CENTRAL VALLEY
FLOOD MANAGEMENT
PLANNING PROGRAM

FloodSAFE
CALIFORNIA

Public Draft

2012 Central Valley Flood Protection Plan

Attachment 8J: Cost Estimates

January 2012

STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

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1.0 Introduction

This section states the purpose of this attachment, gives background information (including a description of planning areas, goals, and approaches), overviews the cost estimate work performed, and provides an overview of the report organization.

1.1 Purpose of this Attachment

This attachment documents (1) the cost estimating methodology and approach, and (2) findings that support the cost estimates of the State Systemwide Investment Approach presented in the 2012 Central Valley Flood Protection Plan (CVFPP).

This attachment provides the detailed pre-appraisal level engineering and associated construction costs that support three preliminary approaches and are utilized to develop a pre-appraisal level construction cost for the State Systemwide Investment Approach.

Costs summarized in Section 2 of the 2012 CVFPP can be reviewed in greater detail in this attachment.

1.2 Background

As authorized by Senate Bill 5, also known as the Central Valley Flood Protection Act of 2008, the California Department of Water Resources (DWR) has prepared a sustainable, integrated flood management plan called the CVFPP, for adoption by the Central Valley Flood Protection Board (Board). The 2012 CVFPP provides a systemwide approach to protecting lands currently protected from flooding by existing facilities of the State Plan of Flood Control (SPFC), and will be updated every 5 years.

As part of development of the CVFPP, a series of technical analyses were conducted to evaluate hydrologic, hydraulic, geotechnical, economic, ecosystem, and related conditions within the flood management system and to support formulation of system improvements. These analyses were conducted in the Sacramento River Basin, San Joaquin River Basin, and Sacramento-San Joaquin Delta (Delta).

1.3 CVFPP Planning Areas

For planning and analysis purposes, and consistent with legislative direction, two geographical planning areas were important for CVFPP development (Figure 1-1):

- **SPFC Planning Area –** This area is defined by the lands currently receiving flood protection from facilities of the SPFC (see *State Plan of Flood Control Descriptive Document* (DWR, 2010)). The State of California's (State) flood management responsibility is limited to this area.

- **Systemwide Planning Area** – This area includes the lands that are subject to flooding under the current facilities and operation of the Sacramento-San Joaquin River Flood Management System (California Water Code Section 9611). The SPFC Planning Area is completely contained within the Systemwide Planning Area which includes the Sacramento River Basin, San Joaquin River Basin, and Delta regions.

Planning and development for the CVFPP occurs differently in these planning areas. The 2012 CVFPP focused on SPFC facilities; therefore, evaluations and analyses were conducted at a greater level of detail within the SPFC Planning Area than in the Systemwide Planning Area.

Costs presented herein cover primarily the SPFC Planning Area but some elements of the conceptual level engineering approaches and pre-appraisal level costs are outside of the SPFC Planning Area and contained within the Systemwide Planning Area.

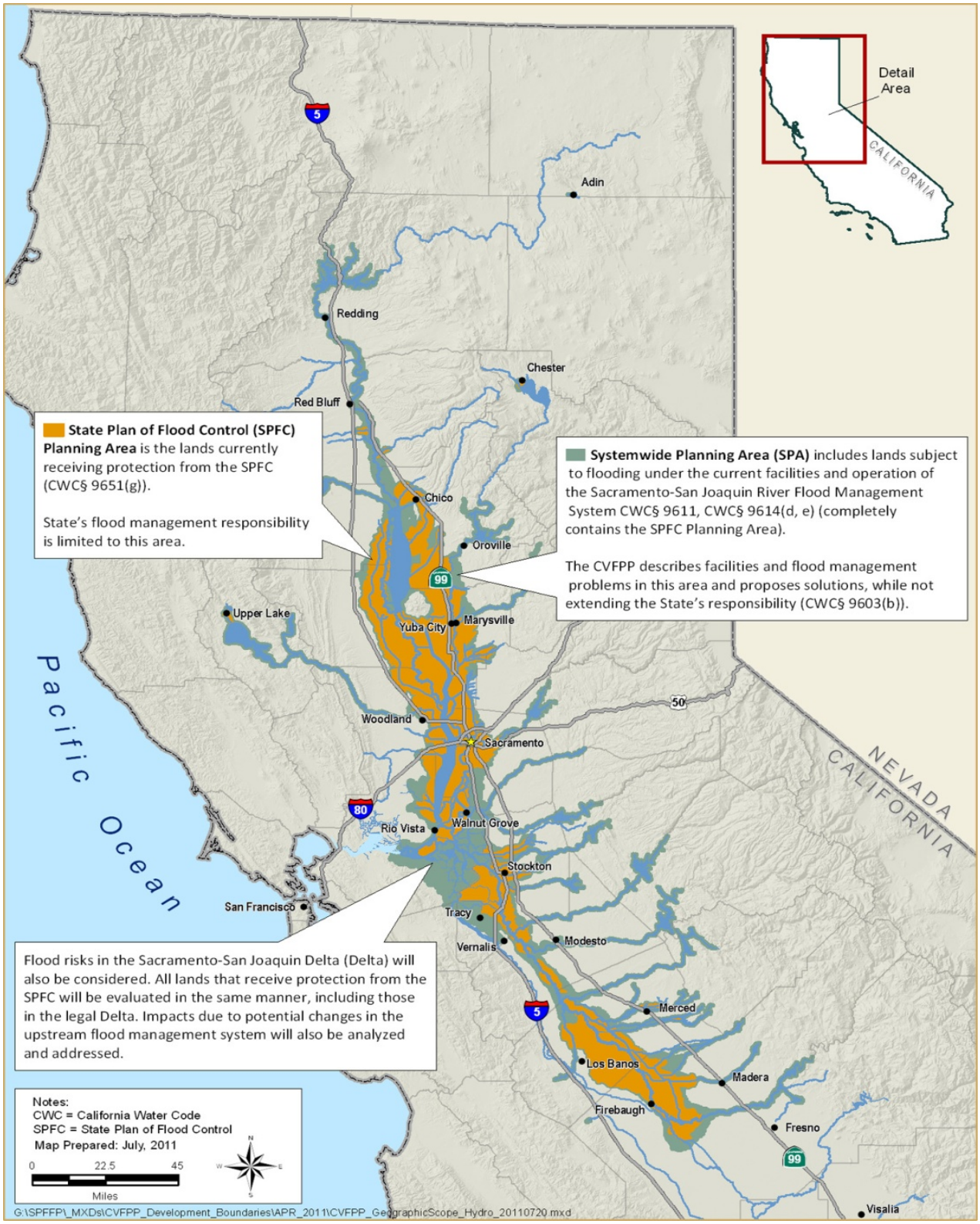

Figure 1-1. Central Valley Flood Protection Plan Planning Areas

1.4 2012 CVFPP Planning Goals

To help direct CVFPP development to meet legislative requirements and address identified flood-management-related problems and opportunities, a primary and four supporting goals were developed:

- **Primary Goal** – Improve Flood Risk Management
- **Supporting Goals:**
  - Improve Operations and Maintenance
  - Promote Ecosystem Functions
  - Improve Institutional Support
  - Promote Multi-Benefit Projects

This attachment supports the goals of the 2012 CVFPP by providing the planning and engineering detail to support cost estimates which are key to plan formulation and ultimately implementation of flood management improvements.

1.5 2012 CVFPP Planning Approaches

In addition to **No Project**, three fundamentally different preliminary approaches to flood management were initially compared to explore potential improvements in the Central Valley. These preliminary approaches are not alternatives; rather, they bracket a range of potential actions and help explore trade-offs in costs, benefits, and other factors important in decision making. The preliminary approaches are as follows:

- **Achieve SPFC Design Flow Capacity** – Address capacity inadequacies and other adverse conditions associated with existing SPFC facilities, without making major changes to the footprint or operation of those facilities.
- **Protect High Risk Communities** – Focus on protecting life safety for populations at highest risk, including urban areas and small communities.
- **Enhance Flood System Capacity** – Seek various opportunities to achieve multiple benefits through enhancing flood system storage and conveyance capacity.

Comparing these approaches helped identify the advantages and disadvantages of different combinations of management actions, and demonstrated opportunities to address the CVFPP goals to different degrees.

Based on this evaluation, a **State Systemwide Investment Approach** was developed that encompasses aspects of each of the approaches to balance achievement of the goals from a systemwide perspective, and includes integrated conservation elements. Figure 1-2 illustrates this plan formulation process.

This attachment contains the costs summarized in the CVFPP for all preliminary approaches and ultimately the State Systemwide Investment Approach.

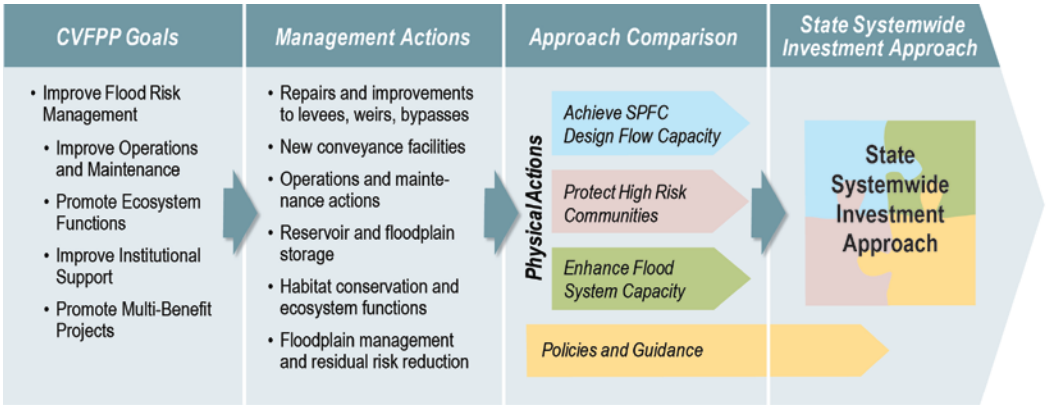

Figure 1-2. Formulation Process for State Systemwide Investment Approach

1.6 Cost Estimates for 2012 CVFPP

This report documents the assumptions and methodology for developing costs, and presents cost estimates for elements of the CVFPP preliminary approaches and the State Systemwide Investment Approach. An appropriate cost estimating methodology, using best available data, was required to evaluate and compare the preliminary approaches. The elements of the preliminary approaches and the methodology to develop them are then presented with their total estimated costs. The cost estimating work completed for the CVFPP was not based on bid-ready engineering documents, but rather conceptual designs and remedial actions extracted from parallel evaluation efforts, and carries an appropriate level of contingency for a conceptual-level planning effort or 25 percent plus/minus for all cost elements.

1.7 Report Organization

Organization of this document is as follows:

- Section 1 introduces and describes the purpose of this document.
- Section 2 summarizes of total estimated costs of the preliminary approaches and the State Systemwide Investment Approach.
- Section 3 lists abbreviations and acronyms used in this document.
- Appendix A documents the cost estimating methodology and provides cost details.
- Appendix B describes the remediation alternative analysis and cost estimates for addressing identified hazard factors for the urban SPFC levees and for achieving 200-year level protection.
- Appendix C describes the remediation alternative analysis and cost estimates for addressing the identified hazard factors for Non-Urban SPFC levees.
- Appendix D documents the conceptual design and cost estimates for providing 100-year level protection for small communities.
- Appendix E documents the conceptual design and cost estimates for the flood corridor expansion features, including levee setback.

2.0 Summary and Findings

The conceptually designed flood management elements used for the preliminary CVFPP cost estimates in this attachment are at a planning level of detail, and should be used for planning purposes only. These cost estimates will be further refined in future feasibility and design studies.

2.1 Cost Estimate Elements

The cost estimates are organized according to four primary flood management elements that address the different types of improvements made to the flood protection system in each approach:

- **System Improvement Element** – The bypass and weir system of the SPFC has provided systemwide benefits of flood protection. System improvements are intended to improve the flood operations for the system as a whole and provide areas to enhance the ecosystem. Considered bypass expansion and weir modifications would lower peak floodflows throughout the system from the reservoirs downstream, providing further improvements in flood protection for urban areas, small communities, and rural-agricultural areas.

- **Urban Improvement Element** – Urban areas located within the region protected by SPFC facilities are defined as developed areas with 10,000 residents or more. The SPFC provides flood protection to nearly1 million people living in urban areas. The urban areas located within the SPFC are generally concentrated in a few regions (Feather River, Lower Sacramento River, and Lower San Joaquin River) in the Sacramento and San Joaquin River basins. Urban improvements are targeted to achieve 200-year level of protection.

- **Rural-Agricultural Improvement Element** – The rural-agricultural improvement addresses the flood protection needs of the largely agricultural areas and small communities throughout these areas (both located within the area protected by the SPFC).

- **Residual Risk Management Element** – Residual risk management addresses additional efforts needed to provide flood protection beyond capital flood protection projects included in the other flood management elements. While this includes features that support improved flood protection throughout the system, it focuses on

providing supplemental flood protection in rural-agricultural areas. It includes three features: Enhanced Flood Emergency Response, Enhanced Operations and Maintenance, and Floodplain Management.

It should be noted that ecosystem enhancements are integrated into the above flood management elements. Ecosystem enhancement features are included in the Enhance Flood System Capacity Approach and the State Systemwide Investment Approach. The Achieve SPFC Design Flow Capacity Approach and the Protect High Risk Communities Approach do not include ecosystem enhancements, but do include cost allowances for mitigation of ecosystem impacts.

2.2 Cost Estimate Summary

The estimated costs for the flood management elements included in the CVFPP preliminary approaches and the State Systemwide Investment Approach are based on 2011 price levels. These costs are not based on bid-ready engineering documents, but rather on conceptual designs and remedial actions extracted from parallel evaluation efforts, and carry an appropriate level of contingency for a conceptual-level planning costs effort or 25 percent plus/minus for all cost elements. The actual implementation cost of flood management actions will depend on many factors that cannot be determined and evaluated in detail at this time. The actual costs will ultimately depend on the features chosen during future feasibility studies, engineering, actual future labor and material costs, competitive market conditions, construction schedule, and other factors. To reflect this uncertainty, estimated costs for the proposed flood management elements are presented as a range of low to high cost. Details of the cost estimate methodology are contained in Appendix A. Additional supporting details for cost estimates appear in Appendices B through E.

Table 2-1 summarizes the costs ranges for each of the flood management elements. Detailed cost estimates are included in Appendix A.

Table 2-1. Summary of Cost Estimate Ranges for Preliminary Approaches and State Systemwide Approach ($-Million)

Flood Management Element	Preliminary Approaches			State Systemwide Investment Approach
	Achieve SPFC Design Flow Capacity	Protect High Risk Communities	Enhance Flood System Capacity	
System Improvements	$90 – $110	$90 – $110	$7,610 – $10,890	$5,140 – $6,500
Urban Improvements	$3,830 – $4,780	$6,360 – $7,540	$5,500 – $5,520	$5,500 – $6,680
Rural/Agricultural Improvements	$13,840 – $17,310	$1,250 – $1,500	$18,090 – $23,080	$1,770 – $1,870
Residual Risk Management	$730 – $900	$1,360 – $1,640	$650 – $800	$1,510 – $1,860
TOTAL	**$18,490 – $23,100**	**$9,060 – $10,790**	**$31,850 – $40,290**	**$13,920 – $16,910**

Key:
SPFC = State Plan of Flood Control

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3.0 Acronyms and Abbreviations

Annual Report ..... Local agency annual report

AEP ..... Annual Exceedence Probability

APN ..... Assessor's Parcel Number

ASPE ..... American Society of Professional Estimators

Board ..... Central Valley Flood Protection Board

CDP ..... Census-Designated Place

Comprehensive Study Sacramento and San Joaquin River Basins Comprehensive Study

CVFPP ..... Central Valley Flood Protection Plan

Delta ..... Sacramento-San Joaquin Delta

DFG ..... California Department of Fish and Game

DWR ..... California Department of Water Resources

FEMA ..... Federal Emergency Management Agency

FIP ..... flood inundation potential

FROA ..... floodplain restoration opportunities analysis

GAR ..... Geotechnical Assessment Report

GIS ..... geographic information system

I-5 ..... Interstate 5

LiDAR ..... Light Detection and Ranging

NGO ..... nongovernmental organization

NULE ..... Non-Urban Levee Evaluations

O&M ..... operations and maintenance

PCET ..... Parametric Cost Estimating Tool

RACER ..... Remedial Alternatives and Cost Estimate Report

ROW ..... right-of-way

SB ..... Senate Bill

SPFC ..... State Plan of Flood Control

State ..... State of California

ULDC ..... Urban Levee Design Criteria

ULE ..... Urban Levee Evaluations

USACE.....U.S. Army Corps of Engineers
USFWS.....U.S. Fish and Wildlife Service

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DRAFT Technical Memorandum

Attachment 8J: Cost Estimates – Appendix A. CVFPP Cost Estimates Methodology

February 2012

STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

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1.0 Introduction

This appendix documents the Central Valley Flood Protection Plan (CVFPP) Cost Estimate Methodology and summarizes the various preliminary approaches and the State Systemwide Investment Approach (SSIA), including the programmatic-level costs for Residual Risk Management.

The CVFPP is being prepared under the authorization of the California Central Valley Flood Protection Act of 2008 (Senate Bill 5) and other associated legislation to begin addressing the many flood management issues facing the Central Valley. The CVFPP is a critical part of the FloodSAFE California Initiative, a comprehensive program to address flood management challenges in the State, with a vision of fostering sustainable, integrated flood management in California. The draft of the 2012 CVFPP was completed and provided to the Central Valley Flood Protection Board (Board) before January 1, 2012, and is expected to be adopted by the Board before July 1, 2012.

CVFPP goals include the primary goal of improving flood risk management and four supporting goals of improving operations and maintenance (O&M), improving institutional support, promoting ecosystem functions, and promoting multi-benefit projects. These goals are described in the 2012 CVFPP. To achieve these goals, the CVFPP has identified four different approaches for Central Valley flood management. These include:

1. Achieve State Plan of Flood Control (SPFC) Design Flow Capacity Approach.

2. Protect High-Risk Communities Approach.

3. Enhance Flood System Capacity Approach.

4. SSIA – the State's preferred approach.

The cost estimates presented in this Appendix are at a reconnaissance (appraisal) level of detail and will be updated as future evaluations are conducted. The costs used in this estimate were assembled from many different sources at various levels of detail. In some cases, materials quantities and unit costs were used to develop some of the cost estimates; in other cases, already existing cost estimates from ongoing efforts were

used. While this may result in a broad range of the level of detail for the costs, it does represent the initial effort to estimate the costs of these approaches. It is expected that the cost estimates will be brought to a more uniform level of detail as part of the feasibility studies.

The purpose of this appendix is to support the 2012 CVFPP by providing relevant information, assumptions, and cost estimates for the system and local/regional improvements to existing facilities, constructing new facilities, and/or other flood management actions. This includes all the components evaluated in the CVFPP for each of the four approaches listed above. This appendix also provides estimates for ongoing annual costs for residual risk management actions, such as O&M.

The remainder of this Appendix is organized into the following sections:

- **Section 2, Background Information** – This section provides general contextual information that is relevant to preparation of this appendix. This information includes:
  - Data sources used in this analysis
  - Descriptions of the regions used to aggregate and summarize cost information
  - Major assumptions used for cost estimates
- **Section 3, Approach Descriptions and Cost Estimates** – This section summarizes the flood management elements included in each of the four CVFPP flood management approaches, including their costs for each flood management element by region. This section also provides a cost summary table comparing all four approaches.
- **Section 4, Flood Management Elements** – This section describes the flood management elements and assumptions used in estimating their costs. The flood management elements are organized into groups based on their primary improvements (systemwide, urban, rural-agricultural). Each flood management element is then further divided into the specific flood management components, which are the most detailed level of information identified and used for purposes of this preliminary cost estimate.
- **Section 5, Acronyms and Abbreviations**
- **Section 6, Detailed Cost Tables –** This includes the details cost tables that are summarized in Section 3.

2.0 Background

This provides background information on planning areas, data sources, and key assumptions for the preliminary cost estimates.

2.1 Planning Area

The SPFC Planning Area is the geographic area that includes the lands currently receiving flood damage reduction benefits from the SPFC. The SPFC Planning Area can be further subdivided into Levee Flood Protection Zones (LFPZ), which are defined as those areas that are protected by a levee that is part of the facilities of the SPFC, as defined under Section 5096.805 of the Public Resources Code. There are currently 221 LFPZs identified in the SPFC Planning Area. For purposes of organizing and presenting information about the approaches and project costs, the SPFC Planning Area was subdivided into nine regions listed below, based on the location of the facilities of the SPFC, as shown in Figure 2-1. The regions are described in more detail in the Draft Location and Description of Levee Flood Protection Zones within the Central Valley Technical Memoranda (June 23, 2011).

- Upper Sacramento/Butte Basin Region.
- Mid-Sacramento Region.
- Feather River Region.
- Lower Sacramento Region.
- Delta North Region.
- Delta South Region.
- Lower San Joaquin Region.
- Mid-San Joaquin Region.
- Upper San Joaquin Region.

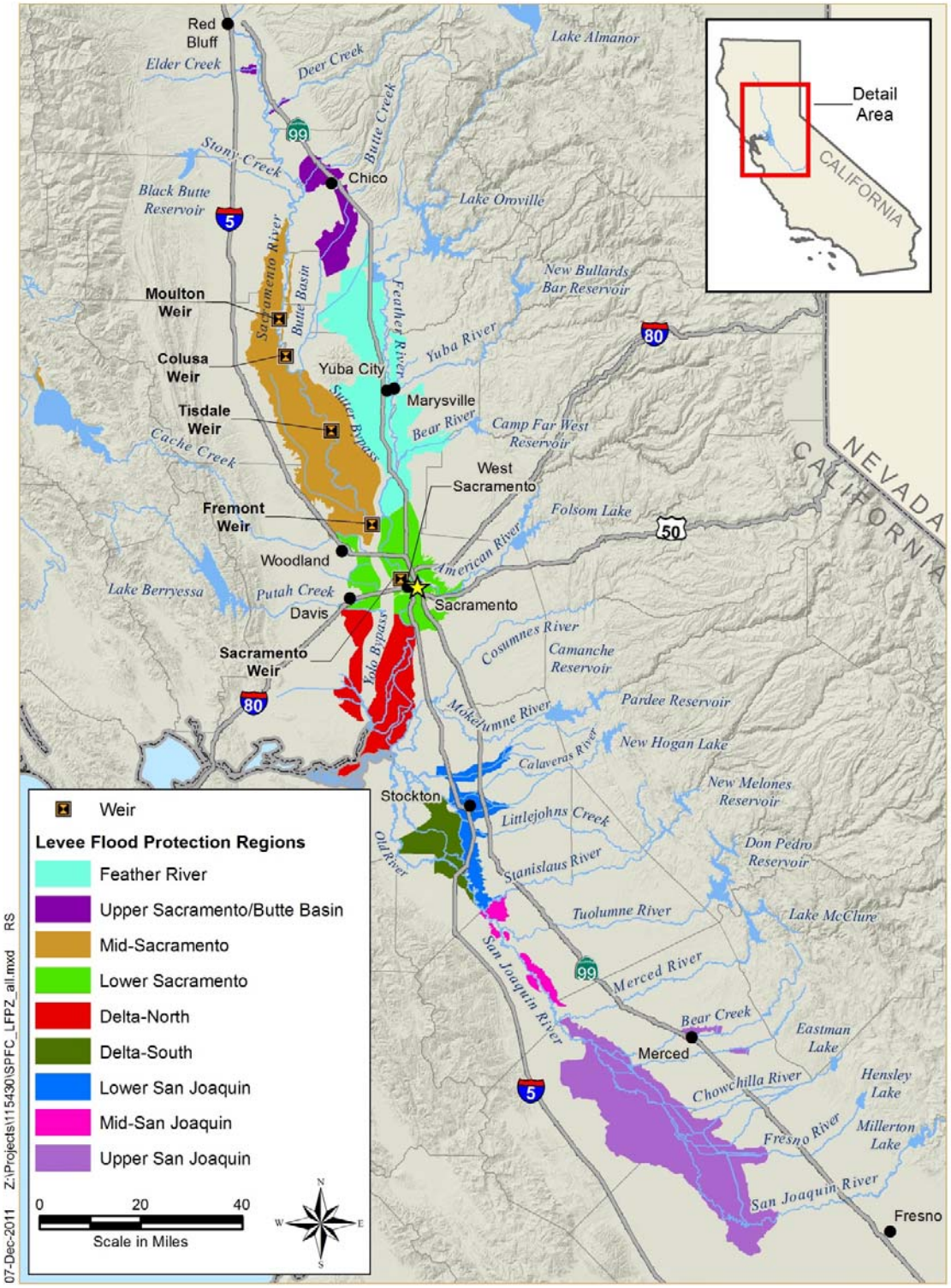

Figure 2-1. Central Valley Flood Protection Plan Implementation Regions and Flood Protection Zones

2.2 Key Cost Estimate Assumptions and Limitations

The estimated project costs are based on 2011 costs.

2.2.1 Cost Uncertainty

The actual cost of future improvements will depend upon a host of factors that cannot be determined and evaluated in detail at this time, so the cost estimates provided here should be considered preliminary. Cost estimates will change as the project is refined during future studies, permitting, design, and construction. The actual costs will ultimately depend on the components chosen, the engineering, the actual future labor and material costs, competitive market conditions, the construction schedule, and other factors. As a result, the final project costs will vary from estimates provided in this appendix.

2.2.2 Cost Ranges

In most cases, a range of costs is provided to account for some of the uncertainty included in the preliminary assumptions. The range of costs includes:

- **Low Estimated Total Cost** – The low estimated total cost is determined using the smaller quantity (when a range is provided) and the lower unit cost (when a range is provided).

- **High Estimated Total Cost** – The high estimated total cost is determined using the larger quantity (when a range is provided) and higher unit costs (when a range is provided).

A range of costs is provided for each of the flood management componentcomponents based on the available supporting information (for each element) and program assumptions. These costs are presented on the tables in this cost estimate.

2.2.3 Risk Assessment, Feasibility, Engineering, and Permitting

In general, an additional 20 to 25 percent contingency is included to both the Low and High Estimated Total Cost to account for potential uncertainty in cost estimates due to future refinement to plan concept and elements, such as:

- Future updates to the CVFPP

- Planned basinwide feasibility studies for the Sacramento River Basin and San Joaquin River Basin
- Updates on risk assessments of the flood management system, including updated geotechnical information, new hydrology, and updated system hydraulic modeling tools.
- Detailed engineering design of the flood management elements and facilities that evaluates site specific conditions
- Permitting process and requirements for the proposed flood management projects
- Cost for mitigating any potential hydraulic impacts
- Other ecosystem mitigation costs not identified in this cost estimate
- Other unidentified cost items

2.3 Data Sources

The following data sources were used to prepare this Appendix:

- Levee hazard information and structural remediation cost estimates developed by Urban and non-urban levee evaluations (ULE and NULE)
- Program-level cost information for residual risk management elements developed by California Department of Water Resources (DWR), Division of Flood Management (DFM)
- Information from local flood management and maintaining agencies
- CVFPP Conservation Framework (CVFPP Attachment 2) and supporting technical documentations (CVFPP Attachment 9)
- Unit costs from recently implemented projects (such as Three River Levee Improvement Authority (TRLIA) and Sacramento Area Flood Control Agency (SAFCA))
- Reconnaissance and pre-feasibility level conceptual designs and costs information on flood management improvements, such as:
    - Sacramento Bypass Expansion Conceptual Design and Cost Estimates (SAFCA, March 2009)

  - Formulation and Analysis of Alternatives for Supplemental Flood Control Program on Yuba River (Yuba County Water Agency (YCWA), 1999)

  - Paradise Cut Bypass Investigation – Draft Technical Memorandum, (Central Valley Flood Management Program, June 2010)

  - Daguerre Point Dam Fish Passage Improvement Project – Alternative Concepts Evaluation (US Army Corps of Engineers, September, 2003)

- Reconnaissance information on storage projects:

  - Shasta Lake Water Resources Investigation (US Department of the Interior, Bureau of Reclamation (Reclamation), 2011)

  - North of Delta Offstream Storage (DWR, 2010)

  - Upper San Joaquin River Basin Storage Investigation (Reclamation, 2008)

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3.0 Approach Descriptions and Cost Estimates

This section summarizes the four approaches evaluated in the CVFPP and their preliminary costs. Three fundamentally different approaches to flood management were initially compared to explore potential flood risk reduction improvements in the Central Valley. These include:

1. Achieve SPFC Design Flow Capacity Approach.
2. Protect High Risk Communities Approach.
3. Enhance Flood System Capacity Approach.

Based on an evaluation of these three approaches, the California Department of Water Resources (DWR) developed the SSIA that encompasses aspects of each of the three preliminary approaches to balance achievement of the goals from a systemwide perspective, and includes integrated conservation elements.

3.1 Flood Management Elements

This cost estimate is organized into four primary flood management elements that address the different types of improvements made to the flood protection system in each approach. The four flood management elements are:

1. System improvement element.
2. Urban improvement element.
3. Rural-agricultural improvement element.
4. Residual risk management element.

The flood management elements are described in more detail in Section 4. Each flood management element is then further divided into the specific flood management components, which are the most detailed level of information identified and used for purposes of this preliminary cost estimate. Tables 3-1 to 3-4 identify which flood management components are included in each approach. It should be noted that many of the ecosystem restoration enhancements are integrated into the above flood

management elements and are componentcomponents of the Enhance Flood System Capacity Approach and the SSIA. The Achieve SPFC Design Capacity Approach and the Protect High-Risk Communities Approach do not include similar ecosystem enhancements, but do include cost allowances for mitigation of ecosystem impacts.

Table 3-1. System Improvement Elements Incorporated in the CVFPP Approaches

Flood Management Component	Achieve SPFC Design Flow Capacity	Protect High-Risk Communities	Enhance Flood System Capacity	State Systemwide Investment Approach
Land Acquisition	NO	NO	YES	YES
Agricultural Conservation Easements	NO	NO	YES	YES
Ecosystem Restoration and Enhancement	NO	NO	YES	YES
New Levee Construction	NO	NO	YES	YES
Improve Existing Levees	NO	NO	YES	YES
Flood System and Fish Passage Structures	NO	NO	YES	YES
Forecast –Coordinated Operations / Forecast-Based Operations	YES	YES	YES	YES
New Reservoir Storage	NO	NO	YES	NO
Easements	NO	NO	YES	NO
System Erosion and Bypass Sediment Removal Project	NO	NO	YES	YES

Table 3-2. Urban Improvement Elements Incorporated in the CVFPP Approaches

Flood Management Component	Achieve SPFC Design Flow Capacity	Protect High-Risk Communities	Enhance Flood System Capacity	State Systemwide Investment Approach
Urban Flood Protection Projects	NO	YES	YES	YES
Achieve SPFC Design Capacity in Urban Areas	YES	NO	NO	NO
Non-SPFC Urban Levee Improvements	YES	YES	YES	YES

Table 3-3. Rural-Agricultural Improvement Elements Incorporated in the CVFPP Approaches

Flood Management Component	Achieve SPFC Design Flow Capacity	Protect High Risk Communities	Enhance Flood System Capacity	State Systemwide Investment Approach
Small Community Improvements	NO	YES	YES	YES
Non-Urban Levee Improvements to Achieve SPFC Design Capacity	YES	NO	YES	NO
Rural Setback Levees	NO	NO	YES	NO
Site-Specific Rural Agricultural Levee Improvements	NO	NO	NO	YES
Known and Identified Erosion Repairs	NO	NO	NO	YES

Table 3-4. Residual Risk Management Elements Incorporated in the CVFPP Approaches

Flood Management Component	Achieve SPFC Design Flow Capacity	Protect High Risk Communities	Enhance Flood System Capacity	State Systemwide Investment Approach
Additional Flood Information Collection and Sharing	YES	YES	YES	YES
All Weather Roads on Levee Crowns	YES	NO	YES	YES
Local Flood Emergency Planning	YES	YES	YES	YES
Additional Forecasting and Notification	NO	YES	NO	YES
Identification and Repair After Event Erosions	YES	YES	YES	YES
Develop and Implement Enhanced O&M Programs and Regional Organizations	YES	YES	YES	YES
Sacramento Channel and Levee Management and Bank Protection	YES	YES	YES	YES
Raising and Waterproofing Structures and Building Berms	NO	NO	NO	YES
Purchasing and Relocating Homes in Floodplains	NO	NO	NO	YES
Land Use and Floodplain Management	YES	YES	YES	YES

3.2 Approach Descriptions and Costs

The CVFPP approaches are more fully described in the Draft 2012 Central Valley Flood Protection Plan. A brief description of the four approaches is provided in this section to provide context for comparing the flood management componentcomponents included in each approach. Table 3-5 provides the cost summary for the four CVFPP approaches. Additional information included improvement costs to each of the nine regions is provided for each approach in the following sections.

Table 3-5. Cost Summary for Four CVFPP Approaches ($millions, 2011 dollars)

Approach	Achieve SPFC Design Flow Capacity	Protect High Risk Communities	Enhance Flood System Capacity	State Systemwide Investment Approach
System Improvements	$91 to $114	$91 to $114	$7,605 to $10,889	$5,142 to $6,501
Urban Improvements	$3,827.0 to $4,783	$5,496 to $6,675	$5,496 to $6,675	$5,496 to $6,675
Rural-Agricultural Improvements	$13,843 to $17,305	$1,253 to $1,504	$18,088 to $23,075	$1,772 to $1,873
Residual Risk Management	$732 to $901	$1,356 to $1,638	$653 to $798	$1,511 to $1,863
TOTAL	$18,493 to $23,103	$8,196 to $9,931	$31,842 to $41,437	$13,921 to $16,912

Notes:
All cost estimates are based on 2011 costs rounded to nearest $million
Cost estimates include 20 to 25 percent contingencies for risk assessment, feasibility, engineering, and permitting.

3.2.1 Achieve SPFC Design Flow Capacity Approach

The Achieve SPFC Design Capacity Approach focuses on reconstructing existing SPFC facilities throughout the system, such that the SPFC can reliably accommodate established project design flows.

This approach was formulated to address legislation that required DWR to consider structural improvements and repairs necessary to reconstruct SPFC facilities to their original design standards (California Water Code 9614 (g)). It also addresses requests from stakeholders to consider repairing the existing flood management system in place, or without major modification to facility locations.

This approach does not consider improving SPFC facilities to carry flows greater than project design flows, nor enhancements (to levee height, width, or footprint, for example) that exceed current SPFC design standards. The

projects and their associated costs included in this approach are distributed among the nine regions, as presented on the Table 3-6.

System Improvements – System improvements are generally not included in the Achieve SPFC Design Capacity Approach.

Table 3-1 identifies the System improvements included in this approach. Tables 4-1 to 4-11 describe the range of costs for the flood management components included in the system improvements.

Urban Improvements – Urban improvements are not a direct element of the Achieve SPFC Design Capacity Approach. There are some improvements to urban levees included in this approach to achieve SPFC design flow capacities around urban areas.

Table 3-2 identifies the urban improvements included in this approach. Tables 4-12 to 4-14 describe the range of costs for the flood management components included in the urban improvements.

Rural Agricultural Improvements – In the Achieve SPFC Design Capacity Approach, rural agricultural improvements focus on the wide range of repairs identified in the NULE Program that provides extensive repairs to the rural levees throughout the system; it is not targeting a specified level of protection, but rather achieving the original design capacity of the SPFC.

Table 3-3 identifies the rural-agricultural improvements included in this approach. Tables 4-15 to 4-20 describe the range of costs for the flood management components included in the rural-agricultural improvements.

Residual Risk Management – Residual risk management is a minor part of the Achieve SPFC Design Capacity Approach because the need is expected to be less than the other approaches due to significant investment in physical flood system improvements, especially in rural areas.

Table 3-4 identifies the residual risk management elements included in this approach. Tables 4-21 to 4-25 describe the range of costs for the flood management components included in residual risk management.

Table 3-6 Improvement Costs for the Achieve SPFC Design Flow Capacity Approach

REGION	System Improvements			Urban Improvements			Rural Improvements			Residual Risk Management			Total Costs		
	Low		High	Low		High	Low		High	Low		High	Low		High
1- Upper Sacramento Region	$12.0	to	$15.0	$0.0	to	$0.0	$510.0	to	$638.0	$44.0	to	$54.0	$566.0	to	$707.0
2- Mid-Sacramento Region	$0.0	to	$0.0	$0.0	to	$0.0	$3,223.0	to	$4,028.0	$103.0	to	$132.0	$3,326.0	to	$4,160.0
3- Feather River Region	$12.0	to	$15.0	$1,196.0	to	$1,495.0	$2,039.0	to	$2,548.0	$88.0	to	$112.0	$3,335.0	to	$4,170.0
4- Lower Sacramento Region	$7.0	to	$8.0	$1,529.0	to	$1,912.0	$1,434.0	to	$1,793.0	$95.0	to	$120.0	$3,065.0	to	$3,833.0
5- Delta North Region	$12.0	to	$15.0	$288.0	to	$360.0	$3,889.0	to	$4,862.0	$155.0	to	$174.0	$4,344.0	to	$5,411.0
6- Delta South Region	$0.0	to	$0.0	$144.0	to	$180.0	$629.0	to	$787.0	$44.0	to	$54.0	$817.0	to	$1,021.0
7- Lower San Joaquin Region	$7.0	to	$8.0	$238.0	to	$296.0	$340.0	to	$425.0	$50.0	to	$61.0	$635.0	to	$790.0
8- Mid - San Joaquin Region	$12.0	to	$15.0	$432.0	to	$540.0	$474.0	to	$592.0	$38.0	to	$46.0	$956.0	to	$1,193.0
9- Upper San Joaquin Region	$29.0	to	$38.0	$0.0	to	$0.0	$1,305.0	to	$1,632.0	$115.0	to	$148.0	$1,449.0	to	$1,818.0
Total	**$91.0**	**to**	**$114.0**	**$3,827.0**	**to**	**$4,783.0**	**$13,843.0**	**to**	**$17,305.0**	**$732.0**	**to**	**$901.0**	**$18,493.0**	**to**	**$23,103.0**

Note:
All cost estimates are based on 2011 costs rounded to nearest $million

3.2.2 Protect High-Risk Communities Approach

The Protect High-Risk Communities Approach focuses on improvements to the flood management system that directly reduce risks to life and life safety. These threats are predominantly in densely populated areas, including urban areas and small communities subject to deep or rapid flooding. This approach would primarily improve levees without major changes to their existing footprints. Rural-agricultural levees would remain in their existing configurations. The projects and their associated costs for this approach are distributed among the nine regions as presented in Table 3-7.

System Improvements – System improvements are generally not included in the Protect High-Risk Communities Approach.

Table 3-1 identifies the system improvements included in this approach. Tables 4-1 to 4-11 describe the range of costs for the flood management components included in the system improvements.

Urban Improvements – The urban improvements are a significant element of the Protect High-Risk Communities Approach. DWR Flood Project Office compiled a list of projects and preliminary cost estimates for achieving a 200-year level of flood protection in the Central Valley. This list was compiled using information from DWR projects and information from local flood maintenance agencies.

Table 3-2 identifies the urban improvements included in this approach. Tables 4-12 to 4-14 describe the range of costs for the flood management components included in the urban improvements.

Rural Agricultural Improvements – Only the small community improvements componentcomponents are included in the Protect High-Risk Communities Approach.

Table 3-3 identifies the rural-agricultural improvements included in this approach. Tables 4-15 to 4-20 describe the range of costs for the flood management components included in the rural-agricultural improvements.

Residual Risk Management – Since the focus of this approach is on small communities and urban areas, a moderate amount of the residual risk management elements is needed. Because this approach does not address rural flood risks, the residual risk management element is smaller than the SSIA.

Table 3-4 identifies the residual risk management elements included in this approach. Tables 4-21 to 4-25 describe the range of costs for the flood management components included in residual risk management.

Table 3-7 Improvement Costs for the Protect High-Risk Communities Approach

REGION	System Improvements			Urban Improvements			Rural Improvements			Residual Risk Management			Total Costs		
	Low		High	Low		High	Low		High	Low		High	Low		High
1- Upper Sacramento Region	$12.0	to	$15.0	$120.0	to	$144.0	$93.0	to	$112.0	$95.0	to	$113.0	$320.0	to	$384.0
2- Mid-Sacramento Region	$0.0	to	$0.0	$0.0	to	$0.0	$238.0	to	$285.0	$220.0	to	$277.0	$458.0	to	$562.0
3- Feather River Region	$12.0	to	$15.0	$891	to	$1,048.0	$399.0	to	$479.0	$165.0	to	$204.0	$1,467.0	to	$1,746.0
4- Lower Sacramento Region	$7.0	to	$8.0	$3,549.0	to	$4,283.0	$0.0	to	$0.0	$139.0	to	$169.0	$3,695.0	to	$4,460.0
5- Delta North Region	$12.0	to	$15.0	$144.0	to	$192.0	$367.0	to	$440.0	$258.0	to	$300.0	$781.0	to	$947.0
6- Delta South Region	$0.0	to	$0.0	$0.0	to	$0.0	$0.0	to	$0.0	$91.0	to	$106.0	$91.0	to	$106.0
7- Lower San Joaquin Region	$7.0	to	$8.0	$626.0	to	$809.0	$0.0	to	$0.0	$93.0	to	$107.0	$726.0	to	$924.0
8- Mid - San Joaquin Region	$12.0	to	$15.0	$0.0	to	$0.0	$4.0	to	$5.0	$84.0	to	$97.0	$100.0	to	$117.0
9- Upper San Joaquin Region	$29.0	to	$38.0	$166.0	to	$199.0	$152.0	to	$183.0	$211.0	to	$265.0	$558.0	to	$685.0
Total	**$91.0**	**to**	**$114.0**	**$5,496.0**	**to**	**$6,675.0**	**$1,253.0**	**to**	**$1,504.0**	**$1,356.0**	**to**	**$1,638.0**	**$8,196.0**	**to**	**$9,931.0**

Note:
All cost estimates are based on 2011 costs rounded to nearest $ million

3.2.3 Enhance Flood System Capacity Approach

The Enhance Flood System Capacity Approach focuses on enhancing flood system storage and conveyance capacity to achieve multiple benefits. This approach combines componentcomponents of the above two approaches and provides more room within flood conveyance channels to lower flood stages throughout most of the system. This approach would represent a major realignment of the existing footprint and function of the flood management system. Flood system capacity enhancements would be designed on a systemwide scale to integrate multiple benefits, including environmental restoration and water supply reliability.

In addition to improving the overall capacity of the system to convey large flood events, additional improvements would be made to protect urban areas and communities where a high threat to public safety exists. The projects and their associated costs for this approach are distributed among the nine regions, as presented in Table 3-8.

System Improvements – System improvements are a significant element of the Enhance Flood System Capacity Approach. Most of the system improvements componentcomponents are needed to expand the bypass system, make the needed levee improvements, or build new levees and needed facilities to move flood waters into and out of the bypass system. Fish passage improvements are also included in this approach. The Enhance Flood System Capacity Approach also includes increases in flood storage in foothill reservoirs, and transitory storage on the floodplains.

Table 3-1 identifies the system improvements included in this approach. Tables 4-1 to 4-11 describe the range of costs for the flood management components included in the system improvements.

Urban Improvements - Urban improvements are a significant element of the Enhance Flood System Capacity Approach. DWR Flood Project Office compiled a list of projects and preliminary cost estimates for achieving a 200-year level of flood protection in the Central Valley. This list was compiled using information from DWR projects and information from local flood maintenance agencies. The Urban Improvements are the same as the Protect High-Risk Communities Approach and SSIA.

Table 3-2 identifies the urban improvements included in this approach. Tables 4-12 to 4-14 describe the range of costs for the flood management components included in the urban improvements.

Rural-Agricultural Improvements – In the Enhance Flood System Capacity Approach, Rural Agricultural Improvements focus on the wide

range of repairs identified in the NULE Program that provides extensive repairs to the rural levees throughout the system. It does not target a specified level of protection, but rather achieving the original design capacity of the SPFC.

In addition, this approach includes setback levees at selected locations throughout the system and the associated environmental restoration of those areas returned to the floodplain. This componentcomponent is not included in any of the other approaches.

Table 3-3 identifies the rural-agricultural improvements included in this approach. Tables 4-15 to 4-20 describe the range of costs for the flood management components included in the rural-agricultural improvements.

Residual Risk Management – Residual risk management is a minor part of the Enhance Flood System Capacity Approach because the need is expected to be less than the other approaches due to the significant investment in physical flood system improvements.

Table 3-4 identifies the residual risk management elements included in this approach. Tables 4-21 to 4-25 describe the range of costs for the flood management components included in residual risk management.

Table 3-8 Improvement Costs for the Enhance Flood System Capacity Approach

REGION	System Improvements			Urban Improvements			Rural Improvements			Residual Risk Management			Total Costs		
	Low		High	Low		High	Low		High	Low		High	Low		High
1- Upper Sacramento Region	$315.0	to	$447.0	$120.0	to	$144.0	$510.0	to	$638.0	$40.0	to	$49.0	$985.0	to	$1,278.0
2- Mid-Sacramento Region	$578.0	to	$784.0	$0.0	to	$0.0	$5,508.0	to	$7,179.0	$117.0	to	$152.0	$6,203.0	to	$8,115.0
3- Feather River Region	$2,120.0	to	$2,729.0	$891	to	$1,048.0	$2,834.0	to	$3,644.0	$81.0	to	$102.0	$5,926.0	to	$7,523.0
4- Lower Sacramento Region	$1,627.0	to	$1,962.0	$3,549.0	to	$4,283.0	$1,434.0	to	$1,793.0	$59.0	to	$72.0	$6,669.0	to	$8,110.0
5- Delta North Region	$754.0	to	$924.0	$144.0	to	$192.0	$4,139.0	to	$5,112.0	$145.0	to	$161.0	$5,182.0	to	$6,389.0
6- Delta South Region	$427.0	to	$549.0	$0.0	to	$0.0	$629.0	to	$787.0	$37.0	to	$45.0	$1,093.0	to	$1,3810.0
7- Lower San Joaquin Region	$7.0	to	$8.0	$626.0	to	$809.0	$340.0	to	$425.0	$48.0	to	$59.0	$1,021.0	to	$1,3010.0
8- Mid - San Joaquin Region	$778.0	to	$1,129.0	$0.0	to	$0.0	$1,370.0	to	$1,847.0	$35.0	to	$42.0	$2,183.0	to	$3,018.0
9- Upper San Joaquin Region	$999.0	to	$2,357.0	$166.0	to	$199.0	$1,324.0	to	$1,650.0	$91.0	to	$116.0	$2,580.0	to	$4,322.0
Total	**$7,605.0**	**to**	**$10,889.0**	**$5,496.0**	**to**	**$6,675.0**	**$18,088.0**	**to**	**$23,075.0**	**$653.0**	**to**	**$798.0**	**$31,842.0**	to	$41,437.0

Note:
All cost estimates are based on 2011 costs rounded to nearest $ million

3.2.4 State Systemwide Investment Approach

The SSIA provides guidance for future State participation in projects and programs for integrated flood management in the Central Valley. The approach combines the most promising and cost-effective public safety, flood storage and conveyance, environmental conservation and restoration, and other elements of the preliminary approaches with policies, guidance, and improvements to routine State flood management functions. In general, this approach incorporates most elements of the Protect High-Risk Communities Approach. It adds the bypass expansions and new bypasses from the Enhance Flood System Capacity Approach. Based on observed rural-agricultural benefits from the Achieve SPFC Approach, select rural-agricultural levee improvements are included without incorporating the extent or expense of the approach.

The projects and their associated costs for this approach are distributed among the nine regions as presented in Table 3-9. The locations of some of the major system improvements for the SSIA are shown for the Sacramento River Basin and the San Joaquin River Basin on Figures 3-1 and 3-2 respectively.

System Improvements – System improvements are a significant element of the SSIA. Most of the system improvements componentcomponents are needed to expand the bypass system, make the needed levee improvements, or build new levees and needed facilities to move flood waters into and out of the bypass system. Fish passage improvements are also included in this approach.

Table 3-1 identifies the system improvements included in this approach. Tables 4-1 to 4-11 describe the range of costs for the flood management components included in the system improvements.

Urban Improvements - Urban improvements are a significant element of the SSIA. DWR FPO compiled a list of projects and preliminary cost estimates for achieving 200-year level of flood protection in the Central Valley. This list was compiled using information from DWR projects and information from local flood maintenance agencies.

Table 3-2 identifies the urban improvements included in this approach. Tables 4-12 to 4-14 describe the range of costs for the flood management components included in the urban improvements.

Rural-Agricultural Improvements – In the SSIA, rural-agricultural improvements focus on those identified and known deficiencies at specific areas based on recent levee inspections rather than providing a very broad level of repairs and improvements for the entire rural levee system. This is

intended to provide a more cost-effective approach to rural levee improvements that, when combined with some of the floodplain management componentcomponents, provides a mechanism that is available to address the flood threat for the approximately 20,000 houses identified in the rural areas protected by the SPFC.

Table 3-3 identifies the rural-agricultural improvements included in this approach. Tables 4-15 to 4-20 describe the range of costs for the flood management components included in the rural-agricultural improvements.

Residual Risk Management – Residual risk management is a significant part of the SSIA, by providing cost-effective alternative (through floodplain management componentcomponents) to provide protection (reduced risk) in rural floodplains through the enhanced flood emergency response and floodplain management componentcomponents (which is more comprehensive than in the other approaches). The floodplain management componentcomponents provide a mechanism that is available to address the flood threat for the approximately 20,000 houses identified in the rural areas protected by the SPFC.

Table 3-4 identifies the residual risk management elements included in this approach. Tables 4-21 to 4-25 describe the range of costs for the flood management components included in residual risk management.

