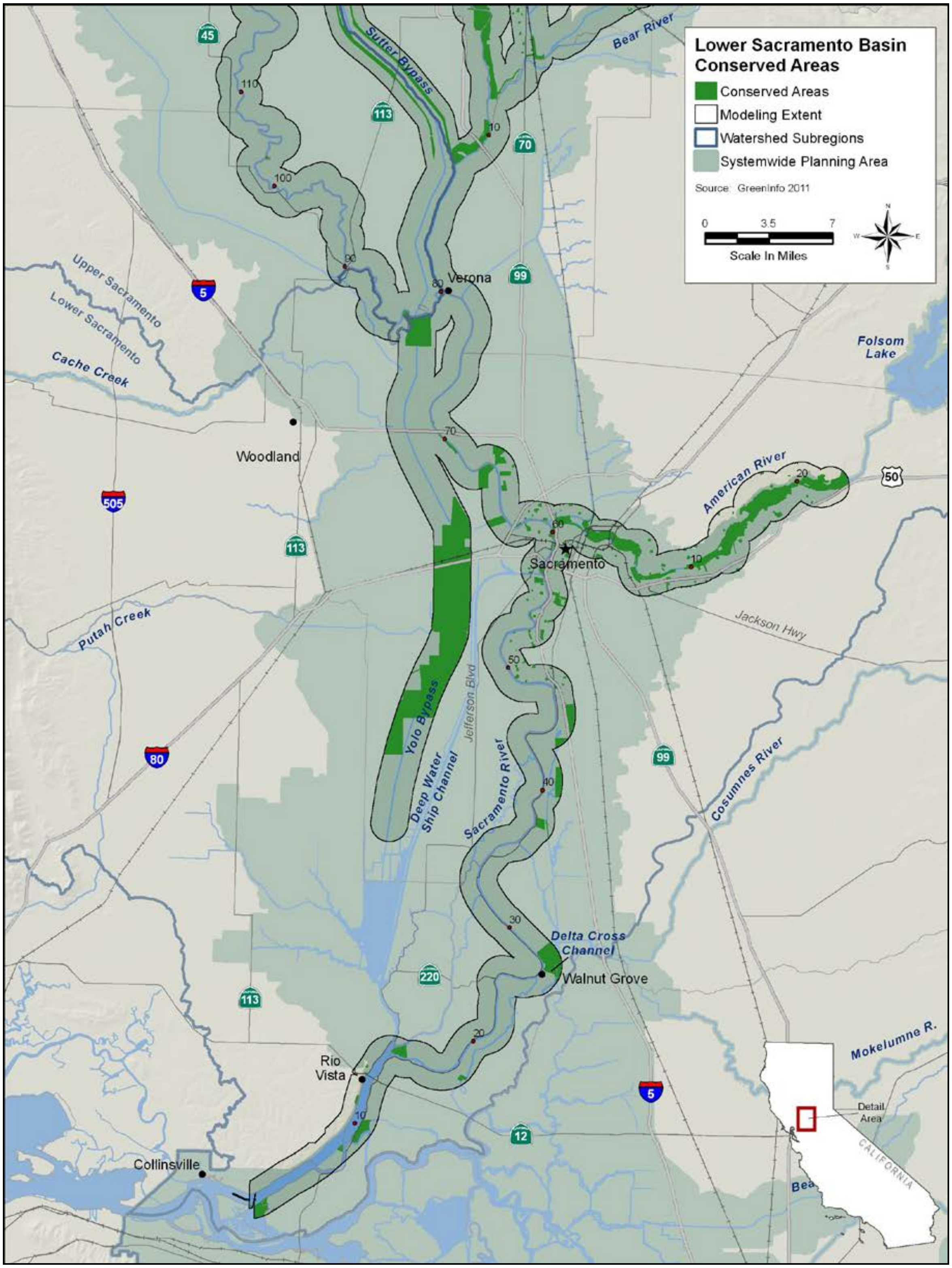

Figure 3-14. Conserved Areas of River Corridors in the Lower Sacramento Basin

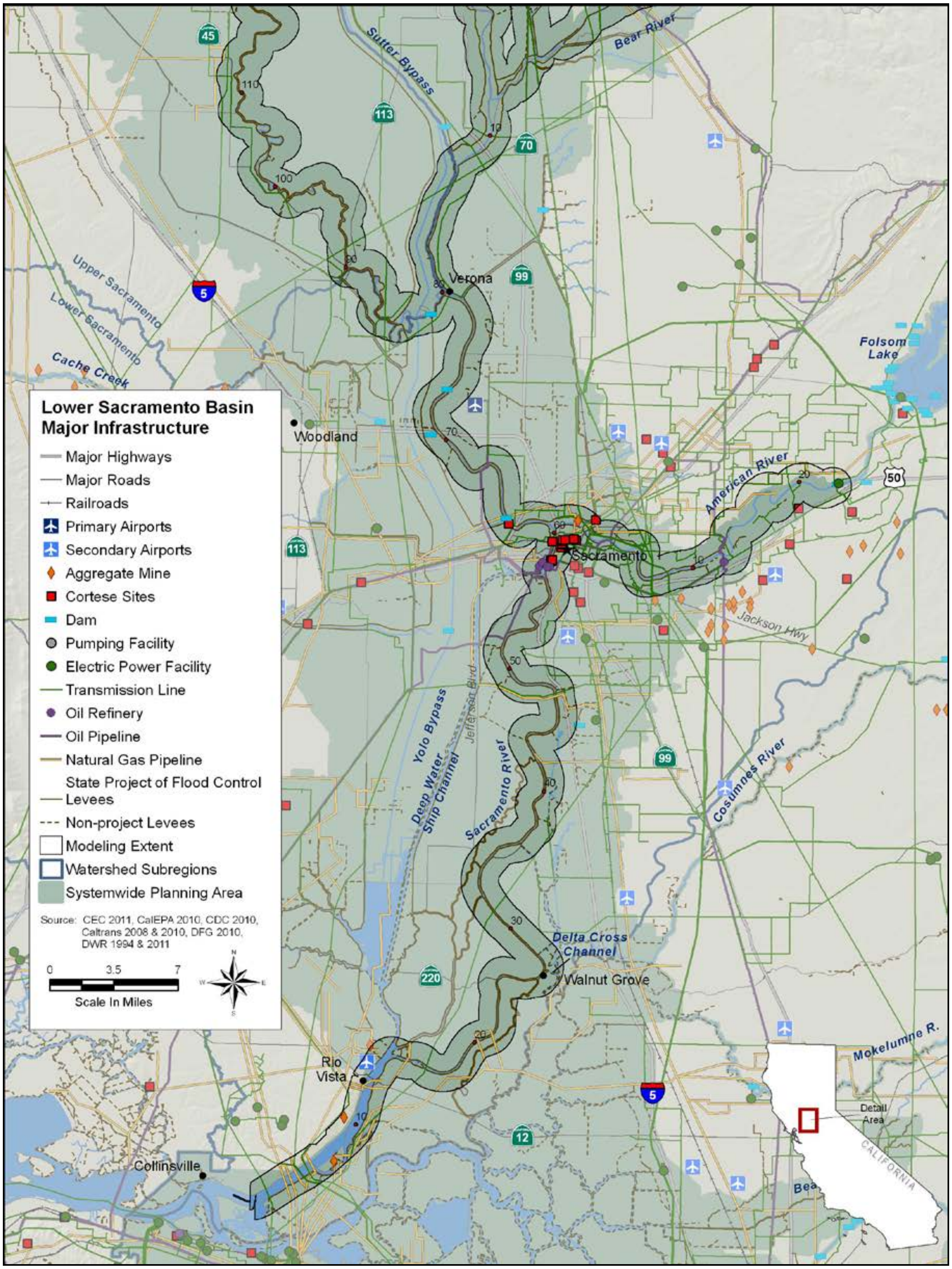

Figure 3-15. Major Infrastructure in River Corridors in the Lower Sacramento Basin

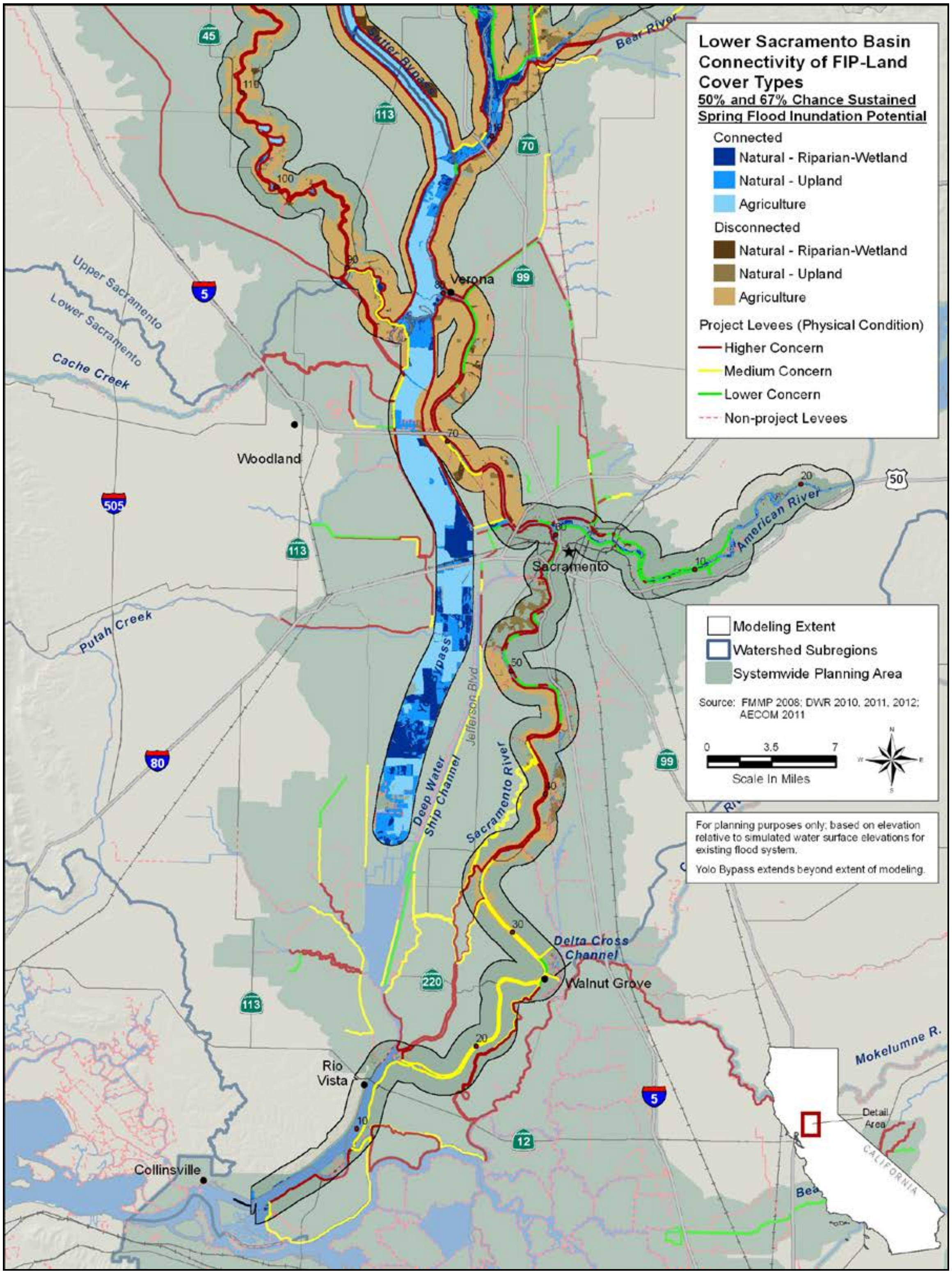

Figure 3-16. Connectivity of FIP-Land Cover Types in Lower Sacramento Basin

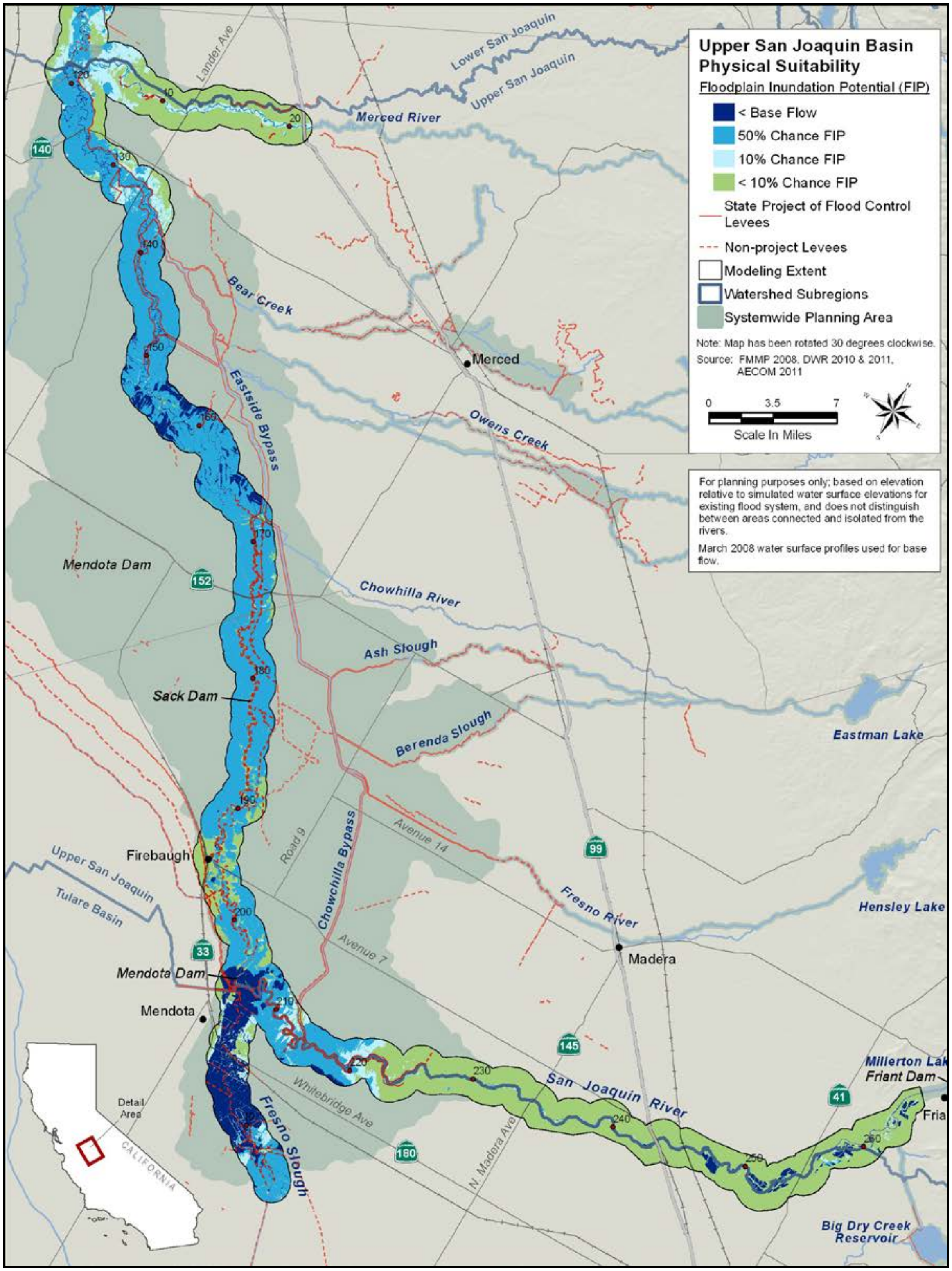

Figure 3-17. Floodplain Inundation Potential of River Corridors in the Upper San Joaquin Basin

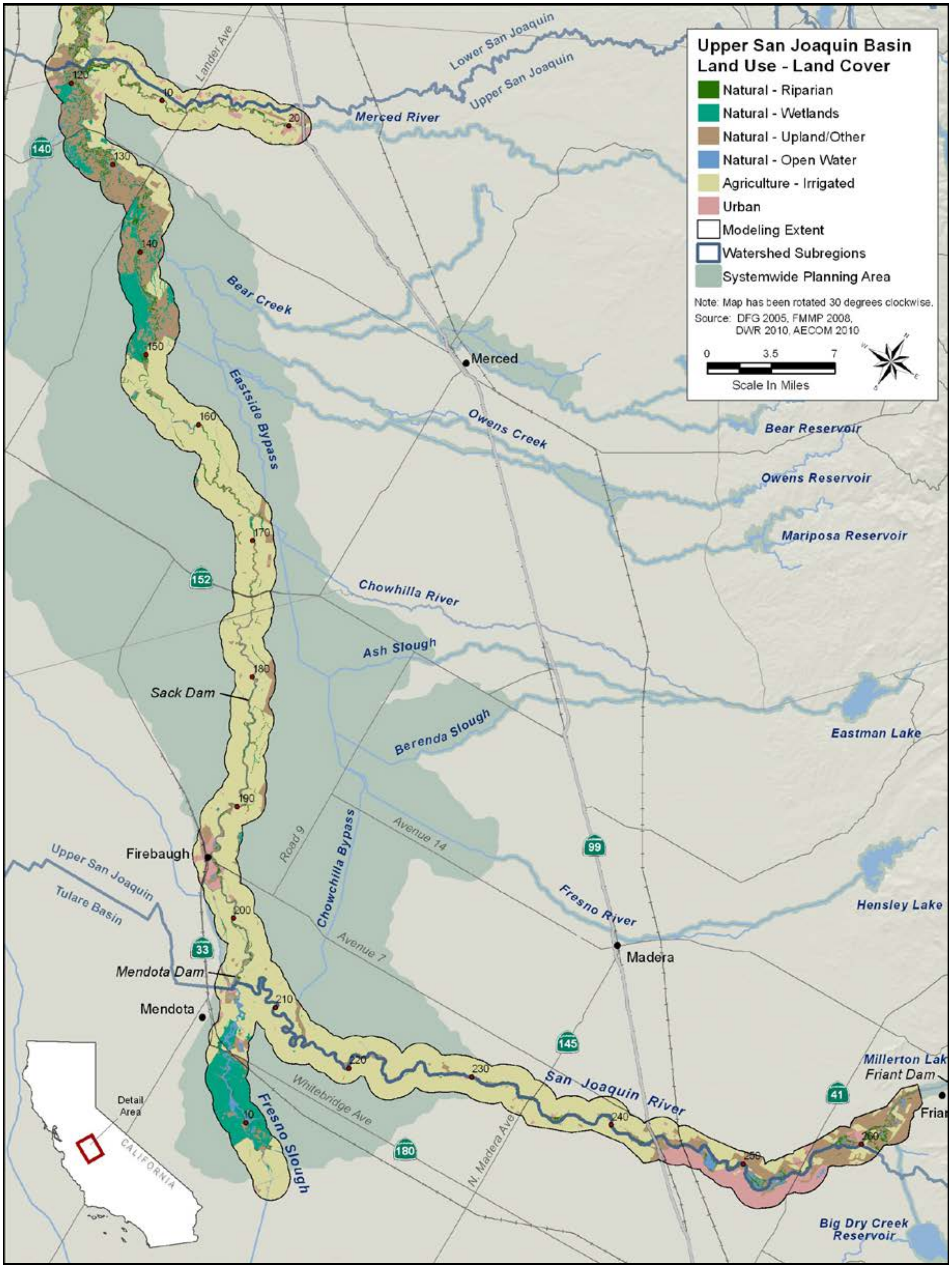

Figure 3-18. Land Use/Land Cover of River Corridors in the Upper San Joaquin Basin

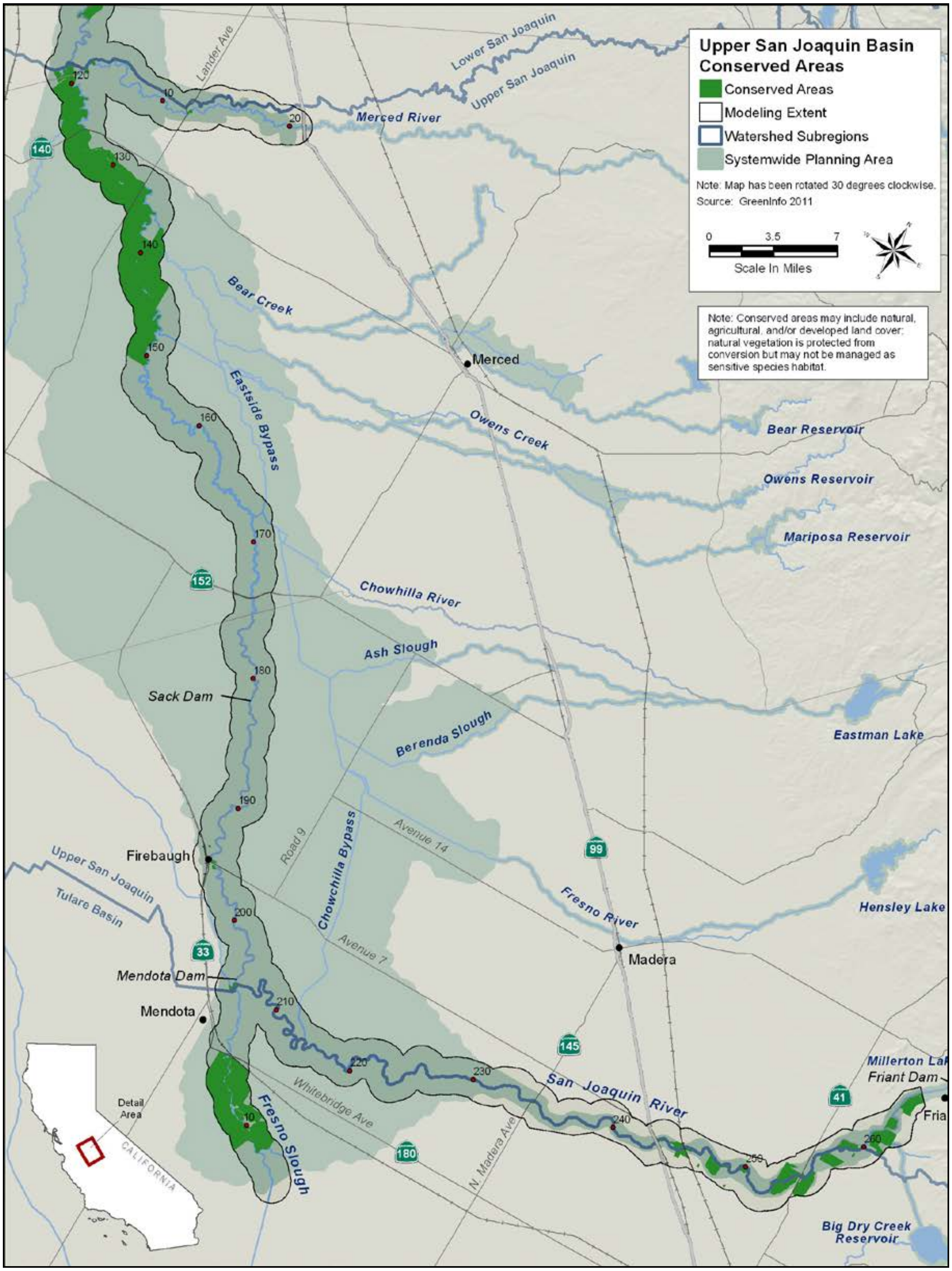

Figure 3-19. Conserved Areas of River Corridors in the Upper San Joaquin River Basin

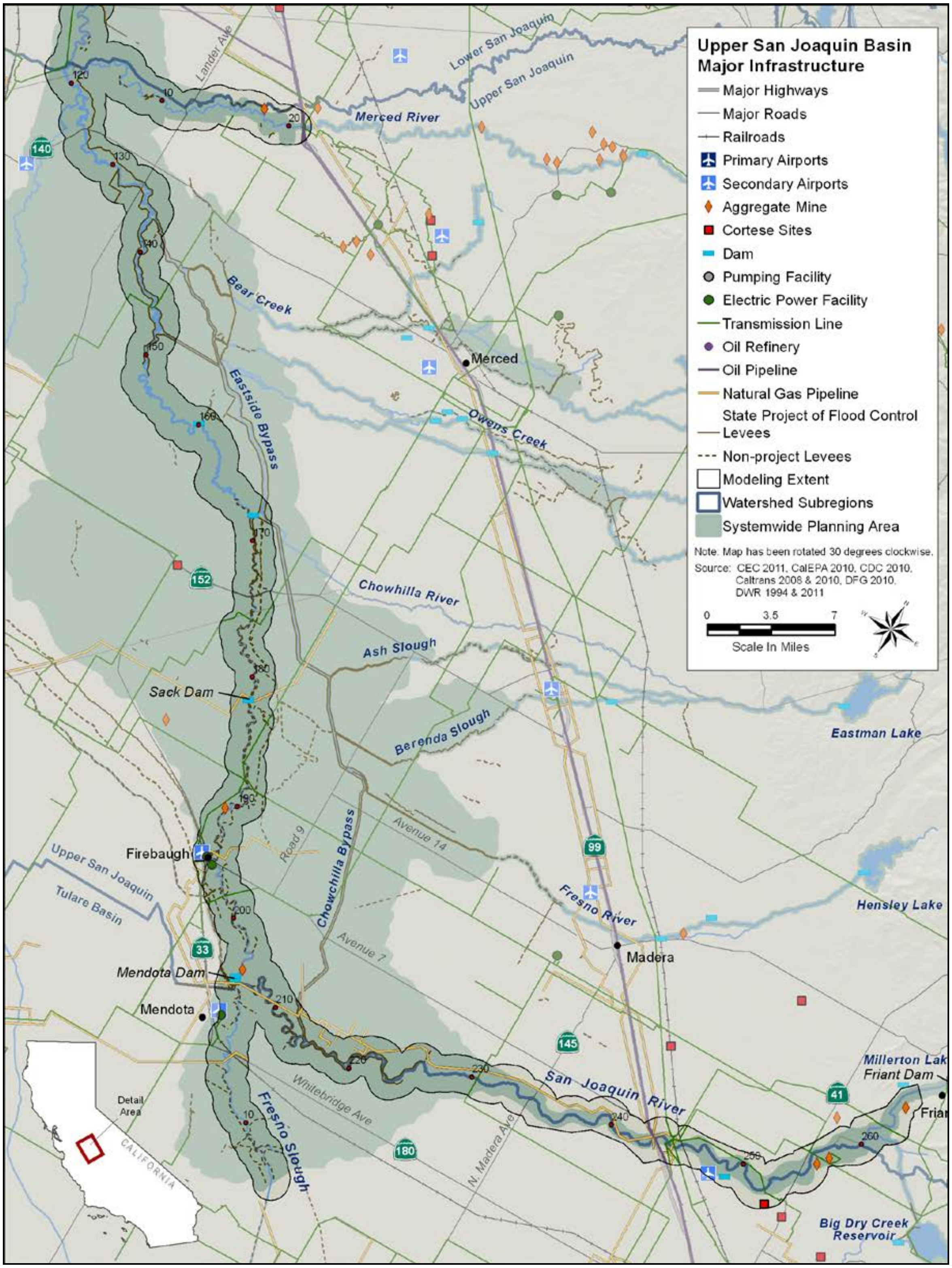

Figure 3-20. Major Infrastructure in River Corridors in the Upper San Joaquin Basin

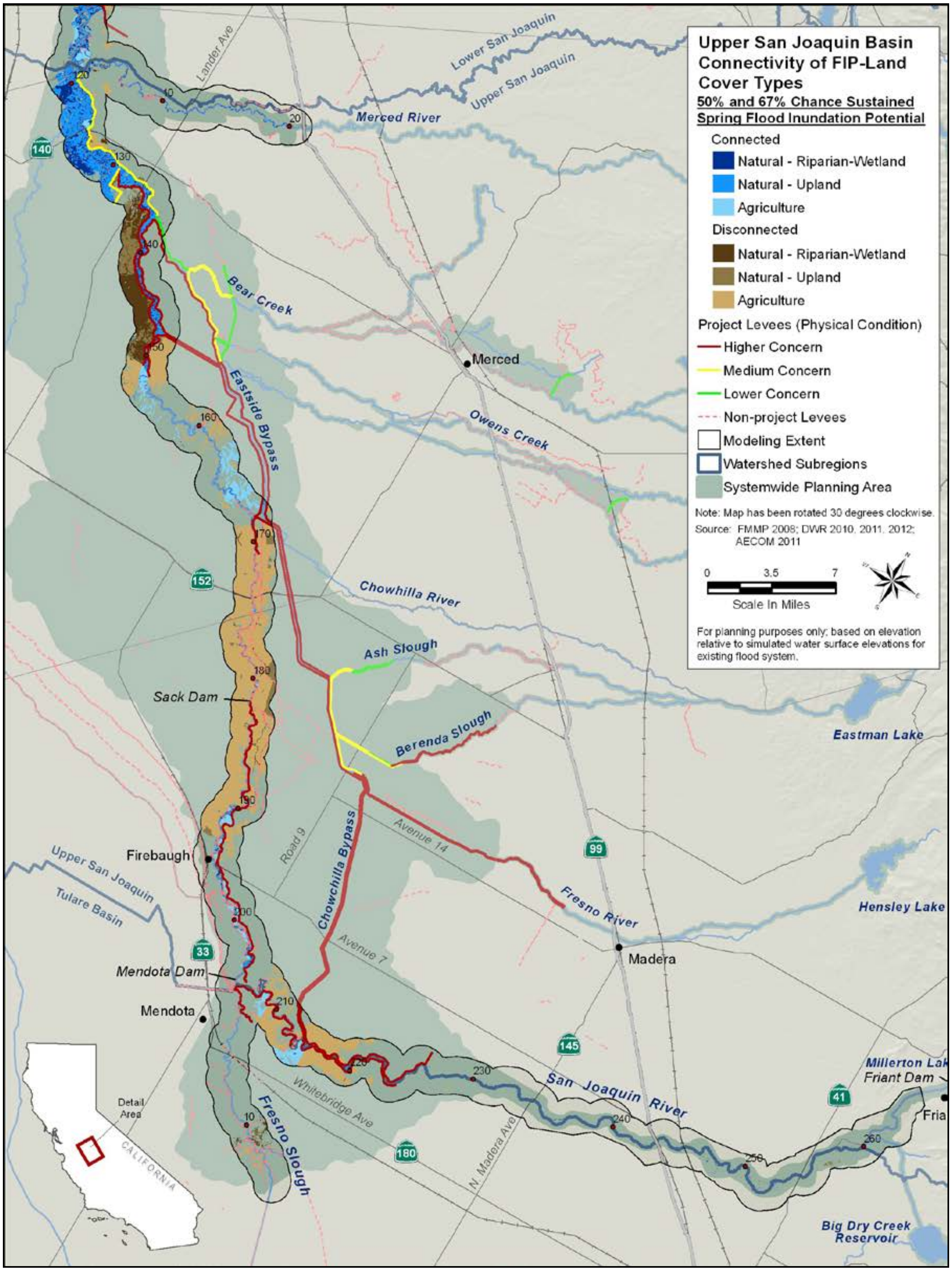

Figure 3-21. Connectivity of FIP-Land Cover Types in the Upper San Joaquin Basin

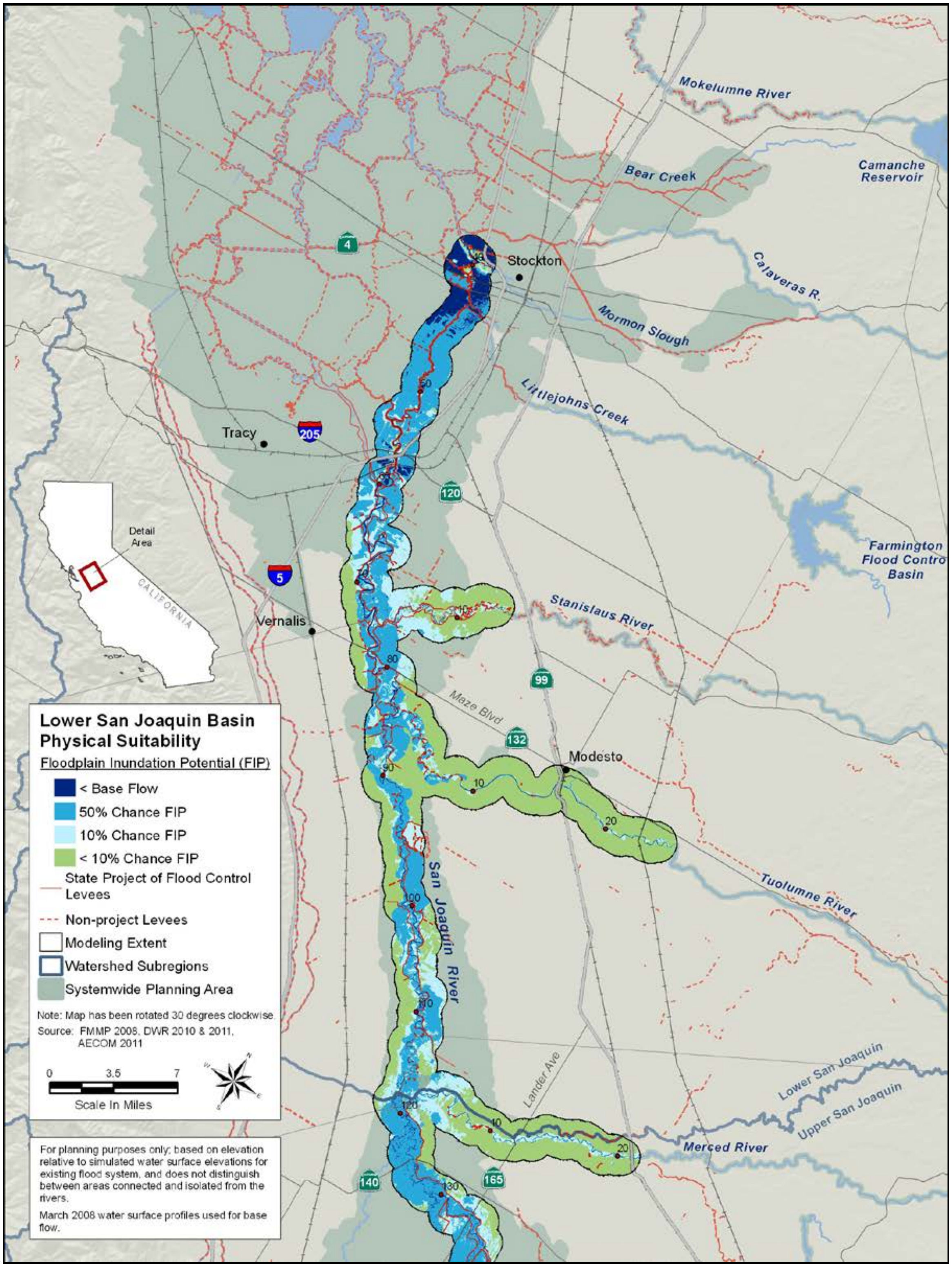

Figure 3-22. Floodplain Inundation Potential of River Corridors in the Lower San Joaquin Basin

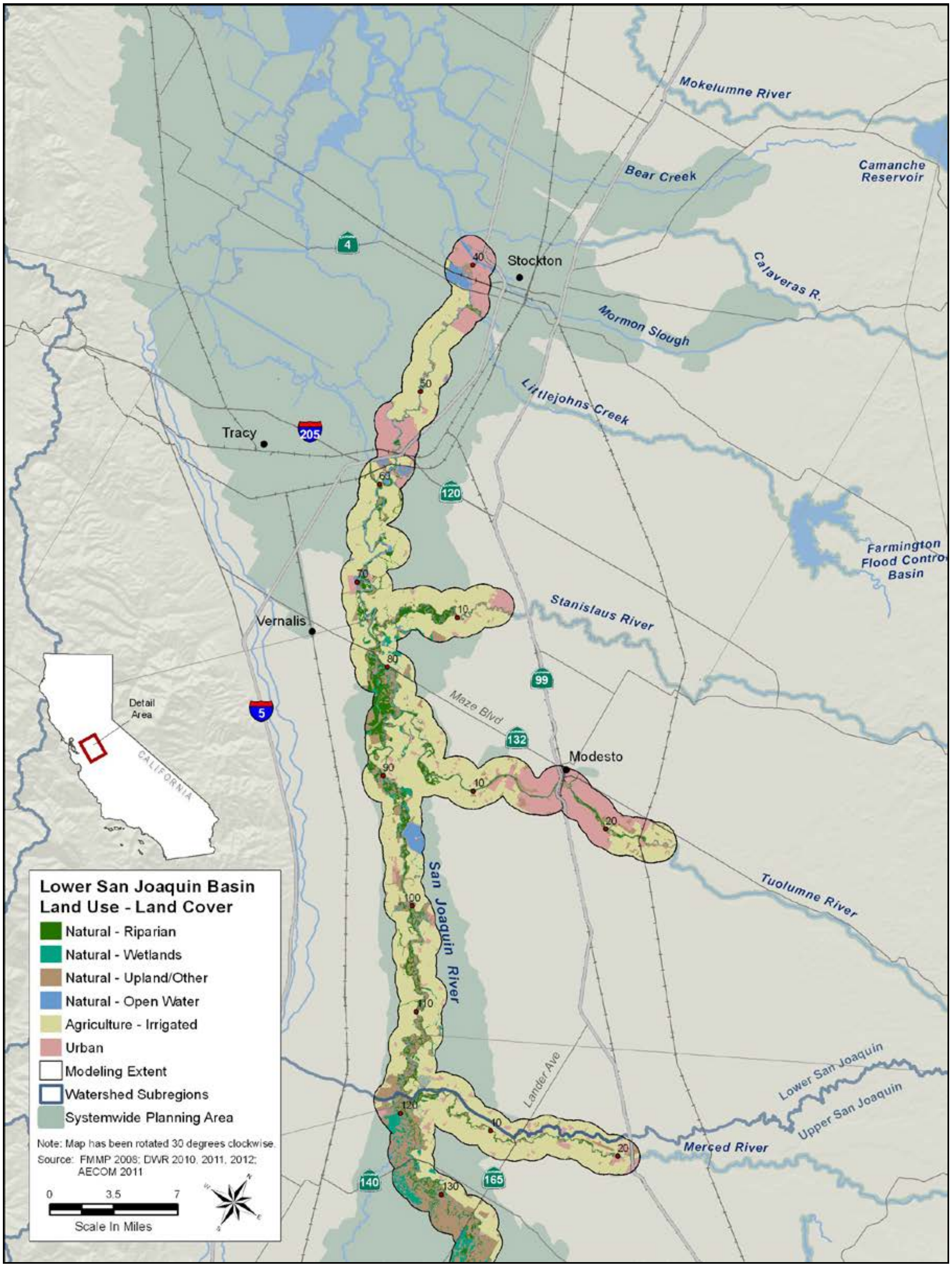

Figure 3-23. Land Use/Land Cover of River Corridors in the Lower San Joaquin Basin

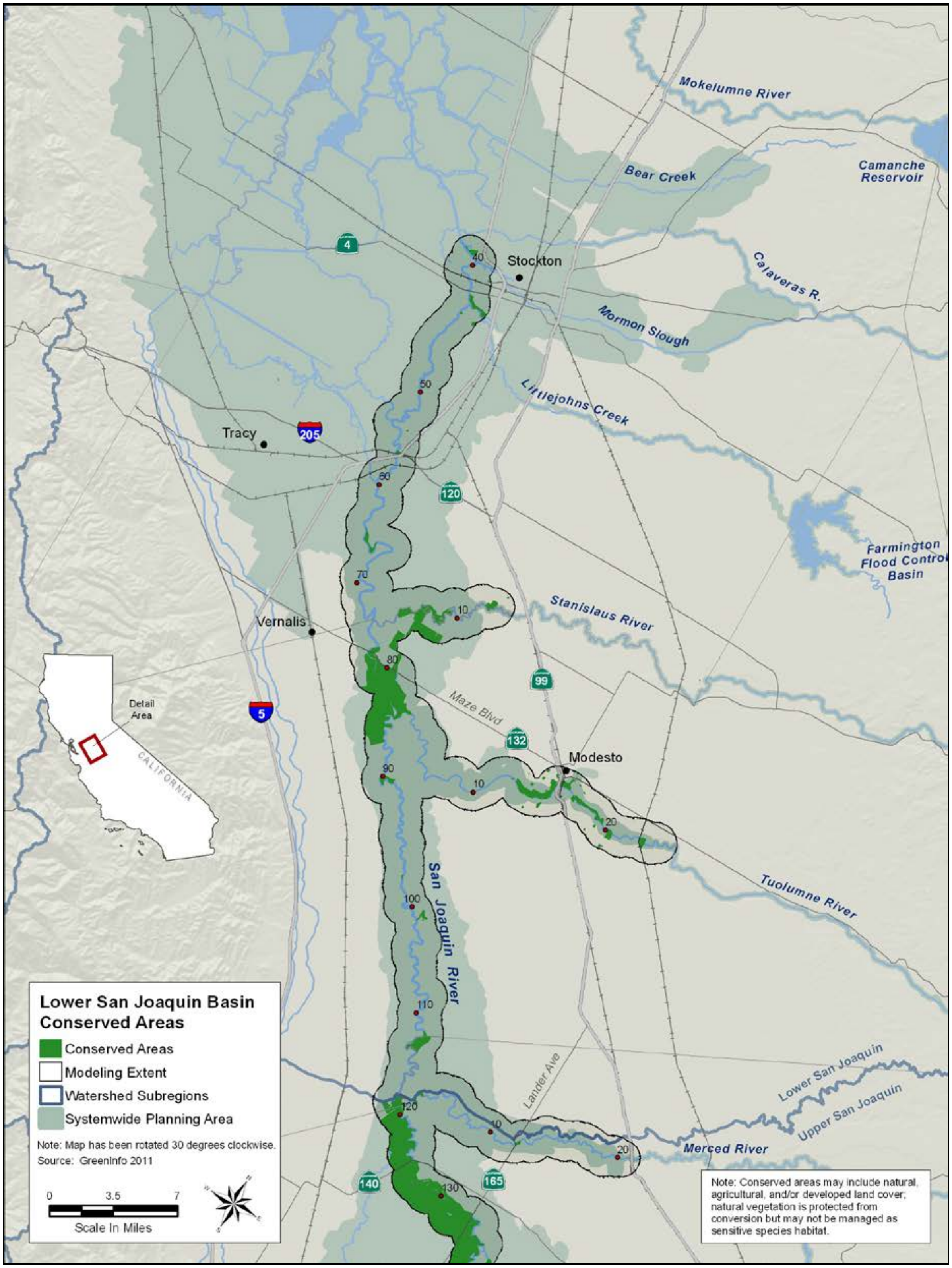

Figure 3-24. Conserved Areas of River Corridors in the Lower San Joaquin Basin

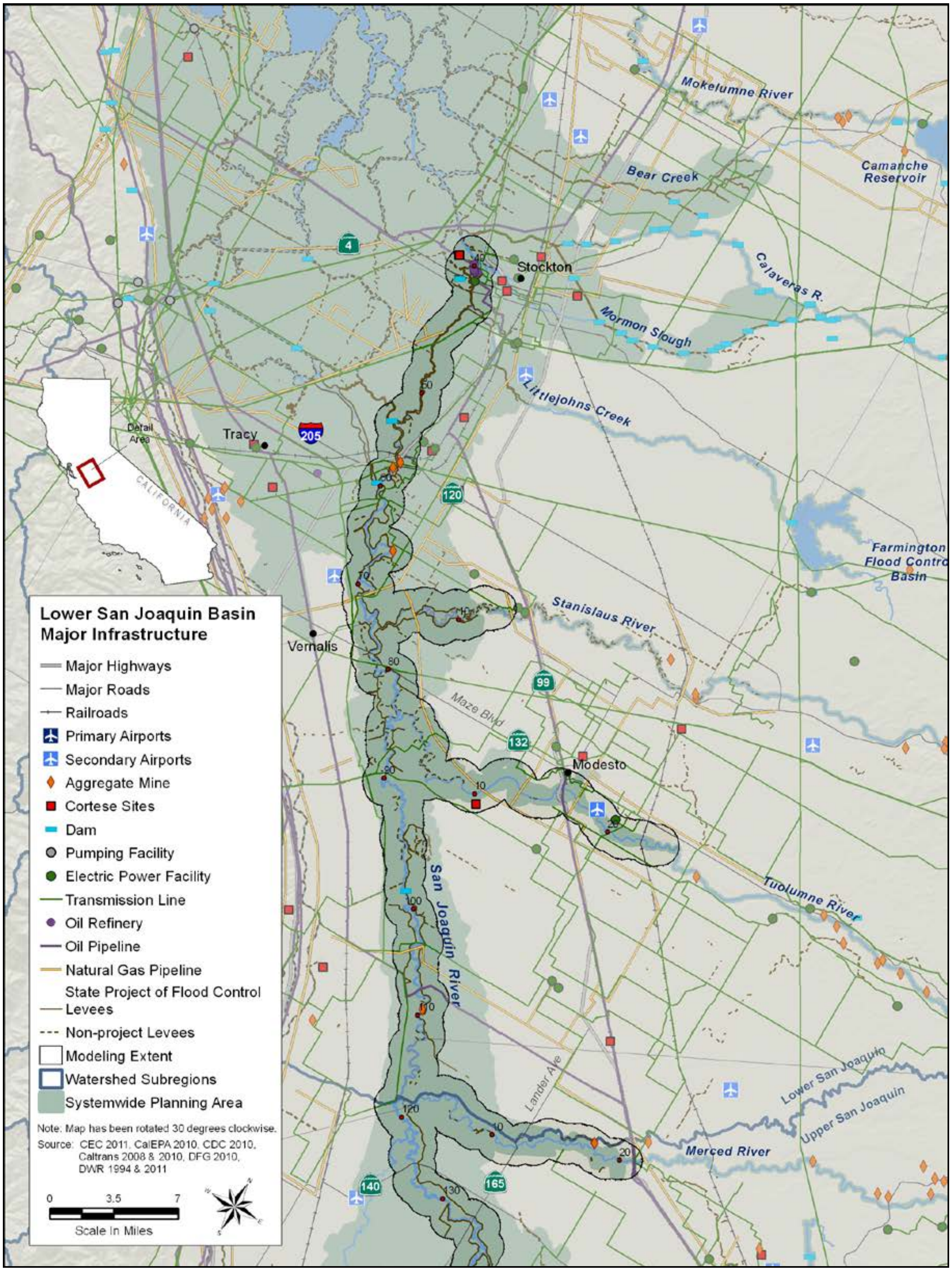

Figure 3-25. Major Infrastructure in River Corridors in the Lower San Joaquin Basin

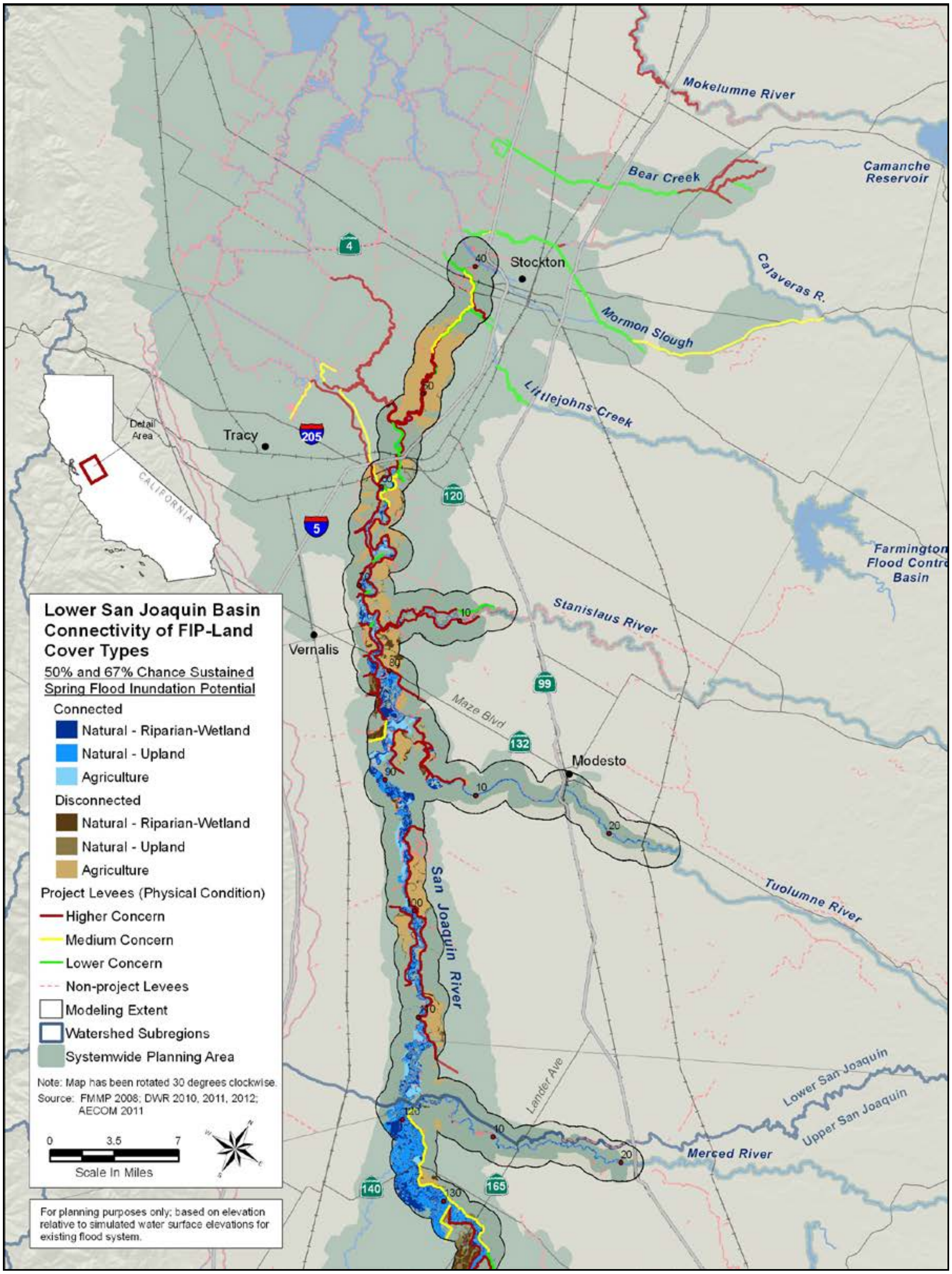

Figure 3-26. Connectivity of FIP-Land Cover Types in Lower San Joaquin Basin

Table 3-1. Floodplain Inundation Potential of Sacramento River

Reach	Modeled Area[1] (Acres)	Floodplain Inundation Potential[2] (Percent of Modeled Area)					
		< Base Flow[3]	67% Chance Spring[4]	50% Chance[5]	10% Chance[6]	< 10% Chance[7]	Total
Upper Sacramento Valley							
Woodson Bridge State Recreation Area–Chico Landing	26,800	7	<1	32	32	28	100
Chico Landing–Colusa	56,400	6	<1	71	12	11	100
Lower Sacramento Valley							
Colusa–Verona	71,400	27	10	61	0	2	100
Verona–American River	24,700	5	25	66	1	2	100
American River–Freeport	17,000	20	28	43	4	4	100
Freeport–Delta Cross Channel	24,800	61	31	5	1	2	100
Delta Cross Channel–Deep Water Ship Channel	16,200	93	3	2	1	2	100
Deep Water Ship Channel–Collinsville	14,600	60	0	3	1	35	100

Source: Data generated for this analysis by AECOM, 2011

Notes:

1 Data are for a corridor extending 1 mile from the centerline of evaluated rivers; acreages are rounded to the nearest 100 acres and percentages are rounded to the nearest percent.

2 Based on potential hydrologic regime using categories described by Williams et al., 2009, as indicated by floodplain inundation potential (FIP) determined using technique of Dilts et al., 2010, and AECOM, 2011.

3 Elevation below or at water surface elevation of March 2008 base flow (i.e., LiDAR FIP ≤1 foot.). Elevations within 1 foot of base flow were considered to represent the water surface because estimated elevations varied within 1 foot of true elevations.

4 Elevation above water surface of base flow but at or below that of 67 percent chance spring flow sustained for at least 7 days (i.e., LiDAR FIP > 1 foot, and 67 percent chance Sustained Spring FIP ≤1 foot.); 67 percent chance Sustained Spring FIP corresponds to Frequently Activated Floodplain of Williams et al., 2009, and Salmonid FIP of pilot study.

5 Elevation above water surface of 67 percent chance spring flow sustained for at least 7 days but below that of 50 percent chance flow (i.e., 67 percent chance Sustained Spring FIP >1 foot. and 50 percent chance FIP ≤1 foot.).

6 Elevation above water surface of 50 percent chance flow but below that of 10 percent chance flow (i.e., 50 percent chance FIP >1 foot. and 10 percent chance FIP ≤1 foot).

7 Elevation above water surface of 10 percent chance flow (i.e., 10 percent chance FIP >1 foot).

Table 3-2. Nonurban Floodplain Connectivity Percentages for the Sacramento River

Reach	Floodplain Inundation Potential[2]					
	67% Chance Sustained Spring[4]			50% Chance[5]		
	Extent (Acres)	Connectivity[6] (Percent)		Extent (Acres)	Connectivity[6] (Percent)	
		Connected	Disconnected		Connected	Disconnected
Upper Sacramento Valley						
Woodson Bridge State Recreation Area–Chico Landing	<100	100	0	7,600	86	14
Chico Landing–Colusa	200	98	2	37,900	41	59
Lower Sacramento Valley						
Colusa–Verona	6,800	6	94	42,400	12	88
Verona–American River	5,600	4	96	13,400	5	95
American River–Freeport	2,200	5	95	1,600	10	90
Freeport–Delta Cross Channel	7,100	3	97	1,000	7	93
Delta Cross Channel–Deep Water Ship Channel	400	22	78	200	56	44
Deep Water Ship Channel–Collinsville	<100	75	25	400	71	29

Source: Data generated for this analysis by AECOM, 2011

Notes:

1 Data are for a corridor extending 1 mile from the centerline of evaluated rivers; acreages are rounded to the nearest 100 acres and percentages are rounded to the nearest percent.

2 Based on potential hydrologic regime using categories described by Williams et al., 2009, as indicated by floodplain inundation potential (FIP) determined using technique of Dilts et al., 2010, and AECOM, 2011. Connectivity not modeled for areas with 10 percent chance and > 10 percent chance FIP.

3 Elevation below or at water surface elevation of March 2008 base flow (i.e., LiDAR FIP ≤1 foot.). Elevations within 1 foot of base flow were considered to represent the water surface because estimated elevations varied within 1 foot of true elevations.

4 Elevation above water surface of base flow but at or below that of 67 percent chance spring flow sustained for at least 7 days (i.e., LiDAR FIP > 1 foot, and 67 percent chance Sustained Spring FIP ≤1 foot.); 67 percent chance Sustained Spring FIP corresponds to Frequently Activated Floodplain of Williams et al., 2009, and Salmonid FIP of EFM (used in pilot study).

5 Elevation above water surface of 67 percent chance spring flow sustained for at least 7 days but below that of 50 percent chance flow (i.e., 67 percent chance Sustained Spring FIP >1 foot. and 50 percent chance FIP ≤1 foot).

6 Connected to or disconnected from river system during a 50 percent chance flow (i.e., modeled as as below and connected to river channel by terrain below elevation of 50 percent chance flow).

Table 3-3. Sacramento River Distribution of Nonurban 67 Percent Chance Sustained Spring and 50 Percent Chance FIP by Connectivity, Land Use, and Conservation Status[1]

Landscape Category	Percentage of Evaluated Corridor by Reach[2]							
	W. Bridge SRA–Chico Landing	Chico Landing–Colusa	Colusa–Verona	Verona–American River	American River–Freeport	Freeport–Delta Cross Channel	Delta Cross Channel–Deep Water Ship Channel	Deep Water Ship Channel–Collinsville
Connected[3]								
Conserved-Riparian/Wetland	7	5	<1	1	<1	<1	<1	<1
Conserved-Natural Upland	1	2	1	1	<1	<1	0	<1
Conserved-Agricultural	1	2	<1	<1	0	<1	<1	<1
Not Conserved-Riparian/Wetland	4	8	2	2	1	<1	<1	<1
Not Conserved-Natural Upland	2	4	1	<1	<1	<1	<1	1
Not Conserved-Agricultural	9	6	3	<1	<1	<1	<1	<1
Connected Subtotal	*24*	*28*	*8*	*4*	*2*	*1*	*1*	*2*
Disconnected[3]								
Conserved-Riparian/Wetland	<1	<1	<1	<1	<1	<1	<1	0
Conserved-Natural Upland	<1	<1	<1	<1	<1	1	<1	<1
Conserved-Agricultural	1	<1	<1	4	0	1	<1	<1
Not Conserved-Riparian/Wetland	<1	1	1	3	<1	<1	<1	<1
Not Conserved-Natural Upland	<1	<1	2	4	8	3	<1	<1
Not Conserved-Agricultural	2	37	57	61	11	26	2	<1
Disconnected Subtotal	*4*	*39*	*61*	*73*	*20*	*32*	*2*	*1*
Total	**28**	**68**	**69**	**77**	**22**	**33**	**3**	**3**

Source: DFG 1997, DOC 2008, DWR 2010, and Data generated for this analysis by AECOM, 2011

Notes:

1 Based on potential hydrologic regime using categories described by Williams et al., 2009, as indicated by floodplain inundation potential (FIP) determined using technique of Dilts et al., 2010, and AECOM, 2011. 67 percent chance Sustained Spring FIP represents elevations above water surface of base flow (i.e., March 2008 flows; LiDAR FIP) but at or below that of 67 percent chance spring flow sustained for at least 7 days (i.e., LiDAR FIP > 1 foot. and 67 percent chance Sustained Spring FIP ≤1 foot.). 50 percent chance FIP represents elevations above water surface of 50 percent chance flow but below that of 10 percent chance flow (i.e., 50 percent chance FIP >1 foot, and 10 percent chance FIP ≤1 foot.).

2 Data are for a corridor extending 1 mile from the centerline of evaluated rivers; percentages are rounded to the nearest percent.

3 Connected to or disconnected from river system during a 50 percent chance flow (i.e., modeled as inundated by flood flows under 2008 infrastructure and topography).

Table 3-4. Floodplain Inundation Potential of Sacramento River Tributaries

Reach	Modeled Area[1] (Acres)	Floodplain Inundation Potential[2] (Percent of Modeled Area)					
		< Base Flow[3]	67% Chance Spring[4]	50% Chance[5]	10% Chance[6]	< 10% Chance[7]	Total
Feather River							
Thermalito Afterbay–Yuba River	35,800	4	0	41	28	27	100
Yuba River–Bear River	18,600	5	1	86	6	2	100
Bear River–Sutter Bypass	5,800	6	1	89	1	2	100
Sutter Bypass–Sacramento River	8,600	4	12	83	1	1	100
Other Tributaries							
Yuba River	15,400	8	1	11	26	54	100
Bear River	14,600	3	12	37	35	14	100
American River	26,500	4	1	14	28	53	100

Source: Data generated for this analysis by AECOM, 2011

Notes:

[1] Data are for a corridor extending 1 mile from the centerline of evaluated rivers; acreages are rounded to the nearest 100 acres and percentages are rounded to the nearest percent.

[2] Based on potential hydrologic regime using categories described by Williams et al., 2009, as indicated by floodplain inundation potential (FIP) determined using technique of Dilts et al., 2010, and AECOM, 2011.

[3] Elevation below or at water surface elevation of March 2008 base flow (i.e., LiDAR FIP ≤1 foot.). Elevations within 1 foot of base flow were considered to represent the water surface because estimated elevations varied within 1 foot of true elevations.

[4] Elevation above water surface of base flow but at or below that of 67 percent chance spring flow sustained for at least 7 days (i.e., LiDAR FIP > 1 foot, and 67 percent chance Sustained Spring FIP ≤1 foot.); 67 percent chance Sustained Spring FIP corresponds to Frequently Activated Floodplain of Williams et al., 2009, and Salmonid FIP of pilot study.

[5] Elevation above water surface of 67 percent chance spring flow sustained for at least 7 days but below that of 50 percent chance flow (i.e., 67 percent chance Sustained Spring FIP >1 foot. and 50 percent chance FIP ≤1 foot.).

[6] Elevation above water surface of 50 percent chance flow but below that of 10 percent chance flow (i.e., 50 percent chance FIP >1 foot. and 10 percent chance FIP ≤1 foot).

[7] Elevation above water surface of 10 percent chance flow (i.e., 10 percent chance FIP >1 foot).

Table 3-5. Nonurban Floodplain Connectivity Percentages for Sacramento River Tributaries

Reach	Floodplain Inundation Potential[2]					
	67% Chance Sustained Spring[4]			50% Chance[5]		
	Extent (Acres)	Connectivity[6] (Percent)		Extent (Acres)	Connectivity[6] (Percent)	
		Connected	Disconnected		Connected	Disconnected
Feather River						
Thermalito Afterbay–Yuba River	100	100	<1	11,900	69	31
Yuba River–Bear River	200	70	30	14,200	31	69
Bear River–Sutter Bypass	100	87	13	5,100	35	65
Sutter Bypass–Sacramento River	1,000	57	43	7,000	57	43
Other Tributaries						
Yuba River	100	38	62	1,200	47	53
Bear River	1,200	14	86	5,200	15	85
American River	200	98	2	1,100	84	16

Source: Data generated for this analysis by AECOM, 2011

Notes:

1 Data are for a corridor extending 1 mile from the centerline of evaluated rivers; acreages are rounded to the nearest 100 acres and percentages are rounded to the nearest percent.

2 Based on potential hydrologic regime using categories described by Williams et al., 2009, as indicated by floodplain inundation potential (FIP) determined using technique of Dilts et al., 2010, and AECOM, 2011. Connectivity not modeled for areas with 10 percent chance and > 10 percent chance FIP.

3 Elevation below or at water surface elevation of March 2008 base flow (i.e., LiDAR FIP ≤1 foot.). Elevations within 1 foot of base flow were considered to represent the water surface because estimated elevations varied within 1 foot of true elevations.

4 Elevation above water surface of base flow but at or below that of 67 percent chance spring flow sustained for at least 7 days (i.e., LiDAR FIP > 1 foot, and 67 percent chance Sustained Spring FIP ≤1 foot.); 67 percent chance Sustained Spring FIP corresponds to Frequently Activated Floodplain of Williams et al., 2009, and Salmonid FIP of EFM (used in pilot study).

5 Elevation above water surface of 67 percent chance spring flow sustained for at least 7 days but below that of 50 percent chance flow (i.e., 67 percent chance Sustained Spring FIP >1 foot. and 50 percent chance FIP ≤1 foot).

6 Connected to or disconnected ("Discon.") from river system during a 50 percent chance flow (i.e., modeled as inundated by flood flows under existing conditions).

Table 3-6. Sacramento River Tributaries Distribution of Nonurban 67 Percent Chance Sustained Spring and 50 Percent Chance FIP by Connectivity, Land Use, and Conservation Status[1]

Landscape Category	Percentage of Evaluated Corridor by Reach[2]						
	Feather River				Other Tributaries		
	Thermalito Afterbay to Yuba River	Yuba River to Bear River	Bear River to Sutter Bypass	Sutter Bypass to Sacramento River	Yuba River	Bear River	American River
Connected[3]							
Conserved-Riparian/Wetland	1	8	4	0	<1	<1	2
Conserved-Natural Upland	1	3	9	0	<1	<1	1
Conserved-Agricultural	<1	1	<1	0	<1	<1	0
Not Conserved-Riparian/Wetland	4	7	9	6	1	3	<1
Not Conserved-Natural Upland	2	2	8	9	2	2	<1
Not Conserved-Agricultural	14	4	2	37	<1	1	<1
Connected Subtotal	*23*	*25*	*32*	*53*	*4*	7	4
Disconnected[3]							
Conserved-Riparian/Wetland	3	0	0	0	<1	<1	<1
Conserved-Natural Upland	1	<1	<1	0	<1	<1	<1
Conserved-Agricultural	<1	<1	<1	0	0	0	0
Not Conserved-Riparian/Wetland	<1	1	<1	<1	<1	1	<1
Not Conserved-Natural Upland	1	3	7	1	2	7	<1
Not Conserved-Agricultural	5	49	49	38	1	30	<1
Disconnected Subtotal	*10*	*53*	*57*	*40*	*5*	*38*	*1*
Total	**33**	**78**	**89**	**93**	**9**	**44**	**5**

Source: DFG 1997, DOC 2008, DWR 2010, and Data generated for this analysis by AECOM, 2011

Notes:

[1] Based on potential hydrologic regime using categories described by Williams et al., 2009, as indicated by floodplain inundation potential (FIP) determined using technique of Dilts et al., 2010, and AECOM, 2011. 67 percent chance Sustained Spring FIP represents elevations above water surface of base flow (i.e., March 2008 flows; LiDAR FIP) but at or below that of 67 percent chance spring flow sustained for at least 7 days (i.e., LiDAR FIP > 1 foot, and 67 percent chance Sustained Spring FIP ≤1 foot). 50 percent chance FIP represents elevations above water surface of 50 percent chance flow but below that of 10 percent chance flow (i.e., 50 percent chance FIP >1 foot. and 10 percent chance FIP ≤1 foot).

