American River Basin: Upper Unionhouse Creek Flood Protection Project

Attachment 3: Work Plan

Att3_SWF_SAFCA_Workplan_2of2 includes the following supporting documentation:

- Inundation-Reduction Benefit Analysis for Unionhouse Creek Memorandum
- American River-Folsom Modifications Economic Analysis
- American River Watershed, California Folsom Dam Modification Project, Final Limited Evaluation Project
- American River Watershed, California Folsom Dam Modification Project, Draft Economic Reevaluation Project

Inundation-Reduction Benefit Analysis for Unionhouse Creek Memorandum

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MEMORANDUM

To: Tim Washburn and Pete Ghelfi, PE

From: Tom Molls, PE, PhD, Nathan Pingel, PE, and Natalie King, PE

Date: April 5, 2011

Subject: Inundation-reduction (IR) benefit analysis for Unionhouse Creek in support of California Department of Water Resources (DWR) Integrated Regional Water Management (IRWM) grant application

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Situation

The Sacramento Area Flood Control Agency (SAFCA) is designing (following a deterministic approach) a project along Unionhouse Creek to reduce flood damages and contain the event with an annual exceedence probability of 0.010, or the so-called "100-yr event".

The primary feature of this project is widening Unionhouse Creek from just downstream of its confluence with Strawberry Creek downstream to Franklin Boulevard. A full project description is included in the accompanying Unionhouse Creek flood control project narrative description document.

As part of the Department of Water Resources (DWR) Integrated Regional Water Management (IRWM) grant application, an inundation-reduction (IR) benefit analysis is required.

IR benefit concept

The IR benefit is defined as the value of damage prevented: damage incurred without the project less damage incurred with the project in place. For example, if a flood would cause $1 million damage to property in an impact area without the proposed damage-reduction features, and if that same flood would cause only $0.4 million with the project, then the IR benefit (the money saved due to the project) is $0.6 million for that flood.

In urban settings, flood damage analysis traditionally is restricted to an accounting of damage due to the largest event that occurs each year, a restriction that we use here. Clearly more than a single damaging flood could occur in a year. However, the time required for recovery, repair, and reconstruction will limit the loss incurred by a second or third flood, so the total loss in the year is most likely a function of the largest of the floods.

Of course, in some years, no flooding will occur. In that case, a flood-damage reduction project will provide little or no benefit. In other years, large floods could cause significant damage, so by protecting people and property, the project will yield a great benefit. The random nature of flooding makes it impossible to predict the damage prevented in any particular year of the project's life because we can't predict flood flows years in advance.

Consequently, for evaluation of flood-damage-reduction plan performance, the *Economic and environmental principles and guidelines for water and related land resources implementation studies* (US Water Resources Council 1983) stipulates use of the statistical average damage value. This average is known commonly as the expected annual damage (EAD).

Task

Our task was to answer the question: what is the IR benefit for the SAFCA project along Unionhouse Creek?

Analysis procedure

To answer this question, we followed the State's and Corps' economic analysis procedures, incorporating uncertainty analysis. (Hereinafter, we refer to this analysis as the IR benefit analysis). For evaluation of the SAFCA project, we computed EAD for without- and with-project conditions in the study area. The difference is the expected annual IR benefit.

We computed EAD using the statistical sampling procedure developed by the Corps (USACE 1996). This commonly is known as the risk and uncertainty analysis procedure, or R&U. This procedure is included in Corps' computer program HEC-FDA. To compute EAD with HEC-FDA, the following are required:

- Discharge- or elevation-probability function for each index point. This describes the annual probability or frequency of the channel water surface in the river (exterior channel) reaching a specified elevation. If a discharge-probability function is used, then both a discharge-probability and a discharge-elevation function are required.
- Exterior-interior elevation function for each impact area. This function relates the water surface elevation in the channel (exterior) at the index point to the elevation of flooding in the floodplain adjacent to the channel (interior).
- Elevation-damage function for each impact area. This function relates economic damage in the floodplain to floodplain (interior) water surface elevation.

Action

To compute EAD and IR benefits here, we:

1. Coordinated with the project team to define the conditions of the study, including the without-project condition (no channel improvements) and the with-project condition (completion of channel improvements).
2. Identified impact areas for the IR benefit analysis, which are delineations of the study area. The 2 selected impact areas used are illustrated in Figure 1.
3. Identified index points for each impact area. The hydrologic and hydraulic characteristics of an index point represent those characteristics for a reach of stream adjacent to the impact area.
4. Developed an elevation-damage function for each impact area. For this, we relied on information developed by the Corps as part of its American River economic reevaluation report (ERR) (USACE 2007). Specifically, we

used the structure inventory, structure values, and depth-percent damage functions from the Corps' ERR study. We updated the structure values to current dollars using the Engineering News-Record construction cost index.

5. Developed the required hydrologic and hydraulic input at each index point. For this, we used existing hydrologic and hydraulic models and their associated boundary conditions. Specifically, we used the SacCalc and HEC-RAS models provided by Sacramento County. The SacCalc model was used to develop the discharge-probability function at the index point and the HEC-RAS model was used to develop the discharge-elevation functions.
6. Developed the required exterior-interior elevation functions for each impact area. For this, we again used existing hydrologic and hydraulic models and topographic data provided by the County.
7. Computed expected annual damages (EAD) for each impact area and for the study area as a whole using computer program HEC-FDA.
8. Computed the IR benefit for the study area.

Details of the EAD computations and HEC-FDA model configuration are included in Attachment A. Attachment B lists the hydrologic and hydraulic inputs used in the EAD analysis. And, Attachment C provides a summary of the structure inventory.

Result

Table 1 shows total EAD values computed for without- and with-project conditions for the current floodplain property. Column 3 of the table shows the corresponding annual IR benefit, computed as the difference between with- and without-project EAD. Using a 50-yr period of economic analysis and the current State discount rate of 6.0%, the present value of the IR benefit is shown in column 4. The present value of the IR benefit is the accrued benefit over the life of the project.

This analysis and reported IR benefit considers only runoff from Unionhouse Creek. Impacts of flooding for both without- and with-project conditions from neighboring streams such as Morrison Creek, Florin Creek, and Elder Creek are not considered in this analysis.

Table 1. Expected annual flood damage and IR benefit for Unionhouse Creek channel improvements

Project plan (1)	**EAD[1,2] ($1,000) (2)**	**Annual value IR benefit ($1,000) (3)**	**Present value IR benefit[3] ($1,000) (4)**
Without-project condition	530	—	—
With-project condition	366	164	2,587

1. EAD values include damage to structures and content.
2. Values reported are in May 2011 dollars.
3. Present value computed using the current State discount rate of 6.0% and a 50-yr period of economic analysis.

Figure 1. Unionhouse Creek IR benefit analysis study area (Image source: Google Earth map, Europa Technologies, 2011)

References

US Army Corps of Engineers (USACE). (1996). *EM 1110-2-1619 Risk-based analysis for flood damage-reduction studies,* Office of the Chief of Engineers, Washington, DC.

USACE. (2004). *San Joaquin River Basin South Sacramento County Streams, Appendix: Economic Re-evaluation*, Sacramento District, Sacramento, CA.

USACE. (2007). *Draft economic reevaluation report: American River watershed project, Folsom Dam modification and Folsom Dam raise projects*, Sacramento District, Sacramento, CA.

US Water Resource Council. (1983). *Economic and environmental principles and guidelines for water and related land resources implementation studies*, Institute for Water Resources, Washington, DC.

Attachment A. Flood damage analysis overview

For the Unionhouse Creek IR benefit analysis, we followed State and Corps economic analysis procedures, incorporating uncertainty analysis. These incorporate the best-available hydrologic, hydraulic, geotechnical, and economic information to compute expected annual damage (EAD), accounting explicitly for uncertainty in the information.

Table 2 summarizes key aspects of this IR benefit analysis as well as key inputs and information sources.

Table 2. Summary of Unionhouse Creek IR benefit analysis procedure

Aspect (1)	Details (2)
Computer model used for EAD computations	HEC-FDA version 1.2.5a. This computer program is available at <http://www.hec.usace.army.mil/software/hec-fda/downloads.html>
Characterization of hydrologic and hydraulic inputs in risk modeling framework	Specified a "graphical" discharge-probability function and a channel discharge-to-elevation function. The peak discharges for the "graphical" probability function were developed based on simulations of design precipitation events.
Source of ground contour elevations for study area	2-ft contours were obtained from the Sacramento County staff for the study area. These were used to develop the elevation-volume relationship in each impact area as well as determine ground elevations for each structure. The elevations used for this analysis are in NGVD1929.
Source of structure inventory	The structure inventory used was extracted from the larger study in the area: *Draft economic reevaluation report: American River watershed project, Folsom Dam modification and Folsom Dam raise projects* (ERR) (USACE 2007). This study provided structure identification, categorization, and valuation.
Source of hydrologic inputs	The hydrologic inputs, specifically peak flows and hydrographs for various design events, were developed using the SacCalc model provided by Sacramento County staff on March 2, 2011. The SacCalc model was configured to use a 24-hr storm duration and provided input for the hydraulic analysis.
Source of hydraulic inputs	The hydraulic inputs, specifically the channel discharge-channel elevation function and the channel elevation-floodplain elevation function were developed using the HEC-RAS and HEC-2 models provided by Sacramento County on March 4, 2011. For this analysis, the HEC-2 model was converted to HEC-RAS before use. For development of the discharge-elevation function, a series of steady-flow simulations were completed. For development of the exterior-interior functions, a series of unsteady-flow simulations were completed. The unsteady-flow simulations were required to assess the volume of water that flowed into each of the impact areas. With the volume, the elevation-volume function developed based on the elevation contours was used to identify the floodplain elevation for each simulation. The channel elevation was identified by pairing the corresponding channel flow from the unsteady flow simulation with the discharge-elevation function. We obtained an HEC-RAS model from the Sacramento District of the Corps on March 10, 2011, of

Aspect (1)	Details (2)
	Unionhouse Creek that represented another with-project condition (a different channel geometry than the one used herein). Because of the different geometry, it was not useful here. However, the downstream boundary condition was useful here. This boundary condition is where Unionhouse Creek flows into Morrison Creek. The downstream stage boundary condition is entered as discharge-elevation relationship. We used the most conservative (higher) channel elevations from among several Corps stage boundary conditions. For reference, the channel elevation used for the p=0.01 event was 16.5 ft. The discharge-elevation and the exterior-interior elevation functions used are listed in Attachment B.
Source of depth-percent damage functions	Depth-percent damage functions developed by the Corps and used for the Corps' ERR (USACE 2007) were used here.
Description of uncertainties	In HEC-FDA, we described uncertainty in the following inputs: • Graphical discharge-probability function using an equivalent record length = 30 years, consistent with the Corps' studies (USACE 2004) and EM1110-2-1619 (USACE 1996). • Discharge-elevation relationship using a normal distribution with a standard deviation equal 0.5 ft, considering the Corps' studies (USACE 2004) and EM1110-2-1619 (USACE 1996). • Elevation-damage relationships using descriptions of the uncertainty in the various components used to develop the relationship consistent with the Corps' ERR (USACE 2007). Specifically, uncertainty was described for structure value, percent damage given a flood depth, and first-floor elevation.
Non-damaging flood elevations	In the EAD computations, for perched channels such as along Unionhouse Creek, a non-damaging threshold elevation can be specified. With this, no floodplain damage occurs when the channel elevation is below the threshold. When the channel elevation exceeds the threshold, the floodplain elevation is found using the exterior-interior function and then corresponding damage from the elevation-damage relationship is assessed. This non-damage threshold elevation is specified in HEC-FDA using the "levee features" option. For the right bank (north of Unionhouse Creek) an elevation equal 19.5 ft was used. For the left bank (south of Unionhouse Creek) an elevation equal 19.7 ft was used. These elevations correspond to low points in the channel banks.

Attachment B. Unionhouse Creek IR benefit hydrologic and hydraulic inputs

As noted in Table 2, the hydrologic and hydraulic inputs used for the analysis were developed based on models provided by Sacramento County on March 2 and 4, 2011. These hydrologic and hydraulic inputs include:

- Discharge-probability function, shown in Table 3.
- Channel discharge-elevation function, shown in Table 4.
- Without-project exterior-interior elevation function, shown in Table 5.
- With-project exterior-interior elevation function, shown in Table 6.

Table 3. Discharge probability function used for Unionhouse Creek IR benefit analysis[1]

Annual exceedence probability (1)	**Discharge (cfs) (2)**
0.999[2]	400.0
0.500	949.0
0.200	1480.0
0.100	1804.0
0.040	2061.0
0.020	2200.0
0.010	2297.0
0.005	2333.0
0.002	2523.0

1. Values determined using unsteady state hydraulic model at Unionhouse Creek river mile 1.75.
2. As required by HEC-FDA, we graphically extrapolated the 0.999 value

Table 4. Channel discharge-elevation function used for Unionhouse Creek[1]

Discharge (cfs) (1)	Elevation (ft NGVD29)[2] Without-project (2)	With-project (3)
1.0	6.70	6.70
1000.0	17.04	15.35
1500.0	18.62	16.81
1600.0	18.93	17.14
1700.0	19.22	17.48
1800.0	19.52	17.77
1900.0	19.80	18.08
2000.0	20.07	18.40
2100.0	20.45	18.93
2200.0	20.90	19.56
2300.0	21.43	20.34
2400.0	21.65	21.15
2500.0	22.24	21.84
2600.0	23.01	22.73

1. Values determined using steady state hydraulic model at Unionhouse Creek river mile 1.718.

Table 5. Without-project exterior-interior elevation function used for Unionhouse Creek IR benefit analysis

Exterior elevation (ft NGVD29) (1)	Water surface elevation in impact area (IA) (interior) IA 36[1] (ft NGVD29) (2)	IA 45[2] (ft NGVD29) (3)
19.53	13.08	14.43
20.30	14.32	16.28
20.90	14.85	17.00
21.41	15.25	17.49
21.50	15.56	17.85
22.42	16.05	18.25

1. For IA 36 the non-damaging elevation threshold = 19.5 ft.
2. For IA 45 the non-damaging elevation threshold = 19.7 ft.

Table 6. With-project exterior-interior elevation function used for Unionhouse Creek IR benefit analysis

Exterior elevation (ft NGVD29) (1)	**Water surface elevation in impact area (IA) (interior)**	
	IA 36[1] (ft NGVD29) (2)	**IA 45[2] (ft NGVD29) (3)**
17.78	13.08	14.43
18.72	14.32	16.28
19.56	14.85	17.00
20.32	15.25	17.49
20.61	15.56	17.85
22.04	16.05	18.25

1. For IA 36 the non-damaging elevation threshold = 19.5 ft.
2. For IA 45 the non-damaging elevation threshold = 19.7 ft.

Attachment C. Unionhouse Creek structure inventory

As noted in Table 2, the structure inventory inputs, and thus the elevation-damage relationship, used for the analysis were developed based on information from the Corps' ERR (USACE 2007). Here, we summarize the key structure inventory information, including the structure identification, structure values, and the depth-percent damage relationships.

Structure identification

For convenience, we used geographic information system (GIS) tools to identify the relevant structures for this analysis. We started with the structure centroid shapefile used for the Corps' ERR study. This was provided to us by Tetra Tech Inc. on March 24, 2011, for use in SAFCA studies. By intersecting (overlaying) this with a GIS delineation of the impact areas, we identified structures within each impact area. In all, we identified 4,272 structures for our inventory; locations are shown in Figure 2. A breakdown of these structures by structure category is included in Table 7.

All of the structures shown in Figure 2 and Table 7 are included in the development of the total elevation-damage relationship. The number of structures damaged for a given "event" is dependent on several factors. For reference, Figure 3 and Figure 4 show "best estimate" without-project condition p=0.01 and p=0.002 event floodplains. These floodplain elevations were developed by combining the hydrologic and hydraulic inputs from Attachment B without considering uncertainties. Even though they are not used directly in the EAD computations with HEC-FDA, they are useful to visualize the approximate flooding extents.

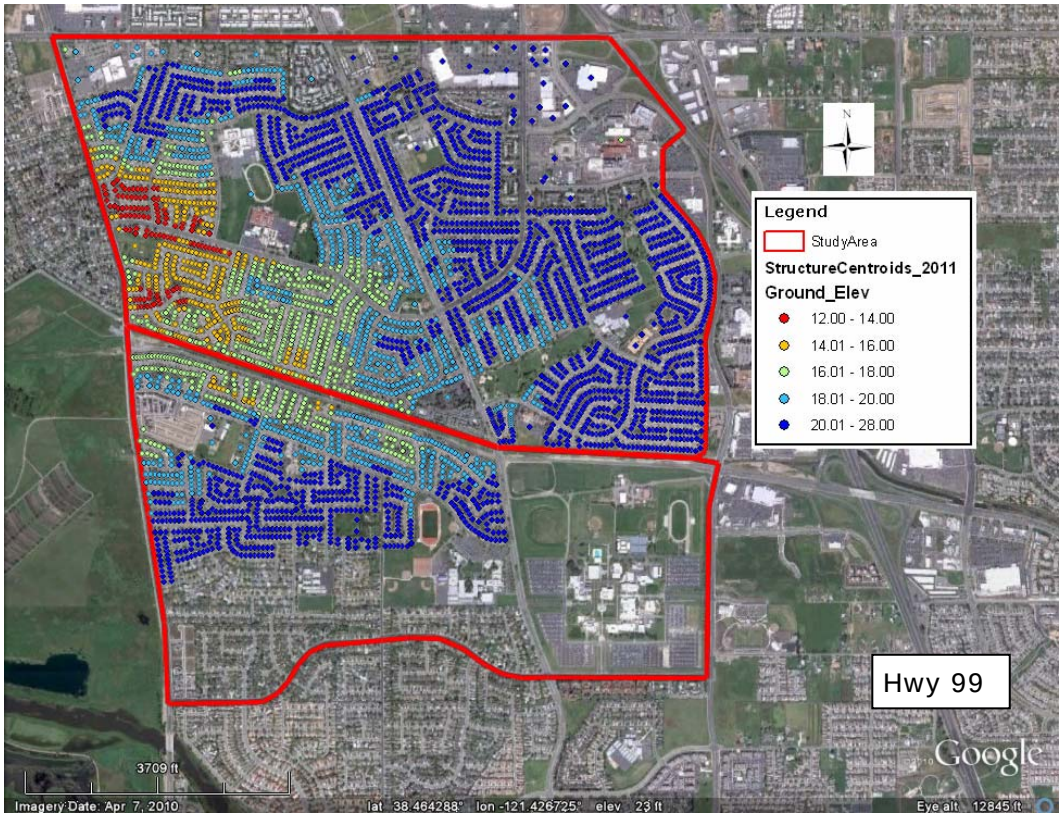

Figure 2. Location of structures within the Unionhouse Creek IR benefit analysis structure inventory

Table 7. Unionhouse Creek IR-benefit analysis structure inventory categories and number of structures

Structure category (1)	**Number of structures (2)**
Single family, 1 story	3,530
Single family, 2 story	684
Multi-family, 2 story	11
Commercial	47
Total	4,272

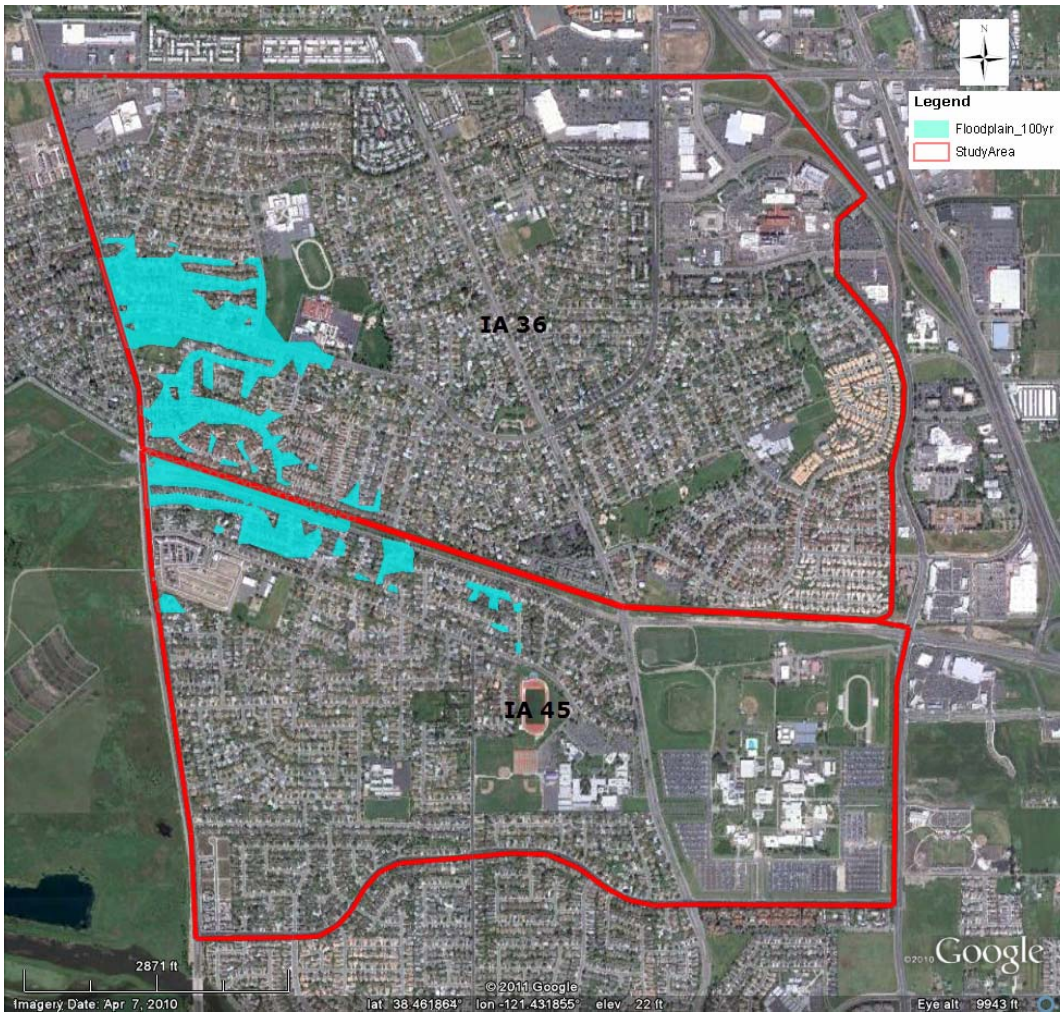

Figure 3. Unionhouse Creek without-project p=0.010 event inundates approximately 277 structures in the study area (Image source: Google Earth map, Europa Technologies, 2011)

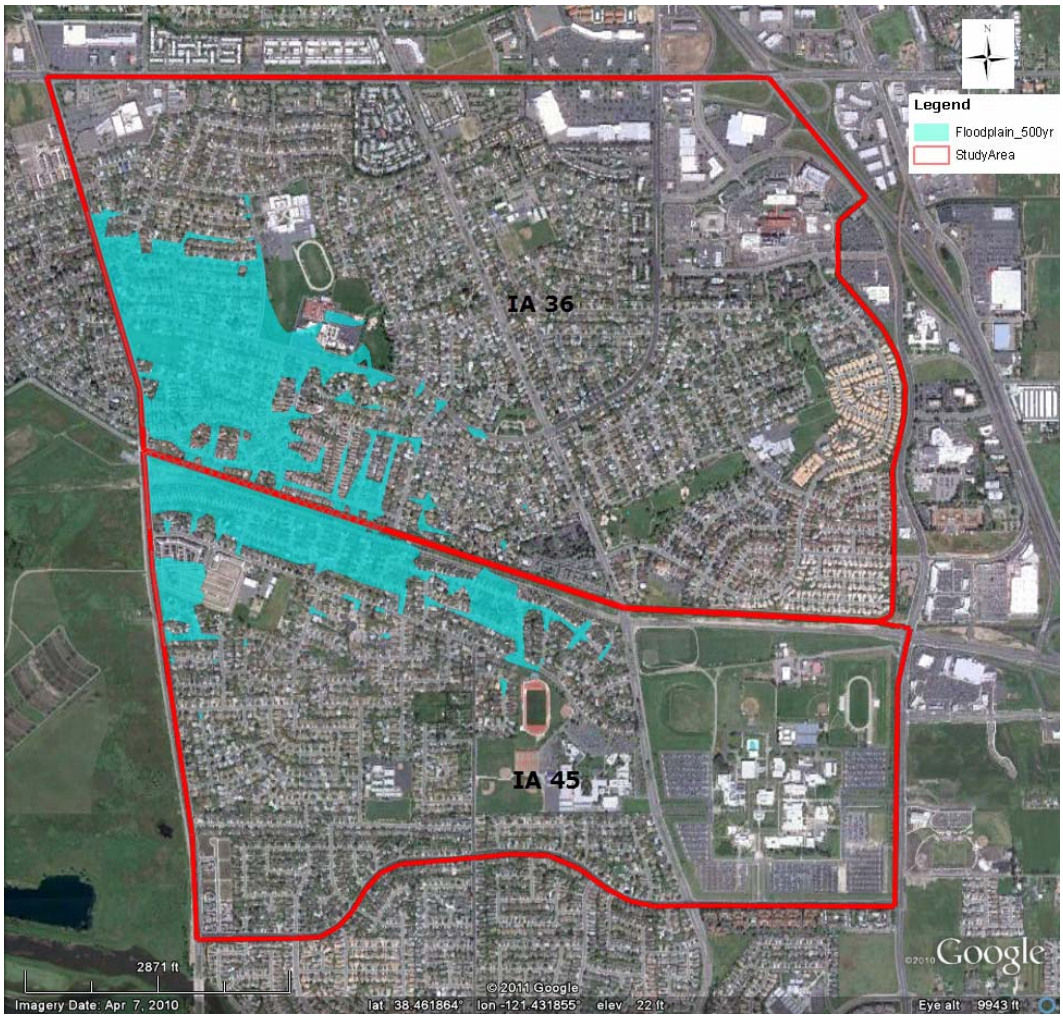

Figure 4. Unionhouse Creek without-project p=0.002 event inundates approximately 618 structures in the study area (Image source: Google Earth map, Europa Technologies, 2011)

Structure and content value

Table 8 summarizes the structure and content value of those structures included in the analysis and shown in Figure 2. As noted in the Corps' ERR report (USACE 2007), these values represent the total depreciated replacement value estimated for the structures.