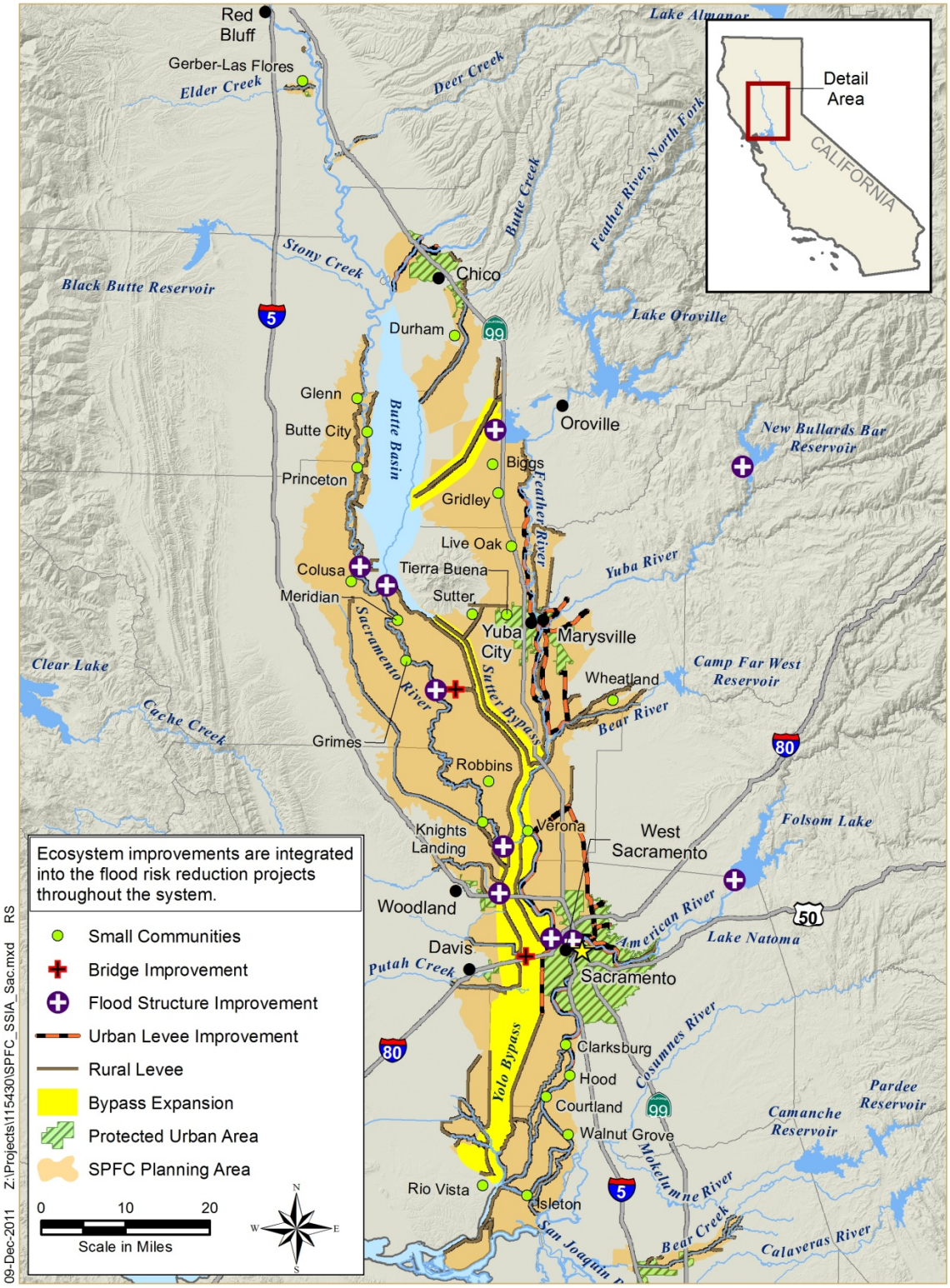

Figure 3-1. Location of Major System Improvements in the Sacramento River Basin

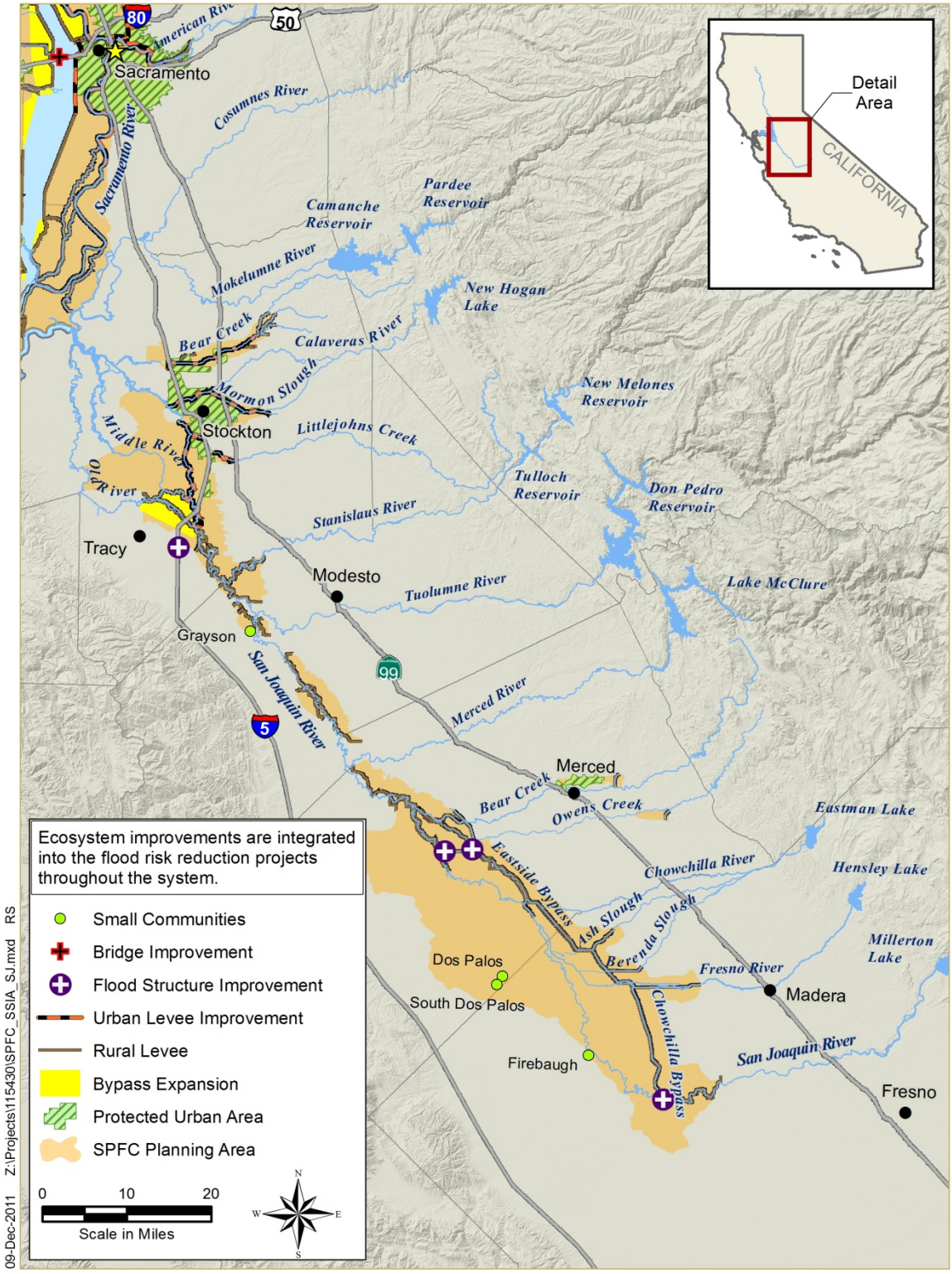

Figure 3-2. Location of Major System Improvements in the San Joaquin River Basin

Table 3-9. Improvement Costs for the State Systemwide Investment Approach

REGION	System Improvements			Urban Improvements			Rural Improvements			Residual Risk Management			Total Costs		
	Low		High	Low		High	Low		High	Low		High	Low		High
1- Upper Sacramento Region	$109.0	to	$180.0	$120.0	to	$144.0	$154.0	to	$168.0	$95.0	to	$114.0	$478.0	to	$606.0
2- Mid-Sacramento Region	$234.0	to	$340.0	$0.0	to	$0.0	$360.0	to	$379.0	$261.0	to	$333.0	$855.0	to	$1,052.0
3- Feather River Region	$1,695.0	to	$2,139.0	$891	to	$1,048.0	$282.0	to	$289.0	$170.0	to	$212.0	$3,038.0	to	$3,688.0
4- Lower Sacramento Region	$1,627.0	to	$1,962.0	$3,549.0	to	$4,283.0	$77.0	to	$88.0	$138.0	to	$169.0	$5,391.0	to	$6,502.0
5- Delta North Region	$754.0	to	$924.0	$144.0	to	$192.0	$604.0	to	$634.0	$266.0	to	$311.0	$1,768.0	to	$2,061.0
6- Delta South Region	$427.0	to	$549.0	$0.0	to	$0.0	$47.0	to	$52.0	$110.0	to	$135.0	$584.0	to	$736.0
7- Lower San Joaquin Region	$7.0	to	$8.0	$626.0	to	$809.0	$17.0	to	$19.0	$82.0	to	$97.0	$732.0	to	$933.0
8- Mid - San Joaquin Region	$60.0	to	$102.0	$0.0	to	$0.0	$48.0	to	$55.0	$81.0	to	$96.0	$189.0	to	$253.0
9- Upper San Joaquin Region	$229.0	to	$297.0	$166.0	to	$199.0	$183.0	to	$189.0	$308.0	to	$396.0	$886.0	to	$1,081.0
Total	**$5,142.0**	**to**	**$6,501.0**	**$5,496.0**	**to**	**$6,675.0**	**$1,772.0**	**to**	**$1,873.0**	**$1,511.0**	**to**	**$1,863.0**	**$13,921.0**	**to**	**$16,912.0**

Note:
All cost estimates are based on 2011 costs rounded to nearest $ million

4.0 Flood Management Elements

This section documents the cost assumptions details for the following four primary flood management elements:

1. System Improvement Element
2. Urban Improvement Element
3. Rural-Agricultural Improvement Element
4. Residual Risk Management Element

The flood management elements used in this preliminary cost estimate are at an appraisal level of detail, and should be used for planning purposes only. These cost estimates will be further refined in future feasibility studies.

4.1 System Improvement Element

The bypass and levee system of the SPFC have provided systemwide benefits of flood protection. The System improvements are intended to improve the flood operations for the system as a whole and provide areas to enhance the ecosystem. These systemwide improvements would lower peak flood flows throughout the system from the reservoirs downstream, providing further improvements in flood protection for urban, small communities, and rural-agricultural areas.

This flood management element includes purchasing land and easements for the bypasses and levees, making environmental improvements to the lands included in the expanded bypasses. Additional and improved flood management structures are needed to pass the flood flows into and out of the bypass system. This includes weirs, gates, pumping plants, fish screens, and bypass structures to improve fish passage. Reservoir improvements for flood protection include improved and coordinated operations and expanded flood storage. In addition to using the foothill reservoirs to manage the flood peaks, additional storage is being considered on the valley floor. Historic use of the bypass system has resulted in sedimentation near some of the gates and weirs in the bypasses that reduces their performance. Therefore, rehabilitation of existing facilities is also required.

The locations of the major system improvements for the Sacramento River Basin and San Joaquin River Basin are shown in Figures 3-1 and 3-2, respectively. The flood management components identified to support System improvements include:

- Land acquisition
- Agricultural conservation easement
- Ecosystem restoration and enhancement
- Levee improvements for new and expanded bypasses
- New levee construction
- Improving existing levees
- Flood system structures
- Major flood system structures
- Fish passage structures
- Forecast-Coordination Operations (F-CO) and Forecast-Based Operations (F-BO)
- New reservoir flood storage/enlarge flood pool
- Easements
- System erosion and bypass sediment removal projects

Each of these system improvement flood management elements is described in detail below and includes assumptions used for the planning-level cost estimates.

4.1.1 Land Acquisition

The land acquisition component includes the purchase of lands (fee and title) needed for expansion and extension of the bypasses identified in the CVFPP Framework. The specific projects and the associated land acquisition acreages are listed in Table 4-1. The cost to acquire lands varies throughout the Sacramento and San Joaquin River Basins due in part to their location relative to urban areas, and the existing agricultural development (i.e., lands with permanent crops have a higher cost than annual crops). The range of cost estimates for land acquisition is listed in

Table 4-2. Land acquisition costs are based on a market value analysis and include costs of structure relocations. Additional information on development of land acquisition acreage and cost are included in Attachment 8J, Appendices B through E.

Table 4-1. Land Acquisition Acreage for Bypass Expansions

Name	Region	Area (acres)
Feather River Bypass	Feather River Region	5,000
Sutter Bypass Expansion	Feather River Region	4,000
Yolo Bypass Expansion	Lower Sacramento and Delta North Regions	25,500
Sacramento Bypass Expansion	Lower Sacramento Region	1,300
Lower San Joaquin Bypass Expansion	Delta South Region	1,000
Total		**36,800**

Table 4-2. Land Acquisition Costs for Bypass Expansions

Region	Land Purchase Price ($/acre)
1- Upper Sacramento	$10,000 to $12,000
2- Mid-Sacramento	$10,000 to $12,000
3- Feather River	$15,000 to $17,000
4- Lower Sacramento	$18,000 to $20,000
5- Delta North	$12,000 to $14,000
6- Delta South	$12,000 to $14,000
7- Lower San Joaquin	$15,000 to $17,000
8- Mid-San Joaquin	$11,000 to $13,000
9- Upper San Joaquin	$11,000 to $13,000

4.1.2 Agricultural Conservation Easements

Agricultural conservation easements include lands on the landward side of levees that will be preserved in current land use (primarily agriculture). This will also reduce future development in the floodplains. While specific agricultural conservation easements (acreages) have not been identified at this time, the assumptions for the distribution of agricultural conservation easements are listed in Table 4-3. The cost for agricultural conservation easements is estimated to be 35 percent of the cost to purchase lands (listed in Table 4-2). Agricultural conservation easement costs estimated at 35 percent of the actual land-use costs are based on the range of agricultural

easement costs from other projects in the Central Valley identified by DWR Flood Projects Office and Flood Maintenance Office.

Table 4-3. Agricultural Conservation Easements

Region	Area (acres)
1- Upper Sacramento	5,000 to 10,000
2- Mid-Sacramento	10,000 to 15,000
3- Feather River	15,000 to 25,000
4- Lower Sacramento	5,000 to 10,000
5- Delta North	5,000 to 10,000
6- Delta South	10,000 to 15,000
7- Lower San Joaquin	0 to 0
8- Mid-San Joaquin	10,000 to 15,000
9- Upper San Joaquin	10,000 to 15,000
Total	**70,000 to 115,000**

4.1.3 Ecosystem Restoration and Enhancement

The ecosystem restoration and enhancement elements are integrated within two of the approaches and are primarily associated with the system improvements. These include development of habitat within the flood corridor described in this section, and fish passage improvements that are presented in the Flood System Structures section.

The ecosystem restoration and enhancement elements include the costs for making environmental enhancements to the lands acquired for bypass expansions to improve habitat and provide for a more contiguous habitat throughout the flood protection system. The land acreage estimates are based on individual bypass areas identified in the CVFPP. Acreages estimates based on GIS analysis are listed in Table 4-4. These reflect a fairly uniform distribution of the acreage throughout the area where bypass expansions are planned. This may be modified, based on future studies, to reflect environmental conservation priorities.

For planning purposes, it was estimated that 25 percent of the lands acquired for bypass expansion would be developed for environmental conservation. The remaining 75 percent of the lands (not used for levee construction) would be leased back to farmers for environmentally friendly agricultural practices such as planting of corn, rice, and other grains. For the Sutter Bypass Expansion it was assumed that 50 percent of the lands

acquired for the bypass expansion would be developed for environmental conservation.

The costs for environmental conservation are estimated to range from $35,000 to $45,000 per acre. These cost estimates are based on recent environmental conservation in the Sacramento River Basin identified by DWR Division of Flood Management, which includes activities such as permitting and planting native vegetation.

The Enhanced Flood System Capacity Approach and the State Systemwide Investment Approach include $50 million for ecosystem improvement projects associated with the Upper San Joaquin River Restoration.

Table 4-4. Environmental Conservation Acreages

Name	Region	Area (acres)
Feather River Bypass	Feather River	1,300
Sutter Bypass Expansion	Feather River	2,000
Yolo Bypass Expansion	Lower Sacramento and Delta North	6,500
Sacramento Bypass Expansion	Lower Sacramento	400
Lower San Joaquin Bypass Expansion	Delta South	300
Total		**10,500**

4.1.4 Levee Improvements for New and Expanded Bypasses

Improvements to the flood protection system levees for bypass expansion are intended to cost effectively expand the capacity of the SPFC by removing known flow constraints and increase the capacity of the bypasses to carry more water at a lesser stage. This approach includes building new levees where needed to extend or expand the bypass capacity and, where appropriate, make improvements to existing levees to bring them up to current levee performance criteria. In the case of expanded bypasses, the approach only moves the levee on one side of the bypass to provide the increased capacity, and improves the levee on the other side to meet the current performance standards. For purposes of this analysis, generally levees on the uphill side of the bypass would be improved while the levees on the downhill side of the bypass would be relocated. The specifics of the system levee improvements are described below.

New Levee Construction

New levee construction includes levees needed to construct new or expanded bypasses identified in the CVFPP. The levee lengths were

estimated based on GIS analysis at the specific levee locations listed in Table 4-5. These lengths are rounded up to the nearest half mile. Costs for the new levee construction are estimated to range from $22 million (low) to $26 million (high) per levee mile. These estimates are based on recent urban levees constructed for SAFCA and Three Rivers Levee Improvement Authority (TRLIA) projects.

Table 4-5. New Levees Needed for System Improvements

Name	Region	Length	Estimated Range of Costs ($ millions)
Cherokee Canal – left bank	Feather River	15.5 miles	$341 to $403
Sutter Bypass – left bank	Feather River	15 miles	$330 to $390
Sacramento Bypass – left bank	Lower Sacramento	2.0 miles	$44 to $52
Yolo Bypass near Freemont Weir left bank	Lower Sacramento	2.5 miles	$55 to $65
Yolo Bypass upstream of Putah Creek – right bank	Lower Sacramento	16.5 miles	$363 to $429
Yolo Bypass downstream of Putah Creek and near Rio Vista – right bank	Delta North	18.5 miles	$407 to $481
Lower San Joaquin Bypass Expansion Paradise Cut/San Joaquin River – left bank	Delta South	7.5 miles	$165 to $195
Total		**77.5 miles**	**$1,705 to $2,015**

Improving Existing Levees

This component includes improving existing levees that provide a system benefit as identified in the CVFPP. The levee lengths were estimated based on GIS analysis. Levee lengths are based on the specific levee locations listed on Table 4-6. The cost estimates range from $14 million (low) to $18 million (high) per levee mile. The cost estimates are based on per-mile estimates from the DWR Levee Evaluations Program included in Attachment 8J, Appendices B and C. The selected levee improvements for expanding and extending the bypass system required a total of 77.5 miles of new levees and improvements to 23.5 miles of existing levees.

Table 4-6. Levee Repairs Needed for System Improvements

Name	Region	Length	Estimated Range of Costs ($ millions)
Cherokee Canal – right bank	Feather River	15.0 miles	$210 to $270
Sacramento Bypass – right bank	Lower Sacramento	2.0 miles	$28 to $36
Lower San Joaquin Bypass Expansion Paradise Cut/San Joaquin River – right bank	Delta South	6.5 miles	$91 to $117
Total		**23.5 miles**	**$329 to $423**

4.1.5 Flood System Structures

In addition to the improvements and expansion of the levee system identified above, improvements are needed to existing hydraulic structures to improve the ability to move flood waters into and out of the bypass system, and provide additional ecosystem benefits such as supporting improved fish passage (described below). The major flood system structures are identified in Table 4-7. Where available, facility-specific cost estimates were used for the new system improvements. When no information was available for identified new facilities, the facility-specific cost estimates were used to guide cost estimates. Costs for additional improvements needed to increase or restore capacity for existing facilities were identified and estimated by the DWR Flood Maintenance Office.

Table 4-7. Flood System Structures Included in System Improvements

Major Flood System Structures	Region	Estimated Range of Costs ($ millions)
Intake Structure for Feather River Bypass	Feather River	$30 to $35
Butte Basin Small Weir Structures	Upper Sacramento	$15 to $20
Upgrade and Modification of Colusa and Tisdale Weirs and Modification to County	Mid-Sacramento	$25 to $35
Freemont Weir Widening	Mid-Sacramento	$25 to $40
Sacramento Weir Widening and Automation	Lower Sacramento	$200 to $240
Gate Structures and/or Weir for new Lower San Joaquin Bypass (Paradise Cut)	Delta South	$20 to $25
Upgrade Structures in the Upper San Joaquin Bypasses (includes Chowchilla, Mariposa, and East Side Bypasses)	Upper San Joaquin	$45 to $55
Low Level Reservoir Outlets on New Bullards Bar	Feather River	$35 to $50
Identified Flood Structure Improvements	Various	$133 to $192
TOTAL		**$528 to $692**

4.1.6 Fish Passage Structures

Additional ecosystem benefits such as supporting improved fish passage can be included in the expansion and improvements to the bypass system as identified above. Fish passage improvement opportunities include primarily projects located within the SPFC, but also include additional projects located outside the SPFC that are critical to fish passage through the SPFC. Fish passage priorities developed based on information from the CVFPP Attachment 9C: Fish Passage Assessment.

No detailed costs estimates are available for the fish passage improvements being considered at this time, so the costs were approximated using information from other comparable projects. A 2003 draft report of alternative fish passage improvement projects on the Yuba River at Daguerre Point Dam that evaluated eight concepts for improving fish passage with costs ranging from $2.5 million to $97 million was used to bookend potential fish passage improvement costs. This report demonstrates the potential range of costs for an individual fish passage improvement project, which depends on location, number, and size of the required improvements. The projects identified at this time (and their estimated project costs) are listed in Table 4-8.

Table 4-8. Fish Passage Improvements Included in System Improvements

Major Fish Passage Improvement Structures	Region	Estimated Range of Costs ($ millions)
Sutter Bypass and Streams East of Butte Basin	Feather River	$80 to $85
Fremont Weir Improved Fish Passage	Lower Sacramento	$15 to $20
Yolo Bypass Fish Passage Improvements/Willow Slough Weir	Lower Sacramento	$30 to $40
Deer Creek Project	Upper Sacramento	$5 to $10
TOTAL		**$110 to $155**

Additional activities to improve fish passage include the following.

- **Fish Passage Collaboration** – This component includes collaboration activities with the U.S. Department of the Interior, Bureau of Reclamation and other agencies to advance fish passage opportunities. Costs for these activities are estimated at $25 million, and are included in the risk assessment, feasibility, engineering, and permitting of the fish passage projects. The collaboration activities may include the following reservoirs:

  - Shasta
  - Keswick
  - Cottonwood
  - Red Bluff Diversion
  - New Bullards Bar
  - Daguerre Point
  - Englebright
  - Thermalito Diversion
  - Oroville dams
  - New Melones
  - Tulloch
  - Camanche
  - Pardee
  - Don Pedro
  - New Hogan

  - Exchequer
  - Webster
  - La Grange
  - McSwain
  - Friant
  - Goodwin

- **Fish Passage Feasibility Studies** – This component includes fish passage assessments and feasibility studies to improve fish passage opportunities for SPFC facilities. Costs for these activities are included in the risk assessment, feasibility, engineering, and permitting, of the residual risk management cost element.

4.1.7 Reservoir Operations – Forecast-Coordinated Operations/Forecast-Based Operations

Forecast-Coordinated Operations and Forecast-Based Operations provide systemwide flood benefits by supporting the coordinated reoperation of multiple reservoirs on both the Sacramento River Basin (up to seven reservoirs) and the San Joaquin River Basin (up to eight reservoirs). The costs are estimated to range from $4.5 million to $6.0 million per reservoir to develop F-CO/F-BO capabilities. The total cost for this component is estimated to range from $69 to $90 million. These costs are estimated based on current F-CO project costs for Yuba-Feather River Basin Forecast-Coordinated Operations. The range of costs for this element was reviewed by the DWR Hydrology and Flood Operations Office.

4.1.8 New Reservoir Flood Storage/Enlarge Flood Pool

This flood management component includes additional storage developed in existing foothill reservoirs, either through physical improvements to the facilities or for the costs to replace water supply lost through increasing the flood storage conservation pool.

It should be noted that the enlargement of Folsom Dam to provide additional flood storage has already been authorized as part of the improvements to increase the level of flood protection to the City of Sacramento, so it is included in the urban improvements. Raising Shasta Dam to increase the flood conservation pool was also considered, but is not included because it was not determined to be cost effective for flood management. The costs presented in Table 4-9 are estimated based on prior reports. Some of the data sources used to estimate the range of costs for new flood storage or multipurpose facilities or replacement for water supplies to mitigate for storage reallocation or reoperation include:

- Shasta Lake Water Resources Investigation (Reclamation, 2011)
- North of Delta Offstream Storage (DWR, 2010)
- Upper San Joaquin River Basin Storage Investigation (Reclamation, 2008)
- Formulation and Analysis of Alternatives for Supplemental Flood Control Program on the Yuba River (YCWA, 1999)

Table 4-9. New Reservoir Flood Storage

New Reservoir Storage	Region	Estimated Range of Costs ($ millions)
Lake Oroville and New Bullards Bar	Feather River	$200 to 300
Don Pedro and McClure Reservoirs	Mid-San Joaquin	$400 to $600
Friant Dam or New Upstream Reservoir	Upper San Joaquin	$500 to $1,500
Total		**$1,100 to $2,400**

4.1.9 Easements

Easements include the temporary and periodic storage of peak flood flows from adjacent rivers or waterways through the modification of certain floodplain areas acquired through easement or fee title. While specific transitory storage locations were not identified, the regional assumptions of the need for and corresponding costs for transitory storage are listed in Table 4-10. These estimates are based on the assumption of needing approximately 200,000 acre-feet of storage in the Sacramento River Basin, and 100,000 acre-feet of storage in the San Joaquin River Basin, based on preliminary hydraulic modeling studies. Additional facilities such as flow control structures are needed in addition to the acreage requirements listed in Table 4-10. The costs include estimates for the easements and facilities. The land acreage costs were estimated to be 60 percent of the region's land purchase costs listed in Table 4-2 for the low and high ends of the range. Additional information about the land costs is included in Attachment 8J, Appendices B-E. Table 4-10 includes the costs for the additional facilities needed to move water into and out of the easements. The costs for these facilities were estimated using the approach used to estimate the new flood structures listed above.

Table 4-10. Easements

Region	Area (acres)	Estimated Range of Costs ($ millions)
1- Upper Sacramento	10,000 to 15,000	$165 to $213
2- Mid-Sacramento	20,000 to 25,000	$275 to $355
3- Feather River	5,000 to 10,000	$140 to $172
4- Lower Sacramento	None	$0
5- Delta North	None	$0
6- Delta South	None	$0
7- Lower San Joaquin	None	$0
8- Mid-San Joaquin	10,000 to 15,000	$174 to $222
9- Upper San Joaquin	5,000 to 10,000	$116 to $148
Total	**50,000 to 75,000**	**$870 to $1,110**

4.1.10 System Erosion and Bypass Sediment Removal Projects

System erosion and bypass sediment removal projects address the need to remove sediment that has accumulated over time in the bypasses and behind weirs. These projects are necessary to maintain proper functioning of the bypass system. While sediment removal can be considered a routine operations and maintenance (O&M) cost, these projects identified here represent specific large-scale projects that have been identified at this point in time as a result of deferred maintenance. It is anticipated that maintenance will be performed on a routine and ongoing basis to avoid such projects in the future. Table 4-11 lists the sediment removal projects included as part of the system improvement flood management components.

Table 4-11. System Erosion and Bypass Sediment Removal

Region	Estimated Range of Costs ($ millions)
1- Upper Sacramento	None
2- Mid-Sacramento Cache Creek Settling Basin Sediment Management Project	$30 to $35
3- Feather River	None
4- Lower Sacramento Sacramento System Sediment Remediation Downstream from Weirs	$30 to $40
5- Delta North	None
6- Delta South	None
7- Lower San Joaquin	None
8- Mid-San Joaquin	None
9- Upper San Joaquin	None
Total	**$60 to $75**

4.2 Urban Improvement Element

Urban areas located within the areas protected by the facilities of the SPFC and non-SPFC appurtenant facilities are defined as a developed area in which there are 10,000 residents or more. The SPFC provides flood protection to close to 1 million people living in urban areas. The urban areas located within the SPFC are generally concentrated in a few regions (Feather River, Lower Sacramento, and Lower San Joaquin) in the Sacramento and San Joaquin river basins as shown on Figures 4-2 and 4-3.

Three options are considered for urban improvements.

4.2.1 Option 1: 200-Year Level of Protection Projects

In this option, the urban areas are looking to achieve an urban level of protection that is defined as the ability to withstand flooding that has a 1-in-200 chance of occurring in any given year using criteria consistent with, or developed by, the DWR.

DWR Flood Project Office compiled a list of projects and preliminary cost estimates for achieving 200-year level of flood protection in the Central Valley. This list was compiled using information provided by local agencies to DWR. Table 4-12 lists projects that were identified for inclusion as urban improvements.

Because many of these projects have a higher level of engineering and include allowances for engineering contingencies in their estimates, the risk assessment, feasibility, engineering, and permitting costs are set at 20 percent of the estimated project cost instead of 25 percent as is for the other improvements. This markup is included on the project list shown in Table 4-12.

A project cost was provided by DWR Flood Projects Office for each urban area. For purposes of this cost estimate, these were estimated to be low cost. In most cases, the low project cost estimate was increased by 20 percent to provide the high end of the cost estimate. For projects that have advance design studies, or are in progress or completed, the low and high costs are the same (i.e. 0 percent increase between low and high estimate). These projects also have a higher level of engineering already completed compared to other urban improvement projects, so there are no additional risk assessment, feasibility, engineering, and permitting costs included in the estimates.

Option 1 costs are used in the Protect High-Risk Communities Approach, Enhance Flood System Communities Approach, and the SSIA.

Table 4-12. Flood Risk Reduction Projects Included in Urban Improvements

Name	Region	Estimated Range of Costs ($ millions)
Chico Urban Levee Improvements	Upper Sacramento	$100.0 to $120.0
Sutter County Feasibility Study	Feather River	$8.5 to $10.2
Feather River West Levee SBFCA	Feather River	$245.0 to $294.0
LD1-EIP-Lower Feather River Setback Levee at Star Bend *	Feather River	$20.8
Marysville Ring Levee Reconstruction	Feather River	$161.9 to $194.3
Yuba River Basin GRR	Feather River	$15.4 to $18.5
TRLIA – EIP – Feather River Levee Improvement Project	Feather River	$222.0 to $266.4
TRLIA – EIP – Upper Yuba River Levee Improvement Project *	Feather River	$68.0
RD 2103 EIP - Bear River North Levee Rehabilitation *	Feather River	$18.2
American River Common Components Project/GRR	Lower Sacramento	$12.8 to $15.4
American River Common Components-WRDA96/99 Projects/Remaining Sites	Lower Sacramento	$282.0 to $338.4
Folsom Dam Modifications - Joint Federal Project (Gated Auxiliary Spillway)	Lower Sacramento	$800.0 to $1,000.0

Table 4-12. Flood Risk Reduction Projects included in Urban Improvements (contd.)

Name	Region	Estimated Range of Costs ($ millions)
Folsom Dam Raise – Reservoir Enlargement	Lower Sacramento	$125.0 to $130.0
Folsom Dam Raise, Bridge Element and Implementation	Lower Sacramento	$130.0 to $140.0
South Sacramento County Streams	Lower Sacramento	$104.0 to $124.8
SAFCA-EIP-NCC Natomas Levee Improvement Project	Lower Sacramento	$70.0 to $84.0
SAFCA-NLIP, Natomas Levee Improvement Project	Lower Sacramento	$310.0 to $372.0
Natomas Basin Design and Construction	Lower Sacramento	$385.0 to $462.0
Magpie Creek Project	Lower Sacramento	$9.8 to $11.8
American River South and Sacramento River Future Improvements	Lower Sacramento	$500.0 to $600.0
Slip Repair	Lower Sacramento	$53.0 to $63.6
WSAFCA-EIP-CO West Sacramento	Lower Sacramento	$105.0 to $126.0
West Sacramento Project GGR	Lower Sacramento	$10.0 to $12.0
Woodland/ Lower Cache Creek Feasibility Study and Implementation	Lower Sacramento	$190.0 to $210.0
Davis-Willow Slough	Lower Sacramento	$30.0 to $36.0
Lower San Joaquin Feasibility Study	Lower San Joaquin	$15.4 to $18.5
RD 17-EIP-100-Year Levee Seepage Area Project	Lower San Joaquin	$76.0 to $91.2
Mormon Slough Bypass/ Stockton Diverter Canal	Lower San Joaquin	$40.0 to $48.0
Smith Canal Closure Structure (EIP Project)	Lower San Joaquin	$30.0 to $36.0
Merced County Streams Group (Bear Creek Unit)	Upper San Joaquin	$137.7 to $165.2
TOTAL		**$4,277.0 to $5,097.0**

Key:
EIP = Early Implementation Program
GRR = General Reevaluation Report
LD = lacking sufficient data
NCC = Natomas Cross Canal
NLIP = Natomas Levee Improvement Project
RD = Reclamation District
SAFCA = Sacramento Area Flood Control Agency
SBFCA = Sutter Buttes Flood Control Agency
TRLIA = Three Rivers Levee Improvement Authority
WSAFCA = West Sacramento Area Flood Control Agency

Notes:
* Construction of flood improvement project is completed. Not cost range is identified and contingencies for risk assessment, feasibility, and permitting are not applied.

4.2.2 Option 2: Urban Levee Improvements to Achieve SPFC Design Flow Capacity

The ULE Program evaluated the condition of approximately 290 miles of SPFC urban levees and the cost of the necessary remediations. The ULE Program cost estimates used in this analysis are based on achieving the SPFC design capacity, but may not necessarily provide the 200-year level of protection established as one of the goals of the CVFPP. In this option, repairs to urban project levees were identified by the Urban Levee Evaluations Program. Table 4-13 summarizes the extent of the levee repairs needed for the urban areas included in the ULE Program. While this option improves the urban levees to achieve the SPFC design flow capacity, the actual level of flood protection varies with location and may not provide a 200-year level of flood protection. Additional analysis is needed to determine the level of protection provided from implementation of this option.

The levee repair lengths shown in Table 4-13 represent the repair lengths (determined independently) for structural remediations, erosion remediations, freeboard and geometry remediations, and pier wall or joint remediations. As such, the repair lengths may differ from the total levee length shown in Table 4-13. The costs used in Table 4-13 are estimates from the ULE Program (Attachment 8J, Appendix B) and were used as the low end of the costs estimate.

Table 4-13. SPFC Urban Levee Improvements from the Urban Levee Evaluation Program

Urban Area	Region	Total Levee Length (Feet)	Levee Repair Length (Feet)	Estimated Range of Repair Costs ($ millions)
Marysville	Feather River	39,220	43,830	$146 to $176
RD 784	Feather River	22,940	35,750	$62 to $75
Sutter	Feather River	241,970	262,140	$790 to $948
American River	Lower Sacramento	9,910	9,910	$17 to $21
Natomas NWS	Lower Sacramento	40,040	40,040	$123 to $148
Natomas EMDC East	Lower Sacramento	38,000	30,740	$123 to $148
Natomas EMDC West	Lower Sacramento	76,880	79,120	$128 to $154
Sacramento River	Lower Sacramento	18,400	28,900	$174 to 209
West Sacramento	Lower Sacramento	84,600	77,620	$395 to $474
Davis	Lower Sacramento	96,500	139,550	$150 to $180
Woodland	Lower Sacramento	82,800	125,510	$168 to $202
RD 17	Lower San Joaquin	50,400	48,500	$135 to $ 162
RD 404	Lower San Joaquin	10,300	20,600	$26 to $32
SJAFCA Calaveras River	Lower San Joaquin	7,690	7,680	$22 to $27
SJAFCA Bear Creek	Lower San Joaquin	86,910	23,910	$17 to $21
Total		**906,560**	**973,280**	**$2,476 to $2,977**

4.2.3 Option 3: Non-SPFC Urban Levee Improvements

This component includes improving existing non-SPFC urban levees. There are approximately 120 miles of non-SPFC urban levees that support the SPFC urban levees to provide some level of flood protection. The levee lengths were estimated based on GIS analysis. The conditions of these levees will not be evaluated by ULE until 2013. For purposes of this cost estimate it was assumed that some level of repair to these levees would be necessary to avoid having weak links in the urban flood protection. These levees are typically located on the tributary streams and not in the deep floodplain, so they may be smaller than other urban levees. In addition, some of these levees in the Stockton area have already had some improvements completed through the efforts of the San Joaquin Flood Area Flood Control Agency. As a result, the improvements for the non-SFPC urban levees are lower than the SPFC urban levees (Attachment 8J, Appendix B) and are estimated to range from $6 million (low) to $8 million

(high) per levee mile. Table 4-14 presents the distribution of the non-SPFC levee miles and estimated costs used in this estimate.

Option 3 costs are used in the Achieve SPFC Design Capacity Approach, Protect High-Risk Communities Approach, Enhance Flood System Communities Approach, and the SSIA.

Table 4-14. Non-SPFC Urban Levee Improvements

Region	Estimated Levee Length (miles)	Estimated Range of Costs ($ millions)
1- Upper Sacramento	0	$0
2- Mid-Sacramento	0	$0
3- Feather River	0	$0
4- Lower Sacramento	40	$240 to $320
5- Delta North	20	$120 to $160
6- Delta South	0	$0
7- Lower San Joaquin	60	$360 to $480
8- Mid-San Joaquin	0	$0
9- Upper San Joaquin	0	$0
Total	**120**	**$720 to $960**

Key:
SPFC = State Plan of Flood Control

4.3 Rural-Agricultural Improvement Element

The Rural-Agricultural Improvements flood management element addresses the flood protection needs of the largely agricultural rural areas and the small communities that are disbursed throughout these areas (both located within the area protected by the SPFC).

In contrast to the urban areas, the rural-agricultural areas include a total population of approximately 100,000, which are disbursed throughout the areas protected by the SPFC. In the Sacramento and San Joaquin river basins, much of the lands in the rural-agricultural areas are agricultural, and landowners cannot afford the level of flood protection proposed for the urban areas.

For planning purposes, a cost improvement threshold of $30,000 per person (approximately $100,000 per household) threshold was established to determine the type and extent of improvements that may be practical and cost effective for the rural-agricultural areas. Two methods are considered

to address the flood threat in rural-agricultural areas. If costs for structural methods exceed the threshold, then non-structural methods would be used, as follows:

- Structural methods include repairs to existing rural-agricultural levees and/or the construction of new levees. These include the small community improvements and the rural-agricultural levee improvements.

- Nonstructural methods include flood-proofing houses or purchasing and relocating houses (estimated to be applied in the rural-agricultural areas). These nonstructural methods are described later in the floodplain management element of residual risk management.

4.3.1 Small Community Improvements

There are small communities at high flood risk in the rural-agricultural areas. Some of the small communities that are subject to flooding are located in low-lying areas or adjacent to the rivers and may already have some level of flood protection offered by existing levees. Table 4-15 presents the distribution of the small communities by region.

Table 4-15. Identified Small Communities within State Plan of Flood Control

Region	Small Communities
1- Upper Sacramento	Durham, Gerber-Las Flores
2- Mid-Sacramento	Knights Landing, Glenn, Meridian, Colusa, Grimes, Butte City, Robbins, Princeton
3- Feather River	Verona, Biggs, Gridley, Live Oak, Sutter, Tierra Buena, Wheatland
4- Lower Sacramento	
5- Delta North	Rio Vista, Clarksburg, Courtland, Hood, Walnut Grove, Isleton
6- Delta South	
7- Lower San Joaquin	
8- Mid-San Joaquin	Grayson
9- Upper San Joaquin	Dos Palos, South Dos Palos, Firebaugh
Total	

The assumptions for estimating the small community improvement costs are listed below. Because the small community improvements are addressed differently in each approach, they are all described here and summarized in Table 4-16. Attachment 8J, Appendix D, provides additional information about the small community cost estimates.

Table 4-16. Comparison of Levee Improvements for Small Communities

	Achieve SPFC Design Flow Capacity Approach	Protect High Risk Communities Approach	Enhance Flood System Capacity Approach	State Systemwide Investment Approach
Number of Communities Receiving Improved Flood Protection from System, Urban or Rural-Agricultural Improvements	27	5	16	5
Number of Communities Explicitly Protected by Small Community Improvement	None	22	11	15
Number of Communities Receiving Benefits from Improved Floodplain Management	None	None	None	7
Approximate New Levee Miles	None	N/A	60[1]	40[3]
Approximate Fixed Levee Miles	60[2]	N/A	60[2]	40[3]
Combined Fixed/New Levee Miles	None	120	N/A	80
Estimated Population benefited from Small Community Improvement	None	47,000	47,000	39,000
Estimated Cost	None	$1,003 million	$344 million	$555 million

Notes:
[1] Estimated one-half of the total levee miles for the small communities would be new.
[2] Existing levees around small communities would be improved as part of the recommendations from the Non-Urban Levee Evaluation Program. Estimated one-half of the total miles would receive repairs.
[3] The 80-mile estimate is the total length of new levees (40-miles) and improved levees (40-miles) needed to protect the selected 15 communities.
Key:
N/A = Not Applicable
SPFC = State Plan of Flood Control

4.3.2 Rural-Agricultural Levee Improvements

The facilities of the SPFC currently provide flood protection to rural-agricultural areas through the approximately 1,200 miles of rural-agricultural levees. These levees provide varying degrees of flood protection to different areas, and differ in their condition and state of repair. The need for improvements to the rural levee system has been recently identified though two separate options:

- **Option1** – Site-specific rural-agricultural improvements
- **Option 2** – NULE Program

Option 1: Site Specific Rural-Agricultural Improvements

The alternative rural-agricultural improvements include improvements identified from recent levee inspections and other levee deficiencies as described below.

- **2011 Levee Inspection Reports for the Sacramento and San Joaquin Basins** – The results of the 2011 inspections identified more than 40 miles of levee repairs on the nonurban levees of the SPFC in both the Sacramento and San Joaquin river basins. These include repairs on the water side and land side of the levees. The levee repair lengths and estimated repair costs are summarized by region in Table 4-17. Cost estimates were provided by DWR Flood Maintenance Office.
- **Levee Improvements** – Levee improvements includes levee freeboard improvements identified in the NULE Program (Attachment 8J, Appendix C – Non-Urban Levee Evaluations Project Remediation Alternatives and Cost Estimate Report). Improvements are estimated for all rural levees (1,200 miles) less system bypass levees (approximately 350 miles) by region. Table 4-18 includes the estimated distribution of levee miles and approximate costs.

Table 4-17. Erosion Repair Needs and Cost Estimate per Region

Region	Erosion Length (feet)	Repair Length (feet)	Estimated Costs ($ millions)
1- Upper Sacramento	628	942	$2.3
2- Mid-Sacramento	31,607	47,410	$118.5
3- Feather River	7,416	11,125	$27.8
4- Lower Sacramento	6,306	9,460	$23.7
5- Delta North	83,308	124,962	$312.4
6- Delta South	4,830	7,245	$18.1
7- Lower San Joaquin	1,255	1,882	$4.7
8- Mid-San Joaquin	2,535	3,802	$9.5
9- Upper San Joaquin	1,570	2,355	$5.9
Total	**139,455**	**289,183**	**$522.9**

Table 4-18. Levee Improvements

Region	Rural Levee Length (miles)	Estimated Range of Costs ($ millions)
1- Upper Sacramento	71	$46 to $57
2- Mid-Sacramento	211	$62 to $77
3- Feather River	72	$24 to $30
4- Lower Sacramento	23	$37 to $46
5- Delta North	202	$93 to $117
6- Delta South	54	$18 to $22
7- Lower San Joaquin	38	$8 to $10
8- Mid - San Joaquin	51	$25 to $31
9- Upper San Joaquin	128	$19 to $24
Total	**850**	**$332 to $414**

Option 2: Non-Urban Levee Evaluation Program

The purpose of the NULE Program was to determine the approximate cost to repair non-urban project and non-project levees in the Sacramento and San Joaquin river basins. The results of these efforts are summarized in Attachment 8J, Appendix C – Non-Urban Levee Evaluations Project Remediation Alternatives and Cost Estimate Report, and include remediation alternatives to address deficiencies and determine likely conceptual planning-level remediation costs. The deficiencies identified in

the Geotechnical Assessment Report (GAR) included under seepage, through seepage, stability, erosion, and freeboard/geometry deficiency that could exist along levee segments for the design basis water level. The deficiencies were identified based on limited, existing surface and subsurface levee data and past performance history. The costs of the nonurban levee repairs are summarized by region in Table 4-19.

These estimates include repairs to SPFC project levees only. The NULE cost estimates for non-project levees were removed from the cost estimate because the non-project levees were not included in the CVFPP. The State may choose to participate in funding improvements for non-SPFC levees under other State programs. Each levee segment is characterized based on its hazard level, as defined below.

- **Hazard Level A** – When water reaches the assessment water-surface elevation (WSE), there is a low likelihood of either levee failure or the need to flood-fight to prevent levee failure.

- **Hazard Level B** – When water reaches the assessment WSE, there is a moderate likelihood of either levee failure or the need to flood-fight to prevent levee failure.

- **Hazard Level C** – When water reaches the assessment WSE, there is a high likelihood of either levee failure or the need to flood-fight to prevent levee failure.

- **Lacking Sufficient Data (Category LD)** – The segment is currently lacking sufficient data about past performance or hazard indicators to be able to assign a hazard level, or there is poor correlation between past performance and hazard indicators.

In the CVFPP, these hazard designations are identified as listed below:

- Low Concern (Hazard Level A)

- Medium Concern (Hazard Level B)

- High Concern (Hazard Level C)

All deficiencies categorized as B, C, or LD were estimated to require remediation. Segments with an overall Category A classification that had a freeboard/geometry deficiency were remediated for the freeboard/geometry deficiency.

Table 4-19. Non-Urban Levee Evaluation Program

Region	Corresponding Geotechnical Assessment Report Area	Estimated Cost ($ millions)
1- Upper Sacramento	NULE North GAR 1	$408
2- Mid-Sacramento	NULE North GAR 2	$2,577
3- Feather River	NULE North GAR 3	$1,630
4- Lower Sacramento	NULE North GAR 4	$1,147
5- Delta North	NULE North GAR 5	$3,111
6- Delta South	NULE South GAR 1 (70%)	$503
7- Lower San Joaquin	NULE South GAR 1 (30%)	$272
8- Mid-San Joaquin	NULE South GAR 2	$378
9- Upper San Joaquin	NULE South GAR 3	$1,043
Total		**$11,069**

Key:
GAR = Geotechnical Assessment Report
NULE = Non-Urban Levee Evaluation

4.3.3 Setback Levees

This component includes the construction of setback levees at nine locations in the Sacramento and San Joaquin river basins. These projects include the replacement of approximately 93 miles of levees with 65 miles of new levees and the in-place repair of 60 miles of levees. These projects will require the purchase of between 26,000 and 35,000 acres for the setback areas and associated lands that are part of the same land parcels. As part of these projects, the levees that are being replaced will have to be removed. Ecosystem restoration of the lands, returned to the floodplain will take place through the natural riverine processes (no additional restoration activities are included in this cost estimate). These projects have limited hydraulic impact/benefit, but do provide for localized improved levees and add lands to the floodplain. The project cost estimates listed in Table 4-20 were developed based on Attachment 8J –Appendix E – Flood Corridor Expansion.

Table 4-20. Setback Levees

Location	Region	Range of Estimated Cost ($ millions)
FTR_01	Feather River	$380 to $520
MSAC_01	Mid-Sacramento	$ 200 to $300
MSAC_02	Mid-Sacramento	$390 to $550
MSA_03	Mid-Sacramento	$350 to $490
LSJ_01	Lower San Joaquin	$360 to $510
LSJ_02	Lower San Joaquin	$340 to $480
MSJ_01	Mid-San Joaquin	$400 to $540
USJ_01	Upper San Joaquin	$270 to $380
USJ_02	Upper San Joaquin	$560 to $760
Total		**$3,250 to $4,530**

4.4 Residual Risk Management Element

Residual risk management addresses the additional efforts needed to provide flood protection beyond capital flood protection projects included in the other flood management elements. While the residual risk management element included components that support improved flood protection throughout the system, it focuses on providing supplemental flood protection in the rural-agricultural areas. It includes three components:

1. Enhanced flood emergency response.
2. Enhanced O & M.
3. Floodplain management.

Each of these is described below.

4.4.1 Enhanced Flood Emergency Response

Even with the major physical improvements to the flood management system, the risk of flooding can never be entirely eliminated. The Central Valley floodplains will always be at risk of flooding, whether from unanticipated facility failures or extreme storm events. This component supports additional planning and response efforts in preparation of flood events beyond the current level of each of these components, and supports

real-time communications. The enhanced flood emergency response components include:

- All-weather roads on levee crowns
- Additional flood information collection and sharing
- Local flood emergency response planning
- Additional forecasting and notification

All-weather Roads on Levee Crowns

This component includes construction of all-weather roads on the levee crowns for rural-agricultural levees, which will improve access to inspect levees and flood-fighting activities during high-water events. This component includes approximately 1,200 miles of SPFC) of rural-agricultural levees. This one-time estimated cost is $50,000 per mile, based on estimates from the DWR Flood Maintenance Office.