[2] Data are for a corridor extending 1 mile from the centerline of evaluated rivers; percentages are rounded to the nearest percent.

[3] Connected to or disconnected from river system during a 50 percent chance flow (i.e., modeled as inundated by flood flows under 2008 infrastructure and topography).

Table 3-7. Floodplain Inundation Potential of Upper San Joaquin River

Reach	Modeled Area[1] (Acres)	Floodplain Inundation Potential[2] (Percent of Modeled Area)					
		< Base Flow[3]	67% Chance[4]	50% Chance[5]	10% Chance[6]	< 10% Chance[7]	Total
Friant Dam–State Route 99	22,500	9	1	1	4	85	100
State Route 99–Gravelly Ford	19,400	2	1	2	2	92	100
Gravelly Ford–Chowchilla Bypass	10,500	6	13	29	18	34	100
Chowchilla Bypass–Mendota Dam	8,400	31	26	22	14	7	100
Mendota Dam–Sack Dam	23,800	4	3	66	1	27	100
Sack Dam–Sand Slough Control Structure	14,900	2	10	83	1	5	100
Sand Slough Control Structure–Mariposa Bypass	19,200	20	69	9	0	1	100
Mariposa Bypass–Bear Creek	9,700	2	6	90	1	1	100
Bear Creek–Merced River	16,00	4	4	52	19	20	100

Source: Data generated for this analysis by AECOM, 2011

Notes:

[1] Data are for a corridor extending 1 mile from the centerline of evaluated rivers; acreages are rounded to the nearest 100 acres and percentages are rounded to the nearest percent.

[2] Based on potential hydrologic regime using categories described by Williams et al., 2009, as indicated by floodplain inundation potential (FIP) determined using technique of Dilts et al., 2010, and AECOM, 2011.

[3] Elevation below or at water surface elevation of March 2008 base flow (i.e., LiDAR FIP ≤1 foot.). Elevations within 1 foot of base flow were considered to represent the water surface because estimated elevations varied within 1 foot of true elevations.

[4] Elevation above water surface of base flow but at or below that of 67 percent chance spring flow sustained for at least 7 days (i.e., LiDAR FIP > 1 foot, and 67 percent chance Sustained Spring FIP ≤1 foot.); 67 percent chance Sustained Spring FIP corresponds to Frequently Activated Floodplain of Williams et al., 2009, and Salmonid FIP of pilot study.

[5] Elevation above water surface of 67 percent chance Sustained Spring FIP but below that of 50 percent chance flow (i.e., 67 percent chance Sustained Spring FIP >1 foot. and 50 percent chance FIP ≤1 foot).

[6] Elevation above water surface of 50 percent chance flow but below that of 10 percent chance flow (i.e., 50 percent chance FIP >1 foot. and 10 percent chance FIP ≤1 foot).

[7] Elevation above water surface of 10 percent chance flow (i.e., 10 percent chance FIP >1 foot).

Table 3-8. Nonurban Floodplain Connectivity Percentages for Upper San Joaquin River

Reach	Floodplain Inundation Potential[2]					
	67% Chance Sustained Spring[4]			50% Chance[5]		
	Extent (Acres)	Connectivity[6] (Percent)		Extent (Acres)	Connectivity[6] (Percent)	
		Connected	Disconnected		Connected	Disconnected
Friant Dam–State Route 99	200	69	31	200	88	12
State Route 99–Gravelly Ford	300	100	0	300	96	4
Gravelly Ford–Chowchilla Bypass	1,400	19	81	2,800	11	89
Chowchilla Bypass–Mendota Dam	2,100	35	65	900	23	77
Mendota Dam–Sack Dam	600	68	32	9,300	13	87
Sack Dam–Sand Slough Control Structure	1,100	17	83	11,700	1	99
Sand Slough Control Structure–Mariposa Bypass	5,800	39	61	1,700	10	90
Mariposa Bypass–Bear Creek	500	57	43	4,800	21	79
Bear Creek–Merced River	700	99	1	7,800	84	16

Source: Data generated for this analysis by AECOM, 2011

Notes:

[1] Data are for a corridor extending 1 mile from the centerline of evaluated rivers; acreages are rounded to the nearest 100 acres and percentages are rounded to the nearest percent.

[2] Based on potential hydrologic regime using categories described by Williams et al., 2009, as indicated by floodplain inundation potential (FIP) determined using technique of Dilts et al., 2010, and AECOM, 2011. Connectivity not modeled for areas with 10 percent chance and > 10 percent chance FIP.

[3] Elevation below or at water surface elevation of March 2008 base flow (i.e., LiDAR FIP ≤1 foot.). Elevations within 1 foot of base flow were considered to represent the water surface because estimated elevations varied within 1 foot of true elevations.

[4] Elevation above water surface of base flow but at or below that of 67 percent chance spring flow sustained for at least 7 days (i.e., LiDAR FIP > 1 foot, and 67 percent chance Sustained Spring FIP ≤1 foot.); 67 percent chance Sustained Spring FIP corresponds to Frequently Activated Floodplain of Williams et al., 2009, and Salmonid FIP of EFM (used in pilot study).

[5] Elevation above water surface of 67 percent chance spring flow sustained for at least 7 days but below that of 50 percent chance flow (i.e., 67 percent chance Sustained Spring FIP >1 foot. and 50 percent chance FIP ≤1 foot).

[6] Connected to or disconnected (“Discon.”) from river system during a 50 percent chance flow (i.e., modeled as inundated by flood flows under existing conditions).

Table 3-9. Upper San Joaquin Valley Distribution of Nonurban 67 Percent Chance Sustained Spring and 50 Percent Chance FIP by Connectivity, Land Use, and Conservation Status[1]

Landscape Category	Percentage of Evaluated Corridor by Reach[2]								
	Friant Dam–SR 99	SR 99–Gravelly Ford	Gravelly Ford–Chowchilla Bypass	Chowchilla Bypass–Mendota Dam	Mendota Dam–Sack Dam	Sack Dam–Sand Slough Control Structure	Sand Slough Control Structure–Mariposa Bypass	Mariposa Bypass–Bear Creek	Bear Creek–Merced River
Connected[3]									
Conserved-Riparian/Wetland	0	0	0	<1	0	0	<1	3	12
Conserved-Natural Upland	<1	<1	0	0	0	0	<1	5	24
Conserved-Agricultural	0	0	0	0	0	0	0	<1	0
Not Conserved-Riparian/Wetland	1	1	<1	<1	2	1	1	1	2
Not Conserved-Natural Upland	<1	1	4	1	2	1	1	3	5
Not Conserved-Agricultural	<1	<1	1	10	3	<1	11	0	1
Connected Subtotal	*1*	*3*	*5*	*11*	*7*	*2*	*13*	*13*	*44*
Disconnected[3]									
Conserved-Riparian/Wetland	0	0	0	0	0	0	4	25	2
Conserved-Natural Upland	<1	0	0	0	0	0	2	16	3
Conserved-Agricultural	0	0	0	0	0	0	0	<1	<1
Not Conserved-Riparian/Wetland	0	0	<1	<1	1	1	<1	<1	1
Not Conserved-Natural Upland	<1	<1	<1	1	1	6	<1	<1	1
Not Conserved-Agricultural	<1	<1	34	24	33	77	20	0	2
Disconnected Subtotal	*<1*	*<1*	*34*	*25*	*35*	*84*	*26*	*41*	*8*
Total	**1**	**3**	**42**	**48**	**42**	**92**	**39**	**54**	**52**

Source: DFG 1997, DOC 2008, DWR 2010, and Data generated for this analysis by AECOM, 2011

Notes:

[1] Based on potential hydrologic regime using categories described by Williams et al., 2009, as indicated by floodplain inundation potential (FIP) determined using technique of Dilts et al,. 2010, and AECOM, 2011. 67 percent chance Sustained Spring FIP represents elevations above water surface of base flow (i.e., March 2008 flows; LiDAR FIP) but at or below that of 67 percent chance spring flow sustained for at least 7 days (i.e., LiDAR FIP > 1 foot, and 67 percent chance Sustained Spring FIP ≤1 foot).

[2] Data are for a corridor extending 1 mile from the centerline of evaluated rivers; percentages are rounded to the nearest percent.

[3] Connected to or disconnected from river system during a 50 percent chance flow (i.e., modeled as inundated by flood flows under 2008 infrastructure and topography).

Table 3-10. Floodplain Inundation Potential of Lower San Joaquin River and Tributaries

Reach	Modeled Area[1] (Acres)	Floodplain Inundation Potential[2] (Percent of Modeled Area)					
		< Base Flow[3]	67% Chance[4]	50% Chance[5]	10% Chance[6]	< 10% Chance[7]	Total
San Joaquin River							
Merced River–Tuolumne River	32,900	3	3	38	20	36	100
Tuolumne River–Stanislaus River	9,100	4	3	47	18	28	100
Stanislaus River–Stockton	35,200	18	15	40	19	9	100
Tributaries							
Merced River	18,800	1	1	4	21	73	100
Tuolumne River	25,700	1	1	5	5	88	100
Stanislaus River	10,700	2	<1	4	37	57	100

Source: Data generated for this analysis by AECOM, 2011

Notes:

[1] Data are for a corridor extending 1 mile from the centerline of evaluated rivers; acreages are rounded to the nearest 100 acres and percentages are rounded to the nearest percent.

[2] Based on potential hydrologic regime using categories described by Williams et al., 2009, as indicated by floodplain inundation potential (FIP) determined using technique of Dilts et al., 2010, and AECOM, 2011.

[3] Elevation below or at water surface elevation of March 2008 base flow (i.e., LiDAR FIP ≤1 foot). Elevations within 1 foot of base flow were considered to represent the water surface because estimated elevations varied within 1 foot of true elevations.

[4] Elevation above water surface of base flow but at or below that of 67 percent chance spring flow sustained for at least 7 days (i.e., LiDAR FIP > 1 foot, and 67 percent chance Sustained Spring FIP ≤1 foot.); 67 percent chance Sustained Spring FIP corresponds to Frequently Activated Floodplain of Williams et al., 2009, and Salmonid FIP of pilot study.

[5] Elevation above water surface of 67 percent chance spring flow sustained for at least 7 days but below that of 50 percent chance flow (i.e., 67 percent chance Sustained Spring FIP >1 foot. and 50 percent chance FIP ≤1 foot.).

[6] Elevation above water surface of 50 percent chance flow but below that of 10 percent chance flow (i.e., 50 percent chance FIP >1 foot. and 10 percent chance FIP ≤1 foot).

[7] Elevation above water surface of 10 percent chance flow (i.e., 10 percent chance FIP >1 foot).

Table 3-11. Nonurban Floodplain Connectivity Percentages for Lower San Joaquin River and Tributaries

Reach	Floodplain Inundation Potential[2]					
	67% Chance Sustained Spring[4]			50% Chance[5]		
	Extent (Acres)	Connectivity[6] (Percent)		Extent (Acres)	Connectivity[6] (Percent)	
		Connected	Disconnected		Connected	Disconnected
San Joaquin River						
Merced River–Tuolumne River	1,100	82	18	11,300	52	48
Tuolumne River–Stanislaus River	300	68	32	4,000	40	60
Stanislaus River–Stockton	4,200	9	91	9,300	11	89
Tributaries						
Merced River	100	96	4	500	38	62
Tuolumne River	200	85	15	1,000	49	51
Stanislaus River	<100	83	17	300	30	70

Source: Data generated for this analysis by AECOM, 2011

Notes:

[1] Data are for a corridor extending 1 mile from the centerline of evaluated rivers; acreages are rounded to the nearest 100 acres and percentages are rounded to the nearest percent.

[2] Based on potential hydrologic regime using categories described by Williams et al., 2009, as indicated by floodplain inundation potential (FIP) determined using technique of Dilts et al., 2010, and AECOM, 2011. Connectivity not modeled for areas with 10 percent chance and > 10 percent chance FIP.

[3] Elevation below or at water surface elevation of March 2008 base flow (i.e., LiDAR FIP ≤1 foot). Elevations within 1 foot of base flow were considered to represent the water surface because estimated elevations varied within 1 foot of true elevations.

[4] Elevation above water surface of base flow but at or below that of 67 percent chance spring flow sustained for at least 7 days (i.e., LiDAR FIP > 1 foot, and 67 percent chance Sustained Spring FIP ≤1 foot.); 67 percent chance Sustained Spring FIP corresponds to Frequently Activated Floodplain of Williams et al., 2009, and Salmonid FIP of EFM (used in pilot study).

[5] Elevation above water surface of 67 percent chance spring flow sustained for at least 7 days but below that of 50 percent chance flow (i.e., 67 percent chance Sustained Spring FIP >1 foot. and 50 percent chance FIP ≤1 foot.).

[6] Connected to or disconnected ("Discon.") from river system during a 50 percent chance flow; i.e., modeled as inundated by flood flows under existing conditions).

Table 3-12. Lower San Joaquin Valley Distribution of Nonurban 67 Percent Chance Sustained Spring and 50 Percent Chance FIP by Connectivity, Land Use, and Conservation Status[1]

Landscape Category	Percentage of Evaluated Corridor by Reach[2]					
	San Joaquin River			Tributaries		
	Merced River–Tuolumne River	Tuolumne River–Stanislaus River	Stanislaus River–Stockton	Merced River	Tuolumne River	Stanislaus River
Connected[3]						
Conserved-Riparian/Wetland	1	9	0	<1	<1	<1
Conserved-Natural Upland	1	5	<1	<1	<1	<1
Conserved-Agricultural	0	0	<1	0	0	0
Not Conserved-Riparian/Wetland	7	3	2	1	2	1
Not Conserved-Natural Upland	6	1	<1	<1	<1	<1
Not Conserved-Agricultural	5	1	1	<1	<1	<1
Connected Subtotal	*21*	*20*	*4*	*2*	*3*	*1*
Disconnected[3]						
Conserved-Riparian/Wetland	1	3	0	0	<1	1
Conserved-Natural Upland	<1	2	<1	0	0	<1
Conserved-Agricultural	0	5	<1	0	0	<1
Not Conserved-Riparian/Wetland	1	3	1	<1	<1	<1
Not Conserved-Natural Upland	1	2	1	<1	<1	<1
Not Conserved-Agricultural	14	12	32	1	1	1
Disconnected Subtotal	*17*	*28*	*34*	*2*	*2*	*2*
Total	**38**	**48**	**42**	**4**	**5**	**3**

Source: DFG 1997, DOC 2008, DWR 2010, and Data generated for this analysis by AECOM, 2011

Notes:

[1] Based on potential hydrologic regime using categories described by Williams et al., 2009, as indicated by floodplain inundation potential (FIP) determined using technique of Dilts et al., 2010, and AECOM, 2011. 67 percent chance Sustained Spring FIP represents elevations above water surface of base flow (i.e., March 2008 flows; LiDAR FIP) but at or below that of 67 percent chance spring flow sustained for at least 7 days (i.e., LiDAR FIP > 1 foot, and 67 percent chance Sustained Spring FIP ≤1 foot.). 50 percent chance FIP represents elevations above water surface of 50 percent chance flow but below that of 10 percent chance flow (i.e., 50 percent chance FIP >1 foot. and 10 percent chance FIP ≤1 foot).

[2] Data are for a corridor extending 1 mile from the centerline of evaluated rivers; percentages are rounded to the nearest percent.

[3] Connected to or disconnected from river system during a 50 percent chance flow (i.e., modeled as inundated by flood flows under 2008 infrastructure and topography).

4.0 Floodplain Restoration Opportunities: Conclusions and Recommendations

This chapter summarizes the relative extent of potential restoration opportunities identified along river reaches based on their physical suitability and existing land cover, and makes general recommendations for the future use of FROA results.

4.1 Conclusions

Restoration opportunities are widespread throughout the 2-mile-wide corridors evaluated along the Sacramento and San Joaquin river systems. Outside of urban areas, there are more than 320,000 acres of floodplain with a 67 percent chance Sustained Spring FIP or a 50 percent chance FIP under the existing flow regime of the Sacramento River system and the flow regime planned by the SJRRP for the San Joaquin River system.

These floodplain areas (which have the potential for frequent inundation) are most limited along several of the major tributaries (e.g., the American, Merced, Tuolumne, and Stanislaus rivers), the upper San Joaquin River from Friant Dam to Gravelly Ford, and the lower Sacramento River downstream of the Delta Cross Channel. Floodplain with 67 percent chance Sustained Spring FIP or a 50 percent chance FIP accounts for less than 5 percent of the evaluated corridors along these reaches. However, because 1 percent of a 2-mile-wide corridor is comparable to corridors about 50 feet wide on each river bank, even these reaches have restoration opportunities (e.g., creation of Shaded Riverine Aquatic habitat) that could have systemwide benefits.

Floodplain with the potential for frequent inundation is much more extensive along other river reaches, providing a greater variety of restoration opportunities. In particular, river reaches differ substantially in the extent of the following combinations of hydrologic connectivity to the river system, nonurban land use/land cover, and FIP that represent different types of restoration opportunities:

- Floodplain hydrologically connected to the river, with riparian or wetland vegetation, and with a 67 percent chance Sustained Spring Flow or a 50 percent chance FIP

- Floodplain hydrologically connected to the river, without riparian or wetland vegetation, with a 67 percent chance Sustained Spring Flow or a 50 percent chance FIP

- Floodplain hydrologically disconnected from the river with a 67 percent chance Sustained Spring Flow FIP

- Floodplain hydrologically disconnected from the river with a 50 percent chance FIP

Along all evaluated reaches of the Sacramento and San Joaquin river systems, each of these types of floodplain areas exist (Tables 4-1 and 4-2) and their restoration could provide ecologically important benefits. However, those reaches having the most extensive areas of each type probably represent greater and/or more feasible opportunities for large-scale restoration of riverine and floodplain ecosystems. The types of restoration opportunities represented by these floodplain areas and their distribution among river reaches are described further below. Their distribution among river reaches is also displayed in Tables 4-1 and 4-2.

Less than 40 percent of floodplain with a 67 percent chance Sustained Spring Flow or a 50 percent chance FIP remains hydrologically connected to the river system. Hydrologically connected floodplain is most extensive along the Sacramento River from Woodson Bridge to Colusa, the Feather River from Thermolito Afterbay to the junction with the Sacramento River, and the San Joaquin River from Bear Creek to the junction with the Stanislaus River. Hydrologically connected floodplain with a 67 percent chance Sustained Spring Flow or a 50 percent chance FIP accounts for 20 percent to 53 percent of the 2-mile-wide corridor along these reaches. The majority of this floodplain has a 50 percent chance FIP and is not frequently inundated by sustained spring flows.

Riparian and wetland vegetation covers only about a third (approximately 34 percent) of the floodplain that has remained connected to the river system, including most connected floodplain with a 67 percent chance Sustained Spring Flow FIP. In many of these areas, channel migration processes have been impeded by revetment, which has reduced habitat values. Similarly, the installation of revetment has reduced the amount of Shaded Riverine Aquatic habitat, and habitat for other species (e.g., bank swallow). Thus, there is an opportunity to restore these areas by revetment removal.

Table 4-1. Restoration Opportunities Along Sacramento River System

Reach	Modeled Area[1] (Acres)	Restoration Opportunity[2] (Percent of Modeled Area)					Notes
		Connected[3]		Disconnected[3]		Total	
		Riparian/ Wetland	Other Land Use/ Land Cover	67% Chance SS FIP[2],	50% Chance FIP[2]		
Sacramento River							
Woodson Bridge–Chico Landing	26,792	11	14	0	4	28	Extensive conserved land, bank swallow, yellow-billed cuckoo
Chico Landing–Colusa	56,442	14	14	<1	39	68	Bank swallow, yellow-billed cuckoo
Colusa–Verona	71,376	3	5	9	52	69	Bank swallow, yellow-billed cuckoo
Verona–American River	24,732	2	1	22	51	77	Extensive infrastructure constraints
American River–Freeport	16,969	1	1	12	8	22	Extensive development and infrastructure
Freeport–Delta Cross Channel	24,784	<1	1	28	4	33	Tidally influenced, in legal Delta
Delta Cross Channel–Deep Water Ship Channel	16,192	<1	1	2	1	3	Tidally influenced, in legal Delta
Deep Water Ship Channel–Collinsville	14,641	1	2	<1	1	3	Tidally influenced, in legal Delta
Feather River							
Thermalito Afterbay to Yuba River	35,830	6	18	<1	10	33	Historical and active gravel pits, fall-run Chinook spawning and rearing, bank swallow, yellow-billed cuckoo
Yuba River to Bear River	18,646	15	9	<1	53	78	Bank swallow
Bear River to Sutter Bypass	5,828	13	19	<1	57	89	Bank swallow, yellow-billed cuckoo
Sutter Bypass to Sacramento River	8,643	6	47	5	35	93	Bank swallow
Other Tributaries							
Yuba River	15,390	1	3	1	4	9	Extensive disturbed area (Yuba Gold Fields)
Bear River	14,612	3		7			Fall-run Chinook spawning and rearing (intermittent)
American River	26,489	3	2	<1	1	5	Extensive development and infrastructure, extensive conserved land, bank swallow, fall-run Chinook spawning and rearing

Source: Data generated for this analysis by AECOM in 2011

Notes:

1 Data are for a corridor extending 1 mile from each river bank of evaluated rivers; acreages are rounded to the nearest 100 acres and percentages are rounded to the nearest percent.

2 For nonurban areas and based on potential hydrologic regime using categories described by Williams et al., 2009, as indicated by floodplain inundation potential (FIP) determined using technique of Dilts et al., 2010, and AECOM, 2011. 67 percent chance Sustained Spring (SS) FIP represents elevations above water surface of base flow (i.e., March 2008 flows; LiDAR FIP) but at or below that of 67 percent chance spring flow sustained for at least 7 days (i.e., LiDAR FIP > 1 foot, and 67 percent chance Sustained Spring FIP ≤1 foot); 67 percent chance Sustained Spring FIP corresponds to Frequently Activated Floodplain of Williams et al., 2009, and Salmonid FIP of pilot study. 50 percent chance FIP represents elevations above water surface of 50 percent chance flow but below that of 10 percent chance flow (i.e., 50 percent chance FIP >1 foot. and 10 percent chance FIP ≤1 foot).

3 During 50 percent chance event, simulated under 2008 topography and infrastructure.

Table 4-2. Restoration Opportunities Along San Joaquin River System

Reach	Modeled Area[1] (Acres)	Restoration Opportunity (Percent of Modeled Area)					Notes
		Connected[3]		Disconnected[3]		Total	
		Riparian/Wetland	Other Land Use/Land Cover	67% chance SS FIP[2,]	50% chance FIP[2,]		
San Joaquin River							
Friant Dam to SR 99	22,545	1	<1	<1	<1	1	Extensive development and infrastructure, historical and active gravel pits, potential spawning habitat if salmon reintroduced
SR 99 to Gravelly Ford	19,373	1	2	<1	<1	3	
Gravelly Ford to Chowchilla Bypass	10,511	<1	5	10	24	40	
Chowchilla Bypass to Mendota Dam	8,368	<1	11	16	9	36	Mendota Pool – major infrastructure constraint
Mendota Dam to Sack Dam	23,842	2	5	1	34	42	Mendota Pool – major infrastructure constraint
Sack Dam to Sand Slough	14,895	1	2	6	78	86	
Sand Slough to Mariposa Bypass	19,180	1	12	18	8	39	Carries only local drainage, until modified
Mariposa Bypass to Bear Creek	9,689	5	8	2	39	54	Extensive conserved land
Bear Creek to Merced River	16,263	14	30	<1	8	52	Extensive conserved land
Merced River to Tuolumne River	32,861	8	13	1	17	38	
Tuolumne River to Stanislaus River	9,052	12	8	1	27	48	Riparian woodrat and riparian brush rabbit habitat, extensive conserved land
Stanislaus River to Stockton	35,191	2	2	11	23	38	Extensive development and infrastructure, riparian woodrat and riparian brush rabbit habitat, tidally influenced, in legal Delta
Tributaries							
Merced River	18,782	1	1	<1	2	2	
Tuolumne River	25,666	2	1	<1	2	2	Extensive development and infrastructure
Stanislaus River	10,672	1	<1	<1	2	2	Riparian woodrat and riparian brush rabbit habitat

Source: Data generated for this analysis by AECOM, 2011

Notes:

[1] Data are for a corridor extending 1 mile from each river bank of evaluated rivers; acreages are rounded to the nearest 100 acres and percentages are rounded to the nearest percent.

[2] For nonurban areas and based on potential hydrologic regime using categories described by Williams et al., 2009, as indicated by floodplain inundation potential (FIP) determined using technique of Dilts et al., 2010, and AECOM, 2011. 67 percent chance Sustained Spring FIP represents elevations above water surface of base flow (i.e., March 2008 flows; LiDAR FIP) but at or below that of 67 percent chance spring flow sustained for at least 7 days (i.e., LiDAR FIP > 1 foot, and 67 percent chance Sustained Spring FIP ≤1 foot.); 67 percent chance Sustained Spring FIP corresponds to Frequently Activated Floodplain of Williams et al., 2009, and Salmonid FIP of pilot study. 50 percent chance FIP represents elevations above water surface of 50 percent chance flow but below that of 10 percent chance flow (i.e., 50 percent chance FIP >1 foot. and 10 percent chance FIP ≤1 foot).

[3] During 50 percent chance event, simulated under 2008 topography and infrastructure.

In many areas of floodplain hydrologically connected to the river system and lacking riparian vegetation, riparian vegetation could be established through natural processes or plantings. However, the SPFC often has insufficient capacity to allow for the increased roughness (i.e., resistance to water flow) of additional riparian vegetation. Thus, there is an opportunity to facilitate future restoration of these areas by increasing the capacity of the SPFC to allow for the increased roughness of riparian vegetation.

More than 60 percent of floodplain with a 67 percent chance Sustained Spring Flow or a 50 percent chance FIP is hydrologically disconnected from the river system by levees. Riparian and wetland vegetation cover only several percent of this disconnected floodplain. Also, less than 5 percent of this disconnected floodplain is conserved along most reaches. Reconnecting these floodplains, particularly areas with a 67 percent chance Sustained Spring FIP, to the river system could provide higher quality habitat for salmonids, and other ecological functions.

Disconnected areas with a 67 percent chance Sustained Spring Flow FIP are relatively extensive along the Sacramento River from Verona to the Delta Cross Channel, and along several reaches of the San Joaquin River: Gravelly Ford to Mendota Dam, Sand Slough to the Mariposa Bypass, and from the Stanislaus River to Stockton. However, major infrastructure constraints are also extensive along several of these reaches, in particular along the Sacramento River from Verona to Freeport. Thus, large-scale opportunities to restore these areas by setting back levees or otherwise reconnecting these areas to the river system are limited.

Extensive areas of disconnected floodplain with a 50 percent chance FIP are more widespread along the Sacramento and San Joaquin river systems than areas with a 67 percent chance FIP. Floodplain with a 50 percent chance FIP are extensive along the Sacramento River from Chico Landing to the junction with the American River; the lower Feather River, particularly from the junction with the Yuba River to the junction with the Sacramento River; and much of the San Joaquin River from Gravelly Ford to Stockton.

The feasibility, costs, and benefits of restoring any of these areas are strongly influenced by their relationship to CVFPP projects and policies, and by the content of the Central Valley Flood System Conservation Strategy (CVFSCS). Also, potential benefits differ qualitatively among reaches because sensitive species differ in their distribution. For example, reaches providing salmonid spawning habitat do not provide delta smelt habitat, and reaches providing riparian brush rabbit habitat may not provide bank swallow habitat. Consequently, the identification and prioritization of restoration opportunities are both part of the continuing development of the overall CVFPP and of the development of species-focused conservation planning and corridor management strategies, as described in the Conservation Framework of the 2012 CVFPP.

Based in part on the results of this FROA, DWR is identifying, prioritizing, and further developing specific restoration opportunities for these river reaches. Opportunities are being identified and prioritized on the basis of their potential ecological, flood management, and other benefits (e.g., reduced maintenance and regulatory compliance costs); cost; and regulatory, institutional, technological, and operational feasibility.

4.2 Recommendations

The following are recommendations for future use of the results of this analysis for development of CVFPP projects and the CVFSCS:

- Consider FROA results during project planning as general indicators of potential ecosystem benefits.
- Conduct additional stakeholder interviews to develop a more comprehensive compilation of stakeholder-identified projects.
- Apply FROA results to evaluate the ecosystem effects of alternative actions.
- Apply FROA results to CVFSCS development as a component of baseline ecosystem conditions together with a more comprehensive summary of riverine and riparian-associated species.
- Use FROA results to identify and/or prioritize sites for preservation or restoration.
- Integrate FROA results with mapping of SRA, revetment, and natural banks to more specifically consider reach-scale opportunities for restoring channel migration.

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Reclamation. *See* U.S. Department of the Interior, Bureau of Reclamation.

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6.0 Acronyms and Abbreviations

cfs .... cubic feet per second

CNDDB .... California Natural Diversity Database

Comprehensive Study .... Sacramento and San Joaquin River Basins Comprehensive Study

CVFED .... Central Valley Floodplain Evaluation and Delineation

CVP..................................... Central Valley Project

CVFPP .... Central Valley Flood Protection Plan

CVFSCS.............................. Central Valley Flood System Conservation Strategy

Delta.................................... Sacramento-San Joaquin Delta

DEM .... digital elevation model

DFG .... California Department of Fish and Game

DWR .... California Department of Water Resources

EFR..................................... Ecosystem Function Relationship

ESRI.................................... Environmental Systems Research Institute, Inc.

FIP .... floodplain inundation potential

FROA .... Floodplain Restoration Opportunity Analysis

GIS...................................... geographic information system

HAA..................................... Habitat Analysis Areas

HAR .... Height Above River

HEC-DSS............................ Hydrologic Engineering Center’s Data Storage System

HEC-EFM............................ Hydrologic Engineering Center’s Ecosystem Functions Model

HEC-GeoRAS .... Hydrologic Engineering Center’s River Analysis System

HEC-RAS .... Hydrologic Engineering Center’s River Analysis System

LiDAR.................................. Light Detection and Ranging

MTL..................................... Mean Tidal Level

MWH	MWH Americas, Inc.
NAVD88	North American Vertical Datum 1988
NGVD29	National Geodetic Vertical Datum of 1929
NOAA	National Oceanic and Atmospheric Administration
RM	River Miles
SacEFT	Sacramento River Ecological Flows Tool
SJRRP	San Joaquin River Restoration Program
SPFC	State Plan of Flood Control
SR	State Route
SRA	State Recreation Area
UPID	Union Pacific Interceptor Canal
USACE	U.S. Army Corps of Engineers
USACE-HEC	U.S. Army Corps of Engineers Hydrologic Engineering Center
USGS	U.S. Geological Survey
VELB	Valley elderberry longhorn beetle

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Attachment 9F: Floodplain Restoration Opportunity Analysis Appendix A – Floodplain Inundation and Ecosystem Functions Model Pilot Studies

June 2012

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Appendix A

1.0 Overview

This appendix provides the methods, results, and conclusions of two pilot studies conducted on the lower Feather River to evaluate the suitability of floodplain inundation potential (FIP) (also known as Height Above River (HAR)) (Dilts et al., 2010) and U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center's Ecosystem Functions Model (HEC-EFM) analyses for use in the Floodplain Restoration Opportunity Analysis (FROA). Each pilot study is discussed in a separate section:

- 2.0, Floodplain Inundation Pilot Study
- 3.0, Hydrologic Engineering Center's Ecosystem Functions Model Pilot Study

The approach of the FROA was developed in part from the results and conclusions of these pilot studies.

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2.0 Floodplain Inundation Pilot Study

2.1 Overview

This pilot study is a test of the proposed approach for the FROA displayed on Figure A-1. This approach uses readily available topographic and hydrologic data sets, and straightforward geographic information system (GIS) analyses to identify floodplains inundated under more frequent, ecologically valuable flow events (e.g., 50 and 10 percent chance events). The HAR tool (Dilts et al., 2010) was identified as a method that could potentially be adapted for use in this FIP analysis. GIS layers based on the results of this analysis would show floodplains that could be more readily reconnected to the river during specific flow events. The specific method of this approach is described in the following sections.

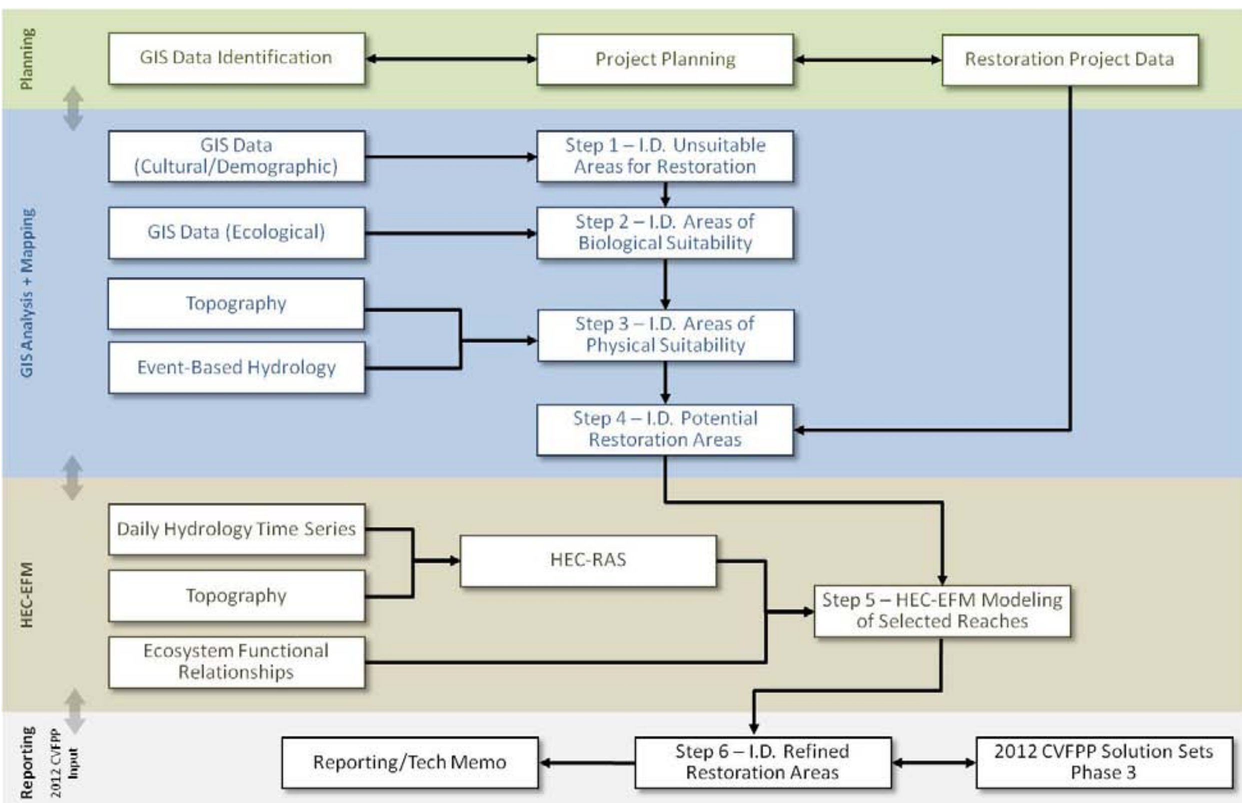

Figure A-1. Proposed Approach for CVFPP Floodplain Restoration Opportunity Analysis

For the purpose of this work, the “FIP method” is the term used to describe a series of GIS tools provided within the Riparian Topography Toolbox, as described by Dilts et al. (2010). These tools are distributed as the ArcGIS Riparian Topography Toolbox by Environmental Systems Research Institute, Inc. (ESRI) (ESRI, 2011).

Through our review and application of the publically available tools in this toolbox, and with the use of unpublished tools provided by Mr. Dilts, we have established a series of steps that constitute the FIP method. These steps are described in the following sections:

- 2.2, Identify Pilot-Study Area
- 2.3, Compile and Review Data
- 2.4, Generate Stream Raster
- 2.5, Calculate Flooplain Inundation Potential
- 2.6, Calculate Flood Height
- 2.7, Calculate Inundation Area

The Riparian Topography Toolbox tools were developed for application to actual river water surface conditions at the time of a Light Detection and Ranging (LiDAR) flight. Since an objective of this pilot study was to investigate the application of these tools to hypothetical flood conditions, other than observed water surface conditions, some deviations were made in the application of the tools; however, the Generate Stream Raster tool was common to all applications.

Section 2.8 describes notes that data were modified to account for two locations in the pilot study area, two locations where levees had been set back after the March 2008 date of the LiDAR flight. Sections 2.9 through 2.11 provide the height above river results, inundation area results, and the conclusions of this pilot study, respectively.

2.2 Identify Pilot-Study Area

An approximately 20-mile reach of the Feather River was selected for the pilot study from the confluence with the Sutter Bypass, upstream to Yuba City at River Station (RS) 27.75 (Figure A-2); the purple rectangle shown on Figure A-2 indicates the specific subreach to which the FIP method was applied.

2.3 Compile and Review Data

The following data were compiled and reviewed in preparation for the application of the HAR tool to the pilot-study area.

1. Terrain Data – Central Valley Floodplain Evaluation and Delineation (CVFED) preprocessed LiDAR and breakline data were obtained and processed into 25-foot digital elevation models (DEM).

2. Water-Surface Profiles – The following water-surface profiles were used in the pilot study:

   a. March 2008 LiDAR water-surface profiles – The river water surfaces at the time of the LiDAR flight were used for initial investigations of the relationship of water levels to floodplain inundation.

   b. Ten- and 20-foot test profiles – Arbitrary heights of 10 and 20 feet above the LiDAR water surface were used initially to evaluate floodplain inundation areas from higher water levels; these heights were replaced by the Sacramento and San Joaquin River Basins Comprehensive Study (Comprehensive Study) (USACE and The Reclamation Board 2002) 50 and 10 percent chance water-surface profiles for further investigations.

   c. Comprehensive Study 50 and 20 percent chance event water-surface profiles – Water-surface profiles for these two return period flood events were obtained by running the Comprehensive Study's model derived from the USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS) for the pilot study river reach.

   d. Vertical datum conversion – Water surface elevations from the HEC-RAS models are in the older National Geodetic Vertical Datum of 1929 (NGVD29) vertical datum and were converted to the current North American Vertical Datum 1988 (NAVD88) vertical datum to match the vertical datum of the terrain data. Figure A-3 summarizes the spatial variation of the conversion factors in the Central Valley. An average of the conversion factors along the pilot-study stream reach was estimated and this value of +2.335 feet was applied to the HEC-RAS NGVD29 elevations to estimate the NAVD88 elevations.

Figure A-2. Lower Feather River Pilot-Study Area

The vertical datum conversion was cross-checked by identifying the latitude/longitude of the pilot-study reach and entering this into the National Geodetic Survey (NGS) on-line tool VERTCON (NGS, 2011) to perform the conversion, and the results were similar.

ArcGIS Riparian Topography Toolbox – The Riparian Topography Toolbox for ArcGIS was downloaded from the ESRI Web site (ESRI, 2011). The HAR tool is one of the tools contained within the Riparian Topography Toolbox and includes tools for calculating FIP, inundation area for a given FIP, and flood height.

The FIP method requires the use of a DEM terrain surface. Two sources of DEMs were evaluated for use in the pilot study: (1) U.S. Geological Survey (USGS) 10-meter DEMs (USGS, 2010), and (2) CVFED preliminary DEMs (DWR, 2010b).

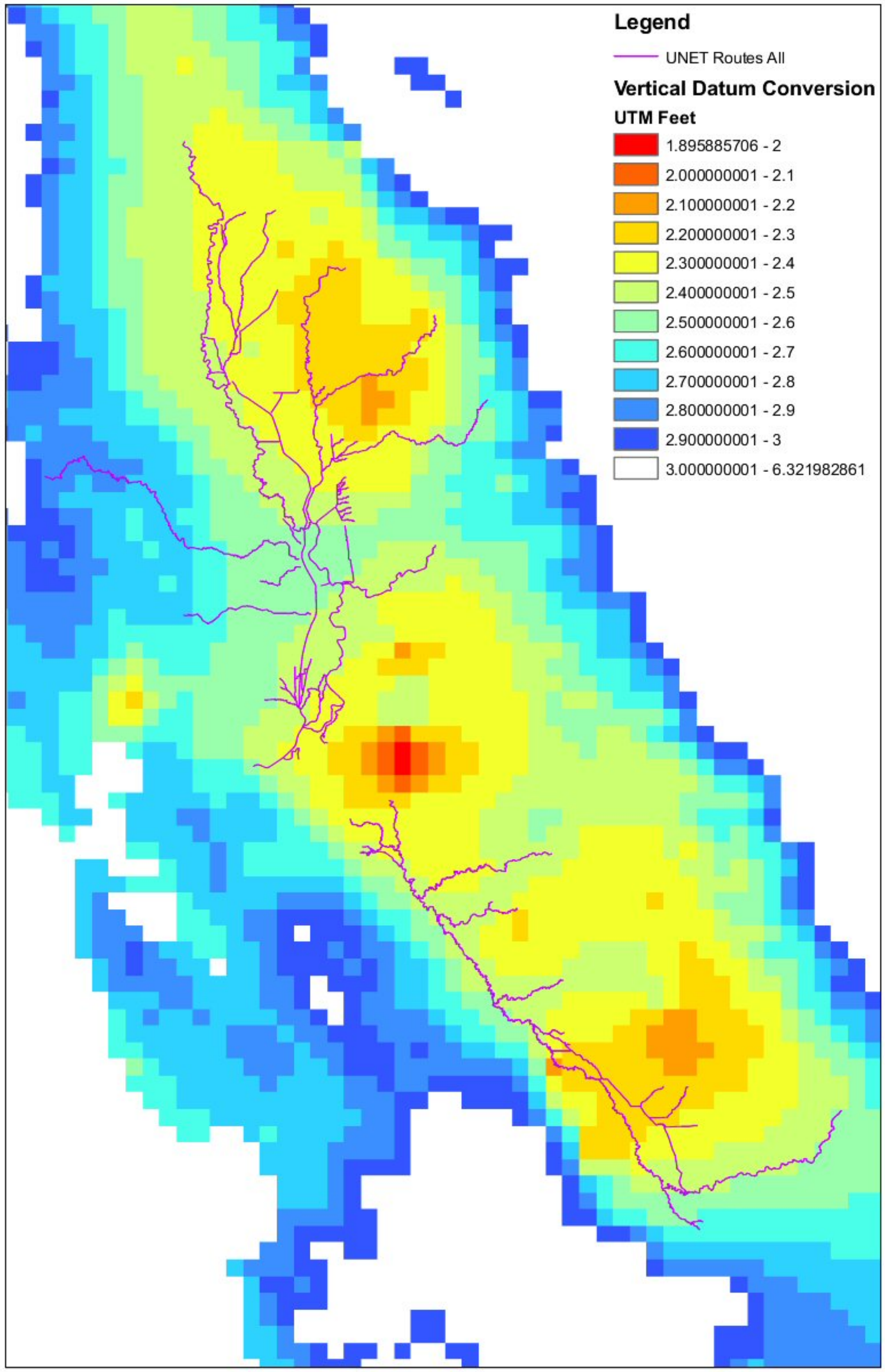

Figure A-3. Central Valley NGVD29 to NAVD88 Vertical Datum Conversion (NAVD88 elevations are higher than NGVD29 elevations)

USGS 10-meter DEMs (USGS, 2010) were obtained and evaluated for their appropriateness of use in the pilot study. Appendix B provides the methods and results of a brief assessment of the data, which led to the decision not to use the USGS data because of the significant inaccuracies found in the delineation of project levees and ground elevations.

New DEMs are being prepared as part of the CVFED program, though the final DEMs have not been completed. Available preliminary CVFED terrain data were obtained for the pilot-study area in October 2010, for use in preparing a DEM for the pilot-study area. The DEM preparation involved incorporating/building breaklines and filling in void areas found in these preliminary CVFED data. The LiDAR data had data voids where water and dense vegetation restricted the triangular irregular network (TIN) from triangulating, essentially leaving large gaps in the TIN. Points were created in those areas to help complete the TIN.

A brief comparison was done to determine the level of effort and resulting data file sizes for the preparation of a DEM with a 5-, 25-, 50-, and 100-foot grid cell resolution (Appendix C). Based on the results of this comparison, DWR decided to develop a 25-foot DEM using preprocessed CVFED data in the pilot-study area. The use of a 25-foot-resolution DEM was determined to provide a reasonable balance between the preparation time, resolution (usability), and file sizes with the intended level of detail for the final products from this planning-level exercise.

2.4 Generate Stream Raster

One of the first tasks required for the FIP analysis was the generation of the Stream Raster. This was previously accomplished through a series of steps using ArcHydro and Arc Map; however, a new unpublished tool “Derive Stream Raster” replaces the previous process and the tool was obtained from Mr. Dilts, the HAR author (Dilts, 2011). The Derive Stream Raster tool was located by navigating through the Topography Tools toolbox as follows: Topography Tools → Riparian Tools → Transverse → 2_Derive Stream Raster. The following steps were taken to complete the generation of the stream raster using Derive Stream Raster, and the input menu is shown on Figure A-4:

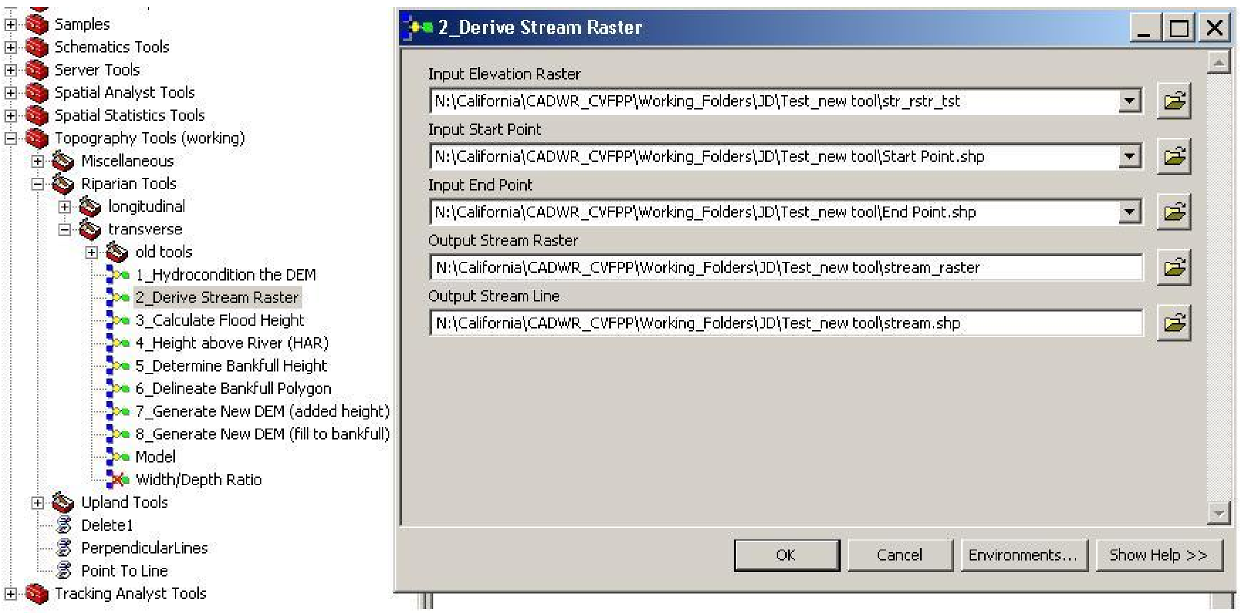

Figure A-4. Toolbox Folder Structure

1. **Input Elevation Raster** – Enter the file location for the 25-foot DEM.

2. **Input Start Point and Input End Point** – Create two new shapefiles, each consisting of one point named “Start Point” and the other “End Point.” In the Start Point shapefile, a point was placed at the start (upstream limit) of the pilot-study stream reach of interest. In End Point shapefile, a point was placed at the end (downstream limit) of the pilot-study stream reach of interest. The DEM was used as a visual aid to locate these points along the centerline of the stream channel.

3. **Output Stream Raster** – Assign name and location to place output stream raster grid cells (Figure A-5a).

4. **Output Stream Line –** Assign shapefile location and filename for stream raster grids converted to polyline (Figure A-5b).

2.5 Calculate Floodplain Inundation Potential

The HAR tool was located by navigating through the Topography Tools toolbox as follows: Topography Tools → Riparian Tools → Transverse → 2_HAR → right-click → Edit. The HAR tool methodology is shown in a flow chart on Figure A-6, where blue ovals indicate data entry steps, the yellow boxes are tool processes, and the green ovals are outputs from processes.

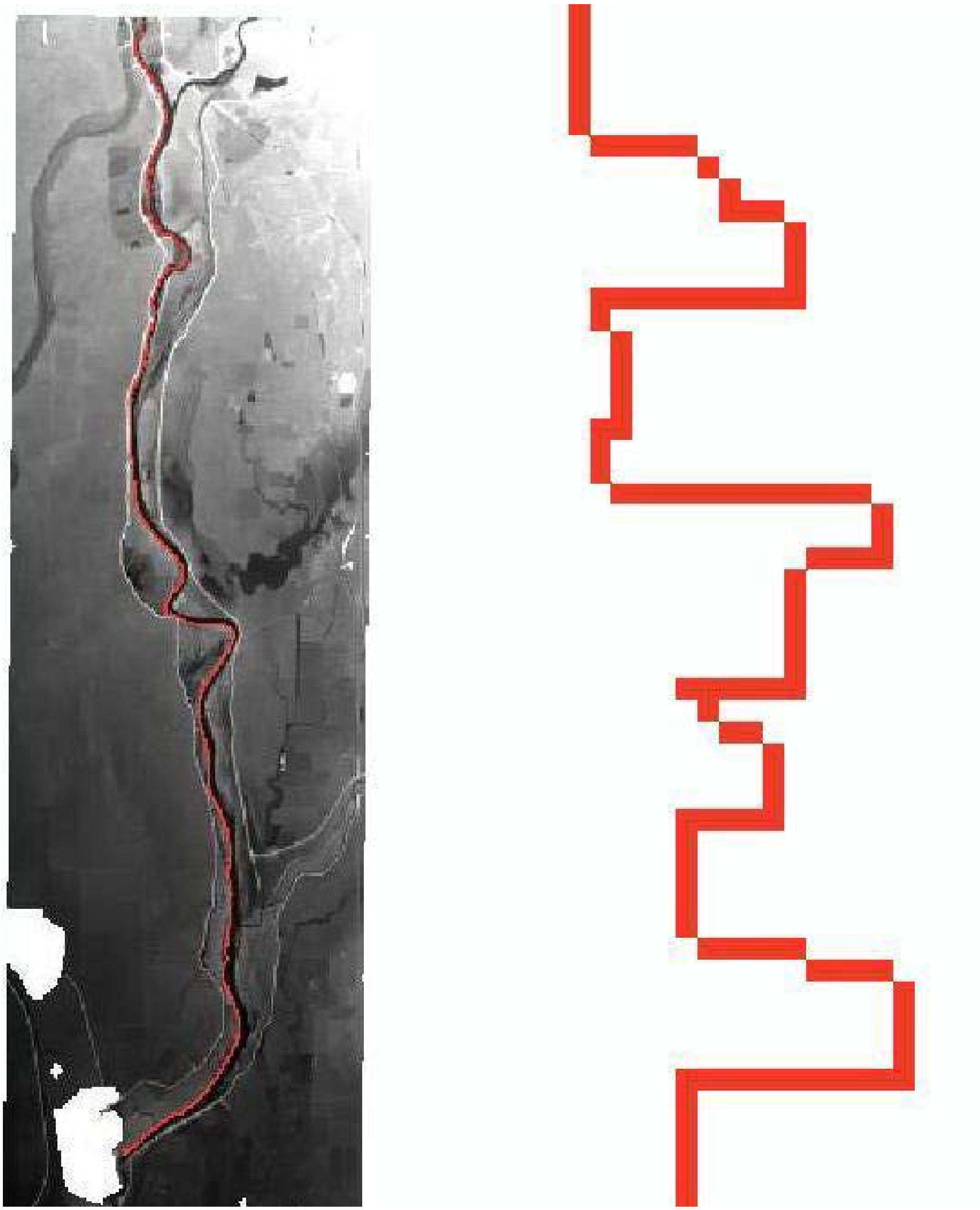

Figure A-5. Output Stream Raster (5a) and Output Stream Line (5b)

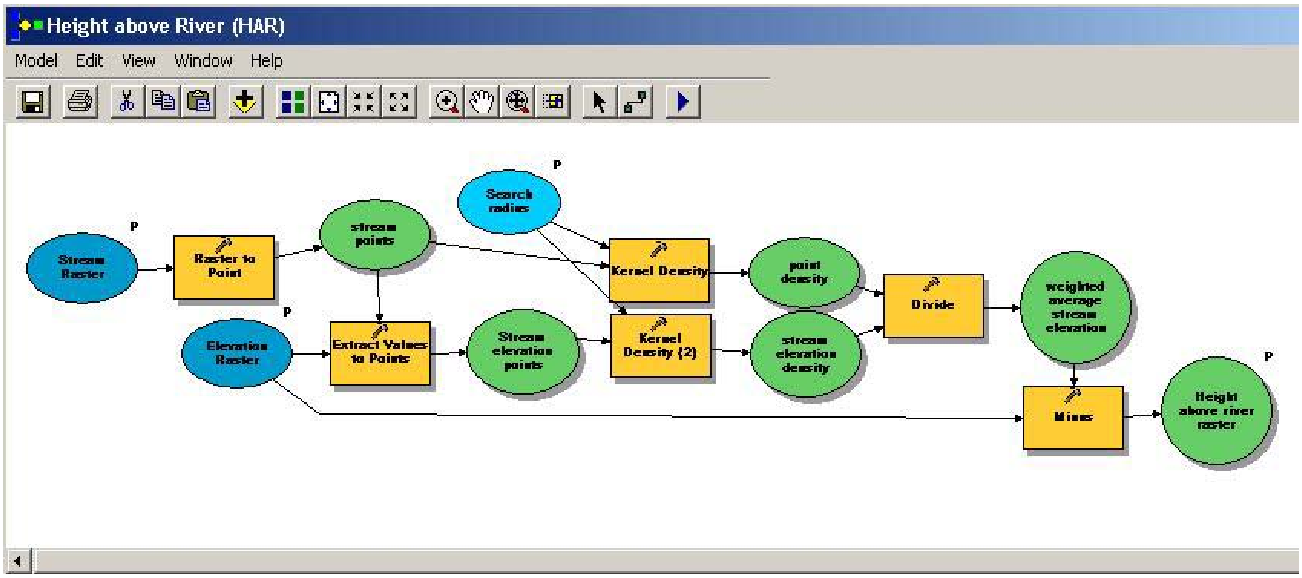

Figure A-6. HAR Tool Methodology

The significant steps in the methodology (indicated by the yellow boxes) are described as follows in the order that they were accomplished during the pilot study:

1. **Stream Raster –** Browse to the location of the output stream raster and input the file path.

2. **Elevation Raster –** Browse to the location of the DEM and input the file path. The first raster used in this process was derived from the LiDAR terrain model. To investigate the conditions associated with the 50 and 10 percent chance flood in the pilot-study reach, the initial LiDAR DEM was modified by adding the 50 and 10 percent chance water-surface profiles from the HEC-RAS model. This was done by extracting the LiDAR water surface elevations (WSEL) and inserting the HEC-RAS 50 and 10 percent chance WSELs, creating an artifically raised surface within the banks of the river channel. The remaining steps in this methodology remain the same and were applied three times to the LiDAR water-surface profile, and the 50 and 10 percent chance water-surface profiles.

3. **Search Radius –** Enter search radius (in feet only). This is the radius that was applied to each point on the stream line created in the next step and establishes the spatial extent of the FIP analysis; during the pilot study, the search radius was increased from 5,280 feet to 7,000 feet after a preliminary review of the output indicated the initial radius length did not capture all of the levees adjacent to the stream reach.

4. **Raster to Point –** The HAR tool pulls the output stream raster and converts it to points and asssigns a new filename with file location assigned by user (Figure A-7).

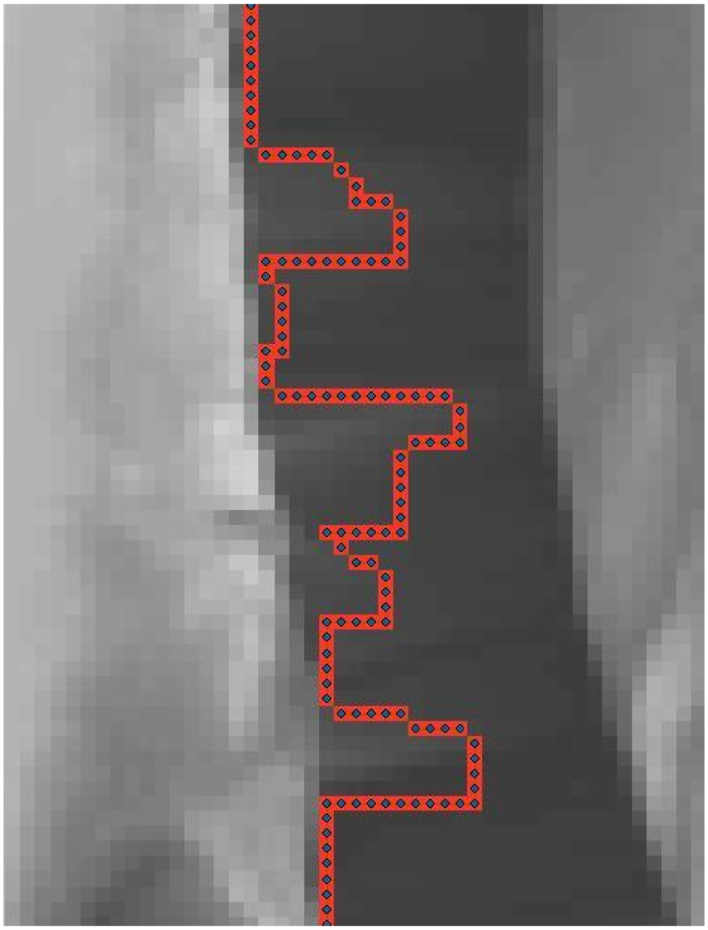

Figure A-7. Raster to Point

5. **Extract Values to Points –** The stream points (Step 4) and elevation raster (Step 2) are identifed, and the filename and file location assigned in Step 4 are assigned again by the user. Note that the HAR tool saves files to the last saved filepath and filename; thus, these default filenames and locations may need to be replaced with the correct values.

6. **Kernel Density –** The HAR tools pulls stream points (Step 4), and the population field is set at "NONE." The filename and file location assigned in Step 4 are assigned again by user. Output cell size (optional) was changed to "25" to match the DEM grid size (in feet). Search radius is pulled from Step 3 and area units was left as default "SQUARE_MAP_UNITS." The output from this process is the stream point density.

7. **Kernel Density 2 –** The HAR tools pulls stream elevation points (Step 4), and the population field is set at “RASTERVALU,” which was manually entered into the population field. The filename and file location assigned in Step 4 are assigned again. Output cell size (optional) was changed to “25” to match the DEM grid size (in feet). Search radius was pulled from Step 3 and area units was left as default “SQUARE_MAP_UNITS.” The output from this process is the stream elevation density.

8. **Divide –** The HAR tool pulls the stream elevation density file (Step 7) and point density file (Step 6) into the Input raster or constant value 1 and 2, respectively, and divides the values of the two rasters on a cell-by-cell basis. The output is the weighted average stream elevation.

9. **Minus** – The HAR tool takes the elevation raster (Step 2) and the weighted average stream elevation (Step 8) and subtracts the value of the weighted average stream elevation from the elevation raster on a cell-by-cell basis. The output is the HAR raster. A closeup of the HAR raster for the LiDAR water-surface profile is shown on Figure A-8a, with the HAR raster for the entire pilot-study reach shown on Figure A-8b.

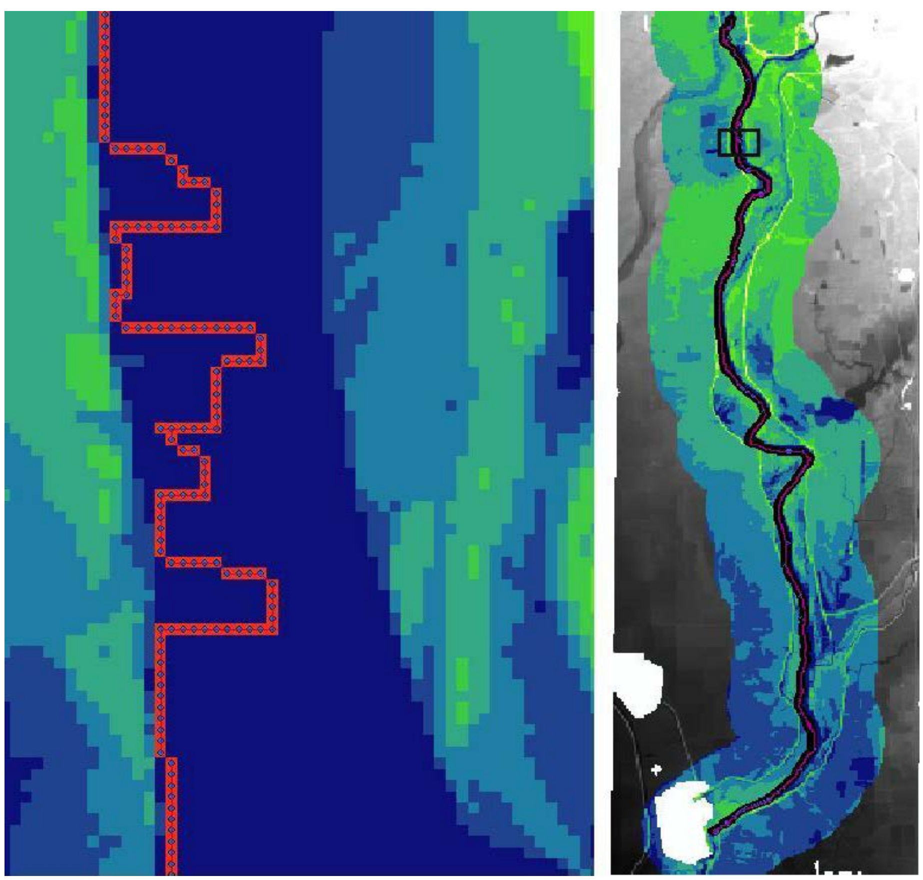

Figure A-8. HAR Closeup (8a) and Pilot Study Reach (8b)

2.6 Calculate Flood Height

A Calculate Flood Height tool is provided in the Riparian Topography Tools toolbox; however, in lieu of this approach, flood height was estimated by changing the symbology of the HAR raster. This method proved to be quicker, provided equivalent results, and involved the following steps:

1. The HAR raster was brought into ArcMap. Pyramids were built when prompted to improve image quality.

2. The HAR raster Properties were selected by right-clicking the HAR raster and clicking Properties.

3. Layer Properties – The Symbology tab was selected and the Show entered “Classified” was choosen and Compute Histogram was activated by clicking Yes when prompted.

4. Classification – The Natural Breaks (Jenks) – The Classify button was clicked to open the Classification menu box. User selects number of Breaks.

5. Break Values – These values were set so the lowest value in the HAR raster was in the same Break Value range as the height of the flooding. No other values were changed because the flood height was the only value necessary. The OK button was selected when values were set.

6. Layer Properties – Color Ramp – Symbol, Range, Label – The symbol for the range containing the lowest HAR raster value and the flood height value was changed to a color different from the rest of the ranges.