Table 8. Structure, content, and total damageable property value by structure category for the Unionhouse Creek structure inventory

Structure category (1)	Structure value ($1,000) (2)	Content value[1] ($1,000) (3)	Total damageable property ($1,000) (4)
Single family, 1 story	386,206	193,103	579,309
Single family, 2 story	95,114	47,557	142,671
Multi-family, 2 story	108,542	54,271	162,813
Commercial	224,430	126,267	350,697
Total	814,292	421,198	1,235,490

1. Residential content is assumed 50% of residential structure value for this table. For EAD computations, the content damage is computed as a function of the structure value.

Elevation-damage functions

For this study, we used depth-percent damage functions and the non-residential content depth-damage functions consistent with the Corps' ERR. In application, the functions are transformed to stage-damage functions by multiplying the percent damage values by the total value and by adding the first floor elevation to depths.

When combining this information, we also needed an estimate of the first-floor elevation of each structure. Using GIS, we estimated the ground elevation of each structure in the database from available contour data supplied by the County of Sacramento. To convert the ground elevation to a first-floor elevation, we used typical foundation heights of 0.5 ft, consistent with values used for the Corps' ERR for structures in the study area.

We used the tools within HEC-FDA to integrate the structure value and depth-damage relationships. In addition, we used the tools in HEC-FDA to develop aggregated elevation-damage functions for each of the impact areas.

American River-Folsom Modifications Economic Analysis

AMERICAN RIVER –FOLSOM MODIFICATIONS
ECONOMIC ANALYSIS

INTRODUCTION

The American River Watershed Project over the last decade has had several reports with a number of features authorized. In this current study of the Folsom Modifications of the project, it is assumed that these features will be completed and be part of the without project condition. The purpose of this analysis is to address economic changes since the 1996 Supplemental Information Report SIR report, define the new without project damages, and estimate benefits of completing the Folsom Modifications.

INVENTORY REVISITED

This section will explain the process used to re-evaluate the structural inventory for the American River Watershed. The original inventory was gathered in 1989-1990 for the 1992 Feasibility Report and then later updated for the 1996 Supplemental Information Report (SIR.) This data was then used as the basis for all damage and benefit estimates found in documents from 1996 (SIR) to the 1999 Section 566 report. In accordance with ER 1105-2-100, those elements that could have the biggest impact on damages and corresponding benefits were given the focus of this reevaluation.

Changes Since 1996 and 1990

Since 1996, there have been several studies[1] performed in the area that indicate that the values and number of residential structures originally computed in the 1990 inventory may have been overestimated. New technologies such as digital databases and GIS were not available in 1989-1990. The residential structure count was based on area averages, developing density (number of units per acre) and using the same relationship throughout the flood plain. Commercial, industrial, and public structures were computed on a structure-by-structure basis and the count did not seem unreasonable. But based on the inconsistencies of residential counts, a 100 % new inventory for residential structures was developed.

Study Area – Economic Reaches

For this re-evaluation, the inventory was grouped geographically into four economic reaches, the Downtown Area, Rancho Cordova, South Sacramento and North Sacramento (for this analysis Natomas reach was excluded as the project does not provide benefits for that area.) The area is extensive, with about 55,000 acres subject to inundation. The reaches and extent of the flood plain can be seen in figure 1.

[1] South Sacramento Streams 1998, Post Flood Assessment 1999, SAFCA Assessment 2000.

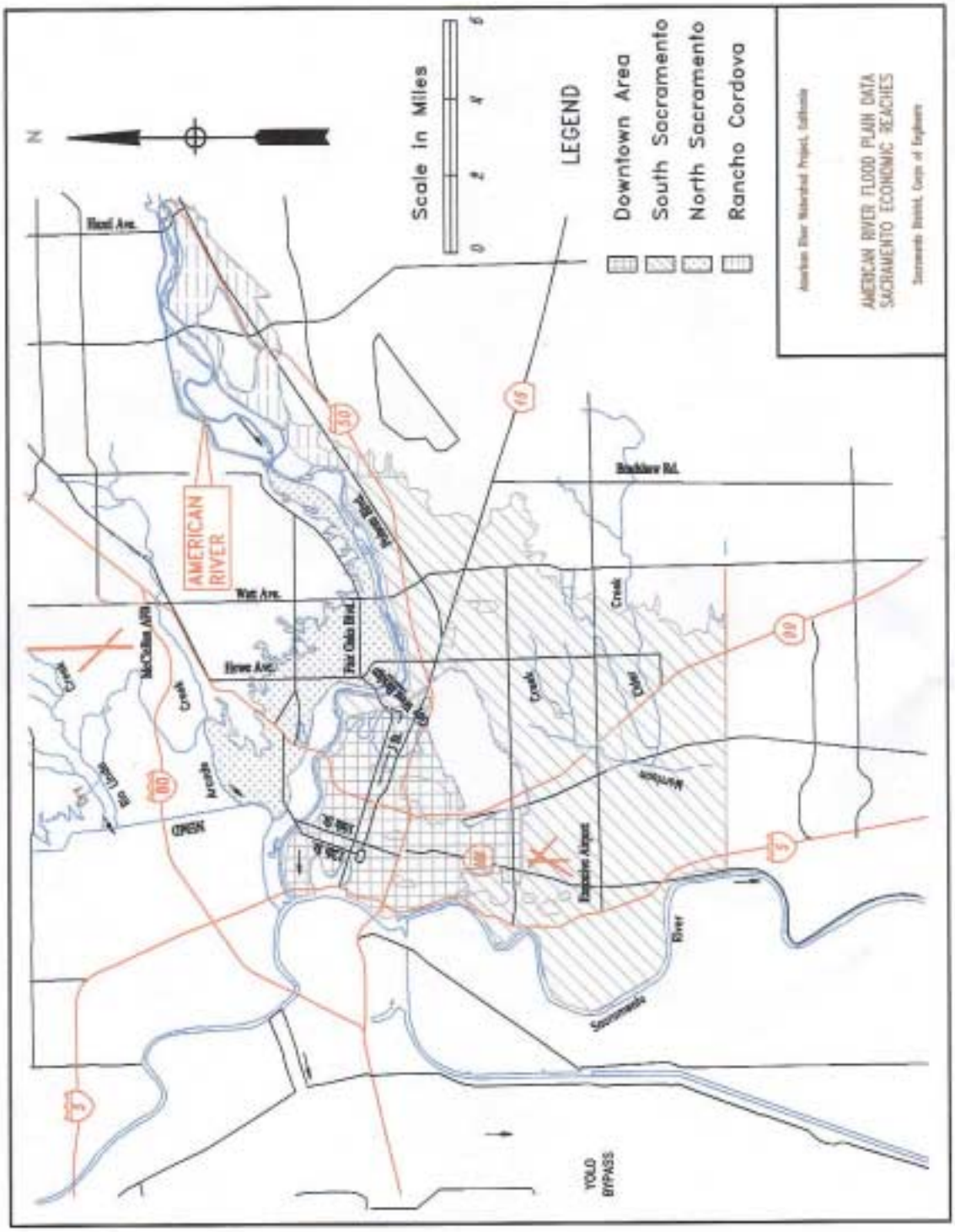
N
Scale in Miles
0
2
4
6
LEGEND
Downtown Area
South Sacramento
North Sacramento
Rancho Cordova
AMERICAN RIVER FLOOD PLAIN DATA
SACRAMENTO ECONOMIC REACHES
AMERICAN RIVER
Blackiew Rd.
Watt Ave.
Howe Ave.
Fair Oaks Blvd.
McClellan AFB
Mather Airport
Sacramento
River
YOLO BYPASS

FIGURE 1

Residential Inventory

The original flood plains for this study included 100-year and 400-year frequency delineations. While these frequencies have changed due to new flow-frequency relationships and completed project elements, the corresponding outflows still would produce similar flooding characteristics (same depths, area extent, duration) but at less likely frequencies. The original flood plains were digitized and used for developing the new inventory utilizing digital parcel data. The new inventory represents all residential structures in the flood plain including new development up to November 1999. Table 1 shows the number of residential units by area. The number of residential structures is about 20 % less than listed in earlier inventories.

Commercial- Industrial-Public Inventory

The updated inventory for the 1996 SIR included the original 1989-1990 inventory plus new development up to the end of 1994. This inventory was complete count (without sampling) and is representative of conditions as of 1994. The current study was focused on identifying new structures developed between 1995 and 1999. These new structures were identified by comparing changes in land use from the 1995 and 1999 digital parcel databases. Parcels that were vacant in 1995 but had improvement values in the new database were verified during field visitation and added to the inventory. Additional structures under current construction were also included. The total number of new structures added: 84 commercial, 3 industrial, and 10 public.

TABLE 1
NUMBER OF STRUCTURES
BY LAND USE AND REACH

REACH	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	PUBLIC	TOTAL
DOWNTOWN	21,869	1,610	47	383	23,909
NORTH SACRAMENTO	12,046	1,229	29	303	13,607
RANCHO CORDOVA	6,830	262	20	14	7,126
SOUTH SACRAMENTO	64,154	1,528	77	513	66,272
TOTAL	104,899	4,629	173	1,213	110,914

Value of Damageable Property

Values were revised using several methods. All values are listed in October 2000 price levels. All values represent depreciated replacement values.

Residential Structures

Residential values were determined by comparing cost per square foot method with adjusted improvement values. For all residential parcels, the assessed value list was gathered and adjusted based on year of recording assessment. This gave a relative value for each and every structure within the flood plain. To verify the depreciated replacement values, a sample of 365 individual structures were randomly selected. Characteristics, such as square footage, type, class, age and condition were gathered from database, Marshall & Swift Valuation, and field visitation. Value was determined as a function of dollar per square foot (by class & type) multiplied by square footage multiplied by percent of remaining value (total value minus depreciation.) This depreciated replacement value was compared to the adjusted improvement value of the 365 sample structures to determine standard deviation and to verify the values used. The total depreciated replacement value of the sample was only two percent greater than the total adjusted improvement value and this percentage adjustment was made to the remaining residential structures.

Commercial, Industrial, and Public Structures

In contrast to the residential structures (which in the 1990 inventory were based on average values that were aggregated per acre,) the original inventory had unique values for each individual commercial, industrial and public structure. To reevaluate these structures, a sample consisting of more than two hundred structures from the original inventory were selected. From this sample the values used in the 1996 SIR were compared to new values. New values were determined based on square footage, land use, type of activity (retail, office, warehouse, etc.) construction class, and condition. Field visitation was performed and data was gathered for each structure in the sample. Current values were based on cost per square foot method (similar to the method used on the residential but with more class and type distinctions for varying land use activities) and compared to the original values from the 1996 SIR study. Based on the summation of the sample, the new values were 5% less than the old values. As with the residential sample, the data was used in determining standard deviations and the structure values were adjusted to represent the 5% difference in value. New structures were valued at depreciated replacement value and were added to the inventory. The values of these structures are displayed in Table 2

Content Value

Content values were estimated as a percentage of the structure value. The percentages used were the same as used in the original study. For residential structures, a fifty percent content to structure ratio was used. For commercial, industrial, and public the content to structure ratio ranged from 24% to 209% depending the different land uses and activities. For new structures, land use and activity categories were identified and assigned content percentage. The values of contents are displayed in Table 2.

TABLE 2
VALUE OF DAMAGEABLE PROPERTY
VALUES IN MILLIONS, OCTOBER 2000 PRICES

LAND USE	AREA REACH				TOTAL
	DOWNTOWN	NORTH SACRAMENTO	RANCHO CORDOVA	SOUTH SACRAMENTO	
RESIDENTIAL					
STRUCTURE	$ 2,050	$ 1,605	$ 945	$ 5,588	$ 10,188
CONTENT	$ 1,025	$ 802	$ 473	$ 2,795	$ 5,095
COMMERCIAL					
STRUCTURE	$ 1,440	$ 1,221	$ 351	$ 1,740	$ 4,752
CONTENT	$ 1,628	$ 1,379	$ 402	$ 1,980	$ 5,389
INDUSTRIAL					
STRUCTURE	$ 23	$ 14	$ 25	$ 154	$ 216
CONTENT	$ 25	$ 14	$ 27	$ 160	$ 226
PUBLIC					
STRUCTURE	$ 904	$ 285	$ 22	$ 871	$ 2,082
CONTENT	$ 377	$ 121	$ 17	$ 456	$ 971
TOTAL	$ 7,472	$ 5,441	$ 2,262	$ 13,744	$ 28,919

FLOOD INUNDATION DAMAGES

Structural and content damages were estimated based on depth of flooding and depreciated replacement value. Depth damage relationships were used to determine the percent of value damaged at a given depth. Depth damage relationships were the same as used in the original study (based primarily on FEMA and TVA curves and verified by other studies.) Uncertainties in structure and content values, first floor elevation, and percent damaged were used in Monte Carlo simulation. These damage relationships (with uncertainty) were estimated for the original non-damaging, the original 100 and 400-year flood plains. The other damage points were interpolated from the original EAD data. Damages to structure and content represent over 95% of the total damages. The other minor damage categories, such as autos, roads and emergency costs, were updated by price indexing and adjusted based on the change in residential structure counts and occupancy.

Stage-Damage Curves

Damages for each category were determined and grouped by the original frequencies used. Damage estimates were then tied to stage (linked by the original flow-frequency relationship) for entry into the MONTE program. The combined stage-damage curve, with uncertainty, is displayed in Table 3. The original stage-damage relationships from the 1992 Feasibility Study reflected zero dollar damages below 43 feet. Since then, a series of levee improvements have brought the zero dollar damage point up to a series of higher stages. This is based on the condition that the levees would not fail below this stage. In the MONTE program, the PNP

(probable non-failure point) determines the stage where damages first occur. With construction completed from the Common Features project, the PNP now equals 49 feet for this study for both with and without project conditions (damages would be zero for all stages below 49 feet.)

TABLE 3
STAGE-DAMAGE CURVE
Damages in $ Millions, October 2000 Prices

Stage in feet	Damage Category					Total Damages	Standard Deviation
	Residential	Commercial	Industrial	Public	Other		
49.33	4,058	1,435	32	585	245	**$ 6,354**	**$ 788**
55.50	4,769	2,620	133	864	355	**$ 8,741**	**$ 952**
63.30	5,525	3,253	158	991	457	**$ 10,385**	**$ 1,025**
67.20	6,255	4,288	195	1,205	627	**$ 12,570**	**$ 1,054**
68.00	6,365	4,454	199	1,236	627	**$ 12,881**	**$ 1,084**

Without Project Conditions

Since the original 1992 Feasibility Report, several project features have been either constructed or authorized. In WRDA 1996, two elements (telemetered gages & slurry wall) were authorized followed by a third (levee repairs/Mayhew drain) in WRDA 1999. The without project condition for the Folsom Modification project includes these three elements.

Expected Annual Damages

Annual damages were estimated using the MONTE program. The stage-damage curve listed above was entered along with flow-frequency, inflow-outflow, and stage-flow curves. In addition to these relationships, potential levee failure was estimated based on PNP (probable non-failure points) and PFP (probable failure points) and was incorporated in the program. Project element accomplishments were simulated by changing either the inflow-outflow curve or the PNP/PFP stages. Without project expected annual damages for this study were based on the completion of the Common Features authorized in WRDA's 1996 and 1999. Expected annual damages for these elements are shown in Table 4 below.

TABLE 4
EXPECTED ANNUAL DAMAGES
WITHOUT AND PRE-PROJECT CONDITIONS
DAMAGES IN $MILLIONS, OCTOBER 2000 PRICES

FEATURE COMPLETED	PROBABLE EXCEEDANCE	EXPECTED ANNUAL DAMAGES
PRE-COMMON FEATURES	0.0120	$117.93
TELEMETERED GAGES	0.0119	$116.18
1996 WRDA SLURRY WALL	0.0111	$111.25
1999 WRDA LEVEE IMPROVEMENTS & WITHOUT FOLSOM MODS	0.0099	$104.23

BENEFIT ESTIMATION

With Project Damages

Expected annual damages were estimated based on with project conditions. Changes were made to the inflow-outflow relationship to simulate conditions for the Folsom Modification Project. The difference between the without project and with project damages represent the benefits attributable to the project. Benefits were also estimated for Folsom Mods at different levels of surcharge storage. These damages and benefits (in Table 5) represent values based on existing economic conditions.

TABLE 5
EXPECTED ANNUAL DAMAGES AND BENEFITS
WITHOUT AND WITH (EXISTING) CONDITIONS
DAMAGES IN $MILLIONS, OCTOBER 2000 PRICES

FEATURE COMPLETED	PROBABLE EXCEEDANCE	WITHOUT DAMAGES	WITH PROJ RESIDUALS	ANNUAL BENEFITS
NO ACTION	0.0099	$104.23	$104.23	$0.00
FOLSOM MODS @ SURCHARGE TO 470	0.0075	$104.23	$80.66	$23.57
FOLSOM MODS @ SURCHARGE TO 474	0.0070	$104.23	$76.02	$28.21

Risk-Based Results

In addition to expected annual damages, the MONTE program provides data describing project performance and potential risk. The following tables show a comparison of long-term risk, project performance, and probabilistic expected annual damages for both with and without project conditions.

TABLE 6
LONG TERM RISK
THE PROBABILITY OF DAMAGE OCCURING OVER A GIVEN PERIOD

CONDITION		RISK OVER A PERIOD OF TIME		
		10 YEARS	25 YEARS	50 YEARS
Without Project		9%	22%	39%
Folsom Mods (no surcharge above 470)		7%	17%	31%
Folsom Mods with Surcharge to 474		7%	16%	30%

TABLE 7
RELIABILITY -PROJECT PERFORMANCE
PROBABILITY OF NON-FAILURE FROM SPECIFIC EVENTS

CONDITION	PROB OF NON-FAILURE FROM VARIOUS EVENTS			
	50 YEAR	100 YEAR	200 YEAR	400 YEAR
	0.02	0.01	0.005	0.0025
Without Project	93.4%	58.6%	17.4%	2.4%
Folsom Mods (no surcharge above 470)	97.6%	76.7%	34.4%	7.7%
Folsom Mods with Surcharge to 474	98.0%	79.4%	38.2%	9.4%

TABLE 8
PROBABILITY THAT EXPECTED ANNUAL DAMAGES EXCEED VALUE SHOWN
VALUES IN $ MILLIONS, EXISTING CONDITIONS , OCTOBER 2000 PRICES

Condition	Probability That EAD is Exceeded		
	75%	50%	25%
Without Project	$ 13	$ 97	$ 154
Folsom Mods (no surcharge above 470)	$ 6	$ 58	$ 133
Folsom Mods with Surcharge to 474	$ 6	$ 12	$ 131

Future Economic Conditions

In the 1996 SIR, future growth within the flood plain was projected out to the study base year, which was 2008. Excluding Natomas, new damageable structures were limited to the fringe areas to the south and east. In the 1996 study, damages were projected to increase by less than 1.1 percent per year and only for events beyond the 100-year. To verify the growth, damages from structures built from 1995 to 1999 were compared with the total inventory. Based on these findings, damages would not increase due to new growth by more than 0.8 percent per year. The original growth estimates were incorporated with the new growth data to update stage-damage curves (Table 9) up to year 2010. By this date the area within the flood plain should reach full build out. Damages under future conditions were estimated and evaluated over the period of analysis to determine average annual equivalent damages. Average annual equivalent benefits are listed in Table 10, and are based on a 2007 to 2056 period of analysis, October 2000 prices, and 6 3/8 % discount rate.

TABLE 9

STAGE DAMAGE CURVES FOR LOWER AMERICAN REACHES

OCTOBER 2000 PRICE LEVELS

DAMAGES IN $MILLIONS

STAGE @ INDEX #7	49.33	55.5	63.3	67.2	68 +
2000	$6,354	$8,741	$10,385	$12,570	$12,881
2001	$6,354	$8,785	$10,457	$12,670	$12,984
2002	$6,354	$8,816	$10,530	$12,765	$13,081
2003	$6,354	$8,847	$10,604	$12,861	$13,180
2004	$6,354	$8,878	$10,678	$12,951	$13,272
2005	$6,354	$8,909	$10,753	$13,042	$13,365
2006	$6,354	$8,940	$10,828	$13,133	$13,458
2007	$6,354	$8,962	$10,883	$13,199	$13,526
2008	$6,354	$8,985	$10,937	$13,265	$13,593
2009	$6,354	$9,007	$10,992	$13,331	$13,661
2010	$6,354	$9,030	$11,047	$13,398	$13,729

TABLE 10
AVERAGE ANNUAL EQUIVALENT BENEFITS
IN $ MILLIONS, OCTOBER 2000 PRICES,
6 3/8% INTEREST RATE, 2007 TO 2056 PERIOD OF ANALYSIS

CONDITION	FUTURE - YEAR 2010		AVERAGE ANNUAL EQUIVALENT DAMAGES WITH PROJECT	AVERAGE ANNUAL EQUIVALENT BENEFITS @ 6 3/8 %
	WITHOUT PROJECT DAMAGES	WITH PROJECT RESIDUALS		
NO ACTION	$109.92	$109.92	$109.75	$0.00
FOLSOM MODS @ 470 surcharge	$109.92	$85.21	$85.08	$24.67
FOLSOM MODS @ 474 surcharge	$109.92	$80.30	$80.18	$29.57

Project Costs-Summary

Detailed explanation of project cost estimates can be found in the engineering appendix. Costs were estimated separately for two project features: 1) Dam Outlets and 2) Surcharge to elevation 474 feet. Interest during construction was estimated based on expenditure start dates for each element, calculated based on mid-year for interest computation up to the base year of 2007. For the outlets, expenditures began in 2000 on Planning Engineering & Design (PED) with construction starting in year 2001. For surcharge, PED is scheduled to begin in 2004 with construction starting in year 2006. All costs were estimated over a 50- year period of economic analysis (2007-2056) using 6 3/8 % interest rate and October 2000 prices.

Benefit Cost Analysis

Benefits and costs were analyzed as two increments. The first, being the completion of the dam outlets, which alone would limit surcharge storage to 470 feet. The second increment, being modifications to the spillway and auxiliary dams, would allow surcharge storage to 474 feet. Table 11 shows the benefits and costs values for these two increments.

Table 11
Benefit Cost Analysis - Folsom Modifications Project
All Values are in $ Millions
Using October 2000 Prices, 6 3/8 % Interest Rates, 50 year period of economic analysis

	Increment of The Project		Total Project
	Outlets	Surcharge	Folsom Modifications
First Costs	$ 108.8	$ 38.6	$ 147.4
IDC	$ 29.6	$ 3.3	$ 32.9
Investment Costs	$ 138.4	$ 41.9	$ 180.3
Annual Costs			
Interest & Amortization	$ 9.2	$ 2.8	$ 12.0
O&M Cost[1]	$ -	$ -	$ -
Total Annual Costs	$ 9.2	$ 2.8	$ 12.0
Average Annual Benefits			
Existing	$ 23.6	$ 4.6	$ 28.2
Future	$ 1.1	$ 0.3	$ 1.4
Total Annual Benefits	$ 24.7	$ 4.9	$ 29.6
Net Benefits	$ 15.5	$ 2.1	$ 17.6
Benefit-Cost Ratio	2.7	1.8	2.5

1 Note: Operation and Maintenance costs would not increase from current without project estimates

American River Watershed, California Folsom Dam Modification Project, Final Limited Evaluation Project

US Army Corps
of Engineers
Sacramento District

American River Watershed, California
Folsom Dam Modification Project

Final Limited Reevaluation Report

Prepared by the
Sacramento District, U.S. Army Corps of Engineers

August 2001

SUMMARY

Current efforts to reduce the risk of flooding to the city of Sacramento from the American River began after the floods of 1986. The Corps, in partnering with its non-Federal sponsors, the State of California Reclamation Board (The Reclamation Board) and the Sacramento Area Flood Control Agency (SAFCA), has prepared two comprehensive studies and developed several alternatives for a long-term solution to the flooding problems in Sacramento, but to date none has gained consensus. Congress has, however, authorized two projects from the American River Watershed Investigation (ARWI), the Common Features Project and the Folsom Dam Modification Project. The Common Features Project primarily includes levee modification work along the lower American River and Sacramento River, and upon completion of this project, scheduled in 2004, the chance of flooding will be reduced to 1 in 100 chance in any one year.