The Achieve SPFC Design Flow Capacity Approach and the Enhanced Flood System Capacity include the All-weather roads as part of the NULE levee improvements. The Protect High Risk Communities does not include this improvement. The State Systemwide Investment Approach includes this improvement as part of Residual Risk Management.

Additional Flood Information Collection and Sharing

This component includes the additional (beyond current levels of implementation) identification and notification of the flood hazards to residents, broadcasting real-time flood information to rural-agricultural areas, mapping evacuation routes and providing them to the public, and increasing the number of flood monitoring stations in rural areas. For planning purposes, the cost is estimated to be a one-time expenditure of $30 million per region. The level of effort is estimated from the DWR Hydrology and Flood Operations Office. The implementation of this component varies among the approaches based on the level of rural-agricultural levee improvements in the given approach.

Local Flood Emergency Response Planning

This component includes assisting local agencies preparing flood emergency response plans, training local agencies in flood patrolling and flood-fighting, conducting flood exercises with local agencies, and developing communication tools and processes for improved flood emergency response.

Implementation of this component is focused at the LFPZs within the SPFC. For planning purposes, the one-time cost for assisting local agencies is estimated to range from $500,000 to $600,000 per LFPZ. The level of effort is estimated from the DWR Hydrology and Flood Operations Office. Table 4-21 lists the number of LFPZs each region, and an estimated range of costs.

The Delta North Region costs include $85 million for a one-time purchase of Delta flood-fight materials and $5 million for increased Delta communications.

Table 4-21. Local Flood Emergency Response Planning Costs

Region	Levee Flood Protection Zones	Estimated Range of Costs ($ millions)
1- Upper Sacramento	10	$5 to $6
2- Mid-Sacramento	16	$8 to $10
3- Feather River	25	$13 to $15
4- Lower Sacramento	38	$19 to $23
5- Delta North	19	$95 to $97
6- Delta South	17	$9 to $11
7- Lower San Joaquin	37	$19 to $23
8- Mid-San Joaquin	19	$10 to $12
9- Upper San Joaquin	40	$20 to $24
Total	**221**	**$198 to $221**

Additional Forecasting and Notification

This component includes additional efforts (beyond current levels) focused at improving the timing and accuracy of flood forecasts, developing additional forecasting points to effectively serve rural communities, and developing additional methods to distribute forecasts to rural areas. For planning purposes, the one-time costs are estimated to total about $10 million per region. The level of effort is estimated from the DWR Hydrology and Flood Operations Office. It should be noted that improving the flood protection system may reduce the flood risk, but no activity completely removes the residual risk, so forecasting and notification is needed in all approaches.

4.4.2 Enhanced Operation and Maintenance

This component provides for future O&M of the flood protection system in response to the continuous activities to keep the SPFC facilities in good working order. Even with the significant capital improvements to the flood management system, the risk of flooding can never be entirely eliminated. The enhanced O&M components include:

- Identification and repair of after event erosions
- Develop and implement enhanced O&M
- Sacramento channel and levee management, and bank protection

Identification and Repair After-Event Erosions

This component includes one-time costs for inspecting the flood system after any major flood event to identify new threats to the flood system, and repair them before they become major repair projects. For planning purposes, the level of effort was estimated for the State Systemwide Investment Approach at approximately $10 million per year. The implementation of this component is expected to vary on a year-to-year basis. Additionally, this level of effort was scaled up or down for each approach, based on the magnitude of rural levee repairs planned to be completed for each of the three approaches. Approaches with larger rural levee improvements would have a lesser need compared to approaches with no or little rural levee improvements. The more significant the levee repairs to address existing erosion sites, the smaller the expected erosion repairs need after future high-water events. Table 4-22 lists the level of implementation of this flood management component in each of the four CVFPP approaches. These costs are distributed among all the regions based on the number of rural project levees.

Table 4-22. Identification and Repair of After Event Erosion Implementation

Approach	Implementation	Estimated Range of Costs ($ millions)
Achieve SPFC Design Flow Capacity Approach	Past problems would have been addressed as part of the repairs to rural levees as defined in the NULE Program, so it is expected that future levee erosion problems would be reduced through these repairs	$119 to $150
Protect High Risk Communities Approach	Past problems would not be addressed, so there is a greater need to address past levee deficiencies	$456 to $600
Enhance Flood System Capacity Approach	Past problems would have been addressed as part of the repairs to rural levees as defined in the NULE Program, so it is expected that future levee erosion problems would be reduced through these repairs	$119 to $150
State Systemwide Investment Approach	Some rural levee repairs will address some of the historic levee repair needs thereby preventing them from becoming large issues in the future, which will require greater efforts to repair.	$231 to $300

Key:
NULE = Non-Urban Levee Evaluation
SPFC = State Plan of Flood Control

Develop Enhanced O&M Programs and Regional Maintenance Organizations

This component includes the development and implementation of enhanced O&M programs and establishment of regional maintenance organizations. For planning purposes, the cost for this component is estimated to total $5 million per year for 25 years (total of $125 million). The funds will be regionally distributed, based upon distribution of LFPZs. Implementation of this component will be the same in each of the four CVFPP approaches.

Sacramento Channel and Levee Management, and Bank Protection

This component includes the Sacramento River Bank Protection Program and the Channel and Levee Management Program.

The cost for this component is estimated to total $4 million to $5 million per year for 25 years (total of up to $125 million) with the distribution of the funds generally reflecting the number of rural miles per region. This estimate is based on the recent annual expenditures for this program. Table 4-23 lists the estimated distribution of funds for implementation of this flood management component. It will be implemented in each of the four CVFPP approaches.

Table 4-23. Sacramento Channel and Levee Management, and Bank Protection Implementation

Region	Rural Levee Length (miles)	Estimated Range of Costs ($ millions)
1- Upper Sacramento	71	$12 to $15
2- Mid-Sacramento	301	$53 to $65
3- Feather River	162	$28 to $35
4- Lower Sacramento	43	$7 to $10
5- Delta North	0	$0
6- Delta South	0	$0
7- Lower San Joaquin	0	$0
8- Mid-San Joaquin	0	$0
9- Upper San Joaquin	0	$0
Total	**0**	**$100 to $125**

4.4.3 Floodplain Management

This component focuses on activities in the floodplain to reduce the existing flood threat and support changes in land uses to reduce future flood threat in rural areas. It includes improvements to individual houses to protect them from flood waters (by raising them or flood-proofing them) or

purchasing them to remove them from the threat of future floods. Floodplain management is important and necessary because it presents a cost-effective approach to protect houses or remove them from the threat of flooding. These activities can be done in a more cost-effective manner than trying to protect every single house from flooding.

The floodplain management component is intended to provide a nonstructural option to providing improved flood protection for a portion of the approximately 20,000 houses scattered across the rural areas protected by the SPFC. It is a cost-effective approach to providing flood protection to individual houses, compared to making significant and expensive improvements to flood protection system that cannot be supported by the limited benefits provided. Individual participation (by household) in this flood management component would be voluntary, and the actual level of participation is not known at this time. This component, along with the small community improvements, is intended to provide improved flood protection for all houses located in the rural-agricultural areas of the SPFC.

This component includes:

- Raising and waterproofing structures and building berms
- Purchasing and relocating homes in the floodplains
- Land use and floodplain management

Raising and Waterproofing Structures and Building Berms

This is one of the nonstructural components that may be used in place of the structural improvements described in Section 4.3.1 or purchasing and relocating houses (described below) to protect rural households. This component includes flood-proofing and raising structures in the floodplain. For planning purposes, this estimate assumes that this component would be applied to up to 3,000 houses at a cost of up to $100,000 per house, so it would have a total cost of up to $300 million. The number of houses that may participate in this program was estimated based on the distribution of houses in the rural areas as listed in Table 4-24.

Table 4-24. Costs for Raising and Waterproofing Structures and Building Berms

Region	Potential Number of Households	Estimated Range of Costs ($ millions)
1- Upper Sacramento	150	$11 to $15
2- Mid-Sacramento	660	$50 to $66
3- Feather River	270	$20 to $27
4- Lower Sacramento	120	$9 to $12
5- Delta North	390	$29 to $39
6- Delta South	270	$20 to $27
7- Lower San Joaquin	60	$5 to $6
8- Mid-San Joaquin	120	$9 to $12
9- Upper San Joaquin	960	$72 to $96
Total	**3,000**	**$225 to $300**

Purchasing and Relocating Homes in Floodplains

This is one of the nonstructural components that may be used in place of the structural improvements described in Section 4.3.1 or the raising and waterproofing structures and building berms (described above) to protect rural households. For planning purposes, this component includes purchasing up to 3,000 houses in high-risk areas of rural floodplain at up to $100,000 per house (totals $300 million) to reduce the future flood damages in rural areas. The distribution of houses that may participate in this program is estimated based on the distribution of houses in the rural areas as listed in Table 4-25.

Table 4-25. Costs for Purchasing and Relocating Homes in Floodplains

Region	Potential Number of Households	Estimated Range of Costs ($ Millions)
1- Upper Sacramento	150	$11 to $15
2- Mid-Sacramento	660	$50 to $66
3- Feather River	270	$20 to $27
4- Lower Sacramento	120	$9 to $12
5- Delta North	390	$29 to $39
6- Delta South	270	$20 to $27
7- Lower San Joaquin	60	$5 to $6
8- Mid-San Joaquin	120	$9 to $12
9- Upper San Joaquin	960	$72 to $96
Total	**3,000**	**$225 to $300**

Land Use and Floodplain Management

This component includes the integration of land use and floodplain management to support the preparation of local/regional planning efforts such as multi-hazard plans, floodplain management plans, and local general plan updates. For planning purpose, this was estimated up to $200 million (about $25 million per region). This component will be applied the same in each approach.

5.0 Acronyms and Abbreviations

Board	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
DWR	California Department of Water Resources
F-BO	Forecast-Based Operation
F-CO	Forecast-Coordination Operation
GAR	Geotechnical Assessment Report
GIS	geographic information system
LD	lacking sufficient data
LFPZ	Levee Flood Protection Zone
NULE	North Non-Urban Levee Evaluation
O&M	operations and maintenance
RACER	Remediation Alternatives and Cost Estimate Report
SAFCA	Sacramento Area Flood Control Agency
SPFC	State Plan of Flood Control
TRLIA	Three Rivers Levee Improvement Authority
ULE	Urban Levee Evaluation
WSE	water surface elevation

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6.0 Detailed Cost Tables

This section includes the detailed cost tables for the three preliminary approaches and SSIA. Summary of these detailed tables are provided included in Section 3.

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Table 6-1. System Improvement Costs for the Achieve SPFC Design Flow Capacity Approach

REGION	Land Acquisition (1)		Agricultural Conservation Easement(2)		Ecosystem Restoration and Enhancement(3)		LEVEES				Flood System and Fish Passage Structures (6)	Reservoir Operations		Easements (9)	System Erosion and Bypass Sediment Removal Project (10)	Estimated Total Cost	Risk Assessment, Feasibility, Engineering, and Permitting (25%)	Range of Estimated Total Cost over Program Duration
							New Levee Construction (4)		Improve Existing Levees (5)			Forecast-Coordinated Operations / Forecast-Based Operations (7)	New Reservoir Storage (8)					
	Acreage	Cost	Acreage	Cost	Acreage	Cost	Length	Cost	Length	Cost	Cost	Cost	Cost	Cost	Cost			
	(acres)	Low High	Low High	Low High	(acres)	Low High	(miles)	Low High	(miles)	Low High	Low High	Low High	Low High	Low High	Low High	Low High	Low High	Low High
1 - Upper Sacramento Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$9 to $12	$0 to $0	$0 to $0	$0.0 to $0.0	**$9.0 to $12.0**	**$3.0 to $3.0**	**$12.0 to $15.0**
2 - Mid-Sacramento Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$0 to $0	$0 to $0	$0 to $0	$0.0 to $0.0	**$0.0 to $0.0**	**$0.0 to $0.0**	**$0.0 to $0.0**
3 - Feather River Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$9 to $12	$0 to $0	$0 to $0	$0.0 to $0.0	**$9.0 to $12.0**	**$3.0 to $3.0**	**$12.0 to $15.0**
4 - Lower Sacramento Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$5 to $6	$0 to $0	$0 to $0	$0.0 to $0.0	**$5.0 to $6.0**	**$2.0 to $2.0**	**$7.0 to $8.0**
5 - Delta North Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$9 to $12	$0 to $0	$0 to $0	$0.0 to $0.0	**$9.0 to $12.0**	**$3.0 to $3.0**	**$12.0 to $15.0**
6 - Delta South Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$0 to $0	$0 to $0	$0 to $0	$0.0 to $0.0	**$0.0 to $0.0**	**$0.0 to $0.0**	**$0.0 to $0.0**
7 - Lower San Joaquin Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$5 to $6	$0 to $0	$0 to $0	$0.0 to $0.0	**$5.0 to $6.0**	**$2.0 to $2.0**	**$7.0 to $8.0**
8 - Mid - San Joaquin Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$9 to $12	$0 to $0	$0 to $0	$0.0 to $0.0	**$9.0 to $12.0**	**$3.0 to $3.0**	**$12.0 to $15.0**
9 - Upper San Joaquin Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$23 to $30	$0 to $0	$0 to $0	$0.0 to $0.0	**$23.0 to $30.0**	**$6.0 to $8.0**	**$29.0 to $38.0**
Total	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$69 to $90	$0 to $0	$0 to $0	$0 to $0	**$69.0 to $90.0**	**$18.0 to $23.0**	**$91.0 to $114.0**

NOTE:
4 All cost estimates are based on 2011 costs rounded to nearest $million.
System Improvement Assumptions:
(1) Land Acquisition:
Not included in this approach
(2) Agricultural Conservation Easement:
Not included in this approach
(3) Ecosystem Restoration and Enhancement:
Not included in this approach
(4) New Levee Design and Construction:
Not included in this approach
(5) Improve Existing Levees:
Not included in this approach
(6) Flood System Structures:
Not included in this approach
(7) F-CO / F-BO:
Includes up to 15 F-CO/F-BO in the Sacramento Basin (up to seven reservoirs) and the San Joaquin Basin (up to eight reservoirs)
(8) New Reservoirs:
Not included in this approach
(9) Easements:
Not included in this approach
(10) System Erosion and Bypass Sediment Removal Project:
Not included in this approach

Table 6-2. Urban Improvement Costs for the Achieve SPFC Design Flow Capacity Approach

Urban Levee Improvements (ULE) - Design Capacity Improvements for SPFC and Non-SPFC Levees (12)									
REGION	**Estimated Project Cost (11)**			**Risk Assessment, Feasibility, Engineering, and Permitting (25%) (13)**			**Range of Estimated Total Cost over Program Duration**		
	Low		**High**	**Low**		**High**	**Low**		**High**
1 - Upper Sacramento Region	$0.0	to	$0.0	$0.0	to	$0.0	$0.0	to	$0.0
2 - Mid-Sacramento Region	$0.0	to	$0.0	$0.0	to	$0.0	$0.0	to	$0.0
3 - Feather River Region	$997.0	to	$1,246.0	$199.0	to	$249.0	$1,196.0	to	$1,495.0
4 - Lower Sacramento Region	$1,274.0	to	$1,593.0	$255.0	to	$319.0	$1,529.0	to	$1,912.0
5 - Delta North Region	$240.0	to	$300.0	$48.0	to	$60.0	$288.0	to	$360.0
6 - Delta South Region	$120.0	to	$150.0	$24.0	to	$30.0	$144.0	to	$180.0
7 - Lower San Joaquin Region	$198.0	to	$247.0	$40.0	to	$49.0	$238.0	to	$296.0
8 - Mid - San Joaquin Region	$360.0	to	$450.0	$72.0	to	$90.0	$432.0	to	$540.0
9 - Upper San Joaquin Region	$0.0	to	$0.0	$0.0	to	$0.0	$0.0	to	$0.0
Urban Levee Improvements (ULE) Subtotal	**$3,189.0**	**to**	**$3,986.0**	**$638.0**	**to**	**$797.0**	**$3,827.0**	**to**	**$4,783.0**

Urban Improvements Total	**$3,189.0**	**to**	**$3,986.0**	**$638.0**	**to**	**$797.0**	**$3,827.0**	**to**	**$4,783.0**

Assumptions:
NOTE: All cost estimates are based on 2011 costs rounded to nearest $million.

(11) Estimated Project Costs:
(12) Levee Improvements to for Urban - Design Capacity Improvements
SPFC Levee Improvements based on ULE Cost Estimates for individual urban areas identified on Table A8.
Non-SPFC Urban Levee Improvements
Improvement costs estimated at $6 to $8 million per mile for approximately 120 miles of Non-SPFC Urban Levees because no levee evaluation data is available at this time.
These improvement area costs are less than other improvement cost estimates because these levees are generally on smaller tributary streams and are smaller than other levees.
(13) Risk Assessment, Feasibility, Engineering, and Permitting (20%)
Ranges by project from 0% to 20% depending on level of project development

Table 6-3. Rural-Agricultural Improvement Costs for the Achieve SPFC Design Flow Capacity Approach

REGION	Small Community Improvement (13)	Non-Urban - Design Capacity Improvements (14)	Rural Setback Levees (15)	Site-Specific Rural Agricultural Improvement (16)			Estimated Total Costs (17)		Risk Assessment, Feasibility, Engineering, and Permitting (25%)		Range of Estimated Total Cost over Program Duration	
	Levee Improvement to Provide 100-Year Protection for Small Communities			Miles of Rural Levees	Levee Improvements	Known and Identified Erosion Repairs						
							Low	High	Low	High	($)	
1 - Upper Sacramento Region	$0.0	$408.0	$0.0	0	$0.0 to $0.0	$0.0	$408.0 to	$510.0	$102.0 to	$128.0	**$510.0 to**	**$638.0**
2 - Mid-Sacramento Region	$0.0	$2,578.0	$0.0	0	$0.0 to $0.0	$0.0	$2,578.0 to	$3,222.0	$645.0 to	$806.0	**$3,223.0 to**	**$4,028.0**
3 - Feather River Region	$0.0	$1,631.0	$0.0	0	$0.0 to $0.0	$0.0	$1,631.0 to	$2,038.0	$408.0 to	$510.0	**$2,039.0 to**	**$2,548.0**
4 - Lower Sacramento Region	$0.0	$1,147.0	$0.0	0	$0.0 to $0.0	$0.0	$1,147.0 to	$1,434.0	$287.0 to	$359.0	**$1,434.0 to**	**$1,793.0**
5 - Delta North Region	$0.0	$3,111.0	$0.0	0	$0.0 to $0.0	$0.0	$3,111.0 to	$3,889.0	$778.0 to	$973.0	**$3,889.0 to**	**$4,862.0**
6 - Delta South Region	$0.0	$503.0	$0.0	0	$0.0 to $0.0	$0.0	$503.0 to	$629.0	$126.0 to	$158.0	**$629.0 to**	**$787.0**
7 - Lower San Joaquin Region	$0.0	$272.0	$0.0	0	$0.0 to $0.0	$0.0	$272.0 to	$340.0	$68.0 to	$85.0	**$340.0 to**	**$425.0**
8 - Mid - San Joaquin Region	$0.0	$379.0	$0.0	0	$0.0 to $0.0	$0.0	$379.0 to	$473.0	$95.0 to	$119.0	**$474.0 to**	**$592.0**
9 - Upper San Joaquin Region	$0.0	$1,044.0	$0.0	0	$0.0 to $0.0	$0.0	$1,044.0 to	$1,305.0	$261.0 to	$327.0	**$1,305.0 to**	**$1,632.0**
Total	**$0.0**	**$11,073.0**	**$0.0**	**0**	**$0.0 to $0.0**	**$0.0**	**$11,073.0 to**	**$13,840.0**	**$2,770.0 to**	**$3,465.0**	**$13,843.0 to**	**$17,305.0**

NOTE: All cost estimates are based on 2011 costs rounded to nearest $million.

Assumptions:

(13) Small Community Improvements:

Not included in this approach - Existing levees around small communities would be improved as part of the recommendations from NULE Program

(14) Non-Urban - Design Capacity Improvements:

Estimates from NULE program for improvements to non-urban project levees.

The NULE improvements are expected to include Levee Crown Road All Weather resurfacings for all rural levees (total 1200 miles) at cost of $50,000 per mile.

(15) Rural Setback Levees: Not included in this approach

(16) Site-Specific Rural Agricultural Improvements:

Not included in this approach

(17) High estimate includes 25% increase for Non-Urban Design Capacity Improvements to account for upper cost estimate range.

Table 6-4. Residual Risk Management Costs for the Achieve SPFC Design Flow Capacity Approach

REGION	Enhanced Flood Emergency Response					Enhanced Operation and Maintenance					Floodplain Management					Estimated Total Costs	Risk Assessment, Feasibility, Engineering, and Permitting (25%)	Range of Estimated Total Cost over Program Duration
	Additional Flood Information Collection and Sharing (16)	All Weather Roads on Levee Crowns (17)	Local Flood Emergency Response Planning (18)		Additional Forecasting and Notification (19)	Identification and Repair of After Event Erosions (20)		Develop and Implement Enhanced O&M Programs and Regional Organizations (21)		Sacramento Channel and Levee Management and Bank Protection (22)	Raising and Waterproofing Structures and Building Berms (23)		Purchasing and Relocating Homes in Floodplains (24)		Land Use and Floodplain Management Integration (25)			
			Number of Levee Flood Protection Zones	Cost		Miles of Rural Levees	Cost of Repairs	Number of LFPZs	Cost of Repairs		Potential Number of Homes	Costs	Potential Number of Homes	Costs	Costs			
1 - Upper Sacramento Region	$8.0	$0.0	10	$5.0 to $6.0	$0.0	71	$7.0 to $9.0	10	$4.0 to $6.0	$12.0 to $15.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$7.5 to $10.0	**$44.0 to $54.0**	**$0.0 to $0.0**	**$44.0 to $54.0**
2 - Mid-Sacramento Region	$8.0	$0.0	16	$8.0 to $10.0	$0.0	301	$29.0 to $38.0	16	$7.0 to $9.0	$18.0 to $23.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$33.0 to $44.0	**$103.0 to $132.0**	**$0.0 to $0.0**	**$103.0 to $132.0**
3 - Feather River Region	$8.0	$0.0	25	$13.0 to $15.0	$0.0	162	$16.0 to $21.0	25	$11.0 to $14.0	$27.0 to $36.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$13.5 to $18.0	**$88.0 to $112.0**	**$0.0 to $0.0**	**$88.0 to $112.0**
4 - Lower Sacramento Region	$8.0	$0.0	38	$19.0 to $23.0	$0.0	43	$5.0 to $6.0	38	$16.0 to $22.0	$41.0 to $54.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$6.0 to $8.0	**$95.01 to $120.0**	**$0.0 to $0.0**	**$95.01 to $120.0**
5 - Delta North Region*	$8.0	$0.0	19	$95.0 to $97.0	$0.0	252	$24.0 to $32.0	19	$8.0 to $11.0	$0.0 to $0.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$19.5 to $26.0	**$155.0 to $174.0**	**$0.0 to $0.0**	**$155.0 to $174.0**
6 - Delta South Region	$8.0	$0.0	17	$9.0 to $11.0	$0.0	54	$6.0 to $7.0	17	$7.0 to $10.0	$0.0 to $0.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$13.5 to $18.0	**$44.0 to $54.0**	**$0.0 to $0.0**	**$44.0 to $54.0**
7 - Lower San Joaquin Region	$8.0	$0.0	37	$19.0 to $23.0	$0.0	38	$4.0 to $5.0	37	$16.0 to $21.0	$0.0 to $0.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$3.0 to $4.0	**$50.0 to $61.0**	**$0.0 to $0.0**	**$50.0 to $61.0**
8 - Mid - San Joaquin Region	$8.0	$0.0	19	$10.0 to $12.0	$0.0	51	$6.0 to $7.0	19	$8.0 to $11.0	$0.0 to $0.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$6.0 to $8.0	**$38.0 to $46.0**	**$0.0 to $0.0**	**$38.0 to $46.0**
9 - Upper San Joaquin Region	$8.0	$0.0	40	$20.0 to $24.0	$0.0	228	$22.0 to $29.0	40	$17.0 to $23.0	$0.0 to $0.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$48.0 to $64.0	**$115.0 to $148.0**	**$0.0 to $0.0**	**$115.0 to $148.0**
Total	**$72.0**	**$0.0**	**221**	**$198.0 to $221.0**	**$0.0**	**1,200**	**$119.0 to $150.0**	**221**	**$94.0 to $125.0**	**$98.0 to $125.0**	0	**$0.0 to $0.0**	0	**$0.0 to $0.0**	**$150.0 to $200.0**	**$732.0 to $901.0**	**$0.0 to $0.0**	**$732.0 to $901.0**

NOTE: All cost estimates are based on 2011 costs rounded to nearest $million.

Residual Risk Management Assumptions:

(16) Additional Flood Information Collection and Sharing:

Includes $8 million per region to improve:

- Identification and notification of the flood hazards to residents
- Effectively broadcasting real-time flood information to rural areas
- Map evacuation routes and provide them to public
- Additional flood monitoring stations in rural areas

(17) All Weather Roads on Levee Crowns:

Improvement expected to be made as part of ULE and NULE levee improvements

(18) Local Flood Emergency Response Planning:

Includes a one-time expenditure of $500,000 to $600,000 per Levee Flood Protection Zone to improve:

- Assist local agencies to prepare flood emergency response plan
- Train flood patrolling and flood fight
- Conduct flood exercises with local entities
- Develop communication tool and process for flood emergency response
- *Includes $80 million for purchase of Delta Flood fight materials and $5 million for increased Delta Communications

(19)Additional Forecasting and Notification:

Not included in this approach

Forecasting and Notification will continue to operate at its current level.

(20) Identification and Repair of After Event Erosions:

Inspect the flood system after any major flood event to identify erosion sites. Repair erosion sites in a timely manner before they are expected to become a major remaining project.

(21) Develop and Implement Enhanced O&Ms:

Includes annual expenditures of $4,000,000 to $5,000,000 per year to:

- Develop and implement an enhanced O&M program and establish regional maintenance organizations.

(22) Sacramento Channel and Levee Management and Bank Protection:

Channel and levee management program includes system capacity evaluation and remediation and Sacramento River Bank Protection. Assumes $4 to $5 million per year over next 25 years. State will assume responsibilities for O&M of the bypasses as well as the water side of the project levees in Sacramento River System

(23) Raising and Waterproofing Structures and Building Berms:

Not included in this approach

(24) Purchasing and Relocating Homes in Floodplains:

Not included in this approach because of extensive levee improvements made in ULE and NULE programs

(25) Land Use and Floodplain Management Integration :

Land use and floodplain management integration including preparing multi-hazard plans, multi-hazard plans, floodplain management plan, local general plan updates, etc.

Table 6-5. System Improvement Costs for the Protect High Risk Communities Approach

REGION	Land Acquisition (1)		Agricultural Conservation Easement(2)		Ecosystem Restoration and Enhancement(3)		LEVEES				Flood System and Fish Passage Structures (6)	Reservoir Operations		Easements (9)	System Erosion and Bypass Sediment Removal Project (10)	Estimated Total Cost	Risk Assessment, Feasibility, Engineering, and Permitting (25%)	Range of Estimated Total Cost over Program Duration
							New Levee Construction (4)		Improve Existing Levees (5)			Forecast-Coordinated Operations / Forecast-Based Operations (7)	New Reservoir Storage (8)					
	Acreage	Cost	Acreage	Cost	Acreage	Cost	Length	Cost	Length	Cost	Cost	Cost	Cost	Cost	Cost			
	(acres)	Low High	Low High	Low High	(acres)	Low High	(miles)	Low High	(miles)	Low High	Low High	Low High	Low High	Low High	Low High	**Low High**	**Low High**	**Low High**
1 - Upper Sacramento Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$9 to $12	$0 to $0	$0 to $0	$0.0 to $0.0	**$9.0 to $12.0**	**$3.0 to $3.0**	**$12.0 to $15.0**
2 - Mid-Sacramento Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$0 to $0	$0 to $0	$0 to $0	$0.0 to $0.0	**$0.0 to $0.0**	**$0.0 to $0.0**	**$0.0 to $0.0**
3 - Feather River Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$9 to $12	$0 to $0	$0 to $0	$0.0 to $0.0	**$9.0 to $12.0**	**$3.0 to $3.0**	**$12.0 to $15.0**
4 - Lower Sacramento Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$5 to $6	$0 to $0	$0 to $0	$0.0 to $0.0	**$5.0 to $6.0**	**$2.0 to $2.0**	**$7.0 to $8.0**
5 - Delta North Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$9 to $12	$0 to $0	$0 to $0	$0.0 to $0.0	**$9.0 to $12.0**	**$3.0 to $3.0**	**$12.0 to $15.0**
6 - Delta South Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$0 to $0	$0 to $0	$0 to $0	$0.0 to $0.0	**$0.0 to $0.0**	**$0.0 to $0.0**	**$0.0 to $0.0**
7 - Lower San Joaquin Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$5 to $6	$0 to $0	$0 to $0	$0.0 to $0.0	**$5.0 to $6.0**	**$2.0 to $2.0**	**$7.0 to $8.0**
8 - Mid - San Joaquin Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$9 to $12	$0 to $0	$0 to $0	$0.0 to $0.0	**$9.0 to $12.0**	**$3.0 to $3.0**	**$12.0 to $15.0**
9 - Upper San Joaquin Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$23 to $30	$0 to $0	$0 to $0	$0.0 to $0.0	**$23.0 to $30.0**	**$6.0 to $8.0**	**$29.0 to $38.0**
Total	**0**	**$0 to $0**	**0 to 0**	**$0 to $0**	**0**	**$0 to $0**	**0.0**	**$0 to $0**	**0.0**	**$0 to $0**	**$0 to $0**	**$69 to $90**	**$0 to $0**	**$0 to $0**	**$0 to $0**	**$69.0 to $90.0**	**$18.0 to $23.0**	**$91.0 to $114.0**

NOTE: All cost estimates are based on 2011 costs rounded to nearest $million.

System Improvement Assumptions:
(1) Land Acquisition:
Not included in this approach
(2) Agricultural Conservation Easement:
Not included in this approach
(3) Ecosystem Restoration and Enhancement:
Not included in this approach
(4) New Levee Design and Construction:
Not included in this approach
(5) Improve Existing Levees:
Not included in this approach
(6) Flood System Structures:
Not included in this approach
(7) F-CO / F-BO:
Includes up to 15 F-CO/F-BO in the Sacramento Basin (up to seven reservoirs) and the San Joaquin Basin (up to eight reservoirs)
(8) New Reservoirs:
Not included in this approach
(9) Easements:
Not included in this approach
(10) System Erosion and Bypass Sediment Removal Project:
Not included in this approach

Table 6-6. Urban Improvement Costs for the Protect High Risk Communities Approach

REGION	Estimated Project Cost (11)			Risk Assessment, Feasibility, Engineering, and Permitting (20%) (13)			Range of Estimated Total Cost over Program Duration		
	Low		High	Low		High	Low		High
Upper Sacramento Region	**$100.0**	**to**	**$120.0**	**$20.0**	**to**	**$24.0**	**$120.0**	**to**	**$144.0**
Chico Urban Levee Improvements	$100.0	to	$120.0	$20.0	to	$24.0	$120.0	to	$144.0
Mid-Sacramento Region	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**
	$0.0	to	$0.0	$0.0	to	$0.0	$0.0	to	$0.0
Feather River Region	**$760.0**	**to**	**$891.0**	**$131.0**	**to**	**$157.0**	**$891.0**	**to**	**$1,048.0**
Sutter County Feasibility Study	$8.5	to	$10.2	$1.7	to	$2.0	$10.2	to	$12.2
Feather River West Levee SBFCA	$245.0	to	$294.0	$49.0	to	$58.8	$294.0	to	$352.8
LD1-EIP-Lower Feather River Setback Levee at Star Bend	$20.8	to	$20.8	$0.0	to	$0.0	$20.8	to	$20.8
Marysville Ring Levee Reconstruction	$161.9	to	$194.3	$32.4	to	$38.9	$194.3	to	$233.1
Yuba River Basin GRR	$15.4	to	$18.5	$3.1	to	$3.7	$18.5	to	$22.2
TRLIA-EIP Feather River Levee Improvement Project	$222.0	to	$266.4	$44.4	to	$53.3	$266.4	to	$319.7
TRLIA-EIP-Upper Yuba River Levee Improvement Project	$68.0	to	$68.0	$0.0	to	$0.0	$68.0	to	$68.0
RD 2103-EIP-Bear River North Levee Rehabilitation Project	$18.2	to	$18.2	$0.0	to	$0.0	$18.2	to	$18.2
Lower Sacramento Region	**$3,117.0**	**to**	**$3,726.0**	**$145.0**	**to**	**$173.0**	**$3,261.0**	**to**	**$3,899.0**
American River Common Features Project/GRR	$12.8	to	$15.4	$2.6	to	$3.1	$15.4	to	$18.4
American River Common Features-WRDA96/99 Projects/Remaining Sites	$282.0	to	$338.4	$0.0	to	$0.0	$282.0	to	$338.4
Folsom Dam Modifications-Joint Federal Project (Gated Auxiliary Spillway)	$800.0	to	$1,000.0	$0.0	to	$0.0	$800.0	to	$1,000.0
Folsom Dam Raise, Bridge Element Study and Implementation	$130.0	to	$140.0	$0.0	to	$0.0	$130.0	to	$140.0
Folsom Dam Raise - Reservoir Enlargement	$125.0	to	$130.0	$0.0	to	$0.0	$125.0	to	$130.0
South Sacramento County Streams	$104.0	to	$124.8	$0.0	to	$0.0	$104.0	to	$124.8
SAFCA-EIP-NCC Natomas Levee Improvement Project	$70.0	to	$84.0	$0.0	to	$0.0	$70.0	to	$84.0
SAFCA-NLIP,CO Natomas Levee Improvement Project	$310.0	to	$372.0	$0.0	to	$0.0	$310.0	to	$372.0
Natomas Basin Design and Construction (Future)	$385.0	to	$462.0	$0.0	to	$0.0	$385.0	to	$462.0
Magpie Creek Project (Future)	$9.8	to	$11.8	$2.0	to	$2.4	$11.8	to	$14.1
American River South and Sacramento River Future Improvements	$500.0	to	$600.0	$100.0	to	$120.0	$600.0	to	$720.0
Slip Repair	$53.0	to	$63.6	$10.6	to	$12.7	$63.6	to	$76.4
WSAFCA-EIP-CO West Sacramento	$105.0	to	$126.0	$21.0	to	$25.2	$126.0	to	$151.2
West Sacramento Project GGR	$10.0	to	$12.0	$2.0	to	$2.4	$12.0	to	$14.4
Woodland/ Lower Cache Creek Feasibility Study and Implementation	$190.0	to	$210.0	$0.0	to	$0.0	$190.0	to	$210.0
Davis-Willow Slough	$30.0	to	$36.0	$6.0	to	$7.2	$36.0	to	$43.2
Delta North Region	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**
	$0.0	to	$0.0	$0.0	to	$0.0	$0.0	to	$0.0
Delta South Region	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**
	$0.0	to	$0.0	$0.0	to	$0.0	$0.0	to	$0.0

Table 6-6. Urban Improvement Costs for the Protect High Risk Communities Approach (Continued)

REGION	Estimated Project Cost (11)			Risk Assessment, Feasibility, Engineering, and Permitting (20%) (13)			Range of Estimated Total Cost over Program Duration		
	Low		High	Low		High	Low		High
Lower San Joaquin Region	**$162.0**	**to**	**$194.0**	**$33.0**	**to**	**$39.0**	**$194.0**	**to**	**$233.0**
Lower San Joaquin Feasibility Study	$15.4	to	$18.5	$3.1	to	$3.7	$18.5	to	$22.2
RD 17-EIP-100-Year Levee Seepage Area Project	$76.0	to	$91.2	$15.2	to	$18.2	$91.2	to	$109.4
Mormon Slough Bypass/ Stockton Diverter Canal	$40.0	to	$48.0	$8.0	to	$9.6	$48.0	to	$57.6
Smith Canal Closure Structure (EIP Project)	$30.0	to	$36.0	$6.0	to	$7.2	$36.0	to	$43.2
Mid - San Joaquin Region	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**
	$0.0	to	$0.0	$0.0	to	$0.0	$0.0	to	$0.0
Upper San Joaquin Region	**$138.0**	**to**	**$166.0**	**$28.0**	**to**	**$34.0**	**$166.0**	**to**	**$199.0**
Merced County Streams Group (Bear Creek Unit)	$137.7	to	$165.2	$27.5	to	$33.0	$165.2	to	$198.3
Identified Urban Improvements Subtotal	**$4,277.0**	**to**	**$5,097.0**	**$357.0**	**to**	**$427.0**	**$4,632.0**	**to**	**$5,523.0**

Non-SPFC Urban Levee Improvements - (12)

REGION	Estimated Project Cost (11)		Risk Assessment, Feasibility, Engineering, and Permitting (20%) (13)		Range of Estimated Total Cost over Program Duration	
	Low	High	Low	High	Low	High
1 - Upper Sacramento Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2 - Mid-Sacramento Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
3 - Feather River Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
4 - Lower Sacramento Region	$240.0	$320.0	$48.0	$64.0	$288.0	$384.0
5 - Delta North Region	$120.0	$160.0	$24.0	$32.0	$144.0	$192.0
6 - Delta South Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
7 - Lower San Joaquin Region	$360.0	$480.0	$72.0	$96.0	$432.0	$576.0
8 - Mid - San Joaquin Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
9 - Upper San Joaquin Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Non-SPFC Urban Levee Improvements Subtotal	**$720.0**	**$960.0**	**$144.0**	**$192.0**	**$864.0**	**$1,152.0**
Urban Improvements Total	**$4,997.0**	**to $5,817.0**	**$501.0**	**to $571.0**	**$5,496.0**	**to $6,675.0**

Assumptions:

NOTE: All cost estimates are based on 2011 costs rounded to nearest $million.

(11) Estimated Project Costs:

Costs provided by Project Management Office based on input from local agencies.

Folsom Enlargement is an authorized project to provide flood protection for the City of Sacramento

(12) Non-SPFC Urban Levee Improvements

Improvement costs estimated at $6 to $8 million per mile for approximately 120 miles of Non-SPFC Urban Levees because no levee evaluation data is available at this time.

These improvement costs area less than other improvement cost estimates because these levees are generally on smaller tributary streams as a result are smaller than other levees.

(13) Risk Assessment, Feasibility, Engineering, and Permitting (20%)

Ranges by project from 0% to 20% depending on level of project development

Table 6-7. Rural-Agricultural Improvement Costs for the Protect High Risk Communities Approach

REGION	Small Community Improvement (13)	Non-Urban - Design Capacity Improvements (14)	Rural Setback Levees (15)	Site-Specific Rural Agricultural Improvement (16)			Estimated Total Costs		Risk Assessment, Feasibility, Engineering, and Permitting (25%)		Range of Estimated Total Cost over Program Duration	
	Levee Improvement to Provide 100-Year Protection for Small Communities			Miles of Rural Levees	Levee Improvements	Known and Identified Erosion Repairs	Low	High	Low	High	($)	
1 - Upper Sacramento Region	$77.0	$0.0	$0.0	71	$0.0 to $0.0	$0.0	$77.0 to $89.0		$19.0 to $23.0		**$93.0 to $112.0**	
2 - Mid-Sacramento Region	$190.0	$0.0	$0.0	301	$0.0 to $0.0	$0.0	$190.0 to $228.0		$48.0 to $57.0		**$238.0 to $285.0**	
3 - Feather River Region	$319.0	$0.0	$0.0	162	$0.0 to $0.0	$0.0	$319.0 to $383.0		$80.0 to $96.0		**$399.0 to $479.0**	
4 - Lower Sacramento Region	$0.0	$0.0	$0.0	43	$0.0 to $0.0	$0.0	$0.0 to $0.0		$0.0 to $0.0		**$0.0 to $0.0**	
5 - Delta North Region	$293.0	$0.0	$0.0	252	$0.0 to $0.0	$0.0	$293.0 to $352.0		$74.0 to $88.0		**$367.0 to $440.0**	
6 - Delta South Region	$0.0	$0.0	$0.0	54	$0.0 to $0.0	$0.0	$0.0 to $0.0		$0.0 to $0.0		**$0.0 to $0.0**	
7 - Lower San Joaquin Region	$0.0	$0.0	$0.0	38	$0.0 to $0.0	$0.0	$0.0 to $0.0		$0.0 to $0.0		**$0.0 to $0.0**	
8 - Mid - San Joaquin Region	$3.0	$0.0	$0.0	51	$0.0 to $0.0	$0.0	$3.0 to $4.0		$1.0 to $1.0		**$4.0 to $5.0**	
9 - Upper San Joaquin Region	$121.0	$0.0	$0.0	228	$0.0 to $0.0	$0.0	$121.0 to $146.0		$31.0 to $37.0		**$152.0 to $183.0**	
Total	**$1,003.0**	**$0.0**	**$0.0**	**1,200**	**$0.0 to $0.0**	**$0.0**	**$1,003.0 to $1,202.0**		**$250.0 to $301.0**		**$1,253.0 to $1,504.0**	

NOTE: All cost estimates are based on 2011 costs rounded to nearest $million.

Assumptions:

(13) Small Community Improvements:

Provides 100-year level of protection for small communities within the SPFC that are not protected by other systemwide and/or urban improvements. Cost of implementation is less than $30,000 per person protected (about $100,000 per house).

Non-structural measures will be taken when the cost of protection exceeds $100,000 per house (see Residual Risk Management)

Total population in protected small communities is estimated at 47,000 people, and requires about 120 miles of new or improved levees. All levee improvements to protect small communities for this approach are included in this cost element.

Assumed construction costs include a combination of levee improvements and construction of new levees for each individual community.

Small communities protected by Region are listed below:

1- Upper Sacramento: Durham, Gerber-Las Flores

2 - Mid-Sacramento: Knights Landing, Meridian, Colusa, Glenn, Grimes, Butte City, Robbins, Princeton

3- Feather River: Verona, Biggs, Wheatland, Gridley, Live Oak, Sutter, Tierra Buena

5- Delta North: Rio Vista, Clarksburg, Courtland, Hood, Walnut Grove, Iselton

8 - Mid-San Joaquin: Grayson

9 - Upper San Joaquin: Firebaugh, Dos Palos, So Dos Palos

(14) Non-Urban - Design Capacity Improvements:

Not included in this approach

(15)Rural Setback Levees

Not included in this approach

(16) Site Specific Rural Agricultural Improvements:

Not included in this approach

Table 6-8. Residual Risk Management Costs for the Protect High Risk Communities Approach

REGION	Enhanced Flood Emergency Response					Enhanced Operation and Maintenance					Floodplain Management					Estimated Total Costs	Risk Assessment, Feasibility, Engineering, and Permitting (25%)	Range of Estimated Total Cost over Program Duration
	Additional Flood Information Collection and Sharing (16)	All Weather Roads on Levee Crowns (17)	Local Flood Emergency Response Planning (18)		Additional Forecasting and Notification (19)	Identification and Repair of After Event Erosions (20)		Develop and Implement Enhanced O&M Programs and Regional Organizations (21)		Sacramento Channel and Levee Management and Bank Protection (22)	Raising and Waterproofing Structures and Building Berms (23)		Purchasing and Relocating Homes in Floodplains (24)		Land Use and Floodplain Management Integration (25)			
			Number of Levee Flood Protection Zones	Cost		Miles of Rural Levees	Cost of Repairs	Number of LFPZs	Cost of Repairs		Potential Number of Homes	Costs	Potential Number of Homes	Costs	Costs			
				Low High			Low High		Low High	Low High		Low High		Low High	Low High	Low **High**	**($)**	**($)**
1 - Upper Sacramento Region	$30.0	$0.0	10	$5.0 to $6.0	$10.0	71	$27.0 to $36.0	10	$4.0 to $6.0	$12.0 to $15.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$7.0 to $10.0	**$95.0** to **$113.0**	**$0.0** to **$0.0**	**$95.0** to **$113.0**
2 - Mid-Sacramento Region	$30.0	$0.0	16	$8.0 to $10.0	$10.0	301	$114.0 to $151.0	16	$7.0 to $9.0	$18.0 to $23.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$33.0 to $44.0	**$220.0** to **$277.0**	**$0.0** to **$0.0**	**$220.0** to **$277.0**
3 - Feather River Region	$30.0	$0.0	25	$13.0 to $15.0	$10.0	162	$61.0 to $81.0	25	$11.0 to $14.0	$27.0 to $36.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$13.0 to $18.0	**$165.0** to **$204.0**	**$0.0** to **$0.0**	**$165.0** to **$204.0**
4 - Lower Sacramento Region	$30.0	$0.0	38	$19.0 to $23.0	$10.0	43	$17.0 to $22.0	38	$16.0 to $22.0	$41.0 to $54.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$6.0 to $8.0	**$139.0** to **$169.0**	**$0.0** to **$0.0**	**$139.0** to **$169.0**
5 - Delta North Region*	$30.0	$0.0	19	$95.0 to $97.0	$10.0	252	$95.0 to $126.0	19	$8.0 to $11.0	$0.0 to $0.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$20 to $26.0	**$258.0** to **$300.0**	**$0.0** to **$0.0**	**$258.0** to **$300.0**
6 - Delta South Region	$30.0	$0.0	17	$9.0 to $11.0	$10.0	54	$21.0 to $27.0	17	$7.0 to $10.0	$0.0 to $0.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$14.0 to $18.0	**$91.0** to **$106.0**	**$0.0** to **$0.0**	**$91.0** to **$106.0**
7 - Lower San Joaquin Region	$30.0	$0.0	37	$19.0 to $23.0	$10.0	38	$15.0 to $19.0	37	$16.0 to $21.0	$0.0 to $0.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$3.0 to $4.0	**$93.0** to **$107.0**	**$0.0** to **$0.0**	**$93.0** to **$107.0**
8 - Mid - San Joaquin Region	$30.0	$0.0	19	$10.0 to $12.0	$10.0	51	$20.0 to $26.0	19	$8.0 to $11.0	$0.0 to $0.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$6.0 to $8.0	**$84.0** to **$97.0**	**$0.0** to **$0.0**	**$84.0** to **$97.0**
9 - Upper San Joaquin Region	$30.0	$0.0	40	$20.0 to $24.0	$10.0	228	$86.0 to $114.0	40	$17.0 to $23.0	$0.0 to $0.0	0	$0.0 to $0.0	0	$0.0 to $0.0	$48.0 to $64.0	**$211.0** to **$265.0**	**$0.0** to **$0.0**	**$211.0** to **$265.0**
Total	**$270.0**	**$0.0**	**221**	**$198.0 to $221.0**	**$90.0**	**1,200**	**$456.0 to $600.0**	**221**	**$94.0 to $125.0**	**$98.0 to $125.0**	0	**$0.0 to $0.0**	0	**$0.0 to $0.0**	**$150.0 to $200.0**	**$1,356.0 to $1,638.0**	**$0.0 to $0.0**	**$1,356.0 to $1,638.0**

NOTE: All cost estimates are based on 2011 costs rounded to nearest $million.

Residual Risk Management Assumptions:

(16) Additional Flood Information Collection and Sharing:

Includes $30 million per region to improve:

Identification and notification of the flood hazards to residents

Effectively broadcasting real-time flood information to rural areas

Mapping evacuation routes and provide them to public

Additional flood monitoring stations in rural areas

(17) All Weather Roads on Levee Crowns:

Purchasing and Relocating Homes in Floodplains:

Not included in this approach

(18) Local Flood Emergency Response Planning:

Includes a one-time expenditure of $500,000 to $600,000 per Levee Flood Protection Zone to improve:

Assist local agencies to prepare flood emergency response plan

Train flood patrolling and flood fight

Conduct flood exercises with local entities

Develop communication tool and process for flood emergency response

*Includes $80 million for purchase of Delta Flood fight materials and $5 million for increased Delta Communications

(19) Additional Forecasting and Notification:

Includes a one-time expenditure of $10,000,000 per Region to improve:

Improve timing and accuracy of flood forecasts

Develop additional forecasting points to effectively serve rural communities

Develop an effective way of distribution forecasts to rural areas

*Includes $80 million for purchase of Delta Flood fight materials and $5 million for increased Delta Communications

capital investment in rural levees.

(20) Identification and Repair of After Event Erosions:

Inspect the flood system after any major flood event to identify erosion sites. Repair erosion sites in a timely manner before they are expected to become a major remain project.

(21) Develop and Implement Enhanced O&Ms Programs and Regional Organizations:

Includes annual expenditures of $4,000,000 to $5,000,000 per year to:

Develop and implement an enhanced O&M programs and establish regional maintenance organizations.

(22) Sacramento Channel and Levee Management and Bank Protection :

Channel and levee management program includes system capacity evaluation and remediations and Sacramento River Bank Protection. Assumes $4 to $5 million per year over next 25 years.

State will assume responsibilities for O&M of the bypasses as well as the water side of the project levees in Sacramento River System

(23) Raising and Waterproofing Structures and Building Berms:

Not included in this approach

(24) Purchasing and Relocating Homes in Floodplains:

Not included in this approach

(25) Land Use and Floodplain Management Integration :

Land use and floodplain management integration including preparing multi-hazard plans, multi-hazard plans, floodplain management plan, local general plan updates, etc.

