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110th Congress, 1st Session – – – – – – – – – – – – – – House Document 110–63

FLOOD DAMAGE REDUCTION PROJECT REAUTHORIZATION

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY FOR CIVIL WORKS, THE DEPARTMENT OF DEFENSE

TRANSMITTING

NOTIFICATION THAT THE SECRETARY OF THE ARMY SUPPORTS THE REAUTHORIZATION OF THE AMERICAN AND SACRAMENTO RIVERS, FOLSOM DAM MODIFICATION, CALIFORNIA, AS PROVIDED IN SECTION 3029(b) OF THE WATER RESOURCES DEVELOPMENT ACT OF 2007



OCTOBER 17, 2007.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

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DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

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U.S. HOUSE OF REPS.

AUG 27 2007

Honorable Nancy Pelosi
Speaker of the House
of Representatives
U.S. Capitol Building, Room H-232
Washington, D.C. 20515-0001

Dear Madam Speaker:

The Secretary of the Army supports reauthorization of the American and Sacramento Rivers, Folsom Dam Modification, California, flood damage reduction project as provided in Section 3029(b) of the pending Water Resources Development Act of 2007 at a total cost of $683,000,000. The reauthorization is necessary for the U.S. Army Corps of Engineers to participate in the joint Corps – Bureau of Reclamation project at Folsom Dam because the construction costs for the Corps' features are projected to exceed the maximum allowed by Section 902 of the Water Resources Development Act (WRDA) of 1986. Section 128 of the Energy and Water Development Appropriations Act of 2006, directed the Secretary of the Army and the Secretary of the Interior to collaborate on authorized activities to maximize flood damage reduction improvements and address dam safety needs at Folsom Dam. The collaborative effort led to the enclosed March 2007 Post Authorization Change Report, which explains and supports the cost increase. This report also documents that the project remains economically justified and environmentally acceptable, and recommends Federal cost sharing in accordance with Section 103 of the WRDA of 1986, as amended.

The Folsom Dam Modification Project was authorized by Section 101(a)(6) of the WRDA of 1999 at a cost of $150,000,000, with an estimated Federal cost of $97,500,000 and an estimated non-Federal cost of $52,500,000. Section 902 of WRDA of 1986 established a maximum total project cost, which would be exceeded by the current estimated project cost. Since the original authorization, the project cost has increased by about $533,000,000. About $92,500,000 of the increase is due to inflation, about $412,500,000 is due to refined quantities and construction costs, and the remaining $28,000,000 of the project cost increase is due to changes in project features.

The Post Authorization Change Report also addresses the Folsom Dam Raise Project, authorized by Section 128 of the Energy and Water Development Appropriations Act of 2004, as well as related dam safety concerns. The report identifies the most efficient and effective plan to expeditiously maximize flood damage reduction and address dam safety needs while utilizing the existing authorizations. The resulting recommendation would further modify both Corps projects to reduce flood damages and save costs in concert with the Bureau of Reclamation's dam safety

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measures. The Folsom Dam Modification Project would consist of constructing a new auxiliary spillway and stilling basin in lieu of the authorized outlet and stilling basin modifications, and in lieu of an emergency fuse plug spillway proposed to address dam safety concerns. The Folsom Dam Raise Project would not require additional authority and would raise a wing dam and appurtenant dikes 3.5 feet, replace 3 emergency spillway gates, advance the construction of a single bridge, and retain the ecosystem restoration plan. The modifications would achieve greater downstream flood damage reduction and dam safety more effectively than the previously authorized projects and provide greater net benefits. The chance of exceeding the capacities of downstream levees in the Sacramento area in any given year would improve from a 1 in 81 chance to a 1 in 185 chance. The projects, in conjunction with the Bureau of Reclamation's dam safety work, would enable Folsom Dam to safely pass the Probable Maximum Flood.

Based on October 2006 prices, the Army Corps of Engineers estimates total project first costs for the Folsom Dam Modification Project at $683,000,000. In accordance with the cost sharing requirements of Section 103 of the WRDA of 1986, as amended by Section 202(a) of the WRDA of 1996, the Federal cost is about $444,000,000 and the non-Federal cost is about $239,000,000. The enclosed Post Authorization Change Report provides current data on project benefits and costs, and re-affirms that the project continues to be justified, with annual benefits of $89,900,000, annual costs of $37,900,000 and a benefit-to-cost ratio of 2.4.