This Limited Reevaluation Report (LRR) has been prepared in response to the authorization of the Folsom Dam Modification Project in Section 101(a)(6) of the Water Resources Development Act of 1999. The primary purpose of this report is to demonstrate that the authorized operational and structural modifications to Folsom Dam are economically justified, environmentally acceptable, and technically sound. As part of this evaluation, the design of the authorized plan was refined, and the costs, benefits, and effects were updated. Since a full range of alternatives is presented and evaluated in the 1996 Supplemental Information Report, the formulation and comparison of alternative plans was not conducted as part of this LRR.

The Folsom Dam Modification Project includes two fundamental components: (1) outlet works modifications and (2) surcharge storage. The construction of these two components is being phased for several reasons. First, the design and construction of the outlet works modification component would take about 6 years and can be accomplished with few adverse social or environmental effects. Second, the modification of the use of surcharge storage would provide additional flood control space in the reservoir. Many of the project features that would be needed to implement surcharge may also be needed to implement raising Folsom Dam, one of the alternatives being investigated in the American River Watershed Investigation Long-Term Study. However, some of these features would be different. If the modified use of surcharge is constructed now, Long-Term Study features such as the new emergency spillway tainter gates and dikes may have to be modified again. The phased construction will allow ample time for a decision to be made on the (ARWI) Long-Term Study (LTS). A Chief's of Engineers report on the Long-Term Study will be available in spring 2002.

The outlet component primarily consists of enlarging the eight existing river outlets from 5 feet wide by 9 feet high to 9 feet 4 inches wide by 16 feet 3 inches high. No new outlets would be constructed. The enlarged outlets would increase the release capacity from 34,000 cubic feet per second to 115,000 cubic feet per second (the objective release) at a water-surface elevation of 418 feet (the spillway crest elevation). The outlet works modification component would increase flood protection by reducing the probability of flooding in Sacramento in any one year from 1 chance in 100 to 1 chance in 130. The first cost is $108.8 million. The average annual costs and flood

control benefits amount to $9.2 million and $24.7 million, respectively. The average annual net economic benefits amount to $15.5 million, and the benefit-to-cost ratio is 2.7 to 1. Since the construction work for the outlet works modifications would be restricted to the concrete portion of the dam, there are no significant adverse environmental, recreational, or real estate effects. In addition, the construction of the outlet works modifications is sequenced so that there are no significant operational effects. In addition, road closures are limited to weekends and evenings, so there are no significant traffic effects. Construction could start as early as summer 2001 and could be completed in 2008.

The objective of the surcharge component is to raise the maximum surcharge elevation during a controlled release from elevation 470 feet to 474 feet. The surcharge space would be used before the emergency spillway tainter gates are opened to maintain releases below the probable non-failure point of downstream levees for a longer period. Use of this surcharge operation allows an additional 48,000 acre-feet of space to be credited for flood control. The outlet works modifications with the surcharge component would decrease the risk of flooding in Sacramento to a 1 in 140 chance in any given year. The first cost is estimated to be $38.6 million. The average annual cost is $2.8 million; the average annual flood control benefits are $4.9 million; and the annual net benefits are $2.1 million. The component is economically feasible, and the benefit-to-cost ratio is 1.8 to 1. Mitigation measures would be implemented to reduce any significant environmental or traffic effects. Construction is scheduled to be initiated in 2006 and would be completed in 2008.

The project is fully supported by the non-Federal sponsors, The Reclamation Board and SAFCA, which are financially capable of supporting the project. The project has been closely coordinated with the U. S Bureau of Reclamation (USBR) who owns and operates Folsom Dam and Reservoir. SAFCA, as the non-Federal sponsor, will enter into a cost-sharing agreement with USBR to pay for any portion of the operation, maintenance, repair, and replacement costs related to the new flood control features. The project is economically feasible, environmentally sound, and technically feasible.

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CHAPTER I – INTRODUCTION

PURPOSE AND SCOPE

The purpose of this Limited Reevaluation Report (LRR) is to demonstrate that the project features authorized by Congress in Section 101(a)(6) of the Water Resources Development Act of 1999 (WRDA 99) are economically justified, environmentally acceptable, and technically sound. As part of this evaluation, additional analyses were conducted, and the costs and benefits of the authorized plan were developed. Since a full range of alternatives is presented and evaluated in the 1996 Supplemental Information Report (SIR), the formulation and comparison of alternative plans was not conducted as part of this LRR.

The implementation of the project is being constructed in two phases: (1) outlet works modifications and (2) surcharge component. Upon completion of the Folsom Dam Modification Project, the probability of flooding will be reduced to 1 in 140 chance in any one year. The construction is being phased because many of the project features needed for surcharge may also be needed to implement the Folsom Enlargement Plan, one of the alternatives under consideration in the American River Watershed Investigation Long-Term Study. This study is investigating alternatives for the next step in flood control to meet the long-term minimum goal of the non-Federal sponsors to provide a minimum probability of flooding of 1 in 200 chance in any one year.

LOCATION

Sacramento is located at the confluence of the American and Sacramento Rivers. The American River Watershed (drainage basin) covers about 2,100 square miles northeast of Sacramento and includes portions of Placer, El Dorado, and Sacramento Counties (Plate 1). Runoff from this basin flows through Folsom Reservoir and passes through Sacramento within a system of levees. Folsom Dam and Reservoir are part of the Federal Central Valley Project (CVP) completed by the United State Bureau of Reclamation (USBR).

BACKGROUND

In February 1986, major storms in northern California caused record floodflows in the American River basin. Water releases from Folsom Reservoir reached 134,000 cfs for 24 hours, which is above the non-emergency objective release of 115,000 cfs and was above the design flow for parts of the lower American River levee system. Flows from Folsom Reservoir, together with high flows in the Sacramento River, caused water levels to rise above the design freeboard (safety margin) of the levees protecting the Sacramento area. Emergency repair work was required at several locations along the Garden Highway and in the Pocket area of Sacramento. Had these storms lasted much longer, major sections of levee would likely have failed, causing probable loss of life and billions of dollars in damages.

The effects of the February 1986 storms raised concerns over the adequacy of the existing flood control system, which led to a series of investigations to provide additional flood protection to the Sacramento area. Plate 2 shows the likely area of inundation for a major flood. Many of the flood problems in Natomas have been significantly reduced due to recent levee improvements. (Natomas is just north of downtown Sacramento at the confluence of the American and Sacramento Rivers.)

The U.S. Army Corps of Engineers (Corps), The State of California Reclamation Board (The Reclamation Board), and Sacramento Area Flood Control Agency (SAFCA) completed an initial feasibility study in 1991 for the mainstem American River and Natomas. The scope of that study was to define the flood risks to the Sacramento area and to develop flood protection alternatives consistent with other water resource needs and opportunities in the study area. Many alternatives were evaluated in that study. The resulting plan, recommended in the December 1991 Feasibility Report, was for construction of a flood detention dam just downstream of the confluence of the North and Middle Forks of the American River and levee improvements in the Natomas area sufficient to control runoff from a minimum probability of 1 in 200 chance in any one year. The Reclamation Board and SAFCA have long sought the maximum flood protection possible for the city of Sacramento, with a minimum goal of a probability of 1 in 200 chance in any one year.

Subsequent to completion of the Feasibility Report, Congress provided guidance relating to the American River study in Section 9159 of the Department of Defense Appropriations Act of 1993 (Public Law 102-396). This act authorized the construction of much of the work identified in the Natomas area as described in the Feasibility Report. The act also directed that additional studies be conducted to identify a project for increased flood protection along the American River.

In response to congressional direction, the Corps and its local sponsors, The Reclamation Board and SAFCA, prepared the 1996 SIR to provide additional information. The SIR presented three final candidate plans:

- Folsom Modification Plan (a version of this plan was authorized and is currently analyzed in this LRR),

- Folsom Stepped Release Plan (versions of this plan are under consideration in the Long-Term Study), and

- Detention Dam Plan (this plan was the National Economic Development Plan (NED); however, the plan did not gain local consensus or congressional support).

The Folsom Modification Plan primarily included increasing the release capacity by modifying the spillway and enlarging the eight existing outlets, modifying the lower American River and Sacramento levees, modifying the use of surcharge storage, and increasing the variable flood control space by reoperating the reservoir. The Stepped Release Plan included all the features of the Folsom Modification Plan and in addition

included increasing the objective release to 180,000 cubic feet per second (cfs) and modifying the downstream levee system to handle this increase in flow. The Detention Dam plan included modifying the lower American River and Sacramento levee system, and a concrete gravity dam 508 feet high with a detention capacity of 894,00 acre-feet on the North Fork American River near Auburn.

In Section 101(a)(1) of the Water Resources Development Act of 1996 (WRDA 96), Congress authorized the construction of those features which were common to the three candidate plans identified in the SIR. These features include (1) levee modification along both banks of the lower American River, (2) levee modification along the east bank of the Sacramento River downstream from the Natomas Cross Canal, (3) installation of streamflow gages upstream from Folsom Reservoir and modification to a flood warning system along the lower American River. These project features are currently being implemented. The interim reoperation of Folsom Reservoir for flood control will continue until the completion of Folsom Modification Project.

WRDA 99 authorized modifications to the Common Features Project authorized in WRDA 96. These modifications primarily consist of strengthening and raising levees along the American River. In August 2000, the Corps completed an information paper describing refinements to the modifications in WRDA 99. The WRDA 96 and 99 Common Features Projects are scheduled to be completed in 2004. Once construction of the Common Features Projects has been completed, the chance of flooding in Sacramento will be reduced to 1 in 100 in any given year. The construction of the Common Features Project is part of the without-project condition for the Folsom Dam Modification Project.

Since completion of the 1996 SIR, three information reports have been prepared by both SAFCA and the Corps to provide additional technical information concerning opportunities in the American River watershed. These reports are:

- In March 1998, MBK Engineers, under contract to SAFCA, published the "Folsom Dam Modification Report, New Outlets Plan." This report presented two alternatives that would reduce construction effects, shorten the construction period, and eliminate the temporary reduction in flood protection required by the Folsom Modification Plan in the SIR.

- In August 1999, the Corps published the "American River Watershed, CA, Information Paper" to provide additional information to the SIR. The Information Paper (1) described significant changes in baseline conditions that had taken place since the completion of the SIR and implementation of several flood control features in the Sacramento area, and (2) described and evaluated four supplemental improvement plans (in addition to those in the SIR). The plans included the Folsom Modification Plan, Stepped Release Plan, Folsom Enlargement Plan, and Folsom Modification and Upstream Storage Plan.

- In response to congressional direction in Section 566 of WRDA 99, in January 2000, the Corps prepared the report entitled "Additional Information - Folsom Dam Flood

Control Storage & Downstream Levees," which provided additional information on the Folsom Enlargement Plan and the Stepped Release Plan.

In Section 366 of WRDA 99, Congress authorized the construction of several additional flood control features. The features that have been authorized for the American River Watershed project are described in Section 9159 of the Department of Defense Appropriations Act for fiscal year 1993, in Section 101(a)(1) of WRDA 96, and in Sections 366 and 101(a)(6) of WRDA 99. Section 101(a)(1) authorized the Folsom Dam modifications discussed in this report. (See PROJECT AUTHORIZATION AND GUIDANCE below.)

In 1998, SAFCA completed construction of the North Area Local Project improvements needed to provide flood protection to Natomas basin, a 90-square mile area north of Sacramento, immediately east of the Sacramento River, and extending into Sutter County. Project features consist of levees associated with the Natomas East Main Drain, Arcade Creek, Dry Creek, Pleasant Grove Creek Canal, and Natomas Cross Canal; a pumping plant on the Natomas East Main Drain, and a detention basin at Pleasant Grove Creek. The flood risk to Natomas from the American River would be reduced to 1 in 400 chance in any year.

In addition to the projects described above that have already been authorized, the Corps, The Reclamation Board, and SAFCA are currently conducting a study, authorized in Section 566 of WRDA 1999, to determine the next increment in flood control that would meet the long-standing SAFCA objective of a minimum probability of 1 in 200 chance in any one year. This study is investigating a range of alternatives including enlarging Folsom Dam, increasing the objective release at Folsom Dam, and making advanced flood releases from the dam based on weather forecasting. This study is scheduled for completion in March 2002.

CHAPTER II – EXISTING CONDITIONS

EXISTING FLOOD CONTROL SYSTEM

Over the years, a complex system of levees, upstream dams and reservoirs, and related facilities was built to help reduce flooding in the Sacramento area. Several of the projects are discussed below.

Folsom Dam and Reservoir

Folsom Dam is on the main stem of the American River about 29 miles upstream from the Sacramento River. It is a multipurpose project operated by the USBR as part of the CVP. The dam regulates runoff from about 1,860 square miles of drainage area and has a total (full pool) capacity of about 975,000 acre-feet. The top of the current conservation pool is at elevation 466 feet. The current maximum flood control pool is at elevation 470 feet while maintaining the objective and emergency releases. However, under extreme conditions, the reservoir surcharges up to elevation 475.4 feet (Plate 3). The objective release for flood control from the dam to the lower American River is 115,000 cfs.

Operations

Folsom Dam was constructed with a seasonally designated flood control storage space of 400,000 acre-feet. However, in an interim agreement between the USBR and SAFCA through authorization in WRDA 1996, flood control storage in the reservoir has been changed to a variable space available ranging from 400,000 acre-feet to 670,000 acre-feet, depending on the amount of creditable vacant space in several existing upstream reservoirs in the basin. The USBR and SAFCA are currently working on finalizing this agreement.

Under this reoperation, a flexible rule curve operation is used. This includes varying the flood control space required in Folsom Lake through the crediting of actual space available in reservoirs upstream from Folsom Dam. As upstream reservoirs' creditable space is filled, the variable flood space at Folsom increases to as much as 670,000 acre-feet. Eighteen reservoirs exist in the American River Basin above Folsom. Flood control is not a project function of any of these reservoirs. Of the 18, only 5 are of sufficient size or located at appropriate sites where storage space in them could have a measurable influence on flood operation (Plate 1.) They include French Meadows, Hell Hole, Loon Lake, Union Valley, and Ice House. The drainage basins above the reservoirs have accounted for a minimum of 14 percent of the unregulated flows at Folsom Dam during major flood events.

The maximum creditable upstream space was determined to be 200,000 acre-feet. Any additional space does not benefit Folsom Dam operation during a Federal Emergency Management Agency (FEMA) storm probability with 1 in 100 chance in any one year

because the drainage basins above these reservoirs do not generate a significantly greater volume during the critical period of such an event.

Release Capacity

The existing Folsom Dam has limited capability to make objective flood releases until the reservoir is nearly 75% full. In order to make flood releases of 115,000 cfs, the objective release in the floodway below Folsom, the lake must rise above elevation 418. Currently, a maximum of 34,900 cfs can be released through the power penstocks and low-level outlets (7,500 cfs from the power plant and 27,400 cfs from the outlet works) when the lake level is at the spillway crest of elevation 418 feet. Plate 4 shows the location of the existing lower outlets, tainter gates, and spillway

Dam Safety

Folsom Dam and Reservoir was designed to pass the probable maximum flood (PMF) at the time of its construction. However, with the updated hydrology, the Corps has determined that Folsom Dam's existing spillway capacity is inadequate to protect the dam in the event of an extreme flood. Based on previous evaluations, it is estimated that the Folsom Dam spillway can currently pass approximately 70% of the PMF. This is subject to confirmation by an analysis of the PMF (hydrologic/routing, hydraulic design/model testing, and structural design) to be completed this year. Although dam safety is not currently part of the Folsom Modification Project authorization, dam safety remains an important consideration for any major dam modification project. A PMF fix is currently being evaluated as a dam safety component with the Folsom Dam Enlargement Plan, one of the alternatives being considered in the American River Long-Term study. If a Folsom Dam enlargement plan were authorized, it would likely include enhancements at French Meadows Dam and some combination of new/enlarged outlets, spillway lowering, and/or dam raising (i.e. crest walls). The PMF fix would need to be compatible with the Folsom Dam Outlet Modifications and Surcharge improvements. The main goals of the ongoing PMF studies will be to evaluate, identify, and report out on the best method to satisfy the PMF deficiency; to minimize traffic impacts during implementation; and determine if the changes are cost effective.

There is no current funding to construct a PMF fix, so the PMF deficiency is expected to remain unchanged under the without project condition. There is a potential that the PMF may be fixed through the Federal dam safety program. The USBR is investigating a potential fix and will coordinate its results with the ARWI long Term Study.

American and Sacramento River Levee System

Most of the levees surrounding the Sacramento urban area were first constructed to protect farmlands. These levees were significantly upgraded between 1916 and 1958 and further upgraded in the early 1990's. Additional levee stabilization is currently being accomplished as features of the Federal Sacramento River Flood Control Project, the ARWI Common Features Project, and the North Area Local Project.

FLOOD PROBLEMS

Current estimates are that with Folsom Dam and Reservoir, other upstream reservoirs, and the existing levee system, there is a about a 1 in 85 chance in any year from levee failure and flooding in Sacramento. Upon completion of the levee modifications in the Common Features Project, there will be about a 1 in 100 chance in any year of levee failure and flooding in Sacramento. Plate 2 shows the likely area of inundation for a major flood in Sacramento.

Frequency of Flooding

The chance of levee failure and resultant flooding in Sacramento depends on the frequency of high flows in the American and Sacramento Rivers and on the condition of the existing levee system. System performance is described in two ways: (1) the chance of flooding occurring in any one year (1 in 100 or 1 percent) and (2) the probability of a particular frequency flood event occurring without causing flooding. There is uncertainty as to the flow magnitude for any given flood frequency. Table 1 shows the event conditional non-exceedance of major flooding along the lower American River for four flood events under the without-project conditions (upon completion of the Common Features Project). This information is also shown in Plate 5. As can be seen, even though the project performance is 1 in 100 chance in any one year, the chance of containing the 1 in 50 chance of flooding in any one year is a about 93 percent given the estimation uncertainty. For larger (more rare) storms, the chance of levee failure and flooding increases.

TABLE 1. PROJECT PERFORMANCE[1] UNDER WITHOUT-PROJECT CONDITIONS

Storm		Percent Chance of Flooding	Percent Chance of Not Flooding
Return Period (years)	Exceedance Frequency Per 100 Years (percent)		
50	2.0	7	93
100	1.0	41	59
200	0.5	83	17
400	0.25	98	2

[1] A particular frequency flood event (such as 1 in 100 chance in any one year) will result in a certain river stage in the lower American River levees. If this stage exceeds the capability of the levees to hold back the water, then levee failure and flooding of Sacramento will occur. There are uncertainties about several parameters that determine the stage in the lower American River. These include amount of runoff, peak discharge from Folsom Dam, and stage of that discharge in the American River. The biggest unknown is the amount of runoff from a particular frequency event. These uncertainties are estimated, and this results in a range of river stages that may occur for any particular frequency flood event. All the different possible combinations for a particular frequency flood event are evaluated, and the percentages of those that result in flooding are calculated.

Release Capacity of Folsom Dam

Although the objective release of 115,000 cfs is a major release that can be sustained within the existing levees, Folsom Dam can only release the outlet capacity of 34,900 cfs until the lake's water surface is above the spillway crest. The lake must rise above elevation 418 feet, in order to make the flood releases through the spillway tainter gates of 115,000 cfs, the objective release in the floodway below Folsom. Thus, Folsom Dam does not have an opportunity to make releases to maintain much of its flood control space. This is an inherent inefficiency of the flood control operation of the dam. (See plate 4 for the location of the existing outlets, spillway crest, and tainter gates.)

Economic Damages

The existing average annual damages are $118 million. Upon completion of the Common Features Project, the average annual damages will be reduced to $104 million (including future growth).

CHAPTER III – PROJECT DESCRIPTION

PROJECT AUTHORIZATION AND GUIDANCE

Section 101(a) (6) of WRDA 99 (Public Law 106-53) provides authorization for the Folsom Dam Modification Project:

> AMERICAN AND SACRAMENTO RIVERS, CALIFORNIA. –
>
> *(A) IN GENERAL. - The Folsom Dam Modification portion of the Folsom Modification Plan described in the United States Army Corps of Engineers Supplemental Information Report for the American River Watershed Project, California, dated March 1996, as modified by the report entitled "Folsom Dam Modification Report, New Outlets Plan," dated March 1998, prepared by the Sacramento Area Flood Control Agency, at an estimated cost of $150,000,000, with an estimated Federal cost of $97,500,000 and an estimated non-Federal cost of $52,500,000. The Secretary shall coordinate with the Secretary of the Interior with respect to the design and construction of modifications at Folsom Dam authorized by this paragraph.*
>
> (B) REOPERATION MEASURES. - Upon completion of the improvements to Folsom Dam authorized by subparagraph (A), the variable space allocated to flood control within the Reservoir shall be reduced from the current operating range of 400,000-670,000 acre-feet to 400,000-600,000 acre-feet.
>
> (C) MAKEUP OF WATER SHORTAGES CAUSED BY FLOOD CONTROL OPERATION. - The Secretary of the Interior shall enter into, or modify, such agreements with the Sacramento Area Flood Control Agency regarding the operation of Folsom Dam and reservoir as may be necessary in order that, notwithstanding any prior agreement or provision of law, 100 percent of the water needed to makeup for any water shortage caused by variable flood control operation during any year at Folsom Dam and resulting in a significant impact on recreation at Folsom Reservoir shall be replaced, to the extent the water is available for purchase, by the Secretary of the Interior.
>
> (D) SIGNIFICANT IMPACT ON RECREATION. - For the purposes of this paragraph, a significant impact on recreation is defined as any impact that results in a lake elevation at Folsom Reservoir below 435 feet above sea level starting on May 15 and ending on September 15 of any given year.
>
> (E) UPDATED FLOOD MANAGEMENT PLAN. - The Secretary, in cooperation with the Secretary of the Interior, shall update the flood management plan for Folsom Dam authorized by section 9159(f)(2) of the Department of Defense Appropriations Act, 1993 (106 Stat.1946), to reflect the operational capabilities created by the modification authorized by subparagraph (A) and improved weather forecasts based on the Advanced Hydrologic Prediction System of the National Weather Service.

Corps Headquarters provided guidance on the intent of this authorization in a memo dated January 18, 2000. This memo directed that a decision document be prepared to support the authorized project. This document would not need to reformulate alternatives but would need to show that the proposed project is economically justified, technically sound, and environmentally acceptable. This LRR describes the Folsom Dam Modification Project identified in Section 101(a)(6)(A) of WRDA 99. In addition, this document will serve as the basis for entering into a Project Cooperation Agreement (PCA) on components that will be implemented.

Section 101 (a)(6)(B) directed the Corps and the USBR to modify the operation from 400,000-670,000 acre-feet (see plate 6) to 400,000-600,000 acre-feet (see plate 7),

upon completion of the Folsom Dam Modification Project authorized in Section 101(a)(6)(A). The outlets modification works and the additional surcharge storage will alter the flood control storage, so that the level of protection provided in the 400,000 - 670,000 acre-feet variable flood storage space would differ throughout the variable space. The modification from 400,000 - 670,000 acre-feet to 400,000 - 600,000 acre-feet would provide a "balanced" level of protection. Providing a "balanced" level of protection means that Sacramento would receive the same level of protection anywhere in the variable space ranging from 400,000 - 600,000 acre-feet depending upon space available in upstream reservoirs. Operating at this balanced level of protection would reduce effects to water supply, recreation, and environmental uses of the water at Folsom Reservoir without appreciably affecting flood control. In order to implement this component, the water control manual would need to be modified and a document to meet National Environmental Policy Act requirements would be prepared. Currently, the USBR is preparing an environmental impact statement (EIS) on extending the 400,000-670,000 acre-foot reoperation to a long-term basis. This EIS will define the baseline for the proposed change to 400,000-600,000 acre-feet. With outlet works modifications and increased surcharge in place, Folsom Dam may continue to operate using the 400,000-670,000 acre-foot flood space. Thus, these components are complete without adjustment to the variable space. The reduced reoperation plan to 400,000-600,000 acre-feet is scheduled to be implemented in 2006-2007.

Section 101(a)(6)(E) directed that the Corps and the USBR update the Flood Management Plan to reflect the operational capabilities created by the Folsom Dam Modification Project and improved weather forecasts based on the Advanced Hydrologic Prediction System of the National Weather Service. The Corps in coordination with the USBR has begun preliminary studies to update the Flood Management Plan. This work is expedited because it could affect the Long-Term Study without-project condition that is currently being developed.

Authorized Project

In 1996, the Corps, along with The Reclamation Board and SAFCA, prepared the SIR, which documented the comprehensive flood control analysis of the American River watershed. The Folsom Modification Plan was one of three candidate plans developed in the 1996 SIR. The components of the 1996 Folsom Modification Plan consist of the following fundamental features:

- Increasing the release capacity at Folsom Dam through modification of the spillway and river outlets to maintain releases at or below the objective release of 115,000 cfs for larger events, and

- Modifying the use of surcharge in Folsom Dam through both physical improvements and operational changes to increase the flood storage capacity in order to maintain the objective release of 115,000 cfs for larger events.