Table 6-9. System Improvement Costs for the Enhance Flood System Capacity Approach

REGION	Land Acquisition (1)		Agricultural Conservation Easement(2)		Ecosystem Restoration and Enhancement (3)		LEVEES				Flood System and Fish Passage Structures (6)	Reservoir Operations		Easements (9)	System Erosion and Bypass Sediment Removal Project (10)	Estimated Total Cost	Risk Assessment, Feasibility, Engineering, and Permitting (25%)	Range of Estimated Total Cost over Program Duration
							New Levee Construction (4)		Improve Existing Levees (5)			Forecast-Coordinated Operations / Forecast-Based Operations (7)	New Reservoir Storage (8)					
	Acreage	Cost	Acreage	Cost	Acreage	Cost	Length	Cost	Length	Cost	Cost	Cost	Cost	Cost	Cost			
	(acres)	Low High	Low High	Low High	(acres)	Low High	(miles)	Low High	(miles)	Low High	Low High	Low High	Low High	Low High	Low High	**Low High**	**Low High**	**Low High**
1 - Upper Sacramento Region	0	$0 to $0	5,000 to 10,000	$18 to $42	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$60 to $90	$9 to $12	$0 to $0	$165 to $213	$0.0 to $0.0	**$252.0 to $357.0**	**$63.0 to $90.0**	**$315.0 to $447.0**
2 - Mid-Sacramento Region	0	$0 to $0	10,000 to 15,000	$35 to $63	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$122 to $174	$0 to $0	$0 to $0	$275 to $355	$30.0 to $35.0	**$462.0 to $627.0**	**$116.0 to $157.0**	**$578.0 to $784.0**
3 - Feather River Region	9000	$87 to $98	15,000 to 25,000	$79 to $150	3,300	$165 to $198	31.0	$671 to $793	15.0	$210 to $270	$135 to $190	$9 to $12	$200 to $300	$140 to $172	$0.0 to $0.0	**$1,696.0 to $2,183.0**	**$424.0 to $546.0**	**$2,120.0 to $2,729.0**
4 - Lower Sacramento Region	18,900	$256 to $284	5,000 to 10,000	$32 to $70	4,900	$258 to $307	21.0	$462 to $546	2.0	$28 to $36	$230 to $280	$5 to $6	$0 to $0	$0 to $0	$30.0 to $40.0	**$1,301.0 to $1,569.0**	**$326.0 to $393.0**	**$1,627.0 to $1,962.0**
5 - Delta North Region	7,900	$72 to $83	5,000 to 10,000	$21 to $49	2,000	$94 to $114	19.0	$407 to $481	0.0	$0 to $0	$0 to $0	$9 to $12	$0 to $0	$0 to $0	$0.0 to $0.0	**$603.0 to $739.0**	**$151.0 to $185.0**	**$754.0 to $924.0**
6 - Delta South Region	1,000	$9 to $11	10,000 to 15,000	$42 to $74	300	$14 to $17	8.0	$165 to $195	7.0	$91 to $117	$20 to $25	$0 to $0	$0 to $0	$0 to $0	$0.0 to $0.0	**$341.0 to $439.0**	**$86.0 to $110.0**	**$427.0 to $549.0**
7 - Lower San Joaquin Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$5 to $6	$0 to $0	$0 to $0	$0.0 to $0.0	**$5.0 to $6.0**	**$2.0 to $2.0**	**$7.0 to $8.0**
8 - Mid - San Joaquin Region	0	$0 to $0	10,000 to 15,000	$39 to $69	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$9 to $12	$400 to $600	$174 to $222	$0.0 to $0.0	**$622.0 to $903.0**	**$156.0 to $226.0**	**$778.0 to $1,129.0**
9 - Upper San Joaquin Region	0	$0 to $0	10,000 to 15,000	$39 to $69	0	$50 to $50	0.0	$0 to $0	0.0	$0 to $0	$71 to $88	$23 to $30	$500 to $1,500	$116 to $148	$0.0 to $0.0	**$799.0 to $1,885.0**	**$200.0 to $472.0**	**$999.0 to $2,357.0**
Total	**36,800**	**$424 to $476**	**70,000 to 115,000**	**$305 to $586**	**10,500**	**$581 to $686**	**79.0**	**$1,705 to $2,015**	**24.0**	**$329 to $423**	**$638 to $847**	**$69 to $90**	**$1,100 to $2,400**	**$870 to $1,110**	**$60 to $75**	**$6,081.0 to $8,708.0**	**$1,521.0 to $2,177.0**	**$7,605.0 to $10,889.0**

NOTE: All cost estimates are based on 2011 costs rounded to the nearest $million.

System Improvement Assumptions:

(1) Land Acquisition:

Land Purchase Cost Assumptions by Region

1 - Upper Sacramento	$10,000 to $12,000/acre
2 - Mid-Sacramento	$10,000 to $12,000/acre
3 - Feather River	$15,000 to $17,000/acre
4 - Lower Sacramento	$18,000 to $20,000/acre
5 - Delta North	$12,000 to $14,000/acre
6 - Delta South	$12,000 to $14,000/acre
7 - Lower San Joaquin	$15,000 to $17,000/acre
8 - Mid - San Joaquin	$11,000 to $13,000/acre
9 - Upper San Joaquin	$11,000 to $13,000/acre

(2) Agricultural Conservation Easement:

Agricultural Conservation Assumed % of Land Acquisition by Region

1 - Upper Sacramento	35%
2 - Mid-Sacramento	35%
3 - Feather River	35%
4 - Lower Sacramento	35%
5 - Delta North	35%
6 - Delta South	35%
7 - Lower San Joaquin	35%
8 - Mid - San Joaquin	35%
9 - Upper San Joaquin	35%

(3) Ecosystem Restoration and Enhancement:

Assumes 25% of land purchased for bypasses will be developed for conservation and other 75% will be leased back to farmers for environmentally friendly agricultural practices such as corn, rice, and other grains.

Environmental Conservation Development by Region

1 - Upper Sacramento	$35,000 to $45,000/acre
2 - Mid-Sacramento	$35,000 to $45,000/acre
3 - Feather River	$35,000 to $45,000/acre
4 - Lower Sacramento	$35,000 to $45,000/acre
5 - Delta North	$35,000 to $45,000/acre
6 - Delta South	$35,000 to $45,000/acre
7 - Lower San Joaquin	$35,000 to $45,000/acre
8 - Mid - San Joaquin	$35,000 to $45,000/acre
9 - Upper San Joaquin	$35,000 to $45,000/acre

Includes $50 million for Upper San Joaquin River Restoration Projects.

(4) New Levee Design and Construction:

$22 to $26 million/mile

(5) Improve Existing Levees:

$14 to $18 million/mile

(6) Flood System Structures:

Not included in this approach

(7) F-CO / F-BO:

Includes up to 15 F-CO/F-BO in the Sacramento Basin (up to seven reservoirs) and the San Joaquin Basin (up to eight reservoirs)

(8) New Reservoirs:

Not included in this approach

(9) Easements:

Not included in this approach

(10) System Erosion and Bypass Sediment Removal Project:

Not included in this approach

Table 6-10. Urban Improvement Costs for the Enhance Flood System Capacity Approach

REGION	Estimated Project Cost (11)			Risk Assessment, Feasibility, Engineering, and Permitting (20%) (13)			Range of Estimated Total Cost over Program Duration		
	Low		High	Low		High	Low		High
Upper Sacramento Region	**$100.0**	**to**	**$120.0**	**$20.0**	**to**	**$24.0**	**$120.0**	**to**	**$144.0**
Chico Urban Levee Improvements	$100.0	to	$120.0	$20.0	to	$24.0	$120.0	to	$144.0
Mid-Sacramento Region	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**
	$0.0	to	$0.0	$0.0	to	$0.0	$0.0	to	$0.0
Feather River Region	**$760.0**	**to**	**$891.0**	**$131.0**	**to**	**$157.0**	**$891.0**	**to**	**$1,048.0**
Sutter County Feasibility Study	$8.5	to	$10.2	$1.7	to	$2.0	$10.2	to	$12.2
Feather River West Levee SBFCA	$245.0	to	$294.0	$49.0	to	$58.8	$294.0	to	$352.8
LD1-EIP-Lower Feather River Setback Levee at Star Bend	$20.8	to	$20.8	$0.0	to	$0.0	$20.8	to	$20.8
Marysville Ring Levee Reconstruction	$161.9	to	$194.3	$32.4	to	$38.9	$194.3	to	$233.1
Yuba River Basin GRR	$15.4	to	$18.5	$3.1	to	$3.7	$18.5	to	$22.2
TRLIA-EIP Feather River Levee Improvement Project	$222.0	to	$266.4	$44.4	to	$53.3	$266.4	to	$319.7
TRLIA-EIP-Upper Yuba River Levee Improvement Project	$68.0	to	$68.0	$0.0	to	$0.0	$68.0	to	$68.0
RD 2103-EIP-Bear River North Levee Rehabilitation Project	$18.2	to	$18.2	$0.0	to	$0.0	$18.2	to	$18.2
Lower Sacramento Region	**$3,117.0**	**to**	**$3,726.0**	**$145.0**	**to**	**$173.0**	**$3,261.0**	**to**	**$3,899.0**
American River Common Features Project/GRR	$12.8	to	$15.4	$2.6	to	$3.1	$15.4	to	$18.4
American River Common Features-WRDA96/99 Projects/Remaining Sites	$282.0	to	$338.4	$0.0	to	$0.0	$282.0	to	$338.4
Folsom Dam Modifications-Joint Federal Project (Gated Auxiliary Spillway)	$800.0	to	$1,000.0	$0.0	to	$0.0	$800.0	to	$1,000.0
Folsom Dam Raise, Bridge Element Study and Implementation	$130.0	to	$140.0	$0.0	to	$0.0	$130.0	to	$140.0
Folsom Dam Raise - Reservoir Enlargement	$125.0	to	$130.0	$0.0	to	$0.0	$125.0	to	$130.0
South Sacramento County Streams	$104.0	to	$124.8	$0.0	to	$0.0	$104.0	to	$124.8
SAFCA-EIP-NCC Natomas Levee Improvement Project	$70.0	to	$84.0	$0.0	to	$0.0	$70.0	to	$84.0
SAFCA-NLIP,CO Natomas Levee Improvement Project	$310.0	to	$372.0	$0.0	to	$0.0	$310.0	to	$372.0
Natomas Basin Design and Construction (Future)	$385.0	to	$462.0	$0.0	to	$0.0	$385.0	to	$462.0
Magpie Creek Project (Future)	$9.8	to	$11.8	$2.0	to	$2.4	$11.8	to	$14.1
American River South and Sacramento River Future Improvements	$500.0	to	$600.0	$100.0	to	$120.0	$600.0	to	$720.0
Slip Repair	$53.0	to	$63.6	$10.6	to	$12.7	$63.6	to	$76.4
WSAFCA-EIP-CO West Sacramento	$105.0	to	$126.0	$21.0	to	$25.2	$126.0	to	$151.2
West Sacramento Project GGR	$10.0	to	$12.0	$2.0	to	$2.4	$12.0	to	$14.4
Woodland/ Lower Cache Creek Feasibility Study and Implementation	$190.0	to	$210.0	$0.0	to	$0.0	$190.0	to	$210.0
Davis-Willow Slough	$30.0	to	$36.0	$6.0	to	$7.2	$36.0	to	$43.2
Delta North Region	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**
	$0.0	to	$0.0	$0.0	to	$0.0	$0.0	to	$0.0
Delta South Region	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**
	$0.0	to	$0.0	$0.0	to	$0.0	$0.0	to	$0.0

Table 6-10. Urban Improvement Costs for the Enhance Flood System Capacity Approach (Continued)

REGION	Estimated Project Cost (11)			Risk Assessment, Feasibility, Engineering, and Permitting (20%) (13)			Range of Estimated Total Cost over Program Duration		
	Low		High	Low		High	Low		High
Lower San Joaquin Region	**$162.0**	**to**	**$194.0**	**$33.0**	**to**	**$39.0**	**$194.0**	**to**	**$233.0**
Lower San Joaquin Feasibility Study	$15.4	to	$18.5	$3.1	to	$3.7	$18.5	to	$22.2
RD 17-EIP-100-Year Levee Seepage Area Project	$76.0	to	$91.2	$15.2	to	$18.2	$91.2	to	$109.4
Mormon Slough Bypass/ Stockton Diverter Canal	$40.0	to	$48.0	$8.0	to	$9.6	$48.0	to	$57.6
Smith Canal Closure Structure (EIP Project)	$30.0	to	$36.0	$6.0	to	$7.2	$36.0	to	$43.2
Mid - San Joaquin Region	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**
	$0.0	to	$0.0	$0.0	to	$0.0	$0.0	to	$0.0
Upper San Joaquin Region	**$138.0**	**to**	**$166.0**	**$28.0**	**to**	**$34.0**	**$166.0**	**to**	**$199.0**
Merced County Streams Group (Bear Creek Unit)	$137.7	to	$165.2	$27.5	to	$33.0	$165.2	to	$198.3
Identified Urban Improvements Subtotal	**$4,277.0**	**to**	**$5,097.0**	**$357.0**	**to**	**$427.0**	**$4,632.0**	**to**	**$5,523.0**

Non-SPFC Urban Levee Improvements - (12)

REGION	Estimated Project Cost (11)		Risk Assessment, Feasibility, Engineering, and Permitting (20%) (13)		Range of Estimated Total Cost over Program Duration	
	Low	High	Low	High	Low	High
1 - Upper Sacramento Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2 - Mid-Sacramento Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
3 - Feather River Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
4 - Lower Sacramento Region	$240.0	$320.0	$48.0	$64.0	$288.0	$384.0
5 - Delta North Region	$120.0	$160.0	$24.0	$32.0	$144.0	$192.0
6 - Delta South Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
7 - Lower San Joaquin Region	$360.0	$480.0	$72.0	$96.0	$432.0	$576.0
8 - Mid - San Joaquin Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
9 - Upper San Joaquin Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Non-SPFC Urban Levee Improvements Subtotal	**$720.0**	**$960.0**	**$144.0**	**$192.0**	**$864.0**	**$1,152.0**
Urban Improvements Total	**$4,997.0** **to**	**$5,817.0**	**$501.0** **to**	**$571.0**	**$5,496.0** **to**	**$6,675.0**

Assumptions:

NOTE: All cost estimates are based on 2011 costs rounded to nearest $million.

(11) Estimated Project Costs:

Costs provided by Project Management Office based on input from local agencies.

Folsom Enlargement is an authorized project to provide flood protection for the City of Sacramento

(12) Non-SPFC Urban Levee Improvements

Improvement costs estimated at $6 to $8 million per mile for approximately 120 miles of Non-SPFC Urban Levees because no levee evaluation data is available at this time.

These improvement costs area less than other improvement cost estimates because these levees are generally on smaller tributary streams as a result are smaller than other levees.

(13) Risk Assessment, Feasibility, Engineering, and Permitting (20%)

Ranges by project from 0% to 20% depending on level of project development

Table 6-11. Rural-Agricultural Improvement Costs for the Enhance Flood System Capacity Approach

REGION	Small Community Improvement (13)	Non-Urban - Design Capacity Improvements (14)	Rural Setback Levees (15)	Site-Specific Rural Agricultural Improvement (16)			Estimated Total Costs (17)	Risk Assessment, Feasibility, Engineering, and Permitting (25%)	Range of Estimated Total Cost over Program Duration
	Levee Improvement to Provide 100-Year Protection for Small Communities			Miles of Rural Levees	Levee Improvements	Known and Identified Erosion Repairs			
			Low High				Low High	Low High	($)
1 - Upper Sacramento Region	$0.0	$408.0	$0.0 to $0.0	71	$0.0 to $0.0	$0.0	$408.0 to $510.0	$102.0 to $128.0	**$510.0 to $638.0**
2 - Mid-Sacramento Region	$95.0	$2,577.0	$1,733.0 to $2,426.0	301	$0.0 to $0.0	$0.0	$4,405.0 to $5,743.0	$1,102.0 to $1,436.0	**$5,508.0 to $7,179.0**
3 - Feather River Region	$33.0	$1,630.0	$603.0 to $844.0	162	$0.0 to $0.0	$0.0	$2,267.0 to $2,915.0	$567.0 to $729.0	**$2,834.0 to $3,644.0**
4 - Lower Sacramento Region	$0.0	$1,147.0	$0.0 to $0.0	43	$0.0 to $0.0	$0.0	$1,147.0 to $1,434.0	$287.0 to $359.0	**$1,434.0 to $1,793.0**
5 - Delta North Region	$200.0	$3,111.0	$0.0 to $0.0	252	$0.0 to $0.0	$0.0	$3,311.0 to $4,089.0	$828.0 to $1,023.0	**$4,139.0 to $5,112.0**
6 - Delta South Region	$0.0	$503.0	$0.0 to $0.0	54	$0.0 to $0.0	$0.0	$503.0 to $629.0	$126.0 to $158.0	**$629.0 to $787.0**
7 - Lower San Joaquin Region	$0.0	$272.0	$0.0 to $0.0	38	$0.0 to $0.0	$0.0	$272.0 to $340.0	$68.0 to $85.0	**$340.0 to $425.0**
8 - Mid - San Joaquin Region	$2.0	$378.0	$716.0 to $1,002.0	51	$0.0 to $0.0	$0.0	$1,096.0 to $1,477.0	$274.0 to $370.0	**$1,370.0 to $1,847.0**
9 - Upper San Joaquin Region	$15.0	$1,043.0	$0.0 to $0.0	228	$0.0 to $0.0	$0.0	$1,059.0 to $1,320.0	$265.0 to $330.0	**$1,324.0 to $1,650.0**
Total	**$345.0**	**$11,069.0**	**$3,052.0 to $4,272.0**	**1,200**	**$0.0 to $0.0**	**$0.0**	**$14,469.0 to $18,453.0**	**$3,618.0 to $4,614.0**	**$18,088.0 to $23,075.0**

NOTE: All cost estimates are based on 2011 costs rounded to nearest $million.

Assumptions:

(13) Small Community Improvements:

Provides 100-year level of protection for small communities within the SPFC that are not protected by other systemwide and/or urban level improvements. Cost of implementation is less than $30,000 per person protected (about $100,000 per house).

Non-structural measures will be taken when the cost of protection exceeds $100,000 per house (see Residual Risk Management)

Total population in protected small communities is estimated at 47,000 people, and requires about 60 miles of new levees. The costs associated with the approximately 60 miles of levee improvements are included as part of NULE Design Capacity Improvements.

Assumed construction costs includes a combination of levee improvements and construction of new levees for each individual community.

Small communities protected by Region are listed below:

1- Upper Sacramento: Durham, Gerber-Las Flores

2 - Mid-Sacramento: Knights Landing, Meridian, Colusa, Glenn, Grimes, Butte City, Robbins, Princeton

3- Feather River: Verona, Biggs, Wheatland, Gridley, Live Oak, Sutter, Tierra Buena

5- Delta North: Rio Vista, Clarksburg, Courtland, Hood, Walnut Grove, Isleton

8 - Mid-San Joaquin: Grayson

9 - Upper San Joaquin: Firebaugh, Dos Palos, So Dos Palos

(14) Non-Urban - Design Capacity Improvements:

Estimates from NULE program for improvements to non-urban project levees and related non-urban non-project levees.

The NULE improvements are expected to include Levee Crown Road All Weather resurfacings for all rural levees (total 1200 miles) at cost of $50,000 per mile.

(15) Rural Setback Levees:

Includes updated levee setback costs for land purchase, old levee removal, fixing existing levees, and construction of new levees. New lands introduced to the floodplain by the setback levee will be subjected to future riparian processes to provide ecosystem restoration.

(16) Site-Specific Rural Agricultural Improvements:

Not included in this approach

(17) High estimate includes 25% increase for Non-Urban Design Capacity Improvements to account for upper cost estimate range.

Table 6-12. Residual Risk Management Costs for the Enhance Flood System Capacity Approach

REGION	Enhanced Flood Emergency Response					Enhanced Operation and Maintenance					Floodplain Management							Estimated Total Costs	Risk Assessment, Feasibility, Engineering, and Permitting (25%)	Range of Estimated Total Cost over Program Duration
	Additional Flood Information Collection and Sharing (16)	All Weather Roads on Levee Crowns (17)	Local Flood Emergency Response Planning (18)		Additional Forecasting and Notification (19)	Identification and Repair of After Event Erosions (20)		Develop and Implement Enhanced O&M Programs and Regional Organizations (21)		Sacramento Channel and Levee Management and Bank Protection (22)	Raising and Waterproofing Structures and Building Berms (23)		Purchasing and Relocating Homes in Floodplains (24)		Land Use and Floodplain Management Integration (25)					
			Number of Levee Flood Protection Zones	Cost		Miles of Rural Levees	Cost of Repairs	Number of LFPZs	Cost of Repairs		Potential Number of Homes	Costs	Potential Number of Homes	Costs	Costs					
				Low High			Low High		Low High	Low High		Low High		Low High	Low High			Low **High**	**($)**	**($)**
1 - Upper Sacramento Region	$8.0	$0.0	10	$5.0 to $6.0	$0.0	71	$7.0 to $9.0	10	$4.0 to $6.0	$12.0 to $15.0	0	$0.0 to $0.0	150	$0.0 to $0.0	$3.8 to $5.0			**$40.0** to **$49.0**	**$0.0** to **$0.0**	**$40.0** to **$49.0**
2 - Mid-Sacramento Region	$8.0	$0.0	16	$8.0 to $10.0	$0.0	301	$29.0 to $38.0	16	$7.0 to $9.0	$49.0 to $65.0	0	$0.0 to $0.0	660	$0.0 to $0.0	$16.5 to $22.0			**$117.0** to **$152.0**	**$0.0** to **$0.0**	**$117.0** to **$152.0**
3 - Feather River Region	$8.0	$0.0	25	$13.0 to $15.0	$0.0	162	$16.0 to $21.0	25	$11.0 to $14.0	$27.0 to $35.0	0	$0.0 to $0.0	270	$0.0 to $0.0	$6.8 to $9.0			**$81.0** to **$102.0**	**$0.0** to **$0.0**	**$81.0** to **$102.0**
4 - Lower Sacramento Region	$8.0	$0.0	38	$19.0 to $23.0	$0.0	43	$5.0 to $6.0	38	$16.0 to $22.0	$8.0 to $10.0	0	$0.0 to $0.0	120	$0.0 to $0.0	$3.0 to $4.0			**$59.0** to **$72.0**	**$0.0** to **$0.0**	**$59.0** to **$72.0**
5 - Delta North Region*	$8.0	$0.0	19	$95.0 to $97.0	$0.0	252	$24.0 to $320	19	$8.0 to $11.0	$0.0 to $0.0	0	$0.0 to $0.0	390	$0.0 to $0.0	$9.8 to $13.0			**$145.0** to **$161.0**	**$0.0** to **$0.0**	**$145.0** to **$161.0**
6 - Delta South Region	$8.0	$0.0	17	$9.0 to $11.0	$0.0	54	$6.0 to $7.0	17	$7.0 to $10.0	$0.0 to $0.0	0	$0.0 to $0.0	270	$0.0 to $0.0	$6.8 to $9.0			**$37.0** to **$45.0**	**$0.0** to **$0.0**	**$37.0** to **$45.0**
7 - Lower San Joaquin Region	$8.0	$0.0	37	$19.0 to $23.0	$0.0	38	$4.0 to $5.0	37	$16.0 to $21.0	$0.0 to $0.0	0	$0.0 to $0.0	60	$0.0 to $0.0	$1.5 to $2.0			**$48.0** to **$59.0**	**$0.0** to **$0.0**	**$48.0** to **$59.0**
8 - Mid - San Joaquin Region	$8.0	$0.0	19	$10.0 to $12.0	$0.0	51	$6.0 to $7.0	19	$8.0 to $11.0	$0.0 to $0.0	0	$0.0 to $0.0	120	$0.0 to $0.0	$3.0 to $4.0			**$35.0** to **$42.0**	**$0.0** to **$0.0**	**$35.0** to **$42.0**
9 - Upper San Joaquin Region	$8.0	$0.0	40	$20.0 to $24.0	$0.0	228	$22.0 to $29.0	40	$17.0 to $23.0	$0.0 to $0.0	0	$0.0 to $0.0	960	$0.0 to $0.0	$24.0 to $32.0			**$91.0** to **$116.0**	**$0.0** to **$0.0**	**$91.0** to **$116.0**
Total	**$72.0**	**$0.0**	**221**	**$198.0 to $221.0**	**$0.0**	**1,200**	**$119.0 to $150.0**	**221**	**$94.0 to $125.0**	**$96.0 to $125.0**	0	**$0.0 to $0.0**	3,000	**$0.0 to $0.0**	**$75.0 to $100.0**			**$653.0 to $798.0**	**$0.0 to $0.0**	**$653.0 to $798.0**

NOTE: All cost estimates are based on 2011 costs rounded to the nearest $million.

Residual Risk Management Assumptions:

(16) Additional Flood Information Collection and Sharing:

Includes $8 million per region to improve:

- Identification and notification of the flood hazards to residents
- Effectively broadcasting real-time flood information to rural areas
- Mapping evacuation routes and provide them to public
- Additional flood monitoring stations in rural areas

(17) All Weather Roads on Levee Crowns:

Improvement expected to be made as part of ULE and NULE levee improvements

(18) Local Flood Emergency Response Planning:

Includes a one-time expenditure of $500,000 to $600,000 per Levee Flood Protection Zone to improve:

- Assist local agencies to prepare flood emergency response plan
- Train flood patrolling and flood fight
- Conduct flood exercises with local entities
- Develop communication tool and process for flood emergency response
- *Includes $80 million for purchase of Delta Flood fight materials and $5 million for increased Delta Communications

(19) Additional Forecasting and Notification:

Forecasting and Notification will continue to operate at its current level. No enhancements are included for this approach.

(20) Identification and Repair of After Event Erosions:

Inspect the flood system after any major flood event to identify erosion sites. Repair erosion sites in a timely manner before they are expected to become a major remain project.

(21) Develop and Implement Enhanced O&Ms:

Includes annual expenditures of $4,000,000 to $5,000,000 per year to:

- Develop and implement an enhanced O&M program and establish regional maintenance organizations.

(22) Sacramento Channel and Levee Management and Bank Protection:

Channel and levee management program includes system capacity evaluation and remediation's and Sacramento River Bank Protection. Assumes $4 to $5 million per year over next 25 years. State will assume responsibilities for O&M of the bypasses as well as the water side of the project levees in Sacramento River System

(23) Raising and Waterproofing Structures and Building Berms:

Not included in this approach

(24) Purchasing and Relocating Homes in Floodplains:

Not included in this approach

(25) Land Use and Floodplain Management Integration :

Land use and floodplain management integration including preparing multi-hazard plans, multi-hazard plans, floodplain management plan, local general plan updates, etc.

Table 6-13. System Improvement Costs for the State Systemwide Investment Approach

REGION	Land Acquisition (1)		Agricultural Conservation Easement(2)		Ecosystem Restoration and Enhancement (3)		LEVEES				Flood System and Fish Passage Structures (6)	Reservoir Operations		Easements (9)	System Erosion and Bypass Sediment Removal Project (10)	Estimated Total Cost	Risk Assessment, Feasibility, Engineering, and Permitting (25%)	Range of Estimated Total Cost over Program Duration
							New Levee Construction (4)		Improve Existing Levees (5)			Coordinated Operations / Forecast-Based	New Reservoir Storage (8)					
	Acreage	Cost	Acreage	Cost	Acreage	Cost	Length	Cost	Length	Cost	Cost	Cost	Cost	Cost	Cost			
	(acres)	Low High	Low High	Low High	(acres)	Low High	(miles)	Low High	(miles)	Low High	Low High	Low High	Low High	Low High	Low High	**Low High**	**Low High**	**Low High**
1 - Upper Sacramento Region	0	$0 to $0	5,000 to 10,000	$18 to $42	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$60 to $90	$9 to $12	$0 to $0	$0 to $0	$0.0 to $0.0	**$87.0 to $144.0**	**$22.0 to $36.0**	**$109.0 to $180.0**
2 - Mid-Sacramento Region	0	$0 to $0	10,000 to 15,000	$35 to $63	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$122 to $174	$0 to $0	$0 to $0	$0 to $0	$30.0 to $35.0	**$187.0 to $272.0**	**$47.0 to $68.0**	**$234.0 to $340.0**
3 - Feather River Region	9,000	$87 to $98	15,000 to 25,000	$79 to $150	3,300	$165 to $198	31.0	$671 to $793	15.0	$210 to $270	$135 to $190	$9 to $12	$0 to $0	$0 to $0	$0.0 to $0.0	**$1,356.0 to $1,711.0**	**$339.0 to $428.0**	**$1,695.0 to $2,139.0**
4 - Lower Sacramento Region	18,900	$256 to $284	5,000 to 10,000	$32 to $70	4,900	$258 to $307	21.0	$462 to $546	2.0	$28 to $36	$230 to $280	$5 to $6	$0 to $0	$0 to $0	$30.0 to $40.0	**$1,301.0 to $1,569.0**	**$326.0 to $393.0**	**$1,627.0 to $1,962.0**
5 - Delta North Region	7,900	$72 to $83	5,000 to 10,000	$21 to $49	2,000	$94 to $114	19.0	$407 to $481	0.0	$0 to $0	$0 to $0	$9 to $12	$0 to $0	$0 to $0	$0.0 to $0.0	**$603.0 to $739.0**	**$151.0 to $185.0**	**$754.0 to $924.0**
6 - Delta South Region	1,000	$9 to $11	10,000 to 15,000	$42 to $74	300	$14 to $17	8.0	$165 to $195	7.0	$91 to $117	$20 to $25	$0 to $0	$0 to $0	$0 to $0	$0.0 to $0.0	**$341.0 to $439.0**	**$86.0 to $110.0**	**$427.0 to $549.0**
7 - Lower San Joaquin Region	0	$0 to $0	0 to 0	$0 to $0	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$5 to $6	$0 to $0	$0 to $0	$0.0 to $0.0	**$5.0 to $6.0**	**$2.0 to $2.0**	**$7.0 to $8.0**
8 - Mid - San Joaquin Region	0	$0 to $0	10,000 to 15,000	$39 to $69	0	$0 to $0	0.0	$0 to $0	0.0	$0 to $0	$0 to $0	$9 to $12	$0 to $0	$0 to $0	$0.0 to $0.0	**$48.0 to $81.0**	**$12.0 to $21.0**	**$60.0 to $102.0**
9 - Upper San Joaquin Region	0	$0 to $0	10,000 to 15,000	$39 to $69	0	$50 to $50	0.0	$0 to $0	0.0	$0 to $0	$71 to $88	$23 to $30	$0 to $0	$0 to $0	$0.0 to $0.0	**$183.0 to $237.0**	**$46.0 to $60.0**	**$229.0 to $297.0**
Total	**36,800**	**$424 to $476**	**70,000 to 115,000**	**$305 to $586**	**10,500**	**$581 to $686**	**79.0**	**$1,705 to $2,015**	**24.0**	**$329 to $423**	**$638 to $847**	**$69 to $90**	**$0 to $0**	**$0 to $0**	**$60 to $75**	**$4,111.0 to $5,198.0**	**$1,028.0 to $1,300.0**	**$5,142.0 to $6,501.0**

NOTE: All cost estimates are based on 2011 costs rounded to nearest $million.

System Improvement Assumptions:

(1) Land Acquisition:

Land Purchase Cost Assumptions by Region

1 - Upper Sacramento	$10,000 to $12,000/acre
2 - Mid-Sacramento	$10,000 to $12,000/acre
3 - Feather River	$15,000 to $17,000/acre
4 - Lower Sacramento	$18,000 to $20,000/acre
5 - Delta North	$12,000 to $14,000/acre
6 - Delta South	$12,000 to $14,000/acre
7 - Lower San Joaquin	$15,000 to $17,000/acre
8 - Mid - San Joaquin	$11,000 to $13,000/acre
9 - Upper San Joaquin	$11,000 to $13,000/acre

(2) Agricultural Conservation Easement:

Agricultural Conservation Assumed % of Land Acquisition by Region

1 - Upper Sacramento	35%
2 - Mid-Sacramento	35%
3 - Feather River	35%
4 - Lower Sacramento	35%
5 - Delta North	35%
6 - Delta South	35%
7 - Lower San Joaquin	35%
8 - Mid - San Joaquin	35%
9 - Upper San Joaquin	35%

(3) Ecosystem Restoration and Enhancement:

Assumes 25% of land purchased for bypasses will be developed for conservation and other 75% will be leased back to farmers for environmentally friendly agricultural practices such as corn, rice, and other grains.

Environmental Conservation Development by Region

1 - Upper Sacramento	$35,000 to $45,000/acre
2 - Mid-Sacramento	$35,000 to $45,000/acre
3 - Feather River	$35,000 to $45,000/acre
4 - Lower Sacramento	$35,000 to $45,000/acre
5 - Delta North	$35,000 to $45,000/acre
6 - Delta South	$35,000 to $45,000/acre
7 - Lower San Joaquin	$35,000 to $45,000/acre
8 - Mid - San Joaquin	$35,000 to $45,000/acre
9 - Upper San Joaquin	$35,000 to $45,000/acre

Includes $50 million for Upper San Joaquin River Restoration Projects.

(4) New Levee Design and Construction:

$22 to $26 million/mile

(5) Improve Existing Levees:

$14 to $18 million/mile

(6) Flood System Structures:

Not included in this approach

(7) F-CO / F-BO:

Includes up to 15 F-CO/F-BO in the Sacramento Basin (up to seven reservoirs) and the San Joaquin Basin (up to eight reservoirs)

(8) New Reservoirs:

Not included in this approach

(9) Easements:

Not included in this approach

(10) System Erosion and Bypass Sediment Removal Project:

Not included in this approach

Table 6-14. Urban Improvement Costs for the State Systemwide Investment Approach

REGION	Estimated Project Cost (11)			Risk Assessment, Feasibility, Engineering, and Permitting (20%) (13)			Range of Estimated Total Cost over Program Duration		
	Low		High	Low		High	Low		High
Upper Sacramento Region	**$100.0**	**to**	**$120.0**	**$20.0**	**to**	**$24.0**	**$120.0**	**to**	**$144.0**
Chico Urban Levee Improvements	$100.0	to	$120.0	$20.0	to	$24.0	$120.0	to	$144.0
Mid-Sacramento Region	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**
	$0.0	to	$0.0	$0.0	to	$0.0	$0.0	to	$0.0
Feather River Region	**$760.0**	**to**	**$891.0**	**$131.0**	**to**	**$157.0**	**$891.0**	**to**	**$1,048.0**
Sutter County Feasibility Study	$8.5	to	$10.2	$1.7	to	$2.0	$10.2	to	$12.2
Feather River West Levee SBFCA	$245.0	to	$294.0	$49.0	to	$58.8	$294.0	to	$352.8
LD1-EIP-Lower Feather River Setback Levee at Star Bend	$20.8	to	$20.8	$0.0	to	$0.0	$20.8	to	$20.8
Marysville Ring Levee Reconstruction	$161.9	to	$194.3	$32.4	to	$38.9	$194.3	to	$233.1
Yuba River Basin GRR	$15.4	to	$18.5	$3.1	to	$3.7	$18.5	to	$22.2
TRLIA-EIP Feather River Levee Improvement Project	$222.0	to	$266.4	$44.4	to	$53.3	$266.4	to	$319.7
TRLIA-EIP-Upper Yuba River Levee Improvement Project	$68.0	to	$68.0	$0.0	to	$0.0	$68.0	to	$68.0
RD 2103-EIP-Bear River North Levee Rehabilitation Project	$18.2	to	$18.2	$0.0	to	$0.0	$18.2	to	$18.2
Lower Sacramento Region	**$3,117.0**	**to**	**$3,726.0**	**$145.0**	**to**	**$173.0**	**$3,261.0**	**to**	**$3,899.0**
American River Common Features Project/GRR	$12.8	to	$15.4	$2.6	to	$3.1	$15.4	to	$18.4
American River Common Features-WRDA96/99 Projects/Remaining Sites	$282.0	to	$338.4	$0.0	to	$0.0	$282.0	to	$338.4
Folsom Dam Modifications-Joint Federal Project (Gated Auxiliary Spillway)	$800.0	to	$1,000.0	$0.0	to	$0.0	$800.0	to	$1,000.0
Folsom Dam Raise, Bridge Element Study and Implementation	$130.0	to	$140.0	$0.0	to	$0.0	$130.0	to	$140.0
Folsom Dam Raise - Reservoir Enlargement	$125.0	to	$130.0	$0.0	to	$0.0	$125.0	to	$130.0
South Sacramento County Streams	$104.0	to	$124.8	$0.0	to	$0.0	$104.0	to	$124.8
SAFCA-EIP-NCC Natomas Levee Improvement Project	$70.0	to	$84.0	$0.0	to	$0.0	$70.0	to	$84.0
SAFCA-NLIP,CO Natomas Levee Improvement Project	$310.0	to	$372.0	$0.0	to	$0.0	$310.0	to	$372.0
Natomas Basin Design and Construction (Future)	$385.0	to	$462.0	$0.0	to	$0.0	$385.0	to	$462.0
Magpie Creek Project (Future)	$9.8	to	$11.8	$2.0	to	$2.4	$11.8	to	$14.1
American River South and Sacramento River Future Improvements	$500.0	to	$600.0	$100.0	to	$120.0	$600.0	to	$720.0
Slip Repair	$53.0	to	$63.6	$10.6	to	$12.7	$63.6	to	$76.4
WSAFCA-EIP-CO West Sacramento	$105.0	to	$126.0	$21.0	to	$25.2	$126.0	to	$151.2
West Sacramento Project GGR	$10.0	to	$12.0	$2.0	to	$2.4	$12.0	to	$14.4
Woodland/ Lower Cache Creek Feasibility Study and Implementation	$190.0	to	$210.0	$0.0	to	$0.0	$190.0	to	$210.0
Davis-Willow Slough	$30.0	to	$36.0	$6.0	to	$7.2	$36.0	to	$43.2
Delta North Region	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**
	$0.0	to	$0.0	$0.0	to	$0.0	$0.0	to	$0.0
Delta South Region	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**
	$0.0	to	$0.0	$0.0	to	$0.0	$0.0	to	$0.0

Table 6-14. Urban Improvement Costs for the State Systemwide Investment Approach (Continued)

REGION	Estimated Project Cost (11)			Risk Assessment, Feasibility, Engineering, and Permitting (20%) (13)			Range of Estimated Total Cost over Program Duration		
	Low		High	Low		High	Low		High
Lower San Joaquin Region	**$162.0**	**to**	**$194.0**	**$33.0**	**to**	**$39.0**	**$194.0**	**to**	**$233.0**
Lower San Joaquin Feasibility Study	$15.4	to	$18.5	$3.1	to	$3.7	$18.5	to	$22.2
RD 17-EIP-100-Year Levee Seepage Area Project	$76.0	to	$91.2	$15.2	to	$18.2	$91.2	to	$109.4
Mormon Slough Bypass/ Stockton Diverter Canal	$40.0	to	$48.0	$8.0	to	$9.6	$48.0	to	$57.6
Smith Canal Closure Structure (EIP Project)	$30.0	to	$36.0	$6.0	to	$7.2	$36.0	to	$43.2
Mid - San Joaquin Region	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**	**$0.0**	**to**	**$0.0**
	$0.0	to	$0.0	$0.0	to	$0.0	$0.0	to	$0.0
Upper San Joaquin Region	**$138.0**	**to**	**$166.0**	**$28.0**	**to**	**$34.0**	**$166.0**	**to**	**$199.0**
Merced County Streams Group (Bear Creek Unit)	$137.7	to	$165.2	$27.5	to	$33.0	$165.2	to	$198.3
Identified Urban Improvements Subtotal	**$4,277.0**	**to**	**$5,097.0**	**$357.0**	**to**	**$427.0**	**$4,632.0**	**to**	**$5,523.0**

Non-SPFC Urban Levee Improvements - (12)

REGION	Estimated Project Cost (11)		Risk Assessment, Feasibility, Engineering, and Permitting (20%) (13)		Range of Estimated Total Cost over Program Duration	
	Low	High	Low	High	Low	High
1 - Upper Sacramento Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2 - Mid-Sacramento Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
3 - Feather River Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
4 - Lower Sacramento Region	$240.0	$320.0	$48.0	$64.0	$288.0	$384.0
5 - Delta North Region	$120.0	$160.0	$24.0	$32.0	$144.0	$192.0
6 - Delta South Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
7 - Lower San Joaquin Region	$360.0	$480.0	$72.0	$96.0	$432.0	$576.0
8 - Mid - San Joaquin Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
9 - Upper San Joaquin Region	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Non-SPFC Urban Levee Improvements Subtotal	**$720.0**	**$960.0**	**$144.0**	**$192.0**	**$864.0**	**$1,152.0**
Urban Improvements Total	**$4,997.0**	**to $5,817.0**	**$501.0**	**to $571.0**	**$5,496.0**	**to $6,675.0**

Assumptions:

NOTE: All cost estimates are based on 2011 costs rounded to nearest $million.

(11) Estimated Project Costs:

Costs provided by Project Management Office based on input from local agencies.

Folsom Enlargement is an authorized project to provide flood protection for the City of Sacramento

(12) Non-SPFC Urban Levee Improvements

Improvement costs estimated at $6 to $8 million per mile for approximately 120 miles of Non-SPFC Urban Levees because no levee evaluation data is available at this time.

These improvement costs area less than other improvement cost estimates because these levees are generally on smaller tributary streams as a result are smaller than other levees.

(13) Risk Assessment, Feasibility, Engineering, and Permitting (20%)

Ranges by project from 0% to 20% depending on level of project development

Table 6-15. Rural-Agricultural Improvement Costs for the State Systemwide Investment Approach

REGION	Small Community Improvement (13)	Non-Urban - Design Capacity Improvements (14)	Rural Setback Levees (15)	Site-Specific Rural Agricultural Improvement (16)			Estimated Total Costs		Risk Assessment, Feasibility, Engineering, and Permitting (25%)		Range of Estimated Total Cost over Program Duration
	Levee Improvement to Provide 100-Year Protection for Small Communities			Miles of Rural Levees	Levee Improvements	Known and Identified Erosion Repairs					
					Low High		Low	High	Low	High	($)
1 - Upper Sacramento Region	$74.0	$0.0	$0.0	71	$46.0 to $57.0	$3.0	$123.0 to $134.0		$31.0 to $34.0		**$154.0 to $168.0**
2 - Mid-Sacramento Region	$107.0	$0.0	$0.0	301	$62.0 to $77.0	$119.0	$288.0 to $303.0		$72.0 to $76.0		**$360.0 to $379.0**
3 - Feather River Region	$173.0	$0.0	$0.0	162	$24.0 to $30.0	$28.0	$225.0 to $231.0		$57.0 to $58.0		**$282.0 to $289.0**
4 - Lower Sacramento Region	$0.0	$0.0	$0.0	43	$37.0 to $46.0	$24.0	$61.0 to $70.0		$16.0 to $18.0		**$77.0 to $88.0**
5 - Delta North Region	$77.0	$0.0	$0.0	252	$93.0 to $117.0	$313.0	$483.0 to $507.0		$121.0 to $127.0		**$604.0 to $634.0**
6 - Delta South Region	$0.0	$0.0	$0.0	54	$18.0 to $22.0	$19.0	$37.0 to $41.0		$10.0 to $11.0		**$47.0 to $52.0**
7 - Lower San Joaquin Region	$0.0	$0.0	$0.0	38	$8.0 to $10.0	$5.0	$13.0 to $15.0		$4.0 to $4.0		**$17.0 to $19.0**
8 - Mid-San Joaquin Region	$3.0	$0.0	$0.0	51	$25.0 to $31.0	$10.0	$38.0 to $44.0		$10.0 to $11.0		**$48.0 to $55.0**
9 - Upper San Joaquin Region	$121.0	$0.0	$0.0	228	$19.0 to $24.0	$6.0	$146.0 to $151.0		$37.0 to $38.0		**$183.0 to $189.0**
Total	**$555.0**	**$0.0**	**$0.0**	**1,200**	**$332.0 to $414.0**	**$523.0**	**$1,410.0 to $1,492.0**		**$353.0 to $373.0**		**$1,772.0 to $1,873.0**

NOTE: All cost estimates are based on 2011 costs rounded to nearest $million.

Assumptions:

(13) Small Community Improvements:

Provides 100-year level of protection for small communities within the SPFC that are not protected by other systemwide and/or urban level improvements. Cost of implementation is less than $30,000 per person protected (about $100,000 per house).

Non-structural measures will be taken when the cost of protection exceeds $100,000 per house (see Residual Risk Management)

Total population in protected small communities is estimated at 47,000 people, and requires about 60 miles of new levees. The costs associated with the approximately 60 miles of levee improvements are included as part of NULE Design Capacity Improvements.

Assumed construction costs include a combination of levee improvements and construction of new levees for each individual community.

Small communities protected by Region are listed below:

1- Upper Sacramento: Durham, Gerber-Las Flores

2 - Mid-Sacramento: Knights Landing, Meridian, Colusa, Glenn, Grimes, Butte City, Robbins, Princeton

3- Feather River: Verona, Biggs, Wheatland, Gridley, Live Oak, Sutter, Tierra Buena

5- Delta North: Rio Vista, Clarksburg, Courtland, Hood, Walnut Grove, Isleton

8 - Mid-San Joaquin: Grayson

9 - Upper San Joaquin: Firebaugh, Dos Palos, South Dos Palos

(14) Non-Urban - Design Capacity Improvements:

Estimates from NULE program for improvements to non-urban project levees and related non-urban non-project levees.

The NULE improvements are expected to include Levee Crown Road All Weather resurfacings for all rural levees (total 1200 miles) at cost of $50,000 per mile.

(15) Rural Setback Levees:

Includes updated levee setback costs (9/29) for land purchase, old levee removal, fixing existing levees, and construction of new levees. New lands introduced to the floodplain by the setback levee will be subjected to future riparian processes to provide ecosystem restoration.

(16) Site-Specific Rural Agricultural Improvements:

Not included in this approach

Table 6-16. Residual Risk Management Costs for the State Systemwide Investment Approach

REGION	Enhanced Flood Emergency Response					Enhanced Operation and Maintenance					Floodplain Management					Estimated Total Costs	Risk Assessment, Feasibility, Engineering, and Permitting (25%)	Range of Estimated Total Cost over Program Duration
	Additional Flood Information Collection and Sharing (16)	All Weather Roads on Levee Crowns (17)	Local Flood Emergency Response Planning (18)		Additional Forecasting and Notification (19)	Identification and Repair of After Event Erosions (20)		Develop and Implement Enhanced O&M Programs and Regional Organizations (21)		Sacramento Channel and Levee Management and Bank Protection (22)	Raising and Waterproofing Structures and Building Berms (23)		Purchasing and Relocating Homes in Floodplains (24)		Land Use and Floodplain Management Integration (25)			
			Number of Levee Flood Protection Zones	Cost		Miles of Rural Levees	Cost of Repairs	Number of LFPZs	Cost of Repairs		Potential Number of Homes	Costs	Potential Number of Homes	Costs	Costs			
				Low High			Low High		Low High	Low High		Low High		Low High	Low High	Low **High**	**($)**	**($)**
1 - Upper Sacramento Region	$15.0	$4.0	10	$5.0 to $6.0	$10.0	71	$14.0 to $18.0	10	$5.0 to $6.0	$12.0 to $15.0	150	$11.3 to $15.0	150	$11.3 to $15.0	$7.5 to $10.0	**$95.0** to **$114.0**	**$0.0** to **$0.0**	**$95.0** to **$114.0**
2 - Mid-Sacramento Region	$15.0	$14.0	16	$8.0 to $10.0	$10.0	301	$57.0 to $76.0	16	$7.0 to $9.0	$18.0 to $23.0	660	$49.5 to $66.0	660	$49.5 to $66.0	$33.0 to $44.0	**$261.0** to **$333.0**	**$0.0** to **$0.0**	**$261.0** to **$333.0**
3 - Feather River Region	$15.0	$9.0	25	$13.0 to $15.0	$10.0	162	$31.0 to $41.0	25	$11.0 to $14.1	$27.0 to $36.0	270	$20.3 to $27.0	270	$20.3 to $27.0	$13.5 to $18.0	**$170.0** to **$212.0**	**$0.0** to **$0.0**	**$170.0** to **$212.0**
4 - Lower Sacramento Region	$15.0	$3.0	38	$19.0 to $23.0	$10.0	43	$9.0 to $11.0	38	$17.0 to $21.5	$41.0 to $54.0	120	$9.0 to $12.0	120	$9.0 to $12.0	$6.0 to $8.0	**$138.0** to **$169.0**	**$0.0** to **$0.0**	**$138.0** to **$169.0**
5 - Delta North Region*	$15.0	$11.0	19	$95.0 to $97.0	$10.0	252	$48.0 to $63.0	19	$9.0 to $10.7	$0.0 to $0.0	390	$29.3 to $39.0	390	$29.3 to $39.0	$19.5 to $26.0	**$266.0** to **$311.0**	**$0.0** to **$0.0**	**$266.0** to **$311.0**
6 - Delta South Region	$15.0	$3.0	17	$9.0 to $11.0	$10.0	54	$11.0 to $14.0	17	$8.0 to $9.6	$0.0 to $0.0	270	$20.3 to $27.0	270	$20.3 to $27.0	$13.5 to $18.0	**$110.0** to **$135.0**	**$0.0** to **$0.0**	**$110.0** to **$135.0**
7 - Lower San Joaquin Region	$15.0	$2.0	37	$19.0 to $23.0	$10.0	38	$8.0 to $10.0	37	$16.0 to $20.9	$0.0 to $0.0	60	$4.5 to $6.0	60	$4.5 to $6.0	$3.0 to $4.0	**$82.0** to **$97.0**	**$0.0** to **$0.0**	**$82.0** to **$97.0**
8 - Mid - San Joaquin Region	$15.0	$3.0	19	$10.0 to $12.0	$10.0	51	$10.0 to $13.0	19	$9.0 to $10.7	$0.0 to $0.0	120	$9.0 to $12.0	120	$9.0 to $12.0	$6.0 to $8.0	**$81.0** to **$96.0**	**$0.0** to **$0.0**	**$81.0** to **$96.0**
9 - Upper San Joaquin Region	$15.0	$11.0	40	$20.0 to $24.0	$10.0	228	$43.0 to $57.0	40	$17.0 to $22.6	$0.0 to $0.0	960	$72.0 to $96.0	960	$72.0 to $96.0	$48.0 to $64.0	**$308.0** to **$396.0**	**$0.0** to **$0.0**	**$308.0** to **$396.0**
Total	**$135.0**	**$60.0**	**221**	**$198.0 to $221.0**	**$90.0**	**1,200**	**$231.0 to $300.0**	**221**	**$99.0 to $125.0**	**$98.0 to $125.0**	3,000	**$225.0 to $300.0**	3,000	**$225.0 to $300.0**	**$150.0 to $200.0**	**$1,511.0 to $1,863.0**	**$0.0 to $0.0**	**$1,511.0 to $1,863.0**

NOTE: All cost estimates are based on 2011 costs rounded to nearest $million.
Residual Risk Management Assumptions:
(16) Additional Flood Information Collection and Sharing:
Includes $15 million per region to improve:
Identification and notification of the flood hazards to residents
Effectively broadcasting real-time flood information to rural areas
Mapping evacuation routes and provide them to public
Additional flood monitoring stations in rural areas
(17) All Weather Roads on Levee Crowns:
Includes Levee Crown Road All Weather resurfacings for all rural levees (total 1200 miles) at cost of $50,000 per mile
(18) Local Flood Emergency Response Planning:
Includes a one-time expenditure of $500,000 to $600,000 per Levee Flood Protection Zone to improve:
Assist local agencies to prepare flood emergency response plan
Train flood patrolling and flood fight
Conduct flood exercises with local entities
Develop communication tool and process for flood emergency response
*Includes $80 million for purchase of Delta Flood fight materials and $5 million for increased Delta Communications
(19) Additional Forecasting and Notification:
Includes a one-time expenditure of $10,000,000 per Region to improve:
Improve timing and accuracy of flood forecasts
Develop additional forecasting points to effectively serve rural communities
Develop an effective way of distribution forecasts to rural areas
(20) Identification and Repair of After Event Erosions:
Inspect the flood system after any major flood event to identify erosion sites. Repair erosion sites in a timely manner before they are expected to become a major remain project.
(21) Develop and Implement Enhanced O&M Programs and Regional Organizations:
Includes annual expenditures of $4,000,000 to $5,000,000 per year to:
Develop and implement an enhanced O&M program and establish regional maintenance organizations.
(22) Sacramento Channel and Levee Management and Bank Protection :
Channel and levee management program includes system capacity evaluation and remediation's and Sacramento River Bank Protection. Assumes $4,000,000 to $5,000,000 per year over next 25 years. State will assume responsibilities for O&M of the bypasses as well as the water side of the project levees in Sacramento River System
(23) Raising and Waterproofing Structures and Building Berms:
Includes removing or raising structures within floodplains within rural areas.
Estimated in include about 3,000 homes
Costs estimated at $75,000 to $100,000 per house
A grant program to flood proof structures in rural floodplains (up to $100,000 per house and up to3,000 houses: totals up to $300 million)
(24) Purchasing and Relocating Homes in Floodplains:
Purchasing of houses in high risk areas of rural floodplains (up to $100,000 per house and up to 3,000 houses (totals $300 million)
(25) Land Use and Floodplain Management Integration :
Land use and floodplain management integration including preparing multi-hazard plans, multi-hazard plans, floodplain management plan, local general plan updates, etc.