2.7 Calculate Inundation Area

The “Calculate Inundation Area” tool was located by navigating through the Riparian Topography Tools toolbox as follows: Riparian Topography Tools → Calculate Inundation Area→ right-click → edit. The “Calculate Inundation Area” tool methodology is shown in a flow chart on Figure A-9, where blue ovals indicate data entry steps, the yellow boxes are tool processes, and the green ovals are outputs from processes. The steps in the methodology are described as follows in the order that they were accomplished during the pilot study:

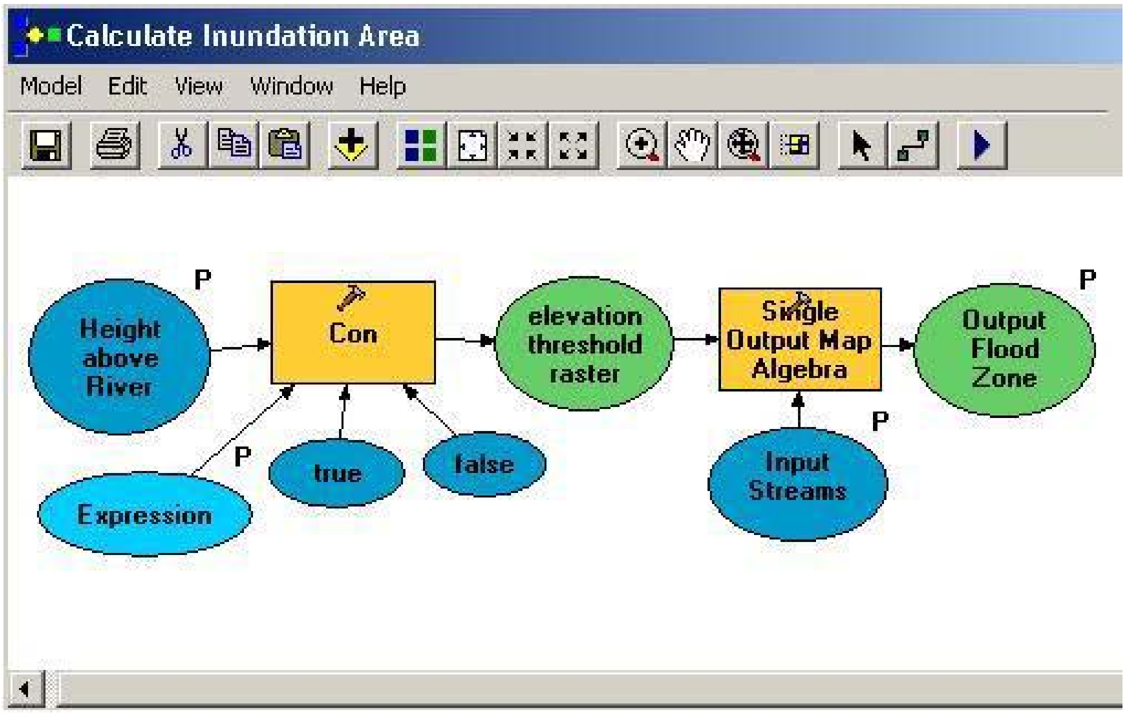

Figure A-9. Calculate Inundation Area

1. **Height above River Raster** – Browse to location of HAR raster and input file path.

2. **Input streams** – Browse to location of stream raster and input file path.

3. **Expression (optional)** – The value entered here is the height above the FIP water-surface profile, and it sets threshold elevation and code values either above or below this surface, with the cells below the FIP value directly connected to the river. Through trial and error we determined that the minimum value to enter here is 1.0 foot owing to the elevation variability imposed on the true water surface by the FIP method.

4. **Output flood zone** – Assign raster location and filename for inundation area.

2.8 Levee Realignment Methodology

Within the Feather River pilot-study reach, the project team noted that there were two locations where levees had been set back after the March 2008 date of the LiDAR flight. This resulted in a need to adjust the DEM terrain surface to show actual current topographic conditions. While the FIP output in this technical memorandum still shows the March 2008 levee positions, a separate effort was made to determine a reasonable methodology to adjust levee locations for subsequent FIP analyses. This methodology is described in Appendix D.

2.9 Height Above River Results

The LiDAR water-surface profile FIP results are shown on Figure A-10, together with an aerial photograph of the same location in the pilot study reach. Only heights above the river (water surface) are shown with increasingly lighter colors representing land areas higher above the water surface.

Figure A-10. LiDAR Water-Surface Profile FIP Output

This initial FIP analysis used the actual WSEL at the time of the CVFED LiDAR flights to define the FIP. The CVFED LiDAR data was flown between March 17, 2008, and March 31, 2008, when the flow was approximately 660 to 670 cubic feet per second (cfs).

The FIP output allows for a quick assessment of adjacent floodplain lands at or below the water surface of the river and above the water surface. In this particular location, the relative extent of low-lying lands west of the river is apparent (where the forested area is shown on the aerial photograph), and it is clear that this area is hydraulically connected only at the downstream end.

Other low-lying land areas are east of the river, immediately landward of the east levee. However, it is noted that in this particular reach of the Feather River, levee setbacks have occurred since the LiDAR flight date, and a portion of the levee locations shown on Figure A-10 are outdated. A technique was developed to realign levees on the DEM; this method was discussed in Section 2.2.8 and will be applied to levee sections where recent restoration projects have resulted in a change in levee alignments since the LiDAR flights in March 2008.

The 50 percent chance water-surface profile (corresponding to a discharge of approximately 80,258 cfs) was added into the DEM and run through the HAR tool. The results shown on Figure A-11 now include depths below the 50 percent chance water-surface profile, as well as above. Land elevations within +/-1 foot of the 50 percent chance water-surface profile are shown in the lightest shade of blue, with depths below this surface shown as increasingly darker shades of blue and heights above this surface shown in white. A +/- 1-foot height was used to approximate a given water surface for mapping purposes because the kernel density radius interpolation of elevation points at hydraulic model cross sections that was used to calculate the water surface resulted in an undulating surface (i.e., the interpolation routine between points of known elevation resulted in estimated elevations that varied within 1-foot of true values). The mapped area includes land area within a 7,000-foot search radius from the stream centerline, with blue shading indicating inundation areas connected to the river and gray shading indicating inundation areas disconnected from the river.

At a glance, it is clear that much of the floodplain land area in this portion of the pilot-study reach is below the 50 percent chance water-surface profile, except for the upper portion of the reach, as shown on Figure A-11.

Figure A-12 provides similar FIP output for the 10 percent chance water-surface profile (corresponding to a discharge of approximately 159,912 cfs). The color ramping of the depth increments below and of the height increments above the water surface and the scaling is consistent between the 50 and 10 percent chance FIP results, and it indicates that floodplain land area throughout the pilot-study reach is significantly below the 10 percent chance water-surface profile, with the levees being the only land features above the water surface.

2.10 Inundation Area Results

The Calculate Inundation Area tool floods all raster cells below a user-specified FIP and shows flooded land areas that are directly connected to the river. The connected and disconnected inundation areas for a portion of the pilot-study reach are shown on Figures A-11 and A-12. The connected and disconnected inundation areas for the entire pilot-study reach for the LiDAR flight (March 17 to 31, 2008), the 50 percent chance, and

10 percent chance flood profiles are provided in Appendix E. As expected, the inundation areas for the return period flood events are contained within the levees.

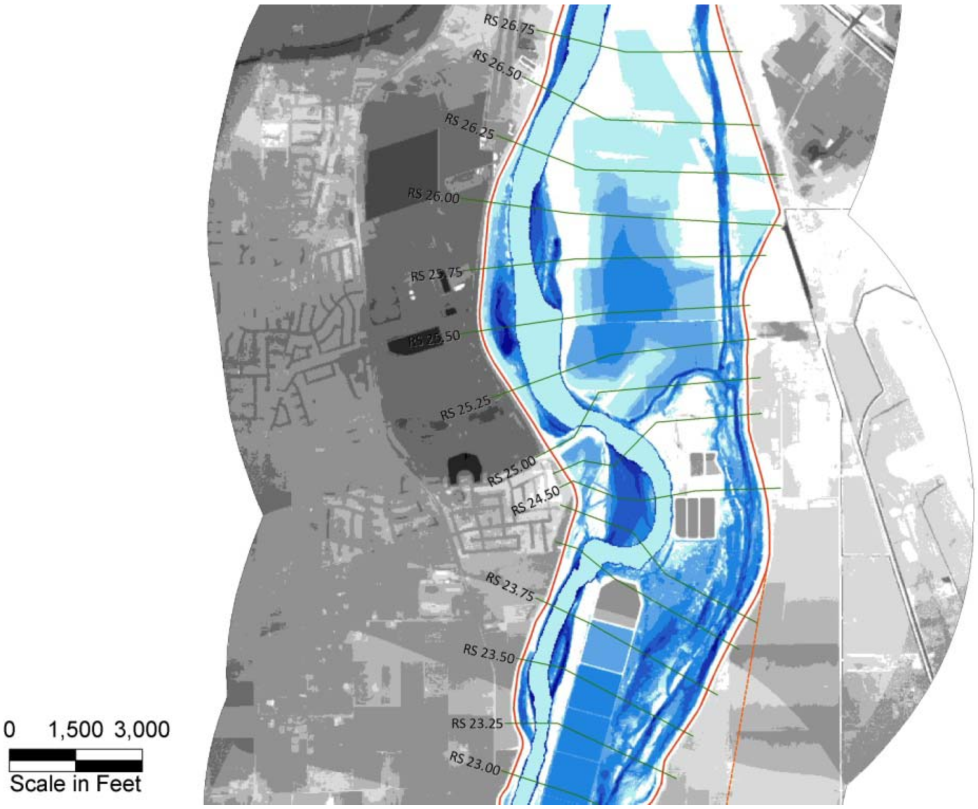

Figure A-11. 50 Percent Chance Water-Surface Profile FIP Output

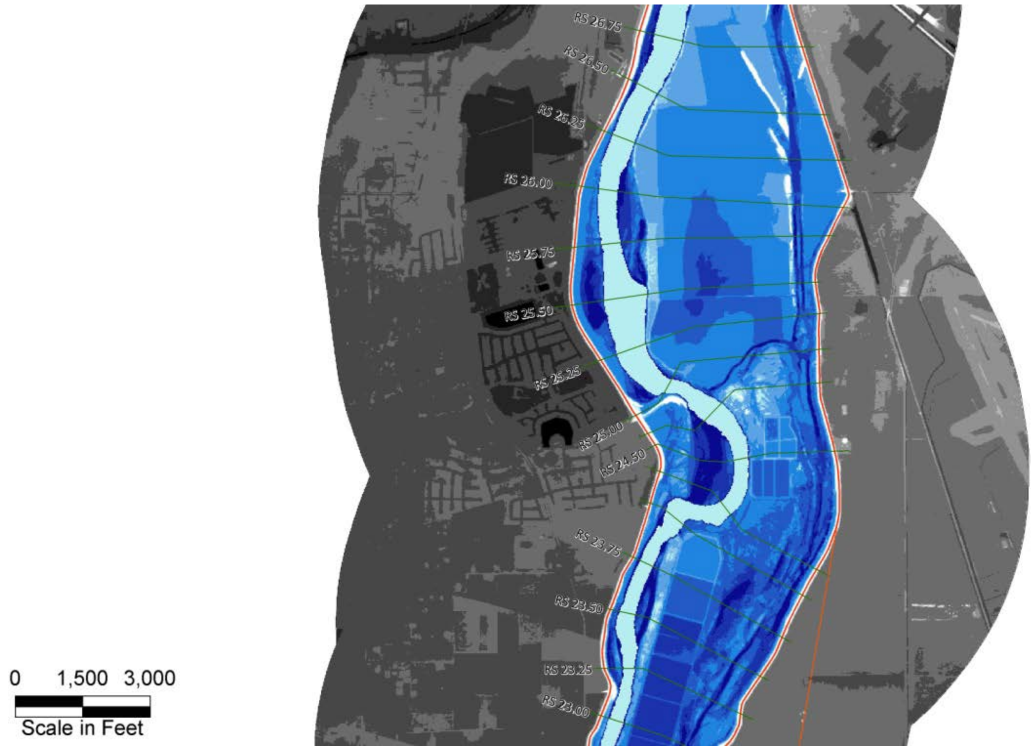

Figure A-12. 10 Percent Chance Water-Surface Profile FIP Output

After a review of these figures, a question arose as to whether the 50 percent chance flood would actually flood most of the land areas between the levees. The HEC-RAS modeling was reviewed to confirm the lateral extent of the 50 percent chance flood. Figure A-13 shows a representative cross section of the 50 percent chance flood stage at RS 19.00 on the Feather River, between the Yuba and Bear river confluences. The 50 percent chance discharge is 80,258 cfs, and the associated 50 percent chance water surface elevation is 47.99 feet. The LiDAR-based water surface elevation at the same location is between 26 feet and 27 feet, or approximately 20 feet lower than the 50 percent chance flood stage.

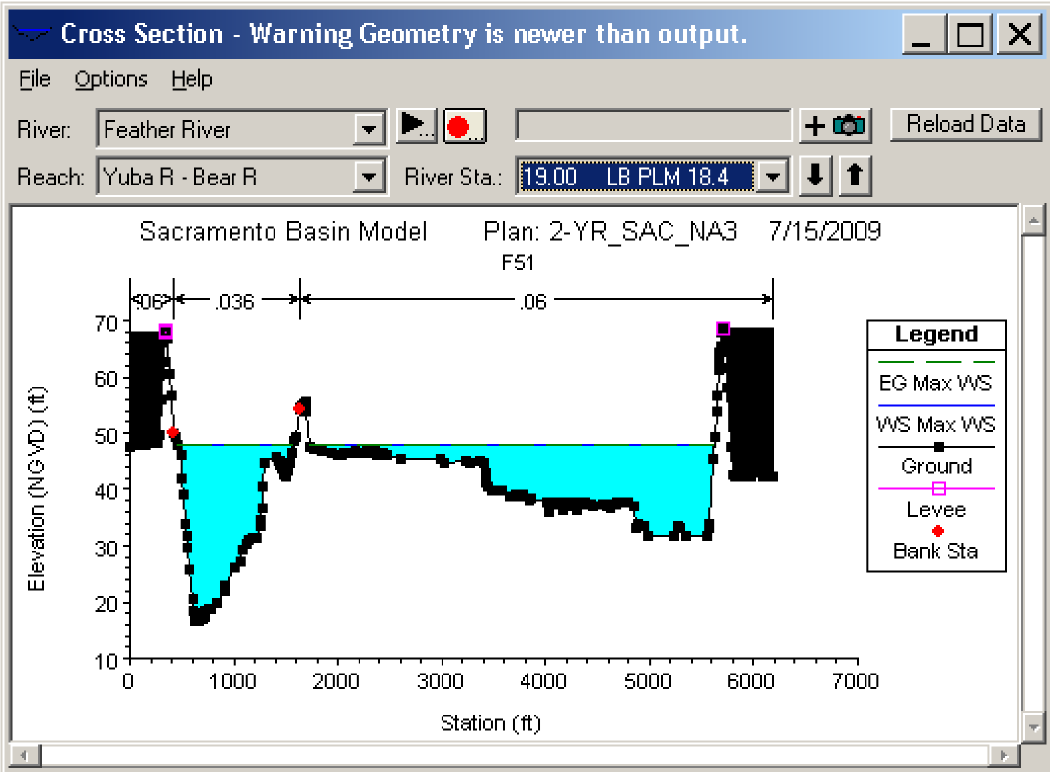

Figure A-13. Cross Section of 50 Percent Chance Flood Profile (RS 19.00)

While the right overbank area appears to be disconnected from the channel, based on the cross-section plot alone, it is possible that this overbank area is connected to the main channel upstream or downstream. Based on the results of the FIP mapping, areas were classified as either "connected" or "disconnected" to the main channel. Disconnected areas do not directly connect to the main channel.

The spatial data on inundation depths for the 50 percent chance and 10 percent chance flood events were summarized in a tabular format and are provided in Table A-1. Recognizing that the connected areas are constrained by the physical presence of levees and the disconnected areas are constrained between the levees and an imposed 7,000-foot search radius from the stream centerline, the relative change in inundation areas by depth was reviewed. For the 50 percent chance flood, the majority of the inundation area falls within the minus 2-foot to minus 9.9-foot depth classes and, as expected, the 10 percent chance inundation area falls within the deeper minus 5-foot to minus 19.9-foot depth classes. Looking at the totals, the 10 percent chance flood only inundates 3,200 additional areas than the 50 percent chance flood, about a 7 percent increase.

Table A-1. Areas of Inundation Depths at 50% and 10% Chance Flood Events

Depth Range	Areas of Inundation Depths at 50% and 10% Chance Flood Events (Acres)			
	50% Chance Connected	50% Chance Disconnected	10% Chance Connected	10% Chance Disconnected
< - 20 feet	200	300	900	1,900
- 15.0 to - 19.9 feet	400	1,100	1,400	7,800
- 10.0 to - 14.9 feet	900	4,600	2,600	15,200
- 5.0 to - 9.9 feet	2,200	13,100	2,600	6,400
- 2.0 to - 4.9 feet	1,800	7,400	700	1,100
- 1.0 to - 1.9 feet	600	1,800	100	200
1 to - 0.9 foot	2,100	3,500	1,300	1,400
Total	**8,200**	**31,800**	**9,600**	**34,000**

2.11 Conclusions

The FIP method is a relatively effective way to quickly and easily find features on the land surface that are either above or below a specified water-surface profile.

The GIS spatial output from the FIP method can provide a benefit for the visualization of floodplain restoration opportunities for planning or reconnaissance-level investigations, including the following specific considerations:

1. Color ramping of FIP output showing height increments both above the river (water surface) and below can provide a rapid visualization of the low-lying land areas physically connected to a river channel, or capable of being connected, and the relative depth of these topographic depressions.

2. The relative depth of adjacent topographic depressions can also be referenced to qualitatively assess the level of effort (e.g., earthwork) necessary for setback levees and/or floodplain terracing as a floodplain restoration technique; for example, setback levees aligned across a topographic depression will require a greater amount of fill to maintain a certain levee crest elevation than if the levee was aligned around the topographic depression on higher ground.

3. The Comprehensive Study HEC-RAS models are limited in extent, in that the model cross sections of the floodplain only extend between the levees (USACE and The Reclamation Board, 2002). The FIP output

> provides estimates of flood profile elevations and flood depths beyond the levees, and this information can be used to guide qualitative investigations into potential levee setback locations. Although the FIP method is not a substitute for detailed hydraulic modeling, it does provide an ability to relatively quickly understand flood characteristics across the floodplain landscape.

Work has been initiated to update tools and unpublished versions have been provided for use in this pilot study. Because of this, the generation of the Stream Raster, which is a very important component to the FIP, is now automated and can be applied more quickly to future FIP investigations.

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3.0 Hydrologic Engineering Center's Ecosystem Functions Model Pilot Study

This section summarizes the HEC-EFM pilot study in four sections:

- 3.1, Methods
- 3.2, Results and Sensitivity
- 3.3, Mapping
- 3.4, Conclusions

3.1 Methods

This section describes the methods and approaches used to perform the HEC-RAS/HEC-EFM (RAS/EFM) analysis on the lower Feather River near Yuba City, California. As discussed, the goal of this study was to document the standard methods and approaches required for a RAS/EFM analysis and to identify potential issues, if any, and/or alternative approaches. The following tasks were conducted as part of the RAS/EFM analysis:

- Selection of the pilot-study area
- Data collection and review
- Identification of Habitat Analysis Areas (HAA)
- HEC-RAS modeling
- HEC-EFM analysis

The remainder of this section describes these tasks in more detail.

3.1.1 Selection of the Pilot-Study Area

The pilot study was conducted on a 21-mile reach of the lower Feather River, from the confluence with the Sutter Bypass, upstream to Yuba City at RS 27.75 (see Figure A-14). The area was chosen for the availability of data and the project team's familiarity with the area. Within the study area, the lower Feather River maintains levees along both banks and receives flow from the Yuba and Bear rivers. It also maintains inflows and outflows resulting from agricultural and groundwater sources.

3.1.2 Data Collection and Review

A steady-state, geo-referenced HEC-RAS model of the Feather River, from the confluence with the Sutter Bypass to the Thermalito Afterbay, and synthetic daily flow hydrographs from October 1, 1921, to September 30, 2003, were provided to AECOM by MWH Americas, Inc. (MWH).

The HEC-RAS model was developed by MWH based on the Feather River Sacramento-San Joaquin Comprehensive Study UNET hydraulic model (USACE and The Reclamation Board 2002). MWH converted the original Comprehensive Study UNET model to HEC-RAS, geo-referenced the model, and calibrated the model to low-flow conditions. The model files were provided via FTP on November 30, 2010.

The Feather River synthetic daily flow hydrographs were developed by MWH from monthly flow hydrographs computed by the CalSim model. Hydrographs were provided by MWH via e-mail on December 8, 2010. Development methodology for the synthetic daily flow hydrographs was

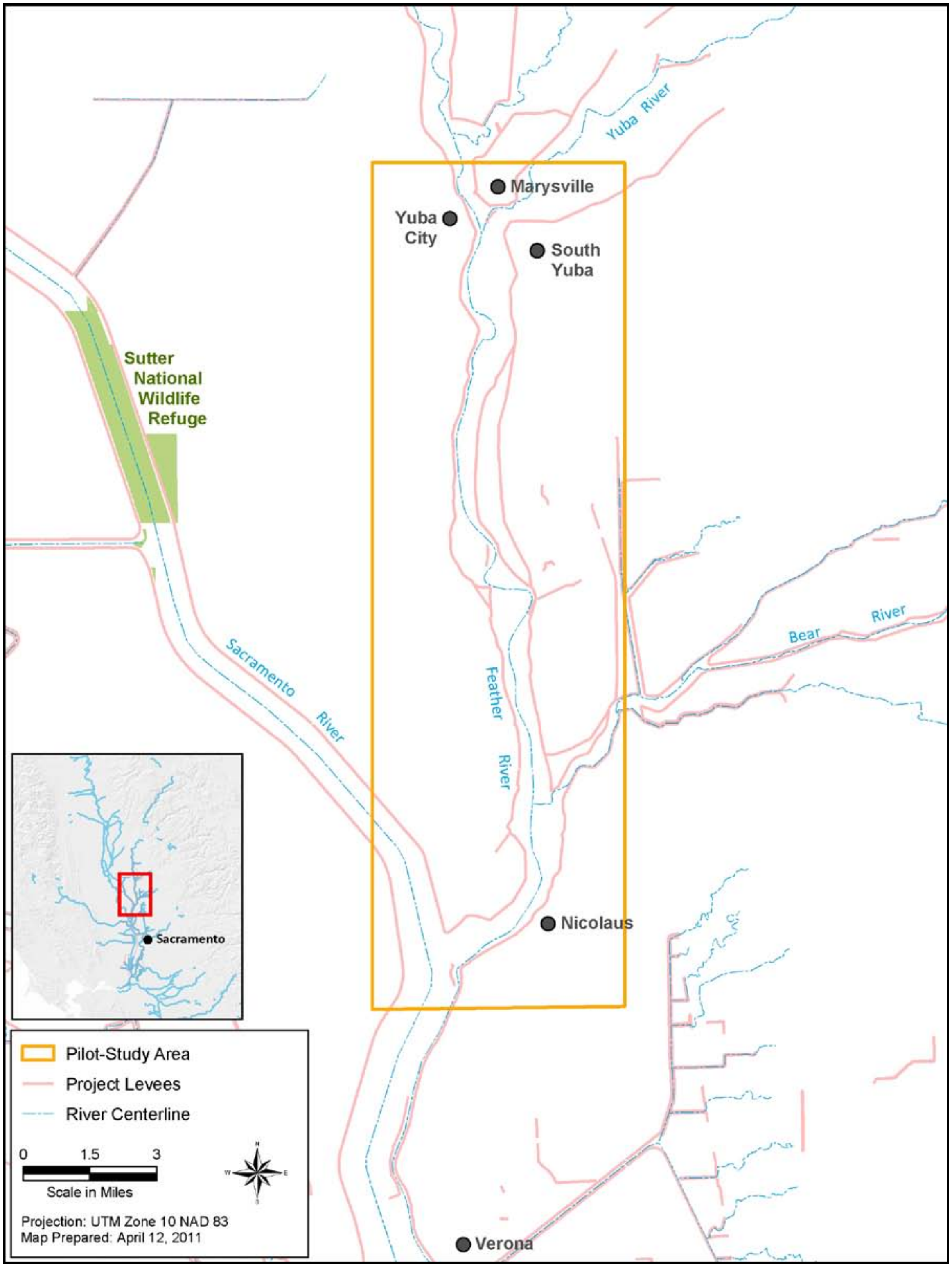

Figure A-14. Lower Feather River Pilot-Study Area

outlined in a draft document prepared by MWH, titled *Feather River Daily Flows for HEC-EFM* (2011). This document is currently being finalized by MWH and will be submitted to California Department of Water Resources (DWR) separately from this report.

The following actions were performed during the review and application of the HEC-RAS model and synthetic daily flow hydrographs.

1. The model was reviewed briefly to confirm its appropriateness for this study and to review the geo-referencing, reach lengths, and Manning's *n* values. Detailed features or assumptions, such as the value of coefficients, the stations, and elevations of levees and ineffective flows areas, and other detailed aspects of the model were not reviewed.

2. Areas of the model upstream from the Feather River and Yuba River confluence were removed and the upstream boundary was set to RS 27.75. This was done to remove unnecessary complexities upstream from the study area. Figure A-15 shows an overview of the revised HEC-RAS model.

3. An unsteady-state version of the model was developed, requiring the following actions:

    a. Modification of the model geometry

       An inline weir was added at RS 24.00 to improve model stability at the Shanghai Bend Falls, where a sudden change in the channel invert can produce super-critical and unstable conditions. The model was adjusted from the original NGVD29 datum to match the terrain datum, NAVD88, by adding 2.335 feet (see AECOM's Technical Memorandum (TM) – Height Above River Investigations (AECOM, 2011a)). The model geometry was not updated using the LiDAR-derived DEMs as described in the Scope of Sub-Consultancy Services Subtask 3.3.1.d, "recut floodplain cross-section data, combine with channel geometry." This task was not performed because official DWR review of LiDAR-derived DEMs was not complete.

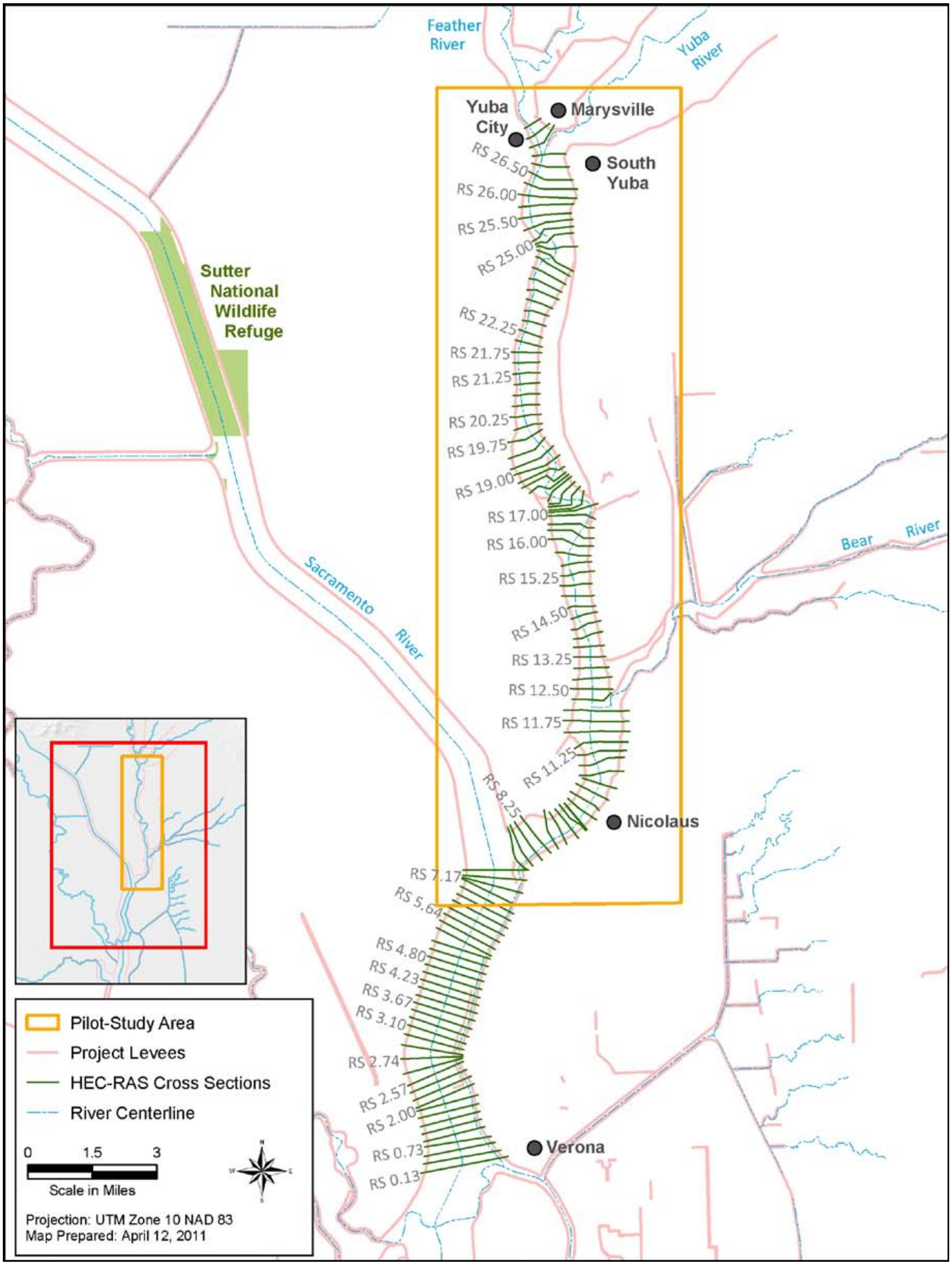

Figure A-15. Revised HEC-RAS Model

b. Development of unsteady-state boundary conditions

Unsteady-state boundary conditions were developed to simulate the synthetic period. The downstream boundary condition at RS 0.13 was set to normal depth with a friction slope of 0.0002 (0.02 percent). The upstream boundary condition at RS 27.75 was set to read the daily synthetic flow hydrograph provided by MWH at Yuba City. Inflows and outflows between Yuba City and the Sutter Bypass were applied based on the synthetic daily flow hydrographs provided by MWH.

c. Review of synthetic hydrographs

The hydrographs provided by MWH included synthetic daily-average flows from October 1, 1921, to September 30, 2003, at locations along the Feather River. The flows were developed from the CalSim State Water Project (SWP)/Central Valley Project (CVP) monthly simulation model.

The flow in the Feather River is controlled by water operations at the upstream Oroville Reservoir. Because of changes in Oroville operations to meet increasing demands both for water supply and environmental purposes, historical flows may not provide the best representation of future flows in the Feather River.

The CalSim model is specifically designed to evaluate the operations of Oroville Reservoir, and the flows in the Feather River, under potential conditions assuming that the historical precipitation from October 1921 through September 2003 reoccurs. The resulting flows may provide a better representation of expected future flows than historical flows.

The synthetic daily average flows provided by MWH to observed daily average flows at USGS flow gages (see Table A-2) were compared to determine whether the synthetic flows provided reasonable values. Figures A-16 and A-17 compare daily averaged flows and resulting flow duration curves for the period of October 1, 1969, through September 30, 1976, (Water Year (WY) 1970 through WY 1976) at Nicolaus (see Figures E-1 through E-4 in Appendix E for the Yuba City and Shanghai Bend locations). The selected period of record represents a time frame when the USGS gages were all in operation.

The comparison illustrates that while the synthetic daily averaged flows often do not reproduce individual daily averaged flows, they do reproduce the various high- and low-flow events. This is confirmed by the flow duration curves, which closely match the observed flow duration curves, although flows are consistently lower than observed.

Table A-2. USGS Gages Within the Pilot-Study Area

USGS Gage No.	Name	Period of Record
11407700	Feather River at Yuba City	10/01/1964–9/30/1976
11421700	Feather River below Shanghai Bend, near Olivehurst, California	10/01/1969–9/30/1980
11425000	Feather River near Nicolaus, California	10/01/1943–9/30/1983

Source: Data downloaded by AECOM in 2011 from USGS, 2011
Key:
USGS = U.S. Geological Survey

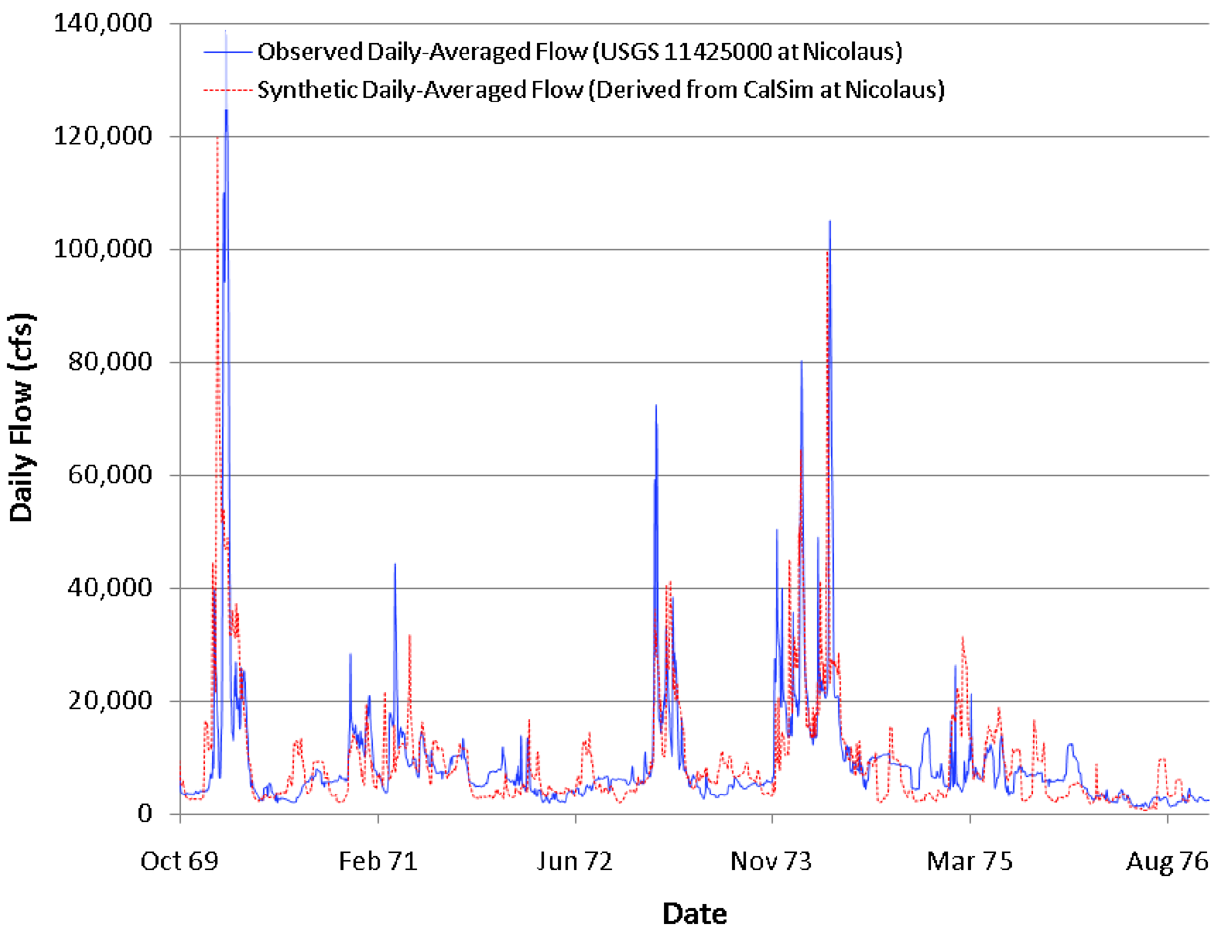

Figure A-16. Synthetic vs. Observed Daily-Averaged Flow – Nicolaus

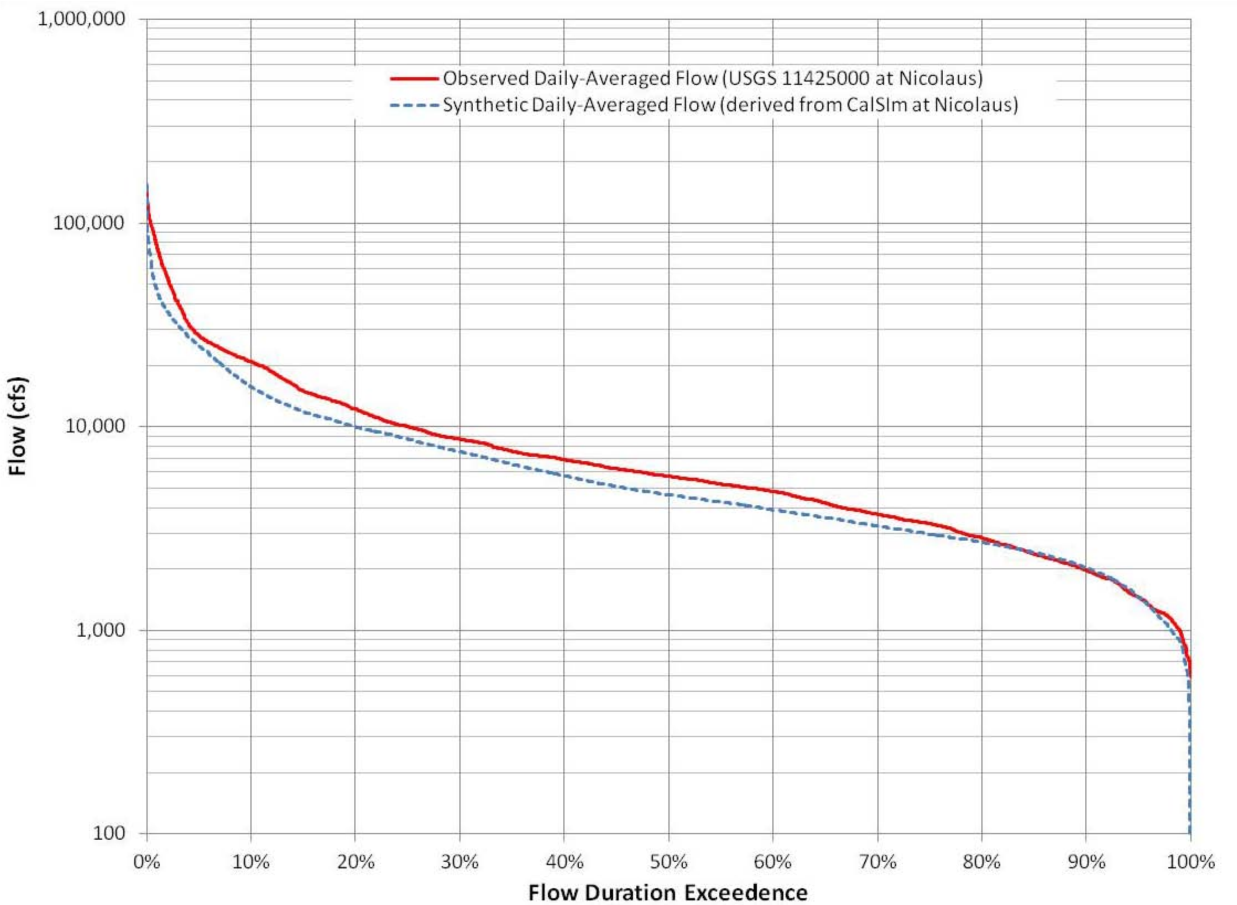

Figure A-17. Synthetic vs. Observed Flow Duration Curve – Nicolaus

d. Modification of synthetic hydrographs for HEC-RAS

The synthetic daily flow hydrographs provided by MWH were modified to be used in the HEC-RAS unsteady-state model. Since each synthetic hydrograph corresponded to the entire channel flow and not the individual inflows and outflows from tributaries, groundwater, agriculture, or other sources, the hydrographs could not be applied directly to the model.

Each Feather River flow hydrograph was subtracted from the upstream hydrograph to produce a hydrograph representing the net accretion (Feather River flow increase) or depletion (Feather River flow decrease) between Feather River flow hydrographs. For example, to estimate the accretion or depletion between the upstream boundary of the model at Yuba City (RS 27.75) and the Yuba River confluence (RS 27.25), flows at Yuba City were subtracted from the flows at the Yuba River confluence. This provided a daily time series of the total net change in flow between Yuba City and the Yuba River confluence. In general, the majority of this change can be attributed to the Yuba River, so the daily time series was applied as the Yuba River inflow hydrograph. This process was repeated at the Bear River confluence (RS 12.25) and at Nicolaus (RS 9.75).

Figure A-18 shows the synthetic daily flow at Yuba River and Nicolaus, as well as the hydrographs produced using the approach above. As shown, this process sometimes results in depletions (see time series "Net Change in Flow from Bear River to Nicolaus"). These depletions correspond to losses in flow between the Bear River and Nicolaus as a result of groundwater and agricultural withdrawals. HEC-RAS handles depletions by removing the flow from the system, which often causes instabilities for unsteady-state models. In this example, the model failed near Nicolaus when the depletions resulted in zero flow at the downstream end. Since the downstream boundary is based on normal depth, which is based in part on flow, the model failed to converge on a solution. To maintain positive flow at the downstream end, a constant flow of 50 cfs was added at RS 9.50. While this introduces a fictitious flow to the system, it is relatively small and does not significantly impact modeled stages or flows.

3.1.3 Identification of Habitat Analysis Areas

The pilot-study area was subdivided into regions, defined as HAAs. For each HAA, a RAS/EFM analysis was performed and the results were mapped in GIS. Table A-3 and Figure A-19 show each HAA, their upstream and downstream bounding cross sections, and a single "representative" cross section. Defining HAAs is critically important to the RAS/EFM analysis because HAAs are viewed by HEC-EFM as maintaining homogenous hydraulic and ecological properties. For example, HEC-EFM assumes that the flow and stage relationship at RS 11.00 is the same for all cross sections between RS 9.75 and RS 12.00. HAAs were therefore subdivided where flow changes occur, where hydraulic structures control, or where the water surface slope was significant. HAAs were subdivided at the Yuba and Bear rivers, upstream from bridges, and at Shanghai Bend.

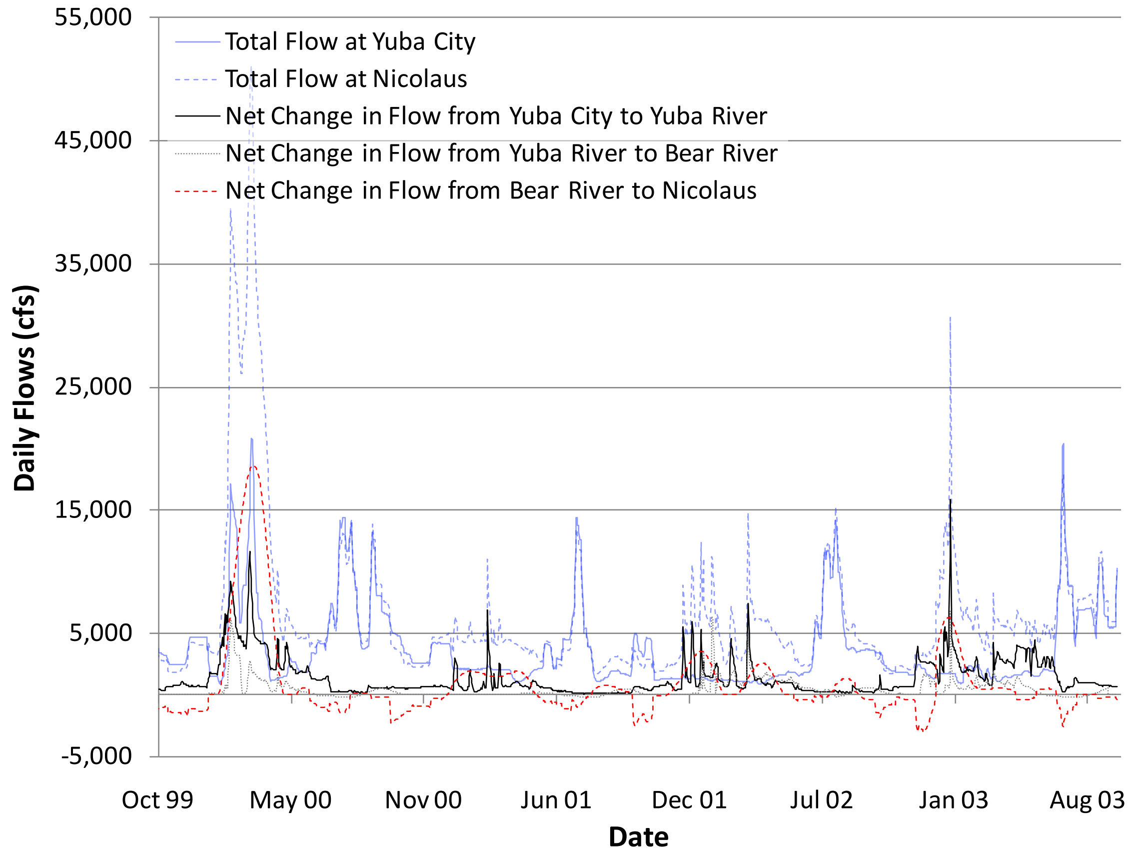

Figure A-18. Revised Daily Flow Time Series Hydrographs

Table A-3. Habitat Analysis Areas

Bounding Cross Sections	Representative Cross Sections
7.55–9.50	8.50
9.75–12.00	11.00
12.25–14.50	13.25
14.75–16.75	15.75
17.00–21.00	19.00
21.25–23.75	22.50
24.00–25.25	24.50
25.50–27.00	26.25

Source: Data generated by AECOM for this report in 2011

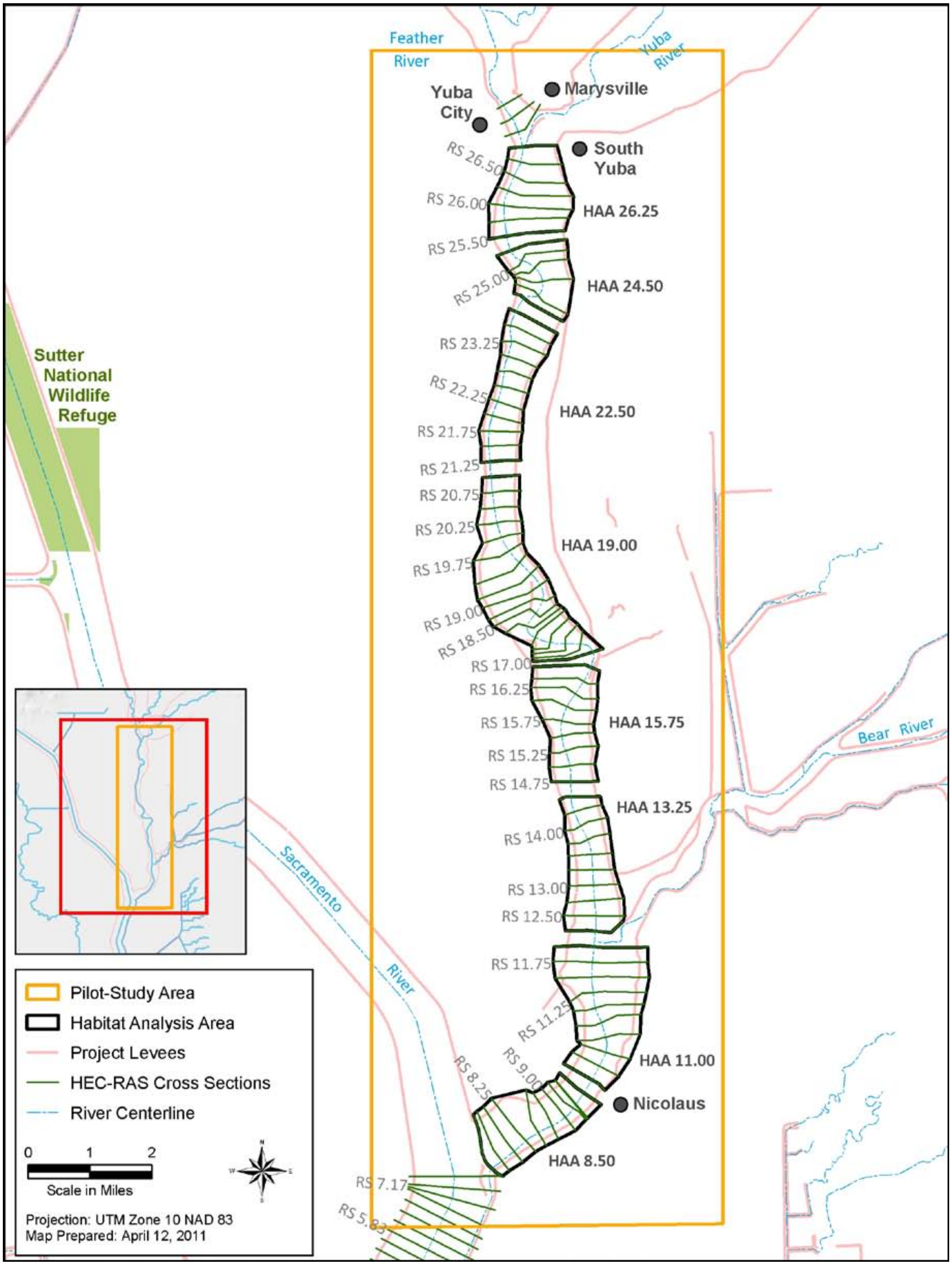

Figure A-19. Habitat Analysis Areas

3.1.4 HEC-RAS Modeling

Once HAAs were identified, the HEC-RAS unsteady-state model was used to produce synthetic stage and flow hydrographs at each representative cross section. These hydrographs were stored in a HEC Data Storage System (HEC-DSS) format database and used as input to HEC-EFM. In addition, a series of steady-state flow profiles was simulated to produce rating curves at each representative cross section. These rating curves were then used during the HEC-EFM modeling, as discussed in the following section.

3.1.5 HEC-EFM Modeling

The HEC-EFM portion of the RAS/EFM analysis consisted of analyzing synthetic stage and flow hydrographs produced by HEC-RAS to determine if and when HEC-EFM Ecosystem Function Relationship (EFR) conditions were met. These conditions, defined by the user, include seasonality, duration, rate of change, and/or return frequency as a function of stage and flow.

Using the stage and flow hydrographs developed by the HEC-RAS unsteady-state model, a HEC-EFM "flow regime" was created for each HAA. These flow regimes identify the flow and stage hydrographs that correspond to each HAA. EFRs were obtained from Table 3 in the September 2010 draft of *2012 Central Valley Flood Protection Plan—Ecosystem Functions Model* (AECOM, 2010b). A summary of each EFR, directly from the above report, is provided in Table A-4. The EFRs used in this study included Salmonid-Rearing Habitat Formation, riparian Cottonwood Seedling Germination, riparian Cottonwood Seedling Inundation (death), and riparian Cottonwood Recruitment. Each EFR was added to HEC-EFM and is shown on Figures F-1 through F-4 in Appendix D-9F.

HEC-EFM was then used to analyze each EFR and HAA. HEC-EFM first performs a statistical analysis on each stage and flow hydrograph for each EFR to determine if and when conditions of the EFRs are met. During this analysis, HEC-EFM produces a stage-flow rating curve for each flow regime based on a statistical sampling of the stage and flow hydrographs. If conditions of the EFR are met, the flow or stage that meets the conditions is then used in conjunction with the rating curve to determine the corresponding flow or stage.

Table A-4. Summary of Ecosystem Functional Relationships

Ecological Process	Summary of Ecosystem Functional Relationship	Flow Parameters			
		Season	Duration	Rate of Change	Event Probability
Riparian Habitat Recruitment	Seedling germination of cottonwood and other early-seral riparian vegetation requires moist soil from April through early June for at least 2 weeks. The river stages must decline at a rate of not more than 1 inch per day to allow newly developing roots to extend with receding river stages. Germination events should occur every 10 years to permit regeneration of new habitat patches.	April 1 to June 15	2 weeks or more	1 inch or less on receding limb of hydrograph	10 percent chance recurrence interval
	Newly germinated cottonwood seedlings are susceptible to death from physiological stress if inundated for prolonged periods of 2 weeks or more following germination.	June 15 to October 30	2 weeks or more	Constant	10 percent chance recurrence interval
	Successful cottonwood recruitment has been documented to occur within specific elevation bands above summer base flow levels.	June 15 to October 30	Constant during time period	Constant	100 percent chance (annual recurrence)
Salmonid-Rearing Habitat	Shallow-water, seasonally inundated floodplains provide valuable rearing habitat for Chinook salmon and steelhead. Ecologically important floodplain inundation is defined as the river stage that is exceeded in at least 2 out of 3 years and sustained for at least 7 days from March 15 to May 15.	March 15 to May 15	1 week or more	Constant	66 percent chance

Source: Data summarized by AECOM in 2011b from USACE, 2002 and ESSA, 2009

An issue was identified during the RAS/EFM analysis that resulted in erroneous stages being produced by HEC-EFM. As discussed, HEC-EFM uses flow and stage hydrographs from HEC-RAS to identify whether the conditions of a given EFR are met. During this process, HEC-EFM develops a rating curve based on the flow and stage hydrograph. If the conditions of the EFR are met, HEC-EFM identifies the corresponding flow or stage and uses the rating curve to determine the complementary flow or stage. While HEC-EFM applies a robust statistical analysis in an attempt to produce a smooth, representative rating curve, for some HAAs the rating curve included erroneous stage values. In some cases, these values were several feet higher than expected, and for Cottonwood Seedling Germination resulted in significant error.

Figure A-20 shows three different rating curves for RS 11.00. The curve shown in red was produced by HEC-EFM, the curve in gray was produced by the HEC-RAS unsteady-state model, and the curve in blue was produced using HEC-RAS steady state as discussed. As shown, the HEC-EFM rating curve includes erroneous stages at several flow rates. As a result of these erroneous stages, HEC-EFM selects values that are not representative of actual conditions. Figure A-21 shows the same rating curves for flow rates up to 15,000 cfs and includes the results of the HEC-EFM analyses for HAA 11.00. This results from the significant amount of hysteresis that occurs at RS 11.00 during the continuous synthetic simulation. Hysteresis is a hydraulic condition in which multiple stages can correspond to a single flow. In general, this occurs when downstream conditions produce backwater that increases the stage during low flows, either because of tidal conditions, a hydraulic structure, or high-flow conditions on a main-steam reach. Within the pilot-study area, hysteresis occurs because (1) the water surface slope is relatively mild at RS 11.00, and (2) the downstream boundary condition is set to normal depth, which allows for a wide range of backwater conditions. The amount of hysteresis is reduced upstream where downstream conditions have minimal impact on stages and where the water surface slope is greater. To address this issue, a HEC-RAS steady-state profile was simulated for flow rates between 100 cfs and 140,000 cfs at 1,000 cfs intervals. This simulation produced the rating curves shown in blue on Figures A-20 and A-21. As demonstrated, this curve matches well with both the HEC-RAS unsteady state and HEC-EFM-derived rating curves. The steady-state rating curve was then used to override the HEC-EFM-derived rating curve.

3.2 Results and Sensitivity

The results of the HEC-EFM analyses are discussed in the following sections. HEC-EFM was initially run using the Sacramento River Ecological Flows Tool (SacEFT)-defined EFRs, which were previously developed for the Sacramento River. To determine whether changes in these EFRs would result in significant changes in the potential habitat area on the lower Feather River pilot-study area, the Cottonwood Seedling Germination and Salmonid Rearing Habitat EFRs were modified. Results for each EFR analyzed are included below.

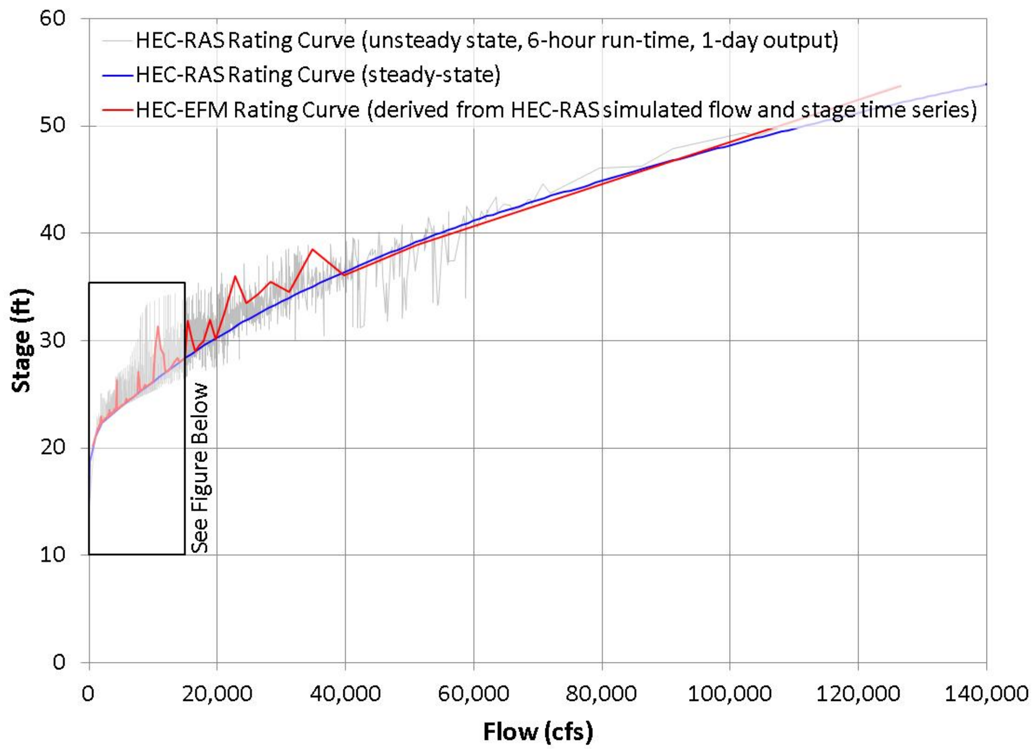

Figure A-20. Comparison of Rating Curves – RS 11.00

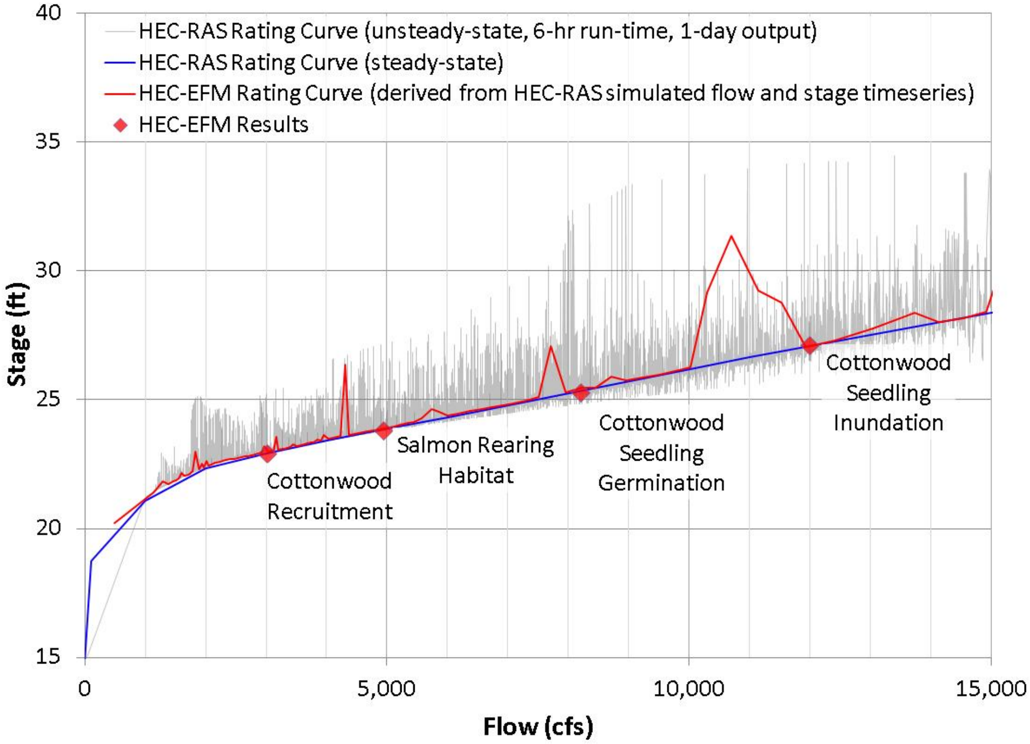

Figure A-21. Comparison of Rating Curves Showing HEC-EFM Results – RS 11.00

3.2.1 SacEFT-Defined EFRs

The results of the HEC-EFM analyses using the SacEFT-defined EFRs are shown in Tables A-5 through A-7. HEC-EFM provides a single flow and stage for each EFR and HAA, if conditions of the EFR are met. The computer processing time required to perform all 32 analyses was approximately 15 minutes.

Table A-5. HEC-EFM Results – RS 26.25–RS 22.50

Ecosystem Function Relationship	RS 26.25		RS 24.50		RS 22.50	
	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)
Cottonwood Seedling Germination	40.6	8,802	40.1	10,710	31.3	5,774
Cottonwood Seedling Inundation	41.8	11,952	40.5	11,953	34.8	11,954
Cottonwood Recruitment	37.7	3,044	37.4	3,029	29.2	3,011
Salmonid Rearing Habitat	38.4	4,142	37.9	4,150	30.2	4,159

Source: Data provided by AECOM in 2011 based on modeling using the U.S. Army Corps of Engineers Hydrologic Engineering Center's Ecosystem Functions Model and River Analysis System

Notes:
cfs = cubic feet per second
RS = River Station

Table A-6. HEC-EFM Results—RS 19.00–RS 13.25

Ecosystem Function Relationship	RS 19.00		RS 15.75		RS 13.25	
	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)
Cottonwood Seedling Germination	29.9	6,959	28.8	7,845	27.7	7,845
Cottonwood Seedling Inundation	32.4	11,962	30.6	11,965	29.0	11,965
Cottonwood Recruitment	27.2	3,015	26.1	3,044	24.9	3,044
Salmonid Rearing Habitat	28.1	4,181	26.9	4,187	25.6	4,181

Source: Data provided by AECOM in 2011 based on modeling using the U.S. Army Corps of Engineers Hydrologic Engineering Center's Ecosystem Functions Model and River Analysis System

Notes:
cfs = cubic feet per second
RS = River Station

Table A-7. HEC-EFM Results—RS 11.00–RS 8.50

Ecosystem Function Relationship	RS 11.00		RS 8.50	
	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)
Cottonwood Seedling Germination	25.3	8,198	23.1	7,635
Cottonwood Seedling Inundation	27.1	11,987	25.6	12,316
Cottonwood Recruitment	22.9	3,015	19.1	2,567
Salmonid Rearing Habitat	23.8	4,942	21.8	5,684

Source: Data provided by AECOM in 2011 based on modeling using the U.S. Army Corps of Engineers Hydrologic Engineering Center's Ecosystem Functions Model and River Analysis System

Notes:
cfs = cubic feet per second
RS = River Station

3.2.2 Modified EFRs

The Cottonwood Seedling Germination and Salmonid Rearing Habitat Formation EFRs were modified to determine whether adjustments to the EFRs would result in significant changes in potential habitat area.

The Cottonwood Seedling Germination EFR Rate of Change of Stage (falling stage) statistical parameter was modified from the SacEFT-defined 1 inch per day to 2 inches per day and 3 inches per day. Also considered was a 1-inch-per-day Rate of Change of Stage from March to July, as opposed to the April to June 15 Sac-EFT-defined values. Lastly, the Rate of Change of Stage parameter was removed and instead germination was analyzed based on the 14-day minimum/maximum parameter (similar to the Cottonwood Seedling Inundation). Tables A-8 through A-10 show the results of these changes.

Table A-8. Cottonwood Seedling Germination Sensitivity – RS 26.25–RS 22.50

Ecosystem Function Relationship	RS 26.25		RS 24.50		RS 22.50	
	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)
1 inch per day	40.6	8,802	40.1	10,710	31.3	5,774
2 inches per day	42.7	14,242	41.3	15,182	35.0	12,395
3 inches per day	42.1	12,587	40.9	13,504	34.3	10,861
March - July	40.4	8,411	40.2	10,909	31.9	6,634
14-day Minimum/Maximum (no Rate of Change)	44.5	19,757	42.4	19,759	38.1	19,760

Source: Data provided by AECOM in 2011 based on modeling using the U.S. Army Corps of Engineers Hydrologic Engineering Center's Ecosystem Functions Model and River Analysis System

Notes:
cfs = cubic feet per second
RS = River Station

Table A-9. Cottonwood Seedling Germination Sensitivity – RS 19.00–RS 13.25

Ecosystem Function Relationship	RS 19.00		RS 15.75		RS 13.25	
	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)
1 inch per day	29.9	6,959	28.8	7,845	27.7	7,845
2 inches per day	33.1	13,680	31.6	14,361	29.9	14,394
3 inches per day	31.9	10,922	30.2	10,972	28.8	11,598
March - July	30.1	7,407	28.7	7,681	27.5	8,489
14-day Minimum/Maximum (no Rate of Change)	35.5	19,763	33.5	19,764	31.7	19,763

Source: Data provided by AECOM in 2011 based on modeling using the U.S. Army Corps of Engineers Hydrologic Engineering Center's Ecosystem Functions Model and River Analysis System

Notes:
cfs = cubic feet per second
RS = River Station

Table A-10. Cottonwood Seedling Germination Sensitivity – RS 11.00–RS 8.50

Ecosystem Function Relationship	RS 11.00		RS 8.50	
	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)
1 inch per day	25.3	8,198	23.1	7,635
2 inches per day	28.4	15,074	27.0	15,429
3 inches per day	26.9	11,562	25.1	11,343
March - July	25.6	8,830	23.1	7,756
14-day Minimum/Maximum (no Rate of Change)	30.8	21,427	30.6	24,908

Source: Data provided by AECOM in 2011 based on modeling using the U.S. Army Corps of Engineers Hydrologic Engineering Center's Ecosystem Functions Model and River Analysis System

Notes
cfs = cubic feet per second
RS = River Station

The following can be concluded:

1. **There appears to be an "optimum" Rate of Change of Stage value that corresponds to a maximum flow and stage and thus maximum potential habitat area.**

   If this optimum Rate of Change of Stage value is considered ecologically "acceptable" (i.e., it still provides viable habitat given the greater rate of change) then it could be used to map the maximum potential habitat area.