The construction of this plan as outlined in the 1996 SIR would require 6 years. During the construction period, there would be effects on operation, including the loss of outflow capacity. The lake would have to be lowered to accommodate the demolition of the spillway crest and the strengthening of the piers. In addition, there would be significant effects on traffic using the Folsom Dam Roadway. Construction would be scheduled and managed to minimize traffic interruptions.

While the SIR was being finalized in 1995, a spillway tainter gate at Folsom Dam failed. The USBR spent the next few years performing construction work on the dam to fix problems that resulted from the gate failure. Completion of the USBR's work was delayed by public concerns over closing the dam road during construction. In anticipation of similar concerns, SAFCA developed and evaluated two additional plans to increase the early release capacity at Folsom Dam while reducing the traffic and operational effects of lowering the spillway. These plans included enlarging existing outlets and/or constructing new outlets. The resulting report concluded that lowering the spillway would result in major effects on traffic from road closure and that the new plans would have fewer effects.

Congress authorized the Folsom Dam modification portion of the Folsom Modification Plan described in the SIR as modified by the SAFCA report. The primary difference between the SIR and the SAFCA report was that SAFCA proposed enlarging existing outlets and adding five new outlets in the emergency spillway and constructing a new emergency spillway stilling basin. This plan avoids lowering the main spillway that was part of the 1996 SIR Modifications Plan.

Implementation of the Authorized Project

The Folsom Dam Modification Project would be constructed in two phases: (1) outlet works modifications and (2) surcharge storage. The intent is to provide the most efficient sequence of events to enable Sacramento to improve its flood protection.

There are several reasons why two phases would be desirable. First, the major portion of flood control benefits is from the outlet works modifications, the design and construction of which would take approximately 6 years. There is a need to accomplish this work as soon as possible to improve the flood protection for Sacramento. The construction of the outlet works modifications could begin as early as spring 2002. Construction of new emergency gates needed for surcharge would create construction conflicts with outlet works modifications if work were done at the same time.

Second, the modification of the use of surcharge storage would provide additional flood control space in the reservoir. Many of the project features that would be needed to implement surcharge may also be needed to implement raising Folsom Dam, one of the alternatives being investigated in the Long-Term Study. However, some of these features would be different. If the modified use of surcharge is constructed now, Long-Term features such as the new emergency spillway tainter gates and dikes may have to be modified again. The phased construction will allow ample time for a decision to be made

on the Long-Term Study. A chief's report on the Long-Term Study will be available in spring 2002.

This LRR includes detailed analyses of the design, costs, benefits, accomplishments, and residual risk of both components. An environmental assessment/Initial Study (EA/IS) has been prepared that evaluates the effects of these two components on environmental resources in the area. During design phase, more detailed analysis will be conducted on the surcharge features.

REFINEMENT OF AUTHORIZED FEATURES

To reduce costs and ensure dam safety, the SIR and SAFCA plans have been analyzed and refined further. More detailed analyses on the design, costs, benefits, and effects were conducted to ensure a cost effective, technically sound, and environmentally acceptable project. The refinements and the fundamental reasons for these refinements are discussed below. Table 2 compares the authorized features and current project.

Increasing the Release Capacity

When the Folsom Modification Plan was developed in the SIR and then modified by SAFCA, the primary objective in relation to the release capacity was to modify the outlet capacity at Folsom Dam so that the objective release of 115,000 cfs could be reached before a water-surface elevation of 418 feet (the spillway crest).

Both the SIR and SAFCA's report included enlarging the existing river outlets to 6 feet wide by 12 feet high. This size was based on construction limitations and concerns about approaching the upper size limits of similar functioning gates in other projects. The possible enlargement of the existing river outlets was examined in greater detail in this report than in the earlier reports. It was determined that the gates could be manufactured in either two or three sections to reduce the size, brought into the chamber, and assembled in place. This would allow the size of the gates to be larger. Full-scale models of gate leafs were constructed and taken through the various adits and shafts in the dam to determine construction constraints.

The SAFCA report also identified the need to construct a new stilling basin downstream of the auxiliary spillway to handle the flows from the new outlets. Enlargement of the existing outlets was examined to determine if the number of new outlets could be reduced and if any new outlets could be moved so that they would discharge into the main spillway basin. This type of design would result in a significant cost savings because the need for a new stilling basin downstream of the auxiliary spillway would be eliminated.

A plan to reduce new outlets and enlarge existing outlets was developed. Two new outlets were evaluated; each outlet gate would be about 6 feet wide by 10 feet high. These outlets would be located in monoliths 12 and/or 17, which are located under the main spillway tainter gates. The new outlets would discharge into the existing main stilling basin, avoiding any major modifications to the emergency spillway stilling basin. The

TABLE 2. AUTHORIZED AND CURRENT PROJECT

Component	Features		Refinements and Justification
	Authorized Plan	**Current Project**	
Increase release capacity	Plan I - New Outlet Plan Construct 5 new outlets (two 7' x 14' slide gates per outlet) under the auxiliary spillway. Construct new stilling basin downstream of auxiliary spillway. Plan II - New and Enlarge Plan Construct 5 new outlets (two 7' x 14' slide gates per outlet) under the auxiliary spillway. Construct new stilling basin downstream of auxiliary spillway. Enlarge 8 existing river outlets to 6'x 12'.	Enlarge 8 existing river outlets to 9'-4" x 16'-3". Modify to allow 100% conjunctive use with spillway.	Further evaluation indicated that the outlets could be enlarged more than originally estimated and that this would meet the project's objective release. This would greatly reduce the cost.
Modify use of surcharge storage	Raise impervious core in Mormon Island Dam, Dike 5, and Dike 7. Modify surcharge operation to provide additional flood space. Construct parapet wall at Newcastle Powerhouse. Raise penstock gate hoists, and relocate hydraulic pumps. Replace 3 emergency spillway tainter gates with 42' x 59' tainter gates. Top-seal tainter gates.	No change. No change. No change. No Change. The tainter gates would include a strong enough foundation so that the gates could be expanded. Top seal would not be used.	Further evaluation indicated that top-seal tainter gates are not technically possible on the existing spillway tainter gates. The foundation support for the gates would be strong enough to allow the gates to be expanded if a future action such as the Folsom Enlargement Plan is implemented.
Revise Reoperation	Reduce the variable space allocated to flood control from 400,000-670,000 acre-feet to 400,000-600,000 acre-feet.	Currently no known changes from authorized plan. To be analyzed in a separate document.	N/A
Update Flood Management Plan	Plan revisions to reflect the operational capabilities created by outlets and surcharge modifications and improved weather forecasts.	New dam operation has not been developed. Update to be formulated and analyzed upon approval of this LRR.	N/A

eight existing river outlets would be enlarged. The enlarged outlet gates would be about 8.5 feet wide by 15 feet high. The enlarged outlets would be designed to allow for concurrent releases with flow over the spillway.

Further examination of this plan revealed significant problems with the gate chambers required for the new gates. There was not enough room to construct the

chambers without impacting some of the other facilities inside the dam. A significant amount of mechanical and electrical equipment would have to be relocated.

Further studies indicated that the eight existing river outlets could be enlarged sufficiently to provide the desired releases of 115,000 cfs at a water-surface elevation of 418 feet. Table 3 summarizes the range of total flows for all eight outlets determined at pool elevation 418 feet for various height and width outlet combinations. More detailed information concerning the refinements of the outlet works modifications can be found in the Engineering Appendix (Appendix 1B).

TABLE 3. DISCHARGE CAPACITY IN CFS OF VARIOUS OUTLET SIZES AT ELEVATION 418 FEET

Height (ft)	Width (ft)				
	8.5	**9**	**9.3**	**9.5**	**10**
14	92,740	98,290	-	103,830	109,370
15	99,830	105,790	-	111,760	117,730
16	106,660	113,040	-	119,410	125,790
16.4	-	-	116,000	-	-
17	113,510	120,300	-	127,080	133,870

Further studies addressed maintaining outlet release capacity during construction. Numerous methods of mitigating loss of release capability during construction were examined. It was determined that the reduced outlet capacity could be mitigated by sequential construction of the outlets. One upper tier outlet would be enlarged first. Most of the work would be accomplished during the non-flood season. If construction is such that the outlet is not operational during a flood season, then operation of the remaining seven outlets would be modified to make up for the one lost upper tier outlet. Currently, once the flows are being released from the spillway and outlets concurrently, the river outlet openings are reduced to 60 percent to reduce the potential for cavitation. The Corps and the USBR have agreed that the river outlets would be held at variable operation with concurrent spillway flows. The proposed variable operation allows reduction of the river outlet openings from 100 percent to 85 percent as the concurrent spillway releases increase to 115,000 cfs. This would make up for the loss of one upper tier outlet and reduce the risk of cavitation. If there is damage due to cavitation, it would be repaired as part of the project prior to the next flood season. Once the first upper tier outlet is enlarged, two can be enlarged concurrently. The new enlarged outlet capacity would be 13,000 cfs. Its capacity of 13,000 cfs plus about 17,000 cfs for the five remaining 5-foot-wide by 9-foot-long outlets (with two outlets being enlarged) and would be greater than the outlet capacity under existing conditions. Therefore there would not be a reduction in the level of flood protection for Sacramento.

As a result of being able to prevent operational effects during construction, the need for any new outlets was eliminated. Based on these analyses, enlarging the existing river outlets to 9 feet 4 inches wide by 16 feet 3 inches high would provide approximately

115,000 cfs (approximately 13,000 cfs for each of the upper tier outlets and 16,000 cfs for the lower tier outlets) at a reservoir water-surface elevation of 418 feet.

Surcharge Storage

Under a controlled release operation, the five existing main spillway tainter gates would be open while flood releases are made. The flood pool could surcharge to elevation 474 feet. There was a concern that if an existing main spillway tainter gate failed in the closed position, releases would be limited to elevation 465 feet. To address this issue, the use of top-seal, a feature that is added to the gates to allow water surface elevations to exceed the existing top of gate, was examined. However, it was determined that the existing gates are not structurally capable of handling the additional head with the top seal. Replacement of all five of the existing main spillway tainter gates was also explored, but this would result in significant costs and required road closures. Therefore, under the revised emergency release diagram, if one of the existing main spillway tainter gates does not open, the surcharge elevation would be limited to elevation 465 feet. This condition is similar to the existing conditions.

In addition, the foundation of the gates would be strong enough to allow the gates to be expanded if a decision was made to enlarge Folsom under the Long-Term Project.

CURRENT PROJECT

The Folsom Dam Modification Project consists of two fundamental components: (1) outlet works modifications and (2) surcharge storage (see Figure 1).

Outlet works modifications

This component primarily includes increasing the release capacity at Folsom so that 115,000 cfs could be released at a reservoir water-surface elevation of 418 feet. The fundamental features, accomplishments and residual risk, and operation and maintenance are described below.

Features

A detailed discussion of the refined features and their functions is included in the Engineering Appendix (Appendix 1B). The features are briefly described below.

<u>Enlarge Eight Existing Outlets.</u> The eight existing river outlets would each be enlarged from 5 feet wide by 9 feet high to 9 feet 4 inches wide by 16 feet 3 inches high. No new outlets would be constructed. Plates 4 and 8 through10 show the downstream elevation, spillway section, and the gate chamber section of the dam with the enlarged outlets.

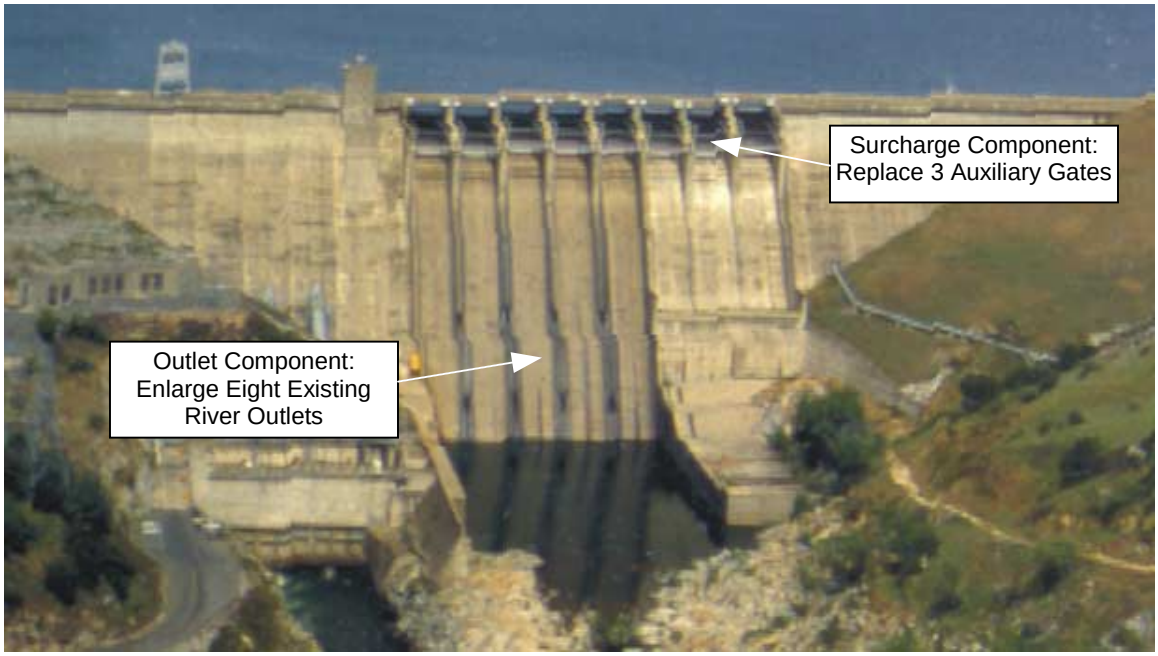

FIGURE 1. MAJOR MODIFICATIONS TO FOLSOM DAM IN THE OUTLET AND SURCHARGE COMPONENTS.

Modify to Allow 100 Percent Conjunctive Use with Spillway. Existing normal river regulation at Folsom Dam is maintained by two tiers of four outlets each, controlled by 5-foot-wide by 9-foot-high slide gates. The outlets consist of rectangular conduits through the dam, which exit on the spillway face and discharge into the spillway stilling pool. Spillway releases are made through five 42-foot-wide by 50-foot-high radial gates located near the crest of the dam. Three additional 42-foot-wide by 53-foot-high radial gates for extremely large flood releases are located to the left of the main spillway and release flow to a flip bucket on the emergency spillway on the downstream face of the dam.

The spillway face and downstream end of the outlets at Folsom Dam incurred considerable damage as a result of cavitation caused by simultaneous flood releases in major storms in the past through the outlets and over the spillway. To prevent damage, sufficient air intakes, entrance curves and bulkheads, and eyebrow deflectors would be included in the enlarged outlets to provide sufficient aeration to prevent cavitation problems. A physical model of the enlarged outlets is being conducted to determine if the aeration provisions are sufficient to allow full outlet operation simultaneous with spillway flows. If not, additional modifications will be investigated with the objective of achieving simultaneous operation.

Accomplishments and Residual Risk

The outlet works modification component would allow flood inflows to be passed through the reservoir more efficiently decreasing the reservoir level for4 a given inflow. As a result, the space allocated for flood storage is maintained until inflow to the reservoir exceeds the capacity of the flood control system below Folsom Dam. This improvement in operating efficiency would increase flood protection by reducing the probability of

flooding in Sacramento in any one year from 1 chance in 100 (upon completion of the Common Features Project) to 1 chance in 130. The component would provide nearly a 98 percent chance of protecting Sacramento during a 1 in 50 chance flood in any one year, a 77 percent chance during a 1 in 100 chance flood in any one year, a 34 percent chance during a 1 in 200 chance flood in any one year, and an 8 percent chance during a 1 in 400 chance flood in any one year. Plate 5 and Table 4 show the percent chance that the without-project conditions and the with-project conditions would contain different frequency floods.

TABLE 4. COMPARISON OF PERCENT CHANCE OF FLOODING DURING DIFFERENT FREQUENCY FLOODS

Feature	Annual Performance (Chance of Design Being Exceeded in any year)	Conditional Annual Percent Chance of Not Flooding / Flooding For Indicated Events			
		0.02 50-yr	0.01 100-yr	0.005 200-yr	0.0025 400-yr
Without Project (Common Features Completed)	1 in 100	93 / 7	59 / 41	17 / 83	2 / 98
Outlet Works Modifications	1 in 130	98 / 2	77 / 23	34 / 66	8 / 92
Outlet Works Modifications and Surcharge Component	1 in 140	98 / 2	79 / 21	38 / 62	9 / 91

As mentioned in Chapter II, Folsom Dam's existing spillway capacity is inadequate to protect the dam from an extreme flood event. Corps studies show that the dam is capable of passing a flood about 70 percent of the PMF. Upon completion of the outlet works modifications, the dam would be capable of passing 75 percent of the PMF.

Surcharge

Surcharge storage is the space above the normal gross pool of a reservoir that is designed to ensure that the dam can safely pass floodwaters without overtopping. Currently at Folsom Dam, the emergency spillway release diagram dictates how the surcharge space is operated to prevent the dam from being overtopped. Under existing conditions, the existing emergency release diagram and the physical features of the dam allow for surcharge storage to elevation 470 feet without overtopping the existing emergency spillway tainter gates while they are in closed position. Under existing conditions, when the reservoir elevation exceeds 470 feet, the emergency spillway tainter gates must be open, and the dam must release more than the objective releases, which raises the potential for levee failure downstream, to permit full use of surcharge space to elevation 475.4 feet. Plate 3 illustrates the existing emergency release diagram.

The proposed project would modify the emergency release diagram and some physical features of the dam to allow dam operators to maintain objective releases, or releases that would not exceed the downstream levee system's capacity, while surcharging to elevation 474 feet. Once the reservoir elevation reaches above 474 feet, the new emergency spillway tainter gates would need to be open, and the dam must release more than the objective releases, which raises the potential for levee failure downstream, to allow the remaining surcharge space from 474 to 475.4 to be used for dam safety. The difference between the existing conditions and the with-project conditions is that under the with-project conditions, the releases made from Folsom would be within the downstream levee system's capacity when the reservoir level is between 470 and 474.

The implementation of the surcharge component features would allow releases to be maintained below the probable non-failure point (PNP) of downstream levees for a longer period. The PNP is the highest water-surface elevation at which levee failure is highly unlikely. The maximum duration of a maximum release of 160,000 cfs would be 48 hours (maximum downstream levee system's capacity upon completion of the Common Features Project). The emergency release diagram would be modified to open the emergency spillway tainter gates if elevation 474 feet is exceeded. A water-surface elevation of 474 feet is the upper limit before major modifications to the dam are needed. Use of this surcharge operation allows an additional 48,000 acre-feet of space to be credited for flood control.

The support structure for the gates would be designed to allow for expansion of the gates to accommodate (at a minimum) a raise with a maximum pool elevation of 487 feet. In addition, the impervious core in Mormon Island Dam and dikes 5 and 7 may need to be raised to the crown crest, and Pacific Gas and Electric Company's Newcastle Powerhouse may need to be floodproofed. A preliminary duration-frequency analysis shows that the dikes and powerhouse are currently inundated at elevations from 470 to 475.4 feet under both the existing and the with-project conditions. The proposed improvements could decrease the frequency of flooding in that elevation range. Therefore, modifications to the dikes and Newcastle Powerhouse may not be needed. Additional analysis would be completed during the design phase to determine the necessity of modifying the dikes and powerhouse. The final design of the surcharge component would be compatible with a raise or dam safety project that may be constructed in the future. The major features and accomplishments, and residual risk are described below. Additional analysis would be completed during the design phase, and the features listed below would be refined.

Features

<u>Replace Three Emergency Spillway tainter gates</u>. Modifications are required to the three emergency spillway tainter gates and bays to allow the emergency spillway release diagram to be modified. The emergency spillway tainter gates would be replaced with 42-foot-wide by 59-foot-high tainter gates (top-of-new-gate elevation at 476 feet). This would allow 2 feet of freeboard on the emergency spillway tainter gates (in a closed position) while the reservoir is operated to maintain the objective release to reservoir elevation 474 feet. The support foundation for these gates would be designed to accommodate

modification and expansion of the gates. Plate 10 shows the existing and new emergency spillway tainter gates.

Stoplogs provided for emergency repairs would be placed sequentially in each of the emergency spillway tainter gate bays to permit gate removal and replacement without the reservoir having to be held lower than normal during each summer construction season.

Revise the Emergency Spillway Release Diagram to Modify Surcharge Operation. Currently, an emergency spillway release diagram dictates how the space is operated to balance dam safety while maximizing flood protection. Once the water surface reaches the existing surcharge space, the dam is operated with the objective of preventing the dam from being overtopped. Once the surcharge storage component is implemented, a new emergency release diagram would be implemented. To accomplish this, the emergency spillway release diagram would be revised to maintain a maximum release of 160,000 cfs (the amount the downstream levees can handle) up to reservoir elevation 474 feet. Plate 11 is a preliminary revised emergency release diagram.

Raise Impervious Core in Mormon Island Dam, Dike 5, and Dike 7. The existing impervious core in Mormon Island Dam and dikes 5 and 7 is at elevation 466 feet. For this surcharge component, the impervious core in these dikes and dam may be raised to the crown crest (see Figure 2). This would most likely be done by installing a slurry wall from the top of the crest (elevation 480.5 feet) down to elevation 466 feet. The work would be done during the non-flood season after the reservoir has been drawn down below elevation 461 feet. Therefore, there would be no adverse operational effects due to construction.

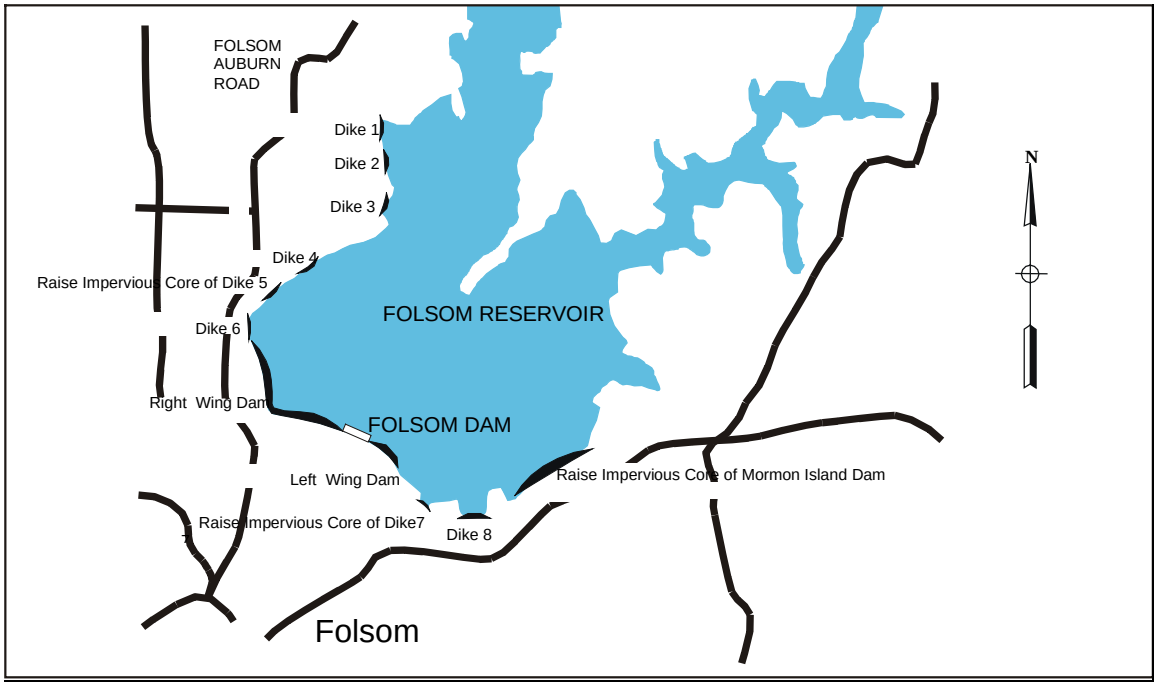

FIGURE 2. PLAN VIEW OF FOLSOM DAM AND RESERVOIR SHOWING LOCATION OF DIKE RAISING IN THE SURCHARGE COMPONENT.

Floodproof Newcastle Powerhouse. At elevation 474 feet, Newcastle Powerhouse (located on the northwest shoreline of the reservoir) would be inundated. To keep the power plant in service under this operation, modifications may be required. If required a parapet wall would be constructed around the powerhouse, and the access road would be raised.

Relocate Hydraulic Power Units for the Penstock Gate Hoists. Currently, the penstock gate hoists are located on the upstream face of the dam and are flooded once the reservoir levels exceed elevation 467 feet. The hydraulic power units for each gate would be relocated.