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FLOOD MANAGEMENT
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2012 Central Valley Flood Protection Plan

Attachment 8J: Cost Estimates – Appendix B. Urban Levee Evaluations Project Remediation Alternatives and Cost Estimate Report

January 2012

STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

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Urban Levee Evaluations Project Remediation Alternatives and Cost Estimate Report (Included on Compact Disc)

This appendix describes the remediation alternative analysis and cost estimates for addressing identified hazard factors for urban SPFC levees. Most of the hazard factors for achieving 200-year level protection were considered in the cost estimates, but not all. Non-structural levee improvements and encroachments which may negatively impact 200-year protection for some areas will likely still need to be addressed to achieve the protection required and these locally specific costs are not included. The urban 200-year cost estimates are incorporated into the overall total costs described in Appendix A.

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Attachment 8J: Cost Estimates – Appendix C. Non-Urban Levee Evaluations Project Remediation Alternatives and Cost Estimate Report

January 2012

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Non-Urban Levee Evaluations Project Remediation Alternatives and Cost Estimate Report (Included on Compact Disc)

This appendix describes the remediation alternative analysis and cost estimates for addressing identified hazard factors for nonurban SPFC levees. The nonurban levee cost estimates are incorporated into the overall total costs described in Appendix A.

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Attachment 8J: Cost Estimates – Appendix D. Protection of Small Communities

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Protection of Small Communities

This appendix documents the conceptual design and cost estimates for providing protection for small communities within the Systemwide Planning Area. Protection approaches 100-year level for structural remediation of existing levees or new levees. However, local drainage issues were not analyzed for 100-year protection and costs and other non-structural improvements may be required to provide 100-year level of protection. Small-community cost estimates are incorporated into the overall total costs described in Appendix A.

Background

Small communities were defined as developed areas with fewer than 10,000 residents. Because small communities do not fall in the category of urban or urbanizing areas (10,000 or more residents, currently or within the next 10 years), they are not required to meet the State-mandated 200-year level of protection requirements for urban areas. However, they are required to continue to meet the Federal Emergency Management Agency (FEMA) standard 100-year level (1 percent Annual Exceedence Probability (AEP)) of protection for property located within the flood hazard zone.

As a part of the Protect High Risk Communities Approach, small communities were identified using the follow data sources:

- California Department of Finance
- Census-Designated Places (CDP)
- California List of Places (U.S. Geological Survey Topographic Quadrangle)

Flood threats to small communities were characterized using attributes related to flood frequency, potential flood depth, and proximity to the nearest river. These characterizations were then used to prioritize the small communities into four categories:

- **Group A (High Hazard)** – Communities subject to high flooding frequency (greater than 1 percent per year) and also subject to deep flooding conditions (potential flood depths exceeding 3 feet on average).

- **Group B (Moderate to High Hazard)** – Communities subject to high flooding frequency (greater than 1 percent per year), subject to sheet flooding conditions (potential flood depths of less than 3 feet on average), and less than two miles from a major flooding source.

- **Group C (Low to Moderate)** – Communities subject to high flooding frequency (greater than 1 percent per year), subject to sheet flooding conditions (potential flood depths of less than 3 feet on average), and more than two miles from a major flooding source.

- **Group D (Low Hazard)** – Communities that are not subject to high flooding frequency (less than 1 percent per year).

Improving protection facilities is one option to mitigate flood threats to small communities. This can be accomplished by strengthening (reconstruction-in-place) existing levees, raising existing levees, and/or constructing new levees. The following sections describe the process of developing designs and cost estimates for the improvements needed to protect each small community. Small communities considered are depicted in Figures D-1 and D-2.

Conceptual Design Approach

A combination of data sources was used to determine a conceptual design for structural fixes needed to provide 1 percent AEP flood level protection to each small community. The first step was to identify existing project and nonproject levee sections surrounding the community identified in Geotechnical Assessment Reports (GAR) for the South and North Non-Urban Levee Evaluations (NULE) Project study areas (April 2010). The NULE GARs evaluated existing levees and recommended remediation needed to restore them to the 1955/57 design criteria. Additional nonproject levees not covered in the NULE GARs were identified in existing geographic information system (GIS) mapping. The levees covered by the NULE GARs were further evaluated to determine if the 1955/57 level remediation would provide the required 3 feet of freeboard for 1 percent AEP water levels by comparing top-of-levee and 1 percent AEP water-level elevations from the hydraulic routing analysis (using a UNET model). If adequate freeboard was not available, a levee raise was recommended for the existing levee.

Updated floodplain depths and extents were not available for use in developing the 2012 CVFPP. To identify small communities at risk, a combination of *Sacramento and San Joaquin River Basins Comprehensive Study* (Comprehensive Study) 1 percent floodplains (FLO-2D) and FEMA 1 percent floodplain mapping was used (USACE, 2002). For communities identified using the FEMA floodplain data, it was not certain whether the source of flooding was SPFC facilities or local drainages; local drainages would be outside the scope of the CVFPP. Consequently, future analyses will be needed to refine the potential State of California (State) interest in improving the level of protection for these communities as part of CVFPP implementation.

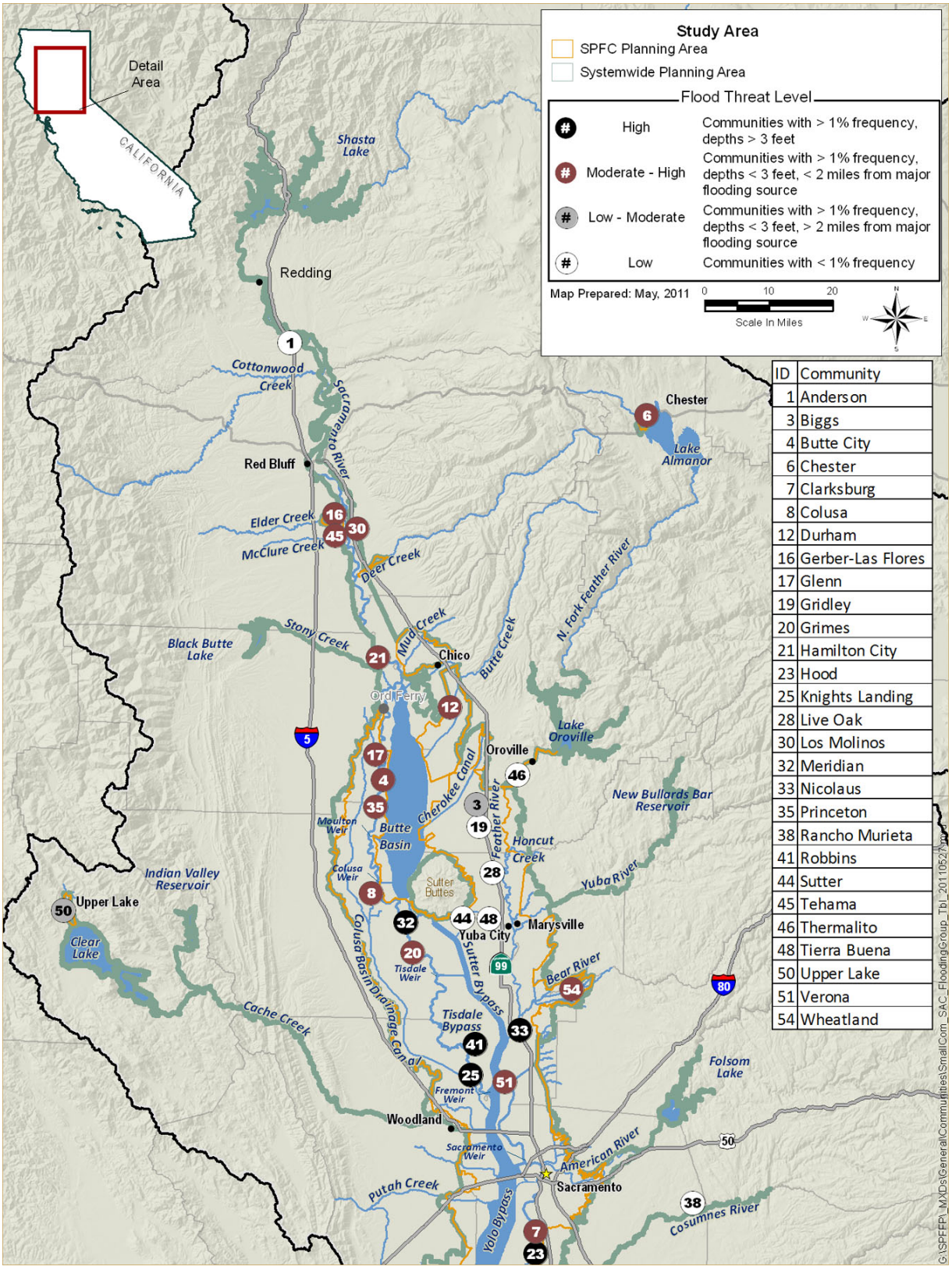

Figure D-1. Small Communities Within Sacramento River Basin

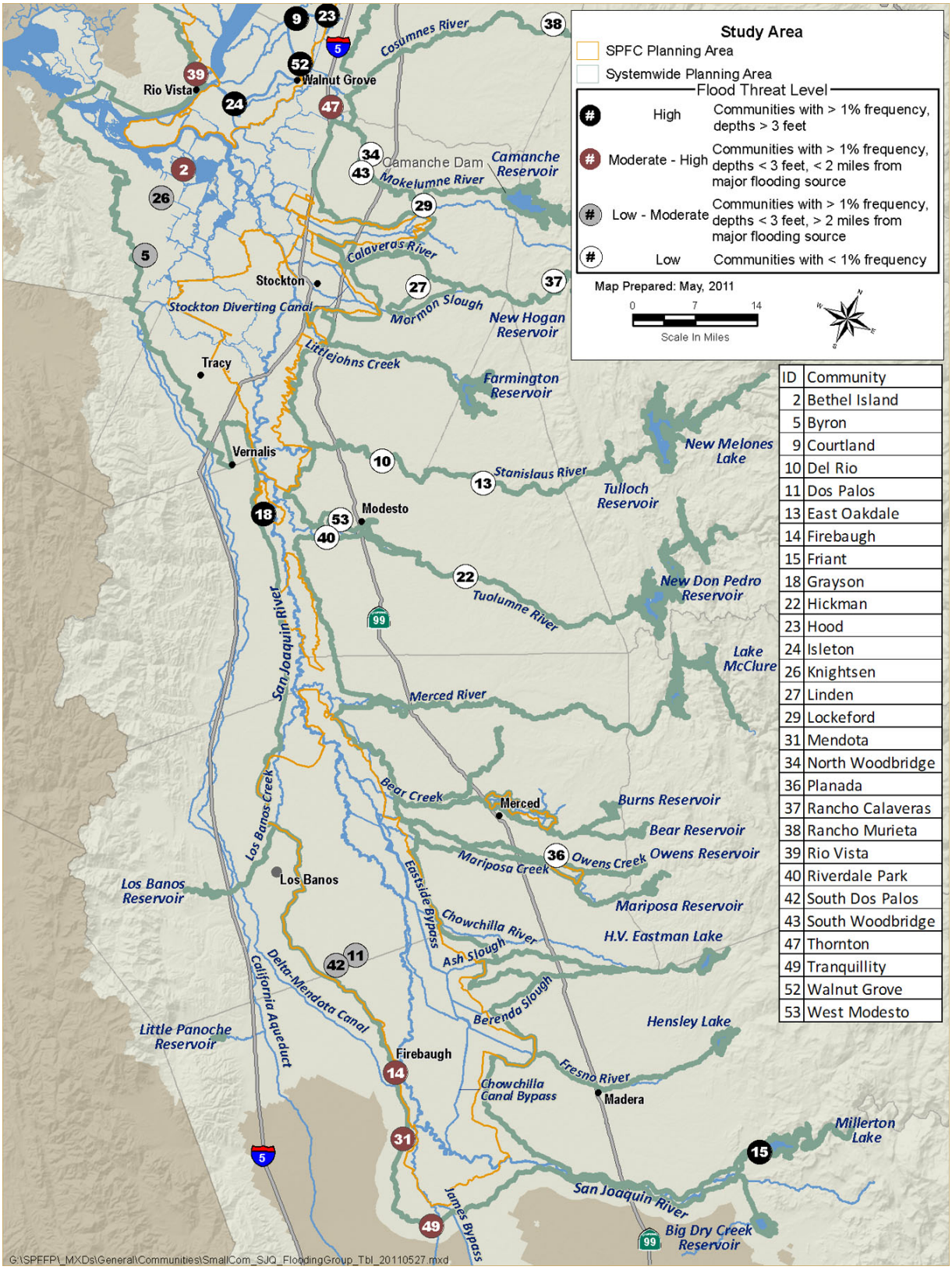

Figure D-2. Small Communities Within San Joaquin River Basin

Using the best hydraulic data available, each small community was also examined to determine if new levees were needed to provide protection either in addition to fixing existing levees in place, or in lieu of a reconstruction-in-place alternative. The new levee category also included existing levees not covered in the NULE GARs; these levees were recommended to be replaced because no information was available to determine a reconstruction-in-place alternative. For "new" and "replaced existing" levees, required levee height was calculated as the depth of flood inundation found on the FLO-2D inundation maps plus 3 feet of freeboard. FLO-2D inundation maps were created in GIS using 1 percent AEP flood inundation depths created using levee performance curves from the Comprehensive Study.

Levee Design Criteria

The DWR Urban Levee Design Criteria (ULDC)[1] were used, as appropriate to levee location and function, in the conceptual design of new levees for this study. Conceptual levee designs include a waterside slope of 3H: 1V and a landside slope of 2H: 1V. For inspection and emergency vehicle access, a 12-foot-wide crown would be constructed with a 10-foot-wide by 6-inch-deep layer of aggregate base material along an entire alignment. Crowns 20 feet wide were used for levees greater than 15 feet in height. Easements would include a permanent, 20-foot-wide right-of-way (ROW) on each side of training, tieback, and ring levees for inspection and maintenance, plus an additional temporary 5 feet on each side of the levees for construction. Easements for new levees along existing channels would include a 20-foot-wide ROW, plus an additional temporary 5 feet on the landside, only. To help prevent erosion, all areas except the 10-foot-wide gravel roadway along the crown would receive a hydroseed application after construction.

Cost Estimating

Cost estimates for each small community were based on two sources:

- Reconstruction-in-place cost extracted from the DWR South and North NULE Project Remediation Alternatives and Cost Estimate Reports (RACER) (June 2011).

- New levee cost developed based on the Parametric Cost Estimating Tool (PCET), which was used in the RACERs.

A description of how these sources were used to provide cost information is included in the following sections.

[1] The ULDC are under development at the time of this report.

Common Elements

A consistent cost approach was applied to the direct and indirect costs (Tables D-1 and D-2). The common elements were based on the same criteria used in the Sacramento and San Joaquin river watersheds for Urban Levee Evaluations (ULE) Project and NULE cost estimating to have comparable costs for establishing the State's priorities and allocations.

Table D-1. Common Elements – Direct Unit Costs

Item	Unit/sum	Unit Cost/Percentage
Excavation	cubic yard	$5
Clearing and Grubbing	acre	$5,000
Stripping	acre	$3,000
Waste Material	cubic yard	$4
Embankment Fill	cubic yard	$16
Fill	cubic yard	$4
Aggregate Road Base	ton	$35
Hydroseeding	acre	$2,000
Permanent Right-of-Way	acre	$10,000 – $300,000
Temporary Easement	acre	$5,000
Unallocated Items	lump sum	5%
Mobilization and Demobilization	lump sum	5%
Environmental Mitigation	lump sum	25%

Table D-2. Common Elements – Indirect Costs

Item	Cost Percentage
Escalation (to October 2011)	3%
Contingency	30%
Engineering and Design	15%
Permitting and Legal	5%
Engineering Services During Construction	2%
Construction Management	15%

Reconstruction-in-Place Cost

Costs were extracted from the NULE RACERs according to the levee segment identified in the NULE GARs and the adverse conditions being remediated. If an entire levee segment was recommended for repair, the least-cost alternative identified in the NULE RACERs was used. If only a portion of the levee segment was recommended for repair, there were two options for associating costs based on the length of the levee portion:

1. If the length of the portion of the levee was greater than the length being remediated in the associated cost option for the entire levee segment, then the cost as described in the RACER to repair the entire levee segment was used.

2. If the length of the portion of the levee was less than the length being remediated in the associated cost option for the entire levee segment, then the cost of remediation was assigned to the alternative on a cost-per-length basis.

For both options, performance events were used to define the most prevalent levee hazard condition in the portion. The cost of remediation for that levee condition issue was used to determine cost. If no performance event was identified, the least-cost alternative was used.

New Levee Cost

The process for estimating costs for new levees began with creating an average levee cross section along a proposed alignment. From FLO-2D hydraulic modeling results, the proposed horizontal and vertical alignments were initially determined. Horizontal alignments for conceptual levees were typically chosen along boundaries of the most densely populated regions of the community. However, proposed horizontal alignments can vary, depending on the layout of a community, existing topography, whether the origin of simulated flood flows can reliably be determined, or a combination of all three.

Vertical alignments for new levees were based on either an average height method or, more conservatively, the uppermost limit of inundation from simulated water depths. The average height method considered the level of inundation from simulated FLO-2D modeling for various lengths of the proposed horizontal alignments and averages them. Both methods for determining vertical alignments included an additional 3 feet of freeboard. After an average levee cross section was established, areas and volumes were then calculated along the proposed alignments.

From these calculated volumes and areas, the following quantities were then produced: clearing, stripping, and grubbing; waste material; embankment fill; aggregate road base for levee crowns; hydroseeding; and easement acquisitions. To create more thorough cost estimates, and to be consistent with the cost-estimating analysis for reconstruction-in-place repairs, additional line items for construction and indirect costs were added. These line items include (as a percentage of civil construction costs) unallocated items, mobilization and demobilization, environmental mitigation (and as a percentage of total costs) escalation, contingency,

engineering design, permitting and legal, engineering services during construction, and construction management.

Small Community Characteristics and Cost

Table D-3 summarizes the characteristics and cost estimates developed for the Group A, B, and C communities. The table includes communities that receive protection from the SPFC and those outside the SPFC Planning Area. It should be noted that ranges reflecting cost uncertainties are not shown in this table. Cost uncertainty ranges are developed in Appendix A.

Table D-3. Summary of Small Community Characteristics and Cost Estimates

	Community Name	2007 Total Population	Flood Threat Level[1]	First Cost	Total Owners Cost	Total Levee Miles	Type of Levee Improvement		
							Fix Existing Levee	New Levee	Cost Curve Applied[2]
Protected by SPFC	Knights Landing	1,776	A	$30,689,566	$7,408,413	2.81	□	■	□
	Grayson	1,172	A	$2,929,545	$792,909	0.70	■	■	□
	Isleton	831	A	$45,893,744	$16,136,223	5.06	□	■	□
	Walnut Grove	811	A	$69,176,968	$23,085,452	10.40	□	■	□
	Meridian	756	A	$18,790,261	$6,711,266	1.85	■	■	□
	Courtland	695	A	$70,976,277	$13,696,872	8.62	■	□	□
	Robbins	367	A	$30,768,589	$12,669,419	2.25	□	■	□
	Hood	212	A	$30,169,271	$11,427,562	1.77	□	■	□
	Firebaugh	6,178	B	$30,918,288	$9,302,383	7.73	■	■	□
	Colusa	5,574	B	$54,053,821	$12,044,135	5.25	■	■	□
	Durham	5,445	B	$50,000,000	$30,355,093	13.69	■	□	□
	Rio Vista	5,255	B	$42,476,797	$10,157,545	-	□	□	■
	Wheatland	2,476	B	$173,483,949	$33,658,506	15.95	■	□	□
	Gerber- Las Flores	1,524	B	$23,420,910	$2,449,337	3.95	■	□	□
	Glenn	1,436	B	$11,575,248	$4,766,279	1.92	□	■	□
	Clarksburg	1,401	B	$33,583,420	$8,493,592	3.36	□	■	□
	Tranquility	849	B	$42,476,797	$10,157,545	-	□	□	■
	Verona	585	B	$42,476,797	$10,157,545	-	□	□	■
	Grimes	516	B	$6,259,914	$1,120,875	1.38	■	■	
	Princeton	489	B	$42,476,797	$10,157,545	-	□	□	■
	Butte City	291	B	$6,217,933	$1,811,935	1.47	■	■	□
	Dos Palos/ So Dos Palos	6,706	C	$89,885,219	$19,889,529	22.95	■	□	□

Table D-3. Summary of Small Community Characteristics and Cost Estimates (contd.)

	Community Name	2007 Total Population	Flood Threat Level[1]	First Cost	Total Owners Cost	Total Levee Miles	Type of Levee Improvement		
							Fix Existing Levee	New Levee	Cost Curve Applied[2]
Protected by SPFC	Biggs	1,959	C	$90,323,215	$21,252,521	9.22	■	□	□
	Upper Lake	963	C	$75,217,182	$15,027,239	5.28	■	□	□
Not Protected by SPFC[3]	Friant	530	A	$41,373,898	$17,036,311	1.38	□	■	□
	Mendota	8,558	B	$38,382,737	$15,804,656	6.45	□	■	□
	Bethel Island	2,624	B	$42,476,797	$10,157,545	-	□	□	■
	Chester	2,366	B	$42,476,797	$10,157,545	-	□	□	■
	Los Molinos	2,068	B	$42,476,797	$10,157,545	-	□	□	■
	Hamilton City	1,885	B	$58,407,219	$24,050,031	3.15	□	■	□
	Thornton	1,467	B	$42,476,797	$10,157,545	-	□	□	■
	Tehama	443	B	$20,597,310	$3,048,821	3.86	■	□	□
	Byron	1,040	C	$42,476,797	$10,157,545	-	□	□	■
	Knightsen	913	C	$42,476,797	$10,157,545	-	□	□	■

Notes:
1 A = flood frequency > 1% per year, flooding depths > 3 feet.; B = flood frequency > 1% per year, flooding depths < 3 feet, < 2 miles from flood source; C = flood frequency > 1% per year, flooding depths < 3 feet, > 2 miles from flood source.
2 Costs for communities lacking specific flood location and flood depth data were estimated parametrically based on communities of similar size and threat level.
3 Non-SPFC costs are not included in the SSIA of the CVFMP. Communities were assessed 100-year protection costs, but are not part of the proposed SPFC total costs.
Key:
Shading =
□= No
■ = Yes
- =
SPFC = State Plan of Flood Control

Group A Communities

This section describes the conceptual design and cost estimate for each Group A community. The following is a list of the communities covered in this section:

- Knights Landing
- Grayson
- Isleton
- Walnut Grove
- Meridian
- Nicolaus
- Courtland
- Robbins
- Hood
- Friant

Knights Landing

Knights Landing is an unincorporated community in Yolo County that sits at the confluence of the Colusa Basin Drainage Canal, Knights Landing Ridge Cut, and Sacramento River, which border the north, west, and southern portions of the community, respectively. FLO-2D hydraulic modeling results overlaid on an aerial photo of Knights Landing (Figure D-3) showed that the water depth from a simulated 1 percent AEP flood would range from 0 to 15 feet in the community.

Two options were identified to protect Knights Landing. Option 1 is a reconstruction-in-place alternative repairing all of Levee Segments 162, 172, and 217, as described in the NULE GAR, with the addition of a 1.4-foot levee raise to the entire length of Segment 162 based on the 1 percent AEP water levels from the UNET model. This option would provide protection to an area beyond the community south, toward the Yolo Bypass. The least-cost alternative, as shown in the RACER, was used for each segment, giving a total capital cost of $10.1 million for Option 1. This cost does not include costs associated with raising all of Levee Segment 162.

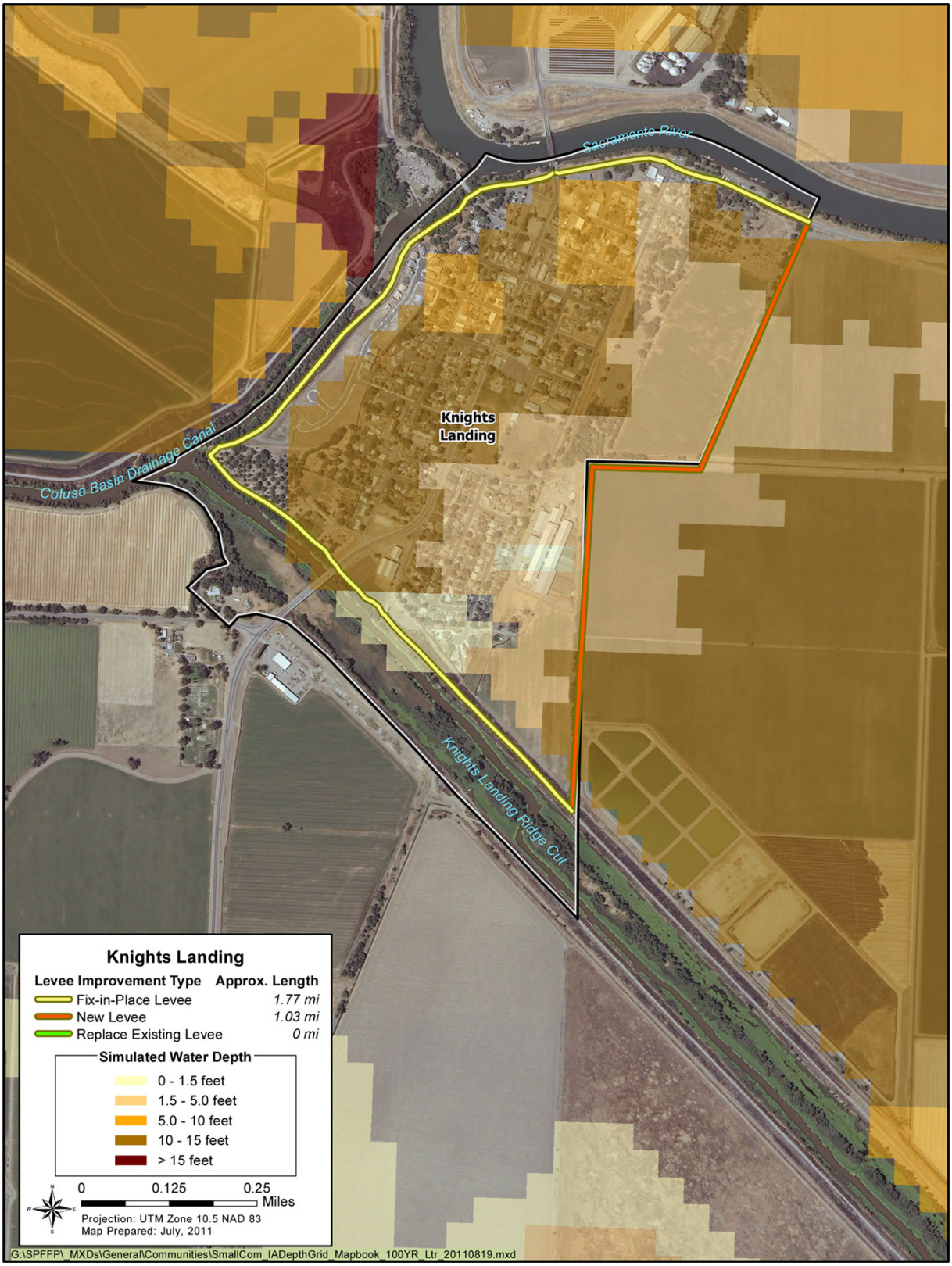

Figure D-3. Knights Landing Levees Approach

Option 2 is a combination alternative that would provide a ring levee system. It would involve reconstruction-in-place repairs to portions of Segments 217 and 162, with the addition of a 1.4-foot levee raise to the portion of Segment 162, as well as construction of a new levee on the south between existing Levee Segments 217 and 162. The new levee would have a 12-foot crown, with an average height of 18 feet, spanning about 1.04 miles. This option would provide protection only to the area within the Knights Landing community (Figure D-3). Cost for portions of Segments 217 and 162 were selected based on the performance events listed for each segment in the segment summaries of the NULE GAR. No performance events were shown for the portion of Segment 217, and the length of the portion was more than the total length of repair for the least-cost alternative for the entire segment; therefore, the least-cost alternative, as shown in the RACER, was used. Segment 162 showed under-seepage issues in the area, and the length of the portion was less than the total length for the cost of remediation that included under-seepage; therefore, the cost per length of the under-seepage alternative was applied to a portion of Segment 162. The new levee cost was assessed using the developed methodology. The total capital cost for Option 2, not including the costs associated with raising the portion of Levee Segment 162, was estimated to be $26.4 million.

Grayson

Grayson is an unincorporated community in Stanislaus County located directly adjacent to the left bank of the San Joaquin River. FLO-2D hydraulic modeling results referenced over aerial photography of Grayson (Figure D-4) revealed that a water depth from a simulated 1 percent AEP storm would be in the range of 1.5 to 10 feet in the areas closest to the San Joaquin River. In addition, GAR and RACER information was reviewed for the type and cost of remediation necessary to repair the existing levee next to Grayson. After analyzing the available data, it was determined that reconstruction-in-place repairs along the left bank of the San Joaquin River, in combination with constructing a new training levee on the northern edge of town, would protect Grayson from a 1 percent AEP storm (Figure D-4).

The recommended repairs along the left bank of the San Joaquin River include remediation for under-seepage, through-seepage, and nonseepage-related stability. The cost to repair the entire 1.8-mile levee segment, identified in the GAR as Segment 207, is estimated at $8.4 million, which calculates to about $4.7 million per mile. The cost per mile was then applied to only a 0.50-mile portion of Segment 207 (Figure D-4), to estimate the reconstruction-in-place costs.

To complete the conceptual layout, a training levee would be constructed beginning at the left bank of the San Joaquin River and extending about 0.2

miles westward along the northern edge of Grayson. The training levee has been conservatively designed with an average height of 5.73 feet. The average height was calculated by using a weighted average of 8 feet (5 feet plus an additional 3 feet of freeboard) for a portion of the alignment, and 4.5 feet (1.5 feet plus an additional 3 feet of freeboard) for the remaining portion. The total cost for construction, including reconstruction-in-place repairs, was estimated to be $2.7 million.

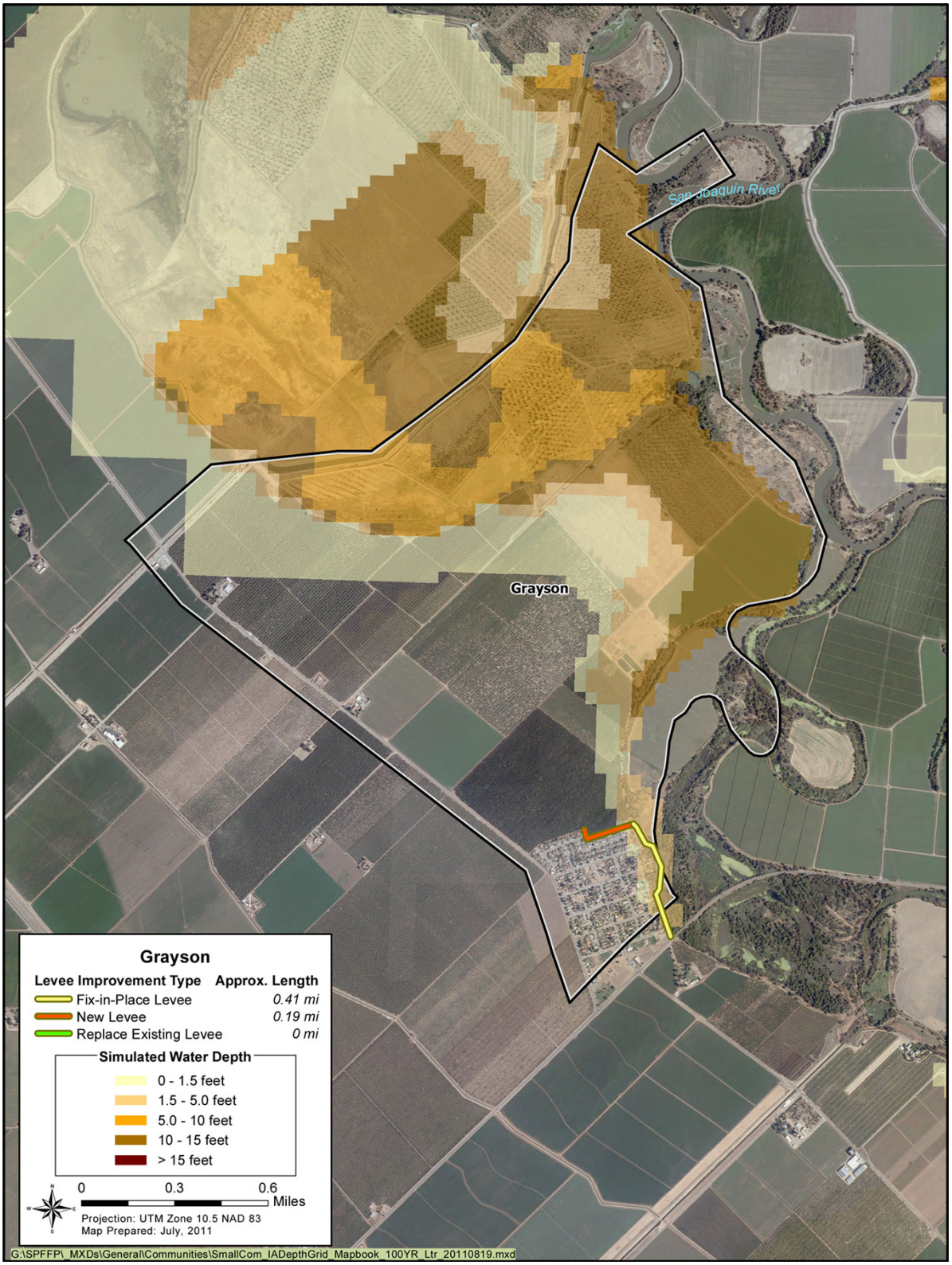

Figure D-4. Grayson Levees Approach

Isleton

Isleton is a city in Sacramento County located on Andrus Island in the Delta. It sits on the left bank of the Sacramento River along California State Route 160. A small portion of the city stretches south to the Georgiana Slough, just east of the oxbow. FLO-2D hydraulic modeling results overlaid on an aerial photograph of Isleton showed that the water depth from a simulated 1 percent AEP flood would range from 5 to 15 feet in the city (Figure D-5).

The conceptual design for Isleton is a combination alternative that would provide a ring levee system. It would involve reconstruction-in-place repairs to portions of Segments 40 and 378, with the addition of a 0.7-foot levee raise to a portion of Segment 378, as well as construction of two new levees on the east and west between existing Levee Segments 40 and 378. The new levees would have a 12-foot crown, with an average height of 18 feet, spanning about 2.8 miles in total. This option would provide protection beyond the city limits (Figure D-5). Cost for the portions of Segments 40 and 378 were selected based on the performance events listed for each segment in the segment summaries of the NULE GAR (DWR 2010). Segment 40 showed under-seepage issues in the area, and the length of the portion was more than the total length of repair for the cost of remediation that included under-seepage; therefore, the under-seepage cost alternative for the entire segment, as shown in the RACER (DWR 2011), was used. Segment 378 showed stability issues in the area, and the length of the portion was less than the total length for the cost of remediation that included stability; therefore, the cost per length of the stability alternative was applied to a portion of Segment 378. The new levee cost was assessed using the developed methodology. The total capital cost for Isleton, not including the costs associated with raising the portion of Levee Segment 378, was estimated to be $34.9 million.

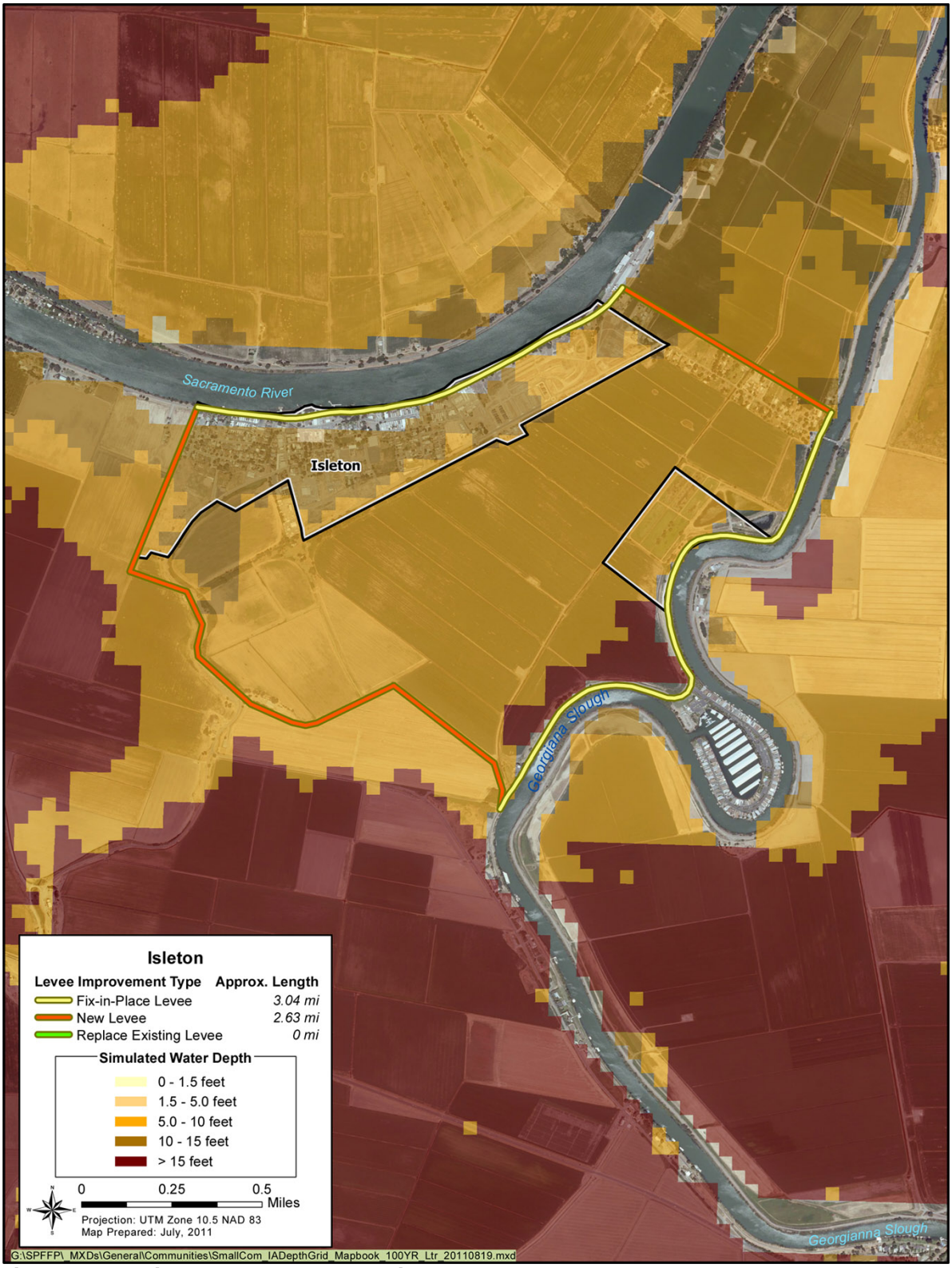

Figure D-5. Isleton Levees Approach

Walnut Grove

Walnut Grove is a Census Designated Place (CDP) in Sacramento County located on portions of Grand and Tyler islands at the confluence of the Sacramento River, Georgiana Slough, Delta Cross Canal, and Snodgrass Slough. FLO-2D hydraulic modeling results overlaid on an aerial photograph of Walnut Grove showed that the water depth from a simulated 1 percent AEP flood would range from 0 to 15 feet in the CDP (Figure D-6).

The conceptual design for Walnut Grove is a combination alternative that would provide a ring levee system. It would involve reconstruction-in-place repairs to portions of Levee Segments 384, 1040, 121, 127, and 128, with the addition of an 0.8-foot levee raise to the portion of Segment 384 based on 1 percent AEP water levels from the UNET model, as well as construction of three new levees and replacing seven existing levees with new levees. The new levees would have a 12-foot crown with an average height of 18 feet, spanning about 1.5 miles in total. This option would provide protection beyond the city limits (Figure D-6). No performance events where shown for the portion of Segments 384 and 1040, and the lengths of the portions were more than the total lengths of repair for the least-cost alternative for the entire segments, respectively; therefore, the least-cost alternatives, as shown in the RACER (DWR 2011), were used. Segments 121, 127, and 128 were categorized as low for all levee condition categories, meaning no repairs were recommended. Therefore, no remediation costs were associated with these segments. The new levee cost was assessed using the developed methodology. The total capital cost for Walnut Grove was estimated to be $40.6 million. This cost does not include costs associated with raising the portion of Levee Segment 384 or other levee raises, which were not assessed at this time because data from the UNET model are pending.

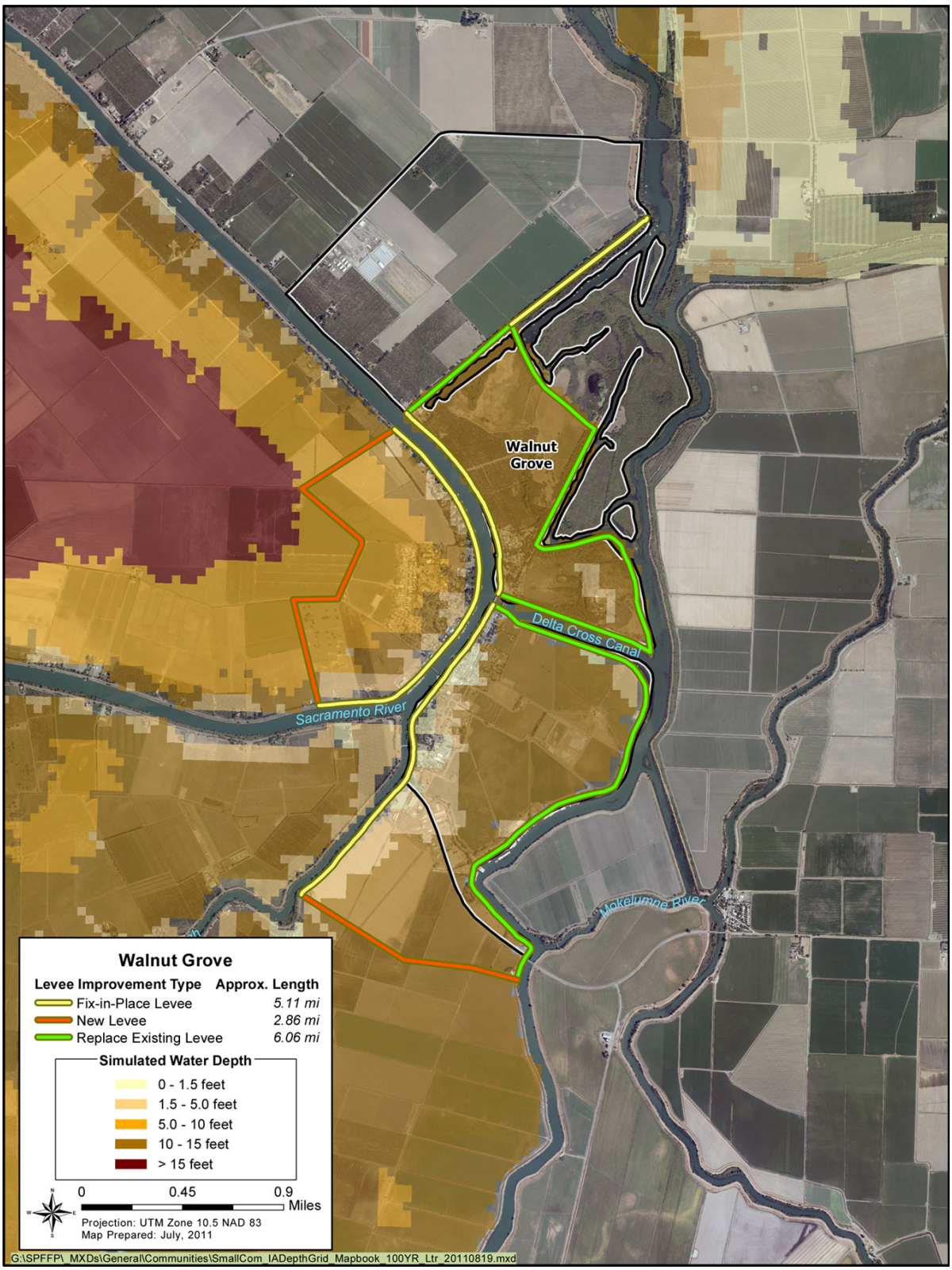

Figure D-6. Walnut Grove Levees Approach

Meridian

Meridian is an unincorporated community located along the left bank of the Sacramento River in Sutter County. FLO-2D hydraulic modeling results referenced over aerial photography of Meridian (Figure D-7) showed that the water depth from a simulated 1 percent AEP flood would be in the range of 0 to 15 feet. In addition, GAR (DWR 2010) and RACER (DWR 2011) information was reviewed for the type and cost of remediation necessary to repair the existing levee adjacent to Meridian. After analyzing the available data, it was determined that reconstruction-in-place repairs along the left bank levee of the Sacramento River, in combination with construction of a ring levee around Meridian, would protect the community from a 1 percent AEP flood (Figure D-7).

The recommended repairs along the left bank of the Sacramento River include remediation for under-seepage, through-seepage, and nonseepage-related stability. The cost to repair a 3.1-mile portion of the levee segment, identified in the GAR as Segment 115, is estimated at $34.3 million, which calculates to about $11.1 million per mile. The cost per mile was then applied to only the 0.34-mile portion of Segment 115 (Figure D-7) to estimate the reconstruction-in-place costs. Although areas of inadequate freeboard related to 1957 design elevations were not identified along Segment 115, more data are needed to determine whether the levee segment has the minimum 3 feet of freeboard for a 1 percent AEP level of protection. Additional costs to increase the crown elevation and overall size of the levee prism may apply.

To complete the conceptual layout, a new ring levee would be constructed to encircle Meridian. The 1.51-mile ring levee would begin and end at the left bank of the Sacramento River, encapsulating the portion of the existing levee to receive reconstruction-in-place repairs. The average height of 12.88 feet was calculated using a weighted average of 18 feet (15 feet plus an additional 3 feet of freeboard), 13 feet (10 feet plus an additional 3 feet of freeboard), 8 feet (5 feet plus an additional 3 feet of freeboard), and 4.5 feet (1.5 feet plus an additional 3 feet of freeboard) for different portions of the ring levee alignment, depending on the simulated water depth from hydraulic modeling. Total cost for construction, including reconstruction-in-place repairs, was estimated to be $12.4 million.