2. **Extending the analysis period did not significantly impact flows or stages.**

   While extending the analysis period did not impact flows or changes on the lower Feather River, results may vary depending on the operational characteristics of upstream controls (e.g., dams) and therefore may vary depending on the stream reach.

3. **Using a 14-day minimum/maximum query, as opposed to the Rate of Change of Stage, significantly increased flow and stage, resulting in greater potential habitat area.**

   Consideration should be given as to the importance of the Rate of Change of Stage query since it significantly reduces the flow and stage and thus potential habitat area.

4. **When assuming a 2-inch rate of change of stage or when removing the rate of change of stage criteria and using a 14-day minimum/maximum criteria, Cottonwood Seedling Germination produces higher flows and stages than Cottonwood Seedling Inundation.**

   This suggests that successful Cottonwood recruitment may be possible under alternative EFR criteria. It should be noted, however, that Cottonwood Seedling Germination and Inundation are not dynamically linked with HEC-EFM and that any conclusions regarding recruitment success must be considered with this in mind.

The Salmonid Rearing Habitat Formation EFR was modified from the SacEFT-defined March through May, 7-day minimum/maximum and 67 percent chance frequency criteria to analyze various frequencies, including 50, 33, 20, and 10 percent chance, a 14-day duration and no duration criteria, and a 7-day duration from March through July. Tables A-11 through A-13 show the results of these changes.

The following can be concluded:

1. **Flow and stage increase linearly with frequency.**

   As expected, lower frequency criteria resulted in greater flow and stage. Figure A-22 shows the corresponding area for each 7-day duration frequency within HAA 11.00. Although the 10 percent chance frequency produces the greatest area (note: the 10 percent chance area includes all areas mapped under the 20 percent chance area, the 20 percent chance area includes all areas mapped under the 33 percent chance area, etc.), much of the area may not correspond to ideal salmonid habitat, given that successful salmonid habitat does not rely as heavily on widespread floodplain inundation but rather habitat located within side channels and along river banks.

2. **Extending the period of the analysis to include June and July significantly increases the flow by 2 to 3 times.**

   Unlike Cottonwood Seedling Germination, increasing the period of analysis results in greater potential habitat area. If June and July were considered ecologically "acceptable" periods for salmonid rearing, the period of analysis could be extended to increase the potential habitat area.

3. **Removing the duration criteria increased the flow and stage minimally, while assuming 14-day duration versus 7-day duration minimally decreased the flow and stage.**

   Adjusting the duration of the event did not significantly impact flows, stages, or potential habitat area.

Table A-11. Salmonid Rearing Habitat Sensitivity – RS 26.25–RS 22.50

Ecosystem Function Relationship	RS 26.25		RS 24.50		RS 22.50	
	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)
67% chance, 7-day duration	38.4	4,142	37.9	4,150	30.2	4,159
50% chance, 7-day duration	39.4	6,231	38.7	6,231	31.7	6,231
33% chance, 7-day duration	41.4	10,901	40.2	10,904	34.3	10,916
20% chance, 7-day duration	43.2	15,673	41.4	15,684	36.5	15,693
10% chance, 7-day duration	47.1	28,466	44.8	28,465	41.1	28,462
67% chance, 7-day duration March-July	41.6	11,265	40.3	11,232	34.4	11,200
67% chance; no duration	39.1	5,661	38.5	5,659	31.3	5,657
67% chance; 14-day duration	38.1	3,733	37.7	3,734	29.8	3,735

Source: Data provided by AECOM in 2011 based on modeling using the U.S. Army Corps of Engineers Hydrologic Engineering Center's Ecosystem Functions Model and River Analysis System

Notes:
cfs = cubic feet per second
RS = River Station

Table A-12. Salmonid Rearing Habitat Sensitivity – RS 19.00–RS 13.25

Ecosystem Function Relationship	RS 19.00		RS 15.75		RS 13.25	
	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)
67% chance, 7-day duration	28.1	4,181	26.9	4,187	25.6	4,181
50% chance, 7-day duration	29.4	6,229	28.0	6,226	26.5	6,219
33% chance, 7-day duration	31.9	10,916	30.2	10,923	28.5	10,931
20% chance, 7-day duration	34.0	15,715	32.1	15,734	30.4	15,756
10% chance, 7-day duration	38.5	28,452	36.2	28,446	24.5	28,445
67% chance, 7-day duration March-July	32.0	11,121	30.2	11,060	28.5	11,031
67% chance; no duration	29.1	5,699	27.7	5,619	26.2	5,582
67% chance; 14-day duration	27.8	3,737	26.6	3,748	25.3	3,758

Source: Data provided by AECOM in 2011 based on modeling using the U.S. Army Corps of Engineers Hydrologic Engineering Center's Ecosystem Functions Model and River Analysis System

Notes:
cfs = cubic feet per second
RS = River Station

Table A-13. Salmonid Rearing Habitat Sensitivity – RS 11.00–RS 8.50

Ecosystem Function Relationship	RS 11.00		RS 8.50	
	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)
67% chance, 7-day Duration	23.8	4,942	21.8	5,684
50% chance, 7-day Duration	25.0	7,536	24.3	9,762
33% chance, 7-day Duration	27.0	11,832	27.1	15,760
20% chance, 7-day Duration	29.1	16,800	29.3	21,232
10% chance, 7-day Duration	34.4	32,453	34.7	38,506
67% chance, 7-day Duration March-July	26.7	11,175	24.7	10,592
67% chance; No Duration	24.7	6,706	23.0	7,443
67% chance; 14-day Duration	23.4	3,999	21.4	5,079

Source: Data provided by AECOM in 2011 based on modeling using the U.S. Army Corps of Engineers Hydrologic Engineering Center's Ecosystem Functions Model and River Analysis System

Notes:
cfs = cubic feet per second
RS = River Station

3.3 Mapping

This section includes the results of the HEC-EFM analysis and the use of various mapping approaches to spatially visualize the HEC-EFM results. It also includes a discussion of how the spatial results can be further refined and reviewed to identify potential alternatives and how the final results can be presented.

3.3.1 Mapping Approaches

While HEC-EFM provides a stage and flow that meets the conditions of a given EFR, additional efforts are required to visualize the spatial area along the river that meets those conditions. Three approaches to mapping the results of HEC-EFM are presented in the following sections.

HEC-GeoRAS

The HEC-EFM results discussed above were mapped using HEC-RAS and the GIS extension to HEC's River Analysis System (HEC-GeoRAS), as recommended in the USACE-HEC *HEC-EFM Quick Start Guide* (USACE-HEC, 2009 (see Figure A-23)). This approach uses the flow rates determined by HEC-EFM but disregards the stages determined by HEC-EFM.

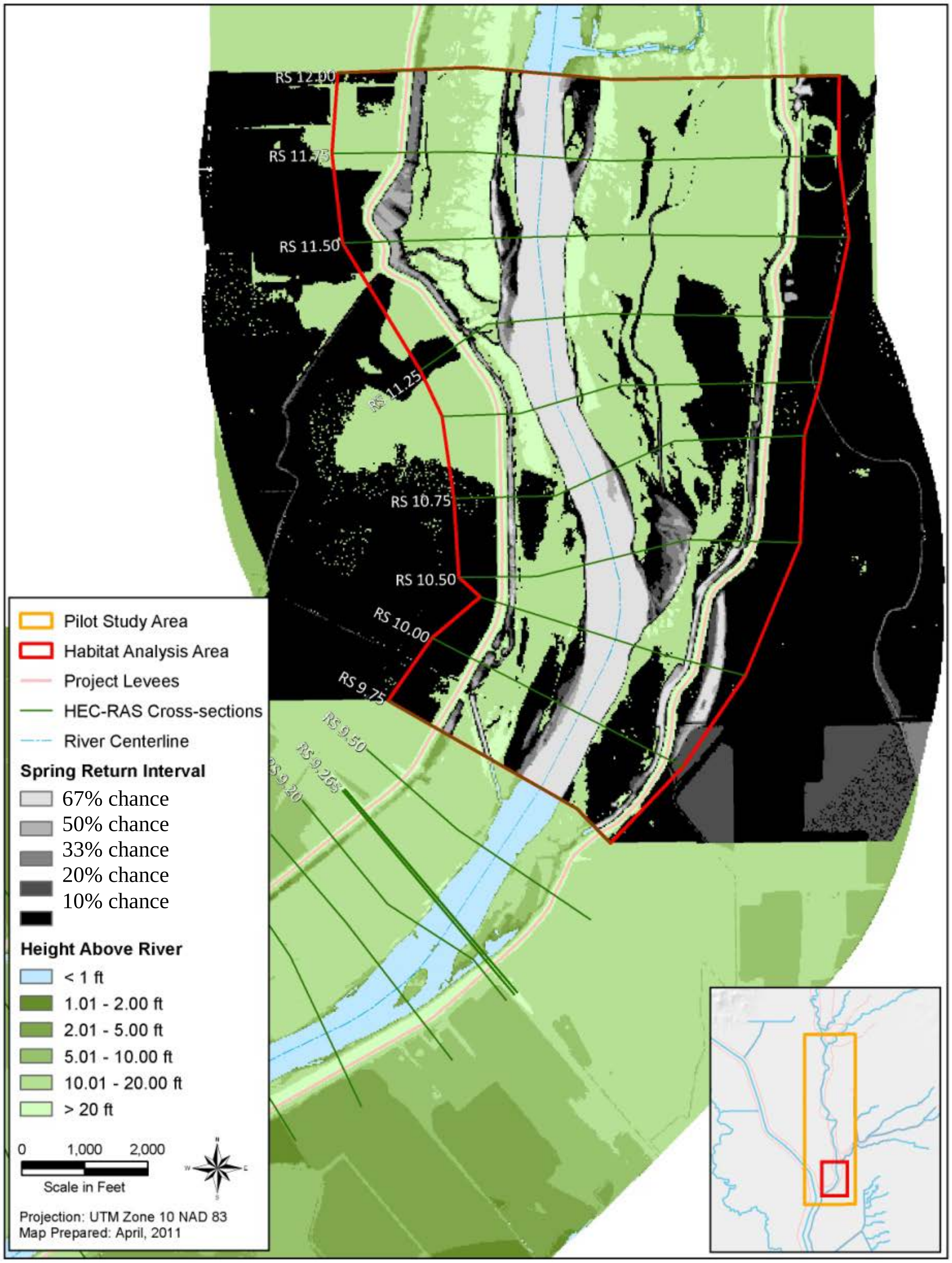

Figure A-22. Salmonid Rearing Habitat for Various Frequency Events in HAA 11.00

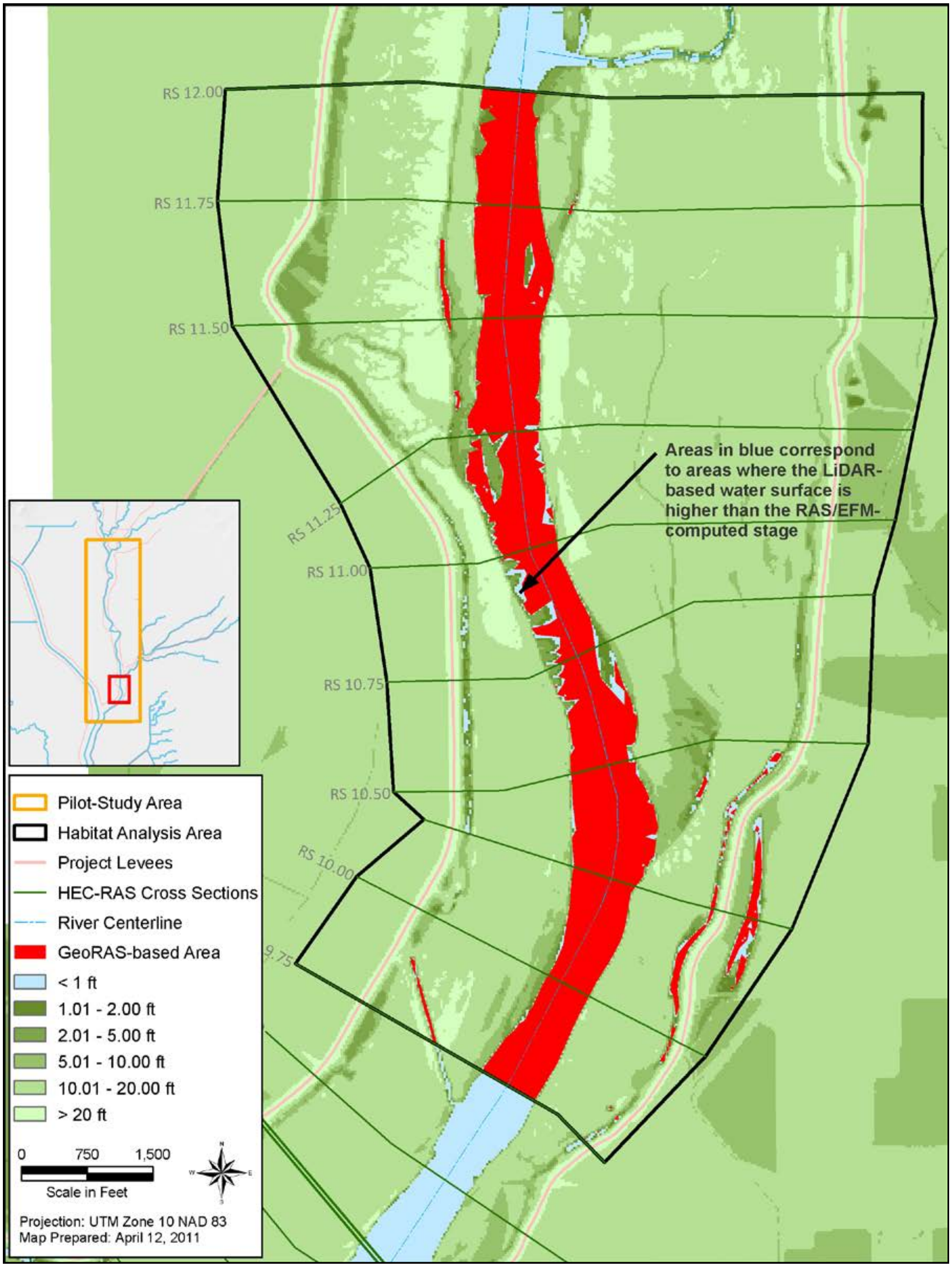

Figure A-23. Salmonid-Rearing Habitat Areas Mapped Using HEC-GeoRAS in HAA 11.00

The flow rates determined by HEC-EFM at each representative cross section were used as input for the HEC-RAS steady-state model. HEC-RAS was then used to compute the water-surface profiles for each HAA that corresponded to the flow determined by HEC-EFM. The entire pilot-study area HEC-RAS model was used to analyze each HAA (i.e., the model was not truncated to each HAA). This was done to maintain proper upstream and downstream boundary conditions and because truncating the model to each HAA would not necessarily reduce and could likely increase the level of effort.

The water-surface profile for each HAA and EFR were then mapped using the HEC-GeoRAS tool within ArcGIS. The water surface areas correspond to areas that meet the EFR conditions, as determined by HEC-EFM and HEC-RAS. It took approximately 10 minutes of processing time to run the HEC-GeoRAS tool for a single HAA and EFR. Each water surface area polygon was then clipped to its respective HAA. It should be noted that the inundation depth grid, a product of HEC-GeoRAS that is used in the HEC-EFM manual to show the extent of potential habitat, is not shown. The depth grid was not shown because the water surface area polygon is simpler for readers to identify with and is easier to work with in ArcGIS. Results are shown on Figures G-1 through G-11 in Appendix G for each HAA and EFR (Cottonwood Recruitment was not mapped because potential habitat areas outside of the channel banks were not identified). The background of each map corresponds to the LiDAR-based FIP.

The following are important findings of this approach:

1. **The water surface areas mapped are the direct, raw product of the RAS/EFM analysis.**

   Areas have not been refined based on additional ecological or biological considerations, such as soil type, vegetation type, bank slope, connectivity, or land use.

2. **HEC-RAS and HEC-GeoRAS cannot map areas beyond the HEC-RAS model cross sections.**

   As a result, areas beyond existing levees are not mapped. Cross sections would need to be extended beyond the levees to map areas outside the existing levee system.

3. **EFRs that produce stages below the LiDAR observed water surface are not mapped by HEC-GeoRAS.**

   When EFR stages are below the LiDAR-observed water surface, water surface area does exist; however, the area is simply below the LiDAR-observed water surface. To resolve this issue, bathymetry would need to be combined with the LiDAR terrain.

Height Above River

Although HEC-GeoRAS is a proven and reliable method for mapping HEC-RAS results, its limitation of mapping within cross-section extents makes it difficult to determine the potential for habitat beyond the existing levee system. Its inability to map below the LiDAR-observed water surface also reduces the value for mapping within channel banks. Thus, an alternative approach was reviewed using the FIP methodology.

After reviewing and testing the FIP approach as well as the HEC-GeoRAS and ArcGIS approaches, the FIP approach was selected as the preferred mapping approach.

Similar to the approach discussed above, HEC-RAS was used to simulate the water-surface profile for each HAA based on the flows determined by HEC-EFM. The results were exported to GIS, and HEC-GeoRAS was used to develop cross-section cut-lines with water surface elevations for each HAA and EFR. ArcGIS was then used to perform FIP analyses for each HAA and EFR. Figure A-24 shows an example of the Cottonwood Seedling Germination habitat area identified using the HEC-GeoRAS approach versus the FIP approach from RS 9.75 through RS 12.00 (HAA 11.00).

The following are important findings of this approach:

1. **The FIP analysis is capable of mapping the RAS/EFM analysis results within the entire FIP study area.**

   Mapping was not limited to the cross-section extents and provides mapping beyond the existing levee system.

2. **The FIP analysis replaces the LiDAR-observed water surface with the water-surface profiles computed by HEC-RAS, based on predefined bank breaklines.**

   As a result, the entire channel, from bank to bank, is shown as meeting the RAS/EFM analysis EFR criteria. This may overestimate the area of potential habitat within the channel. To resolve this issue, bathymetry would need to be combined with the LiDAR terrain.

3. **The water surface areas mapped are the direct, raw product of the RAS/ EFM analysis.**

   Areas have not been refined based on additional ecological or biological considerations, such as soil type, vegetation type, bank slope, connectivity, or land use.

ArcGIS

The approaches discussed above use HEC-RAS to determine the water-surface profile within each HAA that meet the conditions of each EFR. These water-surface profiles are computed by HEC-RAS using the flows determined by HEC-EFM. While these approaches provide hydraulically correct water-surface profiles through each HAA, they require a significant level of effort. An alternative was considered using ArcGIS to directly map the stage determined by HEC-EFM. This approach uses the stage determined by HEC-EFM instead of the flow rate, with the stage mapped within ArcGIS for each HAA and EFR.

This approach assumes that the stage determined by HEC-EFM for a given HAA and EFR applies uniformly across the HAA (i.e., it assumes there is no slope to the water surface throughout the HAA). This assumption may or may not be valid, depending on the hydraulic characteristics of the HAA.

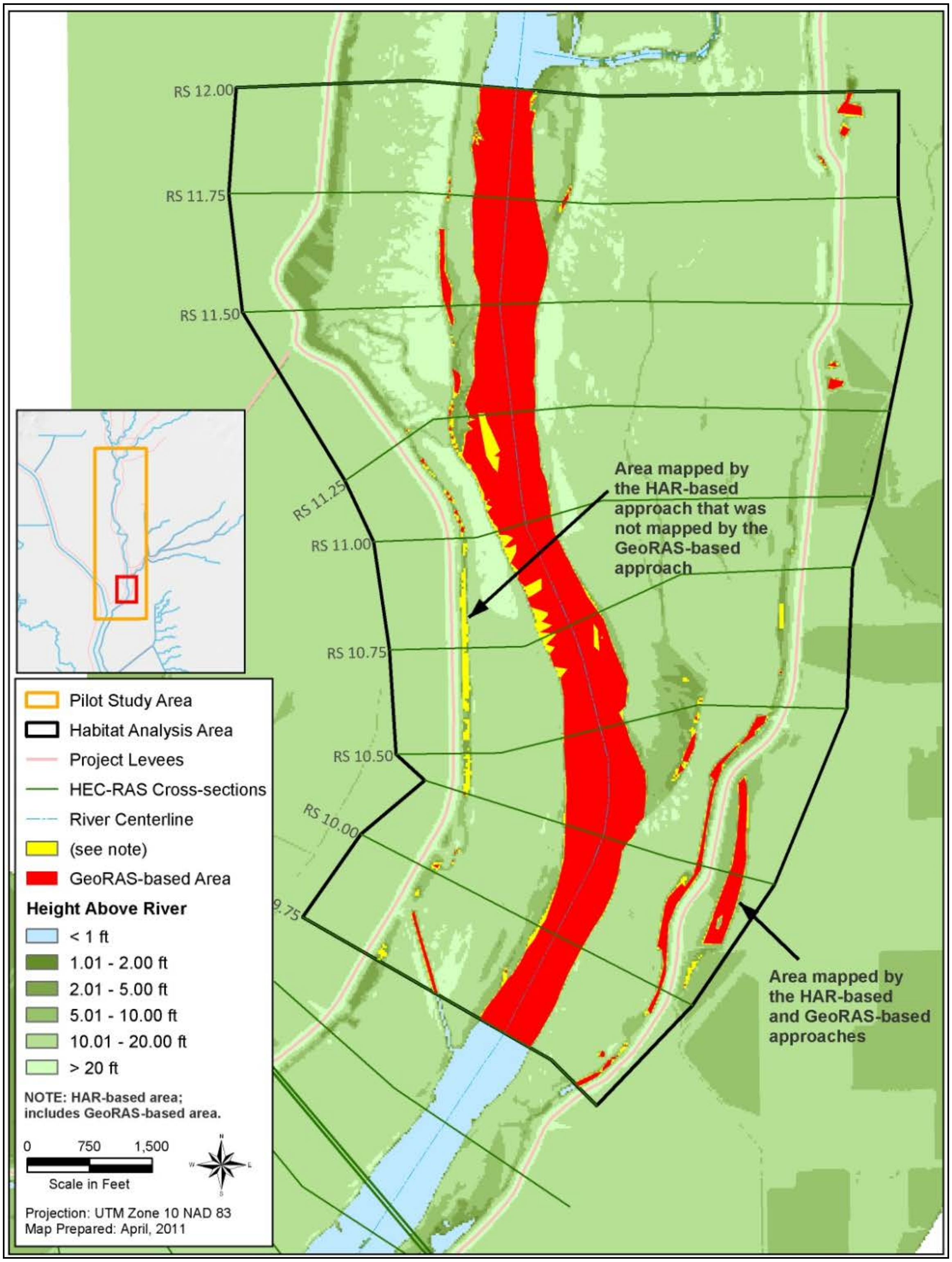

Figure A-24. Cottonwood Seedling Germination Habitat Areas Mapped Using FIP and HEC-GeoRAS in HAA 11.00

Again, this assumption *may be valid* if the HAAs were defined such that their hydraulic conditions were homogenous. Each HAA and EFR was mapped by first creating a water-surface TIN terrain model with a single elevation and then taking the difference between the TIN and the LiDAR terrain. This TIN extends beyond the cross-section extents so that mapping beyond existing levees is possible. As an example, Table A-14 shows the stages determined by HEC-RAS between RS 9.75 and RS 12.00 using the previous two mapping methods. Using this approach, the areas between these river stations would be mapped using the single stage determined by HEC-EFM for RS 11.00: 23.8 feet (see Tables A-5 through A-7).

Table A-14. HEC-RAS-Derived Stages for Salmonid-Rearing Habitat – RS 9.75–RS 11.00

River Station	Stage (feet)	River Station	Stage (feet)
9.75	22.03	11.25	24.09
10.00	22.31	11.50	24.25
10.50	23.27	11.75	24.40
10.75	23.62	12.00	24.84
11.00	23.84		

Source: Data compiled by AECOM in 2011 based on modeling using U.S. Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS)

Figure A-25 compares the mapping results using each method between RS 9.75 and RS 12.00 for Salmonid-Rearing Habitat. For this HAA, while there are differences between each approach, the results are similar, leading to the assumption that a single stage can represent an entire FIP is reasonable. This alternative approach took approximately a half day to map the entire study area for all EFRs, significantly less than the 1 to 2 days required to perform the HEC-GeoRAS- and FIP-based approaches.

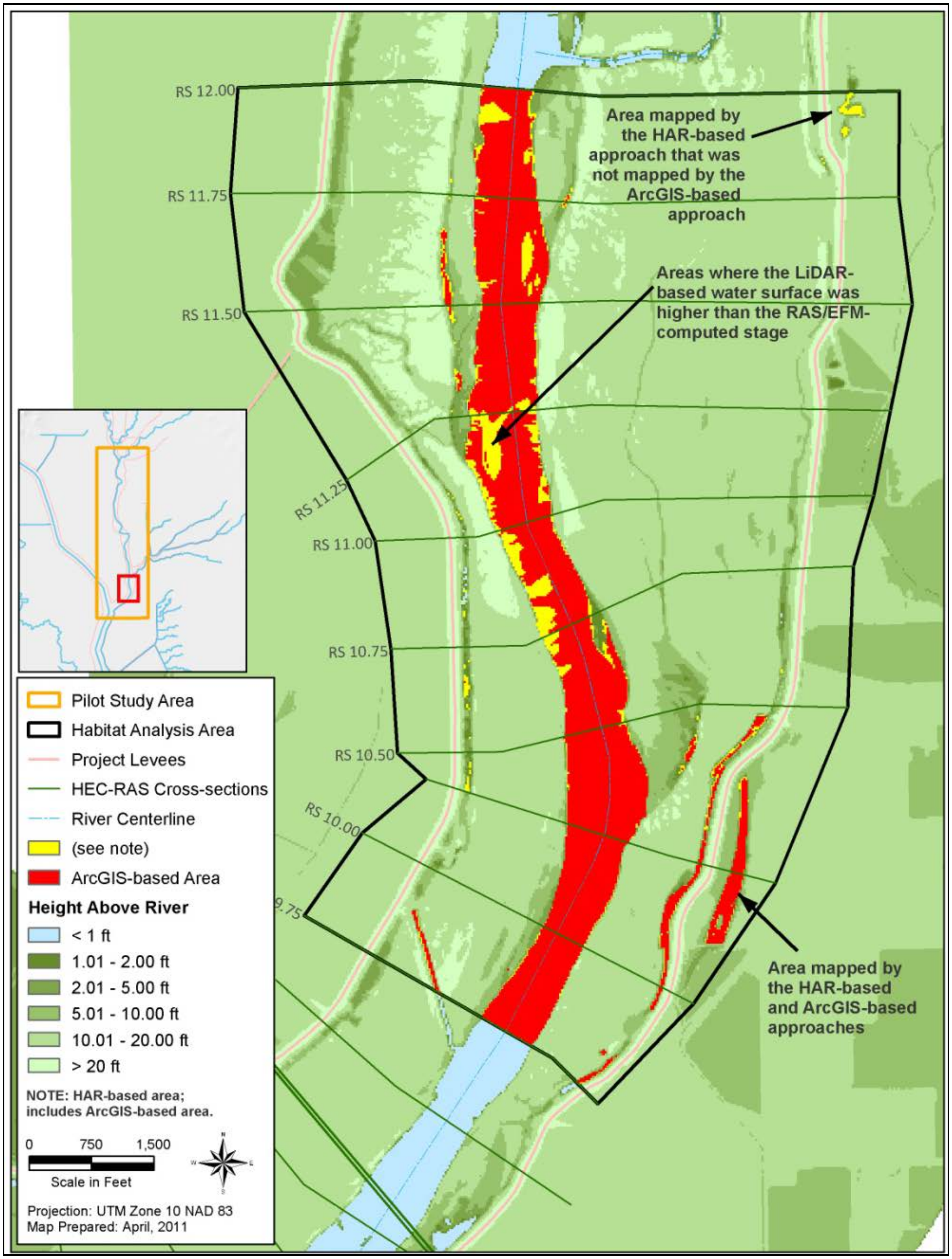

Figure A-25. Salmonid-Rearing Habitat Areas Mapped Using FIP and ArcGIS in HAA 11.00

The following are important findings of this approach:

1. **Mapping stages directly from HEC-EFM may or may not be appropriate, depending on whether the HAA is hydraulically homogenous.**

   For HAA 11.00, this approach provides a reasonable estimate of the area very similar to the FIP-based approach.

2. **The water surface areas mapped are the direct, raw product of the RAS/EFM analysis.**

   Areas have not been refined based on additional ecological or biological considerations, such as soil type, vegetation type, bank slope, connectivity, or land use.

3. **EFRs that produce stages below the LiDAR-observed water surface are not mapped by ArcGIS.**

   When EFR stages are below the LiDAR-observed water surface, water-surface area does exist; however, the area is simply below the LiDAR-observed water surface. To resolve this issue, bathymetry would need to be combined with the LiDAR terrain.

3.3.2 Refinement of Mapping Products

Results of the mapping process can be further refined, quantified, and/or visualized in ArcGIS. For example, a series of spatial analyses could be conducted to calculate the area of potential habitat based on location, connected vs. disconnected (to the main channel), and/or the specific EFR. Other GIS layers, such as soils, known habitat areas, vegetation type, bank slope, connectivity, and depth, could be used to refine the mapping products and assist in identifying areas where alternatives may be used to create additional habitat.

3.4 Conclusions

The purpose of this pilot study was to understand the methods and approaches required for the HEC-RAS and HEC-EFM analysis and to identify any issues with or alternative approaches to the analysis. The intent of this study was not to develop a final restoration opportunities analysis for the lower Feather River. This report should serve to clarify the RAS/EFM analysis and to identify topics for discussion.

The following general conclusions were reached as a result of this pilot study:

1. **While HEC-EFM is a robust tool for querying historic flow records, EFRs rely on a single set of numerical criteria (as opposed to a range) and lack dynamic (i.e., year-to-year) coupling of relationships.**

   The project team and stakeholders expressed concern that a single EFR may not adequately identify potential habitat areas because the EFR defines areas based on a single set of numerical criteria, as opposed to a range. While these criteria may reflect optimal conditions for an ecological process, the ecological process may achieve some success at sub-optimal conditions. Multiple EFRs could be developed for a single ecological process representing "optimal," "sub-optimal," and "minimal" conditions; however, this would significantly increase the level of effort required for a systemwide analysis. As an alternative, a single EFR representing a broader range of conditions could be considered.

   In addition, HEC-EFM does not dynamically couple EFRs. Since Cottonwood Seedling Recruitment relies on germination followed by minimal inundation within the same year, without dynamically coupling the two EFRs, the results are heavily skewed toward the relationship that produces the greater flow and stage.

2. **The SacEFT HEC-EFM EFRs may not be applicable systemwide.**

   The primary concern with using the SacEFT EFRs systemwide, as identified by project team members and Stakeholders, is that the existing EFRs were developed for the Sacramento River mainstem and may not be applicable to the Sacramento River tributaries and/or other rivers in the study area, such as the San Joaquin River and its tributaries.

3. **The pilot study did not identify significant amounts of potential habitat on the lower Feather River and the RAS/EFM analysis would likely produce similar results systemwide.**

   Because of the existing conditions of the lower Feather River and because of how EFRs are defined (as discussed above), limited habitat was identified on the lower Feather River. Given the conditions on other rivers within the project area (e.g., heavily leveed, restrained by dams, and/or incised), similar results may be produced systemwide.

Based on these conclusions, the project team considered developing a single EFR with a broader range of criteria, possibly with an upper- and lower-bound, to represent habitat opportunities. For example, the EFR may represent the peak 50 percent chance flow that occurs during a 7-day duration spring and/or summer storm event. An upper and lower bound EFR may correspond to a higher or lower frequency and/or greater or smaller duration and/or time period. In combination with HEC-EFM and/or other statistical tools (e.g., the USACE HEC Statistical Software Package (HEC-SSP)), the synthetic flow record derived from the CalSim model may be queried at select locations where potential habitat is likely to exist. The EFR criteria will be based solely on flow, and since the CalSim-based flow records are developed wherever significant changes in flow occur, the development of HAAs is not critical. The flows associated with the EFR at these locations would then be mapped using HEC-RAS (steady-state) and the FIP approach. Regardless of whether HEC-EFM and/or other statistical tools, such as HEC-SSP, are used to query the flow records, it is the EFR criteria that ultimately determines the amount of potential habitat area identified. Therefore, the use of HEC-EFM versus other statistical tools should be based primarily on the ease of use, time required to set up, and output results from the software.

4.0 Acronyms and Abbreviations

cfs	cubic feet per second
Comprehensive Study	Sacramento and San Joaquin River Basins Comprehensive Study
CVFED	Central Valley Floodplain Evaluation and Delineation
CVP	Central Valley Project
DEM	digital elevation model
DWR	California Department of Water Resources
EFR	Ecosystem Function Relationship
ESRI	Environmental Systems Research Institute, Inc.
FIP	floodplain inundation potential
FROA	Floodplain Restoration Opportunity Analysis
GIS	geographic information system
HAA	Habitat Analysis Areas
HAR	Height Above River
HEC-DSS	Hydrologic Engineering Center’s Data Storage System
HEC-EFM	Hydrologic Engineering Center’s Ecosystem Functions Model
HEC-GeoRAS	Hydrologic Engineering Center’s River Analysis System
HEC-RAS	Hydrologic Engineering Center’s River Analysis System
HEC-SSP	Hydrologic Engineering Center’S Statistical Software Package
LiDAR	Light Detection and Ranging
MWH	MWH Americas, Inc.
NAVD88	North American Vertical Datum 1988
NGS	National Geodetic Survey
NGVD29	National Geodetic Vertical Datum of 1929
RAS/EFM	HEC-RAS/HEC-EFM

RS .... River Station
SacEFT .... Sacramento River Ecological Flows Tool
SWP .... State Water Project
TIN .... triangular irregular network
TM .... Technical Memorandum
USACE .... U.S. Army Corps of Engineers
USGS .... U.S. Geological Survey
WSEL .... water surface elevations
WY .... Water Year

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Attachment 9F: Floodplain Restoration Opportunity Analysis Appendix B – Investigation of USGS 10-Meter DEM Accuracy

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Appendix B

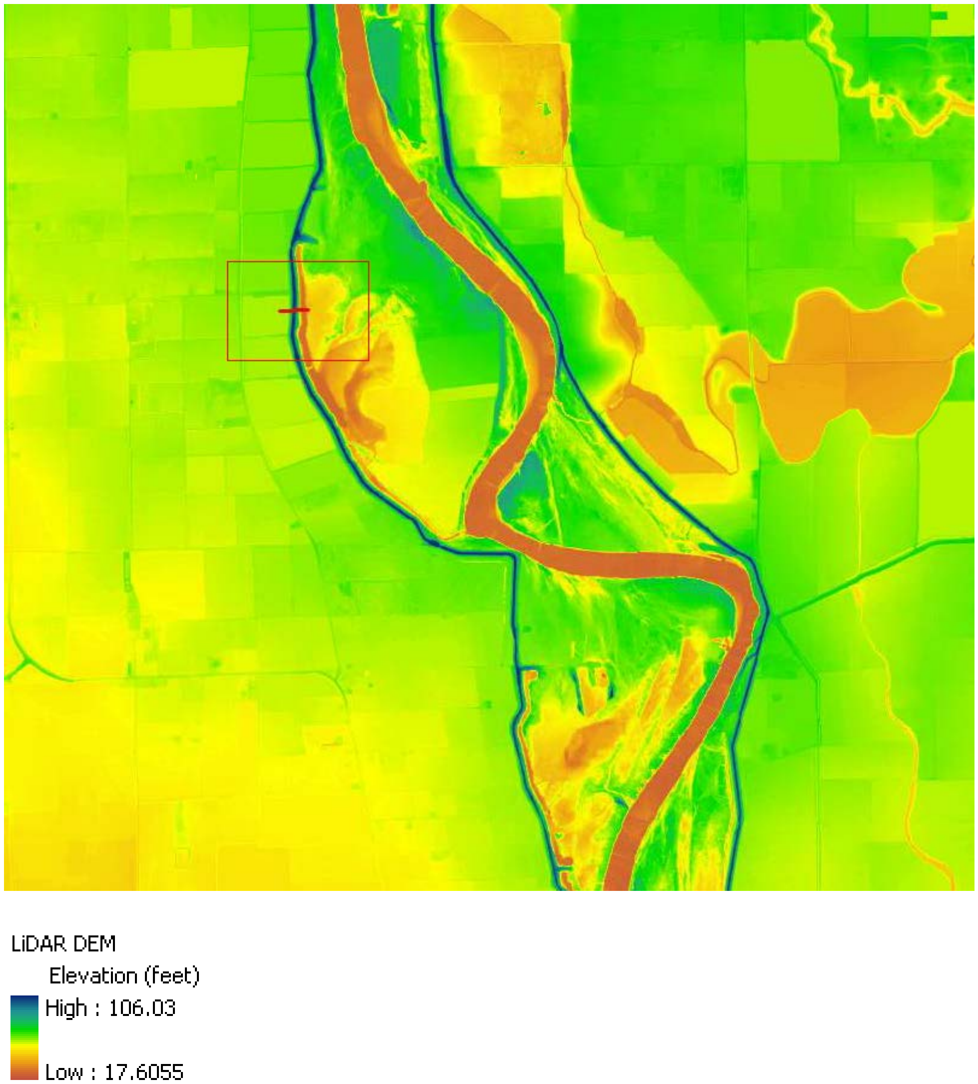
U.S. Geological Survey (USGS) 10-meter digital elevation models (DEM) were obtained (USGS, 2010) and evaluated for their appropriateness of use in the pilot study along the lower Feather River. This appendix provides the methods and results of a brief assessment of these data.

A portion of the California Department of Water Resources Central Valley Flood Evaluation and Delineation Project (CVFED) light detection and ranging (LiDAR)-derived DEM was selected (see inset box on Figure B-1) and a cross section was taken of the levee to compare the elevations from both the USGS DEM and LiDAR-derived DEM.

Elevations in the vicinity of the levee cross section are shown on Figure B-2 from the LiDAR-derived DEM, and Figure B-3 from the USGS DEM, indicating a significant difference in the two data sets with the USGS data presenting essentially “flat” topography in this location.

Figure B-4 provides a profile view of the two cross sections, demonstrating the lack of topographic relief provided in the USGS DEM data, and Figure B-5 provides tabular data indicating a USGS DEM surface is approximately 6 feet higher landward from the levee.

Given this comparison of the USGS DEM against the LiDAR DEM, it was determined that the USGS data does not pick up the crests of project levees. In many cases, the USGS data barely show any increase in elevation at the levee crest, and present a higher ground elevation landward from the levee. Based on this comparison, it was determined that the USGS DEM cannot be used as a substitute for the LiDAR-derived DEM data.



Note: Red line inside red box is a cross section used to compare the elevations of the U.S. Geological Survey digital elevation model and Light Detection and Ranging-derived digital elevation model.

Figure B-1. LiDAR-Derived DEM of the Pilot-Study Reach

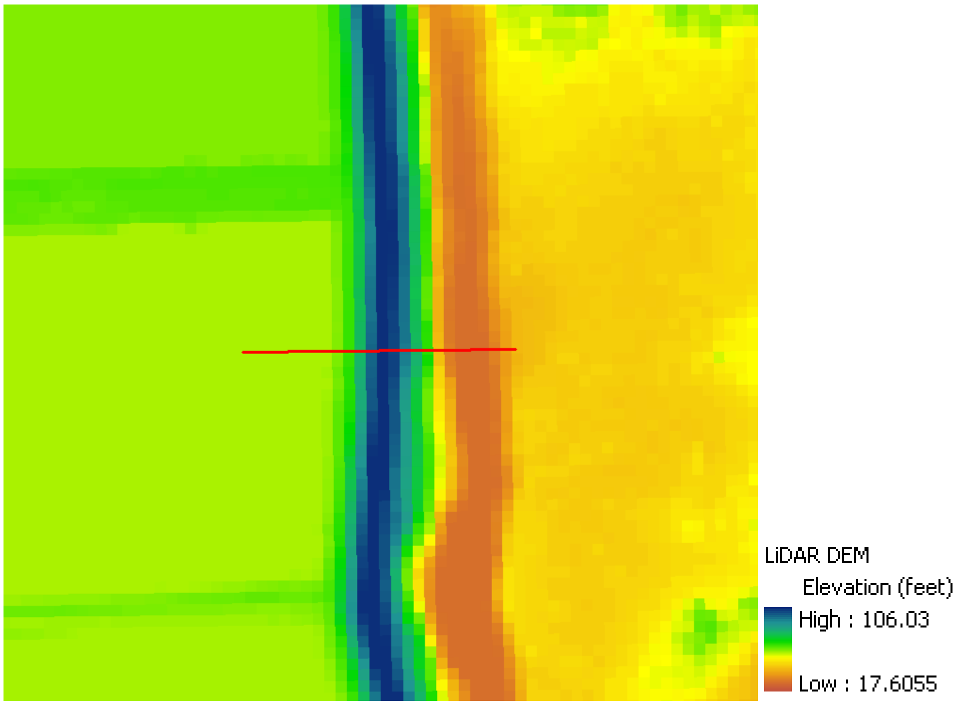


Figure B-2. Closeup of Cross Section on LiDAR DEM

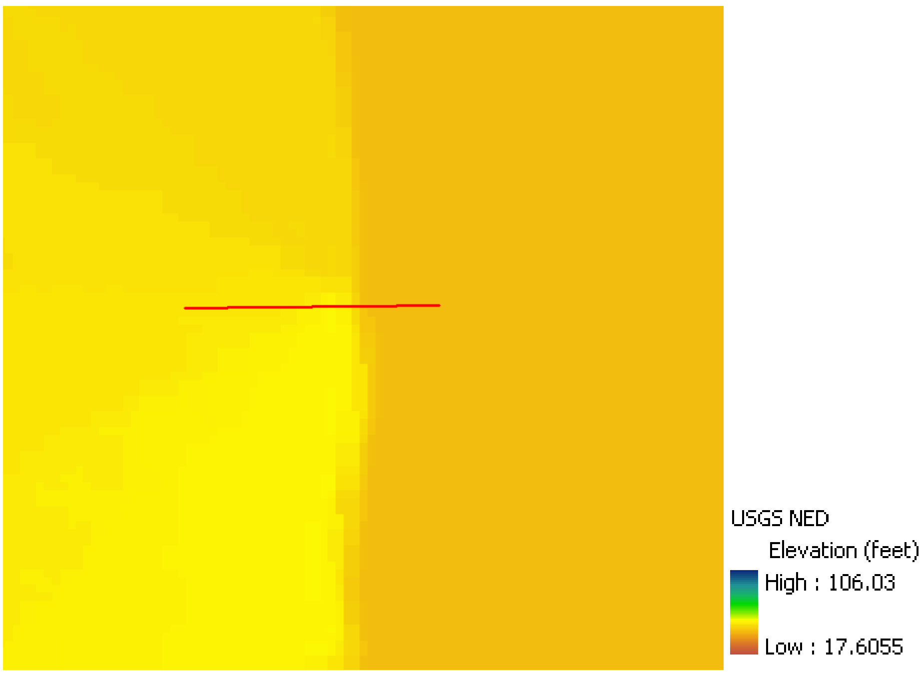


Figure B-3. Closeup of Cross Section on USGS DEM

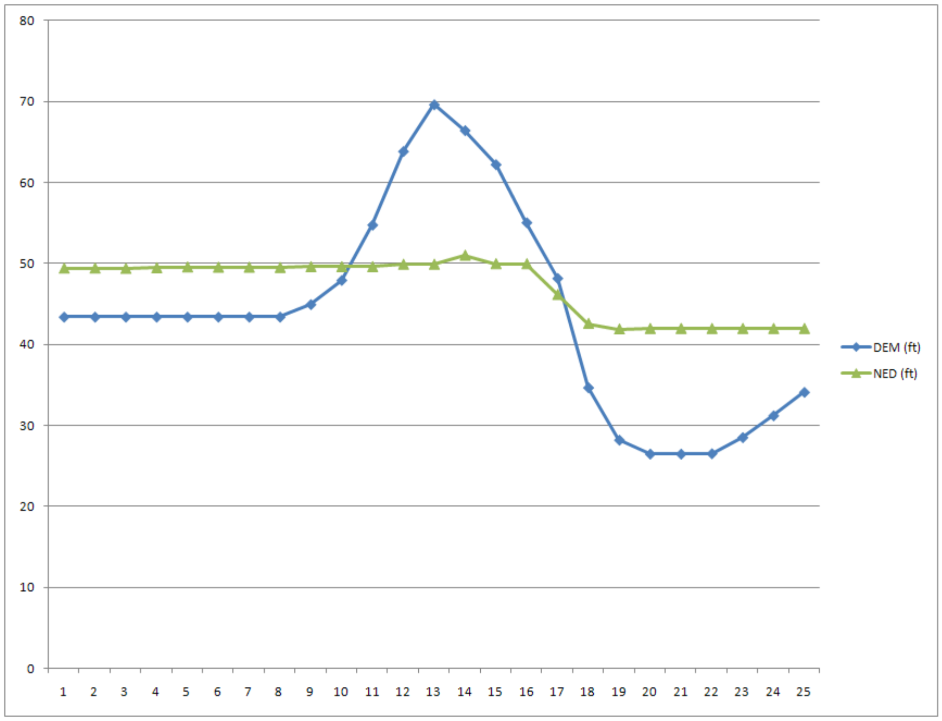


Figure B-4. Cross-Section Profiles

DEM (ft)	NED (m)	NED (ft)
43.41	15.06	49.40
43.41	15.06	49.40
43.41	15.05	49.36
43.41	15.08	49.46
43.41	15.11	49.56
43.41	15.1	49.53
43.41	15.1	49.53
43.41	15.09	49.50
44.96	15.12	49.59
47.95	15.12	49.59
54.78	15.12	49.59
63.87	15.21	49.89
69.64	15.21	49.89
66.45	15.55	51.00
62.24	15.23	49.95
55.07	15.23	49.95
48.19	14.07	46.15
34.68	12.98	42.57
28.21	12.77	41.89
26.49	12.79	41.95
26.49	12.79	41.95
26.54	12.79	41.95
28.53	12.79	41.95
31.22	12.79	41.95
34.12	12.79	41.95

Figure B-5. Tabular Comparison of Cross-Section Elevations

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Attachment 9F: Floodplain Restoration Opportunity Analysis Appendix C – CVFED LiDAR Terrain Data Comparisons

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Appendix C

Since final digital elevation models (DEM) were not available from the California Department of Water Resources (DWR) Central Valley Flood Evaluation and Delineation Project (CVFED) program at the time of this pilot study, the DEM preparation involved the use of preliminary CVFED terrain data and incorporating/building breaklines and filling in void areas found in the data to create a triangulated irregular network (TIN) from which to derive a DEM of a specified grid cell size. An approximate 30-square-mile area was defined for the DEM preparation (Figure C-1). The light detection and ranging (LiDAR) data had data voids where there is water and dense vegetation that restricted the TIN from triangulating, essentially leaving large gaps in the TIN. Points were created in those areas to help complete the TIN.

Factors considered in the completion of the TIN and DEM included:

1. Projection – The were in a standard coordinate system; however, if they were not, then the LAS files would need to be converted to a shapefile and reprojected.

2. Data Voids – Where the data did not have interpolated points/breaklines across data void areas for the TIN to easily triangulate, "filler" points were created to provide a surface across the void areas to enable the completion of the TIN surface.

3. TIN/DEM Build – This process was iterative and required that no gaps remained in the TIN and resulting DEM. For every gap found, a search radius was applied to identify the nearest points to triangulate.

At the request of the Project Team, a comparison was made of the preparation time, resolution (usability), and file size attributes for various DEM grid size resolutions. This comparison included 5-, 25-, 50-, and 100-foot DEMs in the Feather River pilot-study area.

The time difference associated with DEM sampling from the TIN was minor. The time considerations came primarily from the initial TIN build (especially if the LiDAR has data voids) and this was estimated to take 2 to 3 days per 100 square miles. Another potentially significant impact on preparation time would be hydro-correction of the terrain surface; however, this was not done, which preserved the actual topographic condition of the floodplain surfaces.

A sample portion of the pilot-study area was prepared at the various DEM grid cell resolutions to enable a visual comparison of the resolution differences (Figures C-2 to C-5).

The file sizes resulting from the various DEM grid cell resolutions varied dramatically, with exported ASCII DEM file sizes for the same area (approximately 30 square miles) as follows: 5-foot DEM at 365.3 megabytes (MB); 25-foot DEM at 14.3MB; 50-foot DEM at 3.6MB, and 100-foot DEM at 0.9MB.

Based on the results of this comparison a decision was made by DWR to develop a 25-foot DEM using preprocessed CVFED TO20 data in the pilot-study area. The use of a 25-foot resolution DEM was determined to provide a reasonable balance among the preparation time, resolution (usability), and file sizes with the intended level of detail for the final products from this planning-level exercise.

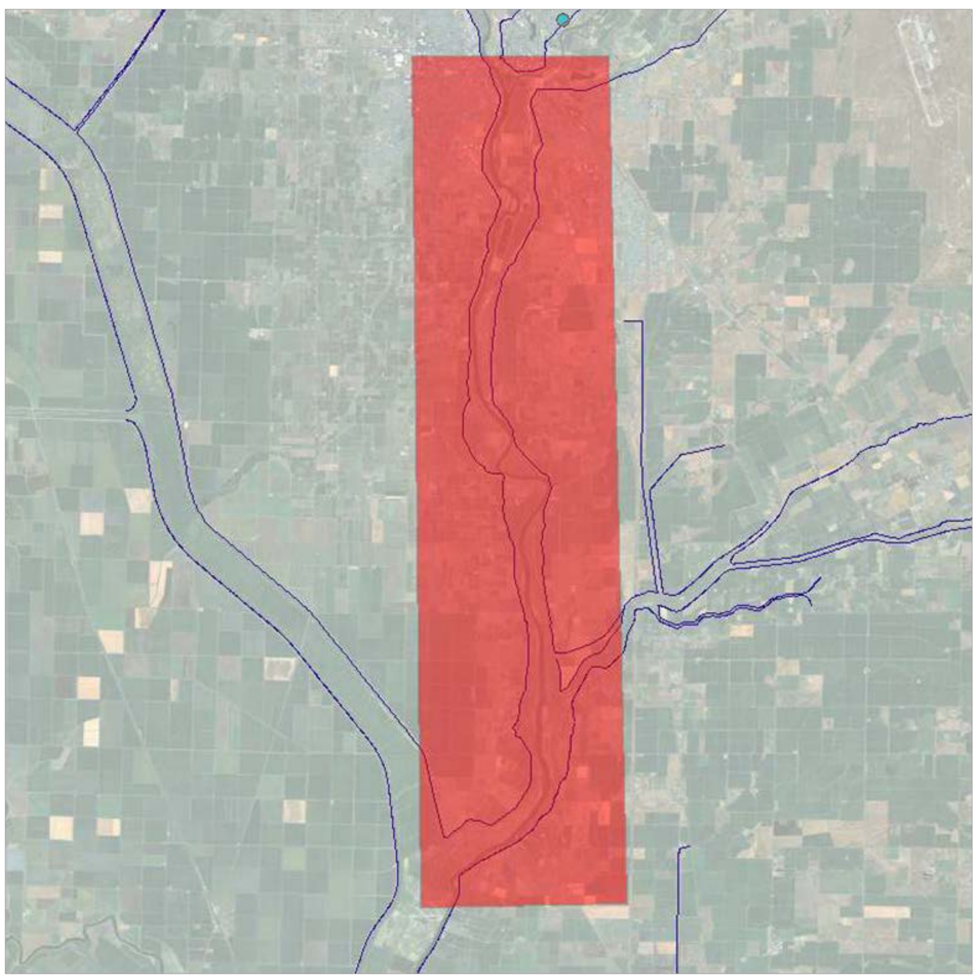

Figure C-1. Pilot-Study DEM Area

5ft DEM

25ft DEM

Figures C-2 and C-3. 5-Foot and 25-Foot DEM Grid Cell Size Resolutions, Respectively

50ft DEM

100ft DEM

Figures C-4 and C-5. 50-Foot and 100-Foot DEM Grid Cell Size Resolutions, Respectively

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Attachment 9F: Floodplain Restoration Opportunity Analysis Appendix D – Levee Realignment Methodology

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Appendix D

Within the Feather River pilot-study reach, the Project Team noted that there were two locations where levees had been set back since the March 2008 date of the light detection and ranging (LiDAR) flight. This resulted in a need to adjust the digital elevation model (DEM) terrain surface to show actual current topographic conditions. While the Height Above River (HAR) output to date still shows the old levee position, a separate effort was made to determine a reasonable approach to adjust levee locations for subsequent HAR analyses.

The following steps were taken to adjust the location of a levee in the DEM.

1. A polygon feature was created around the area of the existing and new levee locations. The polygon was used to clip the DEM, which cut down on the processing time (Figure D-1).

2. A copy of the DEM surface limited to the polygon area was extracted by using the Extract by Mask tool located in the ArcGIS Toolbox -> Spatial Analyst Tools -> Extraction -> Extract by Mask (Figures D-2 and Figure-D3, tool input Items a through c below; and Figure D-4, output resulting from Items a through c below).

    a. Input Raster – Input the DEM.

    b. Input Raster or Feature Mask Data – Input the polygon created in Step 1.

    c. User must set file location and name.

3. The raster was converted into points using the 3D Analyst Toolbar dropdown menu under Convert -> Raster to Features (Figure D-5).

    a. Output Geometry Type – Set to Point.

    b. Input Raster – This is the extracted raster from Step 2.

    c. Field – Set to <Value>.

    d. User must set output file location and name.

4. The existing and new levees were delineated with lines that were then buffered at a distance necessary to capture the entire width of the levee cells in the DEM (Figure D-6).

5. All points within the buffered areas were selected by using Main Menu -> Selection -> Select by Location (Figures D-7 and D-8, tool input Items a through d below; and Figures D-9 and D-10, output from Items a through d below).

   a. I want to – Pull down "Select Features From."

   b. The Following Layer – Click on the points file output from Step 3.

   c. That – Pull down "are within."

   d. The features in this layer – Pull down "New Levees Buffer" created from Step 4.

   e. The DEM polygon points selected within the new levee buffer area were deleted and the DEM polygon points selected within the existing levee buffer were exported using Step 6 before being deleted.

6. The points for the existing levee were selected in Step 5 and then exported by right clicking on the file name in the Layers Catalog: File Name -> Data -> Export Data. (Figures D-11 and D-12, tool input Items a through c below).

   a. Export – Pull down "Selected features."

   b. Use the same coordinate system as – Select "this layer's source data."

   c. Output shapefile or feature class – User sets file location and name.

7. The existing levee points from Step 6 were moved into the location of the deleted new levee points (Step 5e) in the Raster to Features point output from Step 3. This was done from the upstream portion of the levee to the downstream portion, where points from the existing levee were selected in groups and manually moved into the vacant new levee location. Occasionally a group of points needed to be rotated to fit the new area and maintain a consistent levee slope and height (Figure D-13).

8. The existing and new levee point layers were appended (combined) by entering the ArcGIS Toolbox, clicking on the Index Tab at the bottom,

typing “Append” into the “Type in key word to find:” box at the top, and selecting “Append (management)” (Figures D-14 and D-15, tool input Items a through c below). This combines the levee points from Step 3 (as modified in Step 5e) and the newly moved levee points from Step 7 into one file (Figure D-16).

a. Input Datasets – Enter filename for newly moved points from Step 7.

b. Target Dataset – Enter filename for points from Step 3, which were modified in Step 5e.

c. Schema Type (optional) – Pull down “NO TEST.”

9. All levee points were converted into a raster grid using the Features to Raster: Spatial Analyst toolbar -> Covert -> Features to Raster. (Figures D-17 and D-18, tool input Items a through d below).

    a. Input Features – Appended points file from Step 8.

    b. Field – This was set to GRID_CODE in the dropdown box.

    c. Output Cell Size – Should be set to the cell size of the DEM.

    d. Output Raster – User sets the raster file location and name.

10. The output raster had “NoData” value cells in the location of the existing levee because those points are no longer there. The next step involved filling these NoData cells with adjacent elevations from the DEM to create a smooth surface where the existing levee used to be (Figure D-19). This was done using the Spatial Analyst toolbar -> Raster Calculator (Figure D-20). In the expression box the following expression was typed, focalmean ([output raster from Step 9], rectangle, 3, 3, data) (Figure D-21). This expression assigns the NoData cells the Mean of the 3x3 area around them. This expression did not fill in all NoData cells on the first run, so the output of this expression was run through the raster calculator a second and third time until all NoData cells were given an elevation (Figure D-22).

11. The output raster from Step 10 was converted to Points using the same Raster to Features method as in Step 3 (Figure D-23).

12. The DEM was converted to Points using the same Raster to Features method as in Steps 3 and 11 (Figure D-24).

13. Points from the DEM points file, created in Step 12, were selected within the polygon created in Step 1, using Select by Location, which was done in Step 5 (Figure D-25). Once all points within the polygon were selected, they were deleted from the DEM points file from Step 12. The points from Step 11 were fit into the vacant area (Figure D-26).

14. The Points file from Step 13 was combined with the Points file from Step 11 using the Append (management) tool, as done in Step 8.

15. The appended Points shapefile from Step 14 was converted into a raster grid, as done in Step 9 using the Features to Raster tool, and this raster output was the final result (Figure D-27). The new levee is now in the DEM. If there are any NoData cells in the area where the new levee was added in the DEM, the expression from Step 10 can be run in the Raster Calculator.