Accomplishments and Residual Risk

With construction of the surcharge component, the emergency spillway gates would be made taller. This would allow the water-surface elevation of Folsom Reservoir to "surcharge" to a lake level of 474 feet, or 4 feet higher than is currently allowed under controlled conditions. This additional 4 feet of storage adds approximately 45,000 acre-feet of flood control storage, and allows for controlled emergency releases of up to 160,000 cfs for a longer period of time. This component of the project would further increase flood protection to Sacramento by reducing the probability of flooding in any one year from 1 in 130 (upon completion of the outlet works modification increment) to 1 in 140 chance in any one year (combined outlet works modifications and surcharge component). It would provide nearly a 98 percent chance of protecting Sacramento during a 1 in 50 chance storm in any one year, a 79 percent chance during a 1 in 100 chance storm in any one year, a 38 percent chance during a 1 in 200 chance storm in any one year, and a 9 percent chance during a 1 in 400 chance storm in any one year. Plate 5 and table 4 show the percent chance that this project would contain different frequency floods.

Operation and Maintenance

When a project is completed, ownership is normally transferred to the non-Federal sponsor who is then responsible for the operation, maintenance, repair, replacement, and rehabilitation of the project. However, the Folsom Dam Modification Project would improve facilities owned by the Federal Government. Ownership would not be transferred because of the modifications, but SAFCA would be responsible for any increase in operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) costs of the modified structures due to the Folsom Dam Modification Project.

The operation of the Folsom Dam would be similar to the without-project condition. Once the construction of the features of the Folsom Dam Modification Project is complete, the Corps would revise the water control manual for Folsom Dam to reflect the new flood control diagram. The USBR, in coordination with the State Flood Operations Center, would continue to operate Folsom Dam in accordance with the revised water control manual.

Operation, maintenance, repair, replacement, and rehabilitation costs of improvement features such as the enlarged river outlets and surcharge component would normally be the responsibility of the non-Federal sponsor. However, since Folsom Dam is owned by the Federal Government, the OMRR&R would continue to be performed by the USBR, but a cost-sharing agreement would be negotiated between SAFCA and USBR to pay the portion of the OMRR&R costs related to the new flood control features. At Folsom Dam, the USBR would inspect completed works.

ENVIRONMENTAL COMPLIANCE

Public Review

The final EA/IS on the project has been prepared as a supplement to the 1996 Environmental Impact Statement/Environmental Impact Report (see Appendix 1A). The draft EA/IS was circulated for public review to resource agencies including the U.S. Fish and Wildlife Service (FWS), National Marine Fishery Service (NMFS), U.S. Environmental Protection Agency, California Department of Fish and Game, California State Historic Preservation Officer, California Department of Water Resources (DWR), and Regional Water Quality Control Board, as well as other concerned organizations and individuals. Following the 30-day public review of the EA/IS, the Corps reviewed the comments received and incorporated them into the final EA/IS, as appropriate. Preparation of the final EA/IS was a joint effort with the FWS, NMFS, SAFCA, and DWR.

Effects and Mitigation

More detailed information on the environmental effects and mitigation can be found in Appendix 1A. The following is a brief summary of the environmental resources evaluated, effects found, and mitigation, if appropriate.

Outlet works modification

Effects on several environmental resources were examined and found to be minor; therefore, they were eliminated from detailed analyses. These resources included:

Agriculture and Prime and Unique Farmlands. There are no agricultural operations or prime and unique farmlands in the project area; therefore, no effects would occur.

Noise. Most of the noise-producing construction (concrete demolition) would take place within the dam structure and in the river canyon. This would not add significantly to noise levels outside the project due to the noise muffling effects provided by the canyon.

Aesthetics. The project would not significantly change the visual appearance of the existing dam so there would be no esthetic effects.

Hazardous, Toxic, and Radiological Waste. There are no known hazardous, toxic, or radiological wastes in the project site. The existing 55-kilowatt emergency generators

located at the northeast corner of the pumping plant would be replaced with a new 500- to 725-kilowatt diesel generator. Any stained soil observed near the existing generator would be removed and disposed of at a permitted site. While minor amounts of hazardous waste would be produced during construction (used oil, paint residue, and similar materials), these would be managed in conformance with existing laws and regulations.

The following environmental resources were examined in more detail.

Fisheries. Construction activities to enlarge the existing river outlets would result in a temporary increase in the level of activity along the upstream face of Folsom Dam when the temporary bulkhead and permanent bulkhead guides are installed. These activities may displace fish that are commonly present in the general construction area. These effects would be short term and would not be significant.

Operation with the enlarged outlets would result in changes in the level of storage in Folsom Reservoir during storm events. In general, water levels in Folsom Reservoir would increase at a slower rate during storm events, peak at a lower level, and return to pre-storm levels more quickly than under the without-project condition because more water could be released through the enlarged river outlets. The ability to release water more efficiently with the enlarged outlets is not expected to affect the stratification of Folsom Reservoir or the volume of the coldwater pool. The rules governing reservoir level during the flood season (November through March) are not changed as a result of the project. However, the increased outlet capacity provided by the project would allow dam operators to more closely match reservoir releases to reservoir inflow, thereby reducing the fluctuation in reservoir levels that occurs during a flood event. In addition, changes relative to the rate of releases would only occur during significant flood events. Under the with-project condition, releases of more than 30,000 cfs would occur earlier than under the without-project condition. This is expected to occur only in the flood season during periods of substantial inflow, and not during the period when stratification occurs (typically April through November). Accordingly, no effects to the coldwater pool of Folsom Reservoir are expected.

Enlarging the eight existing outlets would allow Folsom Dam to operate more effectively and efficiently in compliance with the existing Folsom Dam Operation Diagram. Under the without-project condition, Folsom Dam is limited to 34,000 cfs until the reservoir level is above the spillway crest (elevation 418 feet). The primary change that the outlet component would make is to allow Folsom Dam to release up to 115,000 cfs when the reservoir levels are at or below the spillway crest. There was some concern that changes in the operational capability of Folsom Dam could result in more frequent releases above 34,900 cfs, which in turn would affect gravel transport in the Lower American River below Folsom Reservoir. To mitigate for potential effects to gravel transport, an operational rule restriction would be implemented to ensure that that releases from the modified dam occur only during the large floods when releases would have reached higher levels under the without-project condition. The operational rule would restrict the increase in outflows from Folsom Dam so that outflows from Folsom Dam above 25,000 cfs will be limited to 60% of the actual or forecast inflow. Once the actual or forecast inflow exceeds

150,000 cfs maximum flood releases will be made. Operations outside the range of these flows will be the same as without project condition. Therefore there would be no change in the gravel transport at the critical flow exceedance frequency of 1 in 2.5 chance in any one year to 1 in 10 chance in any one year.

Vegetation and Wildlife. Since the construction of the outlet works modification is generally confined to the interior of Folsom Dam, no effects to vegetation or wildlife are anticipated. During construction, existing access roads would be used, and no removal of vegetation would be necessary.

Vegetation along the lower American River consists primarily of riparian and grassland communities. These communities are adapted to periodic inundation that typically occurs during winter storms, and riparian communities are highly tolerant of the existing flow patterns along the lower American River. Flow changes that may occur with the enlarged outlets are within the normal range of flows experienced by these communities. Therefore, no adverse effects to vegetation and wildlife along the Lower American River are anticipated.

Cultural Resources. The Sacramento District has completed an analysis, which determined that Folsom Dam and Reservoir are not eligible for the National Register of Historic Places. This analysis was coordinated with the SHPO. The outlet component would not affect cultural resources sites along the Lower American River because flood releases are expected to remain within the range of flows that occur under current flood operations.

Traffic. During construction of the outlet component, Folsom Dam Roadway would need to be closed periodically to access the top of the dam. To avoid traffic effects, closure would be primarily limited to weekends and nights outside of primary recreation times. A traffic analysis was conducted which determined that there would be no significant effects as a result of this closure sequence. For further traffic closure clarification see our Environmental Assessment/Initial Study (Appendix 1A). While significant effects of closing Folsom Dam Road were not identified, the Corps and non-Federal sponsors have committed to participate in improving the USBR's communication program designed to inform motorists about road closures. In addition, a temporary traffic signal and other lane markings would be implemented to increase safety in the construction area.

Water Quality. Construction activities would generally be confined to the interior of the dam and would not affect water quality. Construction methods currently proposed include using a conveyor to remove concrete rubble from the interior of the dam. The proximity of construction activities downstream of the dam to the American River poses a potential source for dust and sediment to increase turbidity and suspended solids levels in the river. In addition, the operation, refueling, and maintenance of onsite machinery such as diesel compressors, haul trucks, and other equipment would be required, and these activities have the potential to release hazardous substances into the environment. For all construction activities, normal construction safety practices would be implemented to

ensure that the risk of hazardous materials spills is minimized, which would in turn would minimize the potential for water quality effects. To mitigate for potential effects to water quality, best management practices to control construction-related contamination and to reduce construction effects to less than significant would be implemented.

Sediment that has accumulated along the upstream face of the dam needs to be removed prior to enlargement of the outlets. The Corps estimates that a total of 30,000 cubic yards will need to be removed in the course of construction. The majority of the surface sediments sampled are in the silt and clay size fractions, which would be prone to re-suspension during construction. Sediments sampling revealed potential toxicity due to high nickel, chromium, and copper concentrations. The use of best management practices such as use of environmentally friendly clamshell dredge technology around the construction area during sediment removal would minimize the potential for re-suspended sediments to be transported to areas outside of the localized construction area or to be discharged into the river downstream of Folsom Dam. The Corps, the State, and SAFCA will consult with Reclamation, the San Juan Water District, and the cities of Folsom and Roseville to ensure that dredging activities on the upstream face of Folsom Dam occur during periods of low outflow (both through the river outlet and through the penstocks), and that penstock shutters are configured in a manner that minimized the entrainment of suspended sediment.

Implementation of the operational rule described under the "Fishery" section above, would ensure that releases from the outlet works modifications would only occur during large floods and therefore there would be no erosion related water quality effects along the Lower American River.

Air Quality. Significant air quality impacts have not been identified. However, since the project area is classified as non-attainment, best management practices would be used to control fugitive dust to help protect ambient air quality conditions. The best management practices would include monitoring dust conditions along access roads and within the construction area to ensure that the generation of fugitive dust is minimized.

Recreation. Outlet works modification would generally be confined to the interior of Folsom Dam. Construction of the outlet works modifications would be completed without lowering the reservoir. Therefore, there would be no construction effects to recreational opportunities at Folsom Reservoir.

With outlet works modifications in place, the risk of flooding of recreation facilities near Folsom Lake would be reduced. The flood risk for recreation development at 470 feet elevation, for example, would fall from about a 1 in 85 chance to a 1 in 130 chance. Thus, outlet works modifications would have a somewhat beneficial effect on recreational facilities.

Operation. During the first construction season, only one outlet would be enlarged. The dam would be operated so that the existing release capability of the dam is not reduced during construction. Once the first enlarged outlet capacity is in place, work could begin

on enlarging some of the other existing outlets without decreasing release capability during construction. As a result, there would be no operational effects during construction.

The operational rule restriction would be implemented to ensure that that releases from the modified dam occur only during the large floods when releases would have reached higher levels than under the without-project condition. The operational rule would restrict the increase in outflows from Folsom Dam so that outflows from Folsom Dam above 25,000 cfs will be limited to 60 percent of the actual or forecast inflow. Once the actual or forecast inflow exceeds 150,000 cfs maximum flood releases will be made. Operations outside the range of these flows will be the same as without project condition. More detailed information concerning the operational rule is in the Engineering Appendix.

Surcharge Storage

Effects on several environmental resources were examined and found to be minor; therefore, they were eliminated from detailed analyses. These resources include agriculture and prime and unique farmlands, noise, esthetics, cultural resources and hazardous, toxic, and radiological waste. The reasons why these resources were eliminated are summarized under *Outlet works modification* in ENVIRONMENTAL COMPLIANCE.

The following environmental resources were evaluated in more detail:

Fisheries. Construction activities would generally be occur on the emergency gates of the Folsom Dam and upstream at various dikes around Folsom Reservoir. These activities may temporarily displace fish that are commonly present in the general construction area. These effects would be short term and would not be significant.

Vegetation and Wildlife. As with the outlet works modifications, construction would primarily be confined to the face of the existing structure of Folsom Dam and upstream along dikes that are un-vegetated therefore, no effects to vegetation or wildlife are anticipated. During construction, existing access roads would be used, and no removal of vegetation would be necessary.

As mentioned in Chapter II, in accordance with the Emergency Diagram, Folsom Dam Reservoir could surcharge to 475.4 feet. The difference in the proposed project and the without-project conditions is the frequency of flooding and the duration at the elevation range from 470 to 475.4 feet. The proposed project could decrease the frequency of flooding at this elevation range. The proposed project would reduce the duration of flooding at the elevation range of 470 to 474 feet, and increase the duration of flooding for about 1 day at the elevation range from 474 to 475.4 feet. The tolerance limits of vegetation along the Folsom Reservoir are well above the expected duration of the proposed operational changes.

Effects on wildlife are expected to be minimal because most active animals would be able to move to adjacent upland areas during periods of elevated water levels.

Traffic. During construction of the surcharge component, Folsom Dam Roadway would need to be closed periodically to access the top of the dam. Since most of the traffic occurs during peak commute hours during the week days, road closures would be limited to weekends and non-commute hours (9:00 a.m. to 3:00 p.m.). The measures to reduce impacts to traffic described under the section on outlet modifications would continue through the construction of the surcharge features.

Water Quality. Construction would generally be confined to the surface of Folsom Dam and dikes on the periphery of Folsom Reservoir. As with the outlet component, the proximity of construction activities downstream of the dam to the American River poses a potential source for dust and sediment to increase turbidity and total dissolved solid levels in the river. In addition, the operation, refueling, and maintenance of onsite machinery such as diesel compressors, haul trucks, and other equipment would be required, and these activities have the potential to release hazardous substances into the environment. For all construction activities, normal construction safety practices would be implemented to ensure that the risk of hazardous materials spills is minimized, which would in turn would minimize the potential for water quality effects. To mitigate for potential effects to water quality, best management practices to control construction-related contamination and to reduce construction effects to less than significant would be implemented.

Recreation. Construction activities would primarily be limited to the interior of the dam and upstream at Folsom Reservoir. Construction activities of the surcharge component would not affect the significant recreation area (Granite Bay, Beal's Point, and Browns Ravine) during the recreation season (Memorial Day to Labor Day). Some small staging areas may be needed for potential slurry wall construction on dikes 5 and 7 and Mormon Island. This work would be done during the main construction season, but the staging would be confined to a small area.

During winter floods with a probability of 1 in 85 to 1 in 150 chance of flooding in any one year, operation of the surcharge component would result in Folsom Reservoir water-surface elevations of approximately 457 to 470 feet. These elevations are lower than the water-surface elevations under those same frequencies under the without-project conditions. Therefore, no effect to recreation is anticipated for the marina and boat ramps. During these flood events, the expected reservoir is higher than the functional elevation range for the swimming beaches at Granite Bay and Beal's Point. However, the use period of the beaches is not during the winter; therefore, no effect is expected.

During 1 in 150 to 1 in 165 chance of flooding in any one year, reservoir surface elevations would be 0.2 and 0.4 foot higher than under those same frequencies under without-project conditions. These high water-surface elevations would also occur for longer durations. These levels are also within the functional elevation range for the marina and boat ramps; therefore, no effect on those facilities would occur. These ranges are higher that the functional elevation ranges for swimming, but since these elevations occur during the winter, no effect on swimming is expected.

Air Quality. As with the outlet works modifications, significant air quality impacts have not been identified. However, since the project area is classified as non-attainment, best management practices would be used to control fugitive dust to help protect ambient air quality conditions. The best management practices would include monitoring dust conditions along access roads and within the construction area to ensure that the generation of fugitive dust is minimized.

REAL ESTATE

Since the modifications to Folsom Dam are occurring at the interior of the Dam and upstream at Folsom Reservoir, no new lands are required. The only lands, easements, rights-of-way, relocations, and disposal areas (LERRD's) required consist of providing a disposal site for the excess sediment dredged from the dam during the construction of the outlet works modification component. More information concerning real estate requirements is contained in the Real Estate Plan (see Appendix 1D).

COSTS AND BENEFITS

The total project including both components has a first cost of $147.4 million, with an annual cost of $12.0 million and annual benefits of $29.6 million. The overall benefit-to-cost ratio is 2.5 to 1. A breakdown of the cost and benefits for each component is described below and shown in Tables 5 and 6. Additional information on benefit analysis is included in Appendix 1C.

Outlet Works Modifications

The estimated total first cost would be $108.8 million for outlet works modification. The resulting average annual cost would be $9.2 million. The total average annual benefits for flood control are $24.7 million (including future growth in the flood plain over the project life). Estimated average net annual benefits for flood control are $15.5 million, and the benefit-to-cost ratio is 2.7 to 1. Since the benefits are greater than the costs, the project is economically feasible. The outlet works modification component reduces the average annual damages to $85.1 million.

Surcharge Storage

The estimated total first cost would be $38.6 million for the surcharge storage component. The resulting average annual cost would be $2.8 million. The total average annual benefits for flood control are $4.9 million (including future growth in the flood plain over the project life). The estimated net annual benefits for flood control are $2.1 million, and the benefit-to-cost ratio is 1.8 to 1. Since the benefits are greater than the costs, the component is economically feasible. The surcharge modification component reduces the average annual damages to $80.2 million.

TABLE 5. COMPONENT AND TOTAL COSTS FOR THE PROJECT[1]

MCACES Account	Item	Outlet Works Modifications ($ Million)		Modified Use of Surcharge Space ($ million)		Total	
		Fed	**Non-Fed**	**Fed**	**Non-Fed**	**Fed**	**Non-Fed**
	First Cost						
01	Lands and Damages	0	0	0	0	0	0
02	Relocations	0	0	0	0	0	0
04	Construction	86.6	0	30.7	0	117.3	0
06	Environmental Mitigation	0	0	0	0	0	0
30&31	Engineering, Design, Supervision, and Inspection	22.2	0	7.9	0	30.1	0
	Subtotal	**$108.8**	**0**	**$38.6**	**0**	**$147.4**	**0**
	5 percent cash	(5.4)	5.4	(1.9)	1.9	(7.3)	7.3
	Subtotal	**$103.4**	**$5.4**	**$36.7**	**$1.9**	**$140.1**	**$7.3**
	Adjustment to 65% Federal – 35% Non-Federal						
	Cash Adjustment	(32.7)	32.7	(11.6)	11.6	(44.3)	44.3
	Subtotal	**$70.7**	**$38.1**	**$25.1**	**$13.5**	**$95.8**	**$51.6**
	Percentage	**65.0**	**35.0**	**65.0**	**35.0**	**65.0**	**35.0**

[1]October 2000 price levels, 50-year economic life, and 6-3/8 percent interest rate.
[2]There is a small cost for air quality credits for environmental mitigation, however the cost is small enough that it is rounded to 0. The cost is estimated to be under $50,000 for each component.

TABLE 6. ECONOMIC SUMMARY[1]

Item	Outlet Works Modifications ($ Million)	Modified Use of Surcharge Space ($ Million)	Total ($ Million)
Investment Cost			
Total First Cost	108.8	38.6	147.4
Interest During Construction	29.6	3.3	32.9
Total Investment Cost	**$138.4**	**$41.9**	**$180.3**
Annual Cost			
Interest	8.8	2.7	11.5
Amortization	0.4	0.1	0.5
O&M Cost[2]	0	0	0
Total Annual Cost	**$9.2**	**$2.8**	**$12.0**
Annual Flood Control Benefits	**$24.7**	**$4.9**	**$29.6**
Net Annual Flood Control Benefits	**$15.5**	**$2.1**	**$17.6**
Benefit-to-Cost Ratio	**2.7**	**1.8**	**2.5**

[1]October 2000 price levels, 50-year economic life, and 6-3/8 percent interest rate.
[2]This estimate was based on computed rather than actual OMRR&R costs. OMRR&R costs were estimated by applying OMRR&R cost factors to the capital costs of the gates. It assumes that the existing equipment will have higher average OMRR&R cost factors than the new equipment. It also assumes that with the remaining project life, there will be no replacement costs. Because the OMRR&R cost of using the older existing components (lower capital cost but higher OMRR&R factors) are estimated to approximate the cost of the new equipment (higher capital cost but lower OMRR&R factors), the cost difference between the current OMRR&R and future OMRR&R funding is estimated to be $0. At some point in the future negotiations between the local sponsor and the Bureau of Reclamation will be held. The actual cost of OMRR&R will be calculated for the difference between the old features (by audit) and the new features (by estimate) and an agreement between the parties for the OMRR&R costs will be made.

CHAPTER IV - PROJECT EVALUATION

The January 18, 2000, memo from Corps Headquarters directed that this LRR demonstrate that the authorized project is economically justified, technically sound, and environmentally acceptable. The four basic criteria are (1) completeness, (2) effectiveness, (3) efficiency, and (4) acceptability.

COMPLETENESS

Completeness is the extent to which a project provides and accounts for all necessary investments or other actions to ensure realization of the planned effects. A complete project (1) meets the objectives, (2) needs no further actions for complete fulfillment of the project, (3) is consistent and reliable, (4) is capable of being physically implemented, and (5) mitigates unavoidable adverse effects, as appropriate.

The project meets the objectives in contributing to reduction in flood damage reduction and meets the operational objective of releasing 115,000 cfs at a water-surface elevation of 418 feet. The outlet works modification and surcharge components both can function independently and therefore need no further actions for complete fulfillment. Upon construction of the enlarged outlet capacity, the release capacity will be consistently and reliably increased. Constructability analysis indicates that both components can be physically implemented. Environmental compliance documentation has been completed for the outlet works modification and surcharge components, and appropriate mitigation has been provided.

EFFECTIVENESS

Effectiveness is the extent to which a project resolves the identified problems and achieves the specified objective(s). The effectiveness of this project was defined by the reduction of the flood damages and by meeting the operational objective of releasing 115,000 cfs at a pressure head created by a water-surface elevation of 418 feet.

The project reduces flood damages from $110 million to $80 million (including expected future growth) and reduces risk from about 1 in 100 chance to a 1 in 140 chance of flooding in any one year. In addition, the project meets the operational objective of releasing 115,000 cfs at a water-surface elevation of 418 feet.

EFFICIENCY

Efficiency is a measure of the extent to which a project is the most cost-effective means of alleviating the identified problems while realizing the specified objectives consistent with protecting the Nation’s environment. One measure of efficient is monetary costs versus benefits. Efficiency is shown as net economic benefits and is the extent to which the economic benefits exceed costs.

The total first cost for the outlet component is $108.8 million. The annual cost is $9.2 million, and the annual net benefits are $15.5 million. The benefit-to-cost ratio is 2.7 to 1. The total first cost for the surcharge component is $38.6 million; the annual cost is $2.8 million; and the net benefits are $2.1 million. The benefit-to-cost ratio is 1.8 to 1. Since the benefits are significantly greater than the cost, the project is economically feasible and highly efficient.

ACCEPTABILITY

Acceptability is the workability and viability of a project to other Federal agencies, affected State and local agencies, and public entities, given existing laws, regulations, and public policies. Two primary dimensions to acceptability are implementability and satisfaction. Implementability means that the alternative is feasible from technical, environmental, economic, financial, political, legal, institutional, and social perspectives. Support by a local sponsor, other agencies, and the public is of prime importance in this category. The satisfaction was based on input from the staff of The Reclamation Board, SAFCA, and USBR, and a public assessment vote that residents recently passed. This assessment involved an increase in their SAFCA assessments to pay for flood control and restoration projects, including the Folsom Dam Modification Project.

There are no known environmental effects that are extensive, controversial, or unlawful. All effects are mitigated as much as is practicable. The action complies with Federal and State endangered species acts.

CHAPTER V - COORDINATION

VIEWS OF THE LOCAL SPONSORS

Preparation of this report was accomplished in close coordination with The Reclamation Board and SAFCA. At this time, the local sponsors are willing to enter into the Project Cooperation Agreement (PCA) and begin construction of the project.

COORDINATION WITH OTHER AGENCIES

Preparation of this report was also closely coordinated with the USBR, FWS, and NMFS. The USBR, which owns and operates Folsom Dam, and the State Division of Safety of Dams have reviewed and commented on this document. In addition, some of the design work was completed by the USBR because of their knowledge of Folsom Dam.

COORDINATION WITH THE USBR

A detailed description of the Corps' coordination with the USBR is documented in the Plan for Coordination Document sent to the Corps' South Pacific Division in July 2000.

To ensure proper coordination with the USBR and other agencies, the following have been established: product development team, overview management group, and the executive committee. The project development team consists of all team members producing the decision document, engineering design, and environmental assessment. Since this is a large project and there are many people on the product development team, a coordinator has been identified for each discipline. The discipline coordinators meet monthly. The discipline coordinators then coordinate with other members of the product development team within their discipline. The overview management group consists of executive level members from each agency executive level members from each agency and is used to resolve issues and make decisions that cannot be resolved at the discipline coordinator level. The Reclamation Board, SAFCA, USBR, and the Corps have members that participate in each of these teams. During the construction phase, the Corps will manage the construction and will establish a construction field office at Folsom Dam. This office will allow the Corps to work closely with the contractor and the USBR personnel operating the dam.