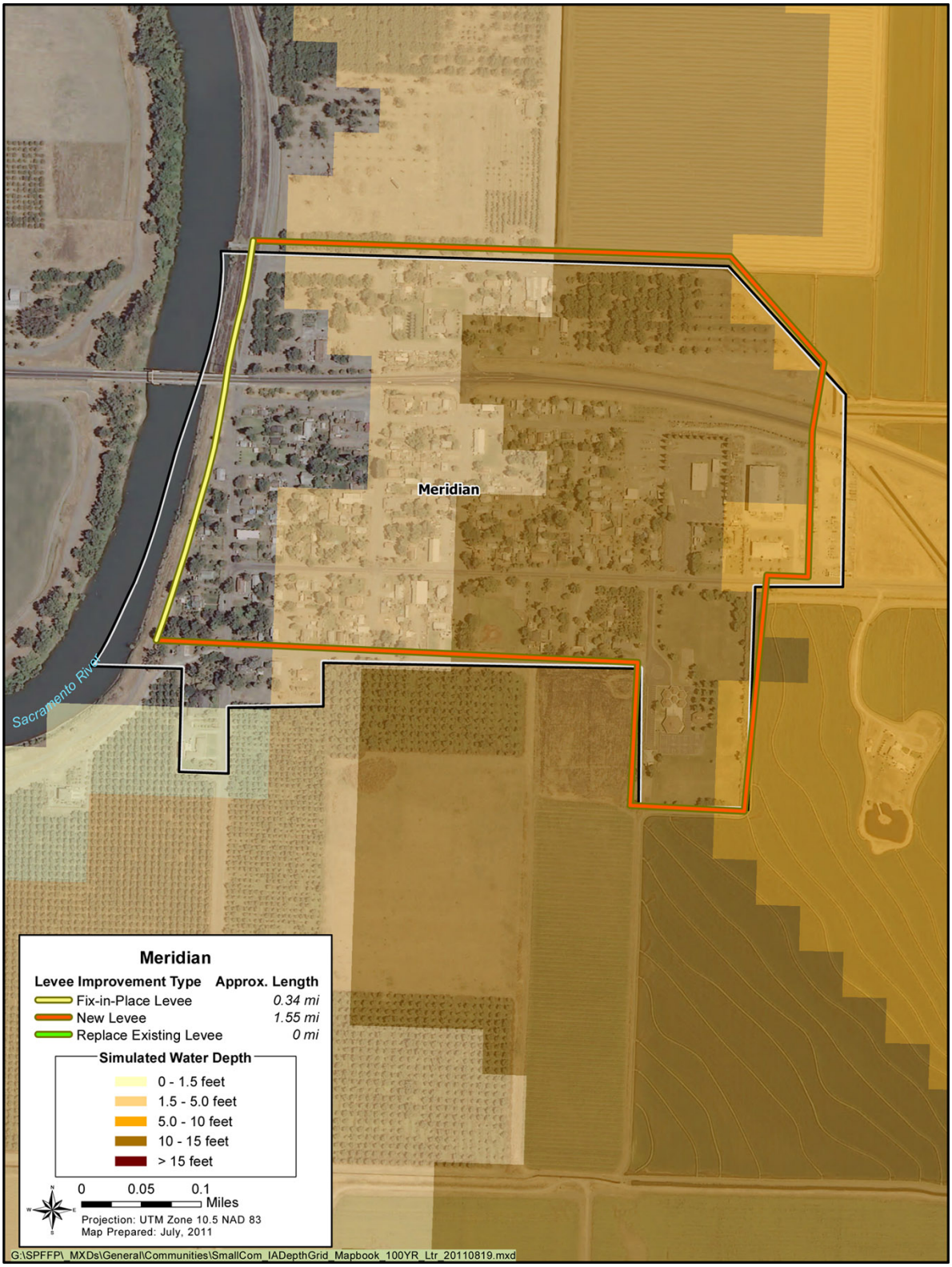

Figure D-7. Meridian Levees Approach

Nicolaus

Nicolaus is an unincorporated town and area in Sutter County along California State Route 99, about 0.1 miles south of the Feather River. FLO-2D hydraulic modeling results overlaid on an aerial photograph of Nicolaus showed no inundation during a 1 percent AEP flood in the town (Figure D-8).

Because no inundation was shown, constructing a new levee was not an option. Therefore, the conceptual design is a reconstruction-in-place alternative repairing all of Levee Segment 247, as described in the NULE GAR (DWR 2010). This option would provide protection to an area beyond the town (Figure D-8). The least-cost alternative, as shown in the RACER (DWR 2011), was used for Segment 247, giving a total capital cost of $1.9 million. This cost does not include expenses associated with levee raises, which were not assessed at this time because data from the UNET model are pending.

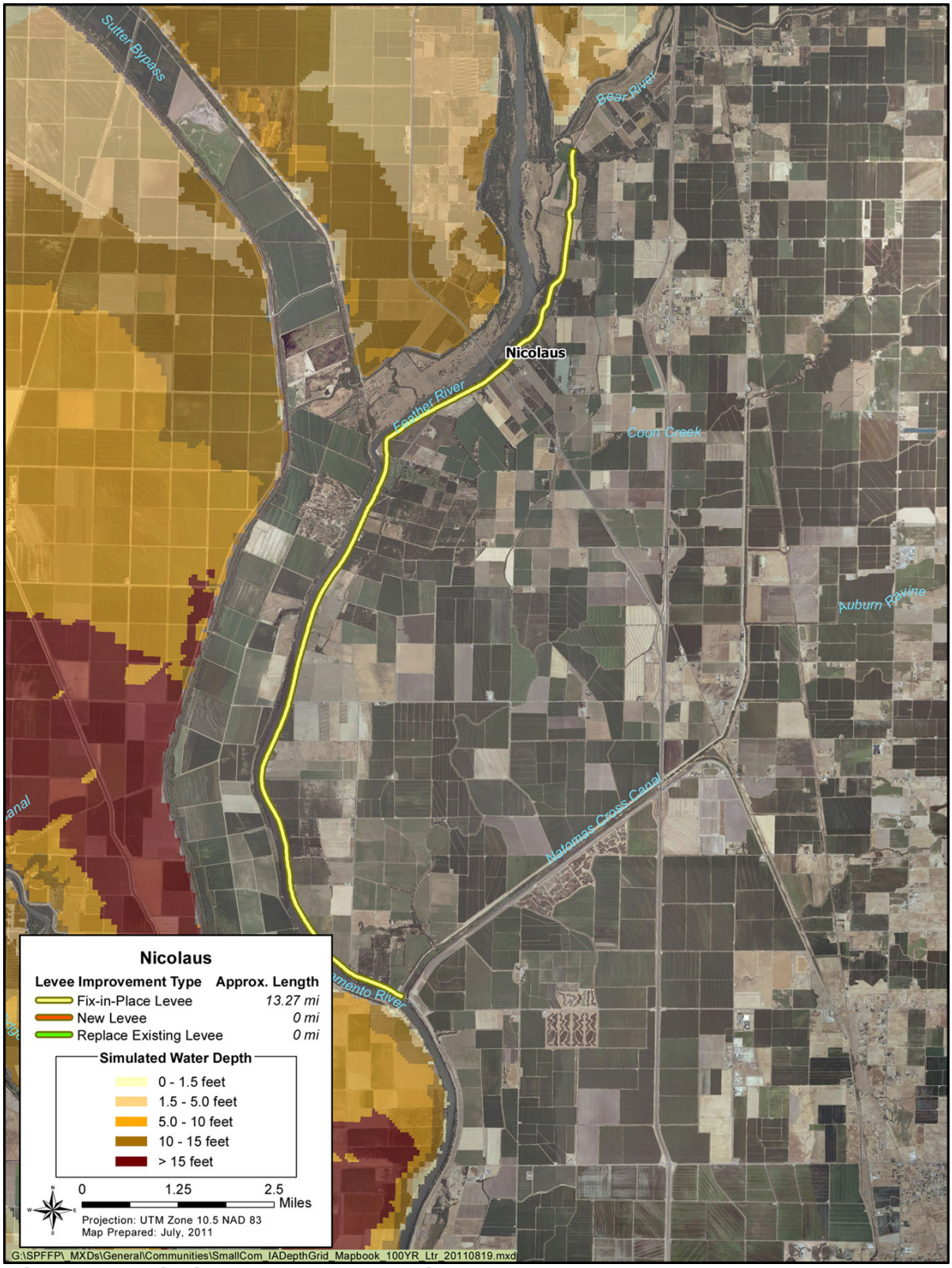

Figure D-8. Nicolaus Levees Approach

Courtland

Courtland is an unincorporated community in Sacramento County located along the left bank of the Sacramento River along California State Route 160, 17 miles south-southwest of Sacramento. FLO-2D hydraulic modeling results overlaid on an aerial photograph of Courtland showed no inundation during a 1 percent AEP flood in the community (Figure D-9).

Because no inundation was shown, constructing a new levee was not an option. Therefore, the conceptual design is a reconstruction-in-place alternative repairing all of Levee Segments 126 and 131, as described in the NULE GAR (DWR 2010). This option would provide protection to an area beyond the community (Figure D-9). The least-cost alternative, as shown in the RACER (DWR 2011), was used for each segment, giving a total capital cost of $12.6 million. This cost does not include expenses associated with levee raises, which were not assessed at this time because data from the UNET model are pending.

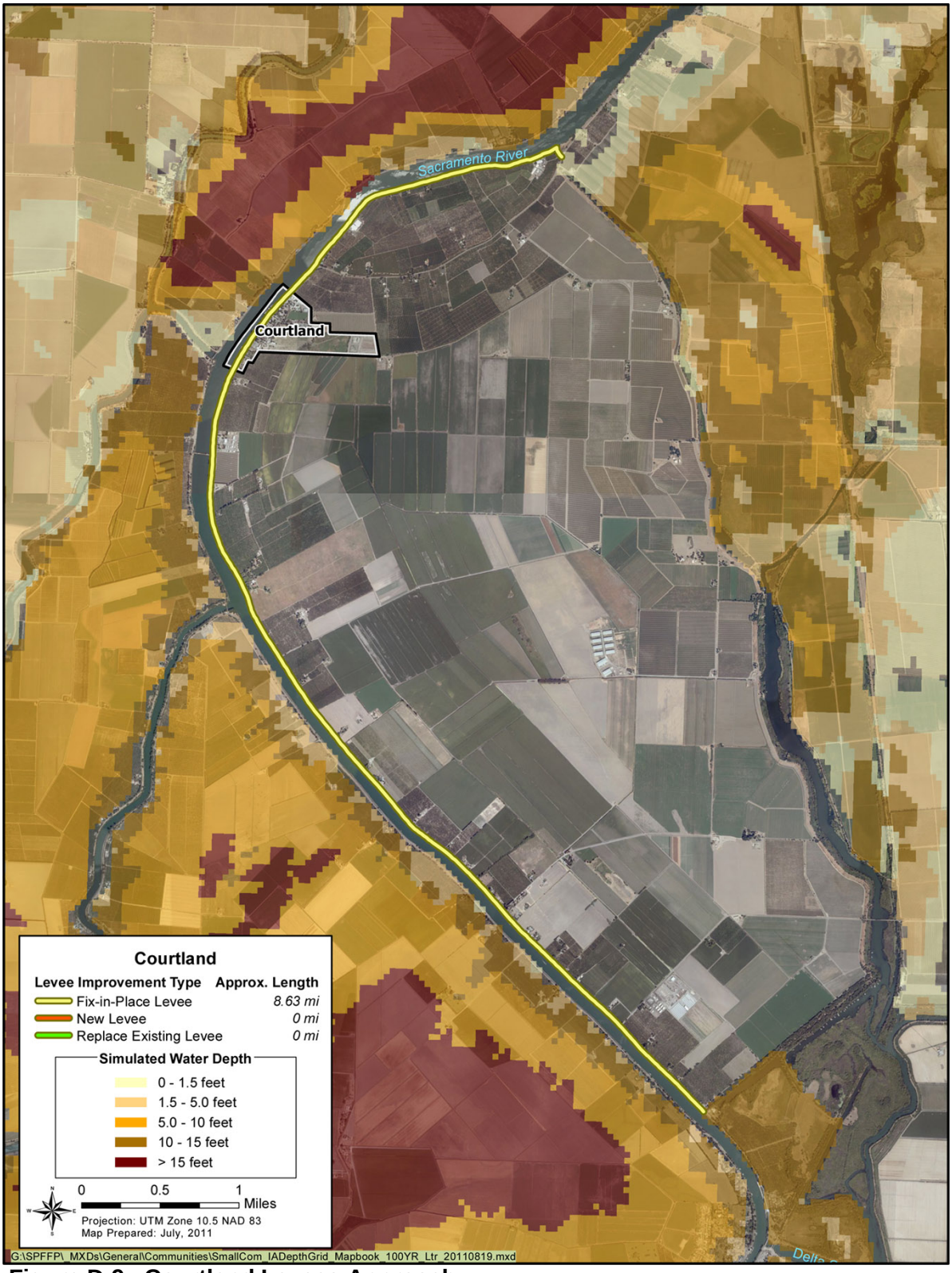

Figure D-9. Courtland Levees Approach

Robbins

Robbins is an unincorporated town in Sutter County situated about 1.5 to two miles from the left bank of the Sacramento River to the west and about 2.5 to three miles from the right bank of the Sutter Bypass to the east. FLO-2D hydraulic modeling results referenced over aerial photography of Robbins (Figure D-10) showed that a water depth from a simulated 1 percent AEP flood would be a minimum of 5 to 10 feet over the entire area, with as much as 10 to 15 feet of inundation in some lower-lying areas. In addition, the GAR (DWR 2010) and RACER (DWR 2011) information was reviewed for the type and cost of remediation necessary to repair existing levees in the Robbins area. Reconstruction-in-place options were ultimately eliminated because of the considerable distance between the existing levees along the Sacramento River and the Sutter Bypass and the town of Robbins. To reliably protect Robbins with reconstruction-in-place options, several miles of existing levees nearest to and upstream from Robbins would require a significant amount of remediation related to under-seepage, through-seepage, and nonseepage-related stability. After considering the geographical size and layout of Robbins, as well as its proximity to existing levees, constructing a ring levee around the town was chosen as the most practical approach to protect Robbins from a 1 percent AEP flood (Figure D-10).

A conceptual ring levee has been conservatively designed with an average height of 13.91 feet. The average height was calculated using a weighted average of 13 feet (10 feet plus an additional 3 feet of freeboard) for most of the ring levee, and 18 feet (15 feet plus an additional 3 feet of freeboard) for the areas with the deepest inundation. The length of levee needed to encircle Robbins was approximated at 2.25 miles, and the total cost for construction was estimated to be $16.5 million.

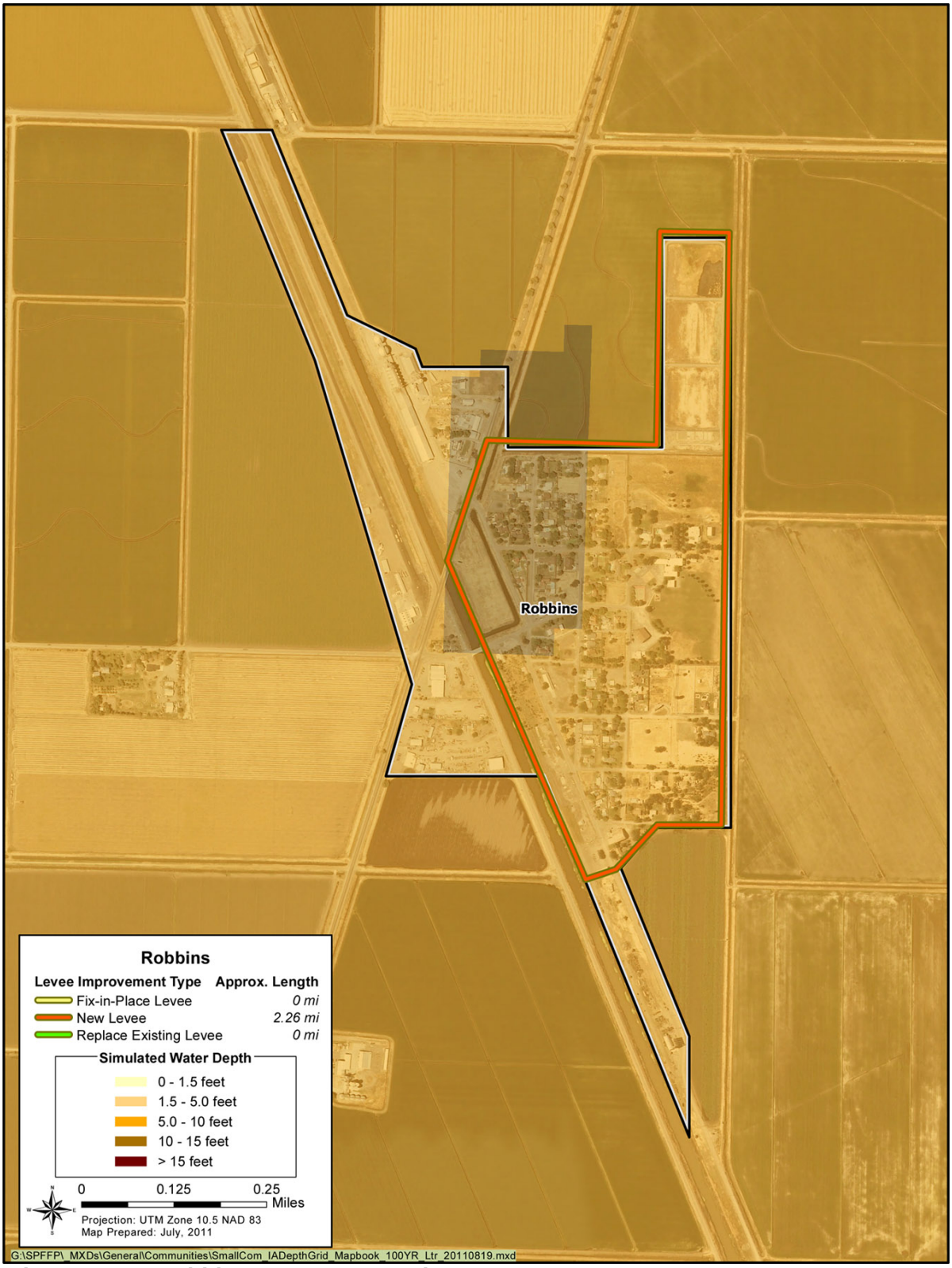

Figure D-10. Robbins Levee Approach

Hood

Hood is an unincorporated community in Sacramento County located on the left bank of the Sacramento River along California State Route 160, 15 miles south of downtown Sacramento. FLO-2D hydraulic modeling results overlaid on an aerial photograph of Hood showed that the simulated water depth from a simulated 1 percent AEP flood would range from 0 to 15 feet (Figure D-11).

The conceptual design for Hood is a combination alternative that would provide a ring levee system. It would involve reconstruction-in-place repairs to portions of Levee Segment 106, as well as construction of new levee on the north and replacement of existing levees with new levees on the east and south. The new levees would have a 12-foot crown, with an average height of 18 feet, spanning about 1.5 miles in total. This option would provide protection beyond the city limits (Figure D-11). Cost for the portions of Segment 106 was selected based on the performance events listed for each segment in the segment summaries of the NULE GAR (DWR 2010). Segment 106 showed under-seepage issues in the area, and the length of the portion was less than the total length for the cost of remediation, which included under-seepage; therefore, the cost per length of the under-seepage alternative was applied to a portion of Segment 160. The new levee cost was assessed using the developed methodology. The total capital cost for Hood was estimated to be $19.9 million. This cost does not include expenses associated with levee raises, which were not assessed at this time because data from the UNET model are pending.

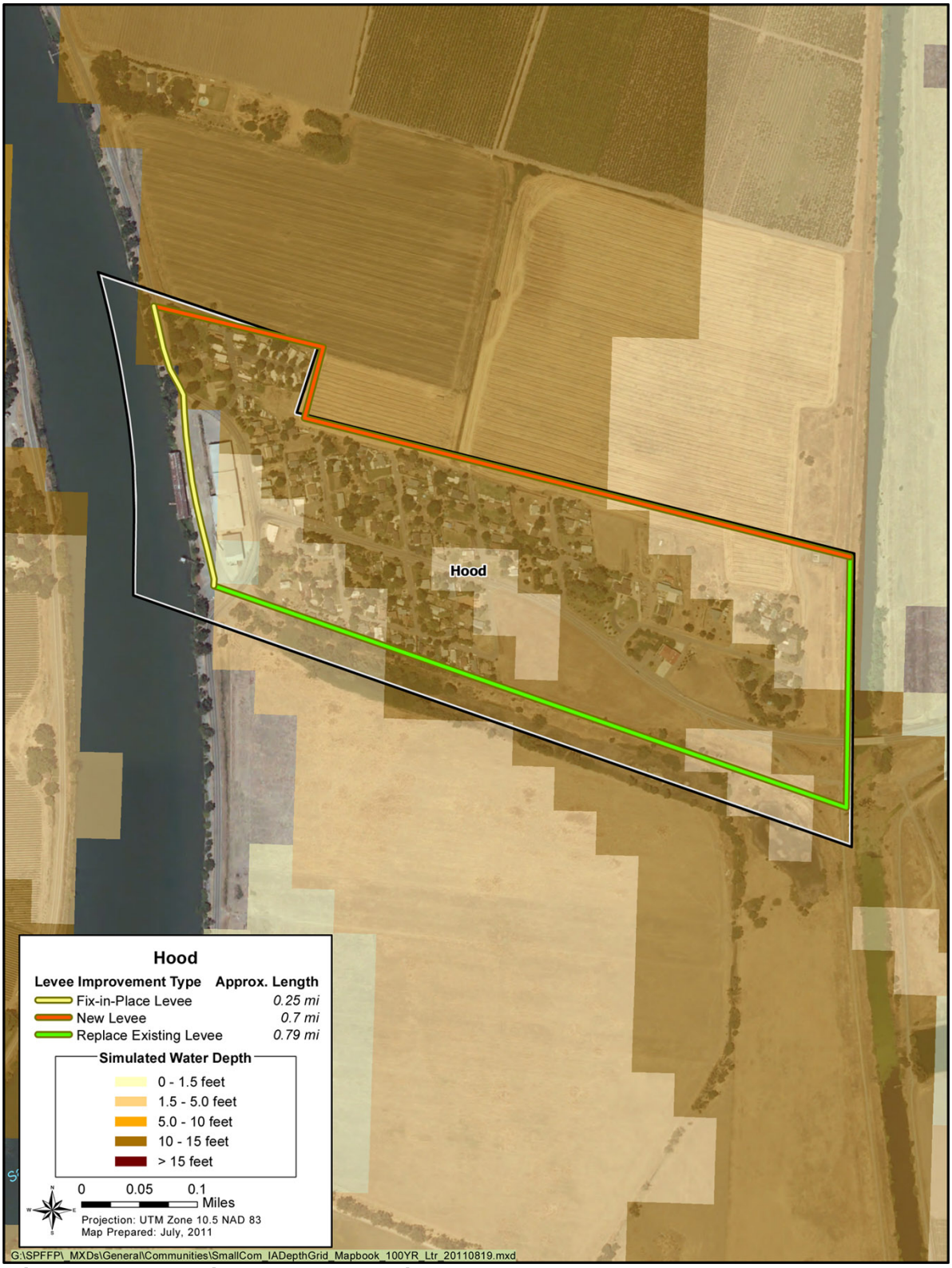

Figure D-11. Hood Levees Approach

Friant

Friant is an unincorporated community in Fresno County located along the left bank of the San Joaquin River, just below Friant Dam and Millerton Lake. FLO-2D hydraulic modeling results referenced over aerial photography of Friant (Figure D-12) revealed that simulated water depth from a simulated 1 percent AEP flood would be greater than 15 feet in areas closest to the San Joaquin River, decreasing farther south into Friant. GAR (DWR 2010) and RACER (DWR 2011) information does not apply because there is no existing levee along the left bank of the San Joaquin River adjacent to Friant. As a result, the conceptual levee layout to protect Friant from a 1 percent AEP flood includes a new, substantial levee along the left bank of the San Joaquin River as well as a less robust tieback levee to the west.

The conceptual left bank levee was designed with a height of 23 feet. Because hydraulic modeling results closest to the river showed the range of water depths to be greater than 15 feet, with no explicit maximum upper limit, the conceptual left bank levee was conservatively designed with a height of 23 feet (20 feet plus an additional 3 feet of freeboard).

The conceptual tieback levee was conservatively designed with an average height of 13 feet. The average height was calculated using a weighted average of 23 feet (20 feet plus an additional 3 feet of freeboard) for the portion of the alignment closest to the left bank levee, and 4.5 feet (1.5 feet plus an additional 3 feet of freeboard) for the remaining portion. The total cost for construction, including reconstruction-in-place repairs, was estimated at $22.6 million.

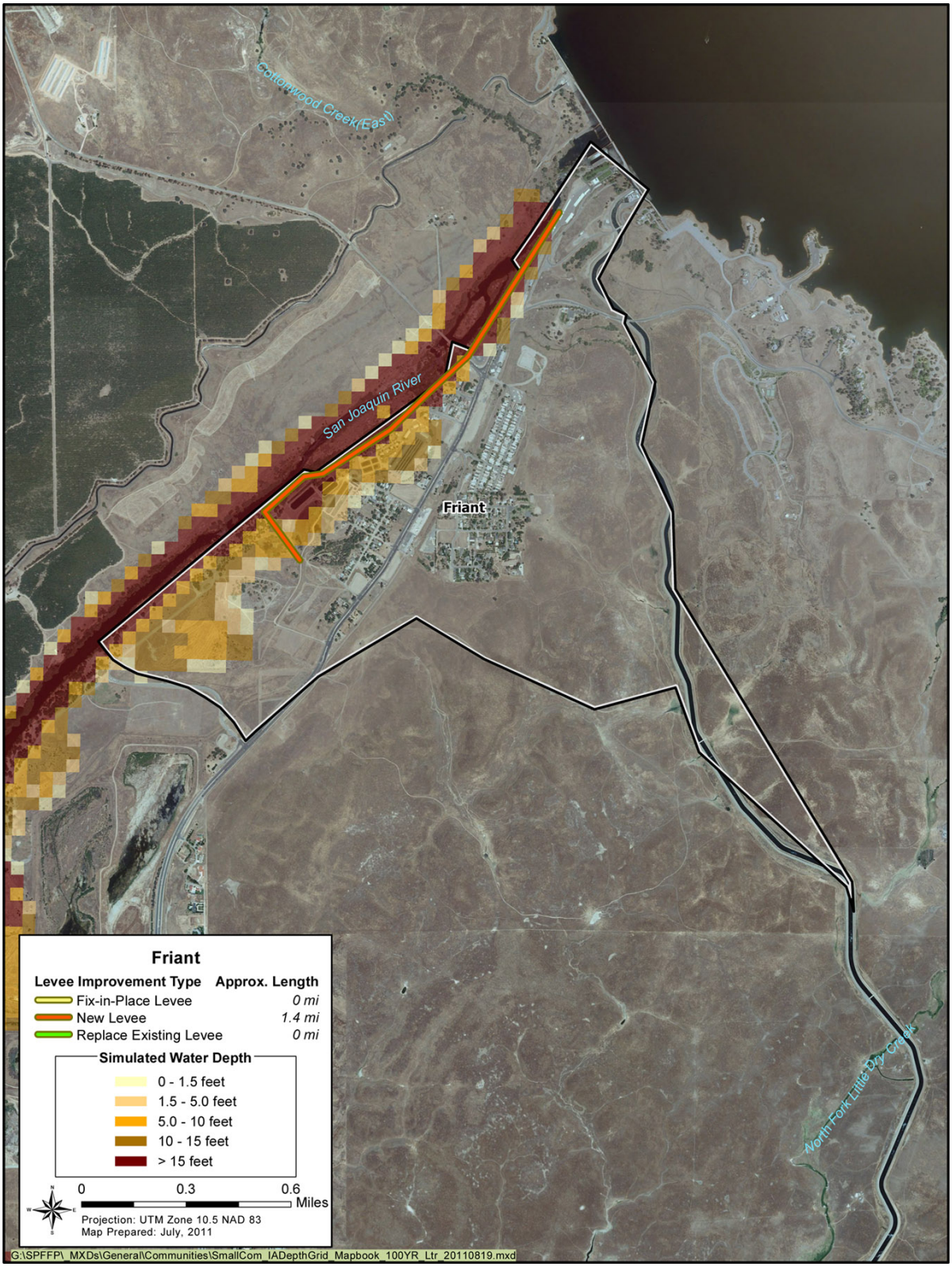

Figure D-12. Friant Levees Approach

Group B Communities

This section describes the conceptual design and cost estimate for each Group B community. The following is a list of the communities covered in this section:

- Firebaugh
- Colusa
- Durham
- Rio Vista
- Wheatland
- Gerber-Las Flores
- Glenn
- Clarksburg
- Verona
- Grimes
- Princeton
- Palermo
- Butte City
- Mendota
- Bethel Island
- Chester
- Los Molinos
- Hamilton City
- Thornton
- Tranquility
- Tehama

Firebaugh

The City of Firebaugh is located along the San Joaquin River in Fresno County. Most of the community lies along the left bank of the San Joaquin River; however, two small subdivisions and a water treatment facility are located on the other side of the San Joaquin River, along the right bank. FLO-2D hydraulic modeling results referenced over aerial photography of

Firebaugh (Figure D-13) showed that the water depth from a simulated 1 percent AEP flood would be in the range of 0 to 15 feet. In addition, the NULE GAR (DWR 2010) and RACER (DWR 2011) information was reviewed for the type and cost of remediation necessary to repair the left and right banks of the San Joaquin River adjacent to Firebaugh. After analyzing the available data, it was determined that reconstruction-in-place repairs along the left bank levee of the San Joaquin River, in combination with the construction of training levees to the north and south, would protect the community west of the San Joaquin River (left bank) from a 1 percent AEP flood (Figure D-13). In addition, construction of two separate ring levees to protect the water treatment facility and the larger of the two subdivisions along the right bank of the San Joaquin River would protect most of the community east of the San Joaquin River from a 1 percent AEP flood. The smaller of the two subdivisions to the east, which contains 11 homes, would be difficult to protect through the use of levees because of its proximity to a canal on one side. To protect the smaller subdivision, costly repairs along the right bank of the San Joaquin River or the construction of a levee/floodwall combination would need to be considered.

The recommended repairs along the left bank of the San Joaquin River include remediation for freeboard and geometry only. About 1.94 miles of the levee segment, identified in the GAR as Segment 5030, were identified as having inadequate freeboard and geometry, with no reference to location. Also, hydraulic modeling results from a 1 percent AEP flood appear to simulate areas of overtopping adjacent to Firebaugh. In the interest of being conservative, the entire cost to fix freeboard and geometry was applied to the 3.64-mile portion of the levee segment identified in the conceptual layout for Firebaugh (Figure D-13) to estimate reconstruction-in-place costs. Although the cost to repair freeboard along Segment 5030 to 1955 design elevations was applied to the current cost estimate, more data are needed to determine if the levee segment has the minimum 3 feet of freeboard for a 1 percent AEP level of protection. Additional costs to increase the crown elevation and overall size of the levee prism may apply.

In addition to reconstruction-in-place repairs along the left bank of the San Joaquin River, two training levees would be constructed, both north and south of Firebaugh, to complete the conceptual layout west of the river. The northern training levee, which would extend 1.37 miles, would begin at the left bank of the San Joaquin River and stretch along the edge of the city to cut off floodflows from the north. The northern training levee was conservatively designed with an average height of 4.65 feet. The average height was calculated by using a weighted average of 8 feet (5 feet plus an additional 3 feet of freeboard) for the portion of the alignment closest to the river, and 4.5 feet (1.5 feet plus an additional 3 feet of freeboard) for the remaining portion.

The southern training levee would begin at the left bank of the San Joaquin River and stretch 0.96 miles along the edge of the city, cutting off encroaching floodflows from the south. The southern training levee was conservatively designed with an average height of 4.72 feet. The average height was calculated by using a weighted average of 8 feet (5 feet plus an additional 3 feet of freeboard) for the portion of the alignment closest to the river, and 4.5 feet (1.5 feet plus an additional 3 feet of freeboard) for the remaining portion.

The conceptual layout east of the San Joaquin River (right bank) consists of two ring levees. The first ring levee would encircle a housing subdivision consisting of about 70 residences and one commercial business. The ring levee totals approximately 1.32 miles, and was conservatively designed with an average height of 4.63 feet. The average height was calculated by using a weighted average of 8 feet (5 feet plus an additional 3 feet of freeboard) for a small portion of the ring levee to the southeast and 4.5 feet (1.5 feet plus an additional 3 feet of freeboard) for the remaining portion.

The second ring levee to the east surrounds a water treatment facility directly adjacent to the right bank of the San Joaquin River. The ring levee extends 0.32 miles, and has been conservatively designed with an average height of 6.83 feet. The average height was calculated by using a weighted average of 8 feet (5 feet plus an additional 3 feet of freeboard) for most of the alignment, and 4.5 feet (1.5 feet plus an additional 3 feet of freeboard) for the remaining portion. The total cost for construction, including reconstruction-in-place repairs, both training levees, and both ring levees, was estimated at $8.8 million.

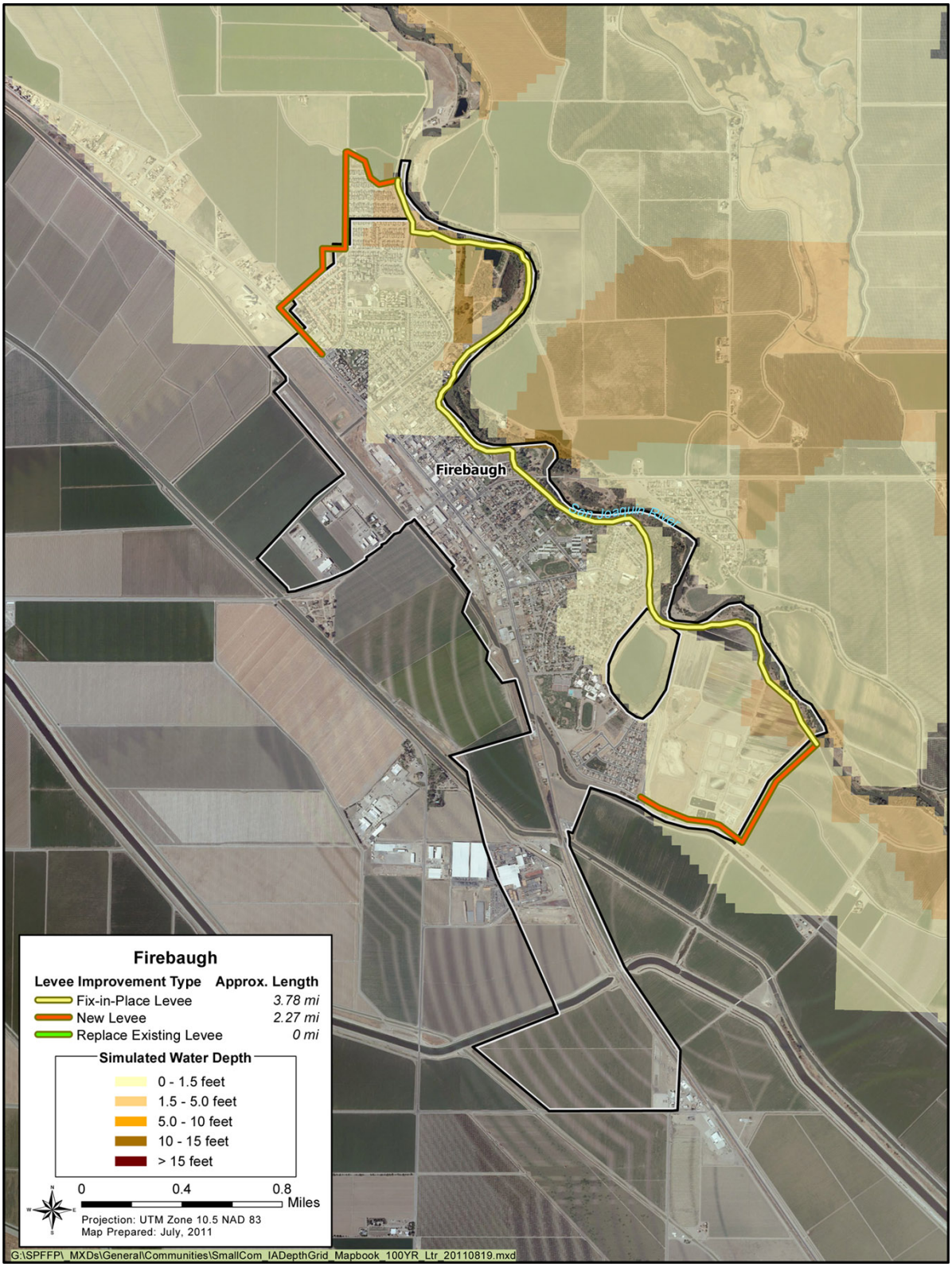

Figure D-13. Firebaugh Levees Approach

Colusa

The City of Colusa is located along the right bank of the Sacramento River in Colusa County. FLO-2D hydraulic modeling results referenced over aerial photography of Colusa (Figure D-14) showed that the water depth from a simulated 1 percent AEP flood would be in the range of 0 to 15 feet. In addition, GAR (DWR 2010) and RACER (DWR 2011) information was reviewed for the type and cost of remediation necessary to repair the existing levee adjacent to Colusa. After analyzing the available data, it was determined that reconstruction-in-place repairs along the right bank levee of the Sacramento River, in combination with construction of a training levee extending along the north and west of Colusa, would protect the community from a 1 percent AEP flood (Figure D-14).

The recommended repairs along the right bank of the Sacramento River include remediation for under-seepage, through-seepage, and freeboard and geometry for the first levee segment, and under-seepage, through-seepage, and erosion for the second segment. More costly repair alternatives were chosen for both levee segments based on previous seepage issues along the segments, and because of sharp meander in the Sacramento River as it approaches Colusa. The cost to repair a 0.63-mile portion of the first levee segment, identified in the GAR as Segment 100, was estimated at $7 million, which calculates to about $9.9 million per mile. The cost to repair the second 4.0-mile levee segment, identified in the GAR as Segment 287, was estimated at $53.5 million, which calculates to about $13.4 million per mile. The cost per mile was then applied to the entire 0.63-mile portion of Segment 100 and a 2.26-mile portion of Segment 287 (Figure D-14) to estimate the total reconstruction-in-place costs. The more expensive repair alternative for Levee Segment 100 was selected because it addresses under-seepage, which has proven to be a problem for Colusa during periods of high water in the Sacramento River. The more expensive repair alternative for Levee Segment 287 was also chosen, because it addresses under-seepage and erosion; boils have been observed in the past, and erosion has occurred. In addition, there are sharp meanders along the Sacramento River upstream and adjacent to Colusa, where the channel is against the levee (no setback). Although the cost to restore freeboard along Segment 100 to 1957 design elevations was applied to the current cost estimate, more data are needed to determine if both Segment 100 and Segment 287 have the minimum 3 feet of freeboard for a 1 percent AEP level of protection. Additional costs to increase the crown elevation and the overall size of the levee prism may apply.

To complete the conceptual layout, a training levee would be constructed beginning from the right bank of the Sacramento River, just north of Colusa. From the right bank of the Sacramento River, the training levee

would first extend about 0.53 miles westward, then run south for an additional 1.83 miles (approximately). The training levee was conservatively designed with an average height of 6.13 feet. The average height was calculated by using a weighted average of 18 feet (15 feet plus an additional 3 feet of freeboard), 8 feet (5 feet plus an additional 3 feet of freeboard), and 4.5 feet (1.5 feet plus an additional 3 feet of freeboard) for different portions of the training levee alignment, depending on the simulated water depth from hydraulic modeling. The total cost for construction, including reconstruction-in-place repairs, was estimated to be $45.3 million.

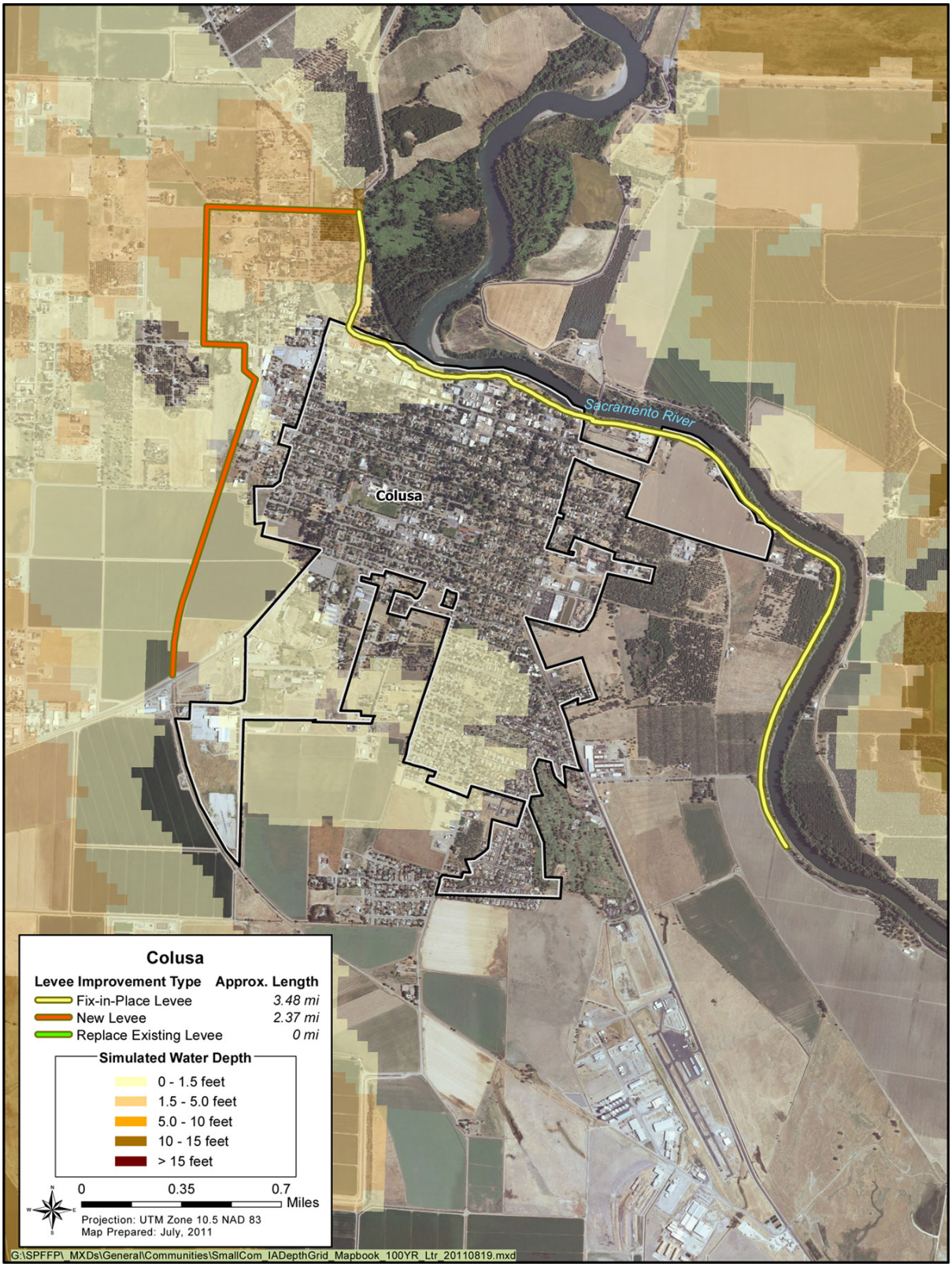

Figure D-14. Colusa Levees Approach

Durham

Durham is a Census-Designated Place (CDP) in Butte County about five miles southeast from Chico and about one mile west from Butte Creek. Because of its close proximity to Chico, Durham may need to be considered when addressing protection for that area. FLO-2D hydraulic modeling results overlaid on an aerial photograph of Durham showed no inundation during a 1 percent AEP flood in the community (Figure D-15).

Because no inundation was shown, constructing a new levee was not an option. Therefore, the conceptual design is a reconstruction-in-place alternative repairing all of Levee Segments 263 and 381, as described in the NULE GAR (DWR 2010). This option would provide protection to an area beyond the community (Figure D-15). The least-cost alternative, as shown in the RACER (DWR 2011), was used for each segment, giving a total capital cost of $29.2 million. This cost does not include expenses associated with levee raises, which were not assessed at this time because data from the UNET model are pending.

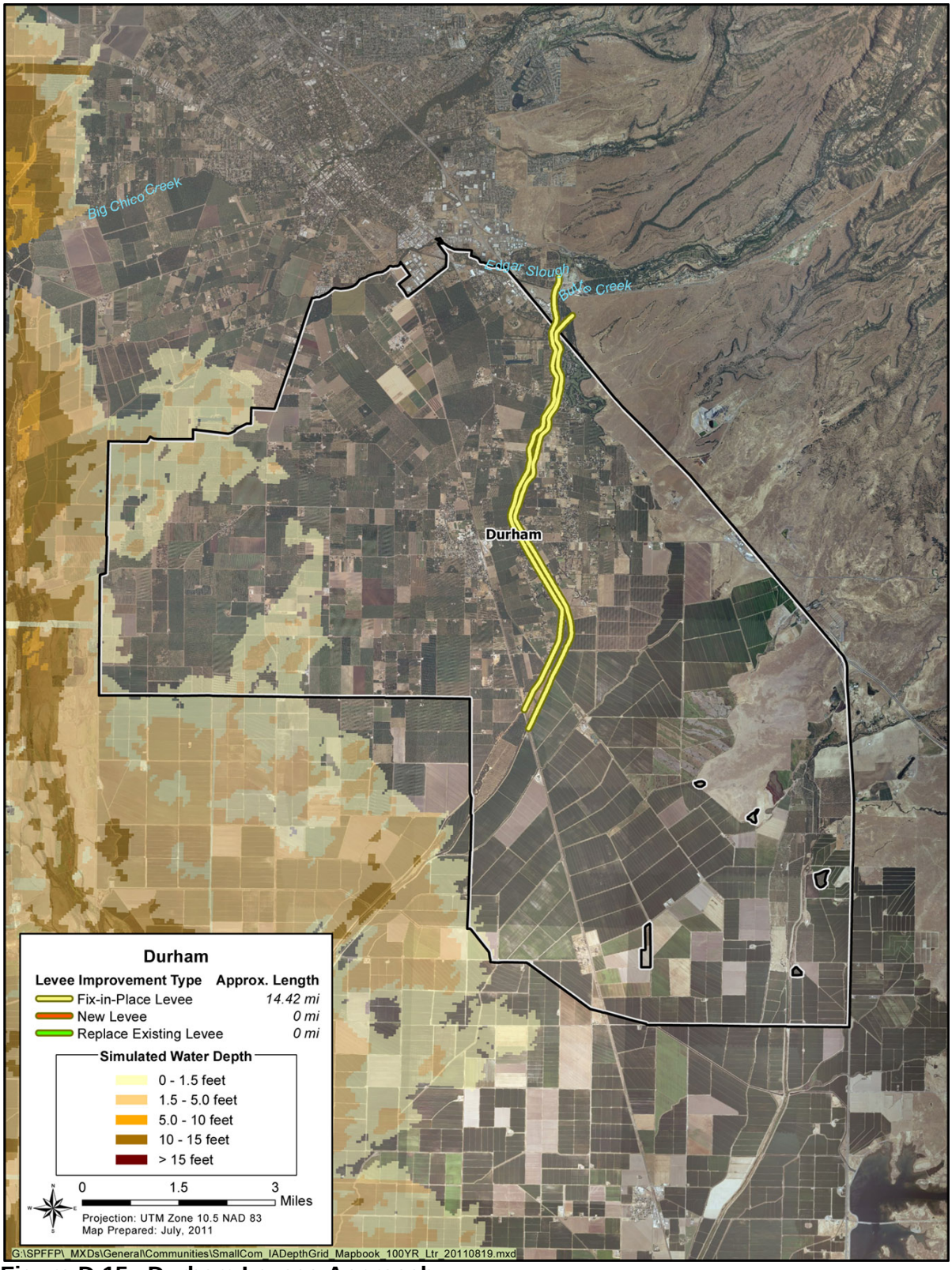

Figure D-15. Durham Levees Approach

Wheatland

The City of Wheatland is a community situated between the left bank of Dry Creek and the right bank of the Bear River in Yuba County. FLO-2D hydraulic modeling results did not show flooding from a simulated 1 percent AEP flood, although Wheatland is identified by FEMA as being in a 1 percent AEP floodplain. GAR (DWR 2010) and RACER (DWR 2011) information was reviewed for the type and cost of remediation necessary to repair the existing levees affecting Wheatland. After analyzing the available data, it was determined that reconstruction-in-place repairs along the entire length of the left bank levee of Dry Creek adjacent to Wheatland would address flooding potential until more data become available (Figure D-16). Flooding potential from the right bank of the Bear River was not considered significant enough in the GAR to merit a cost analysis for reconstruction-in-place repairs at this time.