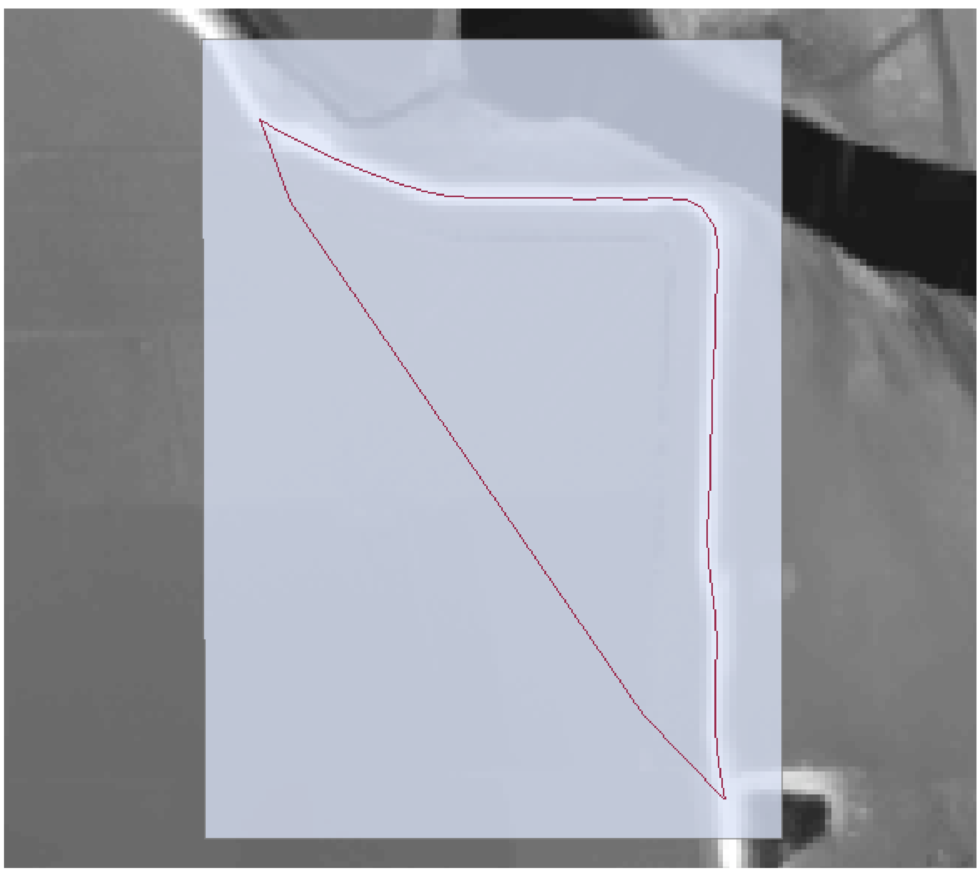

Figure D-1. Polygon Feature for DEM Extraction

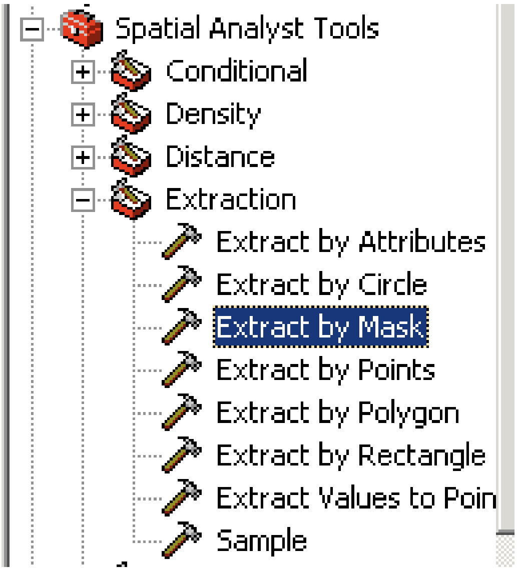

Figure D-2. Extract by Mask Tool in ArcGIS Toolbox

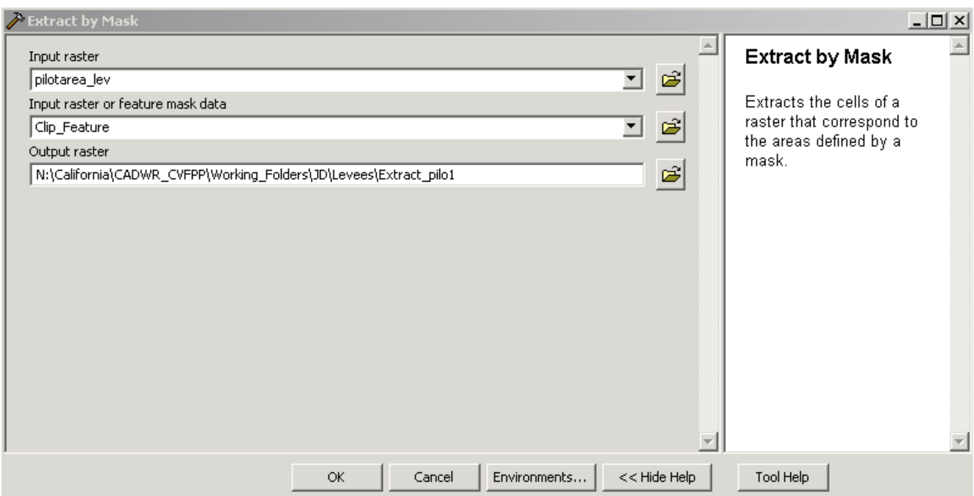

Figure D-3. Extract by Mask Menu Box

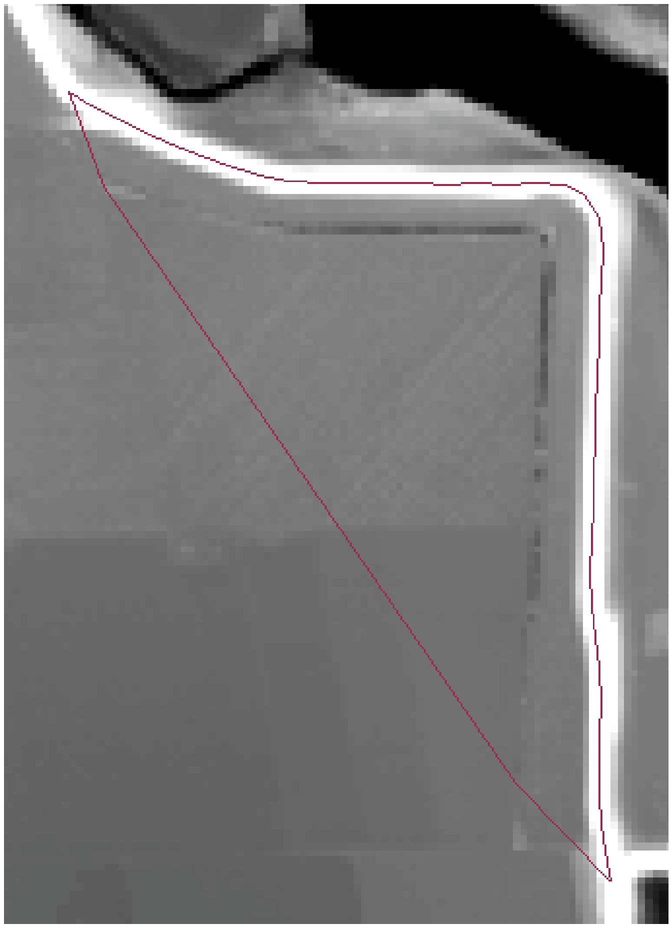

Figure D-4. Extract by Mask Output

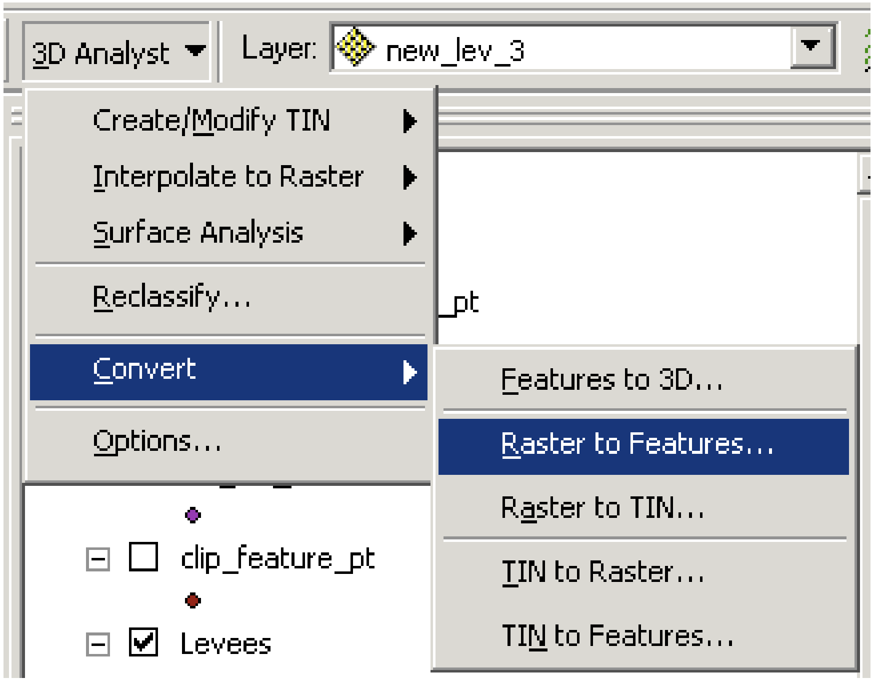

Figure D-5. Raster to Features Location in 3D Analyst Toolbar

Figure D-6. Buffer of Existing and New Levee Lines

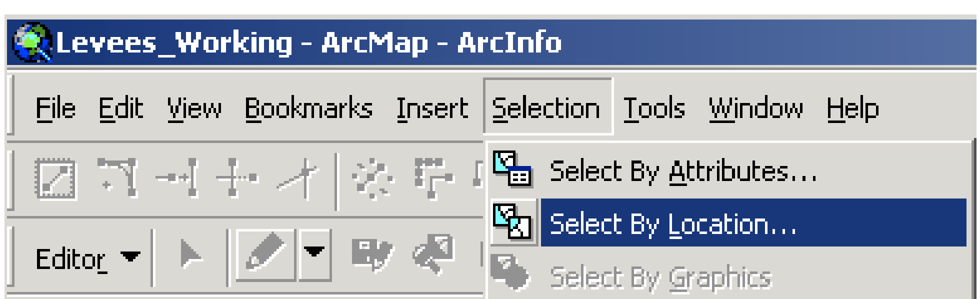

Figure D-7. Select by Location Tool

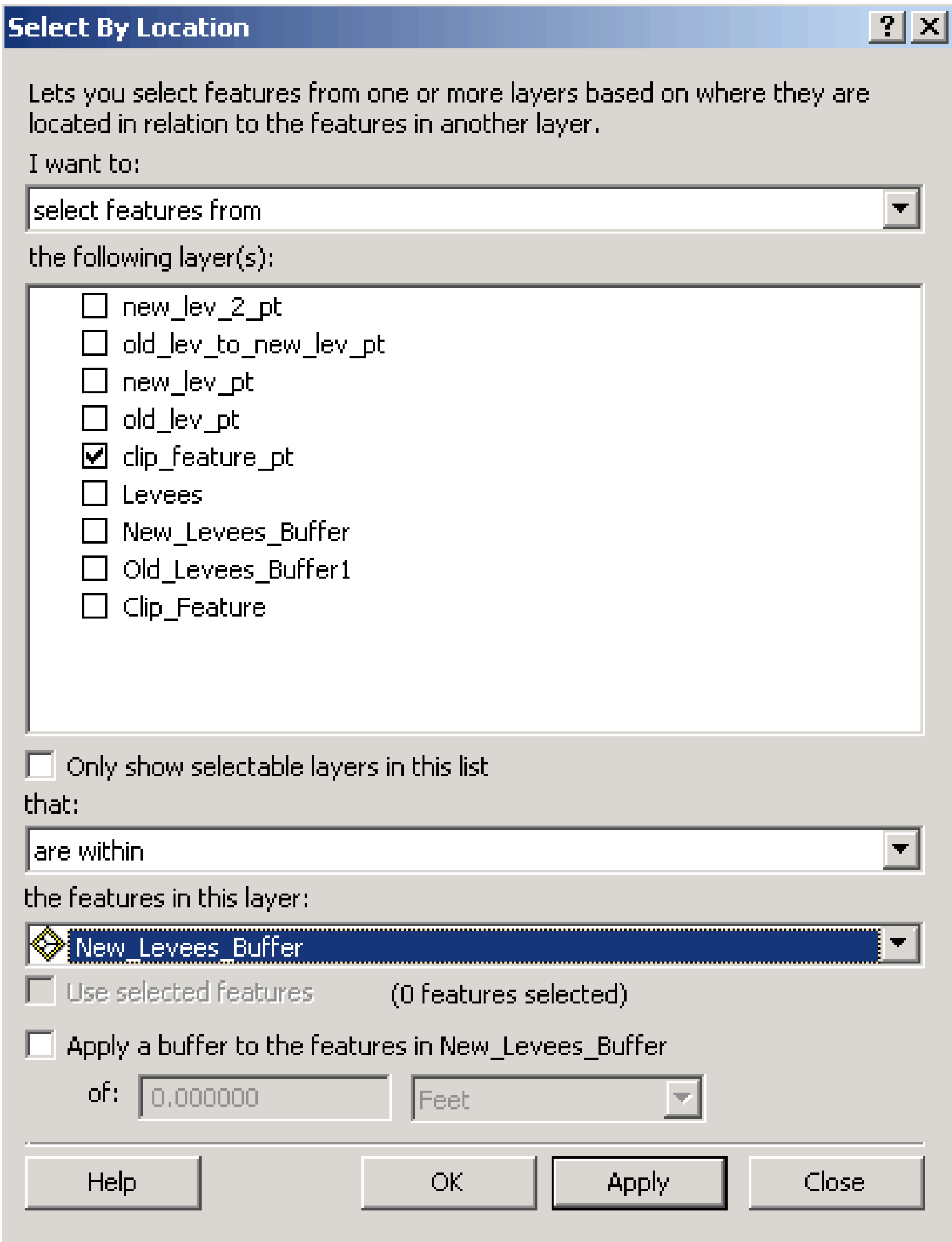

Figure D-8. Select by Location Menu Box

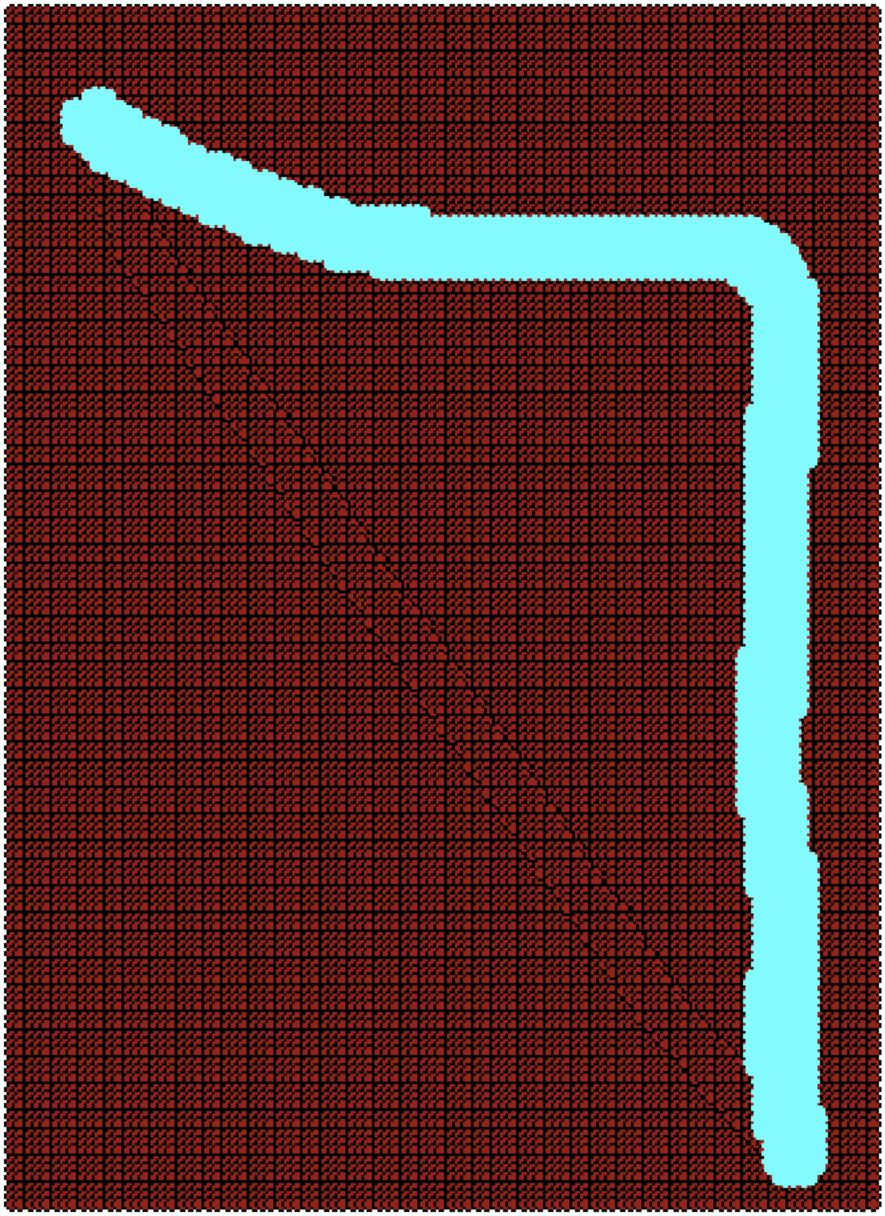

Figure D-9. Existing Levee Points

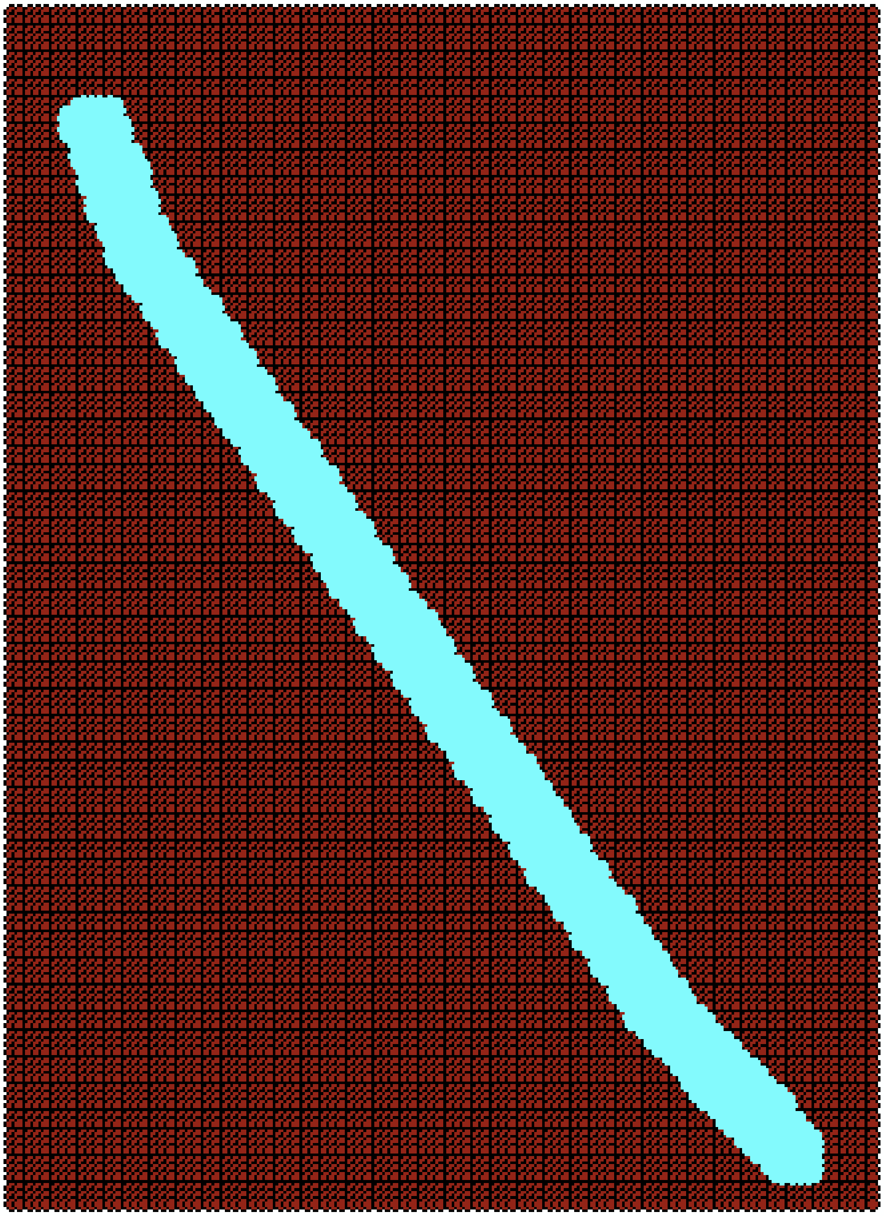

Figure D-10. New Levee Points

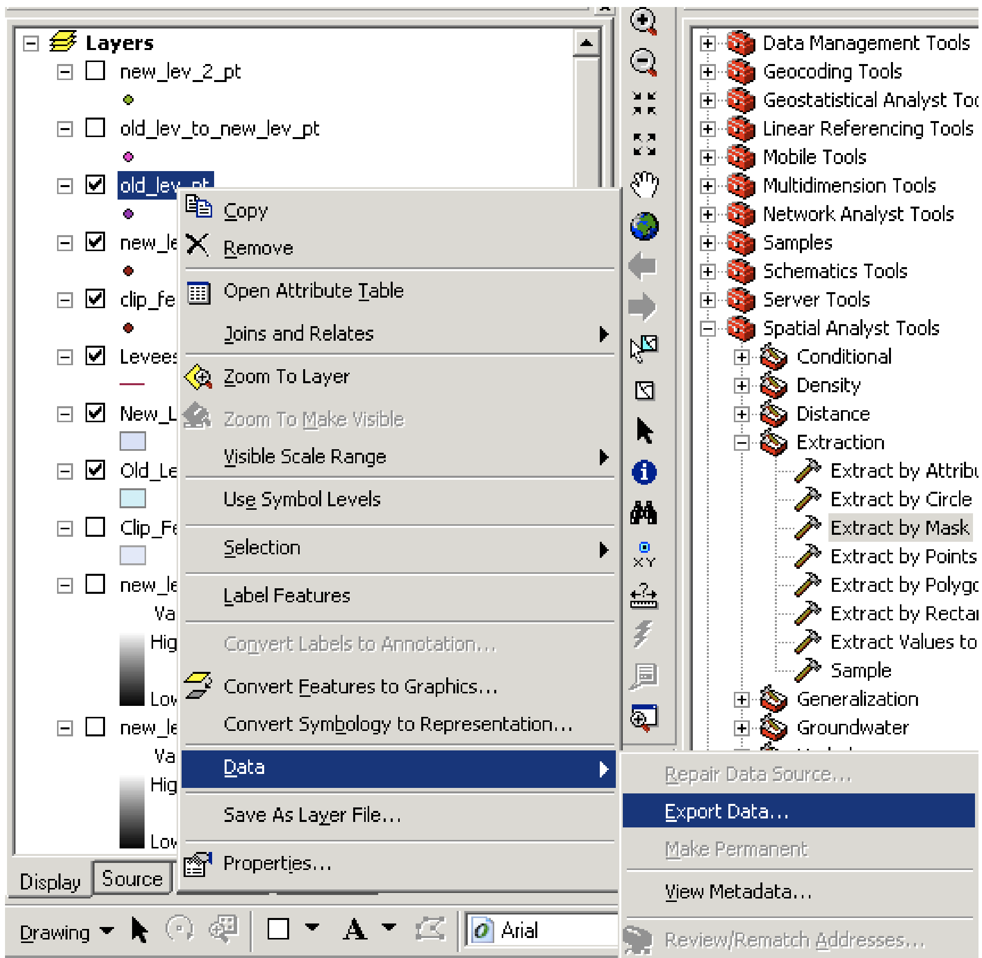

Figure D-11. Location for Export Data of the Existing Levee Points

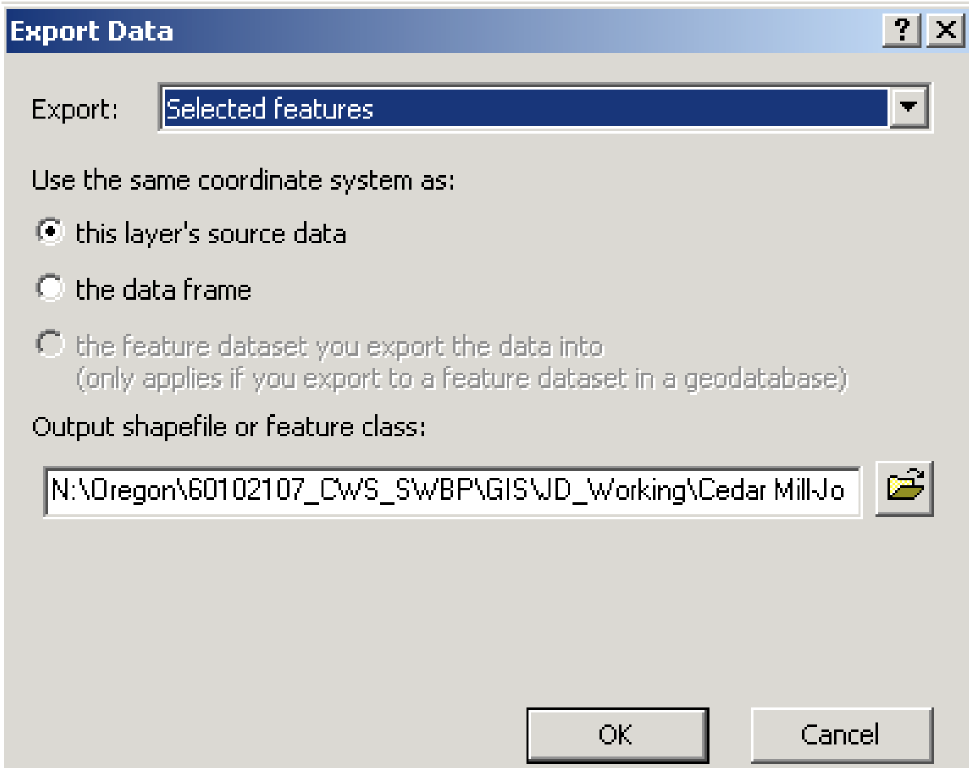

Figure D-12. Export Data Menu Box

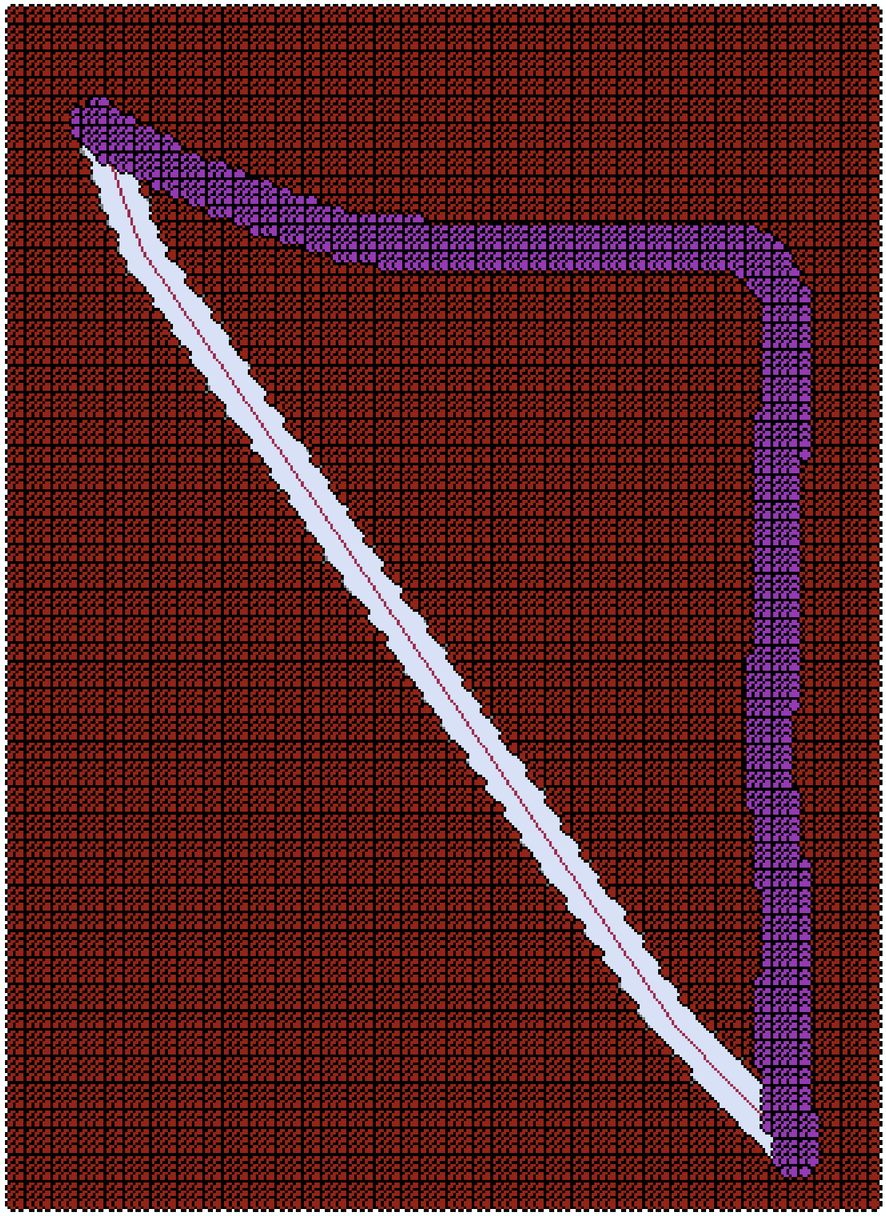

Figure D-13. Existing Levee Points (purple) Moved to New Levee Points (light grey)

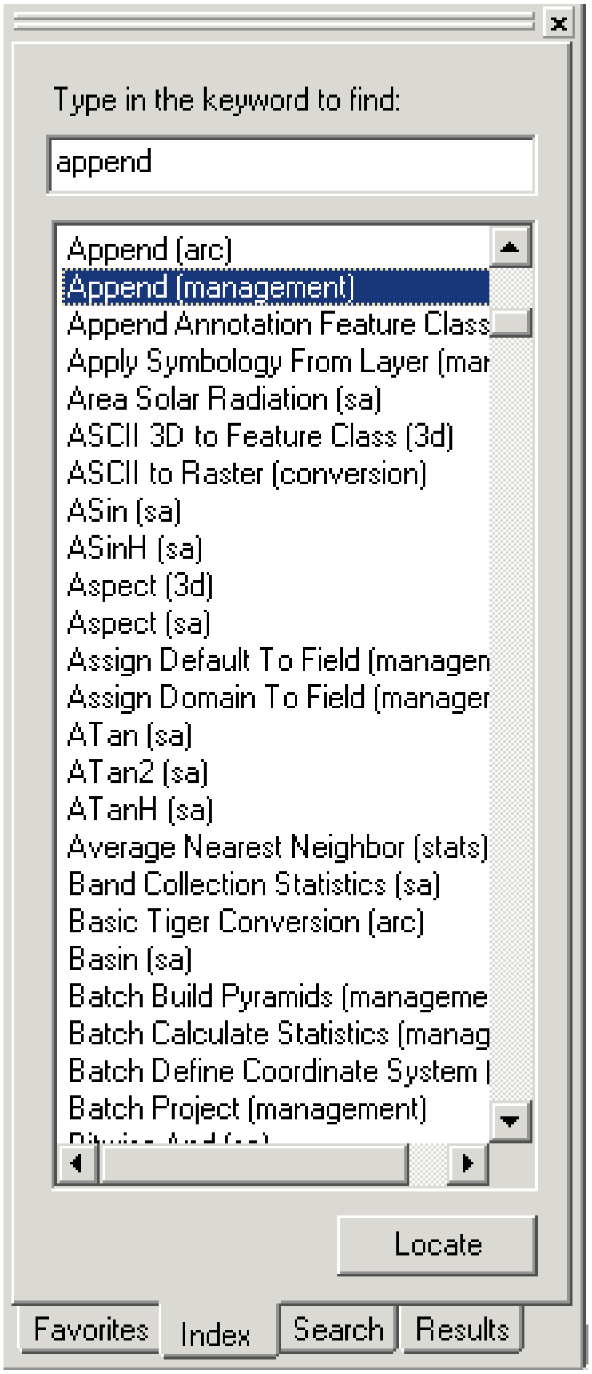

Figure D-14. Append Location in ArcGIS Toolbox

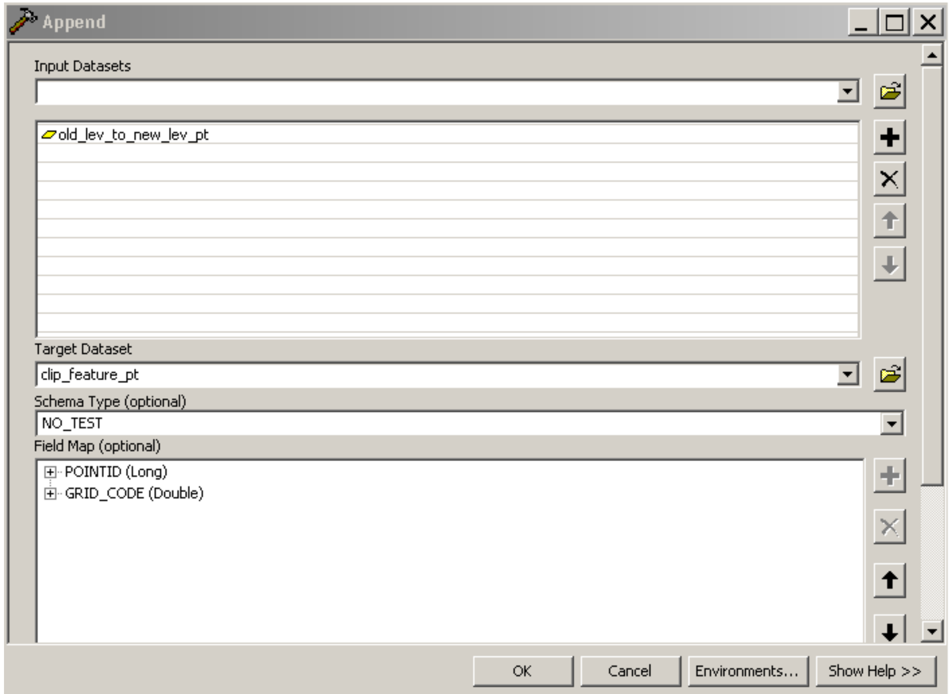

Figure D-15. Append Menu Box

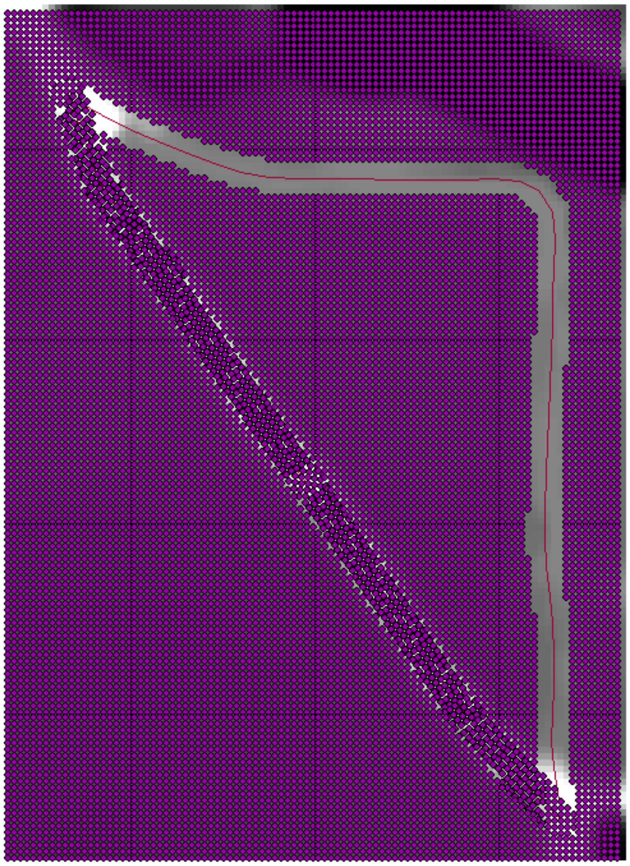

Figure D-16. Append Output

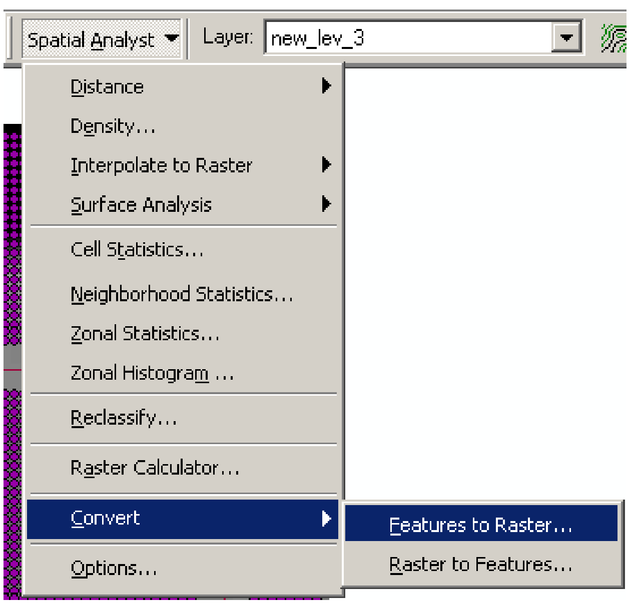

Figure D-17. Feature to Raster Location

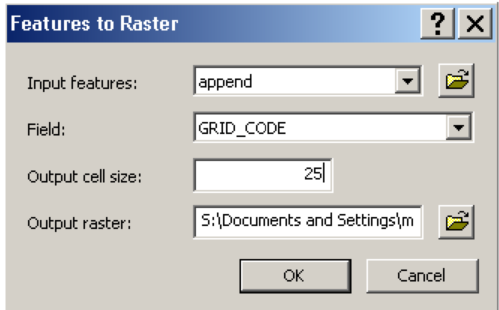

Figure D-18. Feature to Raster Menu Box

Figure D-19. Feature to Raster Output

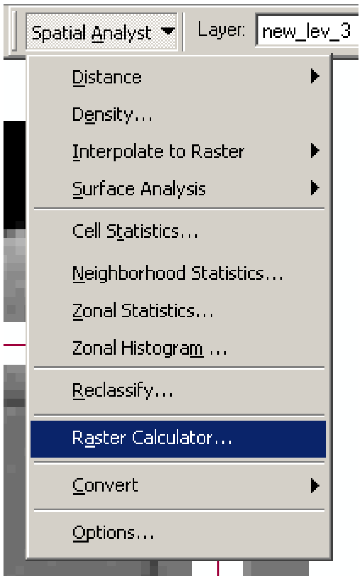

Figure D-20. Raster Calculator Location

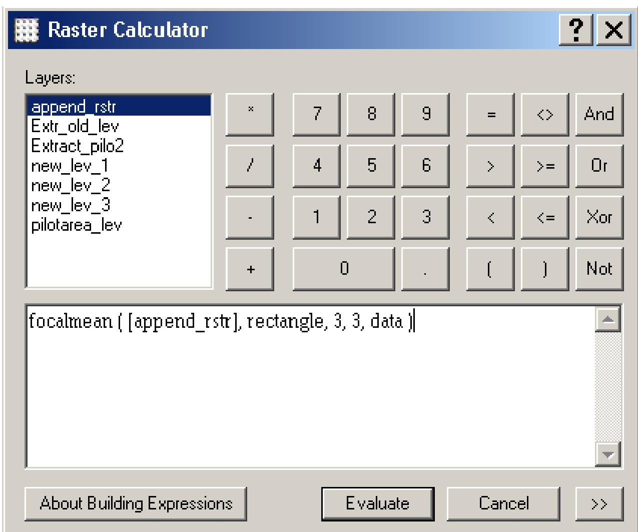

Figure D-21. Raster Calculator

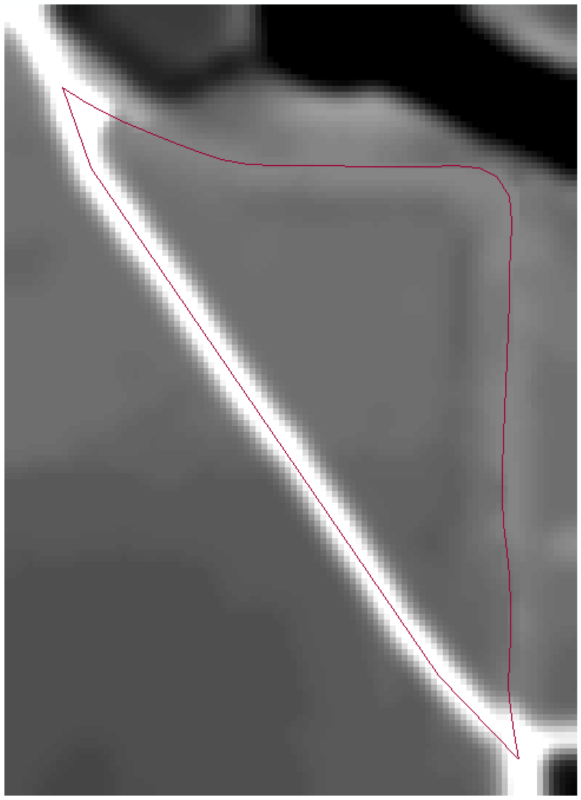

Figure D-22. Final Raster Output with New Levee

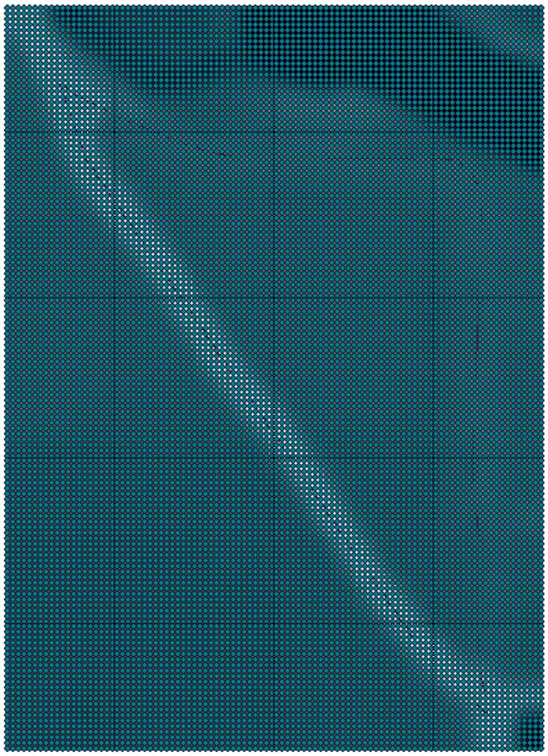

Figure D-23. Final Raster Output Converted into Points

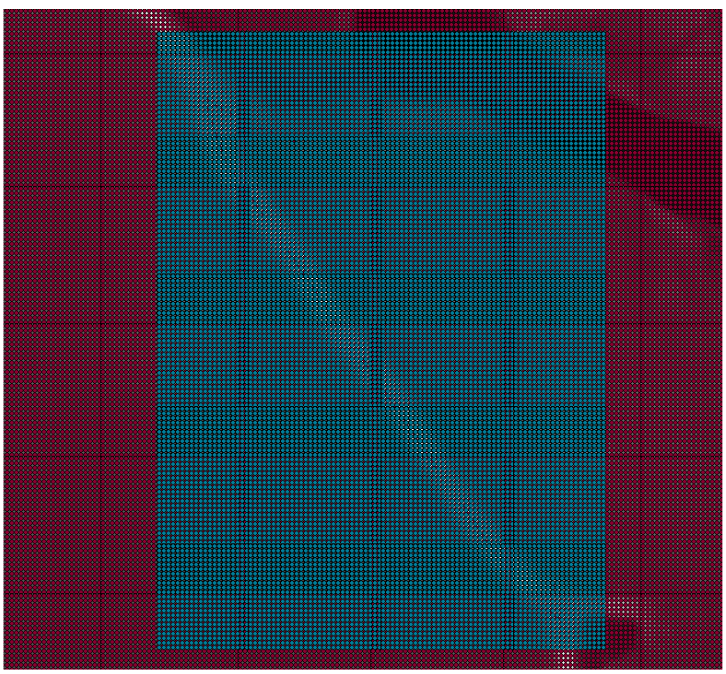

Figure D-24. DEM (outer box) and Final Raster Output (inner box)

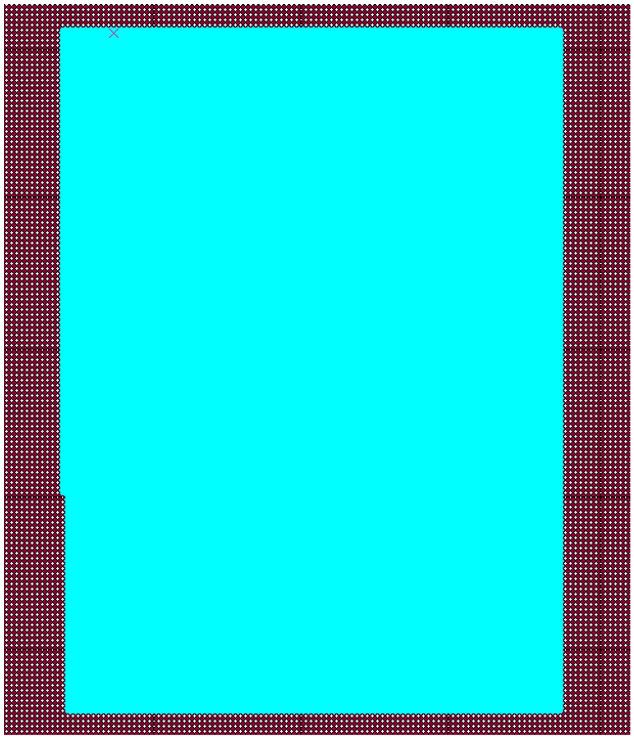

Figure D-25. DEM Points Selected with the Clip Polygon

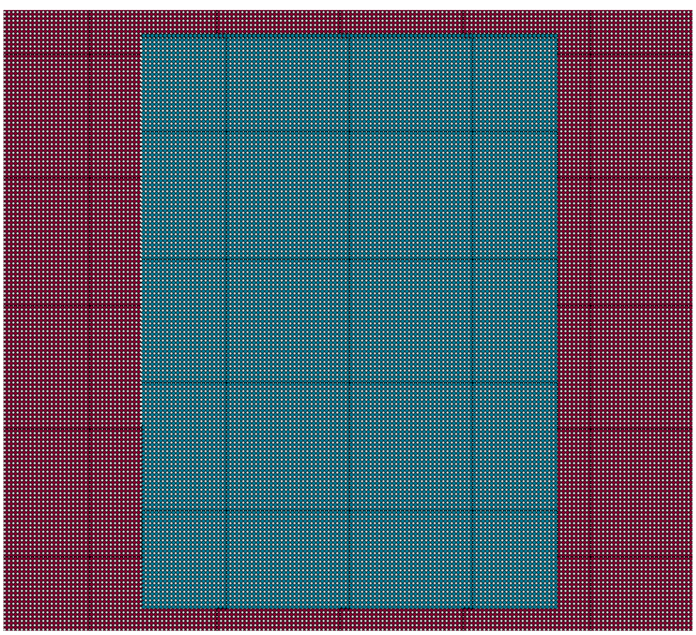

Figure D-26. Final Raster Output Points Combined in DEM

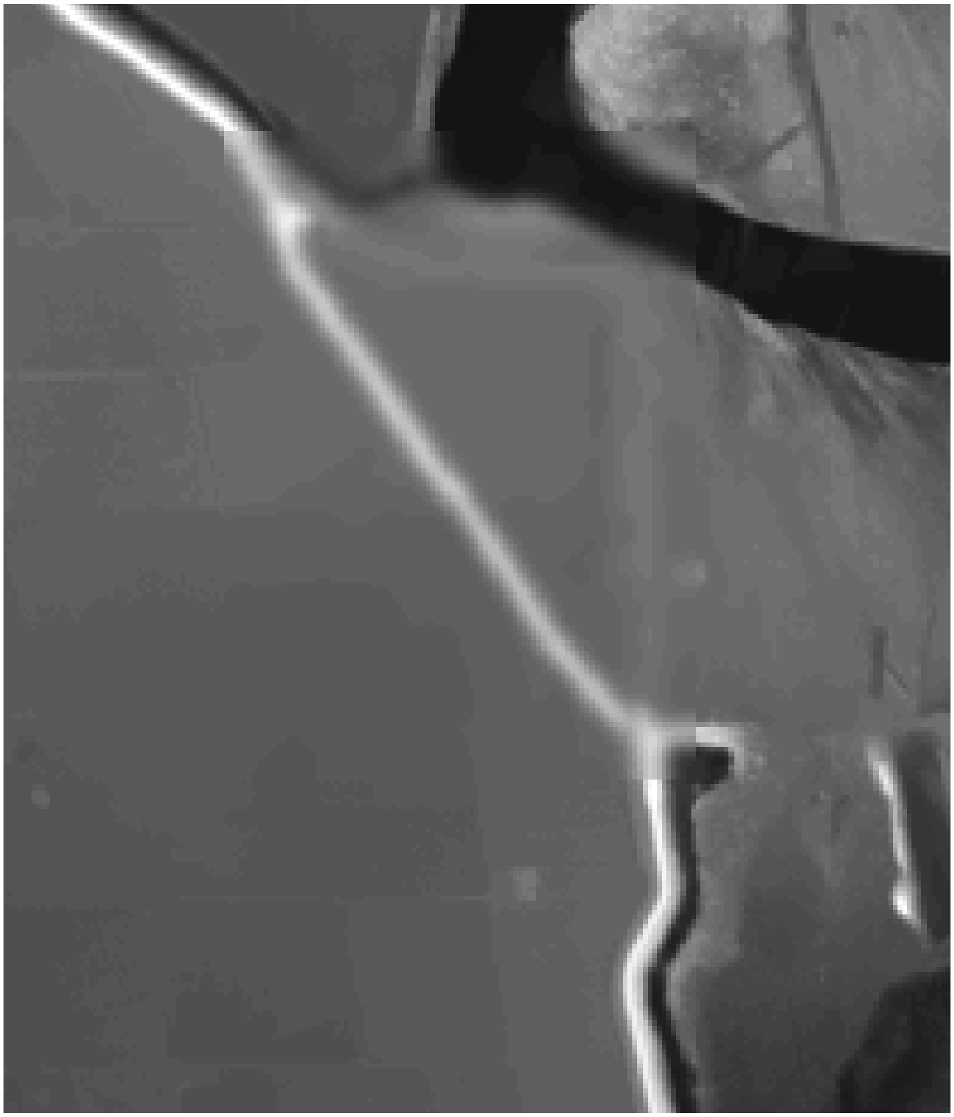

Figure D-27. DEM with New Levee Added in and Old (existing) Levee Removed

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Attachment 9F: Floodplain Restoration Opportunity Analysis Appendix E – Synthetic vs. Observed Hydrographs

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Appendix E

For Yuba City and Shanghai Bend, this appendix provides graphical comparisons of observed Feather River flows, and synthetic daily averaged flows derived from CalSim. These comparisons are displayed as time series and exceedence curves in Figures E-1 through E-4. The selected period of record (October 1, 1969, through September 30, 1976) represents a time frame when both USGS gages were in operation.

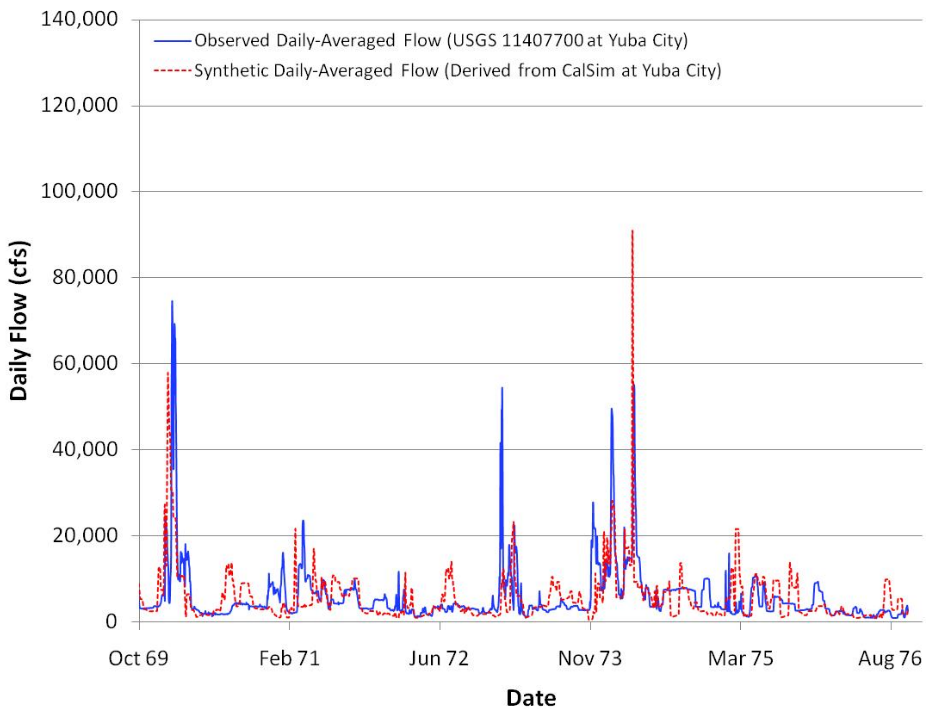

Figure E-1. Synthetic vs. Observed Flow – Yuba City

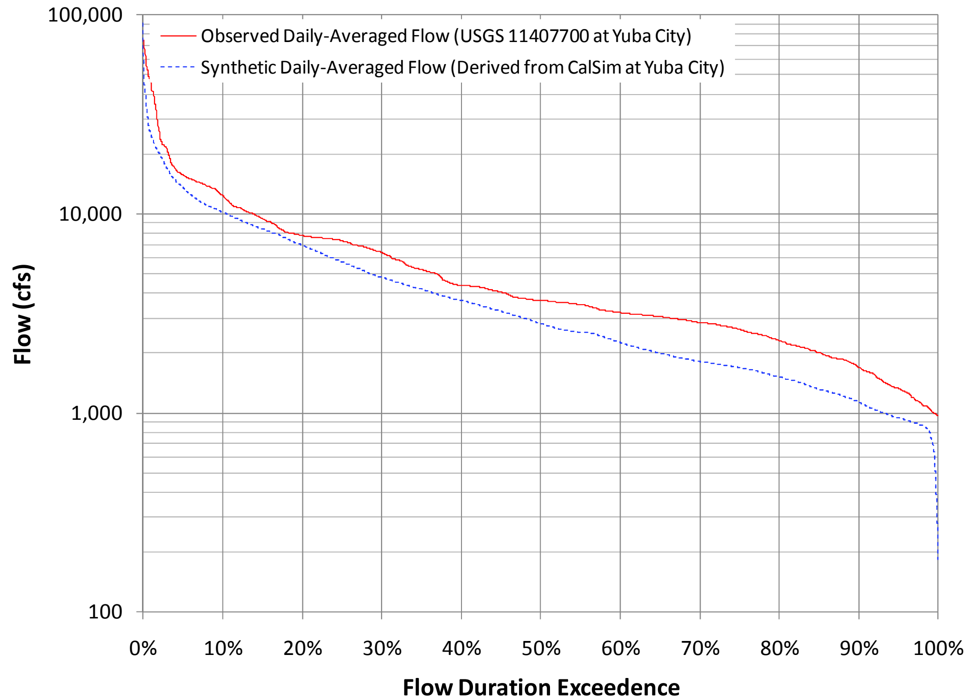

Figure E-2. Synthetic vs. Observed Flow Duration Curve – Yuba City

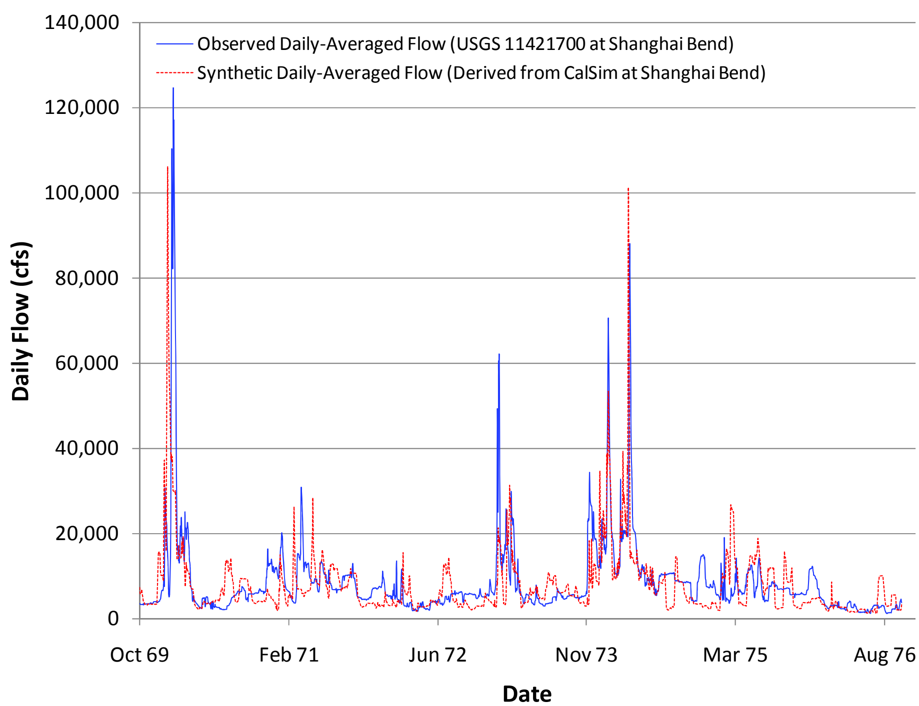

Figure E-3. Synthetic vs. Observed Flow – Shanghai Bend

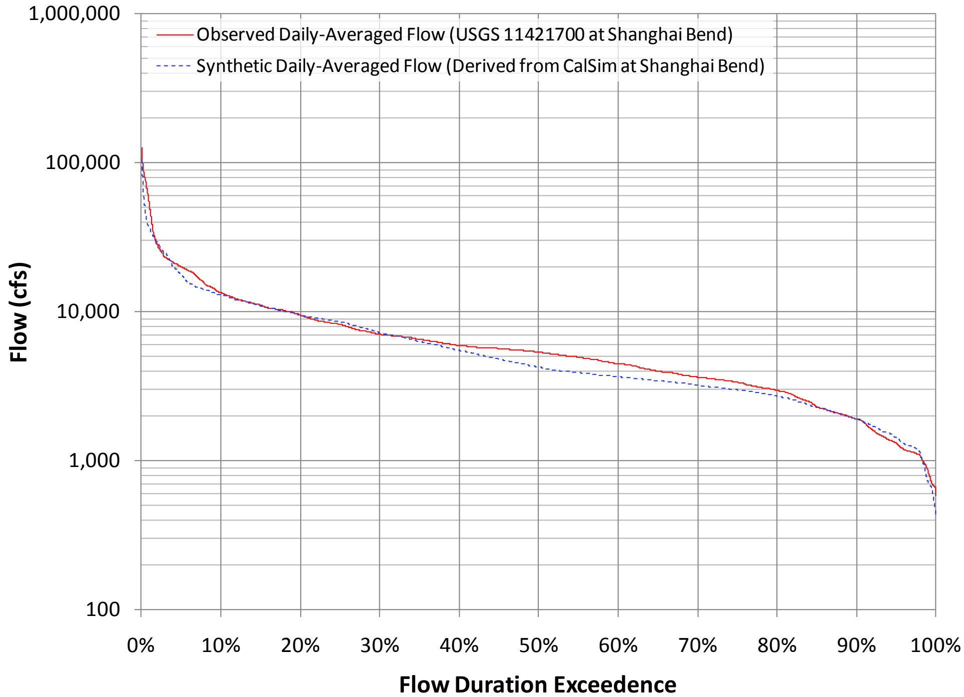

Figure E-4. Synthetic and Observed Flow Duration Curve – Shanghai Bend

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Attachment 9F: Floodplain Restoration Opportunity Analysis Appendix F – HEC-EFM Ecosystem Functional Relationships

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Appendix F

This appendix provides the criteria used for the EFRs used in this study: Salmonid-Rearing Habitat Formation, riparian Cottonwood Seedling Germination, riparian Cottonwood Seedling Inundation (death), and riparian Cottonwood Recruitment. Each of these EFR was added to HEC-EFM and a screenshot of the window with the criteria fields that displays their values is shown in Figures F-1 through F-4.

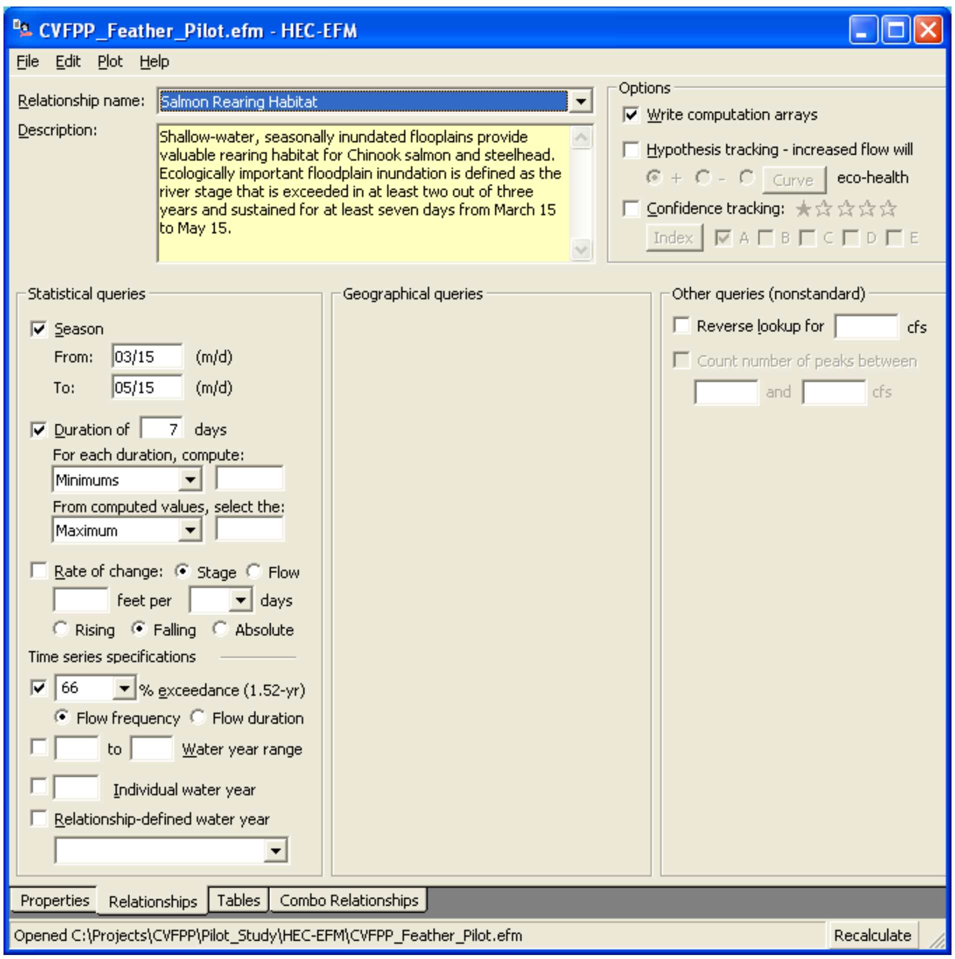

Figure F-1. Salmon Rearing Habitat Formation Ecosystem Functional Relationship (EFR)

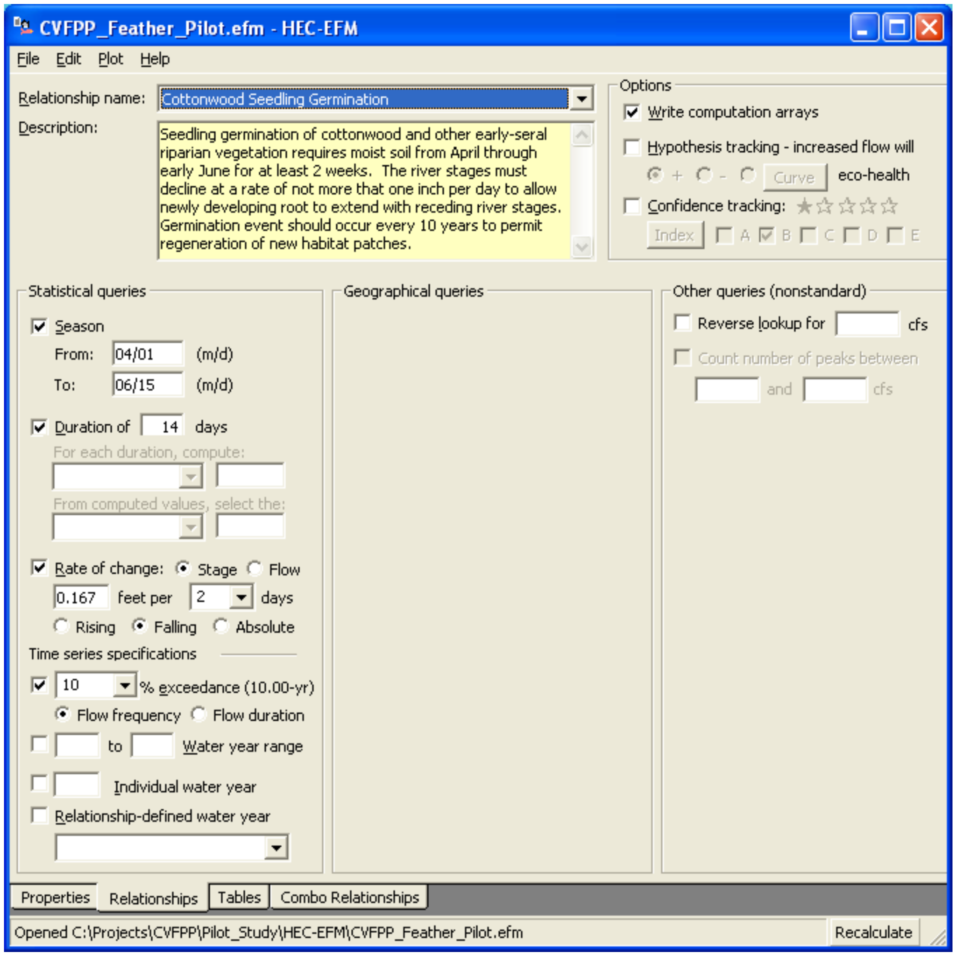

Figure F-2. Cottonwood Seedling Germination EFR

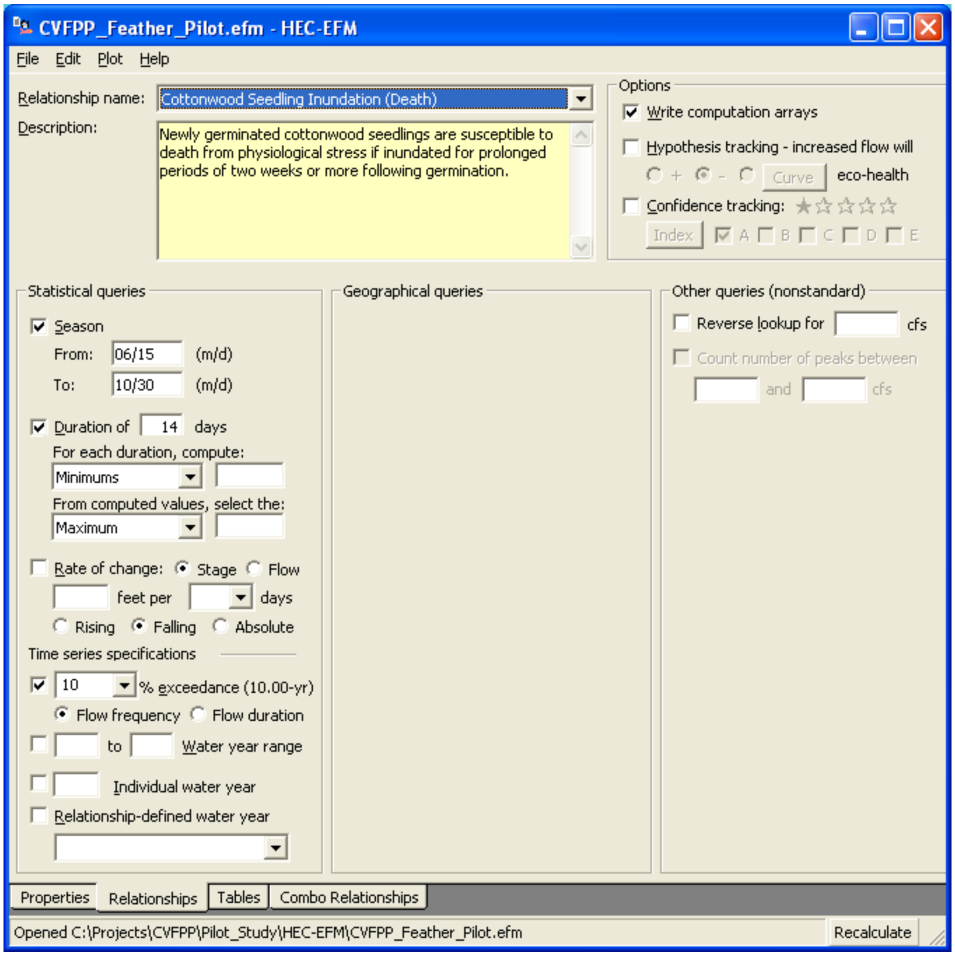

Figure F-3. Cottonwood Seedling Inundation (Death) EFR

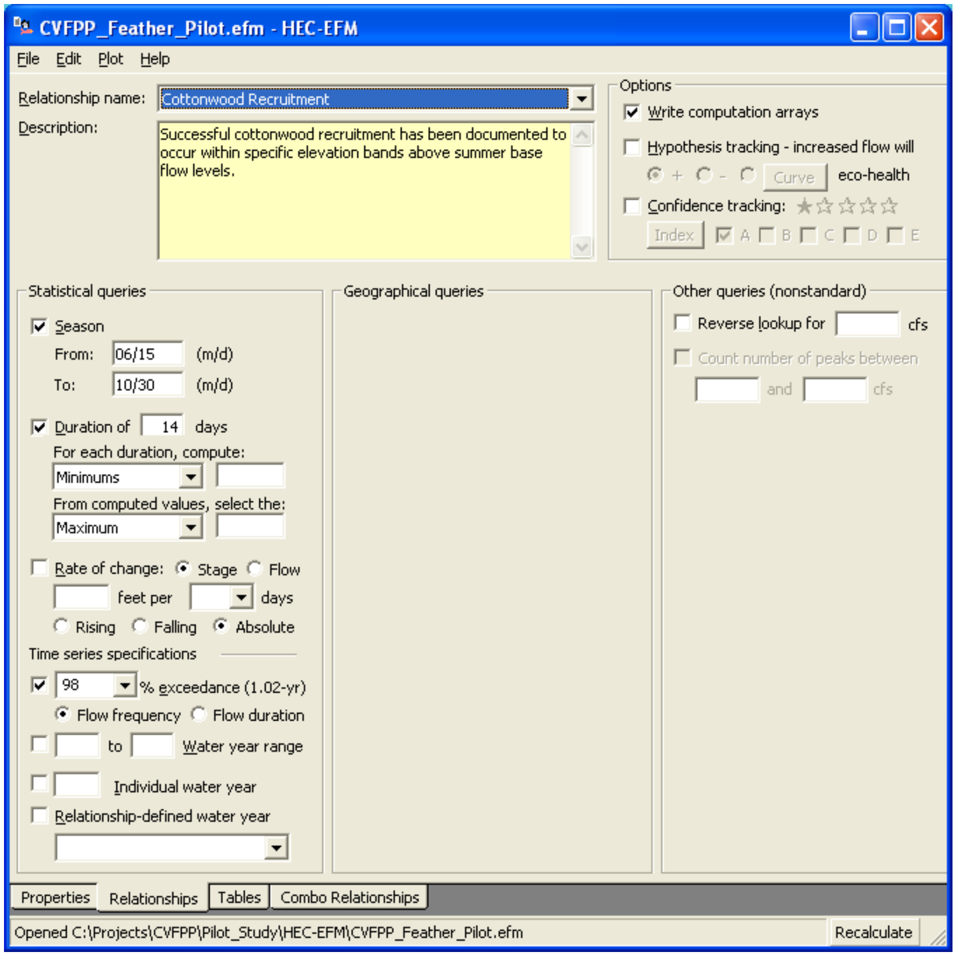

Figure F-4. Cottonwood Recruitment EFR

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Attachment 9F: Floodplain Restoration Opportunity Analysis Appendix G – RAS/EFM Analysis FIP-Based Mapping

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Appendix G

This appendix provides maps of the water-surface areas that meet the EFR conditions, as determined by HEC-EFM and HEC-RAS. These results are shown on Figures G-1 through G-10 for each HAA and EFR. (Cottonwood Recruitment was not mapped because potential habitat areas outside of the channel banks were not identified.) The background of each map corresponds to the LiDAR-based FIP.