CHAPTER VI - PROJECT IMPLEMENTATION

This chapter summarizes the procedures and cost-sharing requirements for implementing the project.

COST SHARING

The non-Federal sponsors are responsible for the LERRD's required for the project. In addition, the sponsors must provide a cash contribution equal to 5 percent of the construction first costs. This is the first adjustment shown in Table 5. The 5 percent cash contribution is required irrespective of the total cost of the LERRD's provided by the sponsors. In accordance with cost-sharing requirements, the sponsors must provide a minimum of 35 percent of the total construction costs. The project costs would be apportioned 65 percent Federal and 35 percent non-Federal in accordance with cost-sharing requirements for flood control projects set forth in Section 202 of WRDA 96. Given the estimated construction cost of $147.4 million (October 2000 price levels), the Federal contribution would be $95.8 million, and the non-Federal contribution would be $51.6 million.

Costs presented so far are first costs at October 2000 price levels. This estimate has been adjusted to represent the fully funded amount. The fully funded estimate accounts for future inflation and is based on the current first cost and the schedule at which contracts will be awarded. The estimate better represents the actual costs that Congress will need to appropriate and the local sponsors will provide in the future to construct the project. The fully funded cost estimate for this project is $174.5 million: $113.4 million is the Federal contribution, and $61.1 million is the non-Federal contribution.

FINANCIAL ANALYSIS

The total estimated fully funded project cost is $174.5 million, and the non-Federal share is $61.1 million.

The Reclamation Board has received authorization for this project through the State legislative process. SAFCA has recently completed a public assessment vote. During this assessment, the residents of Sacramento who are currently in FEMA's probability of 1 in 100 chance in any one year flood plain voted on an increase in taxes to pay for several civil works projects including the Common Features Project and the Folsom Dam Modification Project. This assessment was approved, and SAFCA would obtain funding through this tax to fund their cost share of the Folsom outlet works modification component.

FEDERAL AND NON-FEDERAL RESPONSIBILITIES

Federal and non-Federal obligations and requirements would be further defined in the PCA signed prior to initiation of construction. The non-Federal funds would not have to be provided until after the PCA is signed.

Federal Responsibilities

The Corps will accomplish pre-construction engineering and design studies. Once the PCA is signed and a cash contribution, LERRD's, and assurances are provided by the non-Federal sponsors, the Federal Government will construct the project.

Non-Federal Responsibilities

The State of California Reclamation Board will be responsible to:

- Provide a minimum of 35 percent, but not to exceed 50 percent, of total project costs as further specified below: (1) provide, during construction, funds needed to cover the non-Federal share of design costs; (2) provide, during construction, a cash contribution equal to 5 percent of total project costs; (3) provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or ensure the performance of all relocations determined by the Government to be necessary for the construction, operation, and maintenance of the project; (4) provide or pay the Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the project; and (5) provide, during construction, any additional costs as necessary to make its total contribution equal to at least 35 percent of total project costs.

- Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR part 24 in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

- Provide 35 percent of that portion of total cultural resource preservation mitigation and data recovery costs attributable to structural flood control that are in excess of 1 percent of the total amount authorized to be appropriated for structural flood control.

- Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as would properly reflect total project costs.

- Publicize flood plain information in the area concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the flood plain and in

adopting such regulations as may be necessary to ensure compatibility between future development and protection levels provided by the project.

- Participate in and comply with applicable Federal flood plain management and flood insurance programs.

- Do not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

- Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the non-Federal sponsors shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government.

- Inform affected interests, at least annually, regarding the limitations of the protection afforded by the project.

- Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), which requires a Non-Federal interest to have prepared within one year after the date of signing the PCA, a floodplain management plan. The plan shall be designed to reduce the impacts of future flood events in the project area, including but not limited to, addressing those measures to be undertaken by Non-Federal interest to preserve the level of flood protection provided by this Project. As required by Section 402, as amended, the Non-Federal sponsor shall implement such plan not later than one year after completion of construction of the Project. The Non-Federal Sponsor shall provide an information copy of the plan to the Government upon its preparation.

SAFCA will be responsible to:

- Assume the responsibility for paying for the OMRR&R of flood control modifications made to Folsom Dam as a result of the completed project. USBR manages, operates and maintains Folsom Dam and will continue to so in the future. SAFCA will enter into an agreement with USBR to pay for any additional OMRR&R costs associated with the flood control modifications made to Folsom Dam as a result of this project. The agreement between USBR and SAFCA must be executed prior to execution of the project PCA.

- Assume complete financial responsibility for necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under

lands, easements, or rights-of-way that the Government determines the non-Federal sponsor must provide for the construction, operation, or maintenance of the project.

Both Non-Federal Sponsors will be responsible to:

- Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the WRDA 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof until the non-Federal sponsors have entered into a written agreement to furnish their required cooperation for the project or separable element.

- Hold and save the Government free from all damages arising for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the Government or the Government's contractors.

- Comply with all applicable Federal and State laws and regulations including Section 601 of the Civil Rights Act of 1964, Public Law 88-352, and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7 entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army," and Section 402 of the WRDA 1986, as amended (33 U.S.C. 701b-12), requiring non-Federal preparation and implementation of flood plain management plans.

PROJECT COOPERATION AGREEMENT

Prior to initiation of plans and specifications, the Federal Government and local sponsors will execute a PCA. This agreement will define responsibilities of the local sponsors for plans and specifications, project construction, and project operation and maintenance.

PROJECT SCHEDULE

The current schedule is an expedited schedule. The schedule envisions a strong project delivery team and a robust independent technical review throughout the design process to maintain high quality standards while meeting aggressive milestones. The overall schedule goal and team intent is to provide the project flood protection benefits to the community of Sacramento with an expedited approach.

Complete Public review of draft EA/IS	April 2001
Final Decision Document to SPD/HQUSACE	August 2001

HQ/ASA concurrence	September 2001
PCA executed (outlets and surcharge)	January 2002
Advertise first construction contract	February 2001
Advertise main outlets contract	July 2002[1]
Complete outlets construction	2009
Implement surcharge component	2007-2009

The schedule of related activities is:

• Update Flood Management Plan	2002
• Make decision on long-term flood control	2002
• Revise variable space reoperation	2008-2009
• Implement new Water Control Manual	2009

[1] Current gate size reevaluation may impact schedule date.

CHAPTER VI - CONCLUSIONS AND RECOMMENDATION

CONCLUSIONS

Listed below are the conclusions of the LRR:

- Increasing low-level outlet capacity would enable Folsom Dam to release the objective release of 115,000 cfs much earlier in a flood event. This would more efficiently use Folsom Dam's flood control space and reduce the risk of flooding in Sacramento to a 1 in 130 chance in any given year.

- Outlet works modifications are economically feasible. The first cost is $108.8 million. The average annual costs and flood control benefits amount to $9.2 million and $24.7 million, respectively.

- Modifying the use of surcharge storage space to delay opening the emergency spillway tainter gates until the reservoir water-surface elevation reached 474 feet elevation would increase the Folsom Dam storage space credited to flood control by 48,000 acre-feet. The surcharge storage raise would be accomplished by increasing the height of the emergency spillway tainter gates, retrofitting (without raising) the wing dams, dikes, and Mormon Island Dam, and other appurtenant facilities. Dam operations would be revised to maintain releases below the PNP of downstream levees for a longer period. Combining the outlet works modification and the increased surcharge would reduce the risk of flooding to a 1 in 140 chance in any given year.

- Surcharge storage is an economically justified increment. The first cost is estimated to be $38.6 million; the annual cost is $2.8 million; and the economic benefits are $4.9 million.

- Outlet works modifications combined with raising surcharge storage is economically justified. The first costs are $147.4 million, and the annual costs are $11.5 million. The project annual benefits are $29.6 million. The benefit-to-cost ratio is 2.5.

- Mitigation measures will be implemented to ensure that outlet works modifications and surcharge operations would have no significant adverse environmental effects. The project would have no effect on water supply, hydropower, or recreation. The project would not require any lands in addition to existing project lands.

- Outlets and surcharge work would be done in phases. Because the outlet works modification provides most of the flood control benefit, construction of this component would be initiated as a first phase. The design and construction of the outlet works modification component would take about 6 years. Surcharge work is also delayed because of the possibility that the American River Watershed Long-

Term Study could result in raising Folsom Dam for flood control, in which case the surcharge work would be incorporated into dam raise construction to avoid duplication of work. Thus, design and construction of surcharge facilities would take place after a decision is made on the Long-Term Study. Construction of these surcharge facilities would take approximately one year to complete.

- This purpose of this project is to reduce flood damages. This project does not address the existing dam-safety deficiency of inadequate spillway capacity. The existing capability of the spillway to pass the PMF is 70 percent and after completion of this project, the dam will be able to pass 75 percent of the PMF.

- Analyses conducted during preparation of this LRR indicate that the project is locally supported, environmentally and institutionally acceptable, technically complete, and economically feasible.

- The Reclamation Board and SAFCA, the local sponsors, have set a flood control goal to achieve a minimum of 1 in 200 chance of flooding in any given year for the Sacramento area. The project is strongly supported by the sponsors as a major step towards achieving their goal. Formulation of this project has been closely coordinated with the local sponsors and the USBR.

- Of the total first cost of $147.4 million, the Federal share is $95.8 million, and the local share is $51.6 million. The local sponsors, The Reclamation Board and SAFCA, are willing and financially capable of signing a PCA, contributing their share of the cost of the project, and meeting other sponsor requirements.

RECOMMENDATION

Based on the findings presented, I recommend that the current project described in this report be implemented as a Federal project, subject to cost sharing, financing, and other requirements of WRDA 1999, and that this report be approved as the basis for executing the PCA.

However, these understandings and recommendations reflect the information available at this time and current Department of the Army policies governing this project. They do not reflect program and budgeting priorities inherent in the national civil works construction program or the perspective of higher review levels within the Executive Branch. Consequently, these recommendations may be modified before they are incorporated into the PCA.

Michael J. Conrad
Colonel, Corps of Engineers
District Engineer

American River Watershed, California Folsom Dam Modification Project, Draft Economic Reevaluation Project

American River Watershed Project

Draft Economic Reevaluation Report

American River Watershed Project

Folsom Dam Modification and Folsom Dam Raise Projects

US Army Corps
of Engineers

Sacramento District
South Pacific Region

May 2007

Draft Economic Reevaluation Report
American River Watershed Project, California
Folsom Dam Modification and Folsom Dam Raise Projects

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1 Comparison of ERR 500-Year Without-Project Floodplain with Maximum Extent 2007 PAC Report Floodplain

CHAPTER 1.0
INTRODUCTION

1.1 PURPOSE AND SCOPE OF REPORT

This Economic Reevaluation Report (ERR) has been developed for two purposes: (1) to update the information that provides the basis for economic justification of the American River Watershed Project[1]; and (2) in accordance with project specific guidance to verify the determination of Federal interest in financial participation in the recommendations of the *Folsom Modification and Folsom Dam Raise Projects Post Authorization Change Report, March 2007*[2] *(2007 PAC Report).* It is intended to meet the requirements of a limited reevaluation undertaken specifically for economic reevaluation.

Information to support economic justification for additional investment in the Natomas Basin of the study area is being developed at part of the American River Common Features General Reevaluation Report (GRR) that is specific to the separately justified, authorized project features in the Natomas Basin (Natomas GRR).

1.2 BACKGROUND

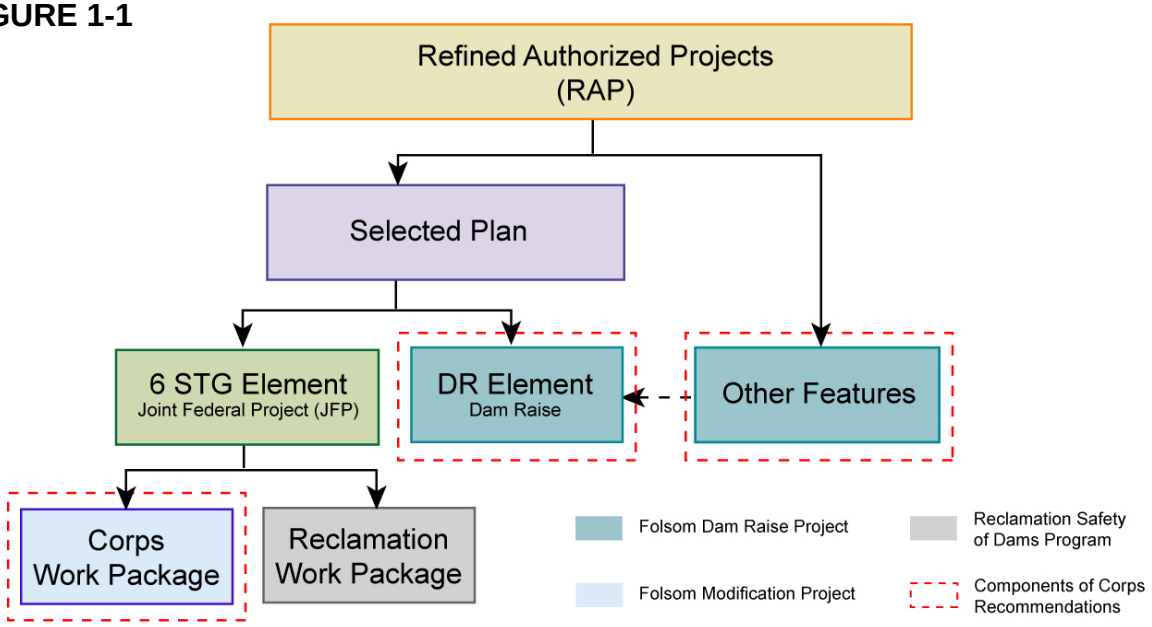
The background of the American River Watershed Project with specific focus on the Folsom Modification and Folsom Dam Raise Projects can be found in the *2007 PAC Report*. The *2007 PAC Report* was approved by the Assistant Secretary of the Army for Civil Works (ASA [CW]) on 3 May 2007. This ERR is a companion document that will provide additional information for use in the annual budgetary process by which the President's administration prioritizes and requests funding from the U.S. Congress.

The pertinent recommendations of the *2007 PAC Report* were to construct an auxiliary spillway with 6 submerged tainter gates (6STG Element) as the refined authorized Folsom Modification Project and to construct a 3.5 foot dam raise as the refined authorized Folsom Dam Raise Project. In the *2007 PAC Report*, the dam raise project was referred to as the Dam Raise Element (DR Element). The 6 STG Element and the DR Element were together referred to as the Selected Plan. The *2007 PAC Report* also reaffirmed two "Other Features," the Ecosystem Restoration Project and Folsom Bridge Project that were previously authorized as part of the Folsom Dam Raise Project. The *2007 PAC Report* referred to the Selected Plan, when combined with those Other Features, as the Refined Authorized Projects (RAP).

[1] ER 1105-2-100, Planning Guidance Notebook, Appendix G; and EC 11-2-187, Corps of Engineers Civil Works Direct Program, Program Development Guidance, Fiscal Year 2008.

[2] CEMP-SPD, Folsom Modification Project, 29 November 2005.

FIGURE 1-1



COMPOSITION OF THE REFINED AUTHORIZED PROJECTS

1.3 AUTHORIZATIONS

A complete discussion of the pertinent project authorities is presented in the *2007 PAC Report*.

1.4 REPORT ORGANIZATION

This ERR presents updated economic information related to the Selected Plan presented in the *2007 PAC Report*. It also presents updated economic information for the array of design refinement alternatives presented in the *2007 PAC Report*. Though a primary purpose of this ERR is to verify the decision made based on the *2007 PAC Report* warrants Federal participation, the updated information on the alternative plans considered is useful information to support that decision. This ERR does not display an update of post authorization comparisons, which was a primary purpose of the *2007 PAC Report* because the determination regarding the Corps' authority to implement the RAP was resolved as part of that reporting process. Also, updated economic information does not affect that determination.

This ERR is organized to provide the reader ease in cross referencing with the *2007 PAC Report*. Only updated information is presented in this ERR; for all other information, the reader is referred to specific sections of the *2007 PAC Report*. Tables presented in this ERR include

their corresponding number from the *2007 PAC Report* and are formatted exactly as in that report; only updated information is changed and is italicized for ease in identification.

CHAPTER 2.0
PROJECT AREA DESCRIPTION

2.1 LOCATION

The project area includes Folsom Dam and Reservoir; inflowing rivers and streams, including the North, South and Middle forks of the American River; the American River downstream to its confluence with the Sacramento River in the City of Sacramento; and other affected flood facilities, including the Sacramento River, Yolo Bypass, and Sacramento Weir. The American River Watershed covers about 2,100 square miles northeast f the City of Sacramento and includes portions of Placer, El Dorado, and Sacramento counties. Plate 1 shows the project area within the American River Watershed.

2.2 EXISTING FLOOD DAMAGE REDUCTION SYSTEM

The existing flood damage reduction system for the American River and the Sacramento area includes Folsom Dam and Reservoir, and the levees along the lower American River. A detailed description of these features and associated structures is presented in the *2007 PAC Report, Chapter 2.0, Section 2.2 Existing Flood Damage Reduction System*. Since the *2007 PAC Report*, one piece of additional information is considered necessary in order to more fully understand the past and existing operations at Folsom Dam and Reservoir.

2.2.1 Prior to 2004 – Pre-existing Condition

The 1986 Emergency Spillway Release Diagram (ESRD) was developed to restrict flows to 160,000 cfs (emergency objective release) for as long as possible, up to pool elevation 470.0 feet. Historical accounts indicate that past revisions to the operations were made to ensure that reservoir releases would not fail or overtop the levees unless all available flood control space or some surcharge space was utilized. At that time, the Corps believed that the levees could sustain flows of 160,000 cfs for several hours. More recent investigations showed that sustained flows of 160,000 cfs could cause extensive erosion and/or failure.

In addition, the dam's emergency gates pose a unique operational problem. The elevation for the FEMA base flood event is roughly 470 plus feet. When the rising water surface reaches 470.0 feet, the tail water discharge must be increased to at least 240,000 cfs to avoid damages at the dam due to operation of the emergency gates. This creates a dilemma for the operators who must operate to avoid either damages at the dam or damages downstream.

2.2.2 Existing Conditions

The existing (2004-2009) condition for Folsom Dam and Reservoir includes an Interim Operations scenario that is in place as a condition of certification of the down stream levees for passing the FEMA Base Flood Event. By the end of 2004, the Corps had completed much work on the American River. After some additional bank and levee hardening work, the Corps reported to the public that the levees downstream of Folsom Dam would be able to handle the

FEMA base flood event with a discharge of 145,000 cfs. Some adjustments were needed to the operations before levee certification could take place. The U.S. Bureau of Reclamation (Reclamation) and the Sacramento Area Flood Control (SAFCA) implemented an interim plan or agreement that would allow the Corps to certify for the FEMA base flood (1 percent annual exceedance probability).

The interim FEMA plan has very aggressive operational requirements. The goal is to limit the discharge to 145,000 cfs while also keeping the maximum water surface from exceeding 470 feet. The plan depends heavily on the additional release capacity gained through 100 percent use of the power penstocks and through 100% use of the river outlets during concurrent operation of the main spillway gates. A 24-hour inflow volume forecast versus projected pool elevation index was developed to aggressively push the releases up to 145,000 cfs, as necessary. At the time of development, the Interim Operating Plan was projected to cover a short period of 5 years – the time needed to complete the enlargement or modification of three upper tier outlets under the Folsom Modification Project. The interim FEMA plan is initiated by extreme events only. The odds of a base flood event occurring over the next five years are 5 percent. The odds of using the interim FEMA operation plan over the next five years are almost 10 percent.

2.3 FLOOD PROBLEMS

The flood related problems in the study area are described in the *2007 PAC Report, Chapter 2, Project Area Description, Section 2.3 Flood Problems*. Analysis conducted for this ERR provides some additional and somewhat revised information from what was presented in the *2007 PAC Report*. For this ERR, the area subject to flood risk has been expanded for some frequency flood events. New floodplains were developed by utilizing current tools and methodologies. By eliminating some previously applied constrains for lower frequency events, such as the Morrison Creek project levee to the south, which was previously treated as an artificial constraint, the area at potential risk of flooding has increased. Plate 1 shows a comparison of the largest floodplain described in the PAC with the largest floodplain developed as part of this ERR.

Current estimates are that below Folsom Dam, with the existing levee system, there is a 1-in-89 chance in any given year that levee failure and flooding will occur in Sacramento from the American River based on annual exceedence probability (AEP). Serious flood risks exist in the Sacramento area downstream along the American River to its confluence with the Sacramento River, as described below. Within the Sacramento area, a major flood would affect more than 400,000 people and in excess of 110,000 structures, with the total value of structures ($39 billion) and contents ($19 billion) potentially at risk of over $58 billion. The average annual equivalent damages in the Sacramento area is about $277.5 million.

2.4 FUTURE WITHOUT-PROJECT CONDITIONS

Currently, Folsom Dam and the downstream levee system help protect the City of Sacramento and areas in Sacramento County from major floods with an AEP of 0.0113 (a 1 in 89 chance of occurrence in any 1 year). The *2007 PAC Report* estimated an AEP of 0.0124 (about a 1-in-81 chance of occurrence in any 1 year). Although the American River levee system has been certified capable of protection against the Federal Emergency Management Agency (FEMA) base flood event using standard FEMA criteria, the Sacramento area has a fairly low level of flood protection for a community of its size and importance. The area at risk of flooding for various frequency events have been updated via new floodplain mapping. These basic floodplains are considered to be representative of the nature of flooding under the future without-project condition.

The *2007 PAC Report* presents a detailed description of assumptions considered to be in place as part of the future-without project condition *(2007 PAC Report*, Chapter 2.0, Section 2.5 Without-Project Conditions). Following is a summary of conditions that were assumed as part of the future-without project description in the *2007 PAC Report*.

- Continuation of the 400,000- to 670,000-acre-foot flood pool interim operation
- Completion of the Corps Common Features Project along the American River
- Implementation of Reclamation seismic and static retrofit work at Folsom facilities
- Construction of a permanent bridge just west of Folsom Dam
- Construction of an emergency fuseplug spillway
- Modification of L.L. Anderson Dam Spillway by PCWA

One additional operation assumption for Folsom Dam is required in order to continue to pass the FEMA base flood event under the future without-project condition. Consequently, the operation plan used for the future without-project condition routing was modified for this ERR. The future without-project condition should reflect passage of the FEMA base flood event through the American River levee system. The current agreement between Reclamation and SAFCA achieves this goal through aggressive operations. This agreement, endorsed by the Corps, was originally intended to cover the interim period between certification of the American River levees for the 100-year base flood event and the second phase of the originally authorized Folsom Modification Project (8 outlets). Instead, upon completion of the Common Features project, a number of refinements must be applied to enable the American River levee system to safely pass the FEMA base flood event. The refinements that could be applied would require either structural modification at Folsom Dam or non-structural changes such as modification to the water control plan. It is important for the purposes of this analysis to identify a refinement that is a reasonable representation of what could be done. Current time constraints do not allow full analysis of the possible refinements. The current operation plan is considered to be similar enough to what would be needed and has therefore been applied as part of the future without-project condition as a reasonable representation of an array of possible refinements. The project

partners agree that, regardless of the ultimate refinement that is ultimately applied in the future, the end condition would be the same: safely pass the FEMA base flood event.

CHAPTER 3.0
TECHNICAL STUDIES

3.1 OVERVIEW

A number of technical studies were undertaken as part of this ERR to update hydrology, hydraulics, floodplains, and economic inventory and valuation of damages in the floodplains. This chapter describes those studies and contracts them to the technical studies and information that served as the basis for the *2007 PAC Report*. More detailed descriptions are included as appendixes to this ERR.

3.2 AMERICAN RIVER HYDROLOGY AND FOLSOM DAM OPERATIONAL ROUTINGS

Hydrology for the American River basin was updated in 2004 and was utilized as a basis for the without-project condition in the *2007 PAC Report*. Following is a description of the hydrology. A detailed discussion is presented in Appendix A – Hydrology and Reservoir Operations.

3.2.1 2007 PAC Report

The future without project condition assumes that the Common Features Project is constructed. With completion of the Common Features Project, it has been estimated that the outflows from Folsom Dam could be increased to as much as 160,000 cfs for a sustained time without a high probability of levee failure. During the *2007 PAC Report*, specifics regarding this duration was under evaluation as part of the hydraulic and geotechnical contributions to this economic update. It was estimated in the *2007 PAC Report* that the American River levee system could handle 160,000 cfs. The operation plan reflects a return to the existing water control plan as defined by the SAFCA/Reclamation 400/670 interim reoperation water control diagram and the 1986 Emergency Spillway Release Diagram. In the *2007 PAC Report*, the Selected Plan reflects 160,000 cfs being sustained up to flood pool elevation 471 feet. The maximum Probable Maximum Flood pool is restricted to elevation 479 feet to prevent the fully open service spillway gates from overtopping.

3.2.2 Updated Analysis

The hydrology used as the basis for this ERR is the same as that which was used during development of the *2007 PAC Report*. In order to continue to pass the FEMA base flood event after the Common Features Project is actually completed, a revised operational assumption for Folsom Dam was included as part of the future without-project condition. The current interim operation plan is considered to be similar enough to what would be needed and has therefore been applied as part of the future without-project condition as a reasonable representation of an array of possible refinements.