The recommended repairs along the left bank of Dry Creek include remediation only for freeboard and geometry. Given that FLO-2D hydraulic modeling results were unable to confirm areas of inundation, the least-cost alternatives were selected to repair the entire length of both levee segments adjacent to Wheatland. The cost to repair the left bank of Dry Creek, identified in the GAR as Segment 138, was estimated to be $0.5 million. The cost to repair the left bank of Dry Creek, identified in the GAR as Segment 154, was estimated to be $0.4 million. Therefore, the total cost to remediate the entire length of each segment was estimated to be $0.9 million. Although the cost to restore freeboard along Segments 138 and 154 to 1957 design elevations was applied to the current cost estimate, more data are needed to determine if both Segments 138 and 154 have the minimum 3 feet of freeboard for a 1 percent AEP level of protection. Additional costs to increase the crown elevation and the overall size of the levee prism may apply.

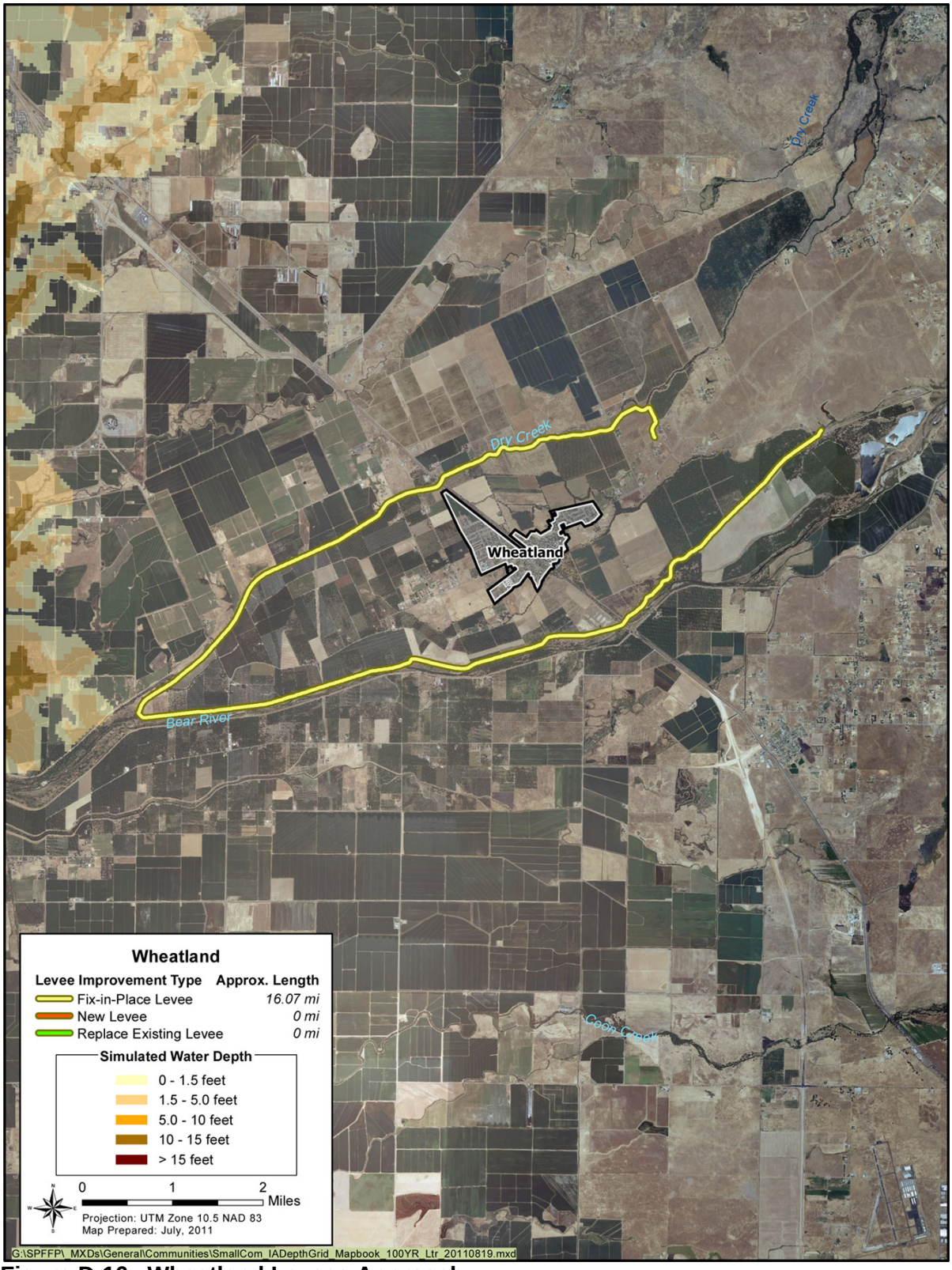

Figure D-16. Wheatland Levees Approach

Glenn

Glenn is an unincorporated community in Glenn County located about one mile west of the Sacramento River, at the intersection of State Route 45 and State Route 162, about 10 miles east of Interstate 5 (I-5). FLO-2D hydraulic modeling results overlaid on an aerial photo of Glenn showed that the water depth from a simulated 1 percent AEP flood would range from 0 to 1.5 feet in the community.

The conceptual design for Glenn would provide a ring levee system. It would involve constructing a new levee on the north, west, and south and replacing a portion of an existing levee along the Sacramento River east of the community with a new levee. The new levees would have a 12-foot crown, with an average height of 4.5 feet, spanning about 1.9 miles in total. This option would provide protection to only the area within the Glenn community (Figure D-17). The new levee cost was assessed using the developed methodology. The total cost estimate for Glenn is $8.6 million.

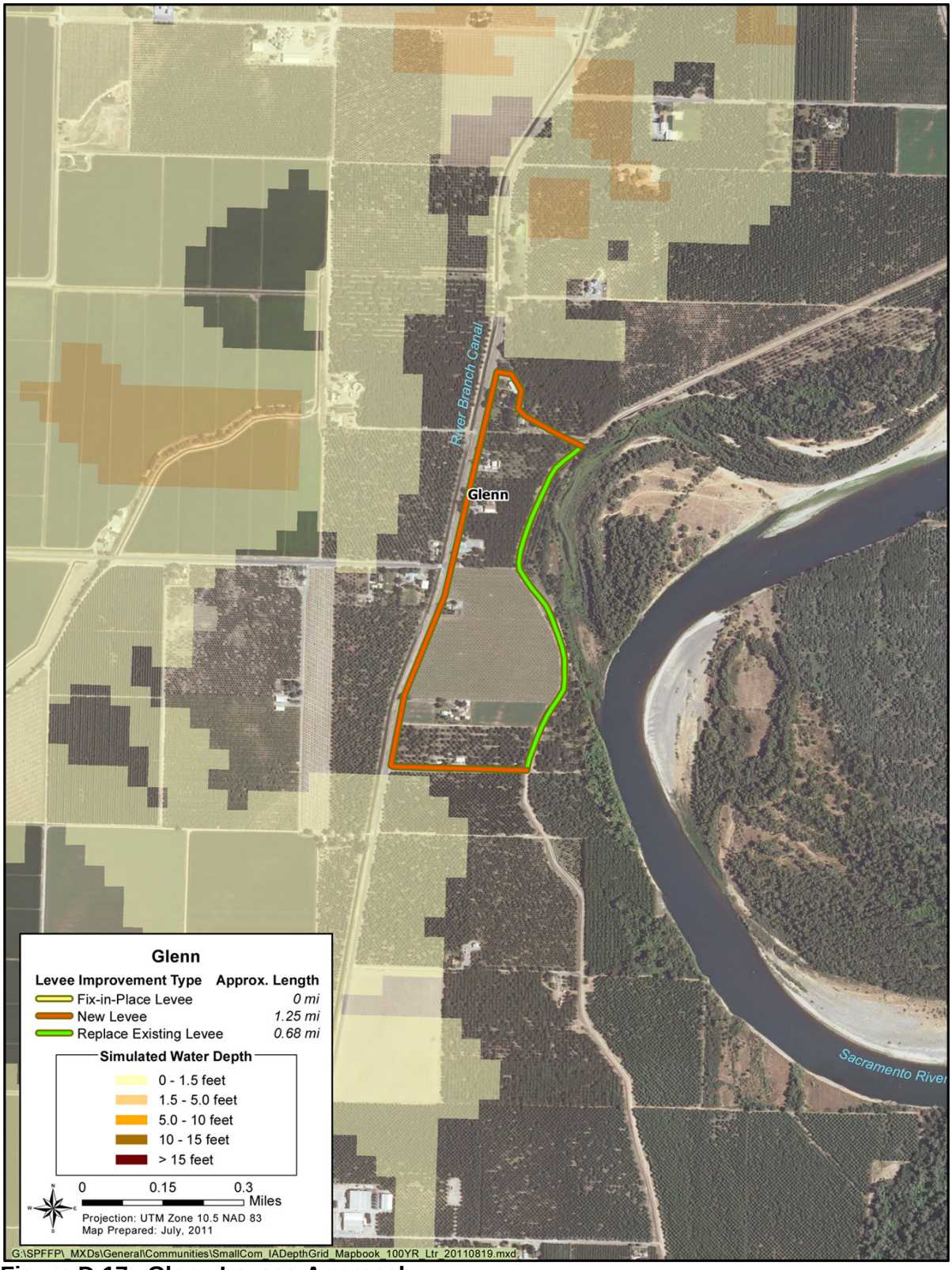

Figure D-17. Glenn Levees Approach

Clarksburg

Clarksburg is an unincorporated community in Yolo County along the right bank of the Sacramento River and Elk Slough. FLO-2D hydraulic modeling results overlaid on an aerial photo of Clarksburg showed that the water depth during a simulated 1 percent AEP flood would range from 0 to 5 feet (Figure D-18).

The conceptual design for Clarksburg is a combination alternative that would provide a ring levee system. It would involve reconstruction-in-place repairs to portions of Levee Segments 303 and 244, as well as construction of new levees on the north and west. The new levees would have a 12-foot crown, with an average height of 8 feet, spanning about 1.6 miles in total. This option would provide protection to only the area within the Clarksburg community (Figure D-18). No performance events were shown for the portions of Segments 303 and 244, and the length of the portions was more than the total lengths of repair for the least-cost alternative for the entire segments respectively; therefore, the least-cost alternatives, as shown in the RACER, were used. The new levee cost was assessed using the developed methodology. The total capital cost for Clarksburg was estimated to be $13.7 million. This cost does not include costs associated with levee raises, which were not assessed at this time because data from the UNET model are pending.

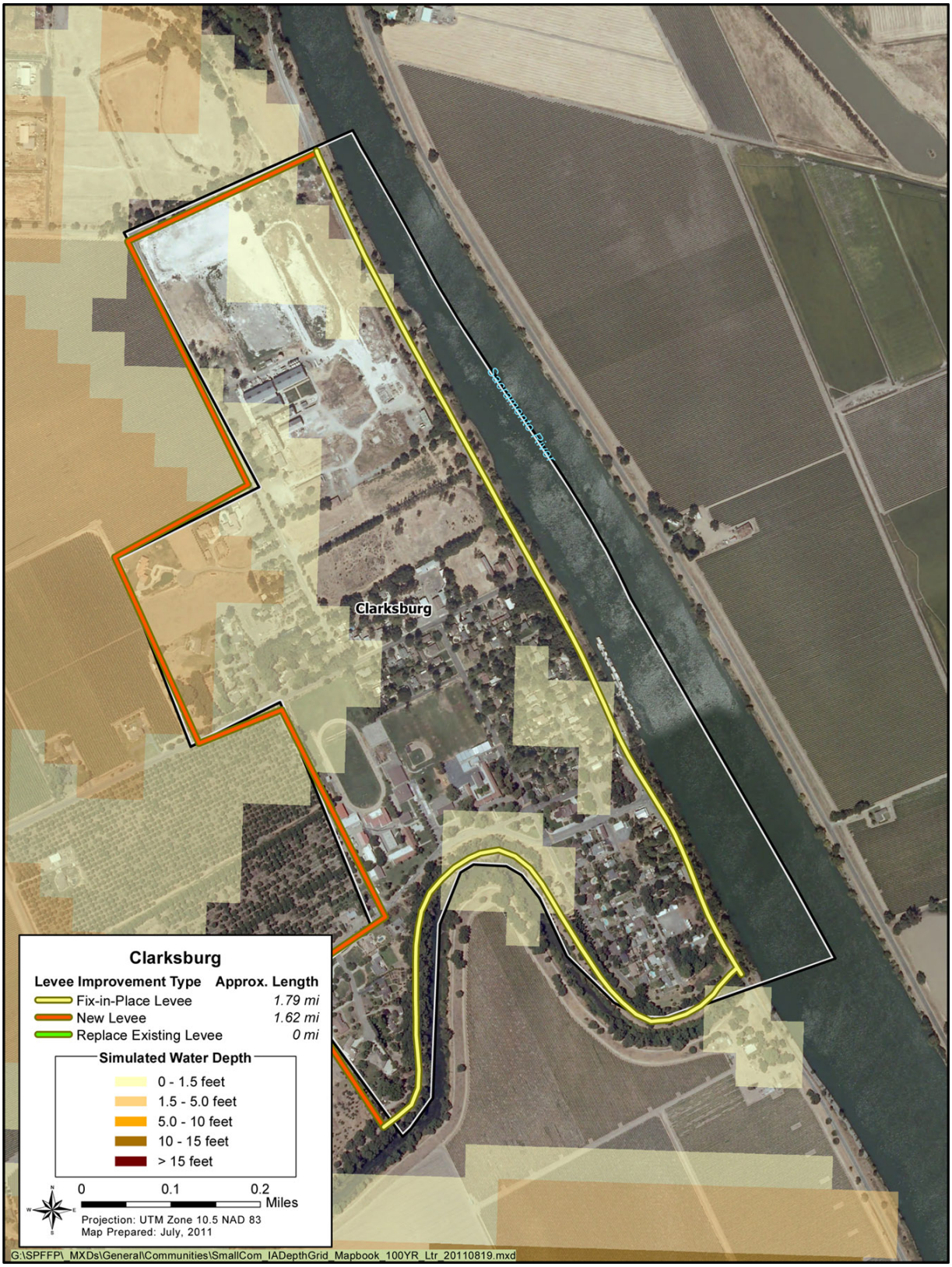

Figure D-18. Clarksburg Levees Approach

Tehama

The City of Tehama is located along the right bank of the Sacramento River in Tehama County. FLO-2D hydraulic modeling results did not show flooding from a simulated 1 percent AEP flood, although Tehama is identified by FEMA as being in a 1 percent AEP floodplain. GAR (DWR 2010) and RACER (DWR 2011) information was reviewed for the type and cost of remediation necessary to repair the existing levees affecting Tehama. After analyzing the available data, it was determined that reconstruction-in-place repairs along the entire length of the right bank levee of Elder Creek adjacent to Tehama would address flooding potential until more data become available. Flooding potential along the right bank of the Sacramento River adjacent to Tehama was not addressed in the GAR because no levees appear to exist (Figure D-19).

Recommended repairs along the right bank of Elder Creek include remediation only for freeboard and geometry. Given that FLO-2D hydraulic modeling results were unable to confirm areas of inundation, the least-cost alternative was selected to repair the entire length of the levee segment adjacent to Tehama. The cost to repair the right bank of Elder Creek, identified in the GAR as Segment 59, was estimated to be $3.8 million. Although the cost to repair freeboard along Segment 59 to 1957 design elevations was applied to the current cost estimate, more data are needed to determine if Segment 59 would have the minimum 3 feet of freeboard for a 1 percent AEP level of protection. Additional costs to increase the crown elevation and overall size of the levee prism may apply.

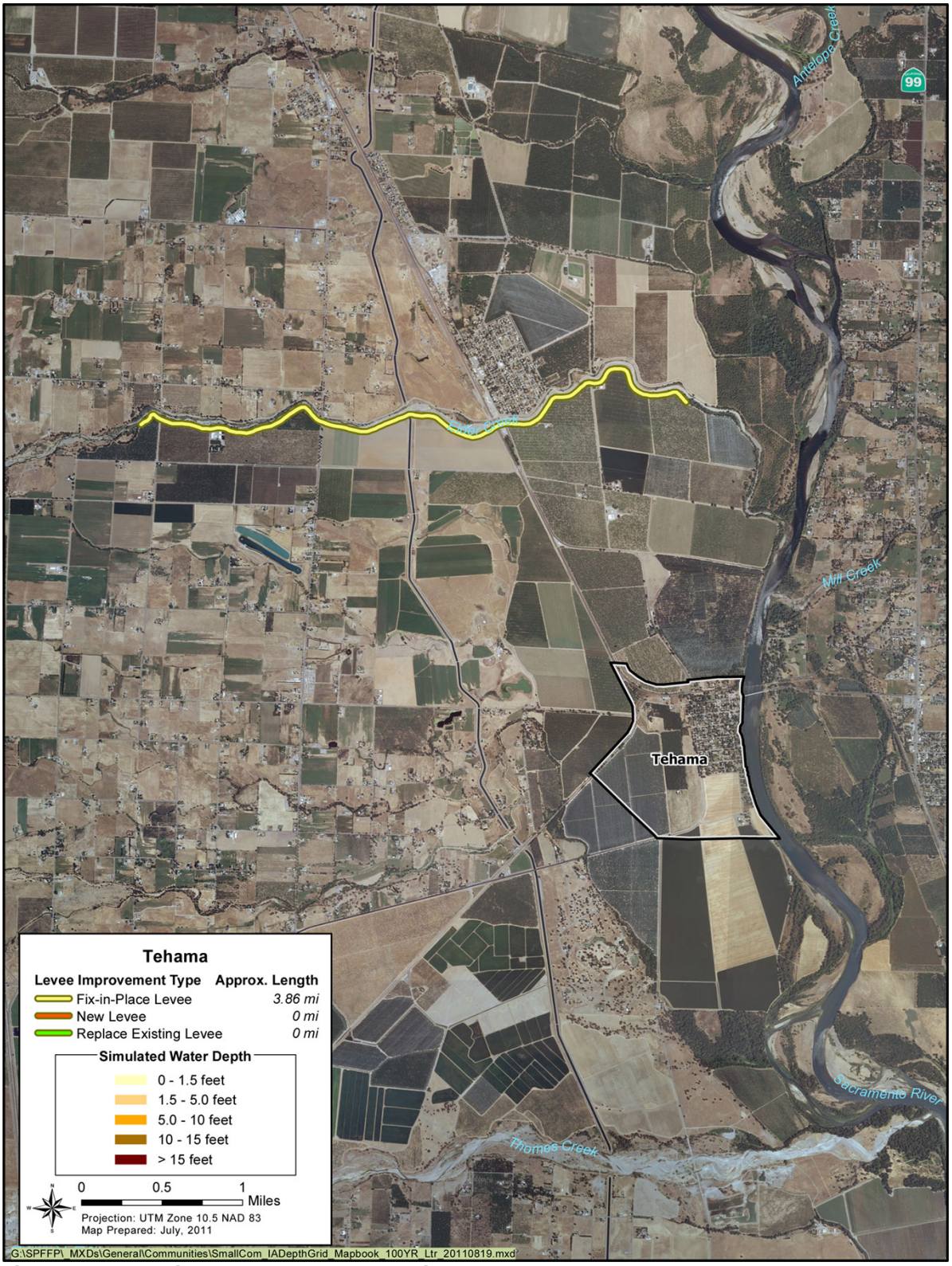

Figure D-19. Tehama Levees Approach

Grimes

Grimes is an unincorporated community located along the right bank of the Sacramento River in Colusa County. FLO-2D hydraulic modeling results referenced over aerial photography of Grimes (Figure D-20) showed that water depth from a simulated 1 percent AEP flood would be 0 to 1.5 feet. In addition, GAR (DWR 2010) and RACER (DWR 2011) information was reviewed for the type and cost of remediation necessary to repair the existing levee adjacent to Grimes. After analyzing the available data, it was determined that reconstruction-in-place repairs along the right bank levee of the Sacramento River, in combination with construction of a training levee south of Grimes, would protect the community from a 1 percent AEP flood (Figure D-20).

Recommended repairs along the right bank of the Sacramento River include remediation for under-seepage, through-seepage, nonseepage-related stability, erosion, and freeboard. The most thorough approach to repairs was chosen because of past performance issues along the levee segment associated with under-seepage, erosion, and possibly through-seepage. The cost to repair a 3.53-mile portion of the levee segment, identified in the GAR as Segment 288, was estimated to be $41.9 million, which calculates to about $11.9 million per mile. The cost per mile was then applied to only the 0.50-mile portion of Segment 288 (Figure D-20) to estimate the reconstruction-in-place costs. Although the cost to repair freeboard along Segment 288 to 1957 design elevations was applied to the current cost estimate, more data are needed to determine if the levee segment has the minimum 3 feet of freeboard for a 1 percent AEP level of protection. Additional costs to increase the crown elevation and overall size of the levee prism may apply.

To complete the conceptual layout, a training levee would be constructed beginning from the right bank of the Sacramento River, just south of Grimes. From the right bank of the Sacramento River, the training levee would extend westward along the edge of the community. The training levee was conservatively designed with a height of 4.5 feet (1.5 feet plus an additional 3 feet of freeboard) along the entire alignment. The total cost for construction, including reconstruction-in-place repairs, was estimated to be $7.0 million.

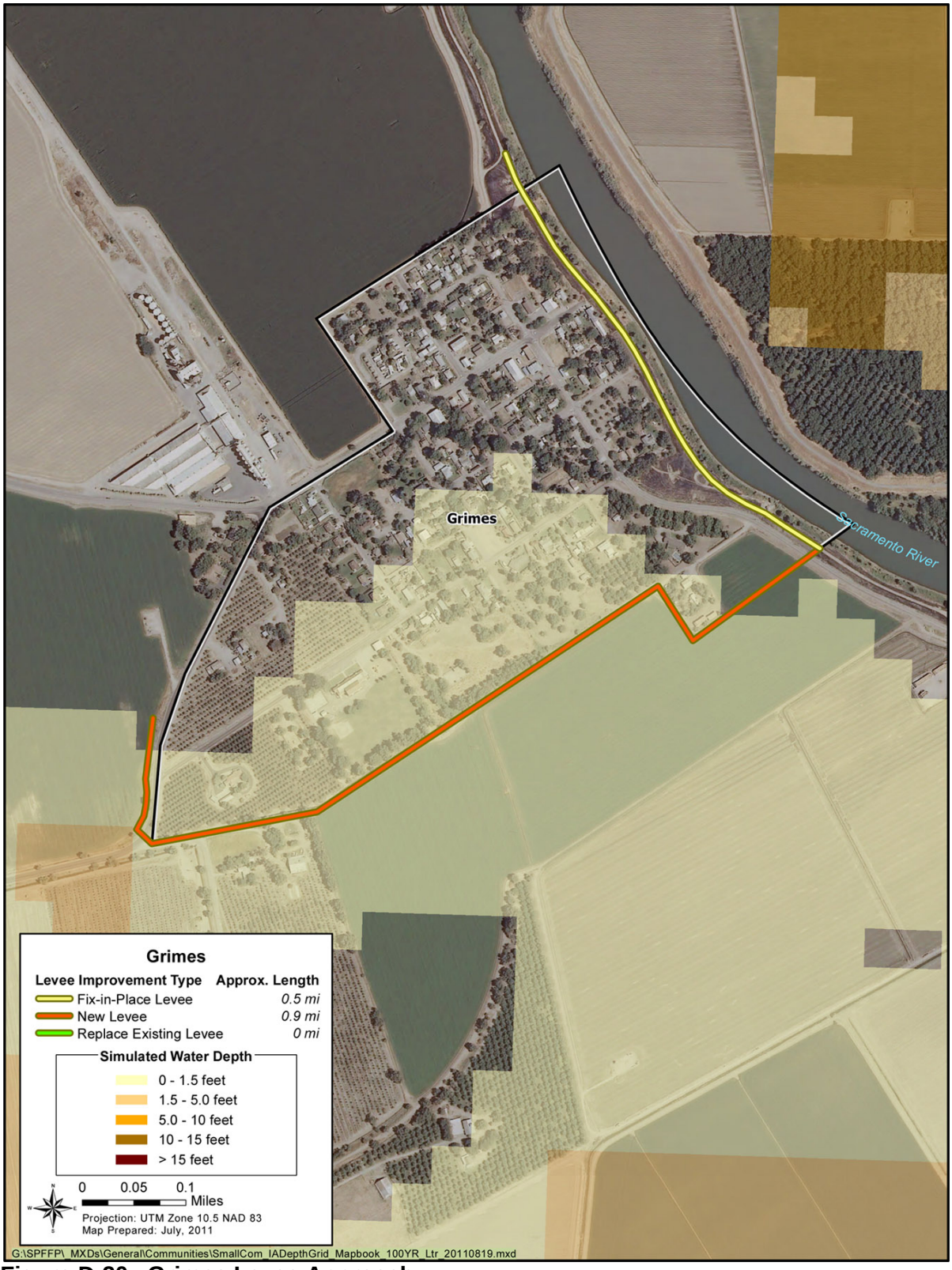

Figure D-20. Grimes Levee Approach

Butte City

Butte City is an unincorporated community located along the left bank of the Sacramento River in Glenn County. FLO-2D hydraulic modeling results referenced over aerial photography of Butte City (Figure D-21) showed that a water depth from a simulated 1 percent AEP flood would be in the range of 0 to 5 feet. In addition, GAR (DWR 2010) and RACER (DWR 2011) information was reviewed for the type and cost of remediation necessary to repair the existing levee adjacent to Butte City. After analyzing the available data, it was determined that reconstruction-in-place repairs along the left bank levee of the Sacramento River, in combination with the construction of a ring levee around Butte City, would protect the community from a 1 percent AEP flood (Figure D-21).

Recommended repairs along the left bank of the Sacramento River include remediation for under-seepage, through-seepage, seepage-related stability, erosion, and freeboard. Costs for erosion, freeboard, and geometry have been included, given previous observations of water backing up at the Highway 162 bridge just downstream from Butte City and The river channel is next to the left-bank levee with no setback. The cost to repair a 4.2-mile portion of the levee segment, identified in the GAR as Segment 68, was estimated to be $33 million, which calculates to about $7.9 million per mile. The cost per mile was then applied to only the 0.34-mile portion of Segment 68 (Figure D-21) to estimate the reconstruction-in-place costs. Although the cost to repair freeboard along Segment 68 to 1957 design elevations was applied to the current cost estimate, more data are needed to determine if the levee segment has the minimum 3 feet of freeboard for a 1 percent AEP level of protection. Additional costs to increase the crown elevation and overall size of the levee prism may apply.

To complete the conceptual layout, a new ring levee would be constructed, completely encircling Butte City. The 0.94-mile ring levee would begin and end at the left bank of the Sacramento River, encapsulating the portion of the existing levee to receive reconstruction-in-place repairs. The average height of 6.25 feet was calculated using a weighted average of 8 feet (5 feet plus an additional 3 feet of freeboard) for part of the alignment, and 4.5 feet (1.5 feet plus an additional 3 feet of freeboard) for the remaining sections. The total cost for construction, including reconstruction-in-place repairs, was estimated to be $6.1 million.

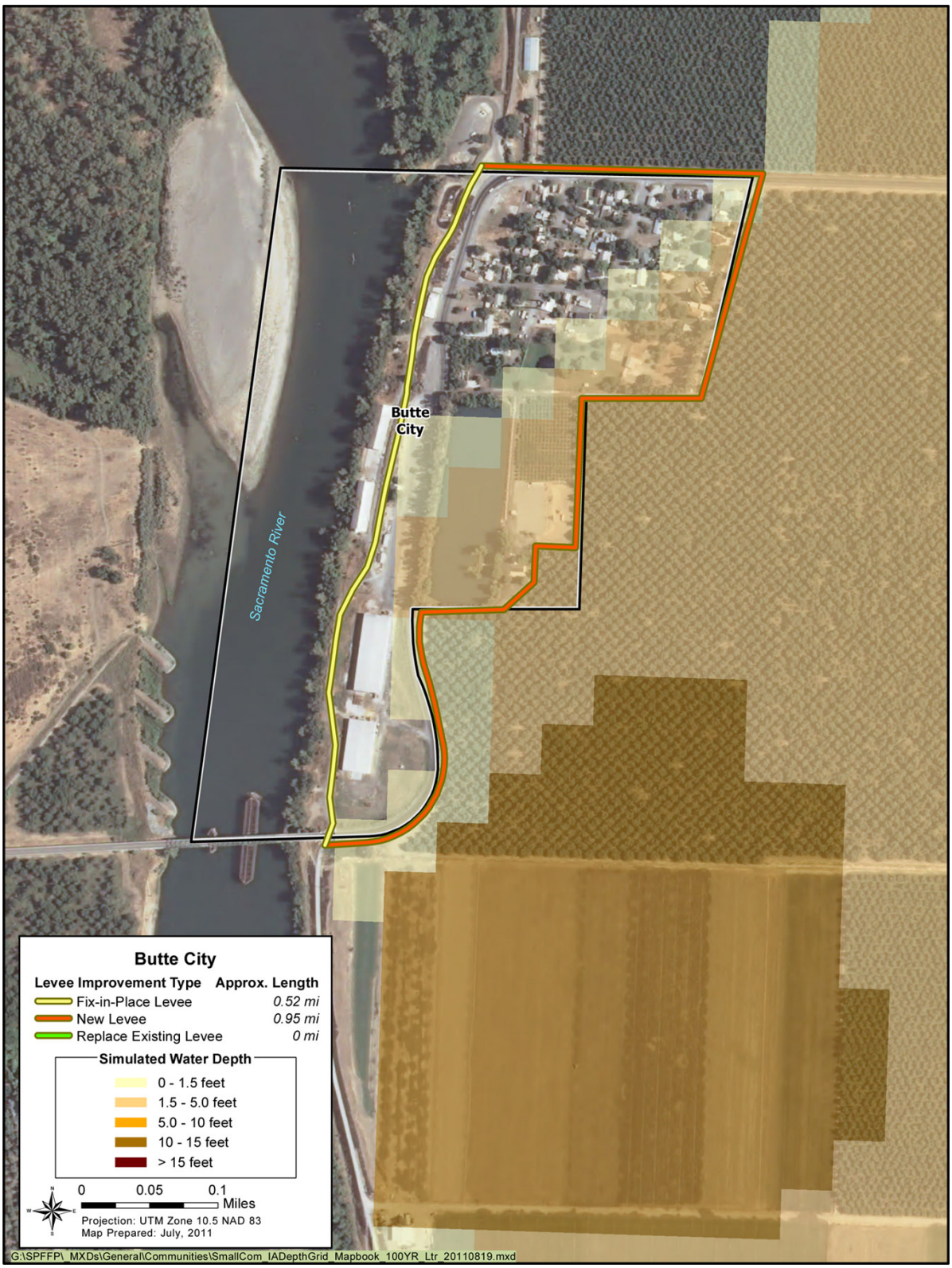

Figure D-21. Butte City Levees Approach

Mendota

Mendota is a city in Fresno County located 8.5 miles south-southeast of Firebaugh and about one mile west of Fresno Slough. FLO-2D hydraulic modeling results overlaid on an aerial photograph of Mendota showed that water depth during a simulated 1 percent AEP flood would range from 0 to 10 feet.

The conceptual design for Mendota would provide a ring levee system. It would involve constructing a new levee on the west, east, and south, and replacing a portion of an existing levee along the canal on the north of the city with new levees. The new levees would have 12-foot crowns, with an average height of 4.5 feet for the new levees, spanning approximately 6.5 miles in total. This option would provide protection to an area beyond the city limits (see Figure D-22). The new levee cost was assessed using the developed methodology. The total capital cost for Mendota was estimated to be $12.7 million.

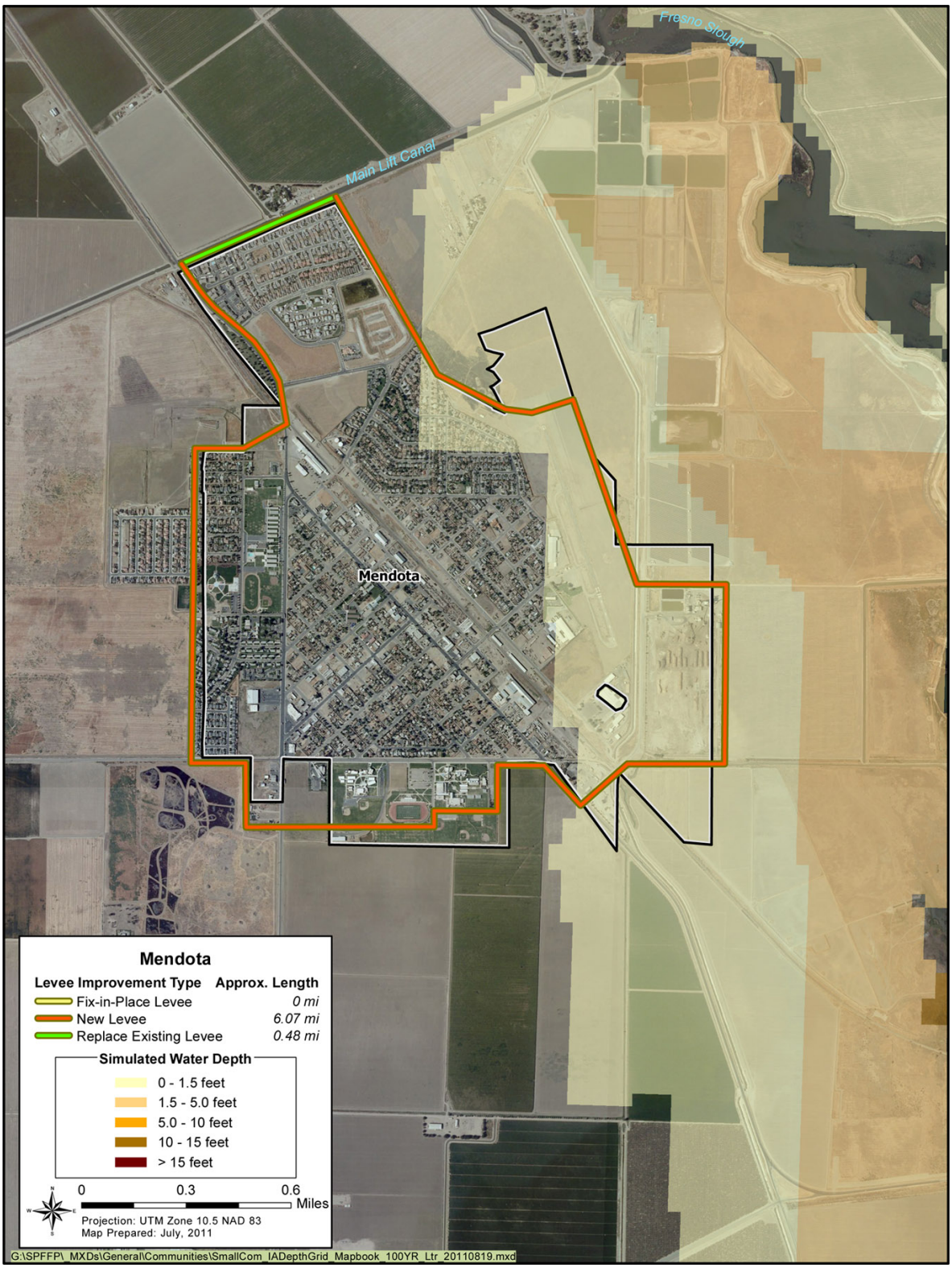

Figure D-22. Mendota Levees Approach

Communities Not Assessed

The communities in this section have been identified by FEMA as being in the 1 percent AEP floodplain. However, the FLO-2D hydraulic data overlaid on the aerial photography did not show 1 percent AEP inundation, and either partial or no data in the NULE GARs (DWR, 2010) were available. Because of the lack of input data, the following communities were not assessed: Palermo, Princeton, Bethel Island, Verona, Thornton, Chester, Los Molinos, Rio Vista, Tranquility, and Gerber-Las Flores. The community of Palermo is a special case because it will be assessed as a part of Oroville in Group B.

Group C Communities

This section describes the conceptual design and cost estimate for each Group C community. The following is a list of the communities covered in this section:

- Dos Palos/South Dos Palos
- Biggs
- Upper Lake
- Byron
- Knightsen

Dos Palos/South Dos Palos

Dos Palos is a city in Merced County located 23 miles south-southwest of Merced. South Dos Palos is a Census-Designated Place (CDP) in Merced County located two miles southwest of Dos Palos. Because these communities are in such close proximity to each other, they were assessed as one area. FLO-2D hydraulic modeling results overlaid on an aerial photograph of Dos Palos/South Dos Palos showed no inundation during a simulated 1 percent AEP flood (Figure D-24).

Because no inundation was shown, constructing a new levee was not an option. Therefore, the conceptual design would be a reconstruction-in-place alternative repairing all of Levee Segments 5028 and 5029, as described in the NULE GAR (DWR 2010). This option would provide protection to an area beyond the city (Figure D-24). The least-cost alternative, as shown in the RACER (DWR 2011), was used for each segment, giving a total capital cost estimate of $2.4 million. This cost does not include expenses associated with levee raises, which were not assessed at this time because data from the UNET model are pending.

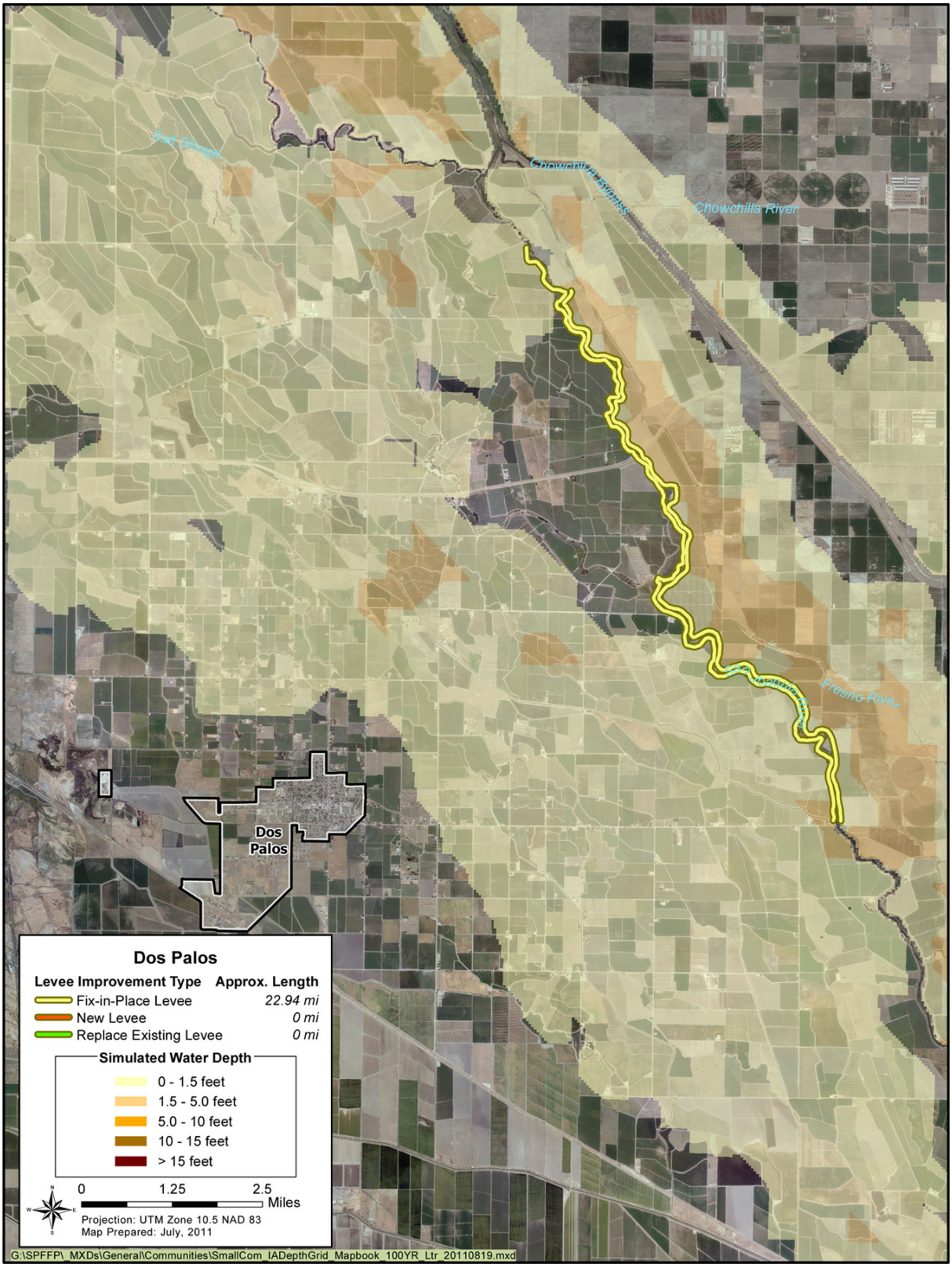

Figure D-24. Dos Palos Levees Approach

Biggs

Biggs is a city in Butte County about one mile west of State Route 99 and three miles north of Gridley. FLO-2D hydraulic modeling results overlaid on an aerial photograph of Biggs showed no inundation during a simulated 1 percent AEP flood.

Because no inundation was shown, constructing a new levee was not an option. A reconstruction-in-place alternative repairing the entire Levee Segment 110, as described in NULE GAR (DWR 2010), was then considered. However, Segment 110 was categorized as low for all levee condition categories, meaning no repairs were recommended and no remediation costs were identified.

Upper Lake

Upper Lake is an unincorporated community situated between the left bank of Middle Creek and the left bank of Alley Creek in Lake County. FLO-2D hydraulic modeling results overlaid on aerial photograph of Upper Lake did not show flooding from a simulated 1 percent AEP flood, although Upper Lake is identified by FEMA as being in a 1 percent AEP floodplain. GAR (DWR 2010) and RACER (DWR 2011) information was reviewed for the type and cost of remediation necessary to repair the existing levees adjacent to Upper Lake. After analyzing the available data, it was determined that reconstruction-in-place repairs along the entire lengths of the left bank levee of Middle Creek and the left bank levee of Alley Creek adjacent to Upper Lake would address flooding potential until more data become available.

The recommended repairs along the left bank of Middle Creek and the left bank of Alley Creek include only remediation for freeboard and geometry. Given that FLO-2D hydraulic modeling results were unable to confirm areas of inundation, the least-cost alternatives were selected to repair the entire length of both levee segments (Figure D-25). The cost to repair the left bank of Middle Creek (Reaches 1 and 2), identified in the GAR as Segment 81, was estimated to be $8.3 million. The cost to repair the left bank of Alley Creek, identified in the GAR as Segment 267, was estimated to be $2.8 million. Therefore, the total cost to remediate the entire length of each segment was estimated to be $11.1 million. Although the cost to restore freeboard along Segment 100 to 1957 design elevations was applied to the current cost estimate, more data are needed to determine if both Segment 81 and Segment 267 have the minimum 3 feet of freeboard for a 1 percent AEP level of protection. Additional costs to increase the crown elevation and the overall size of the levee prism may apply.

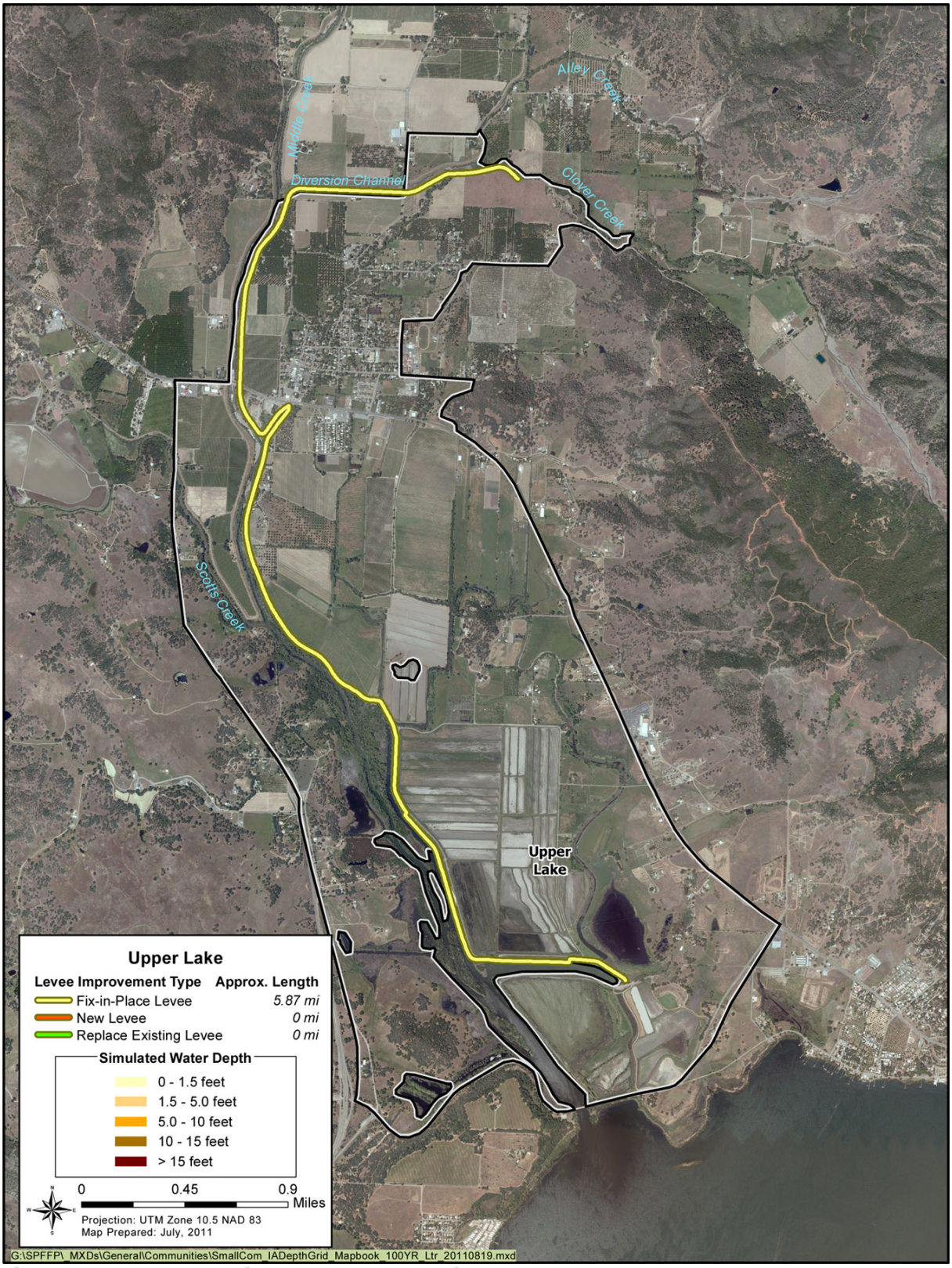

Figure D-25. Upper Lake Levees Approach

Communities Not Assessed

The communities in this section have been identified by FEMA as being in the 1 percent AEP floodplain. However, the FLO-2D hydraulic data overlaid on the aerial photography did not show 1 percent AEP inundation, and either partial or no data in the NULE GARs (DWR 2010) were available. Due to the lack of input data, the communities of Byron and Knightsen were not assessed.

References

California Department of Water Resources (DWR). 2011. South Non-Urban Levee Evaluation (NULE) Project Remediation Alternatives and Cost Estimate Report (RACER). June.

DWR. 2011. North Non-Urban Levee Evaluation (NULE) Project Remediation Alternatives and Cost Estimate Report (RACER). June.

DWR. 2011. Geotechnical Assessment Report (GAR) South NULE Study Area. April.

DWR. 2010. Geotechnical Assessment Report (GAR) North NULE Study Area. April.

DWR. 2011. Flood Control System Status Report (FCSSR). December.

DWR. 2011. Flood Control System Status Report (FCSSR) Conceptual Cost Estimating Memorandum-DRAFT.

DWR. *See* California Department of Water Resources.

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Acronyms and Abbreviatons

AACE ..... Association for the Advancement of Cost Engineering

AF ..... acre-feet

Annual Report ..... Local Agency Annual Report

Board ..... Central Valley Flood Protection Board

CDP ..... Census-Designated Places

CFR..... Code of Federal Regulations

cfs ..... cubic feet per second

CVFPP ..... Central Valley Flood Protection Plan

Delta..... Sacramento-San Joaquin Delta

DWR ..... California Department of Water Resources

FCSSR..... Flood Control System Status Report

GAR ..... Geotechnical Assessment Reports

NULE ..... Non-urban Levee Evaluations

O&M..... operations and maintenance

PCE..... Parametric Cost Estimation

PCET ..... Parametric Cost Estimating Tool

RACER ..... Remedial Alternatives and Cost Estimate Report

RD..... Reclamation District

SPFC ..... State Plan of Flood Control

TRLIA..... Three Rivers Levee Improvement Authority

ULDC ..... Urban Levee Design Criteria

ULE..... Urban Levee Evaluations

USACE..... U.S. Army Corps of Engineers

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CENTRAL VALLEY
FLOOD MANAGEMENT
PLANNING PROGRAM

FloodSAFE
CALIFORNIA

Public Draft

2012 Central Valley Flood Protection Plan

Attachment 8J: Cost Estimates – Appendix E. Flood Corridor Expansion

January 2012

STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

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Flood Corridor Expansion

This appendix documents conceptual design and cost estimates for flood corridor expansion features, including levee setbacks.

Background

The CVFPP goals include the primary goal of Improving Flood Risk Management. Widening sections of the Sacramento and San Joaquin rivers by setting levees back from their existing locations would appear to create additional capacity during floods. However, hydraulic modeling of widened river channels has shown little systemwide hydraulic benefit. This is because flooding potential under the larger hydrologic events is still possible if channel capacity upstream and downstream from the widened section remains constricted, thus creating flood stage levels high enough to threaten existing levee integrity. The limited hydraulic impact of levee setbacks illustrates the need for systemwide analysis when addressing flood risk. However, setback levees can be applied to a comprehensive strategy and even provide benefits outside direct flood stage reduction.