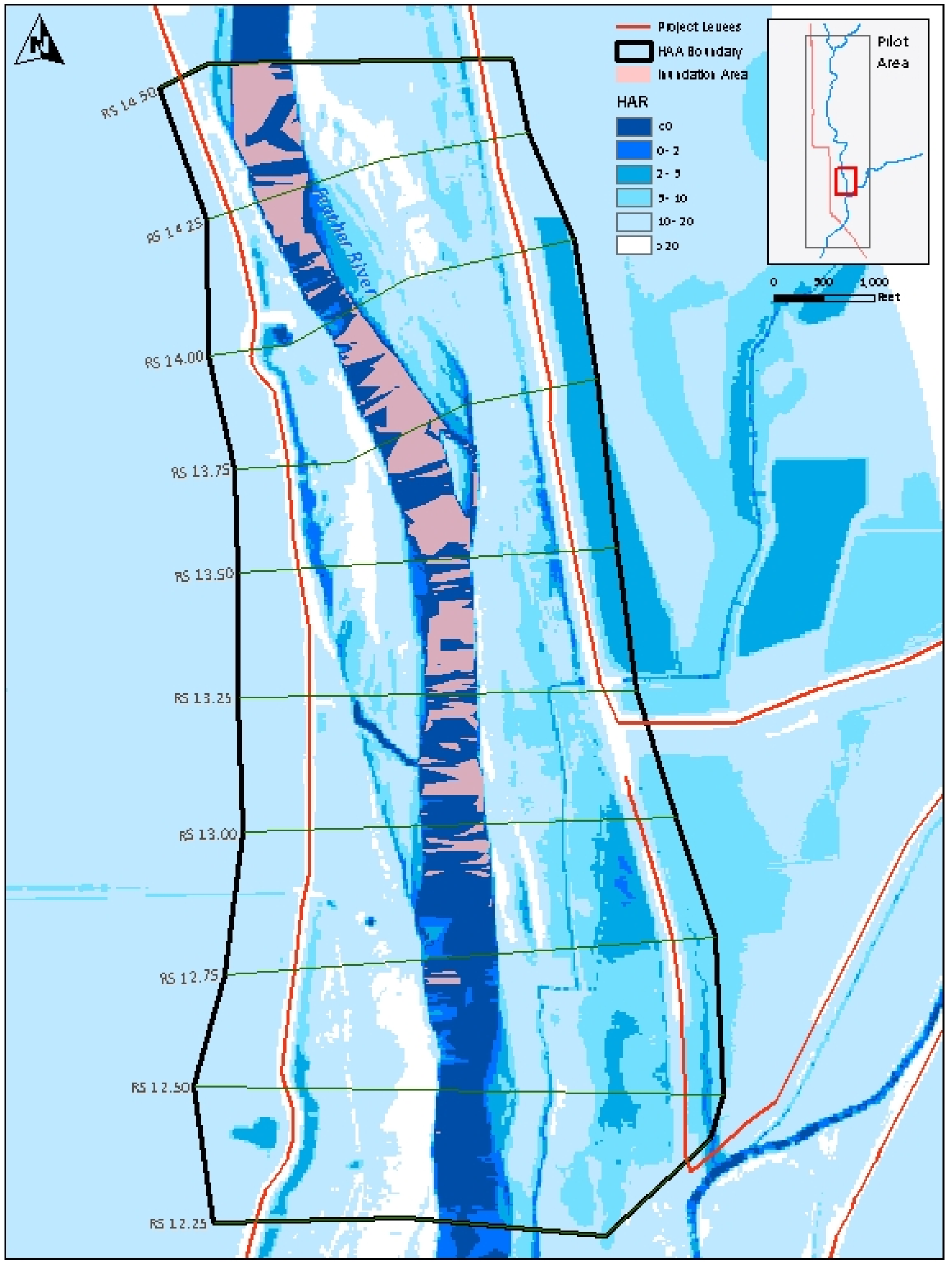

Figure G-1. Cottonwood Seedling Germination – RS 12.25 – RS 14.50

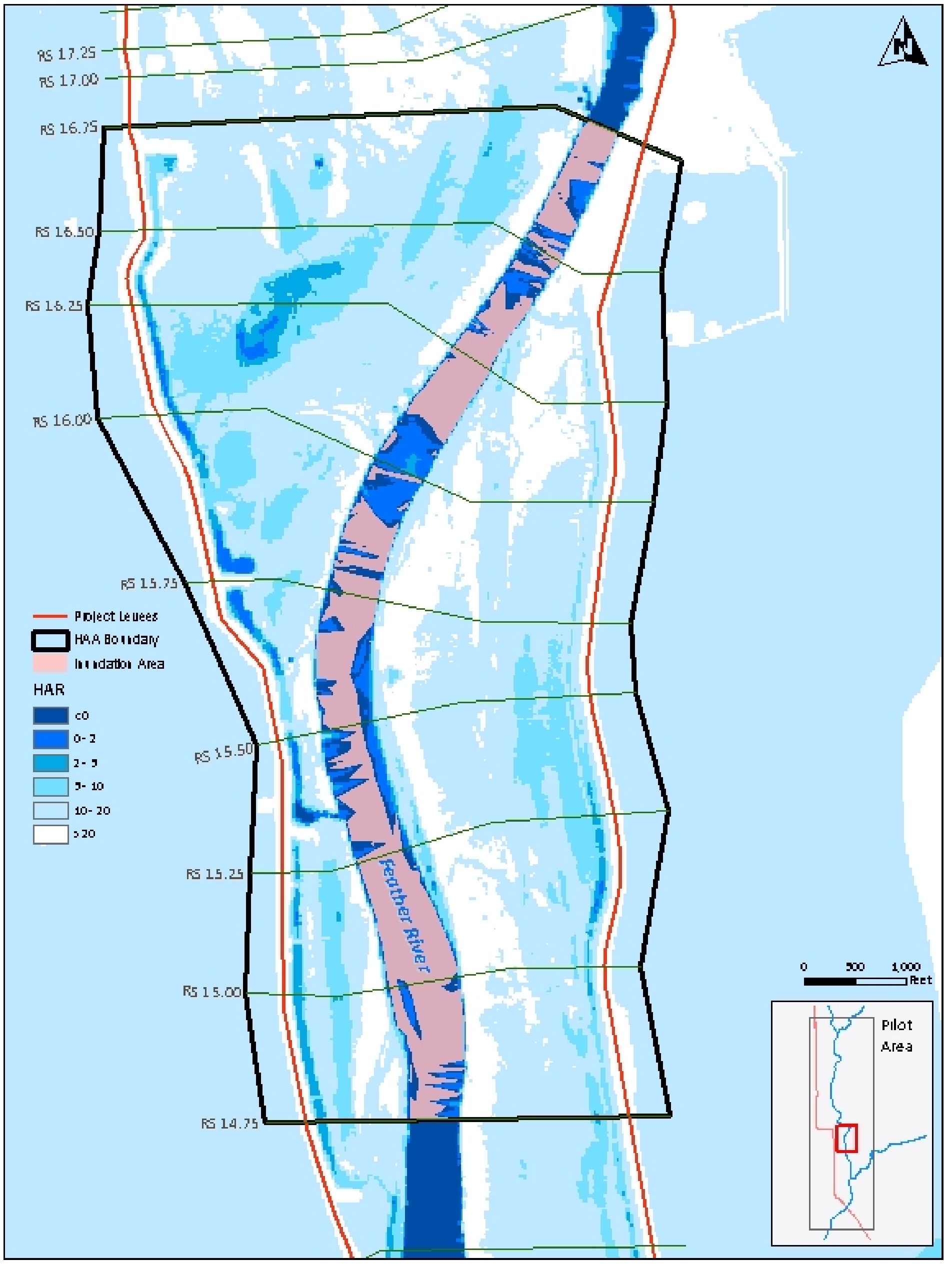

Figure G-2. Cottonwood Seedling Germination – RS 14.75 – RS 16.75

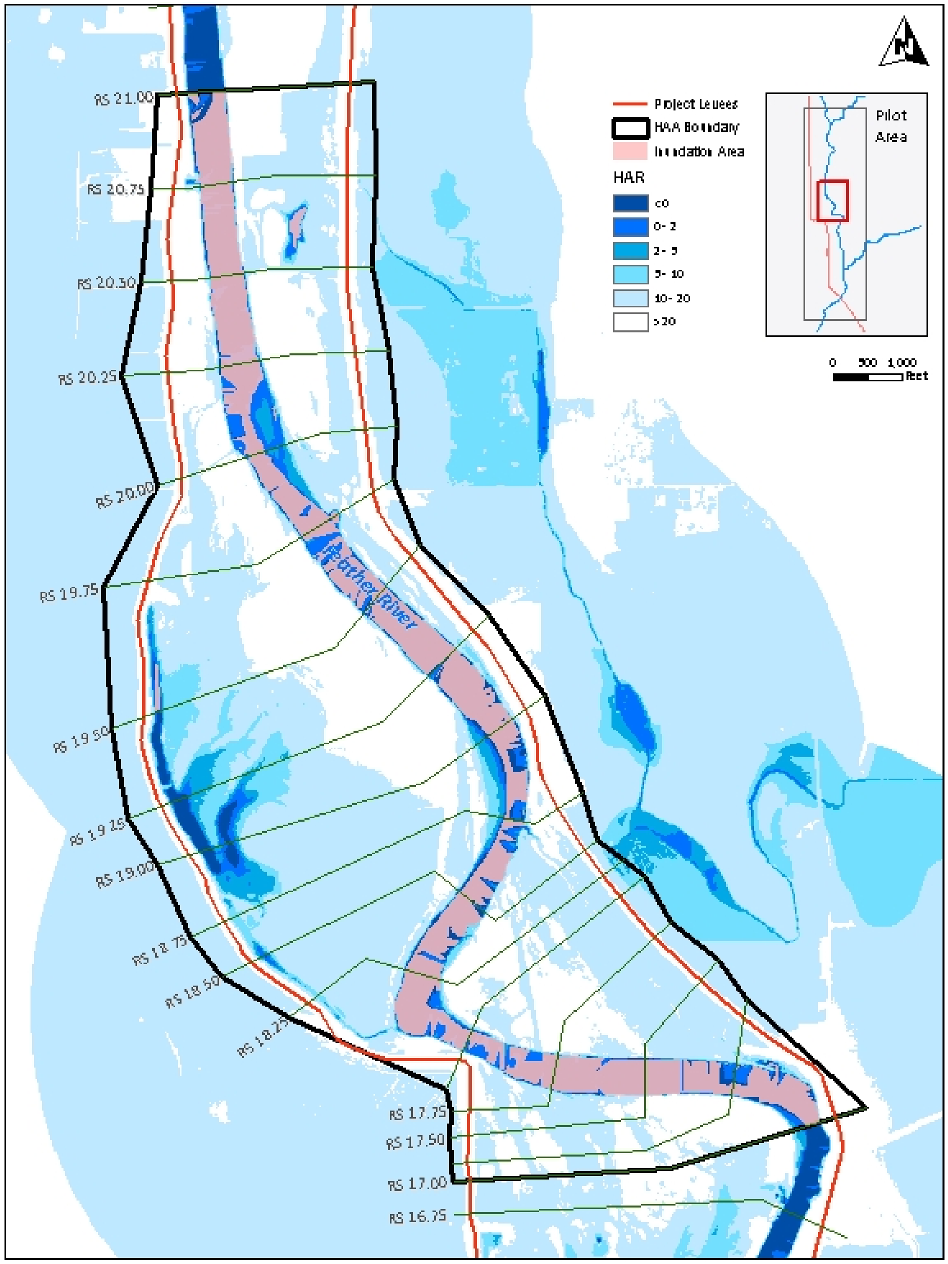

Figure G-3. Cottonwood Seedling Germination – RS 17.00 – RS 21.00

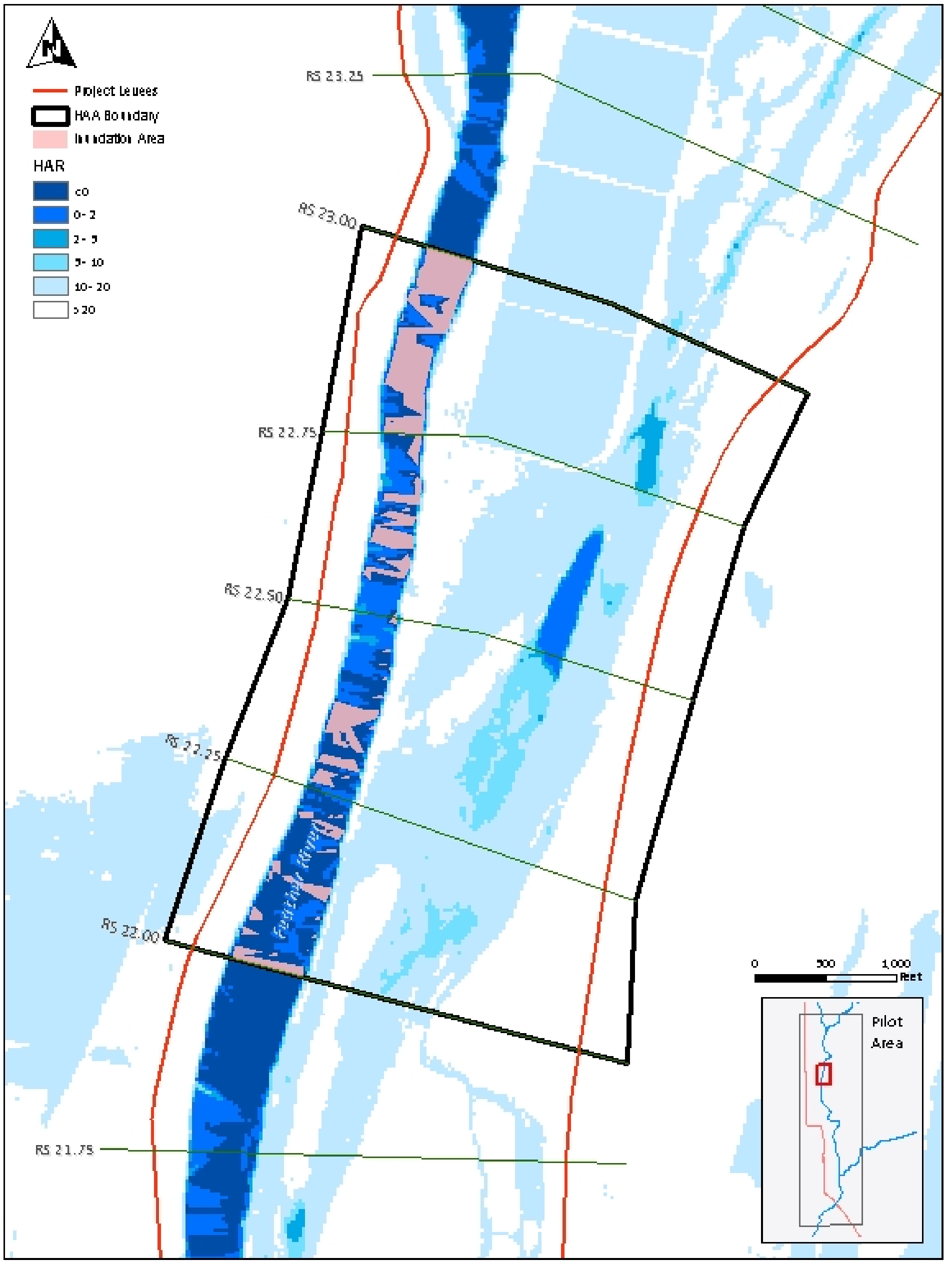

Figure G-4. Cottonwood Seedling Germination – RS 22.00 – RS 23.00

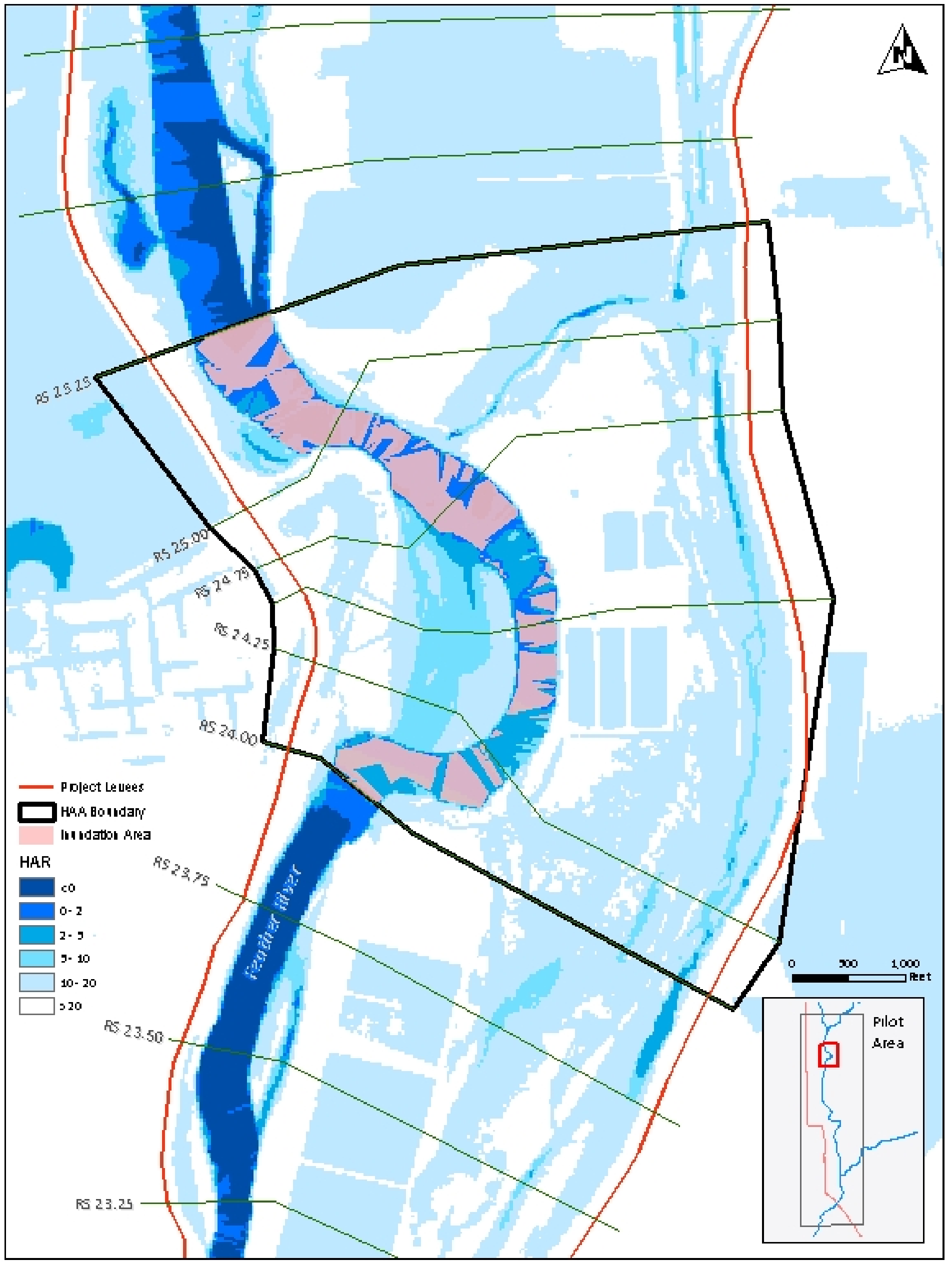

Figure G-5. Cottonwood Seedling Germination – RS 24.00 – RS 25.25

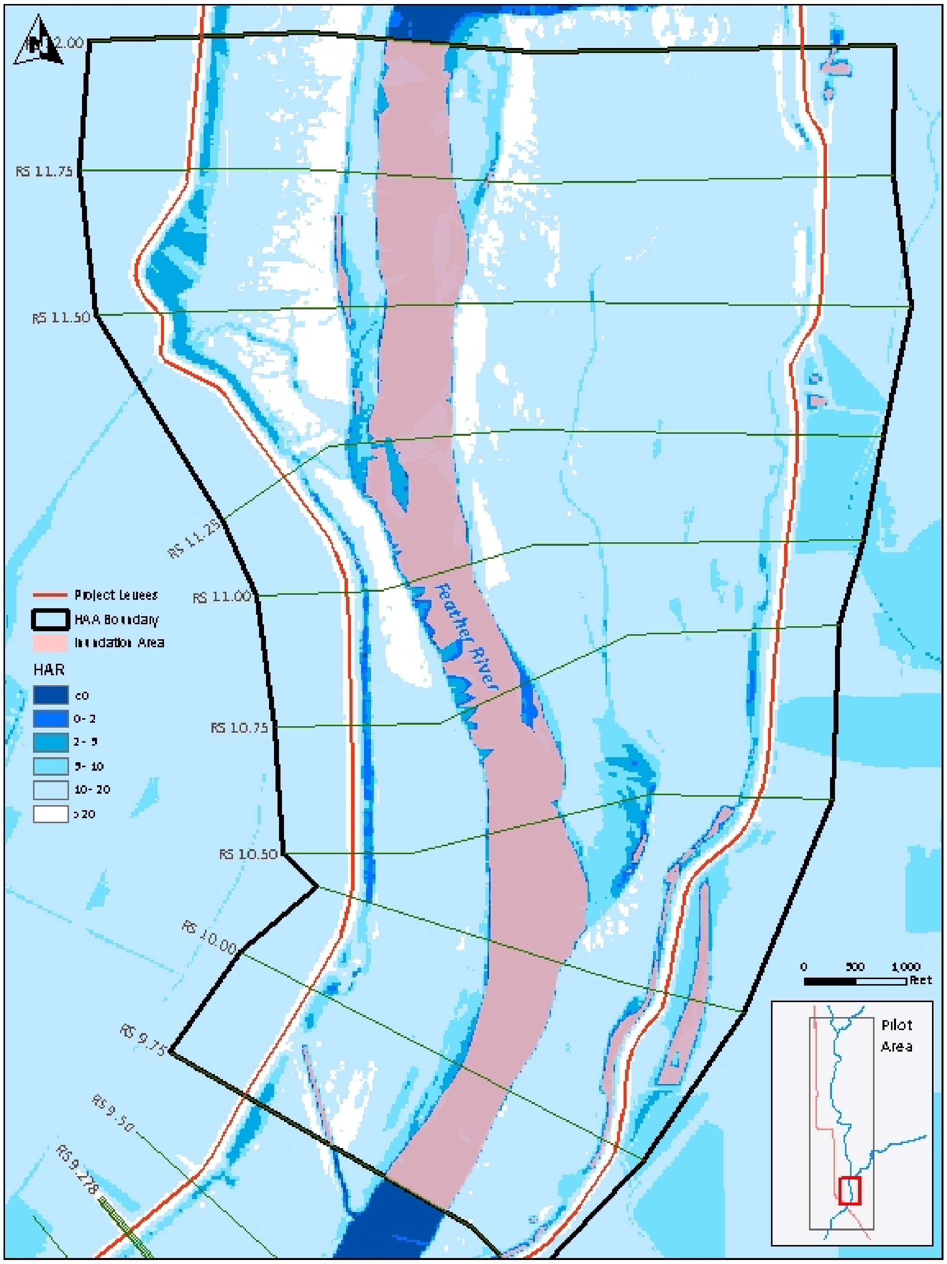

Figure G-6. Cottonwood Seedling Inundation – RS 9.75 – RS 12.00

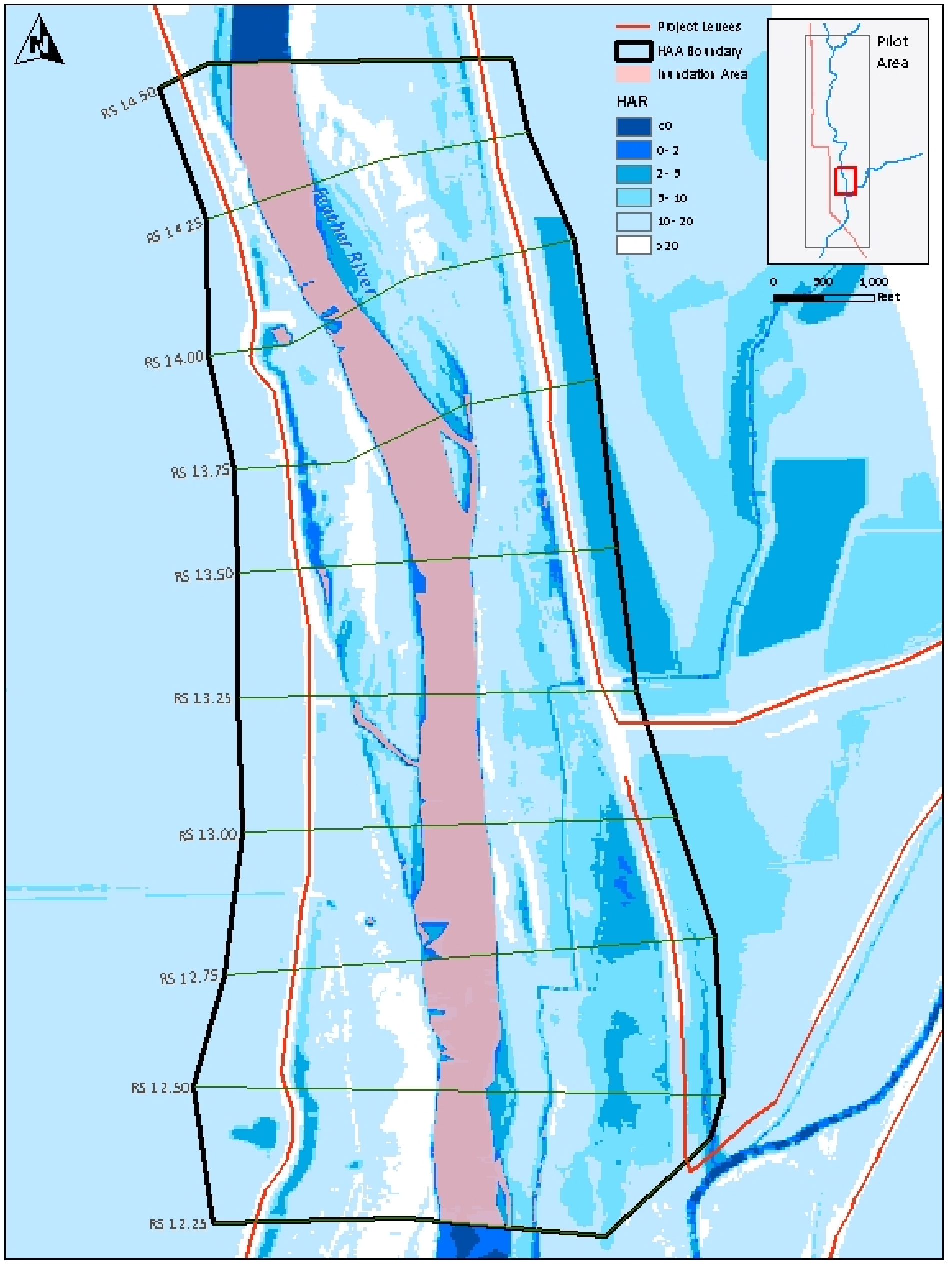

Figure G-7. Cottonwood Seedling Inundation – RS 12.25 – RS 14.50

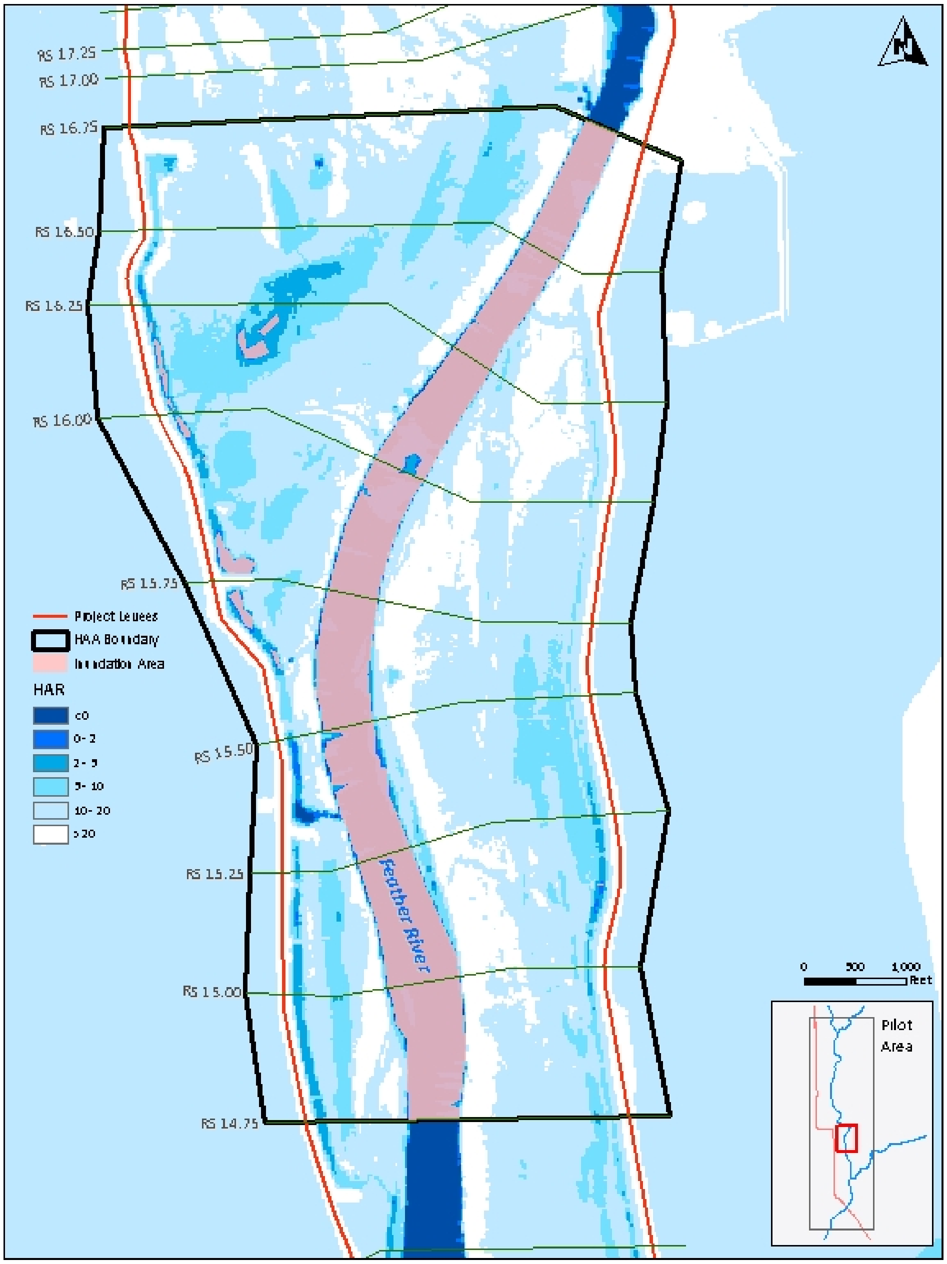

Figure G-8. Cottonwood Seedling Inundation – RS 14.75 – RS 16.75

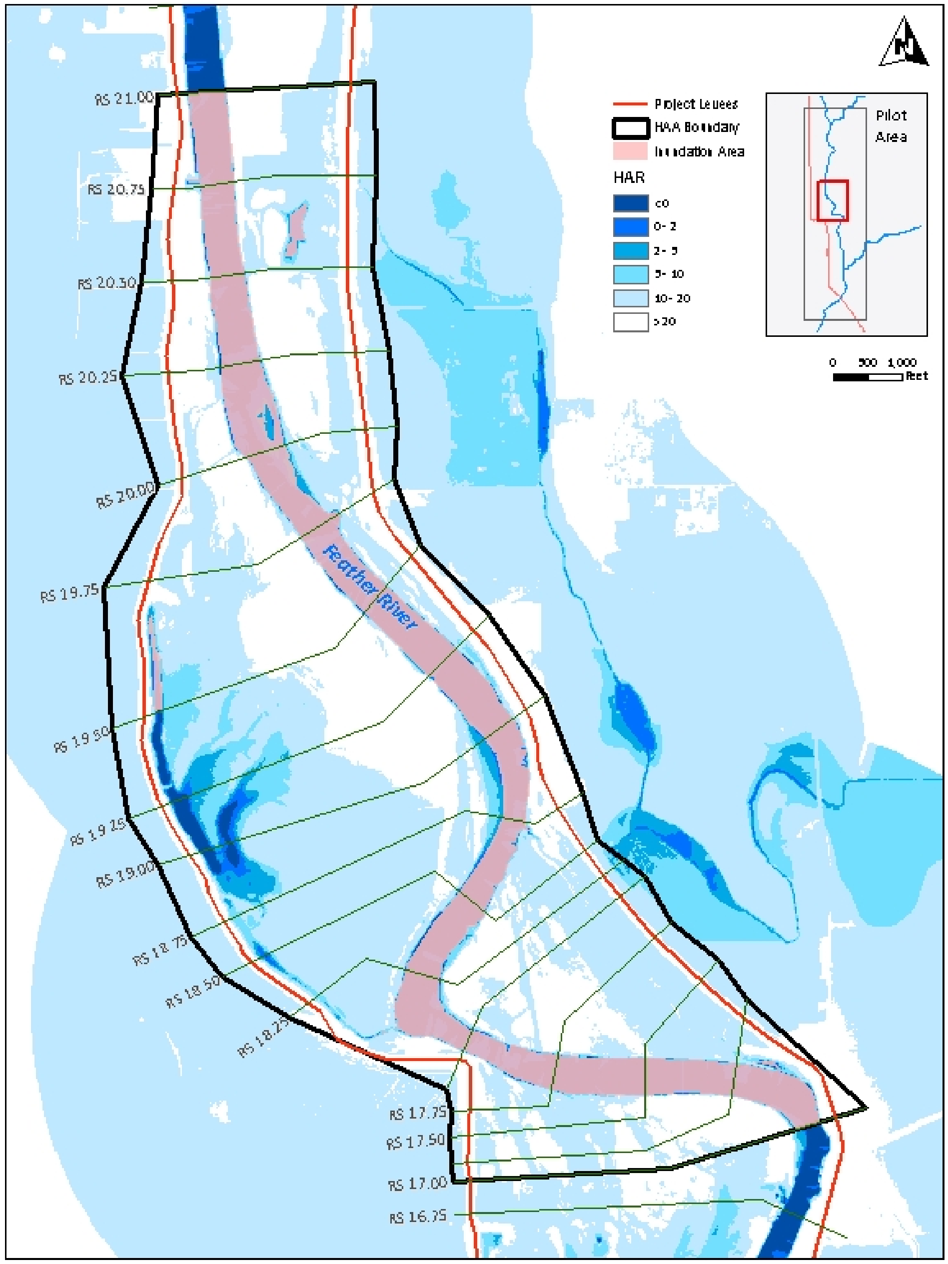

Figure G-9. Cottonwood Seedling Inundation – RS 17.00 – RS 21.00

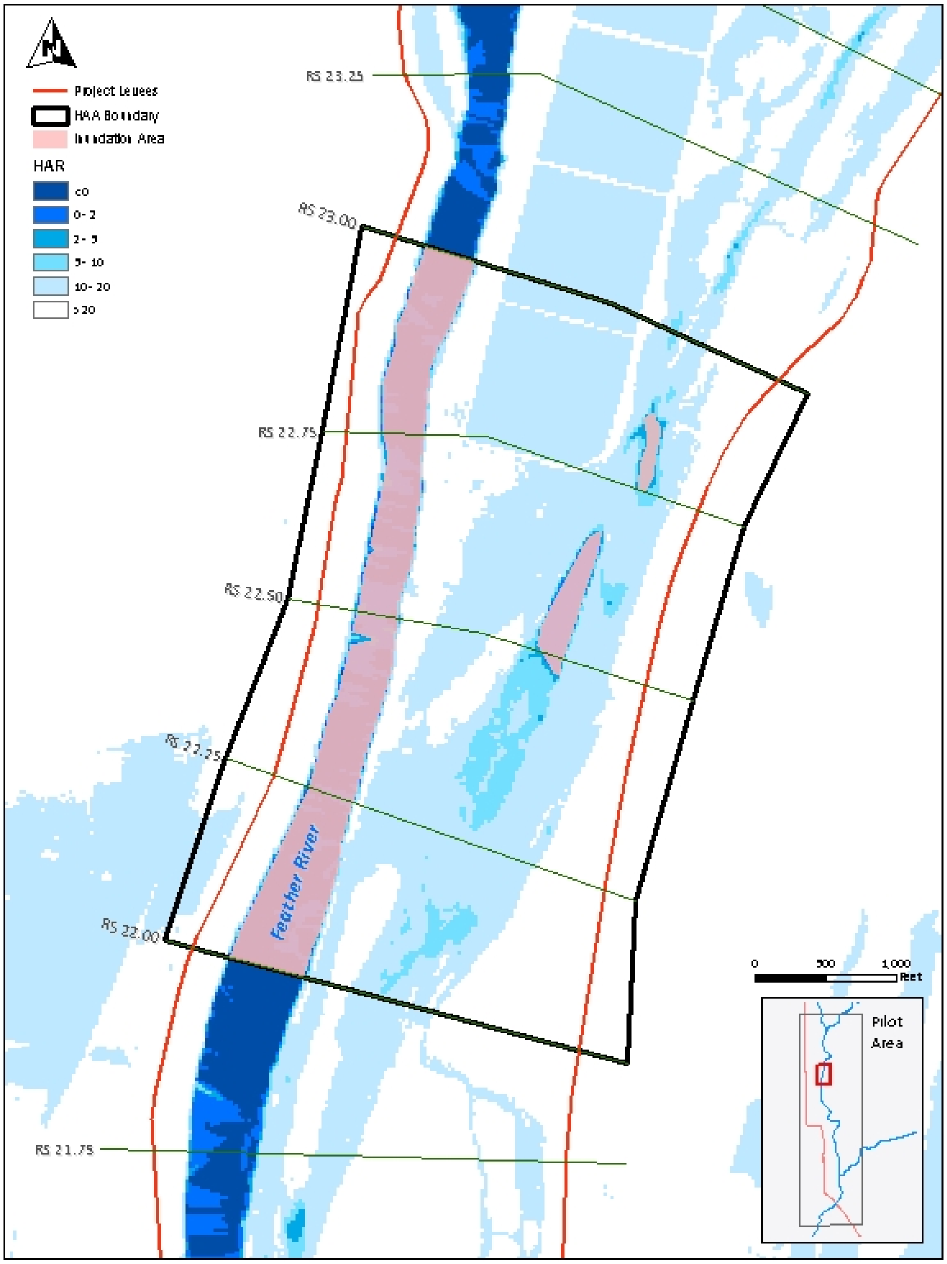

Figure G-10. Cottonwood Seedling Inundation – RS 22.00 – RS 23.00

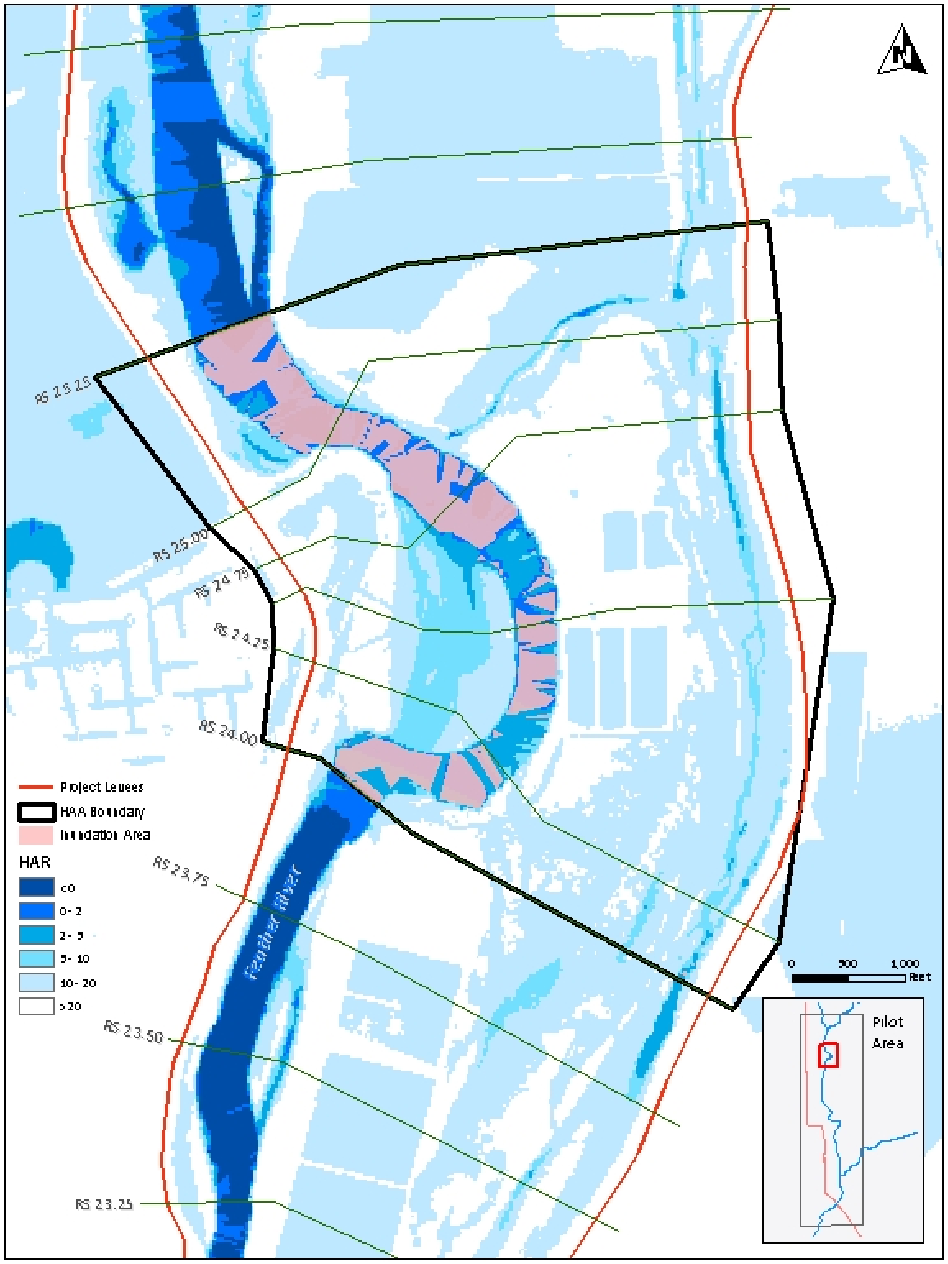

Figure G-11. Cottonwood Seedling Inundation – RS 24.00 – RS 25.25

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Draft BDCP South Delta Corridor Evaluation Summaries

Final Document
included in BDCP Effects Analysis as

BDCP South Delta Habitat and Flood Corridor Planning,
Corridor Description and Assessment Document

September 10, 2012.
Attachment E.A to Appendix 5.E of BDCP

Corridor 1A - Summary

- Assumptions/Changes to Corridor Description made During Evaluation
    - Assume that restoration actions include levee setbacks, but no “active” restoration to enhance channel, floodplain, or riparian habitats or grading. However, fish stranding on the floodplain was assumed to be a “non-issue” because it can be minimized via restoration design.
    - The timeline for passive restoration to mature is late long term (30 – 50 years); this evaluation assumes late long term conditions.
    - Evaluations are based on the existing hydrology of the San Joaquin River and potential changes to hydrology associated with the San Joaquin River Restoration Program. It was acknowledged that the charter for the group also directs evaluators to consider changes to hydrology to improve ecological benefits. Specifically, the charter says the group “will consider how alternatives perform with San Joaquin restoration flows and future flows that result from Water Board orders or climate change.” These additional flow scenarios were not analyzed as part of this evaluation.
    - As part of the original DRERIP evaluations, outcomes and their scores were targeted for physical processes and/or attributes that occur throughout the corridor, and fish species of concern. Outcomes for terrestrial species are not included in the following evaluations.

- Summary of Key Outcomes Related to Objectives
    - *Objective: Increase the extent of ecologically-relevant floodplain habitat to support reproduction and viability of Sacramento splittail and Chinook salmon & Steelhead*
        - Positive Outcomes
            - New floodplain areas available for inundation that would benefit splittail and salmonids
            - Additional food export from this Corridor into critical habitat areas (this would be minimal).
        - Negative Outcomes
            - Relatively-low risk of: floodplain stranding, increased mortality due to water quality degradation, mercury methylation, selenium, or resuspension of toxics.

    - *Objective: Restore habitats and river conditions (i.e., the magnitude and direction of flow in fluvial regimes) that favor survival and growth of juvenile salmonids, sturgeon, delta smelt, longfin smelt, and other native fishes*
        - Positive Outcomes

        - There is a very high probability that channel complexity will increase and natural geomorphic processes will be restored with levee setbacks.
    - Negative Outcomes
        - Very low potential for invasive species colonization (SAV, Clams). Invasive riparian vegetation is a concern.

- Key Uncertainties
    - How future geomorphic response of a less-confined San Joaquin River may result in changes in sediment transport and potentially aggradation of the channel bed. This may modify the stage-discharge relationships for floodplain inundation more-generally. (Note, this would be a positive trend for inundated floodplain habitat).
    - The expected / predicted channel meander potential of the reach with levee setbacks.
    - The presence / absence of sturgeon in this corridor, and the potential for sturgeon habitat benefits / impacts.
    - How the San Joaquin River Restoration Program restoration flow regime and future flows that may be ordered by the SWRCB or result from climate change may influence key habitats and species outcomes and associated scoring. The river's hydrology drives habitat benefits coming from newly-connected floodplain areas.

- Data Gaps
    - Sediment transport data, modeling and sediment budgeting for the Lower San Joaquin River.
    - Sturgeon population / habitat data for this area.

- Potential corridor re-configurations or combinations to increase the worth /decrease the risk of potential implementation.
    - Some evaluators felt that the floodplain inundation frequencies / ecological conditions required to benefit target fish species could be refined. Additional sensitivity analysis will provide additional information on benefits.
    - Some evaluators felt that additional sensitivity analysis should be performed to: a) determine the potential benefits and impacts associated with altered flow regimes, and b) enhance ecological benefits by evaluating different configurations and widths of levee setbacks in this corridor.
    - Active riparian forest restoration will increase the certainty of ecological benefits, and this should be considered in refining this corridor.

Corridor 1A – Detailed Evaluation Notes

Contents

Scientific Evaluation Worksheet & Notes
Corridor 1A

Evaluation Team:
Facilitator: Bruce DiGennaro
Participants: Josh Israel, Mike Hoover, Christine Joab, John Cain, John Clerici, Jeremy. Ron, Ted Sommer, Josh Israel, Michelle Orr, Will Stringfellow, Cathy Marcinkevage.
Note – taker: Kateri Harrison
Revisions: Jeremy Thomas, Eric Ginney

Workshop Date: Wednesday, February 1, 2012

Notes about Corridor 1A:

1) Take home message: San Joaquin River flow regime limits potential ecological benefits.
2) There are four ways to increase floodplain inundation: lower floodplain, change hydrology, raise the channel; block/backwater the channel at a downstream location
3) Sturgeon are not found in this location in significant numbers.
4) One suggestion is to maximize and accelerate benefits by using active restoration techniques such as horticultural riparian vegetation restoration.
5) With a levee corridor this wide, natural geomorphic processes (i.e., floodway expansion and contraction) can reverse channel incision and may lead to enhanced riffle stability---all things that would improve floodplain connectivity even given the existing flow regime.

Notes on revisions to the Corridor 1A Evaluation Worksheet:
Corridor 1A was the first corridor to be evaluated on February 1, 2012, the first of the two-day evaluation workshop. Subsequent to working through the evaluations for Corridor 1A, the group decided to refocus the approach and organize the structure of the evaluation to be consistent with the Problems and Objectives Statement as defined by the South Delta Working Group in the meeting on September 13, 2011. Therefore, the format of the outcomes and objectives originally used in the evaluation of Corridor 1A were changed and standardized for all of the corridors subsequently evaluated. The following evaluation notes were revised to reflect the reorganization of the objectives and outcomes utilized in all of the other corridor evaluations. Because of this change, Corridor 1A did not have all of the same standardized outcomes available during this evaluation, and thus not all of the outcomes examined in the other corridor evaluations are available here.

OBJECTIVE: INCREASE THE EXTENT OF ECOLOGICALLY-RELEVANT FLOODPLAIN HABITAT TO SUPPORT REPRODUCTION AND VIABILITY OF SACRAMENTO SPLITTAIL AND CHINOOK SALMON & STEELHEAD

Potential <u>Positive</u> Ecological Outcomes

Outcome P1: Increased frequency of inundation

Scientific Justification:
Most of the salmon returning to California rivers display a 3 year life cycle. The inundation frequency assumed in the modeling of the corridors is once every four years---this seems too infrequent to some evaluators based on the common salmon life history. Under existing conditions, approximately 900 acres are flooded. With restoration as defined for Corridor 1A, inundation will increase to approximately 2,600 acres of inundation.

It is assumed that hydrology will not change as a result of BDCP implementation. This is an important thing to recognize in regard to the benefits of floodplain restoration as a part of BDCP: that if the flows are not there, the benefits do not accrue.

In the San Joaquin River, during the large inundation (i.e. wet) years, splittail abundance increases and this relates to outcome P2 below.

Key Understanding: San Joaquin River hydrology drives habitat benefits coming from newly-connected floodplain areas.

Magnitude:
Score is a Low “2”, but with some disagreement about whether a 4-yr occurrence interval is an appropriate minimum threshold. BDCP should also integrate factors (i.e. compare to the inundation threshold in Yolo Bypass) to be consistent. Also, the 4-year inundation timeframe is a statistical average, the actual time between inundation events may be much more or less. Magnitude Score: **Low “2”**

Misc. Notes: If better hydrology were provided, the magnitude would increase. Evaluation team experts recommend inundation on an average of once every 2 years, optimally.

Certainty: Evaluation team is very certain that this magnitude will be low. There is a high level of uncertainty because it is not clear whether the once every four years inundation timeframe is representative. Although scientific understanding is high, this situation is dependent on a variable environment. Certainty Score: **Medium "3"**

Certainty of physical habitat on its own merits. **High "4"**, based on the increase in spatial area.

Magnitude for Splittail: There is redundancy with Outcome #P2. Splittail have a 5-7 year life cycle. **Medium "3".**

Certainty for Splittail: Same as Outcome #P2. **Score is Medium"3".**

Notes: Not applicable to sturgeon or smelt

Literature Cited:

- DRERIP Salmonid conceptual models (for salmon life cycle of 3 years).
- Cosumnes River and Yolo Bypass work on inundated floodplains.
- 2009 DRERIP evaluation worksheets have relevant literature citations.

Outcome P2: Increased Spawning Habitat for Splittail and White Sturgeon

Clarifying Assumptions:
Assuming a 21-day inundation period between Feb 1 and May 31 (source: Section 7 Table 3).

Magnitude for Splittail: Splittail have a seven year life-cycle and they spawn every year. Corridor 1A provides a lot of acreage for restoration. Existing inundated floodplain for splittail within existing levees is 412 acres. Assuming the existing flow continues, the restored habitat would be 1,023 acres with another 400 extra acres with the San Joaquin restoration flow regime. See Table 4.12 for Corridor 1A on page 102 in the corridor document. Magnitude is **Medium, Score: "3".**

If the hydrology were to change, then a larger area would be inundated with more frequency of inundation and this would then change the magnitude. In past discussions, Dr. Peter Moyle indicated that an inundation occurrence every 2 years would be satisfactory for native fish.

Certainty for Splittail: The magnitude score is based on peer reviewed studies in the Delta system. However, flooding is unpredictable. There is variability in the human-controlled hydrology of the San Joaquin River. If flows were managed to allow more inundation, then this certainty score would increase. There is a close relationship between floodplain inundation and splittail. **Score is Medium“3”.**

Green Sturgeon: No spawning in the San Joaquin River. Historical evidence and current monitoring does not find green sturgeon on the San Joaquin River. Not present.

Magnitude for White Sturgeon: White Sturgeon spawn in the Tuolumne River. Would white sturgeon spawn if their habitat were provided? Scientists do not have enough information about white sturgeon spawning habitat. Some studies indicate spawning habitat needs to be “in-channel” and have a sandy bottom (not floodplain). White sturgeon were spotted spawning on the San Joaquin River last year. White sturgeon likely use flow as the main characteristic of their spawning habitat. However, there is no indication that flows on San Joaquin River will change as a result of BDCP. Corridor 1A has a more naturalized channel bed, compared to other corridors. Magnitude is **Low “2”.**

Certainty for White Sturgeon: Certainty is **Low “2”.**

Literature Cited:

Sommer, Baxter, and Herbold 2000 “Resiliency of splittail” paper

Outcome P5: Increased Food Export

Notes about Food Production:

Food production is listed a positive outcome. An increase in primary production would yield many benefits for fish species. How much food resources might drift downstream and benefit species in the Delta? See draft corridor document Table 4.1.3a, Figure 4.1.2a, and page 105. When you increase the amount and frequency of floodplain inundation, is that significant for downstream food export? It depends on the size of the floodplain. See HEC-EFM floodplain inundation modeling and assumptions in Section 7.3. The duration of inundation is Dec 1 to May 31, between 2 to 20 days (see Tables 3 and 4 in Section 7.3). Every 4 years at least 30% of the floodplain is inundated.

The San Joaquin River flow regime will not be different as a result of BDCP implementation. Higher flows will not occur with any increase in frequency. Floodplain inundation is only one mechanism by which you get food production. However, the improvements in ecosystem level nutrient production (i.e. food production) are limited for this floodplain creation because of the lack of changes in the San Joaquin River’s hydrology.

The restoration description prescribes 16 river miles of soft banks with trees. This will yield an increase in riparian-based food production. We anticipate that riparian vegetation (assuming passive restoration) will be young fringe trees. At the San

Joaquin River wildlife refuge, very rapid riparian growth has occurred. For some ecosystem functions, it is not about big wood, it is about development of a canopy (i.e., for leaf and insect drop). There is a risk that invasive plants will move into the restoration area. Studies along the Sacramento River show that prior to Shasta Dam (i.e., under normal hydrology) a flow event that drives riparian vegetation recruitment occurs on average every 5 years . However, for the San Joaquin River, the present conditions for riparian recruitment are not good. Using passive restoration techniques and assuming inundation every 4 years, there would not be sufficient re-vegetation. It is recommended that more areas with active riparian revegetation occur as part of the levee setback process. **Clarifying Assumptions:** • Assume passive restoration along the channel margin where levees are removed. • There is a risk of low riparian plant recruitment, unless there is active intervention to increase inundation. Note that no one has mapped existing conditions channel margin habitat. The Delta is a big filter with complex habitats. Nutrients are continually processed during a range of flows. Although there might be a periodic flush of nutrients into the Delta, overall this will not make a significant difference. There is a concern that tidal marsh creation would cause eutrophication. The classic location for eutrophication and low dissolved oxygen is near Stockton. Evaluators considered whether the corridor improvements would lead to a greater export of more nutrients or algae. In the past when the floodplains are inundated (during high flows), then dilution occurs and the intakes would not divert water. Studies by the CA Water Board suggest riparian leaf litter creates microbial activity that reduces the nutrients sent downstream. If the levees are set back and trees grow into large woody debris, then this changes habitat along miles of river. But even so, it is not expected that this would substantially alter nutrient export.
Scientific Justification: **Overall Magnitude**: very low, score is **Minimal "1".** **Overall Certainty:** certainty score is **High"4".** **Magnitude for salmonid food:** Assumes passive restoration. Control strategies for Himalayan blackberries and other non-natives, etc needed. See notes above. **Low "2".** With active re-vegetation, the magnitude score would increase. **Certainty for salmonid food:** The processes are understood, however this is a highly

variable ecosystem, **Medium "3".**

Potential Negative Ecological Outcome(s)

Outcome N2: Increased Mortality Due to Water Quality Degradation (Including Water Temperature, DO, Eutrophication)

General Notes: Soil constituents are not known. Water from natural floodplain and agricultural areas will drain into the river.

Magnitude: The action might benefit water quality given the cold high flows and riparian / floodplain shading. Dam releases in May and June could inundate the floodplain and some evaluators had concerns regarding temperature. However, overall, summer releases will be infrequent. Score: **Low "2".**

Certainty: The length of time inundation will occur on the floodplain is not certain and may be dependent upon the timing of dam releases. Although not a large problem, it is not certain. **Low certainty "2".**

Magnitude for dissolved oxygen (DO): Low "1".

Certainty for dissolved oxygen (DO): High "4".
(NOTE: the "risk" for the DO score is much lower than the overall scoring, so the 'more conservative" score of 2/2 was retained in the spreadsheet).

Outcome N4: Increased Exposure to Selenium

Magnitude: Low "2". This restoration will increase phytoplankton production that contains higher levels of selenium and gets carried up the food chain. Heavy selenium loading from San Joaquin watershed will be available to clams. Sturgeon eat clams and via the food chain may bioaccumulate selenium. However, overall effect on native fish species is **Low "2"**

Certainty: Low "2"

Outcome N5: Increased Mercury Methylation
Clarifying Assumptions: Effects of mercury on terrestrial species, birds, and humans were not discussed during the workshop.
Magnitude: For fish, the effect is minimal because fish are relatively low on the food chain. **Minimal "1"** **Certainty: Medium "3"** Rationale is the same as 2009 DRERIP analysis.

Outcome N6: Increased Mobilization or Re-suspension of Toxics (including pesticides)
Magnitude: If riparian vegetation is established, it could make previously existing toxics bioavailable. If pesticides/herbicides are used in the corridor on non-native vegetation this could be a concern; although they break down fairly quickly. RWQCB does have 303d listings for agricultural areas in the San Joaquin areas. **Low "2"** **Certainty**: If there are agricultural easements and agricultural chemicals are being used on the land, this adds to the uncertainty. There is also a data gap because we do not know what toxics exist on the soil. **Low "2"**

OBJECTIVE: RESTORE HABITATS AND RIVER CONDITIONS (I.E., THE MAGNITUDE AND DIRECTION OF FLOW IN FLUVIAL REGIMES) THAT FAVOR SURVIVAL AND GROWTH OF JUVENILE SALMONIDS, STURGEON, DELTA SMELT, LONGFIN SMELT, AND OTHER NATIVE FISHES

Potential Positive Ecological Outcomes

Outcome P16: Increased Channel Complexity (including in-channel and channel margin riparian vegetation, LWD, and emergent vegetation)

Clarifying Assumptions:
The evaluation team made the following assumptions:

- No grading of the floodplain or in-channel work. The project includes removal of the levee and passive vegetation restoration.
- The timeline for passive restoration to mature is late long term (30 – 50 years); assume evaluation is for the late long term.
- Once levees are removed, natural geomorphic sediment depositional and erosional processes will occur.
- Within 20 years, some vegetation and trees would be established along the channel corridor.
- When the bank becomes more naturalized, channel complexity will increase.

General Notes on Channel Complexity:
If we restore the physical configuration of this corridor with no change in hydrology, then the biological benefits will not be as large as if a change in hydrology were also made (as discussed in Outcome 1A). The proposed restoration may increase channel complexity. There are intrinsic benefits such as micro-scale effects and the creation of more natural interfaces.

Flow is one of many variables. Pushing out the banks or raising the channel invert would allow woody vegetation establishment. If the channel invert were raised, this would increase the frequency of inundation.

Concern that since BDCP alternative #1A is late-long term, the timeframe for realizing ecological / biological benefits would be very long from now. Upstream hydrology may change due to climate change, such that the peak discharges occur earlier in the year. Under climate change, there may be different timing for inundation and this timing may not synchronize with species life cycle. Additional modeling of these assumptions is recommended.

Two ways channel complexity can help salmon: 1) high flows spread out across floodplain, lower velocities, fish less likely to get washed downstream; 2) flows create a complex channel that creates beneficial fish habitat. Fish will use these channels even during lower flows. Ability of downstream migrating smolts to hide from predators was considered. The Vernalis Adaptive Management Plan (VAMP) shows high predation rates near the Stockton wastewater treatment plan. Complex habitat

provides hiding spots for native fish. If the habitat is restored, then more sediment will be generated/ mobilized and this will provide additional hiding opportunities for salmonid juveniles. This outcome also includes the potential beneficial impacts of suspended sediment and turbidity on channel complexity and habitat conditions for affected fish species. Sediment transport generates turbidity, creates complex habitats, and is beneficial for native fish species. This outcome is vague because it intends to create all these benefits. Even with dams, the San Joaquin River has enough energy and enough sediment supply to provide some of these benefits. Ideally, the sediment would move into the Delta to benefit habitats there. Flows in a 4 year event may be over 15,000 cfs. Evaluators wondered: How much can you generate within this reach from those types of flow events? Would this benefit native fish species? Flow is not normally distributed, due to climate and human management of reservoirs etc. A metric could be the average number of days with suspended sediments during a 2-week period. It is anticipated that we would not see a big change in sediment conditions as a result of implementation. An evaluator postulated that if flows are high enough to move sediment downstream over a series of many years, then the beneficial downstream effects could be significant.
Scientific Justification: River is still eroding activity and there is interface with vegetation. This interface will be beneficial. In a situation that is completely channelized then improvement would be significant. **Overall Magnitude:** This outcome pertains to physical habitat conditions. Score is **High “4”.** Note: The Evaluation team has not evaluated outcomes here for splittail, salmon, steelhead, white sturgeon. It likely does not apply to smelt or green sturgeon. For salmon, there is a medium benefit arising from increased complexity of habitat. **Overall Certainty: Not scored by the group (assumed Medium “3” based on sediment processes only and that those processes are a key driver in this outcome).** **Magnitude for sediment processes only**: This is a physical process outcome. Biological resources are not rated here. The corridor is about 16 miles along both banks (i.e. 32 linear miles). Some of the sediment will be eroded and deposited within the reach. Over time, more riparian habitat will develop. **Medium “3”** **Certainty for sediment processes only**: Understanding of the process is high; however, there is considerable uncertainty about the sediment budget and where the sediment will go. The nature of outcome is dependent on variable ecosystem process, such as hydrology. Scientists do understand the physical processes so based on theory alone, the certainty would be high. However, there is natural and human variability

associated with the sediment dynamics and hydrology. **Medium "3"**

(NOTE: only the overall score was retained in the spreadsheet; sediment processes not broken out).

Literature Cited:

- DRERIP sediment model

Potential Negative Ecological Outcome(s)

Outcome N12: Establishment of Invasive Species (SAV, Clams, invasive competitors)

Scientific Justification:

Corbicula is moderately common in the San Joaquin River. Restoration activities will result in the digging up and moving of *Corbicula* more frequently. Are we creating a new template upon which the invasives will establish? Threadfin shad likes deep channels but we are not creating deep channels here, so this is more applicable to other corridors.