The operation plan used in the *2007 PAC Report* was modified for this ERR. The *2007 PAC Report* was limited to elevation 479 feet to avoid overtopping of the service spillway gates at pool elevation 480 feet. After some discussion, Reclamation indicated that overtopping did not appear to be an issue until around elevation 481 feet, based on their model study results Therefore, the flood pool was maximized to achieve the highest possible PMF pool with a minimum of 3 feet of freeboard. The routing for this ERR was modified to reflect 160,000 cfs being sustained up to flood pool elevation 474 feet. The maximum PMF flood pool reaches elevation 481 feet.

3.3 HYDRAULIC ANALYSIS

This section describes the two primary products of the hydraulic analysis: floodplains and rating curve that relates river flows to river stages. A detailed discussion is presented in Appendix B – Hydraulic Engineering.

3.3.1 2007 PAC Report

3.3.1.1 Floodplains

The floodplains that were used in the PAC economic analysis were based on topography from USGS 1:24000 quadrangle maps. These maps include topography from 1948 described in 5-foot contour intervals. Floodplains were developed for the 1/100 and 1/400 flood events based on flood volume estimates and topography. However, these flood volumes and associated frequencies were based upon old hydrology that preceded the PAC. These two floodplains were used to estimate damages for both the with- and without-project conditions in the PAC. Therefore, it was assumed that the extent and depths of the floodplains did not change between the with- and without-project conditions; however, the frequency at which they occurred did.

The spatial extents of these floodplains are bounded by Arcade Creek to the north down to Morrison Creek in the south. The western boundary of the floodplains is the Natomas Cross Canal for the floodplain north of the American River, and the Sacramento River south of the American River. The eastern boundary of the floodplain extends as far east as Nimbus Dam. (See Plate 1.)

3.3.1.2 Rating Curve

The expected annual damage calculations that are products of the HEC-FDA program are dependent on hydrologic, hydraulic, geotechnical, and economic input. The hydraulic input information consists of two things – floodplains, and a rating curve that relates river flows to river stages along with uncertainty bounds. The floodplains are used to calculate damages due to the spatial extent and depths of the floodplains. The rating curve is used to relate flood flows to river stages. These river stages are then related to floodplain depths, which provide a link between river stages and ultimately flood damages. The rating curve used in the PAC analysis was based on an updated HEC-RAS hydraulic model, which was developed in 2001 in support of the American River Common Features Project. The location of the rating curve is just downstream of the Howe Avenue Bridge. This hydraulic information was entered into the risk

analysis program, HEC-FDA, along with input from the other above-mentioned disciplines. The output from this program includes project performance statistics, expected annual damages, and net benefits.

To help assess potential flood damages in the areas of Sacramento that would be subject to major flooding from levee failure were identified. These areas of likely flooding, of floodplains, were developed on the basis of computed river stages, levee stability conditions during high flows, and topography. The floodplain was divided into six sub areas: (1) Natomas, 54,900 acres; (2) Dry Creek, 5,800 acres; (3) North Sacramento 5,900 acres; (4) Rancho Cordova, 4,200 acres; (5) South Sacramento, 44,000 acres; and (6) Richards Boulevard, 1,000 acres. The Natomas and Dry Creek sub areas were not included in the study area of the *2007 PAC Report* because some existing flood risk has been reduced by levee improvements by SAFCA and the residual risk is being addressed as part of the concurrent Natomas Common Features General Reevaluation Report.

If levees failed, the resultant flooding would be severe in parts of downtown Sacramento, and, to some extend, north Sacramento areas – regardless of the frequency of the flood. This is because (1) the ground elevation adjusted to the levees in these locations is lower than the water surface in the river and (2) the volume of water in the American River (and Sacramento River in the case of downtown Sacramento) would cause deep flooding. Shallower flooding would affect the South Sacramento, and Rancho Cordova reaches, but progressively more area would be flooded as increased flows were diverted through the levee break.

3.3.2 Updated Analysis

3.3.2.1 Floodplains

For the updated analysis, new floodplains were developed using current numerical modeling software. The existing steady-state HEC-RAS model that was used in the PAC for rating curve development was also used for the updated analysis. The model was used for both rating curve development and unsteady flow channel routing. Levee breach locations, lateral weirs, and overbank storage areas were added to the model. The water leaves the channel through the levee breaches coded in the HEC-RAS model, and also when water overflows the river's banks in the unleveed portions of the river system. The water leaving the channel is then used as input into a 2-dimensional program called FLO-2D. The FLO-2D models for the American River floodplains consist of 400 foot grid cells. The water leaving the channel model is then brought into the FLO-2D models where the water is routed through the floodplain areas. These models also included topographic features that alter the flow path such as levees and road embankments. The FLO-2D floodplain modeling was done for 7 different flood events for both the future without project condition and the alternative conditions. These new floodplains are more detailed for a number of reasons: 1) the actual number of floodplains used to estimate damages has increased from two to seven, 2) the floodplain topography resolution improved from 1948 5-foot contour information to 2004 2-foot contour LIDAR information, and 3) floodplains associated with floods in which Folsom Dam makes emergency releases were not assumed to be the same for both the with and without project conditions. In the PAC this assumption was made. For example, the 1/500 flood was assumed to be the same for both the

with and without-project conditions. In this particular case, the current analysis found that the two different floodplains were quite a bit different due to changes in operations at Folsom Dam.

3.3.2.2 Rating Curve

The model used to generate the rating curve for the PAC Report was also used for the current analysis. However, the location of the rating curve changed slightly. The location was moved from just downstream of Howe Avenue Bridge to just upstream of the bridge because river stages were more variable for high flows at the upstream end. The risk analysis methodologies remained the same as in the PAC. This hydraulic information was entered into the risk analysis program, HEC-FDA, along with input from the other above-mentioned disciplines.

FLO-2D is a 2-dimensional flood routing model that simulates the movement of water through a floodplain while accounting for the topography and roughness. FLO-2D routes a flood hydrograph through the floodplain while predicting floodwave attenuation due to flood storage and the floodplain characteristics. The FLO-2D model has the ability to account for floodplain details such as geographic levees, street flow, flow obstructions (buildings and berms), infiltration, floodways, rainfall, infiltration and evaporation losses, mobile bed and sediment transport. Two FLO-2D models were developed for the ERR. The first being a model of the floodplain north of the American River and the second being a model of the floodplain south of the American River. The models made use of FLO-2D's ability to model the numerous levee, roadway embankments and buildings (both residence and commercial/industrial) in both floodplains. A system of 400 ft by 400 ft grids was constructed for each floodplain. The study limits for the North Floodplain covers approximately 56 square miles of Sacramento County and is defined as follows:

- Southern boundary -American River from Hazel Avenue to The Natomas East Drainage Canal (NEMDEC);
- Western boundary – NEMDEC (Natomas East Main Drainage Canal, also known as Steelhead Creek);
- Northern boundary – Elverta Road;
- Eastern boundary – high ground.

The study limits for the South Floodplain covers approximately 254 square miles of Sacramento County and is defined as follows:

- Southern boundary –Cosumnes River to confluence with Mokelumne River, Mokelumne River to confluence with Lost Slough, Lost Slough to confluence with Snodgrass Slough, Snodgrass Slough to confluence with Delta Cross Channel, and Delta Cross Channel to confluence with Sacramento River;
- Western Boundary – Sacramento River;
- Northern Boundary - American River from Hazel Avenue to confluence with Sacramento River;
- Eastern Boundary – high ground.

Inflow hydrographs were developed for use as inputs into the FLO-2D models at the location of the levee breakouts. The inflow hydrographs were developed from the HEC-RAS modeling for the various flood events. The inflow hydrographs were then input into the FLO-2D model and run to simulate the flood progression over 400 hours from the time of the beginning of the storm event.

The north and south floodplain FLO-2D models were run for the without project condition, and the four alternatives as described in the PAC report. The floodplain water surface elevations were taken from the FLO-2D results and used in the HEC-FDA modeling. Floodplain delineation and depth maps were created for future without-project condition for the 100-, 120-, 150-, 180-, 200-, 250-, and 500-year events. In addition, with-project mapping was developed for the Selected Plan of the *2007 PAC Report* for the 275-, 300-, 350-, 400-, and 500-year events.

3.4 GEOTECHNICAL ANALYSIS

Following is a summary of the geotechnical analysis associated with the *2007 PAC Report* and the ERR. A detailed discussion is presented in Appendix C – Geotechnical Engineering.

3.4.1 2007 PAC Report

For the *2007 PAC Report*, geotechnical probabilistic assessment for the levee system is believed to have its origins from studies performed for the American River Common Features Project under the authority of WRDA 1999. Under these studies probability of failure were correlated to water surface elevations on the levee. Two water surface elevations were used consisting of the highest vertical elevation on the levee such there is an 85 percent confidence level that the levee would not fail or Probable Non-Failure Point (PNP), and the lowest vertical elevation on the levee such there is an 85 percent confidence level that the levee would fail or Probable Failure Point (PFP). When the probability distribution consists of only the PNP and PFP values, a linear relationship is assumed between the PNP and PFP values. Using the linear relationship the benefits are evaluated assuming all flood damages will be prevented below the PNP and no damages will be prevented above PFP. This methodology follows the guidance in the Corps Policy Letter No. 26, titled *Benefit Determination Involving Existing Levees*, dated December 1991.

3.4.2 Updated Analysis

For this ERR, a geotechnical risk-based analysis utilizing the current guidance found in the Corps Engineering Technical Letter 1110-2-556, titled *Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies* was performed. The results of the analysis provided levee reliability, or conversely levee probability of failure, as a function of water surface elevation resulting in a series of points rather than only PNP and PFP points. In order to support this ERR, it was necessary to make assumptions regarding levee modifications even though these modifications are on-going and at various stages of completion. Weak segments in the levee system were geotechnically evaluated and used in the risk-based analysis. Levee performance modes affecting reliability were included in the analysis consisting of seepage,

slope stability, trees on levees, and underground utilities crossing the levees. Erosion due to current or wind waves were not included in the analysis and are addressed in the hydraulic portion of this report. Considerations were made to the current and anticipated level of protection for the levee system in developing the recommended probability of failure as a function of water surface elevation points. The resulting probability of failure as a function of water surface elevation will allow levee performance to be evaluated below the PNP and above the PFP, rather than assuming that 100 percent reliability below the PNP and 100 percent probability of failure above the PFP.

3.5 ECONOMIC ANALYSIS

The Federal objective in water resource planning is to contribute to national economic development while protecting the nation's environment. The Principles and Guidelines (P&G), published by the U.S. Water Resource Council and used during the study process, have a single Federal objective and provide flexibility to address the concerns of others. Economic and environmental criteria have been incorporated into the P & G's to provide water resource agencies the best current analytical techniques available. The P & G sets forth four accounts to facilitate evaluation and display effects of alternative plans: national economic development (NED), regional economic development (RED), other social effects (OSE), and environmental quality (EQ). Collectively, the four accounts include all significant effects of a plan on the human environment. NED benefits are increases in national wealth, irrespective of where in the United States they may occur. The RED benefits include the regional incidence of NED effects, income transfers, and employment effects. The OSE account displays the effects of a plan on urban and community settings and on life, health, and safety. In light of Engineering Circular 1105-2-409 31, Planning in a Collaborative Environment, May 2005, a greater emphasis is now placed on the other benefit categories. Following is a summary of the economic analysis performed for the *2007 PAC Report* and this ERR. A detailed discussion is presented in Appendix D – Economic Analysis.

3.5.1 2007 PAC Report

Prior American River Project studies were based on the NED account. RED and OSE benefits were not evaluated. The EQ account was fully addressed by the 2007 PAC EIS.

The original 1990 inventory and valuation for the 1991 American River Watershed Investigation Feasibility Report has periodically been revised to account for significant changes (1994 & 2000) prior to the *2007 PAC Report*. Modifications to the inventory such as updating price levels and or Marshal and Swift values were made for the American River Long Term Study and Folsom Modifications LRR, and the 2007 PAC. October 2006 price level and the Federal 2007 fiscal year discount rate of $4^{7}/_{8}$ were used for the *2007 PAC Report*.

In 2000 uncertainty was incorporated into the economic model for the Common Features LRR. The *2007 PAC Report* economics modeling was an updated and adjusted version of the 2001 Common Features LRR model. For the *2007 PAC Report* two floodplains were modeled. The 2001 report through the *2007 PAC Report* had only one modeled reach with one index point.

The *2007 PAC Report* used the same stage-damage functions for both with and without project and simulated benefits by 'shifting' frequency by corresponding flows.

Non-residential contents were previously determined as a percent of structure value ranging from 24 to 209 percent. Damage functions were based on 1988 FIA curves. Emergency costs in the *2007 PAC Report* contained outdated and simplistic assumptions. Cost per person was less than half the value in this analysis. Durations were uniform across flood events and reaches. Previous analysis which had been updated for the *2007 PAC Report* included damages to roads and the cost of debris removal from the roads.

3.5.2 Updated Analysis

For the ERR, three of the four accounts have been evaluated to account for a fuller array of project benefits: NED, RED, and OSE. EQ was fully addressed in the *2007 EIS/EIR* associated with the *2007 PAC Report*.

3.5.2.1 NED

NED benefits were quantified for present (2007) and local conditions and specifically included non-residential contents. The structures and contents of the new 2007 floodplain were inventoried and valued. There are some NED benefits for which there traditionally has been no or peripheral accounting. As part of this economic update, some of these traditional NED benefit categories have been more directly included.

A new inventory was collected for the updated floodplain in early 2007. Ground surveys were conducted for a sample of Single Family Residences (SFR) structures. A 100 percent field survey was conducted for Multiple Family Residences (MFR), Public, and Commercial and Industrial (C&I) structures. This ERR is based on October 2007 price levels and the Federal 2007 fiscal year discount rate of $4^{7}/_{8}$. This ERR inventory represents current land uses and conditions as of spring 2007. The field survey collected depreciation and building quality data that make the inventory valuations differ from the 2000 inventory update.

The FDA model for this ERR is new. Based on the 2007 inventory, using the new non-residential content damage curves, new stage-damage curves were calculated within HEC-FDA. The *1991 American River Watershed Investigation Feasibility Report* through the *2007 PAC Report* had two frequency floodplains. This ERR has seven frequency floodplains and modeled 17 reaches. The increase in floodplains and reaches makes the HEC-FDA modeling more precise and likely more accurate.

Single event damages for structures and contents for both residential and non-residential categories were calculated with uncertainty in HEC-FDA. Auto losses with uncertainty were also estimated by event in the model. Other categories, including humanitarian assistance, dewatering, levee repair, residential and non-residential debris removal were calculated (without uncertainty parameters) outside the HEC-FDA model and were added as manually entered stage-damage functions.

For this ERR, single event damage estimates were calculated in HEC-FDA. Inventory, damage relationships and economic uncertainties were imported into HEC-FDA, water surface profiles imported and then stage-damage functions were computed internally. Data originating from HEC-RAS and FLO-2D was imported into HEC-FDA.

For this ERR an expert elicitation panel was assembled to identify prototype non-residential categories and their contents. 19 non-residential categories were identified. Content values per square foot were and depth damage curves for the 19 categories were computed. This data was collected in 2007 and is specific to Sacramento. It was used to estimate both value and damages in this ERR.

For humanitarian costs, costs that would potentially be borne by the government in providing public assistance and other temporary relief services to affected communities, following disasters, such as a flood event, were taken into consideration. These services would not be necessary, and/or the costs would not be incurred, were it not for the impacts of the disaster. The impacts that have been analyzed under this subcategory are: the potential cost of providing humanitarian assistance; the potential cost of levee repair; the potential cost of dewatering (pumping-out flood-water) the affected community; and the potential cost of debris removal. The potential costs of providing emergency assistance were functions of the number of inundated residential units (or affected population), the duration of flooding, the amount of money made available for such public assistance, levee repair costs per linear foot, length of levee break, flood water in floodplains, cost of pumping, and costs of debris removal from structures. A new analysis was done to estimated damages to automobiles, which takes into account uncertainty. This ERR does not include damages to roads or include clean-up or debris removal from the roads.

3.5.2.2 RED

The RED account shows the effects of plan alternatives on the distribution of regional economic activity in the area where the plan will have significant income and employment effects. All or most of the NED benefits for a plan will accrue to the region. The effects on regional income are the sum of the NED income benefits and transfers from outside the region. Income transfers comprise income from implementation outlays, transfers of economic activities, and indirect and induced effects. Indirect and induced impacts are shown in the RED account; these are not NED benefits but transfers from or to the rest of the nation. The effects of a plan on regional employment parallel those on regional income.

The focus of this RED analysis provided detailed insight into the likely regional economic impacts of 200-year and 500-year flood events in the Sacramento region. Because of the interdependence in the region, the area of impact for such events may extend well beyond Sacramento County and include El Dorado, Placer, Sutter, Yolo, and Yuba Counties. While the quantitative component of the RED analysis is on Sacramento County, other linkages are recognized qualitatively. The RED analysis was modeled using IMPLAN.

3.5.2.3 OSE

The OSE account includes urban and community impacts to income, population and employment distribution, fiscal conditions, and displacement of people and businesses and farms. A flood event may have social impacts through reduced property values, contaminated drinking water, and greater exposure to biological toxins. All regional impacts that are difficult to quantify in the RED account are included in the OSE account. Others which are measurable may fit into the OSE account and concurrently be an RED impact. For example, people in flooded areas may be unable to live in their homes or commute to work. The inability to live in their homes is an OSE impact, while the inability to commute to work is also an OSE impact, but with RED implications. In the latter case, the outputs of industries will decline if employees are unable to reach their places of employment.

This OSE describes the potential effects of the Selected Plan, and the potential effects of hypothetical 200-year and 500-year flood events, for the American River and the associated Sacramento County urban area. Each respective description outlines the possible social effects that may materialize during a flood event and are more likely if a project is not implemented. The social effects of a project are smaller in scope than the effects associated with a flood event. The same general methodology applies to the analysis of both projects. For the analysis of the SP, the region of influence (ROI) for direct social effects is defined as the area bounded by the U.S. Census block groups that are encompassed in whole or in part by a buffer extending 0.5 mile outward from the previously defined project area in all directions. For the analysis of the 200-year and 500-year flood events, the ROI for direct social effects is primarily defined as the U.S. Census blocks within Sacramento County. Beyond basic census data, land use information, parcel data, county-provided locational data related to areas of special interest, and interviews with first-responders and county staff were also used in the analysis of the flood events. Different types of social effects associated with a given project/event may be felt over a larger or smaller area, depending on project phase and the specific nature of the effects themselves. Indirect social effects of a major flood event would likely be felt well beyond Sacramento County itself.

3.6 Conclusions

The inventory identified over $39 billion dollars in structural value that are potentially at risk of flooding from the 500-year without project floodplain. That represents a 72 percent increase over the largest floodplain described in the PAC. Non-residential content values are $8 billion and residential content values are $11 billion, the total value of structures and contents potentially at risk is over $58 billion for a total value increase over the PAC of around 52 percent. Expected annual damages (EAD) were determined for the without project condition using the HEC-FDA model. The model integrates the hydrologic, hydraulic, geotechnical and economic relationships with uncertainty to create exceedance probability-damage functions with uncertainty. In total, EAD was estimated at $269 million which represents an increase of 36 percent over the $198 million shown in the PAC report. EAD, to structures and contents, increased by 18 percent over the EAD listed in PAC. The largest increases were seen in the emergency costs/humanitarian assistance. Previous and current American River analysis does not account for floodwater cleanup or decontamination that may be necessary due to hazardous mold or flood water. Catastrophes like flooding cause a wide range of damages and losses. These impacts cause major disruptions to the social and economic life, as well as significant costs and losses to government, businesses and affected communities.

CHAPTER 4.0
UPDATED BENEFITS OF SELECTED PLAN AND ALTERNATIVE DESIGN REFINEMENTS

4.1 Alternative Design Refinement Plans

The No-Action Plan and the Alternative Design Refinement Plans are described in detail in the *2007 PAC Report, Chapter 4.0, Authorized Project Refinement, Section 4.5 Alternatives*. This ERR presents updated information. New estimate future without-project damages are based on the updated floodplain delineation and inventory. Refined estimates of levee performance have resulted in changes in without and with-project performance, in terms of annual exceedence probability, for each alternative. The updated floodplain delineation, inventory and valuation of the inventory have redefined economic benefits for with-project each alternative. First costs for each with-project alternative remain the same as presented in the *2007 PAC Report*. In the *2007 PACR Report*, costs and benefits for each with-project alternative were not brought into the same base year. Consequently, annual costs were not accurately estimated. This error has been corrected for this ERR. The result has no effect on selection of Alternative C as the Selected Plan.

4.1.1 No-Action Plan

The No-Action Plan is essentially the same as what was described in the *2007 PAC Report*, with one exception. The modified operation assumption considered to be in place as part of the future without-project condition for this ERR translates into a modification to the No-Action Plan. Following physical completion of the Common Features Project, one additional operation assumption for Folsom Dam is required in order to continue to pass the FEMA base flood event as part of the No-Action Plan. The interim operation plan in place during construction of the Common Features Project is considered to be similar enough to what would be needed and has therefore been applied as part of the future without-project condition as a reasonable representation of an array of possible refinements. The project partners agree that, regardless of the ultimate refinement that is ultimately applied in the future, the end condition would be the same: safely pass the FEMA base flood event.

Under the No-Action Plan, much of the Sacramento area would have protection from the 100-year single event flood. This equates to a 1 in 89 chance in any given year that levee failure and flooding will occur in Sacramento from the American River based on annual exceedence probability (AEP). The estimated expected annual damages in Sacramento are about $277.5 million (October 2007 price levels). A description of estimated flood damages under the No-Action Plan as well as for each of the action alternative plans below is contained in Appendix D – Economics.

4.1.2 Alternative A – Eight Main Dam Outlets and Fuseplug Spillway

This action alternative plan consists of three major features: (1) enlarging six of the eight existing outlets, (2) constructing two new outlets along the upper outlet tier, and (3) constructing

an emergency fuseplug spillway. Because of hydrologic, geotechnical, and structural problems, the two lower tier outside outlets (Outlets 1 and 4) would not be modified and would retain their original dimensions. The resulting outlet modifications would be capable of releasing 115,000 cfs at a spillway crest elevation of 418.0 feet. The four upper tier gates would be enlarged to 9 feet, 4 inches wide, by 14 feet high, and the four lower tier outlets would be enlarged to 9 feet, 4 inches, by 12 feet. The second major feature is the emergency fuseplug spillway. As mentioned, lacking implementation of major features to help reduce flood damages along the lower American River, Reclamation plans to construct an emergency fuseplug spillway as part of an effort to address dam safety at Folsom Dam. The fuseplug spillway would be composed of an earthen embankment on top of concrete lining and a concrete-lined chute that would convey flows away from the fuseplug to the American River. The earthen embankment would be designed to erode at a predicted rate as the pool level approaches the minimum freeboard level. After the embankment is washed away, the remaining concrete spillway (combined with discharge facilities from the main dam) would be capable of passing the PMF. In addition to the above, this alternative also includes retention of a variable flood space in Folsom Reservoir that would range between 400,000 and 600,000 acre-feet. Fuseplug spillway construction would be to address the PMF (dam safety), and the outlet modification and retained reservoir operation would be for flood damage reduction.

4.1.2.1 Accomplishments- Flood Damage Reduction

As shown in **Table 4-2**, this plan would result in a reduced flood risk to Sacramento by reducing the AEP of flooding along the American River to 0.0070 (a 1 in 143 chance in any year). This plan would provide the capability for Folsom Dam and Reservoir to pass, with sustained outflows of 160,000 cfs, the 180-year design flood event. Accordingly, this would not meet the minimum requirement of SAFCA and The Reclamation Board of the State of California (The Reclamation Board). Over the course of a decade (see **Table 4-2**), it is estimated that there would be a 7 percent chance of flooding with this plan versus about an 11 percent chance under existing conditions. Within the span of a 30-year home mortgage, it is estimated that there would be a 19 percent chance of flooding with this plan versus a 30 percent chance under existing conditions. Further, over a 50-year period, there would be an estimated 30 percent chance of being flooded versus a 43 percent chance under the existing project. With this plan, average annual equivalent flood damages would be reduced by approximately 33 percent to about $179.9 million.

Table 4-1 *(2007 PAC Report Table 4-2)*
Long-Term Risk and Annual Exceedence Probability of All alternative Plans

Item	Alternative				
	No-Action	A	B	C	D
Annual Exceedence Probability (AEP)	*1-in-101 to 1-in- 185*[1]	*0.0070 (1 in 143)*	*0.0068 (1 in 147)*	*0.0061 (1 in 164)*	*0.0052 (1 in 192)*
Long-Term Risk (%)					
10 Years	*11*	*7*	*7*	*6*	*5*
30 Years	*29*	*19*	*18*	*17*	*14*
50 Years	*43*	*30*	*29*	*26*	*23*

Note: 1. Chance of flooding in any 1 year.