The CVFPP goals also include the following supporting goals:

- Improve Operations and Maintenance
- Promote Ecosystem Functions
- Improve Institutional Support
- Promote Multi-Benefit Projects

Levee setback opportunities that do not create significant additional flow capacity can still provide benefits to many of the CVFPP supporting goals.

Promote Ecosystem Functions

If setbacks are created in areas with strong potential for frequent high water inundation, those areas may create improved riparian habitat for many species.

Improve Operations and Maintenance

A primary cost element in levee maintenance is the repair of erosion areas after high flow events. In other words, the more often a levee is used to contain high flow events, the more likely it is to lose material and its preferred geometry. Levees that are frequently challenged by high flow events and are left unmaintained or unrepaired for erosion issues have a higher probability of a structural failure. Setting back levees in such areas can reduce the average flow cycles of wetting and erosion, thereby reducing the long-term erosion repair costs.

The simplest reduction in Operations and Maintenance (O&M) effort and costs comes from the reduction of levee length. Levees that are set back and no longer follow the historical meander of the river can be straightened, thus shortening the length of the levee asset. The river channel would be allowed to meander within the levee boundaries, but the setback levees would not constrain the river's path in a direct way for lower flow.

Promote Multi-Benefit Projects

Setback levees created in the right areas can reconnect a river system to historical floodplain areas, oxbow lakes and ponds, as well as native tree groves. In the future, these areas can be developed into habitat restoration areas or used to foster recreation opportunities.

Improve Institutional Support

As setback levee locations are identified, and modern levees are built to replace older levees, flood risk management improves because of the greater structural reliability of levees built to current standards. In this way, setback levees can gain additional local support. Additional support can be obtained for improved flood risk management based on the natural synergy between levee setback projects and nongovernment organizations (NGO) advocating plant and wildlife restoration. Also, recent projects have been able to demonstrate additional financial benefits from new or preserved wildlife habitats created by levee setbacks. Projects that may have previously had participation only from a local agency or government entities such as DWR or USACE now have participation from the California Department of Fish and Game (DFG) and the U.S. Fish and Wildlife Service (USFWS).

Additional stakeholder and institutional support increases a project's potential for success. As projects are increasingly assessed for not only their economic benefits, but also for their social and environmental benefits, additional institutional support becomes helpful, and in some cases, necessary for project completion.

Conceptual Design Approach

As part of the CVFPP, hydrologic and hydraulic analyses were combined with detailed topographic information from Light Detection and Ranging (LiDAR) data to identify areas adjacent to existing levees in the Sacramento and San Joaquin river watersheds that were likely to inundate with spring wet-weather river flow in 1.5-year and two-year recurrence intervals.

A map demonstrating this inundation potential modeling is shown in Figure E-1.

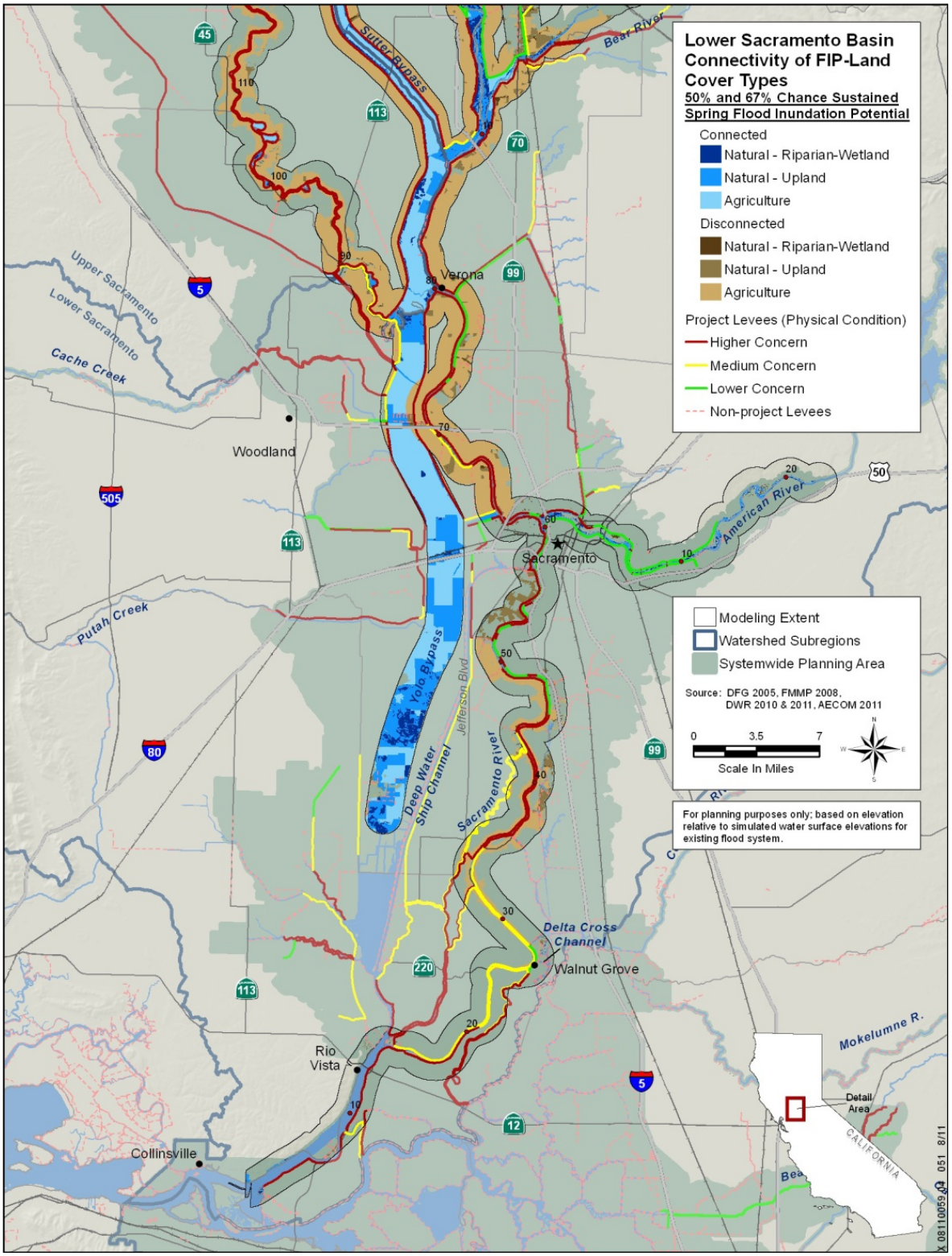


Figure E-1. Generalized Map of 1.5-Year and 2-Year Spring Flow Floodplain Inundation Potential – Sacramento River

Floodplain Restoration Opportunities Analysis

Ecosystem restoration is a key component of the CVFPP, and management actions related to habitat restoration have been drafted as part of the CVFPP planning process. Further refinement of these management actions will be formed by an understanding of habitat restoration opportunities, in terms of the location, acreage, and expected ecosystem benefits of each management action, that are possible within the context of the SPFC. Specifically, identifying suitable setback area locations, defining the extent of the work, and developing a preliminary cost can advance the habitat restoration component of the CVFPP.

The basis for a preliminary assessment of setback levee locations was output of the floodplain restoration opportunities analysis (FROA). Attachment 2: Conservation Framework and its supporting documentation contain detailed descriptions of the ecosystem restoration opportunities analysis. Figure E-2 shows the conceptual intent of setback levees for restoration opportunities and the hydraulic connectivity that can be achieved seasonally.

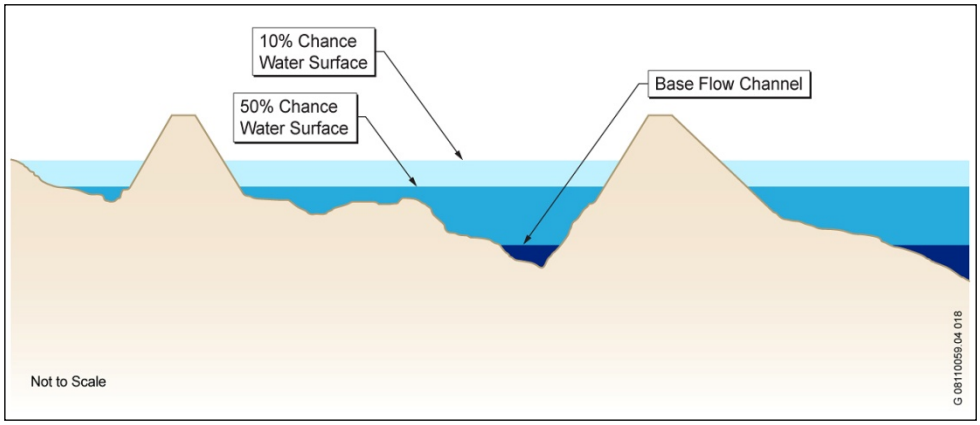


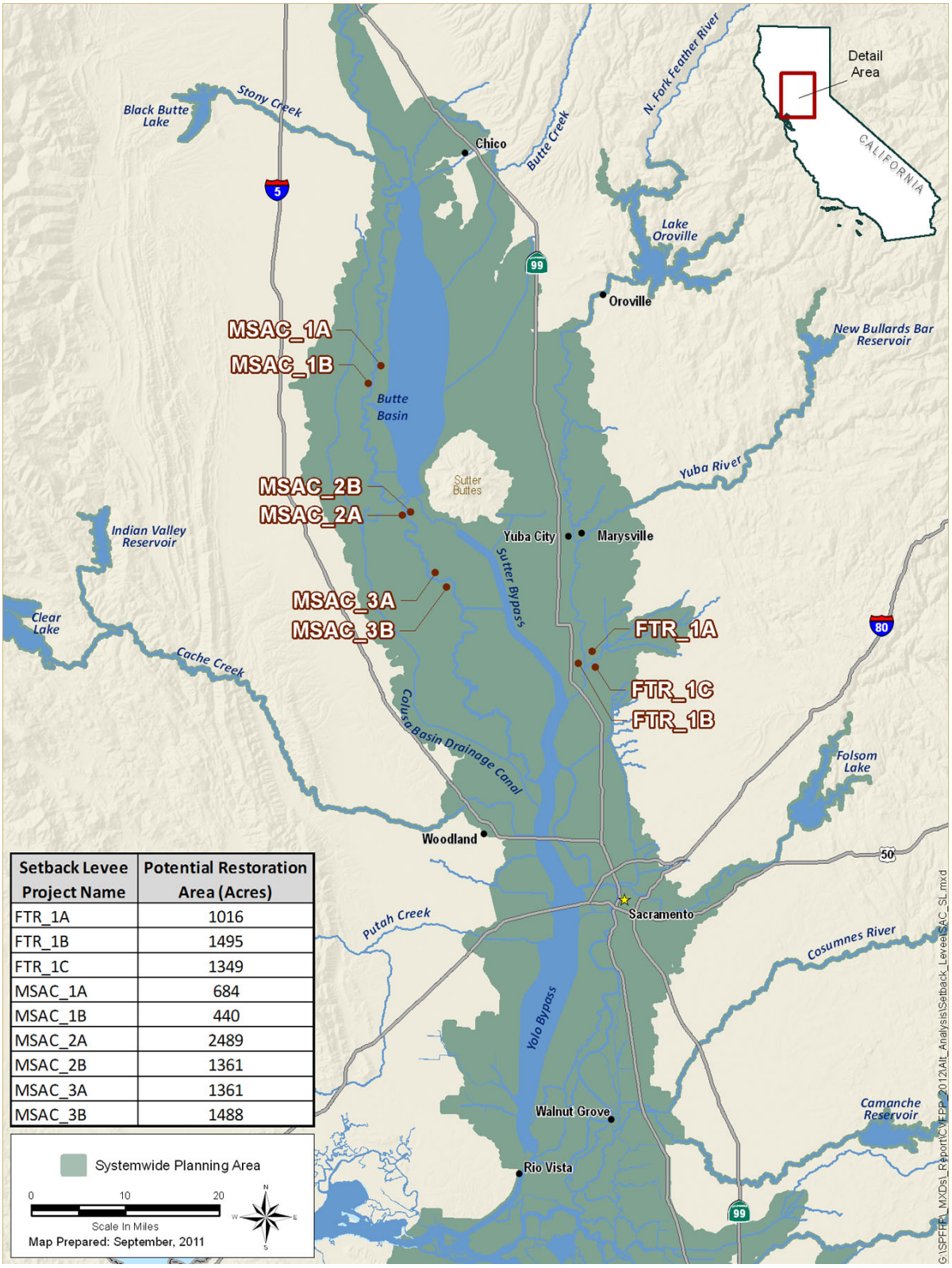
Figure E-2. Hypothetical Cross Section with Boundary Water Surfaces of Floodplain Inundation Potential Categories

Results of the FROA support identification, prioritization, and further development of specific restoration opportunities. Opportunities are 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.

The cost component of the restoration opportunities should come from some level of specific analysis of restoration potential and conceptual design of the setback levees themselves. In this way, specific project

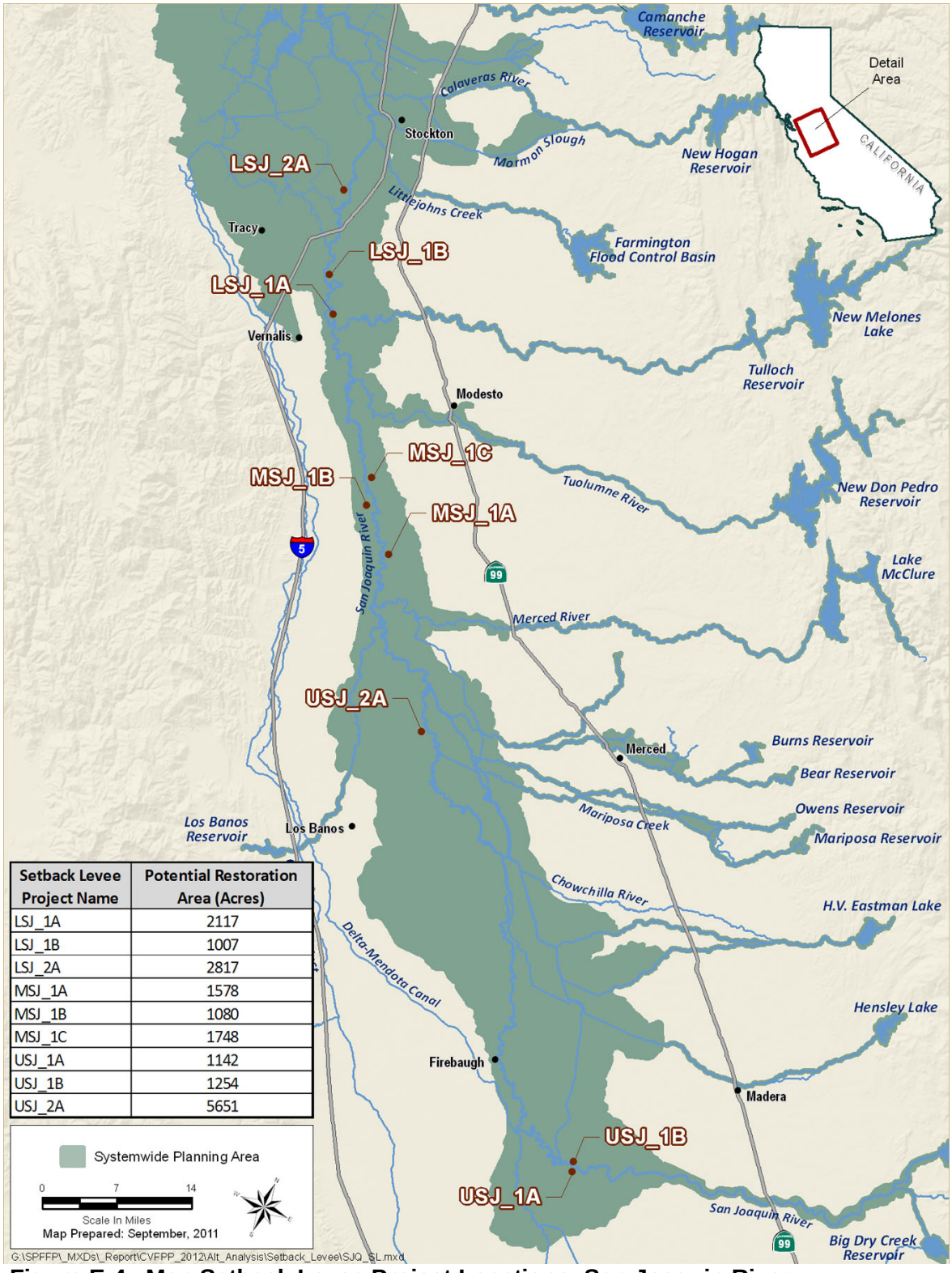
impacts and quantities can be estimated, and accepted cost principles applied.

Using the Flood Inundation Potential (FIP) maps, setback levees were located to follow existing contours and avoid removing and replacing major infrastructure such as roads, canals, bridges, and residential and agricultural/industrial developments. Preliminary locations estimated for levee setbacks are shown in Figures E-3 and E-4.



Setback Levee Project Name	Potential Restoration Area (Acres)
FTR_1A	1016
FTR_1B	1495
FTR_1C	1349
MSAC_1A	684
MSAC_1B	440
MSAC_2A	2489
MSAC_2B	1361
MSAC_3A	1361
MSAC_3B	1488

Figure E-3. Setback Levee Project Locations, Sacramento River



Setback Levee Project Name	Potential Restoration Area (Acres)
LSJ_1A	2117
LSJ_1B	1007
LSJ_2A	2817
MSJ_1A	1578
MSJ_1B	1080
MSJ_1C	1748
USJ_1A	1142
USJ_1B	1254
USJ_2A	5651

Figure E-4. Map Setback Levee Project Locations, San Joaquin River

Specific conceptual levee setback opportunities are shown in the following figures. The length of the new levees, removal of existing levees, and area of land created by these conceptual setback levee projects formed the basis and provide the quantities for the cost estimates.

Costs Basis and Development

Costs were generated for setback levees parametrically. Unit costs were developed based on land type and levee function from other representative studies and construction projects for setback levees. Table E-1 lists cost development assumptions.

Table E-1. Cost Assumptions for Setback Levees

Element	Cost or Percentage
Environmental, Permitting, Engineering, and Feasibility	25%
ROW Cost	$22,000 per acre
New Setback Levee Cost	$20 – $25 million/mile
Levee Removal Cost	$5 – $10 million/mile
Fix-in-Place Levee Cost	$15 – $20 million/mile

Key:
ROW = right-of-way

Setback projects and data are listed in Table E-2. Four conceptual setback levee projects were identified in the Sacramento River, and five conceptual setback levee projects were identified in the San Joaquin River.

Table E-2. Conceptual Setback Projects and Quantities

Project	Basin	Region	New Levee Length (miles)	Removed Levee Length (miles)	Fix-in-Place Levee Length (miles)	Restored Area (acres)
FTR1	Sacramento	Feather	5.6	8.4	9.3	4,000
MSAC1	Sacramento	Mid-Sac	4.3	5.7	4.3	1,000
MSAC2	Sacramento	Mid-Sac	8.4	15.2	5.2	3,000
MSAC3	Sacramento	Mid-Sac	7.8	10.7	6.2	2,000
LSJ1	San Joaquin	Lower SJ	5.6	12.8	7.7	3,000
LSJ2	San Joaquin	Lower SJ	5.6	8.4	9.3	2,000
MSJ1	San Joaquin	Middle SJ	10.6	11.6	2.5	4,000
USJ1	San Joaquin	Upper SJ	7.1	8.5	2.6	2,000
USJ2	San Joaquin	Upper SJ	10.4	11.3	12.5	5,000
Totals			**65.4**	**92.6**	**59.4**	**26,000**

Key:
Sac = Sacramento
SJ = San Joaquin

The conceptual setback projects would create 26,000 acres of potential riparian habitat. The habitat created may bring additional institutional support and financial benefits to the CVFPP. Setback projects would also reduce monitored and maintained levee length by 27 miles. This would save a significant amount of money in annual maintenance.

If these projects were to move forward toward implementation, they would require a feasibility analysis of alternatives. The analysis would need to further assess the impacts to existing agricultural uses, local infrastructure, and river and levee access. Additional detail for the conceptual setback levee approach is shown for each project in Figures E-5 through E-13.

The high and low range of conceptual construction costs are listed in Table E-3. The nine projects would cost between $3.2 billion and $4.5 billion to construct. This cost does not include long-term maintenance and restoration costs (tree, shrub, grass plantings, temporary irrigation) for the restoration acreage.

Table E-3. Summary of Setback Levee Costs

Project	Total Construction Cost (low)	Total Construction Cost (high)
FTR1	$381,408,500	$519,854,050
MSAC1	$201,276,950	$294,718,650
MSAC2	$386,807,260	$552,329,180
MSAC3	$345,190,150	$490,166,950
LSJ1	$356,844,340	$509,253,520
LSJ2	$337,408,500	$475,854,050
MSJ1	$395,038,150	$540,414,650
USJ1	$268,030,710	$381,322,830
USJ2	$562,191,900	$755,309,700
Totals	**$3,234,196,460**	**$4,519,223,580**

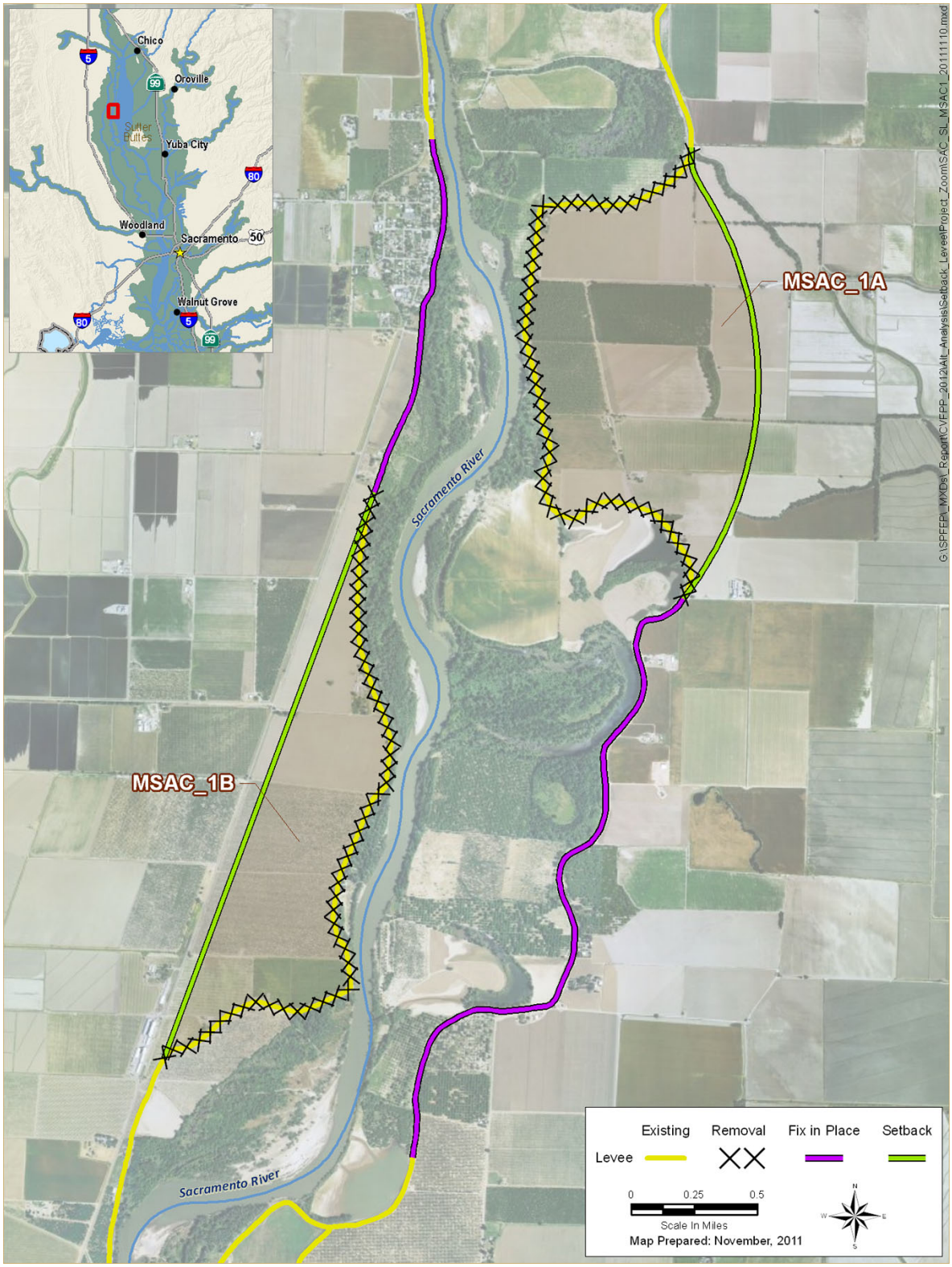


Figure E-5. MSAC1 Conceptual Setback Area, Sacramento River

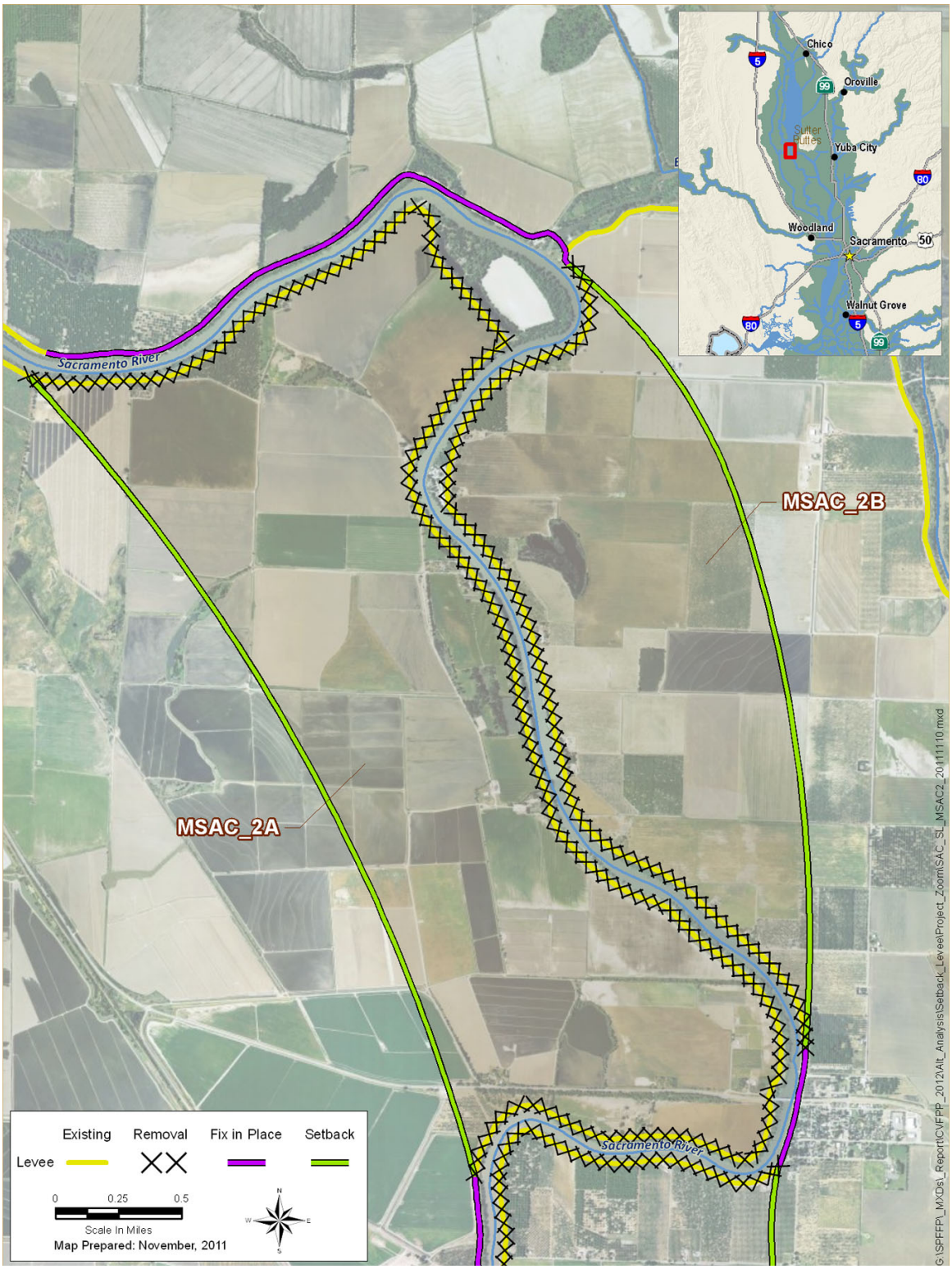


Figure E-6. MSAC2 Conceptual Setback Area, Sacramento River

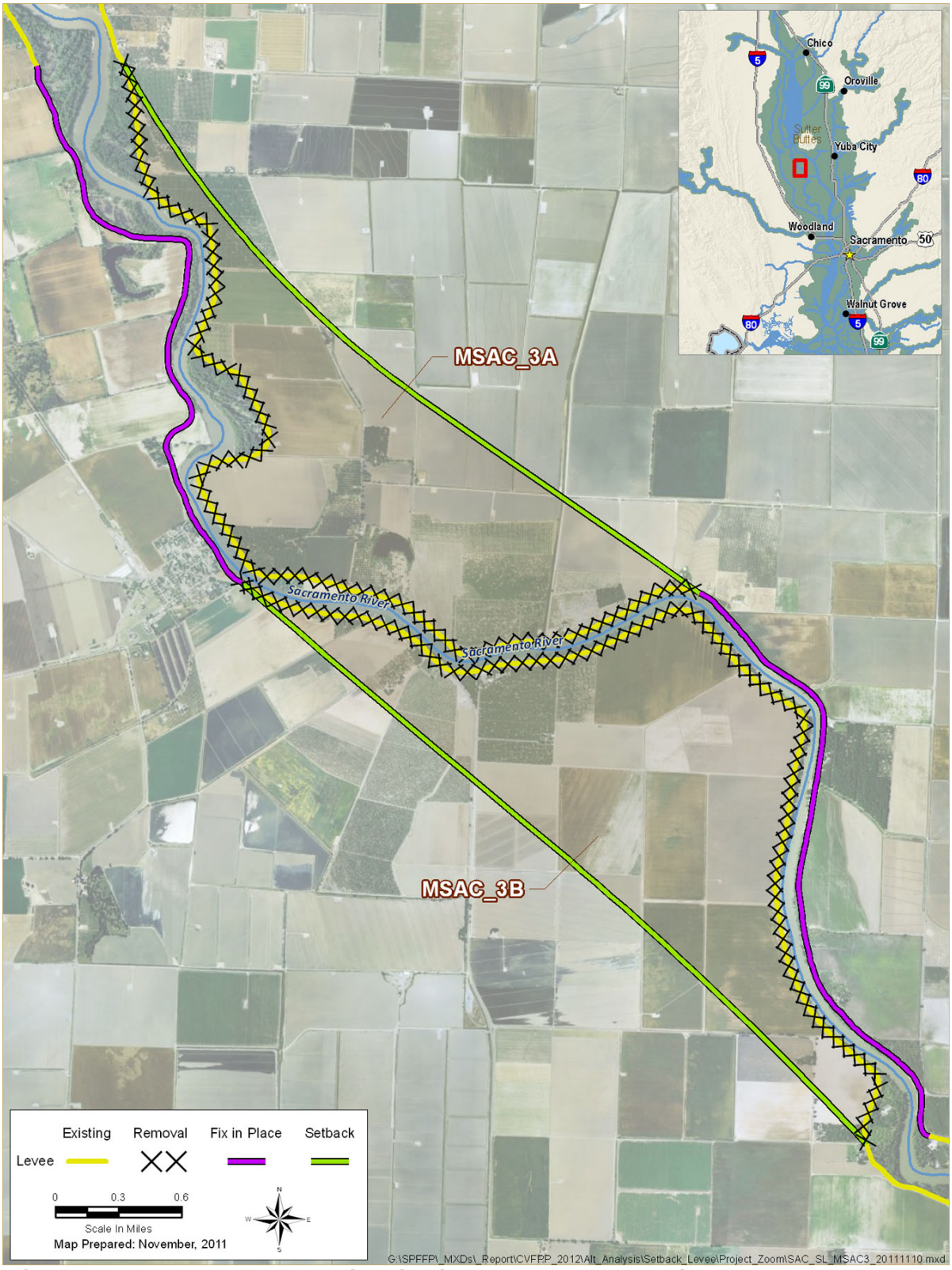


Figure E-7. MSAC3 Conceptual Setback Area, Sacramento River

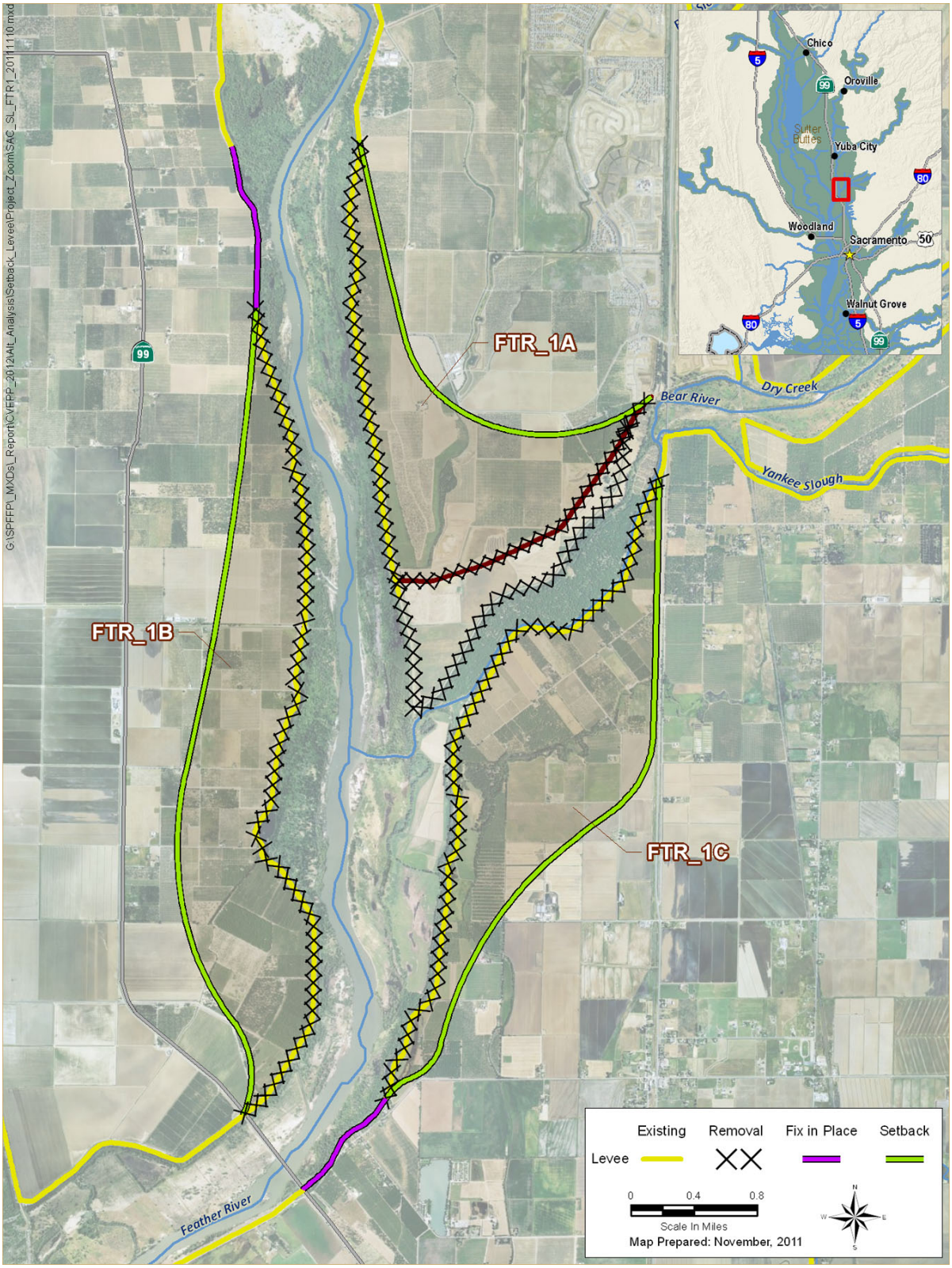


Figure E-8. FTR1 Conceptual Setback Area, Feather River

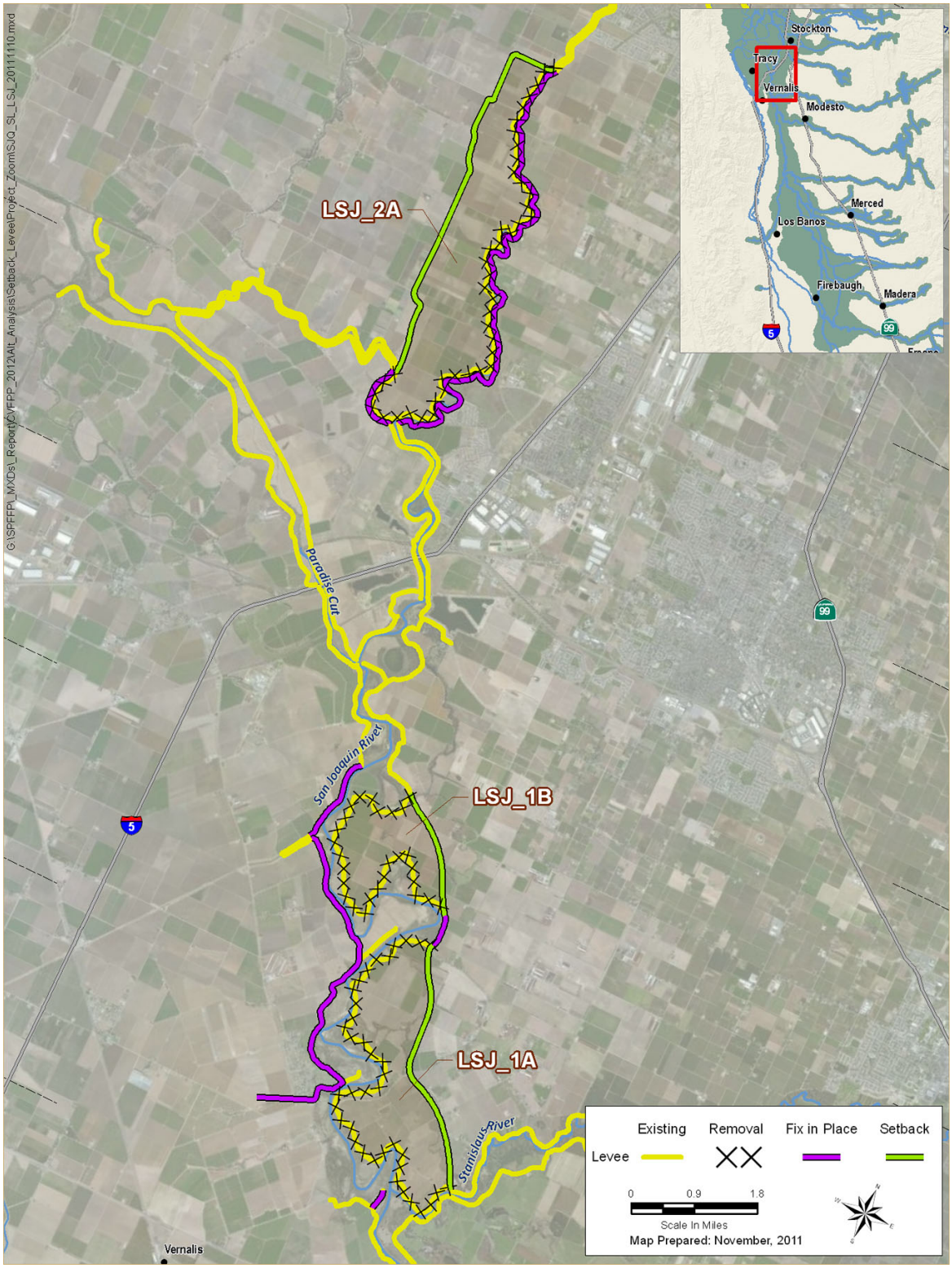


Figure E-9. LSJ1 & LSJ2 Conceptual Setback Area, San Joaquin River

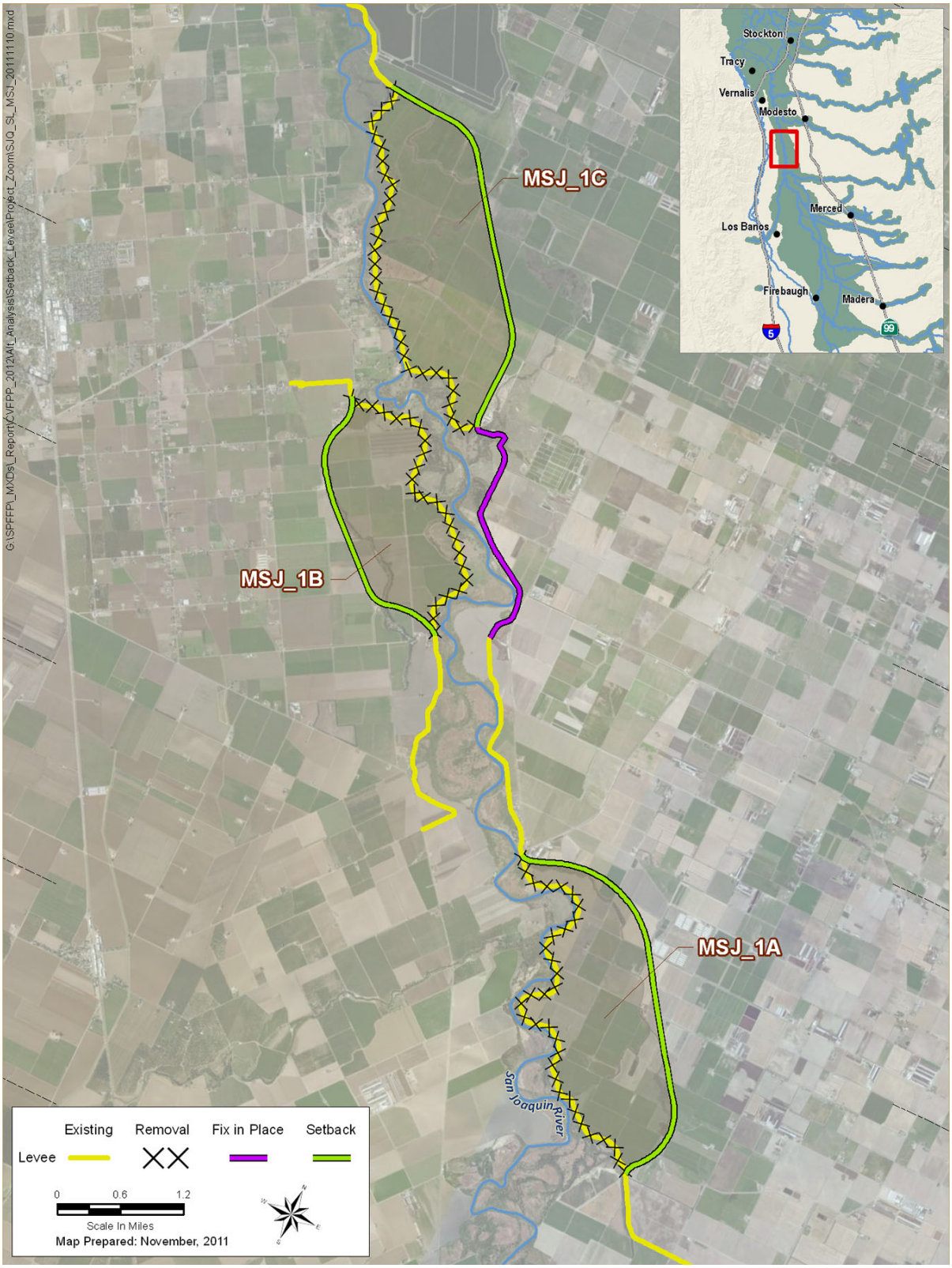


Figure E-10. MSJ1 Conceptual Setback Area, San Joaquin River

Figure E-11. USJ1 Conceptual Setback Area, San Joaquin River

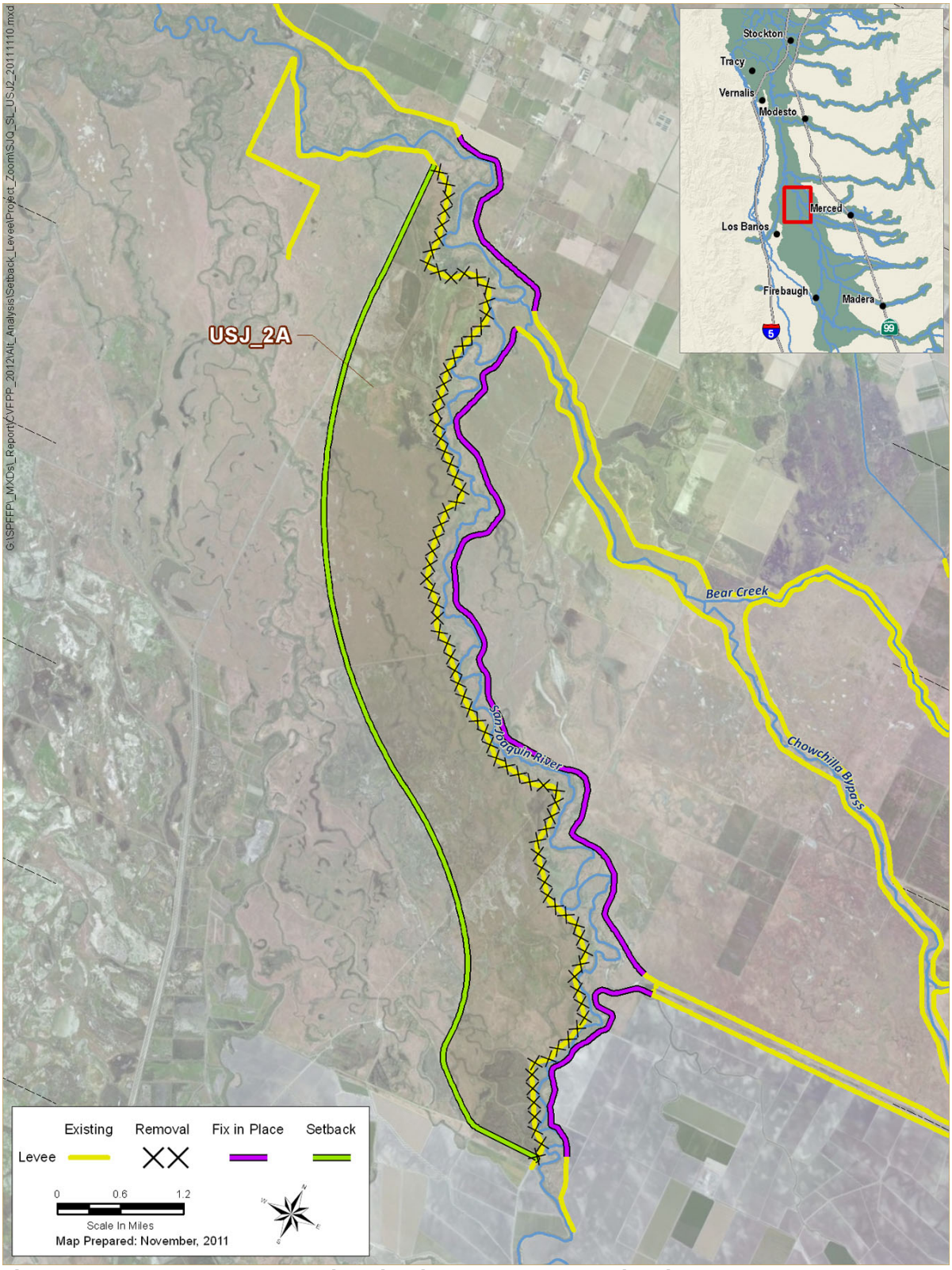


Figure E-12. USJ2 Conceptual Setback Area, San Joaquin River

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References

California Department of Water Resources (DWR). 2010. State Plan of Flood Control Descriptive Document. November.

DWR. 2011. South Non-Urban Levee Evaluation (NULE) Project Remediation Alternatives and Cost Estimate Report (RACER). June.

DWR. 2011. North Non-Urban Levee Evaluation (NULE) Project Remediation Alternatives and Cost Estimate Report (RACER). June.

DWR. 2011. Geotechnical Assessment Report (GAR) South NULE Study Area. April.

DWR. 2010. Geotechnical Assessment Report North NULE Study Area. April.

DWR. 2011a. Flood Control System Status Report. December.

DWR. 2011b. Flood Control System Status Report Conceptual Cost Estimating Memorandum-DRAFT.

DWR. *See* California Department of Water Resources.

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Acronyms and Abbreviations

AACE	Association for the Advancement of Cost Engineering
AF	acre-feet
Annual Report	Local Agency Annual Report
Board	Central Valley Flood Protection Board
CDP	Census-Designated Place
CFR	Code of Federal Regulations
cfs	cubic foot per second
CVFPP	Central Valley Flood Protection Plan
Delta	Sacramento-San Joaquin Delta
DWR	California Department of Water Resources
FCSSR	Flood Control System Status Report
GAR	Geotechnical Assessment Report
FROA	Floodplain Restoration Opportunities Analysis
NULE	Non-urban Levee Evaluations
O&M	operations and maintenance
PCE	Parametric Cost Estimation
PCET	Parametric Cost Estimating Tool
RACER	Remedial Alternatives and Cost Estimate Report
RD	Reclamation District
SPFC	State Plan of Flood Control
TRLIA	Three Rivers Levee Improvement Authority
ULDC	Urban Levee Design Criteria
ULE	Urban Levee Evaluations
USACE	U.S. Army Corps of Engineers

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