Magnitude: Minimal "1"

Certainty: **Medium "3"**

DATA GAPS & KEY UNCERTAINTIES

Data Needs:

- A better understanding of sediment transport dynamics and sediment budgets for each corridor for the range of flow conditions is necessary.
- Assess the meander potential of the reach based on current channel configuration, geology, and soils. Corridor 1A has high potential for channel migration.
- Determine the presence/absence of sturgeon. Studies last year found evidence of white sturgeon spawning in the lower San Joaquin River. We need to know

what kind of habitat sturgeon spawn on. From a population perspective, perhaps high velocity habitats limit sturgeon spawning. High velocity in this case means 25,000 cfs (i.e. wet years). The Bay Study has done carrying capacity studies. There are spawning adults; however flows are not large enough for those adults to produce eggs that survive. VAMP flows are either low or high. Are intermediate flow years sufficient? Perhaps to get adults to spawn, but not enough for eggs to survive. For example, in the Columbia River, during intermediate years, predators eat the young sturgeon. It is hypothesized that sturgeon need good nursery habitat to avoid predators and this type of habitat is not presently found in Corridor 1A. Changes in channel morphology associated with the levee setbacks will produce variations in velocities through the channel. This may result in increased sediment deposition, increasing stage through the reach for a given discharge.

- Sediment deposition may also create some areas where velocities increase and that could benefit sturgeon. Sturgeon are long-lived fish. If there is a really wet year, 70,000 eggs could be spawned with a 5% survival ratio.
- Even with dams, the San Joaquin River has enough energy and enough sediment supply to provide some ecosystem benefits. How much turbidity can be generated within Corridor 1A from those types of flow events? Would this benefit native fish species (in the corridor and downstream)? A suggested metric could be the average number of days with suspended sediments during a 2-week period. It is anticipated that we would not see a big change in sediment conditions as a result of implementation. An evaluator postulated that if flows are high enough to move sediment downstream over a series of many years, then the beneficial downstream effects could be significant.

FOR FUTURE SOUTH DELTA PLANNING

Important New Ideas or Understandings:

- One way to improve hydrology would be to consider operational issues on the San Joaquin River. Ecological benefits relate to flow timing, magnitude, frequency, and durations.
- The charter for the South Delta Workgroup directs evaluators to consider changes to hydrology to improve ecological benefits. Specifically, the charter says the group “will consider how alternatives perform with San Joaquin restoration flows and future flows that result from Water Board orders or climate change.” These additional aspects should be considered as South Delta planning continues.
- Communication between ecologists and DWR engineers is a key aspect of

successful water planning in this region.

- American Rivers is leading a study on the lower San Joaquin River to quantify the potential benefits for flood management, water supply and ecosystem improvements in this portion of the Delta from expanded floodplains and bypasses.
- Sensitivity analysis with different hydrologic regimes would be interesting and illustrative of potential future benefits if flow regimes were to be altered.

Corridor 2A - Summary

- Assumptions/Changes to Corridor Description made During Evaluation
  - The Evaluation Team agreed to evaluate Corridor 2A assuming an Isolated Old River Corridor (IROC) to decrease uncertainty related to the lack of available information.
  - Passive riparian restoration is assumed, which lowers certainty on benefits coming from riparian.
  - The timeline for passive restoration to mature is late long term (30 – 50 years); this evaluation assumes late long term conditions.
  - Fish stranding on the floodplain was assumed to be a "non-issue" because it can be minimized via restoration design.
  - The group decided not to evaluate the entrainment/export issue because the uncertainty is very high (i.e. there is no certainty at all; lack of data). The group considered coming back to re-visit the entrainment issue later, but never did, feeling it more important to move on to other corridors.

- Summary of Key Outcomes Related to Objectives
  - *Objective: Increase the extent of ecologically-relevant floodplain habitat to support reproduction and viability of Sacramento splittail and Chinook salmon & Steelhead*
    - Positive Outcomes
      - New floodplain areas available for inundation that would benefit splittail and salmonids
      - Lower Paradise Cut weir could increase export of juveniles and food to other parts of the South Delta (i.e., not just
    - Negative Outcomes
      - Relatively-low risk of: floodplain stranding, increased mortality due to water quality degradation or mercury methylation; more uncertainty with microcystis and selenium

  - *Objective: Restore habitats and river conditions (i.e., the magnitude and direction of flow in fluvial regimes) that favor survival and growth of juvenile salmonids, sturgeon, delta smelt, longfin smelt, and other native fishes*

  - Positive Outcomes
    - Channel complexity will increase with wider bypass
  - Negative Outcomes
    - Potential for additional invasive species colonization in downstream end of expanded Paradise Cut bypass.

- Key Uncertainties
  - The hydrodynamics (spatially, and temporally [within each water year and by water year type]) of the flow split from the San Joaquin River to a lowered Paradise Cut weir. This split influences the distribution of food and outmigrating fishes.
  - How the San Joaquin River Restoration Program restoration flow regime and future flows that may be ordered by the SWRCB or result from climate change may influence key habitats and species outcomes and associated scoring.
  - How future geomorphic response of a less-confined San Joaquin River may result in aggradation of the channel bed and thus modify the stage-discharge relationships at the weir and for floodplain inundation more-generally. (Note, this would be a positive trend for inundated floodplain habitat).

- Data Gaps
  - Multi-dimensional hydrodynamic modeling (as related to entrainment and water quality) is of particular interest as it is a key driver in many of the important processes and outcomes considered.
  - Details regarding the configuration of the weir, the Old River Corridor (i.e. the presence or absence of an IROC) need to be further refined (including sensitivity analysis) to enable additional evaluation of this corridor, especially as it relates to other corridors.
  - Additional information/research on site-specific marsh habitat design options that can improve water quality conditions/mitigate potential adverse conditions that might be generated by creation of tidal marsh habitats in the South Delta. (See also the separate M&I and Agriculture WQ Evaluations in June, 2012)

- Potential corridor re-configurations or combinations to increase the worth /decrease the risk of potential implementation.
  - Salmon and splittail could potentially end up in Fabian Tract (after being routed through a lowered Paradise Cut weir) which would have marsh habitat. The combination of Corridors 2A and 2B should be considered as a coupled pair if in the future this corridor shows promise.
  - If in future South Delta Planning this corridor appears a promising option, it will be important to evaluate Corridor 2A with and without an IROC.
  - Some evaluators felt that the December date in the assumed ecologically-relevant hydrology for salmonids (Dec. 1 – May 31) is too broad. Additional sensitivity analysis will provide additional information on benefits.

- Active riparian forest restoration will increase the certainty of ecological benefits, and this should be considered in refining this corridor.

Corridor 2A– Detailed Evaluation Notes

Contents

Scientific Evaluation Worksheet & Notes
Corridor 2A

Evaluation Team:
Facilitator: Bruce DiGennaro
Participants: Eric Ginney, Coach; Jeremy Thomas, Ray McDowell, John Cain, Steve Cimperman, Sheng Jun Wu, Christine Joab, Deanna Sereno, Mike Hoover, Michelle Orr, Andrea Thorpe, Cathy Marcinkevage, Ted Sommer, Val Connor, Josh Israel, Ray McDowell, John Cain
Note-taker: Kateri Harrison

Date: Thursday, February 2, 2012

Corridor Scale: Large

Introductory notes:

- Evaluators asked if this Bypass significantly different from DWR's Central Valley Flood Protection Plan? Answer: DWR's Central Valley Flood Protection Plan contains placeholder maps; however, it does not contain any specific modeling. The CVFPP did not make specific assumptions, and did not make any specific proposals for an assumed expansion of the Paradise Cut weir. The specific assumptions in the Corridor Document, upon which the modeling of the corridors is based, are an amalgamation of previous proposals and modeling efforts from the River Islands' bypass expansion proposal and other modeling. Corridor 2A is an initial placeholder configuration that is not a final configuration—simply something to test the outcomes of an expanded weir/bypass. If a project evolves that might include Paradise Cut, additional refinement and alternatives development would be required.

- Corridor 2A includes the following:
    - The assumed changes to the Paradise Cut weir result in the San Joaquin River beginning to overtop at 6,040 cfs (assuming Model Run F conditions, no SLR; see Section 7.3). In comparison, the existing Paradise Cut weir is modeled (using a MHW downstream boundary condition, without SLR), to begin to overtop at 12,957 cfs. Flow

stays in channel until ~10,000 cfs (i.e., floodplain inundation in Paradise Cut begins when river discharge is above 10,000 cfs).

- The group noted that to make Fabian Tract (Corridor 2B) most effective, consider routing more flow through Old River rather than Grant Line Canal. Old River doesn't get much flow under existing conditions, most flow goes through Grant Line. Terrestrial species of interest such as brush rabbit, swainson hawk, waterfowl and general migratory birds were not covered in today's evaluation but can be considered later.

OBJECTIVE: INCREASE THE EXTENT OF ECOLOGICALLY-RELEVANT FLOODPLAIN HABITAT TO SUPPORT REPRODUCTION AND VIABILITY OF SACRAMENTO SPLITTAIL AND CHINOOK SALMON & STEELHEAD.

Potential Positive Ecological Outcomes

Outcome P1: Increased Frequency of Inundation

Scientific Justification:
The restoration seems to create a reliable floodplain inundation. Inundation of this magnitude (for salmonids: 777 acres compared to 46 acres for existing conditions) happens every 4 years, for at least 14 days, sometime between December 1 and May 31 and is a sustained, but minor effect. Lower magnitude levels of inundation occur more frequently or for a longer duration.

Magnitude: Medium "3".

Certainty: The team felt certain that these flows would happen infrequently—but were also reminded that the outcome is based on real data and historical operations. Thus, while the magnitude of the acres is low, and the frequency is only every 4 years, there is some statistical certainty of that occurring. Overall, the group agreed that the San Joaquin River's flows are highly-altered, and that benefits will only manifest during times with high variability and flooding; this is unpredictable. The flows are beyond the control of BDCP and are reliant on meteorology and the river's hydrology. Understanding is high but outcome is dependent of highly variable process. It is hard to predict when the flood flows will occur. **Medium "3".**

Outcome P2: Increase Spatial Extent of Spawning Habitat for Splittail

Clarifying Assumptions:
The Evaluation Team discussed how/whether Old River would be isolated from pumps. *It was agreed to evaluate assuming an Isolated Old River Corridor (IROC) to decrease uncertainty in available information.* However, it will be important to evaluate this corridor in the future without an IROC if the corridor appears promising.

Scientific Justification:
Splittail need a minimum duration of flooding for 21-days. Page 10 of Section 7 document states 11,600 cfs is the ecologically significant flow w/out SJRRP needed to achieve this. Under existing conditions 11 acres would be flooded. Post-restoration corridor condition is modeled to be 445 acres. So, 400+ acres will be flooded every 4 years. Essentially doubling splittail spawning acreage from 413 ac (Corridors 1a and 2) to add 445 in corridor 2A. This flooding will occur from Feb to May. However, the temperature during this timeframe will obviously be variable.

Magnitude for splittail: Currently, very little floodplain gets wet (11 acres). This proposed 2A will be a significant improvement. **Medium "3".**

Certainty for splittail: Group discussed how much or whether BDCP can control the hydrology. The timing, frequency and duration of the assumed hydrology used by the consultants to identify the inundated area for splittail is based on peer reviewed studies in the Delta system. However, flooding is unpredictable. There is variability in the human-controlled hydrology of the San Joaquin River. If flows were managed to allow more inundation, then this certainty score would increase. There is a close relationship between floodplain inundation and splittail. **Medium "3".**

Outcome P3: Increased Rearing Habitat for Salmon

Note: Some evaluators felt that the December date in the assumed ecologically-relevant hydrology for salmonids (Dec. 1 – May 31) is too broad. There is some variation in the timing for juvenile (spring-run) out-migration; however, it may be a mistake to say that inundation in December would necessarily benefit salmon. In the future, sensitivity analyses would be informative. The consultant team noted they were more "inclusive" than "exclusive" in terms of the time period examined for the ecologically-relevant flows.

There is a 20-fold increase, from 46 acres to 845 acres; however, this occurs only once every 4 years. In comparison, corridor 1A's reach improves 910 acres. Corridor 2A will double the amount of physical habitat, in combination with corridor 1A. Frequency of inundation drives the score. Salmon cohorts have a 3-year life cycle; however, inundation occurs only once every 4 years, and other frequencies should be examined in the future if this corridor shows promise.
Notes, salmon could potentially end up in Fabian Tract which could have marsh. The combo of 2A and 2B should be considered as a coupled pair if in the future this corridor shows promise.

Magnitude: Score is a "2", but with some disagreement about whether a 4-yr occurrence interval is an appropriate minimum threshold. BDCP should also integrate factors as compared to the Yolo Bypass, to be consistent. What is the threshold in Yolo?
Low "2"

Certainty: The Evaluation Team is very certain that this magnitude will be low. There is a high level of uncertainty because it is not known how representative this once every four years inundation is. The EMF model could be re-run to sort this out. Unnaturally reduced flows on the San Joaquin are a problem. Scientific understanding is high; however this situation is dependent on a variable environment. **Medium "3".**

Outcome P4: Increased Local Aquatic Primary and Secondary Production

Scientific Justification:
Notes about Food Production - Food production is listed a positive outcome. An increase in primary production would yield many benefits for fish species. How much food resources might drift downstream and benefit species in the Delta? See draft corridor document Table 4.1.3a, Figure 4.1.2a, and page 105. When you increase the amount and frequency of floodplain inundation, is that significant for downstream food export? It depends on the size of the floodplain. See HEC-EFM floodplain inundation modeling and assumptions in Section 7.3. The duration of inundation is Dec 1 to May 31, between 2 to 20 days (see Tables 3 and 4 in Section 7.3). Every 4 years at least 30% of the floodplain is inundated.

The San Joaquin River flow regime will not be different as a result of BDCP implementation. Higher flows will not occur with any increase in frequency. Floodplain inundation is only one mechanism by which you get food production. However, the improvements in ecosystem level nutrient production (i.e. food production) are limited for this floodplain creation because of the lack of changes in the San Joaquin River's hydrology.

The restoration description prescribes 16 river miles of soft banks with trees. This will yield an increase in riparian-based food production. We anticipate that riparian vegetation (assuming passive restoration) will be young fringe trees. At the San Joaquin River wildlife refuge, very rapid riparian growth has occurred. For some ecosystem functions, it is not about big wood, it is about development of a canopy (i.e., for leaf and insect drop).
There is a risk that invasive plants will move into the restoration area. Studies along the Sacramento River show that prior to Shasta Dam (i.e., under normal hydrology) a flow event that drives riparian vegetation recruitment occurs on average every 5 years . However, for the San Joaquin River, the present conditions for riparian recruitment are not good. Using passive restoration techniques and assuming inundation every 4 years, there would not be sufficient re-vegetation. It is recommended that more areas with active riparian revegetation occur as part of the levee setback process.

Magnitude: Assumes passive restoration. Control strategies for Himalayan blackberries and other non-natives, are needed.
Low "2"

Certainty: The processes are understood, however there is a highly variable ecosystem, **medium "3"**

Outcome P5: Increased Food Export

Clarifying Assumptions:
The weir will be lower, so there is a higher likelihood that food will be pushed downstream through this corridor. However, the export would go down Grant Line and into an isolated Old River corridor (i.e. if in this evaluation Fabian Tract is not assumed). There is a concern that any food production would be exported to the pumping facilities if an IROC is not assumed. However, dual conveyance is assumed, so in some operation scenarios this might be a lesser concern (i.e., in the wet years, there would not be a lot of south Delta pumping during December to May).

Several evaluators recommended modeling of OMR flows with an IROC. However modeling is not currently available to assess this. Also, general entrainment modeling is not currently available. Modeling would need to consider operations year-by-year etc. Modeling should consider with and without the barrier. This type of modeling is recommended in order to thoughtfully analyze these issues.

During wet years, not much pumping will occur in the south Delta facilities. However, foodweb productivity in normal or dry years might be a concern (export of primary productivity via the pumps during dry years). The entrainment issue is speculative. South Delta pumping (i.e. level of diversions) is directly related to the pumping allowed from the north Delta.

The group decided not to evaluate the entrainment/export issue because the uncertainty is very high (i.e. there is no certainty; lack of data). The group considered coming back to re-visit this outcome later, but never did, feeling it more important to move on to other corridors.

Potential Negative Ecological Outcomes

Outcome N1: Increased Stranding on the floodplain
Clarifying Assumptions: Stranding on the floodplain can be minimized via design. The evaluation team assumed the aquatic habitats, including the floodplain and marsh would be designed such that the site functions and operates in a manner that avoids stranding. Designers should allow for mostly complete drainage behind the Paradise Cut weir. Although it is recognized that microhabitats such as pools will develop and this might create minimal stranding. This type of minimal fish stranding due to microhabitat is acceptable. Designers should think about areas upstream and downstream. Also, designers should review the SFEI historical ecology materials Assumption: the potential for stranding will be designed out of this floodplain.
Scientific Justification: **Magnitude:** Conceptually stranding is an issue **Low "2".** There is project level mitigation (good design) that needs to happen. **Certainty: High "4".**

Outcome N2: Increased Mortality Due to Water Quality Degradation (including water temperature, DO, eutrophication)

General Notes: The downstream area is tidally influenced so might have longer residence time. Between 6,000 to 10,000 cfs water is simply flushing thru the system. Above 10,000 cfs the water is held on the floodplain. There was a lot of speculation about these processes by the evaluators and the consensus was that more modeling is needed.

RWQCB has water bodies on 303d list of impaired water bodies. Also, the soil constituents (residue pesticides) on the restoration site are not currently known.

Above 10,000 cfs temperature might be better or worse, depending on residence time etc. However in corridor 2B, residence time will increase and so water temperatures might be a concern under that other alternative. Floodplain dynamics are not well defined here.

Scientific Justification:

Magnitude for general water quality: The action might benefit water quality given the cold high flows and riparian / floodplain shading. Dam releases in May and June could inundate the floodplain and some evaluators had concerns regarding temperature. However, overall, summer releases will be infrequent. **Low "2"**

Certainty general water quality: The length of time inundation will occur on the floodplain is not certain and may be dependent upon the timing of dam releases. Although not a large problem, it is not certain. **Low "2"**

Outcome N3: Increased Microcystis

Scientific Justification:

Magnitude: The spatial extent is minimal (a few hundreds of acres). **Low "2".**

Certainty: Very little information is available on the dynamics of this floodplain. **Low "2".**

Outcome N4: Increased Exposure to Selenium

Scientific Justification:

Magnitude: Low "2". This restoration will increase phytoplankton production that contains higher levels of selenium and gets carried up the food chain. Heavy selenium loading from San Joaquin watershed will be available to clams. Sturgeon eat clams and via the food chain may bioaccumulate selenium. However, overall effect on native fish species is **Low "2"**

Certainty: Low "2"

Outcome N5: Increased Mercury Methylation

Clarifying Assumptions:
Effects of mercury on terrestrial species, birds, and humans were not discussed during the workshop.

Magnitude: For fish, the effect is minimal because fish are relatively low on the food chain. **Minimal "1"**

Certainty: Medium "3"

Rationale is the same as 2009 DRERIP analysis.

OBJECTIVE: RESTORE HABITATS AND RIVER CONDITIONS (I.E., THE MAGNITUDE AND DIRECTION OF FLOW IN FLUVIAL REGIMES) THAT FAVOR SURVIVAL AND GROWTH OF JUVENILE SALMONIDS, STURGEON, DELTA SMELT, LONGFIN SMELT, AND OTHER NATIVE FISHES

Potential Positive Ecological Outcomes

Outcome P16: Increased Channel Complexity (including in-channel and channel margin riparian vegetation, LWD, and emergent vegetation)

Clarifying Assumptions:
The evaluation team made the following assumptions:

- No grading of the floodplain (except to mitigate for potential fish stranding) or in-channel work. The project includes removal of the levee and passive vegetation restoration.
- The timeline for passive restoration to mature is late long term (30 – 50 years); assume evaluation is for the late long term.
- Once levees are removed, natural geomorphic sediment depositional and erosional processes will occur.
- Within 20 years, some vegetation and trees would be established along the channel corridor.
- When the bank becomes more naturalized, channel complexity will increase.

Magnitude: High "4".

Certainty: Medium "3".

Potential Negative Ecological Outcomes

Outcome N12: Establishment of Invasive Species (SAV, Clams, invasive competitors)
General Notes: This site waters from the back end, up the channel in direction of Fabian Tract. So, the bottom half of Paradise Cut would be wet and top half dry. It will be dry for 3 out of 4 years. When wet it will be from flooding.
Magnitude for SAV: Minimal "1" **Certainty SAV: High "4"** **Magnitude for Clams:** the bottom half has tidal influence and perennially wet. However, this restoration will not change this situation. Corbicula dies off due to contaminants. If high flows dilute the contamination, the clams may increase in population abundance. San Joaquin River currently has stretches that are clam-free due to contamination. Scoring this is too speculative. Not rated.

Data Gaps & Key Uncertainties

Data Needs *(indicate specific models, DLO relationships, or other information indicating the need):* • Entrainment and water quality (as related to multi-dimensional hydrodynamics) are of particular interest as they are a key driver in many of the important processes and outcomes considered. • Details regarding the configuration of the weir, the Old River Corridor (ie the presence or absence of an IROC).
Key Uncertainties and Research Needs *(describe specific research activities that could be employed to increase understanding):* • Additional information/research on site-specific habitat design considerations that can improve water quality conditions/mitigate potential adverse conditions, generated by creation of tidal marsh habitats in the altered hydrologic conditions of the South Delta. (See also the separate M&I and Agriculture WQ Evaluations in June, 2012) • Notes, salmon could potentially end up in Fabian Tract which could have marsh. The combo of 2A and 2B should be considered as a coupled pair if in the future this corridor shows promise.

Corridor 2B - Summary

- Assumptions/Changes to Corridor Description made During Evaluation
  - For purposes of this DRERIP evaluation, Corridors 2A and 2B are being parsed such that: 2A+Fabian Tract=2B. Corridor 2A was evaluated previously and separately from this evaluation. The scores below represent both 2A and 2B together.
  - The evaluation team agreed to parse out two viewpoints expressed by the group and assume “two scenarios”:
    - Scenario 1 is the approach as described in the Corridor Document and modeled by the consultants; it includes a considerable area of sub-tidal acreage.
    - Scenario 2 would have the marsh designed such that most acreage is emergent tidal marsh. (This assumes that the portion in the yellow elevation range on the map would become emergent tidal marsh that was created by tule planting). This 2 scenario concept provides a better approach to manage/avoid negative outcomes.
  - Phasing will be ignored for purposes of this evaluation; the assumption is that the tules get planted tomorrow and the marsh is in “full affect”.
  - The late-long term condition will be analyzed by the evaluations today for both scenarios.
  - The Evaluation Team evaluated Corridor 2B considering both an Isolated Old River Corridor (IROC) and “no IROC”; details on assumptions are presented in each outcome.

- Summary of Key Outcomes Related to Objectives
  - *Objective: Increase the extent of ecologically-relevant floodplain habitat to support reproduction and viability of Sacramento splittail and Chinook salmon & Steelhead*
    - Positive Outcomes
      - New floodplain areas (that transition into marsh habitat) would be available for inundation that would benefit splittail and salmonids
  - *Objective: Increase the spatial extent and connectivity of tidal marsh.*
    - Positive Outcomes
      - New marsh area would be well connected to upstream floodplains, but downstream connection into the Delta links to poor habitat

            - Minimal habitat for smelt; some habitat for splittail spawning and salmonid rearing and white sturgeon rearing.
        - Negative Outcomes
            - Invasive species (clams, SAV) will certainly occur, but adverse effect on fish species is uncertain and likely low magnitude
            - Water quality (especially temperature, potentially DO) may be an issue, but numerical modeling data is lacking
    - *Objective: Restore habitats and river conditions (i.e., the magnitude and direction of flow in fluvial regimes) that favor survival and growth of juvenile salmonids, sturgeon, delta smelt, longfin smelt, and other native fishes*
        - Positive Outcomes
            - Channel complexity will increase with Fabian tract inundated
        - Negative Outcomes
            - Potential for entrainment is an issue yet to be examined quantitatively/with modeling, but conceptually is a large factor that needs to be addressed.

- <u>Key Uncertainties</u>
    - The hydrodynamics (spatially, and temporally [within each water year and by water year type]) of how flows come in from the San Joaquin River as well as how tidal action works within an opened-Fabian Tract. These dynamics influence water quality, residence time of fishes for spawning and rearing, and the distribution of food and out-migrating fishes.
    - How sub-tidal habitat areas within a restored marsh area are either managed or modified in the restoration designs such that they are eliminated, in order to reduce undesirable habitat areas.
    - Related to the above, are sub-tidal areas located in the South Delta beneficial for native fish?
    - What were the historical ecological functions of the South Delta for smelt? Is it feasible to re-create those processes/habitats within the context of BDCP South Delta restoration?
    - A "landscape-scale processes conceptual model" would be helpful in understanding ecosystem dynamics (physical and ecological) that occur across the transition between habitat types (i.e., the gradation from floodplain to marsh).
    - An understanding of habitat conditions and outmigration success for fishes that may rear in an inundated Fabian Tract. Also, the relationship between successful outmigration downstream of Corridor 2B compared to that of Corridor 4.

- <u>Data Gaps</u>
    - Multi-dimensional hydrodynamic modeling (as related to inundation of Fabian Tract, entrainment, and water quality) is of particular interest as it is a key driver in many of the important processes and outcomes considered.

- Additional information/research on site-specific marsh habitat design options that can improve water quality conditions/mitigate potential adverse conditions that might be generated by creation of tidal marsh habitats in the South Delta. (See also the separate M&I and Agriculture WQ Evaluations in June, 2012)

- <u>Potential corridor re-configurations or combinations to increase the worth /decrease the risk of potential implementation.</u>
  - An Isolated Old River Corridor (IROC) would decrease the risk of entrainment of fish and food. This is a key consideration in configuring habitat in Corridor 2B.
  - Modification of the Fabian Tract (Corridor 2B) footprint to address the sub-tidal marsh areas that would be created if the entire tract were opened via full levee breaches. In other words, steer restoration design toward what evaluators assumed as "Scenario 2" during these evaluations.
  - In conjunction with the recommendation above, consider that Fabian Tract could be adaptively restored with the floodplain at upstream end completed first with the downstream, more-tidal areas restored later when uncertainty is resolved.
  - Salmon and splittail could potentially end up in Fabian Tract (after being routed through a lowered Paradise Cut weir) which would have marsh habitat. The combination of Corridors 2A and 2B should be considered as a coupled pair if in the future this corridor shows promise. Consider how Corridor 2B itself might be adaptively phased in to an overall South Delta solution (i.e., later than other areas) given uncertainty.
  - In terms of lower/ecologically-relevant flows, consider reconfiguration of the channel split at Old River-Grant Line Canal to favor more flow thru Old River. This need not preclude channel and floodway sizing in these areas to be optimized for flood conveyance.

Corridor 2B - Detailed Evaluation Notes

Contents

Scientific Evaluation Worksheet & Notes
Corridor 2B

Evaluation Team:
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Note-taker: Kateri Harrison

General opening discussion. Reminder that the approach taken in this worksheet is to assess the magnitude and certainty of the objective statement and its associated outcomes. These are tracked in the accompanying spreadsheet. This represents a slightly different approach from that taken during the 2009 DRERIP Evaluations.

For purposes of this DRERIP evaluation, Corridors 2A and 2B are being parsed such that: 2A+Fabian Tract=2B. Corridor 2A was evaluated previously and separately from this evaluation. A key question is whether there are any ecological benefits that we could realize from removing levees and allowing inundation of Fabian Tract? <u>The scores below represent both Corridors 2A and 2B together.</u> *This is a regional landscape change in the Delta.*

Portions of Fabian Tract would be inundated all the time, other portions would not. The exact configuration is not yet determined and would require modeling to better understand such inundation and tidal dynamics. Breaching levees in a tidally influenced area does create flow/discharge. The likely spatial area of habitat with and without grading was considered. Modelers assumed Fabian Tract could have some grading to extend the intertidal zone. The color codes on the tides are based on existing tides and without grading. So grading (filling) would yield less of the yellow sub-tidal elevation range. BDCP's definition of "tidal marsh" includes both sub-tidal and open water. Evaluators noted that in general, there is a lot of concern about situations similar to Frank's Tract which is open water.

South Delta ROA has been mapped in Appendix E of the Draft BDCP. Appendix E includes effects analysis and it may be useful in this evaluation. The consultant team cautioned that while the ROA is clearly presented in Appendix E, the actual "hypothetical" tidal marsh area within that ROA is <u>**not**</u> the same as Corridor 2B (which is only Fabian Tract). The hypothetical for the effects analysis is different and includes **<u>none</u>** of Fabian Tract. A homework assignment for the consultant team was to determine if there is any similarity between the modeling assumptions made in Appendix E and the modeling that ESA/PWA used for the South Delta. *[Consultant Team Answer: after conferring with ICF, it appears that the situation is as was suggested by ESA PWA during the evaluation: the hypotheticals are very different, and the outcomes for salmon (as stated in the effects analysis) are limited to only temperature and turbidity, as taken from one node in DSM2 on the lower San Joaquin River and extrapolated across the hypothetical]*

The evaluators then noted that the BDCP's effects analysis modeling creates confusion because the ROA's are depicted as large blobs on a map. However, when the actual modeling of the hypotheticals within those blobs is run, the analysts do not share that subset or any related assumptions. There is very little definition of what BDCP is doing in the South Delta and this has resulted in unvetted assumptions.

The potential effects on salinity of larger tidal prism are very difficult to model in this area. Small increases in salinity have a big impact on the quality of drinking water. However, small increases in salinity have minimal effect on fish. This issue was noted to be more important for the M&I and Agriculture Water Quality Evaluations held in June. A condition with low exports and with low San Joaquin River flow sets the stage for a tidal system with sea water and associated higher salinity. Additional modeling of salinity intrusion is recommended. This salinity will affect both M&I uses and X2. By creating a tidal basin (Fabian Tract in Corridor 2B) it will increase the tidal prism and bring more sea water into this area. Changes in tides will change dynamics. For example, at Liberty Island restoration the tidal range (difference between high and low tide) shrunk.

In conclusion, restoration in corridors 2A and 2B will increase the variation in salinity. The restoration of 2A and 2B might influence south Delta exports.

Overall Clarifying Assumption for All Corridor 2B analysis

Based on existing elevations and interpreted tidal range, one option for Fabian Tract is to have a large area that is sub-tidal (as shown on the figures for Corridor 2B). Another option would be to in some manner block off this subtidal area (located in the generally northwest corner of Fabian tract) via a new levee, plant tules, to raise the elevation (via subsidence reversal techniques and potentially carbon farming), and eventually the terrestrial could be converted to create tidal marsh. The marsh could be created via grading or via tule marsh accretion.

The evaluators wanted to understand whether sub-tidal areas located in the South Delta would provide benefits for native fish?

The evaluators expressed a tension between analyzing a project as described by BDCP or re-writing the project description to make it better. It was noted that oftentimes BDCP planning teams remove parts of project descriptions that do not seem feasible, practical, or beneficial. Many evaluators felt that this DRERIP evaluation should objectively score the entire project as modeled/originally-conceived. Several evaluators felt that restoring sub-tidal areas is not a good idea. Negative outcomes are associated with sub-tidal open water. Open sub-tidal can be colonized by Egeria. The previously-discussed option of levees and subsidence reversal allows engineers to 1) partition; 2) grade; and/or 3) plant tules. Such a strategy would create all emergent marsh habitat within Fabian Tract, or floodplain. The sub-tidal would be minimized or eliminated. This would require cross-levees and tule planting and the design objective would be to minimize open water and sub-tidal.

After much discussion, the evaluation team agreed to parse out the two viewpoints expressed by the group and assume “two scenarios”. Scenario 1 is the approach as described in the Corridor Document and modeled by the consultants; it includes lots of sub-tidal acreage. Scenario 2 would be designed such that most acreage is emergent tidal marsh, as per the discussion outlined above. This assumes that the portion in yellow (elevation range) on the map would become emergent tidal marsh that was created by tule planting. Phasing will be ignored for purposes of this evaluation. Assume that tules get planted tomorrow. The late-long term condition will be analyzed by the evaluations today for both scenarios. This 2 scenario concept provides a better approach to manage/avoid negative outcomes. The group noted that this is a good example of two differing professional viewpoints and agreed to move ahead to engage them both.

OBJECTIVE: INCREASE FREQUENCY OF FLOODPLAIN INUNDATION TO SUPPORT REPRODUCTION AND VIABILITY OF SACRAMENTO SPLITTAIL AND CHINOOK SALMON.

Potential Positive Ecological Outcome

Outcome P1: Increased Frequency of Inundation
Clarifying Assumptions: 2,500 acres of sub-tidal would be flooded along with 1,000 acres of floodplain. Note: Additional modeling is needed. Topography is flat and inundation will be shallow, so the channel will be relatively deep.

Scientific Justification: Compared to 2A, this restoration improves many more acres (1,500 acres of floodplain is proposed). This proposed restoration will double the amount of inundated acres in this entire area.

Magnitude Scenario #1 includes sub-tidal: Medium to High "3-4"

Certainty Scenario #1 incldues sub-tidal: The Frequency of flooding is not known (need more modeling). Uncontrolled environmental variables **Medium "3"**

Magnitude Scenario #2 all emergent: Same as sub-tidal. **Medium to High "3-4"**

Certainty Scenario #2 all emergent: Same as sub-tidal. **Medium "3"**

Note: Magnitude scores rounded down in the spreadsheet to remain conservative.

Outcome P2: Increased Spawning Habitat for Splittail

Scientific Justification: Same as Corridors 1A and 2A. Under existing conditions there are no ecologically significant benefits on Fabian Tract. The consulting team developed a table explaining the floodplain details. 6,095 acres of floodplain is misleading. There was no 2-D modeling. If you peal out the 1500 acres of floodplain and this is similar to 1A and 2A. We assume fish will not use the tidal marsh based on Dutch Slough studies. Tidal marsh does not serve as splittail spawning habitat

Magnitude Scenario #1 sub-tidal: **Medium "3"**

Certainty Scenario #1 sub-tidal: Same as 1A and 2A, **Medium "3".**

Magnitude Scenario #2 all emergent: Not scored by the group

Certainty Scenario #2 all emergent: Not scored by the group

Outcome P3: Increased Rearing Habitat for Salmon

Magnitude Scenario 1 sub-tidal: Higher than Corridor 2A. If 30-50% of the fish that emerge from San Joaquin gravels and travel downstream to the flow split onto Old River. Splits at Grant Line, so breach there, too. At the flow split there will be a lot of cues. Perhaps fish do not move only with the flows but respond to these cues. If only 50% of fish would by Paradise Cut and get swept into this area. Is 50% sig for the population? Probably minor. However regionally, this is likely the largest area. 1500 new acres of floodplain. **Magnitude: Medium "3"**

Certainty Scenario 1 sub-tidal : Medium "3"

Magnitude Scenario 2 all emergent: Not scored by the group

Certainty Scenario 2 all emergent: Not scored by the group

OBJECTIVE: INCREASE THE SPATIAL EXTENT AND CONNECTIVITY OF TIDAL MARSH.

Un-numbered Outcome: Increase the spatial extent and connectivity of tidal marsh (Note: the group chose to take this entire objective and make it an "outcome" as related to corridor function [see corridor tab in spreadsheet]).
Magnitude Scenario 1 sub-tidal: Not scored by the group. **Certainty Scenario 1 sub-tidal:** Not scored by the group. **Magnitude Scenario #2 all emergent:** Connectivity downstream does not follow a natural gradient. Connectivity to other marshes in interior delta (i.e. regional connectivity) is poor. East Delta and West Delta ROA have issues too. Old River is called "West Canal". Natural gradients are important from both an ecological community perspective and a landscape perspective. There is also an internal site habitat gradient from floodplain upstream to marsh downstream, which appears beneficial but is not well-described because there are no "landscape" conceptual models in DRERIP. There is good connection on this Fabian Tract site between floodplain and mash. Currently this site does not support tidal marsh. The proposed restoration will add several thousand acres of tidal marsh. **Medium "3"**
Certainty Scenario 2 all emergent: The tidal range situation is not clear. Changes to the tidal range could reduce the extent of the marsh. This could be mitigated via design. **Low "2".**

Outcome P6: Increased Spawning Habitat for Splittail

Magnitude Scenario #2 all emergent. Splittail will spawn in marsh. The frequency is not as important. Tidal marsh is not as desirable habitat as compared to floodplain) **Low "2"**

Certainty Scenario #2 all emergent**: Low "2"**

Magnitude Scenario 1 sub-tidal: Not scored by the group.

Certainty Scenario 1 sub-tidal: Not scored by the group.

Outcome P7: Increased Rearing Habitat for Salmonids

Clarifying Assumptions:

- Lower weir. For this outcome, the group reiterated the assumption that Corridor 2A was in effect and the weir would be lower.

Magnitude Scenario 2 all emergent
This habitat is available every single year and if 50% of the San Joaquin River salmon travel down here. In the past, this area was a bottle neck for salmon. The restoration will be a big improvement. **Medium "3".**

Certainty Scenario 2 all emergent: **Low "2".**

Magnitude Scenario 1 sub-tidal: Not scored by the group.

Certainty Scenario 1 sub-tidal: Not scored by the group.

Outcome P8: Increased spawning habitat for Delta smelt

Clarifying Assumptions:

- Currently, the South Delta is a sink for delta smelt. Refer to BDCP effects assessment for additional information on smelt ecology and this phenomenon.

Magnitude Scenario 2 all emergent: **1 minimal**. Ignores sink (this part of the outcomes is captured as a negative outcome, below).

Certainty Scenario 2 all emergent: **1 minimal.**

Magnitude Scenario 1 sub-tidal: Not scored by the group.

Certainty Scenario 1 sub-tidal: Not scored by the group.

Outcome P10: Increased spawning for Longfin smelt

Scientific Justification:

Magnitude Scenario 2 all emergent: Similar to 2009 DRERIP but lower magnitude and certainty. **Minimal "1"**

Certainty Scenario 2 all emergent: Low "2"

Magnitude Scenario 1 sub-tidal: Not scored by the group.

Certainty Scenario 1 sub-tidal: Not scored by the group.

Outcome P12: Increased rearing habitat for Juvenile and Sub-adult White Sturgeon

General Discussion: Sturgeon could be residents year-round. If this is not an isolated (protected) from the facilities, then fish will get entrained.

West Canal is an agricultural canal. Old River is a natural channel of the San Joaquin River, but it has to go past West Canal. West Canal has negative flows right to the facilities. This area has terrible habitat conditions. However, in the future, if we imagine this without entrainment (ie with an IROC), then the quality of the habitat is somewhat better; however, at this time an isolated corridor is not part of the project. If the project changes to incorporate an IROC, then evaluators should return to re-analyze the situation. Hopefully, the project proponents will improve the project description later to alleviate / mitigate the negative effects. There are reports on the IROC, but BDCP has not incorporated it yet. The BDCP proposal in the South Delta appears vague to the evaluators. The hydrodynamics of an IROC were not clearly explained in the description and are generally not well understood. It is important to think of this holistically.

Currently today, the South Delta does not have tidal marsh or riparian habitat. Any habitat that does exist is located within the zone of entrainment. The areas downstream of the South Delta are not particularly good habitat (this is the case for all of the corridors). This is a consistent assumption that applies to all corridors.

Magnitude Scenario 2 all emergent: Even with an isolated facility, still have limited downstream connectivity. Sturgeon are here year round. If water quality conditions were appropriate and if they were outside the zone of entrainment. Overall this restoration represents a small contribution of tidal marsh acreage to the Delta system. Conceptual model is that sturgeon use subtidal, not intertidal **Low "2"**

Certainty Scenario 2 all emergent: Low "2"

Magnitude Scenario 1 sub-tidal: Not scored by the group.

Certainty Scenario 1 sub-tidal: Not scored by the group.

Potential Negative Ecological Outcomes

Outcome N12: Clams & SAV
Scientific Justification: Note that the evaluators referenced back to the 2009 DRERIP evaluation related to Corbicula establishment that could limit, if not eliminate, the productivity befits of the restoration to native fish. Similarly established of SAV and centrarchid predators could lead to predation rates on the site that eliminate any net benefits at a population level. A worst case scenario is that clams eat every bit of production. **<u>Clam</u> - Magnitude** Scenario 1 – sub-tidal, all fish species: The habitat in this region is generally in very poor condition. **Minimal "1"** **<u>SAV</u> Magnitude** Scenario 1 – sub-tidal all fish species: **Low "2".**
SAV & Clams Certainty Scenario 1 - sub-tidal: We have high certainty that clams and SAV will invade (4) and low certainty that this will impact the fish species. **Low "2"** **Clams Magnitude** Scenario 2- all emergent, all fish species: Clams and SAV will not be in the emergent marsh. However, if food is exported off the marsh, we will see well-fed clams. **Minimal "1"** **SAV Magnitude** Scenario 2 all emergent all fish: SAV will grow in adjacent channels, but not grow in marsh. **Low "2"** **SAV & Clams** Certainty 2 – all emergent: **Low "2"**

Outcome N3C: Invasive fish / Predators [note that *zero magnitude* meant that this outcome was not included in the spreadsheet]

Magnitude Scenario 2 – **all emergent for salmon and splittail**: this restoration action (and any tidal habitat) will create more habitat for invasive fish species. Predation is currently high (already at 97%) and this rate will stay the same. More complex habitat will create more places for native fish to hide from predators. Tidal marsh will provide a net benefit, even with predation.

This is a wash "**zero" 0 magnitude** or a small net benefit.

Certainty Scenario 2 – **all emergent**: Evaluators are fairly certain that increased abundance of invasive predators will occur. However, the effect of this increase in predation on salmon and other native fish populations, given the already high rates, is less certain. **Low "2"**

Outcome N7a: Increased Mortality Due to Water Quality Degradation (including water temperature, DO, eutrophication)

Scientific Justification: This restoration will increase residence time and therefore may increase water temperature. If there were no Isolated Old River Corridor there might be better water quality due to flow thru of San Joaquin River (?). This restoration will be increasing the tidal prism and pulling in more water from the sea. Higher tidal velocity in the river downstream of Fabian Tract. Solar radiation on subtidal areas would increase temperature. If water temperatures increase just a little bit, then predators will eat more due to bioenergetics.

An example is Mildred Island where temperatures did increase in the sub-tidal zone 5 ft. depth. The overall south Delta will have an increased residence time, which will influence temperature.

Magnitude for Scenario 1 sub-tidal: Splittail are resident fish species but moving to western Delta. Smelts are sensitive to temperature and therefore would experience greater impact. It is not a High 4 magnitude because there may be some pools of cooler temperature refugia. Fish may avoid high temperature areas. Sustained minor population effect. **Medium "3".**

Certainty: We do not understand the timing or magnitude of the temperature changes. Habitat Suitability Index (HSI) for temperature flattens for a while and then drops. Spring season is the time of most concern for some species. **Minimal "1"**

Magnitude for Scenario 2 – all emergent all fish: Less solar radiation and temperature increase would be less. Some discrepancy regarding whether the "Chris Enright hypothesis" about cooling via marsh vegetation applies here in the south Delta. It was noted that the tules do have a lot of surface area and evaporative cooling. **Low "2"**

Certainty for Scenario 2 – all emergent all fish: Minimal "1"

Outcome N7b: Low Dissolved Oxygen (note, because this is a sub-part of Outcome N7, and scores in that outcome were higher [more negative], those scores were retained in the spreadsheet for conservatism)

Clarifying Assumptions:
Vegetation will die back. More nutrients released. Frank's Tract dissolved oxygen problems may not have been measured. Big dissolved oxygen problems are Suisun and Stockton DWSC. Longer residence time. SAV and higher temperatures contribute to a lower dissolved oxygen.

Comparatively Frank's Tract is not a good area to compare to because it has better flows. Snodgrass Slough on the east side is better example.

Magnitude Scenarios 1 and 2 all native: Problem during summer and fall. Salmon are present in April. The modeling shows dissolved oxygen is suitable, but this modeling is constrained and may not apply here. The RWQCB has water quality objectives for dissolved oxygen, if the water quality objective and this scenario reduces the water quality objective, then that is a problem. **Low "2"**

Certainty Scenarios 1 and 2 all native: The low dissolved oxygen is a hypothesis. **Minimal "1".**

Outcome N3F: Increased Microcystis (Not applicable to the aquatic species being evaluated; no score in spreadsheet)

Clarifying Assumptions:
Longer resident time and warmer temps will increase occurrence of Microcystis. Microcystis is present in Aug and Sept. Fish are not present at this time. However, this is a key water quality issue for M&I. See June 2012 M&I / Agricultural Water Quality Evaluation.

Scientific Justification:

Magnitude: N/A to fish but see note above regarding M&I

Certainty: N/A.

Outcome N10: Increased Mercury Methylation

Magnitude for scenario 1: sub-tidal and open water will demethylate mercury via photo-demethylation. The site will be a sink for mercury and that is a positive thing. **Minimal to low "1-2".**

Certainty: **High "4"**

Magnitude for scenario 2 all emergent: Most of the emergent marsh will be low marsh. High marsh would be more of a problem. **Minimal to low "1-2.**

Certainty: For fish, certainty is **High"4".**

(Note, for other species, there is less certainty Minimal "1" and this is not directly applicable to today's evaluation)

Outcome N9: Increased Exposure to Selenium

Clarifying Assumptions:

- Higher residence time. Selenium is bio-accumulated by clams. More opportunities for selenium to get into food chain for those fish that eat clams. The fish have plenty of clams to eat.
- There are selenium clean-ups in progress and so the situation could improve

Magnitude for scenario 1 sub-tidal: Higher concentration within San Joaquin River water (as compared to Sacramento River water) so would have a higher concentration of selenium. Residence time is the mechanism. If the clams have a higher selenium concentration, this is not an issue for salmon. Bio-accumulation of selenium in sturgeon may reduce their reproductive capacity. Daily dose level has been exceeded. Sturgeon are already past the selenium threshold, so the additional 3% more is the proverbial drop in the bucket. Score for most native fish is **Low "2**". However for salmon magnitude is a **Minimal "1".**

Certainty for scenario 1 sub-tidal: Minimal to Low "1-2"

Magnitude for scenario 2 all emergent: Tules no net change in # of clams. However, will be increased residence time in the tidal marsh. Pumping pattern also increases residence time.
Score for most native fish is **Low "2**". However, score for salmon magnitude is **Minimal "1".**

Certainty for scenario 2 all emergent: Minimal to Low "1-2".

OBJECTIVE: RESTORE HABITATS AND RIVER CONDITIONS (I.E., THE MAGNITUDE AND DIRECTION OF FLOW IN FLUVIAL REGIMES) THAT FAVOR SURVIVAL AND GROWTH OF JUVENILE SALMONIDS, STURGEON, DELTA SMELT, LONGFIN SMELT, AND OTHER NATIVE FISHES

Potential Positive Ecological Outcomes

Outcome P16: Increased Channel Complexity (including in-channel and channel margin riparian vegetation, LWD, and emergent vegetation)

Scientific Rationale: Currently the channel is constrained between two levees and it is a low energy environment and fish biologists often recommend more channel complexity. However, if levees are removed natural channel erosion, deposition, migration and related ecological processes will be rehabilitated. Channel complexity will increase over time due to big flow events moving thru with depositional features. Re-vegetation will occur. Flow goes thru Grant Line. Junction is an issue. There is an expanded Paradise Cut. Flows to the Delta would increase with concurrent higher discharge and increased velocity through Paradise Cut.

Bathymetric evolution; there is a balance. Physical habitat needs to be coupled with hydrodynamic flow regime. Rate of natural channel evolution will be slow in Corridor 2B (in-Delta environment, not the San Joaquin River). It will take a long time to develop this into a complex sediment balance. This will be a low velocity area. Physical complexity has to come with the right flows. Slow flows, so slow geomorphic change. Could allow rafting of large woody debris, which would be valuable.

Magnitude on intermediate outcome – physical only: Low "2"

Certainty for physical only: Fairly well understood condition is a **medium "3"**

Magnitude on native fish: Minimal to Low "1-2"

Certainty for all fish "**minimal "1**"

Outcome NX Entrainment (unnumbered outcome; added at end of spreadsheet and not counted in roll up scores because of lack of data)

Clarifying Assumptions:

- Entrainment will increase a lot if there is habitat in Corridors 2A and 2B that ends up adjacent to the pumps.
- Restoration will increase native fish population abundance so overall, a greater number of fish would get entrained. The Evaluation Team recognizes that rate or % of population entrained is a better metric.

Any fish that goes down this channel will get entrained in the pumps if they are operating. If Paradise Weir is not improved (via this restoration), these fish may have stayed in than San Joaquin River. Depends on operations such as amount of pumping in the south Delta and water year type, and the configuration of the Weir and any operable barriers (at Paradise Weir, in the mainstem San Joaquin River, or elsewhere).

Magnitude without Old River corridor: Caveat: Magnitude depends on the operations. This could have a high adverse effect on salmon, but there is not enough information available to make a specific determination. This negative outcome is a **medium to High "3-4"**

Certainty without Old River corridor: Medium "3"

Magnitude Scenario 2 with isolated Old River corridor. Fewer fish will be entrained. May have significant effects on pelagic fish, but we do not have enough data. The entrainment zone may shift to Middle River; but there have been several hypotheses on this. **Minimal - Low "1-2"**

Certainty Scenario 2 with isolated Old River corridor: Modeling runs should be available for this somewhere. **Minimal "1"**

Notes: This may affect water supply or OCAP BO's RPA.

Data Gaps & Key Uncertainties

Data Needs *(indicate specific models, DLO relationships, or other information indicating the need):*

- Multi-dimensional hydrodynamic modeling of Fabian Tract inundation. This plays into water quality, entrainment of food and individuals of certain species, and also influences habitat itself. This is a key driver.

Key Uncertainties and Research Needs *(describe specific research activities that could be employed to increase understanding):*

- Is sub-tidal areas located in the South Delta beneficial for native fish?

- Does it matter exclusively on entrainment and water quality?
- What were the historical ecological functions of the South Delta for smelt? Is it feasible to re-create those processes/habitats within the context of BDCP South Delta restoration?
- A "landscape-scale processes conceptual model" would be helpful in understanding ecosystem dynamics (physical and ecological) that occur across the transition between habitat types (ie the gradation from floodplain to marsh).
- An understanding of habitat conditions and outmigration success for fishes that may rear in an inundated Fabian Tract. Also, the relationship between successful outmigration downstream of Fabian Tract compared to downstream of Corridor 4.

Corridor 4 - Summary

- Assumptions/Changes to Corridor Description made During Evaluation
    - The late-long term condition was analyzed for these evaluations.
    - Fish stranding locations are assumed to be "designed-out" of restoration actions.
    - Sturgeon are assumed to be potential year-round residents of this corridor.
    - Floodplain inundation *was modeled without HORB as the HORB was not a part of the original corridor assumptions*. With HORB, most of the fish move through Corridor 4.

- Summary of Key Outcomes Related to Objectives
    - *Objective: Increase the extent of ecologically-relevant floodplain habitat to support reproduction and viability of Sacramento splittail and Chinook salmon & Steelhead*
        - Positive Outcomes
            - New floodplain areas (that transition into marsh habitat) would be available for inundation that would benefit splittail and salmonids—and all outmigrating fish would go through this corridor if the HORB is in place. Low risk of stranding.
    - *Objective: Increase the spatial extent and connectivity of tidal marsh.*
        - Positive Outcomes
            - New marsh area would be well connected to upstream floodplains, but downstream connection into the Delta links to

poor habitat—Stockton Deep Water Ship Channel (SDWSC; which negating the pumps is worse than downstream of Fabian)

        - Minimal habitat for smelt; some habitat for splittail spawning and salmonid rearing and white sturgeon rearing.
    - Negative Outcomes
        - Water quality (especially DO and temperature) is likely an issue with the downstream SDWSC , but numerical modeling data is lacking
- *Objective: Restore habitats and river conditions (i.e., the magnitude and direction of flow in fluvial regimes) that favor survival and growth of juvenile salmonids, sturgeon, delta smelt, longfin smelt, and other native fishes*
    - Positive Outcomes
        - Channel complexity will increase with the new setback floodplain and an unconstrained, erodible left-bank.
    - Negative Outcomes
        - Risk of invasive species (clams, SAV) similar to other corridors.
- *Objective: Reduce entrainment mortality of juvenile salmonids, smelt, sturgeon, splittail, and other native fishes*
    - While entrainment was conceptually-evaluated and was scored for this corridor, it was not used in the rollups because the other corridors do not have scores for entrainment.

- <u>Key Uncertainties</u>
    - The marsh at the downstream end of the corridor will have longer residence times. Any increase in organic matter loading will contribute more to the problem of already-low levels of DO in the SDWSC, and the proximity of this corridor to the SDWSC is a concern. A potential mitigating effect is greater velocities due to the increase in the tidal prism.
    - A "landscape-scale processes conceptual model" would be helpful in understanding ecosystem dynamics (physical and ecological) that occur across the transition between habitat types (i.e., the gradation from floodplain to marsh).

- <u>Data Gaps</u>
    - Multi-dimensional hydrodynamic modeling (especially as related to water quality) is of particular interest as it is a key driver in many of the important processes and outcomes considered.
    - Examine runoff into Corridor and evaluate potential for water quality impacts

- <u>Potential corridor re-configurations or combinations to increase the worth /decrease the risk of potential implementation.</u>
    - Analyze the effects of potential HORB operation and integrate into future corridor evaluations. There is a need to examine potential negative effects of HORB outside Corridor 4.

Corridor 4 – Detailed Evaluation Notes

Contents

Scientific Evaluation Worksheet & Notes

Corridor 4

Evaluation Team: Facilitator: Bruce DiGennaro

Participants: John Clerici, Ron Melcer, Eric Ginney, Jeremy Thomas, Ray McDowell, John Cain, Steve Cimperman, Sheng Jun Wu, Christine Joab, Deanna Sereno, Mike Hoover, Michelle Orr, Andrea Thorpe, Cathy Marcinkevage, Ted Sommer, Val Connor, Josh Israel
Note-taker: Kateri Harrison

Date: Thursday, February 2, 2012

For this analysis, the group assumed that:

- Corridors 2A and 2B are not going to be restored.
- The Head of Old River Barrier (HORB) is installed and is operational at low flows (<10,000 cfs), year round.
- Active channel margin enhancement occurs in specified locations.
- All outmigrating fish pass by this location, unless they travel down Old River at a flow higher than 10,000 cfs.

Floodplain inundation was modeled without HORB as the HORB was not a part of the original corridor assumptions. The manifestation of this is that the discharge/area of inundation curves in the corridor document are accurate to how this corridor is being evaluated for flows above 10,000 cfs, which is when there is no HORB [i.e. it is not operational above 10,000 cfs]. For flows less than 10,000 cfs, then the curve in the corridor document is not accurate due to lack of HORB in the model (and would tend to underestimate the floodplain inundation in Corridor 4 because that extra flow would be routed down the mainstem of the San Joaquin River, not Old River). With HORB, most of the fish move through this corridor. We assume some improvements to the right (eastern) bank, and that that the left (western) bank will be allowed to naturally evolve once the levees are set back. Currently the channel is trapezoidal in shape through this reach.

OBJECTIVE: INCREASE THE EXTENT OF ECOLOGICALLY-RELEVANT FLOODPLAIN HABITAT TO SUPPORT REPRODUCTION AND VIABILITY OF SACRAMENTO SPLITTAIL AND CHINOOK SALMON & STEELHEAD

Potential Positive Ecological Outcome(s)

Outcome P1: Increased Frequency of Inundation
Scientific Justification: Under existing conditions, Corridor 4 is constrained by levees on both banks. Levee setbacks would provide up to 6,000 acres of habitat. It is anticipated that this will have a sustained population effect for target species. This corridor spans a larger topographic gradient than other corridors, allowing a diversity of habitat types from floodplain at the upstream end to tidal marsh at the downstream end. It was noted that the northern edge of the proposed left bank levee setbacks may not be optimally configured according to one evaluators understanding. The group pondered if there would be incremental improvements to habitat based on the location of the proposed setbacks, and if would there be a landscape level effect. The consensus was: yes. Alternative 1A has a larger footprint; however, Corridor 4 has more potential for tidal marsh habitat restoration. The group was reminded that this outcome is specifically concerned with floodplain habitat. Based on evaluations, 15,500 cfs is the recommended ecologically-relevant flow for salmon, and 11,600 cfs is the recommended ecologically-relevant flow for splittail. For salmon, these flows occur for a minimum duration of 14 days every 4 years, for splittail these flows occur for a minimum duration of 21 days every 4 years. At these flows, there would be 4,000 acres (at flows of 15,500 cfs), and 3,500 acres (at flows of 11,600 cfs) of floodplain, riparian, and tidal marsh habitat. The group was concerned

about the limited temporal effects on fish populations associated with this evaluation. If the hydrology were different then we may see a different (and potentially improved) ecological benefit.

It was also mentioned that the current topography is less than optimal, and that natural channel morphology changes could change the distribution of habitats along the corridor substantially.

Magnitude Physical Only – Intermediate Outcome: Low "2"

Certainty: High "4".

Outcome P2: Increased Spawning Habitat for Splittail

Scientific Justification:
Same as Corridors 1A and 2A: Larger amounts of inundated floodplain, as proposed here, will benefit the species.

Magnitude: Medium "3"

Certainty: Medium "3"

Outcome P3: Increased Rearing Habitat for Salmon

Scientific Justification:
The group thinks the magnitude of benefit in terms of rearing habitat for salmon will be greater than that for Corridor 2A because there will be a greater frequency of inundation (due to lower topography and more accessible floodplain areas).

Magnitude: Medium "3"

Certainty: Medium "3"

Potential <u>Negative</u> Ecological Outcome(s)

Outcome N1: Increased Stranding
Scientific Justification: Stranding not an issue in tidal marsh habitats; however in floodplain habitats this can be an issue that was assumed to be mitigated through design. **Magnitude: Low "2"** **Certainty: High "4"**

OBJECTIVE: INCREASE THE SPATIAL EXTENT AND CONNECTIVITY OF TIDAL MARSH HABITAT

Potential Positive Ecological Outcome(s)

Outcome Px: Increase the spatial extent and connectivity of tidal marsh habitat (Note – evaluators scored the objective as an outcome.)

Magnitude (intermediate outcome – physical only): Acreages are similar to 2B. **Medium "3".**

Certainty: Changes to the tidal range could reduce the extent of the marsh habitat. This could be mitigated through design. **Low "2".**

Outcome P6: Increased Spawning Habitat for Splittail

Scientific Justification:
Splittail will spawn in marsh habitats. The frequency is not as important. Tidal marsh is not as desirable habitat as compared to floodplain, but floodplains exist in Corridor 4.

Magnitude for the tidal marsh portion: Low "2"

Certainty for the tidal marsh: Low "2"

Outcome P7: Increased Rearing Habitat for Salmonids

Scientific Justification:
This habitat will be available every year, with high probability that at least 50% of the SJR salmon travel through this corridor and could potentially utilize this habitat. In the past, this area was a bottle neck for salmon. The restoration will be a big improvement.

Magnitude for tidal marsh portion: Medium "3".

Certainty: Low "2".

Outcome P10: Increased spawning habitat for Longfin smelt

Clarifying Assumptions:
See 2009 DRERIP

Scientific Justification:
Similar to 2009 DRERIP but with lower magnitude and certainty. The South Delta could have significant negative outcomes for delta and longfin smelt depending on the actual configuration of flood and ecosystem restoration actions.
Magnitude: Minimal "1"

Certainty: Low "2"

Outcome P12: Increased rearing habitat for White Sturgeon

Clarifying Assumptions:

- Sturgeon could be resident year-round.

Scientific Justification:
Downstream connectivity is a concern. Sturgeon are here in this corridor year-round. If water quality conditions were appropriate and if they were outside the zone of entrainment, then they might benefit. Overall this is a small contribution of tidal marsh to the total quantity of marsh habitat in the Delta. Juvenile and sub-adult sturgeon will rear here. Corridor 4 has tidal exchange.

Magnitude: Low "2"

Certainty: Low "2"

Potential Negative Ecological Outcome(s)

Outcome N7: Increased Mortality Due to Water Quality Degradation (including water temperature, DO, eutrophication)

Scientific Justification:
With the HORB in place, there will be shorter residence time in the channels and floodplains and this should yield fewer water quality impacts. The marsh at the downstream end of the corridor will have longer residence times. There are low levels of DO in the Stockton DWSC and any increase in organic matter loading will be contributing to this problem. The proximity of this corridor to the Stockton DWSC is a concern.

RWQCB would like to see some modeling about the potential impacts for this water quality concern. A mitigating impact is greater velocities due to the increase in the tidal prism. As you progress past the WWTP the channel gets deeper. Dissolved oxygen problems are dependent on flow. Stockton upgraded their WWTP in 2006 and their nutrient loading has declined; however dissolved oxygen problem still remains June to October.

Magnitude: Medium "3"

Certainty: Evaluators are unable to understand the timing or magnitude of the temperature changes because the screening-level modeling does not provide for that type of data. Spring season is the time we are most concerned about for some species. **Minimal "1".**
Recommendations for future study: Analyze the effects of the HORB and integrate into the corridor evaluations. Need to look at potential negative effects of HORB outside corridor 4.

Outcome N8: Increased Microcystis

Clarifying Assumptions:

- Longer resident time and warmer temperatures will increase occurrence of Microcystis. Microcystis is present in August and Sept. Fish are not present at this time. However, this is a key water quality issue for M&I.

- Restoration will slow down water and heat up water temperatures. This might affect timing of microcystis bloom and etc. Microcystis occurs in turning basin and part of the Stockton ship channel. Tidal marsh could worsen the microcystis situation.

Scientific Justification:

Magnitude: N/A to fish but see above re: M&I. Microcystis does occur near Stockton DWSC. **Not scored by group.**

Certainty: Not scored by group.

Outcome N9: Increased Exposure to Selenium

Clarifying Assumptions:

- Higher residence times of water in critical habitats can lead to selenium exposure.
- Selenium is bio-accumulated by clams.
- More opportunities for selenium to get into food chain from those fish that eat clams.

Scientific Justification:

Higher concentrations of San Joaquin River water (as compared to Sacramento River water) would lead to higher concentrations of selenium. Residence time is the mechanism. If the clams have a higher selenium concentration, this is not an issue for salmon. However, bioaccumulation in sturgeon will reduce reproductive capacity. Sturgeon have already past the selenium threshold.

For Corridor 4, delivering selenium to the Bay Area is a concern, so allowing bioaccumulation may prevent distribution downstream. This might be a "sink" for selenium.

Magnitude: For most fish **Low "2**". However for **salmon** magnitude is a **Minimal "1".**

Certainty: Minimal to Low "1-2".

Outcome N10: Increased Mercury Methylation

Scientific Justification:

Sub-tidal and open water will facilitate photo-demethylation. High marsh would be more of a problem.

Magnitude: Minimal to Low "1".

Certainty: For fish, certainty is **High "4".**

Note, for other species, certainty would be Minimal "1"; however this is not directly applicable to today's evaluation.

Outcome N11: Increased Mobilization or Re-suspension of Toxics (including pesticides)

Clarifying Assumptions:

- Increased residence time creates higher probabilities for re-suspension.
- Corridor is likely a sink for toxics.

Scientific Justification:
Corridor #4 is adjacent to urbanized areas. There is runoff from urban neighborhoods as well as I-5.

Note: Stockton has raw sewage overflow into Mosher Slough, and Stockton DWSC. The northern part of this corridor might experience this issue, but that is speculation; nothing definitive. In general, urban land-use is something to be aware of. Fish kills along dead end sloughs in Stockton might be related to sewage spills. BDCP-related restoration will not change those sorts of issues. There is high population density along the eastern bank. Will these urban uses impact the fish?

Recommendation: In future planning, examine runoff into Corridor 4 and evaluate potential for water quality impacts

Magnitude: Not scored by group.

Certainty: Not scored by group.

OBJECTIVE: RESTORE HABITATS AND RIVER CONDITIONS (I.E., THE MAGNITUDE AND DIRECTION OF FLOW IN FLUVIAL REGIMES) THAT FAVOR SURVIVAL AND GROWTH OF JUVENILE SALMONIDS, STURGEON, DELTA SMELT, LONGFIN SMELT, AND OTHER NATIVE FISHES

Potential Positive Ecological Outcomes

Outcome P16: Increased Channel Complexity (including in-channel and channel margin riparian vegetation, LWD, and emergent vegetation)
Clarifying Assumptions: Compare assumptions stated for Corridor 1A to Corridor 4
Scientific Justification: The right bank protects the adjacent urbanized area. Because of the location of Corridor 4, it is more constrained than Corridor 1A. However, the channel is fairly wide. **Magnitude:** Score is **Medium "3"** **Certainty:** Score is **Medium "3"**

Potential Negative Ecological Outcome(s)

Outcome N12: Establishment of Invasive Species (SAV, Clams, invasive competitors)
Scientific Justification: See 2009 DRERIP **Clam - Magnitude all fish species:** Compared to other sites, Corridor 4 will have more scour. The habitat in this region is generally in very poor condition. **Minimal "1".** **SAV Magnitude all fish species**: **Low "2".** **SAV & Clams Certainty:** We have high certainty that clams and SAV will invade and low certainty that this will impact the fish species. **Low "2".**

OBJECTIVE: REDUCE ENTRAINMENT MORTALITY OF JUVENILE SALMONIDS, SMELT, STURGEON, SPLITTAIL, AND OTHER NATIVE FISHES

Potential Negative Ecological Outcome(s)

Outcome Nx: Entrainment

(Note: entrainment was not scored for any of the other corridors because of a lack of data. While entrainment was conceptually-evaluated and was scored for this corridor, it was not used in the rollups because the other corridors do not have scores for entrainment.)