4.1.2.2 Economics

Following is a summary of estimated costs and economic benefits for Alternative A. Similar information is provided in following paragraphs for the other action alternative plans. Estimates of first costs are based on October 2006 price levels. Annual costs and benefits were derived using a Federal rate of $4^7/_8$ percent and a 50-year period of analysis. For large civil works projects that include a dam and reservoir, a 100-year period of analysis is normally used in the economic analysis for evaluating annual costs and benefits. However, Folsom Dam and Reservoir have been in service for 50 years. Accordingly, it was determined that a 50-year period of analysis should be used for the current evaluations. Use for all action alternative plans of either period of analysis would result in slightly different annual costs and benefits; however, resulting conclusions relative to benefits and costs between the alternatives would remain unchanged.

It is important to note that for comparison purposes only, costs for all action alternative plans have been prepared to the same level of development. Alternatives and features of alternatives are at different levels of design. Cost estimates include appropriate contingencies and line items to allow alternatives to be compared. Further, annual costs for all alternatives do not include the ongoing costs to replace water supplies foregone due to continued reoperation of the original Folsom Dam operation for flood damage reduction. A preliminary estimate of these costs is included in the *1996 SIR* for the American River Watershed Project; they are to be reevaluated in future studies. The resulting conclusion relative to benefits and costs between the alternatives due to resources replacement would remain unchanged.

- **Costs** – As mentioned in **Section 4.1** above, estimates of first costs developed for the *2007 PAC Report* are considered current and were not updated for this ERR. The estimated total first cost for this plan is $630 million. Updated annual costs attributed to flood damage reduction are $45.1 million.
- **Benefits** – As mentioned, estimates of flood damages under the No-Action Plan (without-project conditions) and for each action alternative plan, and potential economic benefits attributable to flood damage reduction, are contained in **Appendix D**. Based on information from **Appendix D**, and excluding potential benefits for the Folsom Dam Bridge and ecosystem restoration, the total estimated average annual benefit for flood damage reduction of this plan is $97.8 million.

4.1.3 Alternative B – Six Submerged Tainter Gate Auxiliary Spillway

This action alternative plan primarily includes construction of a new gated auxiliary spillway southwest of Folsom Dam. The auxiliary spillway would be at a location similar to that of the fuseplug in Alternative A. However, it would be constructed at a lower elevation (sill elevation 368.0), and include significantly more excavation. Major features include (1) a 1,100-foot-long approach channel beginning in Folsom Lake, (2) control structure, including six submerged tainter flood gates 33 feet high by 23 feet wide, (3) 3,000-foot-long spillway chute with a bottom width of about 169 feet, and (4) stilling basin in the American River. The stilling basin includes an exit channel to return flows to the American River. It also includes

modification of the flood control storage space in Folsom Reservoir from a variable space ranging from 400,000 acre-feet to 670,000 acre-feet, to 400,000 acre-feet to 600,000 acre-feet.

4.1.3.1 Accomplishments - Flood Damage Reduction

This plan would result in a reduced level of flood risk to Sacramento by reducing the AEP of the American River due to levee failure to 0.0068 (a 1 in 147 chance in any year). It would provide the capability for Folsom Dam and Reservoir to pass, with outflows of 160,000 cfs for a sustained period of time (currently under evaluation), the 200-year computed design flood event. This equals the minimum requirement of SAFCA and The Reclamation Board. With this plan, there would be a 7 percent chance of being flooded over the course of 10 years, a 18 percent chance in 30 years, and a 29 percent chance in 50 years (see Table 4-2). Similar to other action alternatives, this plan would control a flood with a 3-day volume approximately 50 percent greater than the 1986 and 1997 historic flood events. With this plan, average annual equivalent flood damages of about $277.5 million would be reduced by approximately 40 percent to about $161.6 million.

4.1.3.2 Economics

- **Costs** – The estimated first cost for this plan is $876 million. The estimated annual cost for the flood damage reduction component is $60.4 million. For comparison of benefits and costs between action alternative plans, the total first cost of this alternative is reduced by an estimate of the cost attributable to dam safety. These costs are being developed by Reclamation. However, for this ERR analysis, $185 million was used to account for the cost of the emergency fuseplug spillway. In addition, neither this nor other action alternative plans included features or costs of the new Folsom Dam Bridge or ecosystem restoration elements contained in the Folsom Dam Raise Project.

- **Benefits** – Excluding potential benefits for the Folsom Dam Bridge and ecosystem restoration, the total estimated average annual benefits attributable to flood damage reduction for this plan are $116.2 million.

4.1.4 Alternative C/Selected Plan – Six Submerged Tainter Gate Auxiliary Spillway, 3.5-Foot Dam Raise, and Three Emergency Spillway Gate Replacements

This action alternative plan primarily consists of construction of a new gated auxiliary spillway southwest of Folsom Dam similar to Alternative B, above, raising Folsom Dam by 3.5 feet, and replacing the three emergency spillway gates at Folsom Dam. It also includes modification of the flood control storage space in Folsom Reservoir from a variable space ranging from 400,000 acre-feet to 670,000 acre-feet, to 400,000 acre-feet to 600,000 acre-feet. The auxiliary spillway would primarily include (1) 1,100 foot-long approach channel beginning in Folsom Lake, (2) control structure, including six submerged tainter gates, (3) 3,000-foot-long spillway chute with a bottom width of about 169 feet, and (4) stilling basin with exit channel to return flows to the American River.

4.1.4.1 Accomplishments – Flood Damage Reduction

This plan would result in a reduced level of flood risk to Sacramento by reducing the AEP of flooding along the American River to 0.0061 (a 1 in 164 chance in any year). This plan would provide the capability for Folsom Dam and Reservoir to pass, with outflows of 160,000 cfs for a sustained period of time (currently being evaluated), the 240-year design flood event. This exceeds the minimum requirement of SAFCA and The Reclamation Board. With this plan, there would be a 6 percent chance of being flooded over the course of 10 years, a 17 percent chance in 30 years, and a 26 percent chance in 50 years (see **Table 4-1**). This plan, similar to the other action alternatives, would control a flood with a 3-day volume approximately 50 percent greater than 1986 and 1997 historic flood events. With this plan, average annual equivalent flood damages of $277.5 million would be reduced by approximately 49 percent to about $136.2 million.

4.1.4.2 Economics

- **Costs** – The estimated first cost for this plan is $988 million. The updated annual cost attributable to flood damage reduction is estimated at $67.1 million.

- **Benefits** – Excluding potential benefits for the Folsom Dam Bridge and ecosystem restoration, the total estimated average annual benefits for this plan are $141.6 million. For this and other action alternative plans, the benefits attributable to dam safety are estimated to be equal to the least costly plan to accomplish that purpose.

4.1.5 Alternative D – Six Submerged Tainter Gate Auxiliary Spillway, 7-Foot Dam Raise, and Eight Emergency and Service Spillway Gate Replacements

This action alternative plan is similar to Alternatives B and C above in that it includes constructing an auxiliary spillway with six submerged tainter gates near the south wing dam of Folsom Dam. The size and location of the spillway and gates are as described for Alternative B. This alternative also includes raising Folsom Dam and appurtenant structures by 7 feet and replacing all eight (five service and three emergency) spillway tainter gates at Folsom Dam.

The dam raise portion of this plan is similar to that for the originally authorized Folsom Dam Raise Project. The raise would be a combination of raising the concrete monolith and embankments and adding a 3.5-foot parapet wall. The five new service and three emergency spillway gates would be 66 feet high, 16 feet taller than the existing five main gates and 13 feet taller than the existing three emergency gates. The top of the new gates would be at elevation 484.0 feet. To accommodate the increased height and loading, the existing piers would be extended and strengthened, and new trunions would be located on the top of new pier extensions. New high-strength, post-tensioned steel cables would be cored and grouted into the existing pier/dam section to provide for trunion anchorages. New hoisting motors and chains, and new catwalks would be constructed. Other major features include replacement of the spillway bridge and modification of the elevator tower. Alternative D also includes modification of the flood control storage space in Folsom Reservoir from a variable space ranging from 400,000 acre-feet to 670,000 acre-feet, to 400,000 acre-feet to 600,000 acre-feet.

4.1.5.1 Accomplishments – Flood Damage Reduction

This plan would lead to a reduced level of flood risk to Sacramento by reducing the AEP of flooding along the American River to 0.0052 (a 1 in 192 chance in any year). This plan would provide the capability for Folsom Dam and Reservoir to pass, with outflows of 160,000 cfs for a sustained time (currently being evaluated), the 275-year design flood event. This plan exceeds the minimum requirement of SAFCA and The Reclamation Board. With this plan, there would be a 5 percent chance of being flooded over the course of 10 years, a 14 percent chance in 30 years, and a 23 percent chance in 50 years (see **Table 4-1**). Similar to other action alternatives, this plan would control a flood with a 3-day volume approximately 50 percent greater than 1986 and 1997 historic flood events. With this plan, the average annual equivalent flood damages of $277.5 million would be reduced by approximately 61 percent to about $105.9 million.

4.1.5.2 Economics

- **Costs** – The estimated first cost for this plan is $1,439 million. The updated total annual cost attributable to flood damage reduction is estimated at $98.5 million.

- **Benefits** – Excluding potential benefits for the Folsom Dam Bridge and ecosystem restoration, the total estimated average annual flood damage reduction benefits for this plan are $172.8 million.

4.2 Comparison of Action Plans

As part of the *2007 PAC Report*, to help identify the Selected Plan, the above action alternative plans were compared using the four general criteria contained in the Federal Water Resources Council's *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (or P&G) (1983). These criteria include (1) completeness, (2) effectiveness, (3) efficiency, and (4) acceptability. Alternative C had the highest relative ranking of the alternatives for each of the 4 planning criteria. The updated economic information alters the input into the evaluation for efficiency.

Efficiency is the extent to which an alternative is the most cost-effective means for realizing project objectives consistent with protecting the Nation's environment. One measure of efficiency is monetary costs versus benefits. Efficiency is displayed as net economic benefits and is the extent to which the economic benefits exceed costs for alternatives providing increased levels of flood damage reduction. **Figure 4-1** is a plot of net benefits for each alternative. Included in **Table 4-2** is an estimate of net economic benefits for each of the alternatives.

It is important to note in the table and figure that the annual net economic benefits are for flood damage reduction. An allowance for potential benefits for passing the PMF is not included in the information presented in the table. It is assumed the value of benefits to pass the PMF will be at least equal to those costs. It is also important to note in **Figure 4-1** that the net benefits curve tends to maximize at an AEP of about a 1 in 164 chance in any year with Alternative C. It should be mentioned that likely other types of alternatives, not including modifications at Folsom Dam and Reservoir, would economically provide greater levels of flood damage reduction.

Because the *2007 PAC Report* primarily constitutes a design refinement, a primary criterion in ultimate plan selection was engineering criteria. To identify a plan that is functionally equivalent to the Folsom Modification Project and Folsom Dam Raise Project, AEP associated with each alternative was compared. AEP can be used to determine if an alternative plan is capable of producing comparable engineering performance to the Folsom Modification Project and Folsom Dam Raise Project. The estimated cumulative AEP of the originally authorized projects is 0.0057 (1 in 175 chance of occurrence in any year). Using updated system operation modeling applied for the *2007 PAC Report*, it was estimated that the cumulative AEP of the projects is 0.0053 (1 in 187 chance equivalency). The updated analysis for this ERR focused on the No-Action and with-project alternatives; the originally authorized projects were not updated with the new modeling assumptions. Had they been, it is reasonable to assume that the estimated AEP's would have decreased similarly to the new alternative information; the relative comparison of updated AEP for the alternatives updated in this ERR results in the same conclusion: that Alternative C is closest in terms of AEP to the originally authorized projects (see **Table 4-2**).

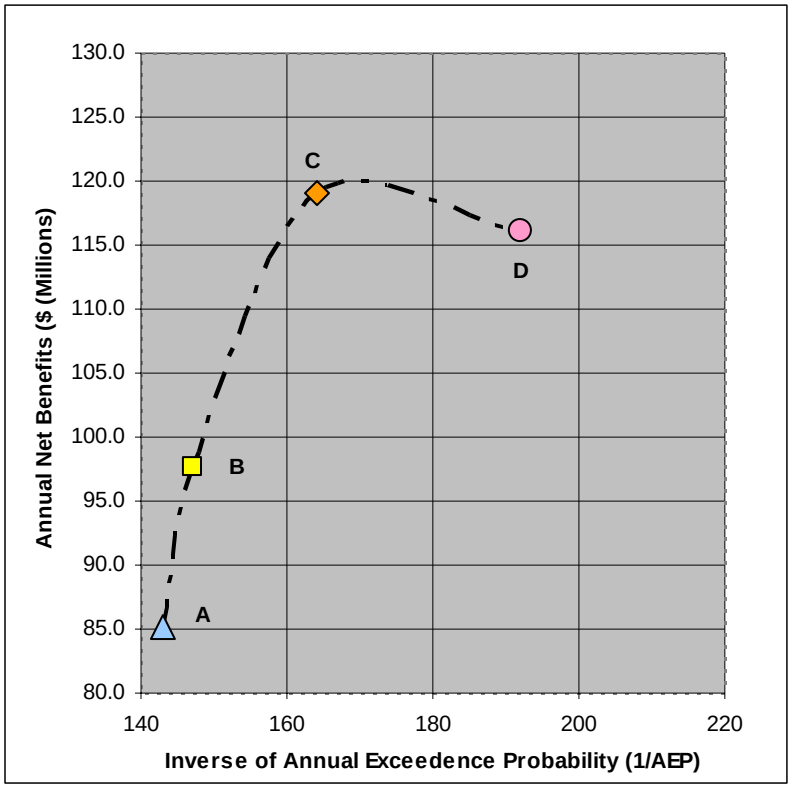


FIGURE 4-1 *(2007 PAC REPORT FIGURE 4-1)*
RELATIONSHIP OF PERFORMANCE TO NET BENEFITS FOR ALTERNATIVES CONSIDERED

TABLE 4-2 *(2007 PAC REPORT TABLE 4-4)*
SUMMARY OF ACTION ALTERNATIVE PLANS CONSIDERED

Item	Alternative			
	A	B	C	D
Major Features				
Outlet Conduits (new and enlarged)	8 outlets	NA	NA	NA
Emergency and Main Spillway Gate Replacement	NA	NA	3 gates	8 gates
No. of Submerged Tainter Gates[1] or Fuseplug	Fuseplug	6 gates	6 gates	6 gates
Folsom Dam Raise (feet)	NA	NA	3.5	7
Performance				
Passes PMF	Yes	Yes	Yes	Yes
Probability of Flooding				
Annual Exceedence Probability	*0.0070*	*0.0068*	*0.0061*	*0.0052*
1 in X Chance in Any Year	*1 in 143*	*1 in 147*	*1 in 164*	*1 in 192*
Design Flood Event (frequency in years)[2]	180	200	240	275
First Cost ($ millions)[3]	630	876	988	1,439
Annual Cost ($ millions)[4]				
Total	60.0	75.3	82.0	113.4
Flood Damage Reduction (less dam safety)	45.1	60.4	67.1	98.5
Annual Flood Damage Reduction Benefits ($ millions)	*130.2*	*143.1*	*171.3*	*199.7*
Net Annual Flood Damage Reduction Benefits ($ millions)	*85.1*	*97.6*	*119.1*	*116.1*
Residual Damages ($ millions)	*97.6*	*115.9*	*141.3*	*172.5*
Percent Damage Reduction	*35*	*42*	*51*	*62*

Key: NA = not applicable No. = number PMF = Probable Maximum Flood

Notes:

1. *Auxiliary spillway submerged tainter gates are 33 feet high by 23 feet wide.*
2. *Design flood event given as the frequency of the maximum computed event that can be safely passed.*
3. *October 2006 price levels.*
4. *50-year period of analysis and 4-7/8 percent discount rate. Does not include ongoing costs to replace water supplies foregone due to continued interim operation; they are to be reevaluated in future studies.*

4.3 Verification of Selected Plan

The information presented in Section 4.2 of this ERR verifies that Alternative C, identified in the *2007 PAC Report* as the Selected Plan, is still an economically viable plan.

4.4 Verification of Refined Authorized Projects

As presented in the *2007 PAC Report*, the Selected Plan, for the Folsom Modification and Folsom Dam Raise projects is Alternative C. The Refined Authorized Projects (RAP) primarily include the Selected Plan, but also include two Other Features. These Other Features are (1) ecosystem restoration components described in the authorized Folsom Dam Raise Project and (2) a permanent bridge increment, also authorized as part of the Folsom Dam Raise Project. The estimated first and annual costs for the RAP are included in **Table 4-3**. The estimated first cost for the Selected Plan based on 2006 price levels is $848.2 million (less the Reclamation dam safety features). The first cost for the RAP in **Table 4-3** is $973.7 million.

The resulting total average annual cost for the Selected Plan component of the RAP attributable to flood damage reduction is $67.1 million. This cost accounts for interest during construction, interest and amortization over the period of analysis, and a current Federal interest rate of $4^7/_8$ percent.

The Selected Plan component of the RAP would reduce the level of flood risk to Sacramento by reducing the probability of flooding from the American River due to levee failure from 1-in-89 chance in any given year that levee failure and flooding will occur in Sacramento from the American River based on annual exceedence probability (AEP) to a 1 in 164 chance.

As **Table 4-3** shows, the estimated net annual flood damage reduction benefits of the RAP are about $119.1 million. The resulting benefit-cost ratio for this plan is 3.3 to 1.

TABLE 4-3 *(2007 PAC REPORT TABLE 4-6)*
SUMMARY OF COSTS AND BENEFITS FOR CORPS PORTION OF SELECTED PLAN AND REFINED AUTHORIZED PROJECTS ($ MILLIONS) [1]

Item	Refined Authorized Projects		
	6 STG Element (Corps Work Package Only)	DR Element + Other Features	Total
First Cost			
Land	0.0	0.2	0.2
Roads and Relocations	0.0	0.0	0.0
Construction	538.6	73.6	612.2
Environmental Mitigation	0.4 [2]	3.0	3.4
Cultural Resources	0.0	0.8	0.8
EDS&A	144.0	37.7	181.7
Subtotal – Selected Plan (less Reclamation Work Package)	683.0	115.3	798.3
Temporary Bridge Increment	0.0	49.9	49.9
Total - Selected Plan (less Reclamation Work Package)	683.0	165.2	848.2
Other Features			
Ecosystem Restoration	0.0	59.8	59.8
Permanent Bridge Increment	0.0	65.7	65.7
Total - RAP (less Reclamation Work Package)	683.0	290.7	973.7
Investment Cost			
First Cost (Selected Plan) [3]	683.0	115.3	798.3
Less Cultural Resources	0.0	-0.8	-0.8
Less Sunk Costs	-55.9	-22.1	-78.0
IDC	*215.4*	*32*	*247.4*
Total	*842.5*	*124.4*	*966.9*
Interest and Amortization	*45.3*	*6.7*	*51.9*
Operation and Maintenance	0.2	0.1	0.3
Subtotal	*45.5*	*6.8*	*52.2*
Annual Flood Damage Reduction Benefits	*143.1*	*28.2*	*171.3*
Net Annual Flood Damage Reduction Benefits	*97.6*	*21.4*	*119.1*
Benefit-to-Cost Ratio for Flood Damage Reduction	*3.1*	*4.2*	*3.3*

Key:
DR = dam raise
EDS&A = engineering, design, supervision, and administration
IDC = interest during construction
MCACES = microcomputer-aided cost engineering system
RAP = Refined Authorized Projects
STG = submerged tainter gate

Notes:
1. *MCACES October 2006 price levels.*
2. *Environmental mitigation for previous work and treated as a portion of sunk costs.*
3. *First and annual cost for the Selected Plan portion of RAP only - less Reclamation Work Package and Other Features costs.*
4. *50-year period of analysis, and $4^{7}/_{8}$ percent interest rate.*

CHAPTER 5.0
CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Conclusions or portions of conclusions set forth in the *2007 PAC Report, Chapter 8, Conclusions and Recommendations,* which are affected by this ERR are updated here with references to bullet order sequence presented in that document.

5th bullet. [6 STG Element.] The average annual equivalent benefits are $143.1 million. The benefit-to-cost ratio is 3.1 to 1.

6th bullet. [DR Element.] The incremental increased average annual equivalent benefits and benefit to cost ratio are $28.2 million and 4.2 to 1, respectively.

7th bullet. [Selected Plan.] The total annual cost attributable to flood damage reduction is $67.1 million. The average annual equivalent benefits are $171.3 million. The benefit-to-cost ratio is 3.3 to 1.....The Selected Plan portion of the RAP would result in a reduction of the flood risk in Sacramento from a 1-in-89 chance to a 1-in-164 chance in any given year that levee failure and flooding will occur in Sacramento from the American River based on annual exceedence probability (AEP) of 0.0061.

8th bullet. [Selected Plan] The AEP of the RAP is 1 in 0.0061.

25th bullet. [RAP.] Following implementation of the project, the estimated average annual flood damages would be reduced by 51 percent to $136.2 million.

5.2 Recommendations

Based on the findings presented in this report and supporting documents, I recommend approval of the ERR, which verifies the recommendation for approval of the RAP that was set forth in the *2007 PAC Report*.

The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program, nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are approved by the agency.

_____
Ronald N. Light
Colonel,
Corps of Engineers
District Commander

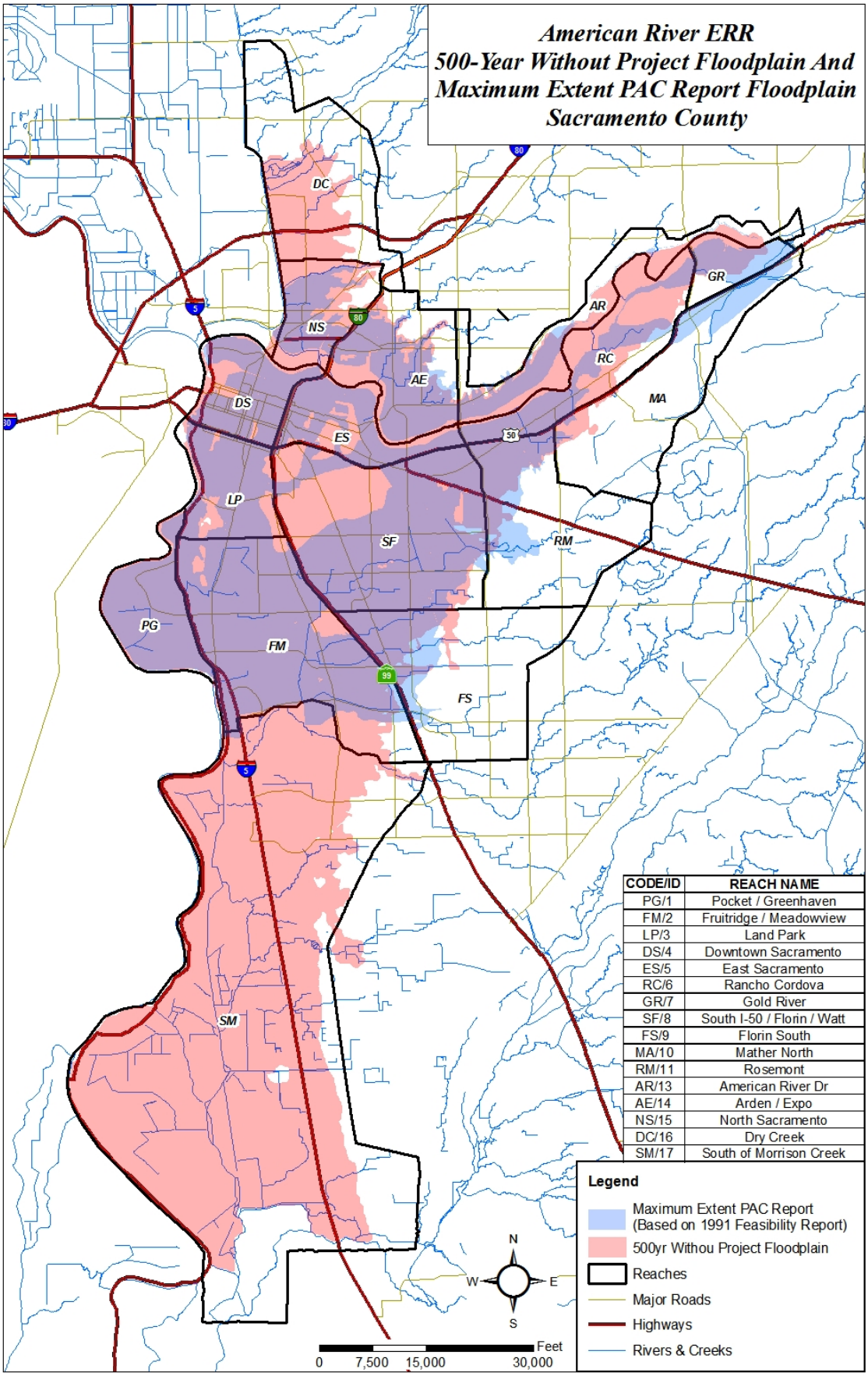


Plate 1. Comparison of ERR 500-Year Without-Project Floodplain with Maximum Extent 2007 PAC Report Floodplain.