Clarifying Assumptions:

- For this particular habitat, it is assumed that HORB will be installed. HORB might prevent entrainment?
- During wet years, there will be pumping from the north Delta facilities.
  If the barrier at head of Old River (HORB) is operational year-round, this is different than Scenario 6. Scenario 6 assumed that 50% leaky between June to October. Unintended consequences for smelt?

Scientific Justification:
HORB in place, so San Joaquin River salmon are OK, but other fish may suffer. More modeling is needed to look at the entrainment issue.

Magnitude for corridor 4: **Minimal to Low "1-2".**

Certainty for corridor 4: It's been analyzed a lot, **Low "2".**

DATA GAPS & KEY UNCERTAINTIES

Data Needs:

- M&I water quality impacts from restoration

Key Uncertainties and Research Needs:

- Examine runoff into Corridor and evaluate potential for water quality impacts
- Analyze the effects of the HORB and integrate into the corridor evaluations. Need to look at potential negative effects of HORB outside corridor 4.
- The marsh at the downstream end of the corridor will have longer residence times. There are low levels of DO in the Stockton DWSC and any increase in organic matter loading will be contributing to this problem. The proximity of this corridor to the Stockton DWSC is a concern. RWQCB would like to see some modeling about the potential impacts for this water quality concern. A mitigating effect is greater velocities due to the increase in the tidal prism.
- The South Delta could have significant negative outcomes for delta and longfin smelt depending on the actual configuration of flood and ecosystem restoration actions.

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BAY DELTA CONSERVATION PLAN

South Delta Habitat Working Group

Meeting 5
Lathrop City Hall, Lathrop CA
February 17, 2012

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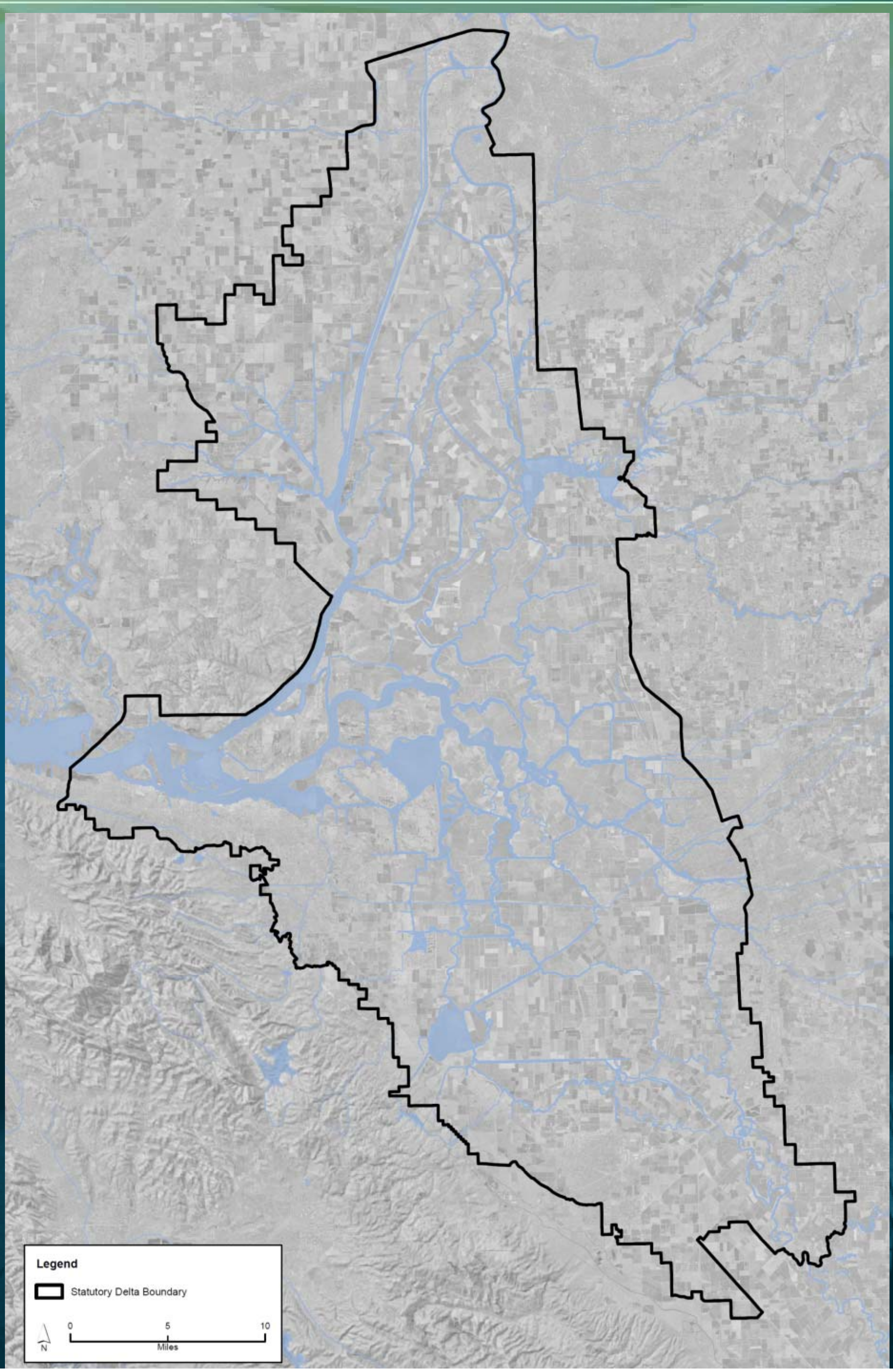
Agenda

1. Review of Working Group purpose and progress to date
2. Overview of the “Corridors Document”:
   a) Screening-level technical analyses
   b) Key “intermediate outcomes”
3. Preliminary findings for Flood & Ecosystem:
   a) Corridors suggestive of additional examination
   b) Identified Issues & Key Understandings
4. Next Steps

BDCP
Bay Delta Conservation Plan

The Delta



BDCP
Bay Delta Conservation Plan

Goal of the South Delta Habitat Working Group

"To identify opportunities where actions in the South Delta are compatible for achieving both ecosystem and flood management improvements"

South Delta Habitat Working Group Process

BDCP
Bay Delta Conservation Plan

- 5 Working Group meetings to date
- Discussion topics:
  - Historic South Delta Environment
  - Existing conditions
  - Opportunities for habitat restoration through flood mitigation
    - Levee setbacks
    - Bypass expansion
  - Rationale for restoration activities and their connection to the BDCP
- Development of Working Group "Corridor Objectives"
- Identification of corridors for further screening
- Screening-level evaluation of corridors

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Who Has Participated?

- Over 100 individuals representing:
  - Delta landowners
  - Local and regional governments
  - Reclamation districts
  - Recreation interests
  - State and Federal resource agencies
  - Environmental concerns
  - State and federal water contractors

What we have learned

- Flood management is of paramount importance
- Opportunities for integrated flood management and habitat improvement exist
- Water quality is important
- Sense of place is critical to the identity of the South Delta
  - Agriculture
  - Recreation
  - Community

and should inform any restoration/flood management activities.

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Flood and Restoration Actions that can be Integrated

- Levee Modifications
  - Height increase
  - Setbacks
- Flood Bypasses / Easements
- Dredging
- Floodproofing

- Habitat Restoration
  - Floodplain habitat
  - Tidal marsh habitat
  - Riparian habitat
  - Channel margin habitat
- Modified Operations
  - Fish passage barriers
  - Flows

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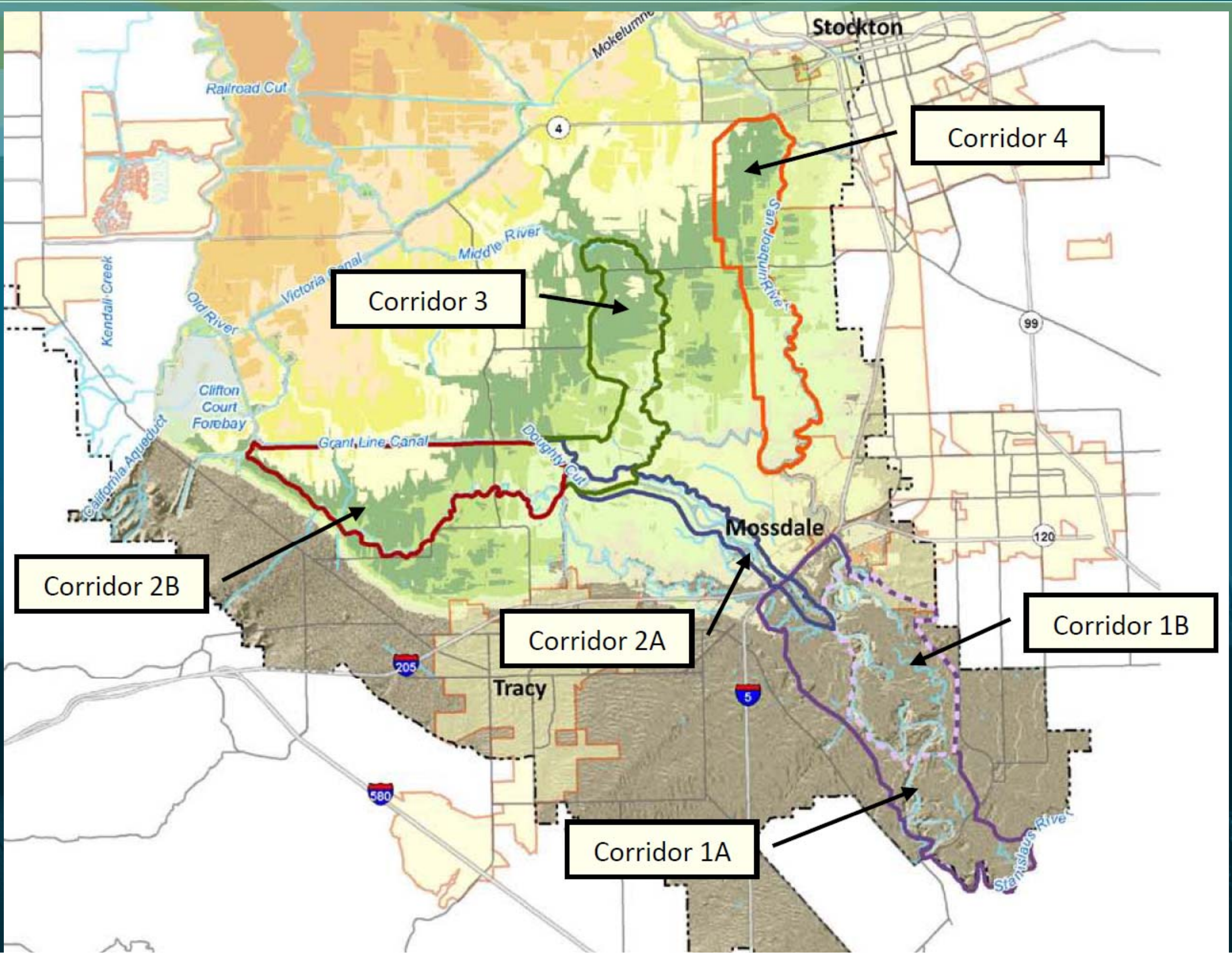
SOUTH DELTA CORRIDORS



BDCP
Bay Delta Conservation Plan

Overview of Corridors Document

- Background on Working Group planning process
- Description of Corridors
- Existing Conditions information:
  - Physical Setting
  - Human Infrastructure (by corridor footprint)
  - Levees & Flood Conveyance
  - Habitats
  - Geomorphology
  - Water Quality
- Screening-level technical analysis results
- Background information on evaluation process

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Screening-level technical analyses

- Hydraulic Model (Corps' software)
  - **Flood outcomes**: water surface elevations; (unsteady flow routing: attenuation; differing flow distributions)
  - Floodplain inundation (area in relation to discharge)
- Hydrologic Model (Corps' software)
  - Identified the flows that create floodplain inundation to benefit:
    - Salmon & splittail
    - Food production (for floodplain areas, not marsh)
- Elevation Relationships (LiDAR data)
  - Tidal marsh extent
- Estimation of Riparian and Agriculture
  - Based on general assumptions

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Estimated Habitat Areas

Corridor	Existing Conditions	Corridor-Conditions									
				Assumed Corridor Land Cover/Habitats							
	Existing Footprint *(Total Existing Area between Levees; river excluded)*	**New Corridor Footprint** *(Additional Area between Levees above Existing; river excluded)*	**Corridor Footprint** *(Total Area between Levees; river excluded)*	**Tidal Wetlands** *(includes SLR accommodation, tidal marsh and shallow subtidal)*		**Riparian Forest**		**Flood-Tolerant Agriculture**		**Length of Channel Margin Habitat Created** *(miles; RB vs LB defined; add active and passive for corridor totals)*	
	acres	acres	acres	acres	percent of new corridor footprint	acres	percent of new corridor footprint	acres	percent of new corridor footprint	Passive	Active
1A	2,524	9,217	11,741	-	0%	8,219	70%	3,522	30%	16 on RB & 16 on LB (32 total both banks)	-
1B	1,593	3,787	5,380	-	0%	3,228	60%	2,152	40%	8.5 (RB only)	-
2A	1,189	1,100	2,289	-	0%	1,145	50%	1,145	50%	0.0	-
Fabian Tract	484	6,487	6,971	6,710	96%	235	3%	26	0%	11.5 (one bank; multpl. chls.)	-
2B	1,673	7,587	9,260	6,710	72%	2,295	25%	255	3%	11.5 (one bank; multpl. chls.)	-
3	706	4,468	5,174	3,530	68%	1,480	29%	164	3%	11 on LB	11 on RB
4	252	5,629	5,881	3,820	65%	2,061	35%	-	0%	12 on LB	12 on RB

Note: Because Corridor 2B is comprised of both Fabian Tract and Paradise Cut, areas for Fabian Tract are shown for clarity.

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Estimated Habitat Areas

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Inundated Habitat Criteria

Key Organism	Life Stage	Season	Minimum Duration	Frequency	Ecologically-Relevant Flow (cfs)	Sources
Sacramento Splittail (*Pogonichthys macrolepidotus*)	Spawning and rearing	Feb. 1 – May 31	21 days	At least once every 4 years	11,600	Sommer et al., 1997; ACOE, 2002; Williams et al., 2009
Chinook salmon (*Oncorhynchus tshawytscha*)	Rearing	Dec. 1 – May 31	14 days	At least once every 4 years	15,550	Sommer et al., 2001a; ACOE, 2002

Estimated Floodplain Inundation Areas

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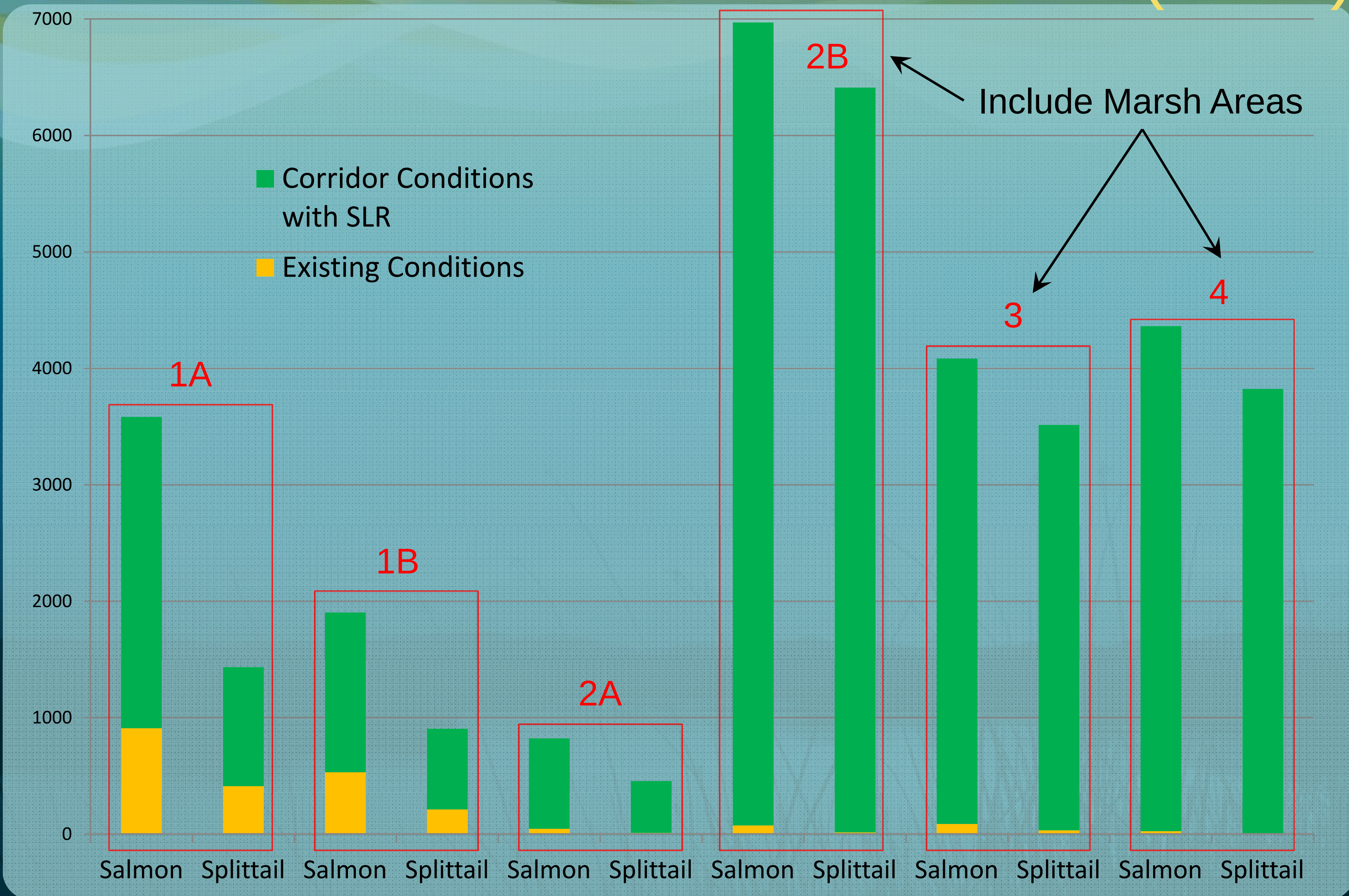
Corridor	Existing Conditions			Corridor Conditions - with Sea Level Rise, existing flow regime				
	Existing Corridor Footprint *(Total Existing Area between Levees; river excluded)*	**Inundated Floodplain Habitat** *assuming Salmon Threshold, 15,500 cfs*	**Inundated Floodplain Habitat** *assuming Splittail Threshold, 11,600 cfs*	**New Corridor Footprint** *(Total Area between Levees; river excluded)*	**Inundated Floodplain Habitat** *assuming Salmon Threshold, 15,500 cfs*		**Inundated Floodplain Habitat** *assuming Splittail Threshold, 11,600 cfs*	
	acres	acres	acres	acres	acres	Percent of new corridor footprint	acres	Percent of new corridor footprint
1A	2,524	910	412	11,741	2,673	23%	1,023	9%
1B	1,593	532	213	5,380	1,372	26%	692	13%
2A	1,189	46	11	2,289	777	34%	445	19%
Fabian Tract	484	29	5	6,710	6,118	91%	5,950	89%
2B	1,673	75	16	8,999	6,895	77%	6,395	71%
3	706	88	33	5,174	3,996	77%	3,481	67%
4	252	26	8	5,881	4,337	74%	3,816	65%

Increase in Ecologically-Relevant Inundation (acres)



South Delta Corridor Evaluations

Ecosystem Team	
Bruce DiGennaro (Facilitator)	ESSEX
Eric Ginney (Coach)	ESA PWA
Jeremy Thomas	NewFields
Michelle Orr	ESA PWA
Ted Sommer	DWR
Cathy Marcinkevage	NOAA Fisheries
Josh Israel	USBR
Christine Joab	RWQCB
Will Stringfellow	UOP
Mike Hoover	USFWS
John Cain	AR
Ron Melcer	DWR
Shengjun Wu	DWR
Deanna Sereno	CCWD

Flood Team	
Betty Andrews (Coach)	ESA PWA
Mark Tompkins	NewFields
Michael Mierzwa	DWR
Scott Woodland	DWR
Joe Bartlett	DWR
Ron Melcer	DWR
Bob Scarborough	DWR
Steve Cimperman	DWR
Samson Haile-Selassie	DWR
Ray McDowell	DWR
Chris Neudeck	KSN Eng.
Mike Archer	MBK Eng.

FLOOD EVALUATION OVERVIEW

- Six hydraulic model runs evaluated
- Each model included one or more “corridors”
- Run results used to assess expected outcomes
- Both positive and negative outcomes evaluated
- Outcomes assessed relative to Working Group flood objectives (focus on urban / urbanizing areas)

Flood Model Runs

Model Run	Corridors					
	1A	1B	2A	2B	3	4
A	X					
B						X
C	X		X			
D	X					X
E		X	X	X		
F			X		X	

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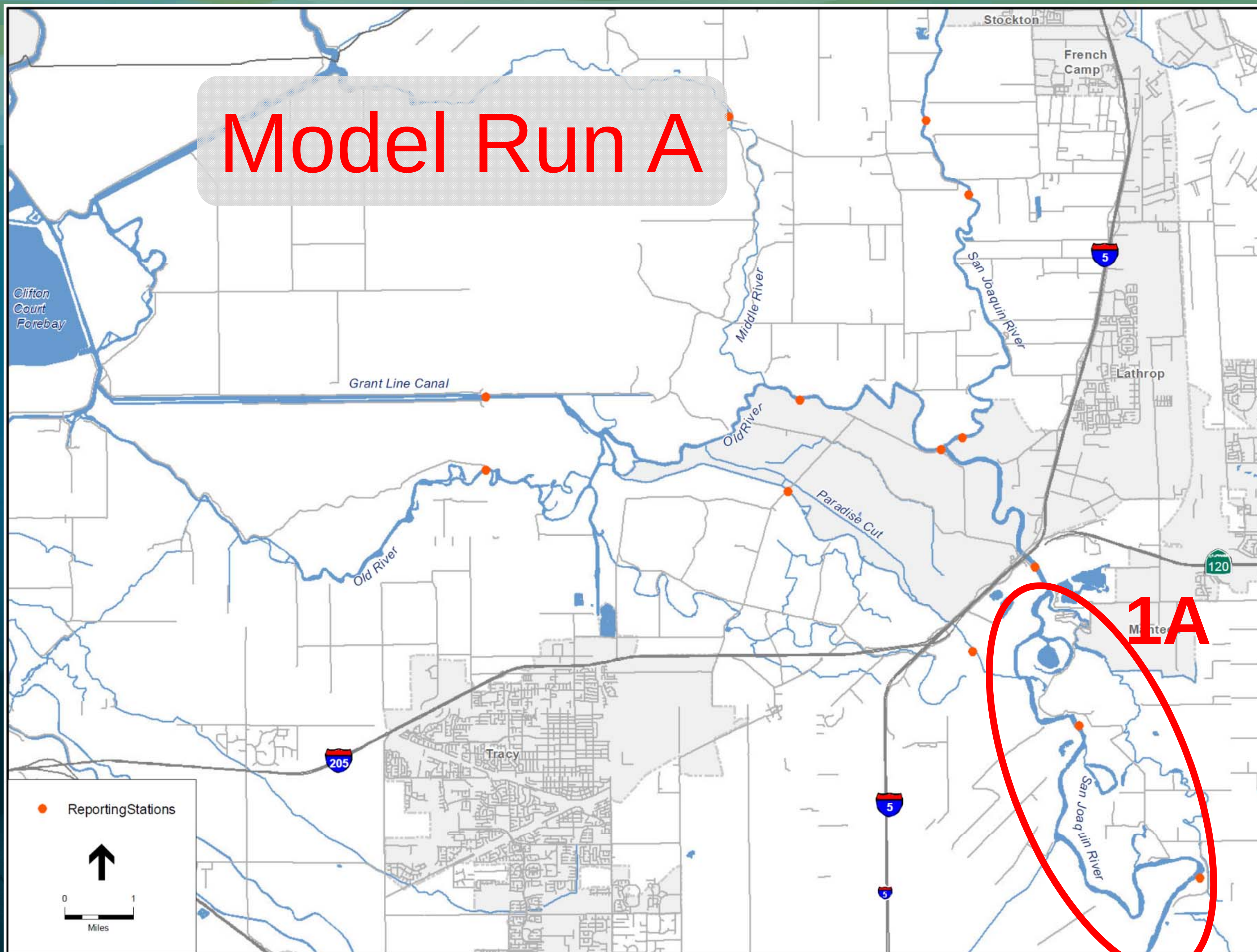
FLOOD MODEL RUNS



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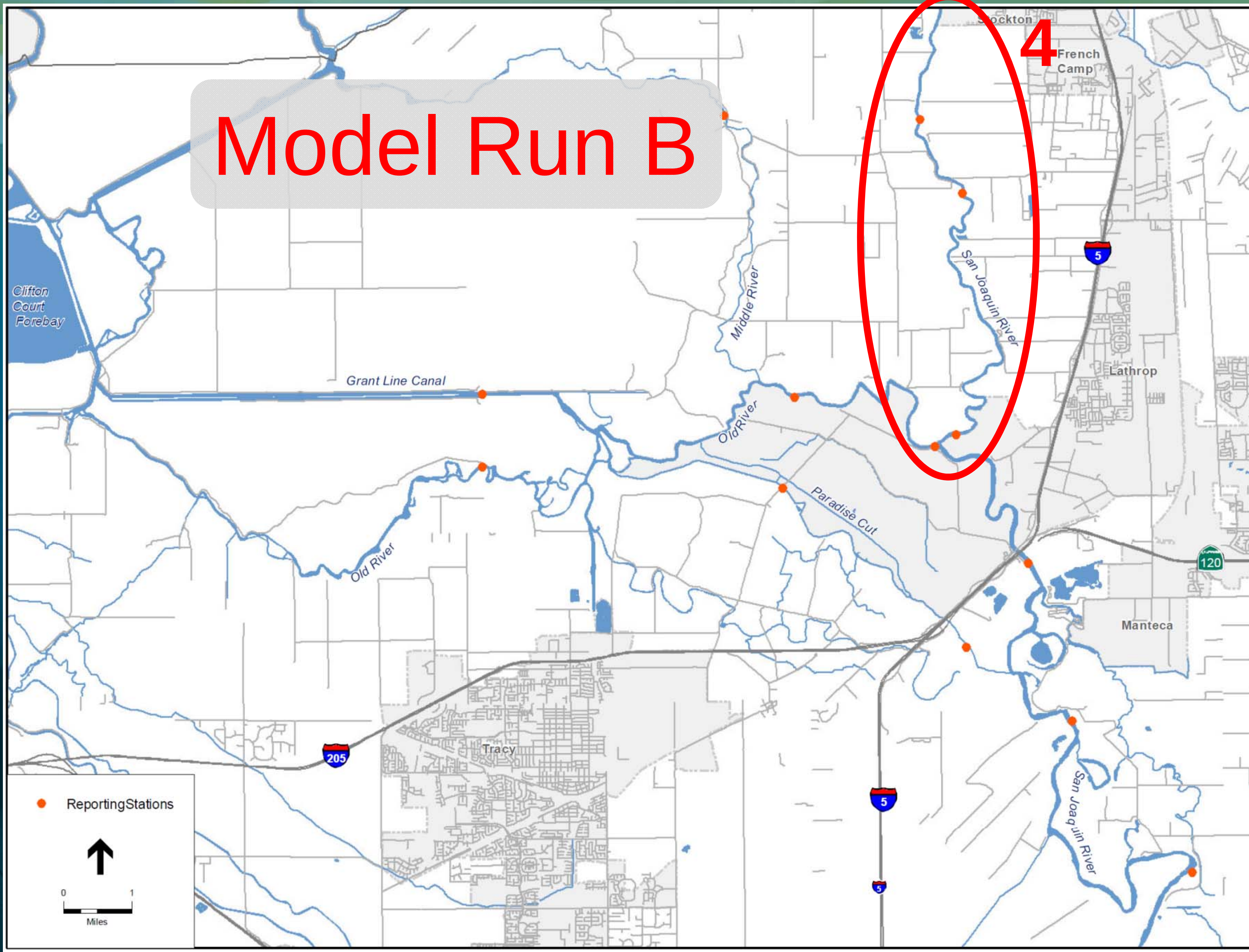
FLOOD MODEL RUNS



FLOOD MODEL RUNS

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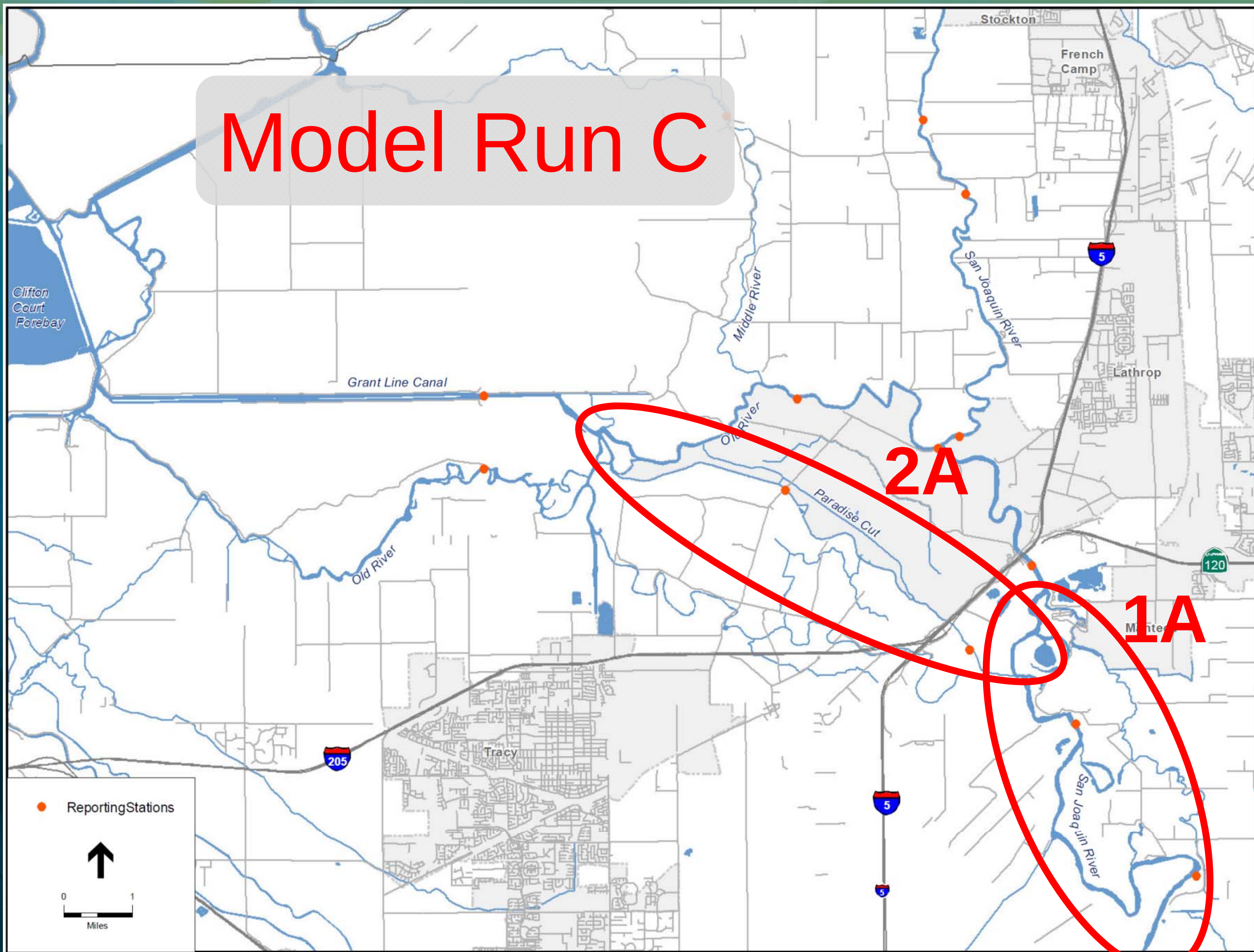

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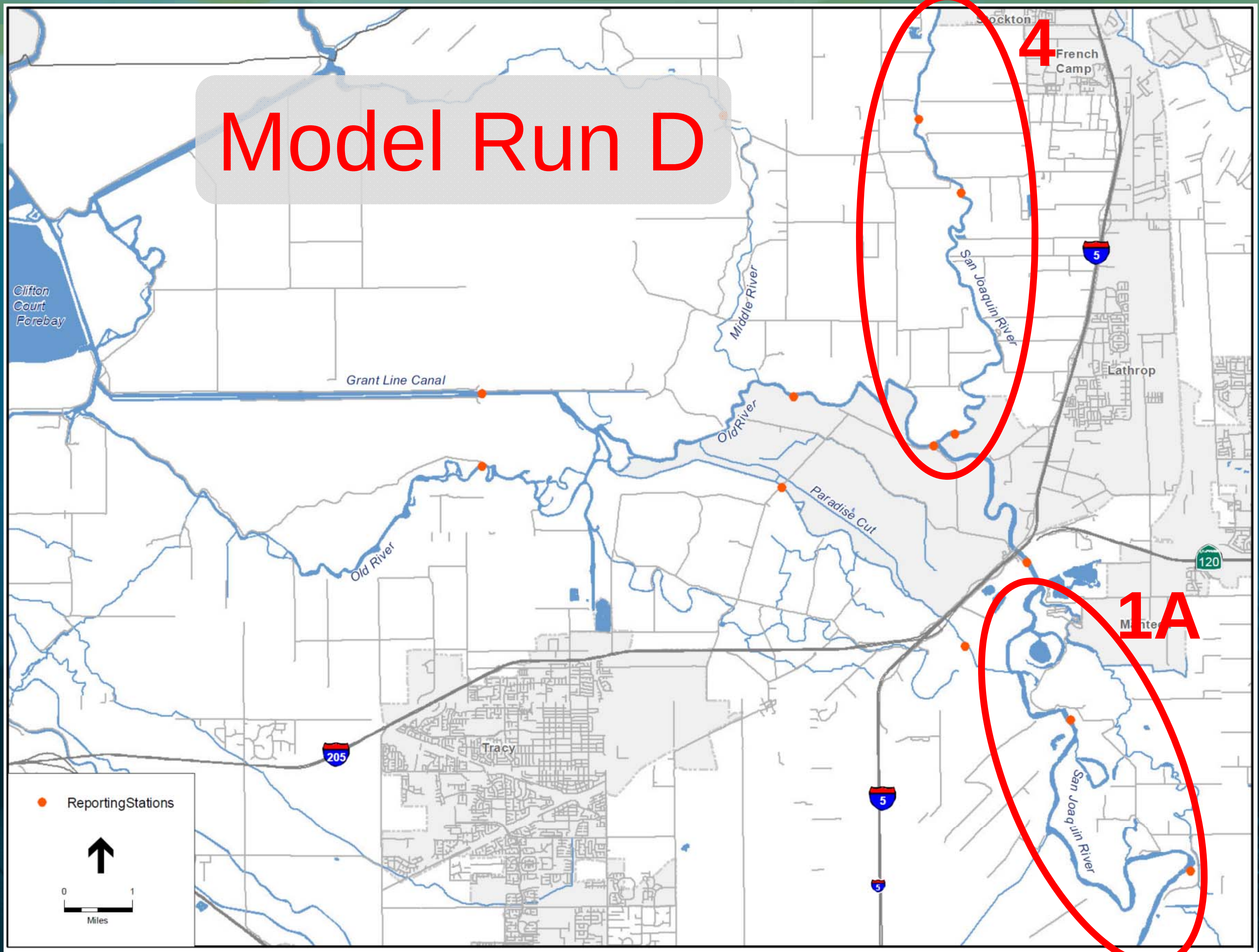
FLOOD MODEL RUNS



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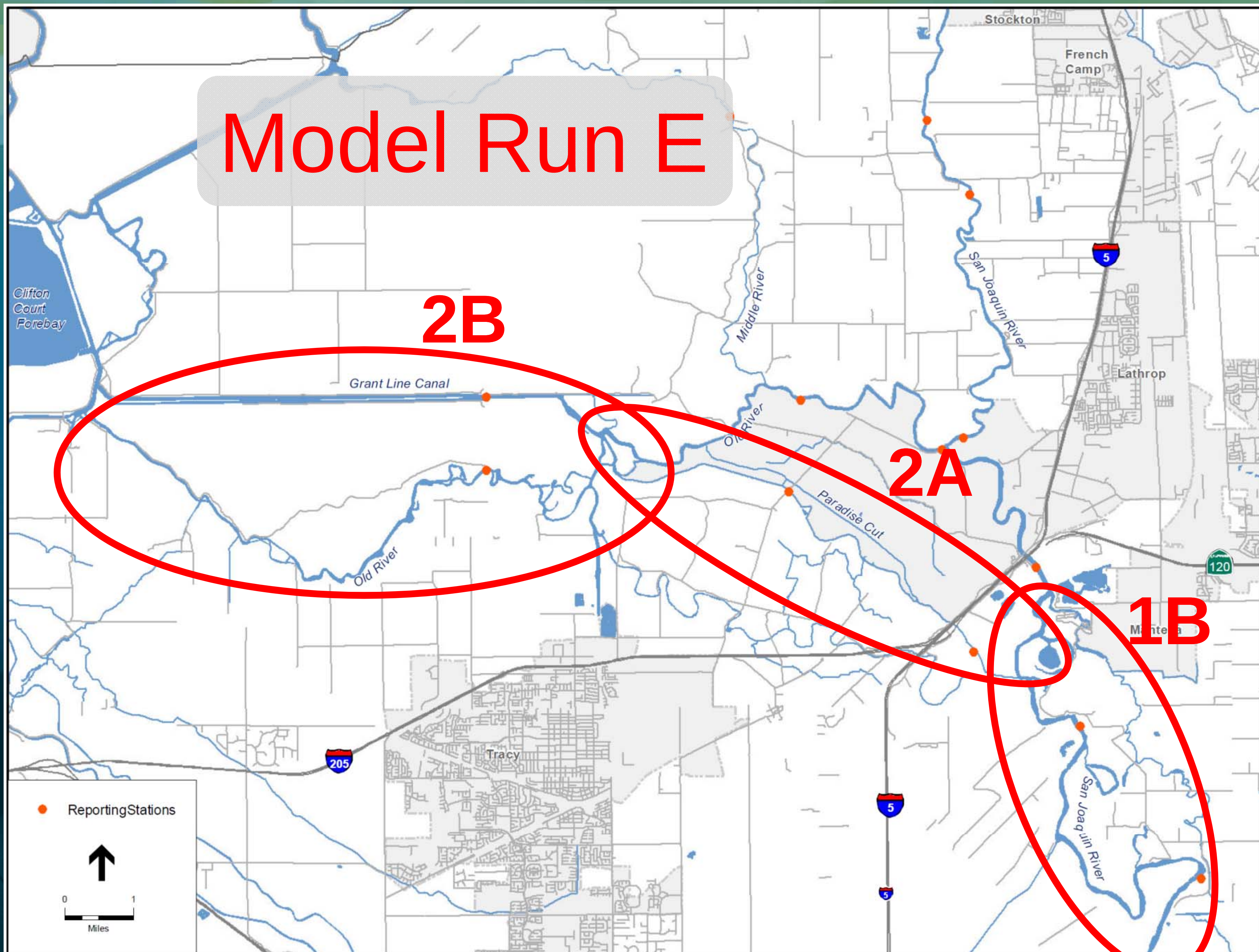

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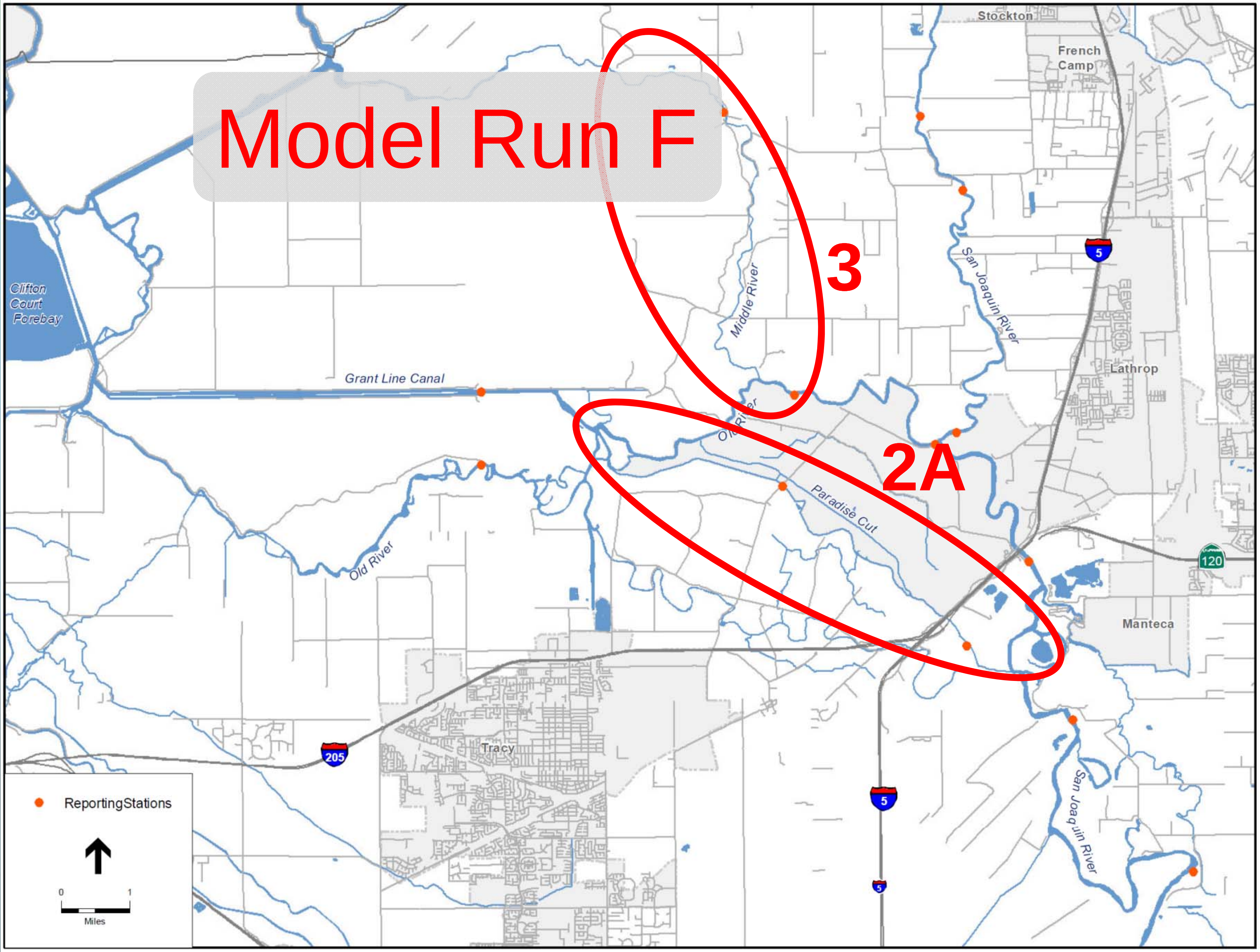
FLOOD MODEL RUNS



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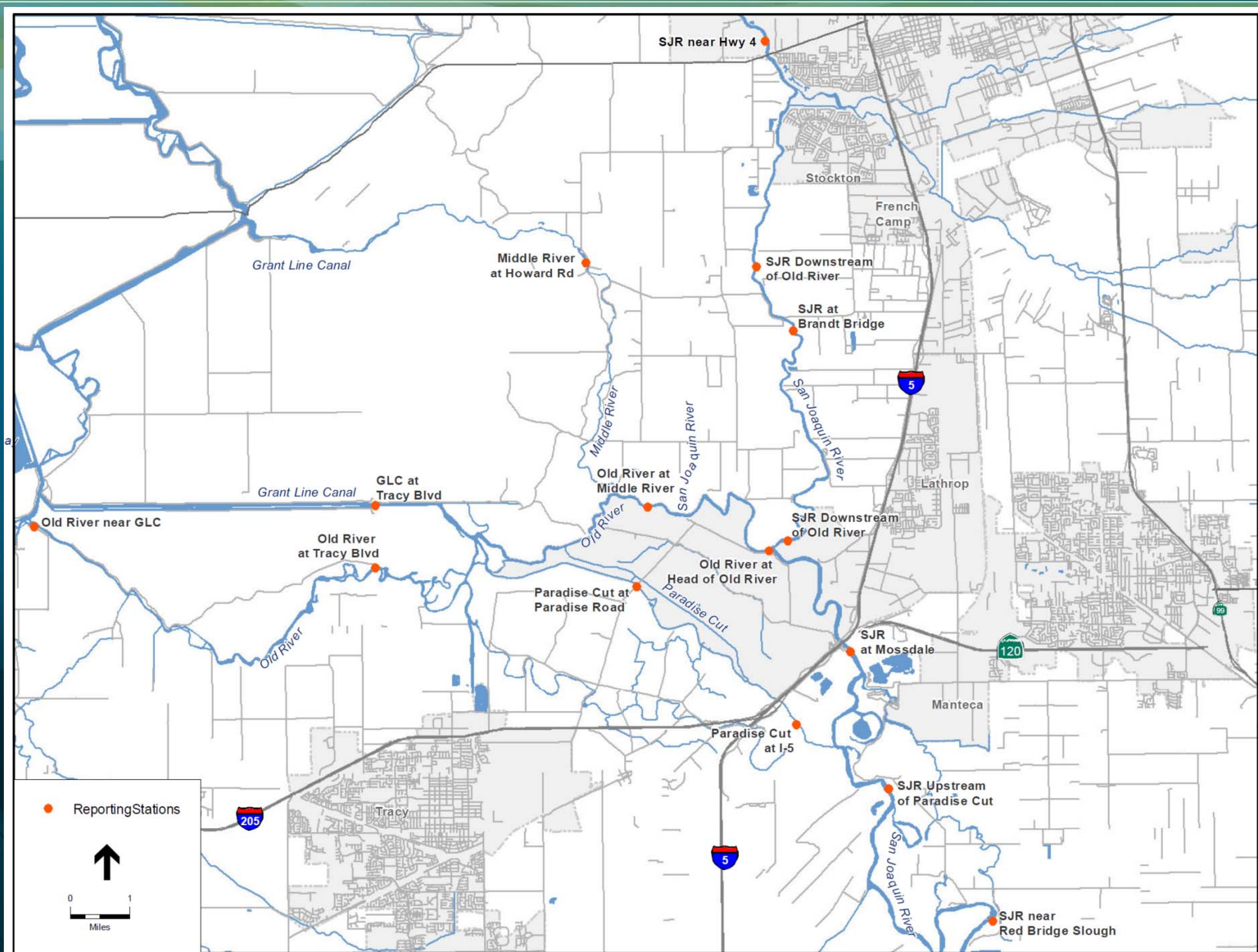
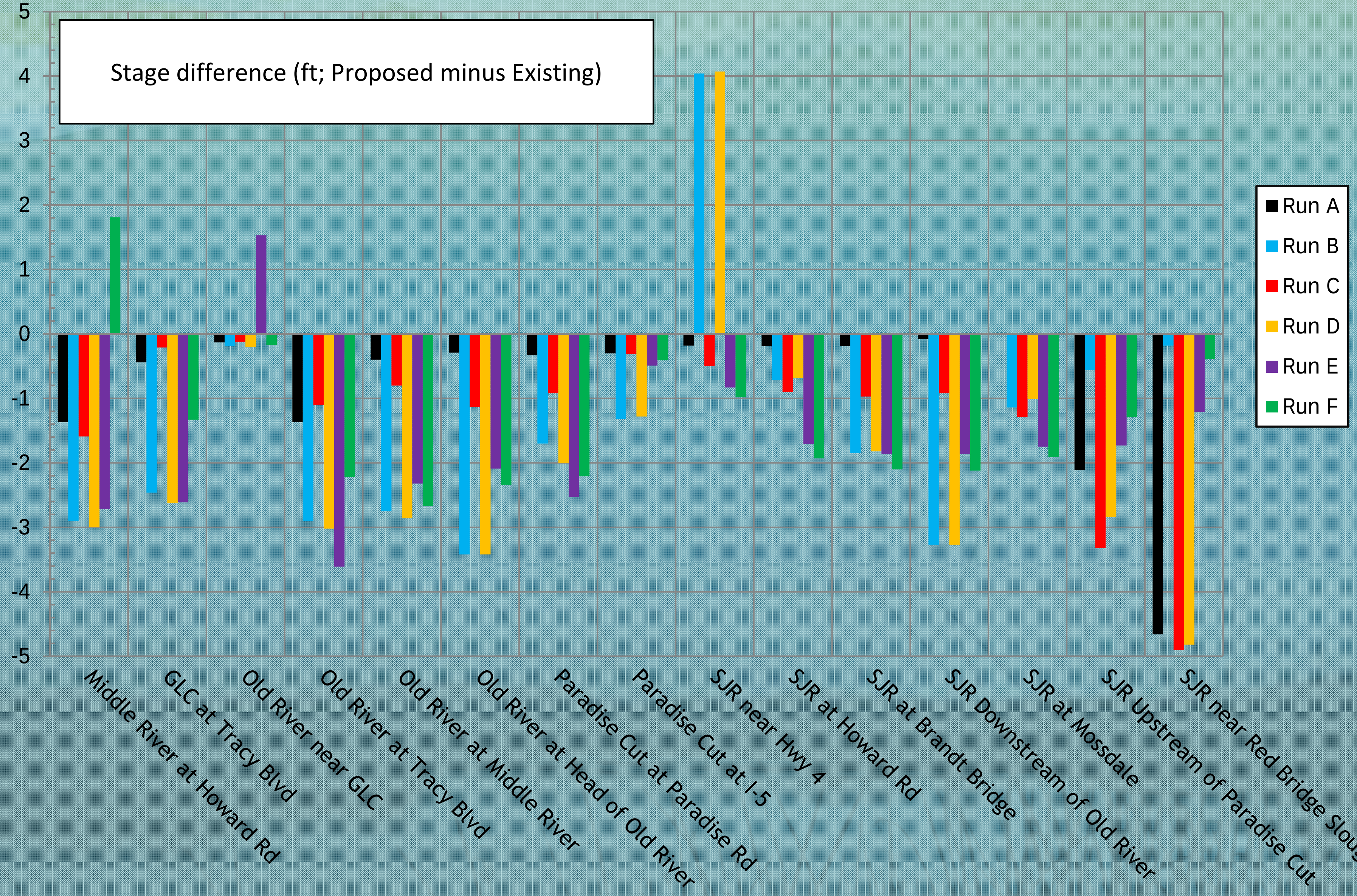
FLOOD REPORTING LOCATIONS



MODELING RESULTS OVERVIEW



EVALUATION RESULTS FROM WORKSHOP

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Outcomes for South Delta Corridors Flood Evaluations		Scale	SCORING without SLR			
Standard Outcome Code	Outcome (brief descriptor)	(0, L,M,S)	Magnitude	Certainty	Worth	Risk
	Run A					
P1F	reduce stage in flood objective locations	0	1	4	M	
N1F	Increased stage	S	1	3		M
	Run B					
P1F	Decreased stage	L	4	4	H	
N1F	Increased stage	S	4	3		H
	Run C					
P1F	Decreased stage	L	2	4	H	
	Run D					
P1F	Decreased stage	L	4	4	H	
N1F	Increased stage	S	4	3		H
	Run E					
P1F	Decreased stage	L	3	4	H	
N1F	Increased stage	0	2	3		M
	Run F					
P1F	Decreased stage	L	3	4	H	
N1F	Increased stage	0	3	2		M

TWO MODEL RUNS SHOWED HIGH WORTH; LOWER OR NO NEGATIVE STAGE OUTCOMES:

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Outcomes for South Delta Corridors Flood Evaluations		Scale	SCORING without SLR			
Standard Outcome Code	Outcome (brief descriptor)	(0, L,M,S)	Magnitude	Certainty	Worth	Risk
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P1F	reduce stage in flood objective locations	0	1	4	M	
N1F	Increased stage	S	1	3		M
	Run B					
P1F	Decreased stage	L	4	4	H	
N1F	Increased stage	S	4	3		H
	Run C					
P1F	Decreased stage	L	2	4	H	
	Run D					
P1F	Decreased stage	L	4	4	H	
N1F	Increased stage	S	4	3		H
	Run E					
P1F	Decreased stage	L	3	4	H	
N1F	Increased stage	0	2	3		M
	Run F					
P1F	Decreased stage	L	3	4	H	
N1F	Increased stage	0	3	2		M

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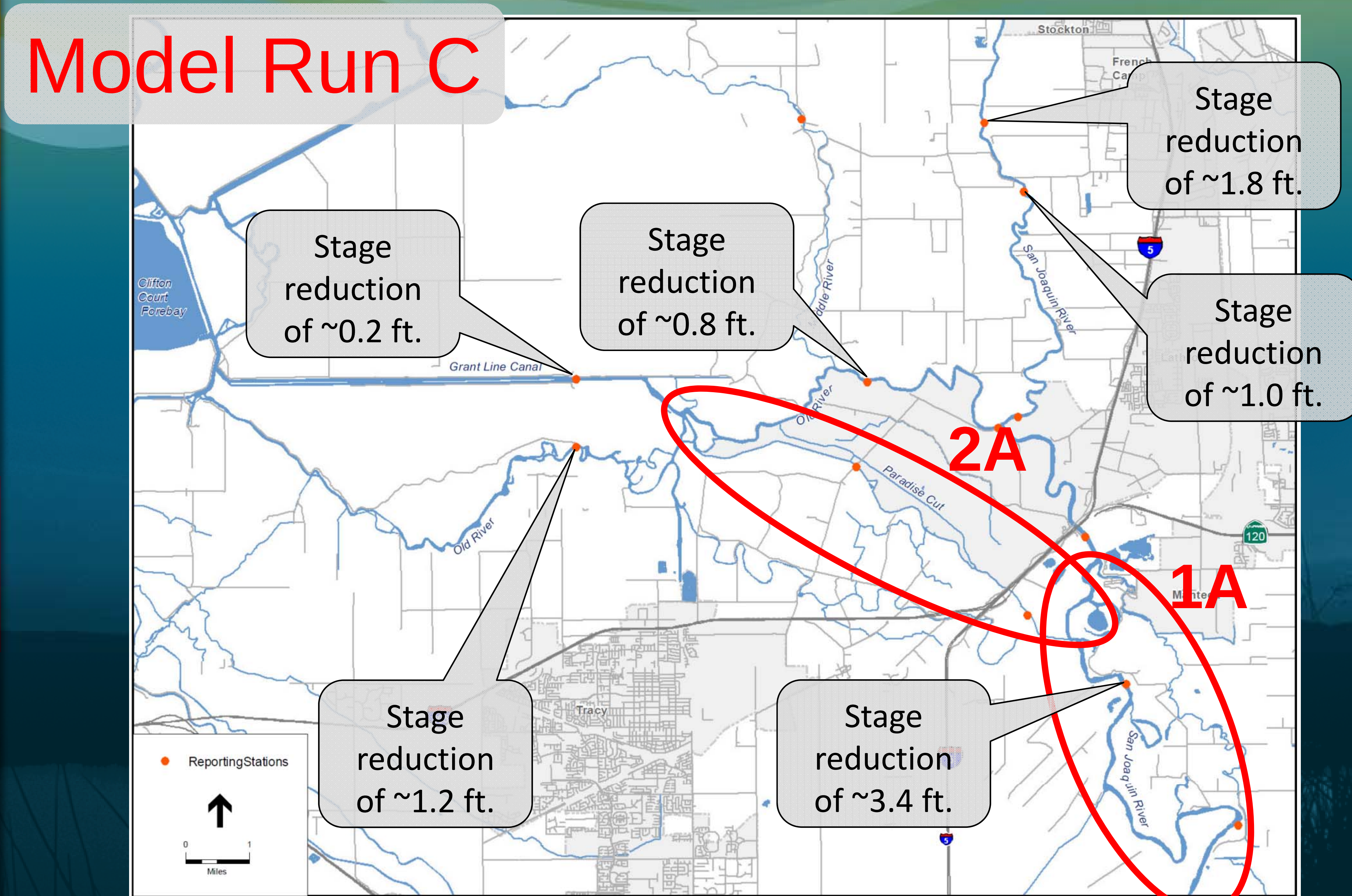
FLOOD EVALUATION RESULTS



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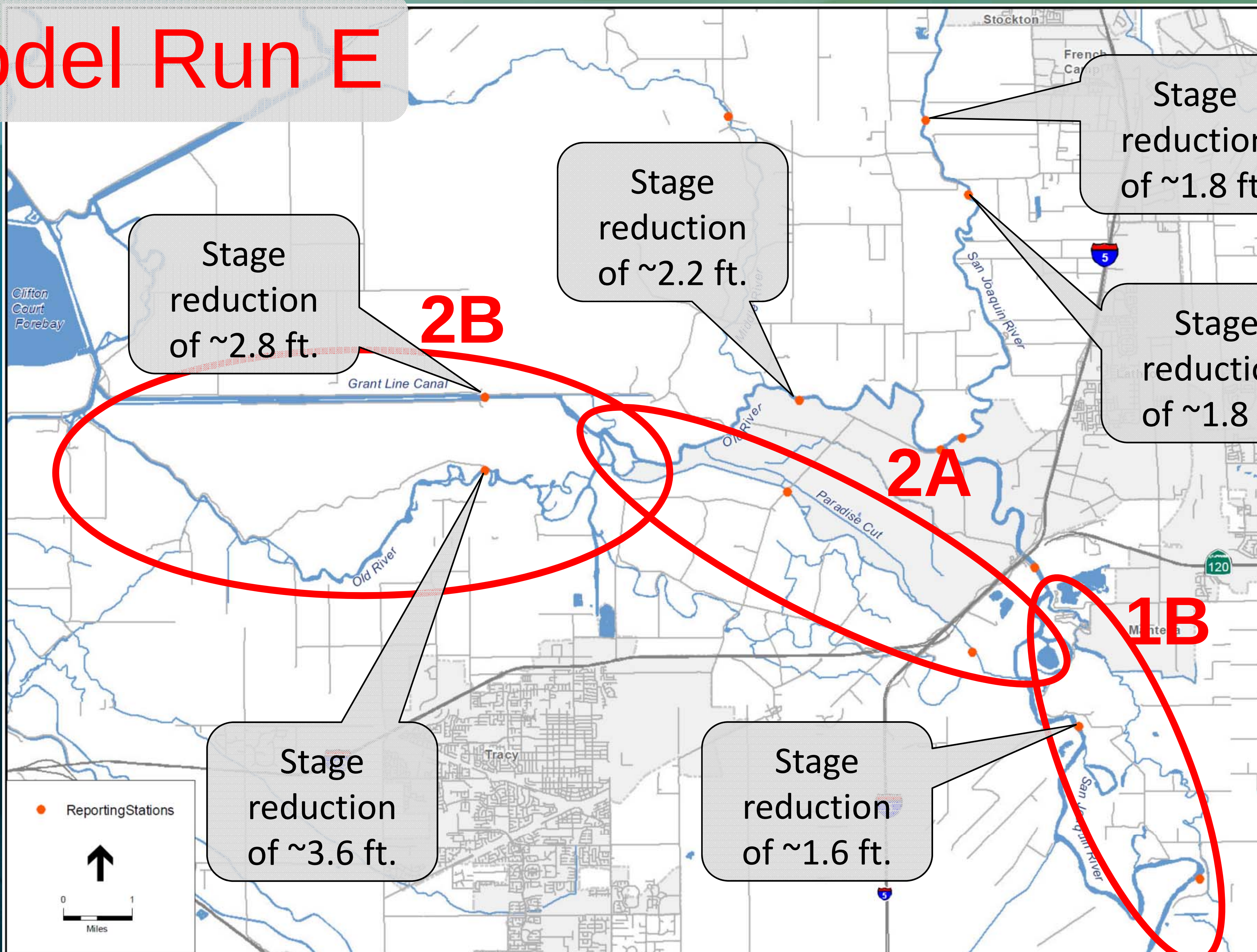
FLOOD EVALUATION RESULTS

Model Run E



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Ecological Evaluation Overview

- Experts screened corridors relative to the Working Group Objectives. Time limitations and illness restricted the teams.
- Specific ecological outcomes assessed (positive and negative)
- Per the charter and suggestion of the evaluators, the group considered:
  - With and without changed hydrology (SJ River Restoration Program; State Board, etc)
  - With and without Isolated Old River Corridor (IORC)
  - With and without Head of Old River Barrier (HORB)
  - With and Without “Sub-Tidal Marsh areas” after construction
- Results presented today are for conditions *assuming optimization;* mostly the addition of barriers.

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Ecological Magnitude & Certainty of Outcomes

Magnitude combines scale of action with extent of effects on populations, productivity, habitats

Certainty combines level of understanding about cause-effect relationships, predictability of the ecosystem processes, and extent to which addresses important cause-effect relationships identified in the models

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Ecological Magnitude

4 - High: major population level effect (natural productivity, abundance, spatial distribution and/or genetic and life history diversity).

3 - Medium: minor population effect or effect on large area (regional) or multiple patches of habitat.

2 - Low: effect limited to small fraction of population, addresses productivity and diversity in a minor way, or limited habitat effects.

1 - Minimal or zero: Conceptual model indicates little or no effect.

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Ecological Certainty

4 - High: Understanding is high + outcome is largely unconstrained by variability in ecosystem dynamics, other external factors, or is expected to confer benefits under conditions or times when model indicates greatest importance.

3 - Medium: Understanding is high but outcome is dependent on other highly variable ecosystem processes or uncertain external factors – OR – Understanding is medium and outcome is largely unconstrained by variability in ecosystem dynamics or other external factors

2 - Low: Understanding is medium and outcome is greatly dependent on highly variable ecosystem processes or other external factors – OR – Understanding is low and outcome is largely unconstrained by variability in ecosystem dynamics or other external factors

1 - Minimal or zero: Understanding is lacking – OR – Understanding is low and outcome is greatly dependent on highly variable ecosystem processes or other external factors

Outcomes Summarized as Worth & Risk

Is it Worthwhile?

		Certainty			
		1	2	3	4
Magnitude	1	***Low***	***Low***	***Med***	***Med***
	2	***Low***	***Med***	***Med***	***High***
	3	***Med***	***Med***	***High***	***High***
	4	***Med***	***High***	***High***	***High***

How Risky is it?

		Certainty			
		1	2	3	4
Magnitude	1	***Med***	***Med***	***Low***	***Low***
	2	***High***	***Med***	***Med***	***Low***
	3	***High***	***High***	***Med***	***Med***
	4	***High***	***High***	***High***	***Med***

Roll-up weights

Value between..	..and	Rank
1	1.5	Low
1.5	2.5	Med
2.5	3	High

EXAMPLE

WORTH		**RISK**	
Grade	**Numeric**	**Grade**	**Numeric**
Med	2		
Med	2		
High	3		
WORTH		**RISK**	
Med	**2.3**	#N/A	**0.0**

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Ecological Evaluation Results

	WORTH	RISK
Corridor 1A	HIGH 2.6	MEDIUM 2.0
Corridor 1B	MEDIUM (X)	MEDIUM (X)
Corridor 2A	HIGH 2.6	MEDIUM 2.0
Corridor 2B	MEDIUM 1.5	HIGH 3.0
Corridor 3	LOW (X)	MEDIUM (X)
Corridor 4	MEDIUM 1.6	HIGH 3.0

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Key Issues

1. San Joaquin River Hydrology drives outcomes on floodplain habitats; actions can be taken to mitigate, to some degree.
2. Barriers and isolated corridors would be critical to reducing risk in certain Corridors 2B, 3, or 4.
3. Details regarding barriers and isolation near conveyance facilities must be further examined (HORB & IORC).
4. Water Quality (temp; food production; M&I supply/export, etc) – pending more data & evaluation
5. Entrainment – assessment preliminary and very conceptual because of lack of particle tracking data

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Which corridors are looking promising?

Preliminary findings:

- Corridor combinations can create substantial habitat and habitat continuity for terrestrial, avian, and certain aquatic species.
- Flood evaluation suggests Corridors 1A, 2A, 2B.
- Ecological evaluation suggests Corridors 1A & 2A have highest benefit levels (worth); 1B, 2B, & 4 rank moderate.
- Flood & Ecosystem benefits “coexist” in Corridors 1A, 2A & 2B—and provide continuity.

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What's next?

- Additional examination of Corridors 1A, 2A, 2B
- More-focused outreach to:
  - Local and regional governments
  - Reclamation & Levee Districts
  - Water providers
  - Flood agencies
  - Environmental interests
- Coordination with on-going flood management efforts in region