The estimated cost for the recommended Folsom Dam Raise Project is $290,700,000, including $165,200,000 for flood damage reduction, $59,800,000 for ecosystem restoration, and $65,700,000 for transportation (bridge). The flood damage reduction element of the project continues to be justified (other portions are or will be addressed separately), with annual benefits of $17,200,000, annual costs of $5,600,000 and a benefit-to-cost ratio of 3.1. In accordance with the cost sharing requirements of Section 103 of WRDA 1986, as amended, the Federal cost of the flood damage reduction element is about $115,200,000 and the non-Federal cost is about $50,000,000. The Federal cost includes $21,500,000 for relocation costs for the bridge feature that are subject to a Bureau of Reclamation determination of the portion, if any, that the Central Valley Project water or power contractors should reimburse. No additional authorization is necessary to implement the Folsom Dam Raise Project.

The Post Authorization Change Report documents there are no fundamental changes in environmental considerations or conditions associated with the project since authorization. The Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR), dated March 2007, documents environmental compliance for the recommended plan. A Record of Decision (ROD) was signed on May 3, 2007, completing the National Environmental Policy Act process.

The Bureau of Reclamation intends to proceed with site work and excavation for the auxiliary spillway and stilling basin later this year under the Safety of Dams Program. However, construction of the Corps of Engineers' Folsom Dam Modification Project can not proceed until the Section 902 cost limit is increased. If the cost limit is

not increased in a timely manner, then the Bureau of Reclamation will likely construct a fuse plug emergency spillway as a temporary, if not permanent, solution to ensure dam safety, and thus eliminate a significant cost savings of the joint efforts. The Folsom Dam Raise Project would be implemented after the Folsom Dam Modification Project is implemented.

The non-Federal sponsors, the State of California (Reclamation Board) and the Sacramento Area Flood Control Agency, are aware of the changes in project features and costs, and remain willing and capable of meeting their increased responsibilities. We plan to construct the projects through the normal budget process.

The Office of Management and Budget (OMB) advises that there is no objection to the submission of the report to Congress. A copy of its letter is enclosed in the report. I am providing a copy of this transmittal and the OMB letter dated August 20, 2007, to the House Subcommittees on Energy and Water Development, and Water Resources and Environment in accordance with the requirements of the Fiscal Year 2006 Omnibus Appropriations Act (P.L. 109-103).

Very truly yours,

John Paul Woodley, Jr.

John Paul Woodley, Jr.
Assistant Secretary of the Army
(Civil Works)

Enclosures

3 Enclosures

1. OMB Clearance Letter, dated August 20, 2007
2. Director of Civil Works Memorandum for Assistant Secretary of the Army (CW), dated April 25, 2007
3. American River Watershed Project, Folsom Dam Modification and Folsom Dam Raise Projects, California, Post Authorization Change Report, March 2007, and Folsom Dam Safety and Flood Damage Reduction, Final Environmental Impact Statement/Environmental Impact Report, Folsom, California, March 2007

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

August 20, 2007

The Honorable John Paul Woodley, Jr.
Assistant Secretary of the Army (Civil Works)
108 Army Pentagon
Washington D.C. 20310-0108

Dear Mr. Woodley:

As required by Executive Order 12322, the Office of Management and Budget has completed its review of your recommendation concerning the Post Authorization Change Report for the American River Watershed Project, Folsom Dam Modification and Folsom Dam Raise Projects.

Your recommendation for this project is consistent with the policy and programs of the President. The Office of Management and Budget does not object to you submitting this report to Congress.

Sincerely,

Richard A. Mertens
Deputy Associate Director
Energy, Science, and Water

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DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET NW
WASHINGTON, D.C. 20314-1000

APR 2 5 2007

CEMP-SPD

MEMORANDUM FOR THE ASSISTANT SECRETARY OF THE ARMY (CIVIL WORKS)

SUBJECT: Post-Authorization Change Report for the American River Watershed, Folsom Modifications and Folsom Dam Raise Projects, California (Folsom Joint Federal Project)

1. PURPOSE: To request approval of the Post-Authorization Changes to the authorized American River Watershed, Folsom Modifications and Folsom Dam Raise Projects, to seek Congressional authorization for an increase in the total cost of the Folsom Modifications project, and to request approval of the Record of Decision for the Joint Federal Project to allow the U.S. Army Corps of Engineers to participate with the Bureau of Reclamation in construction of the Folsom Joint Federal Project.

2. SYNOPSIS: The "Folsom Joint Federal Project" involves construction of an auxiliary spillway with six flood gates that provides the flood damage reduction outputs authorized by the Folsom Modifications project and satisfies the Bureau of Reclamation dam safety needs. The Post-Authorization Change report describes a comprehensive plan to improve flood damage reduction for the City of Sacramento, including: (1) Folsom Modifications; (2) Folsom Dam Raise; and (3) other features. The Folsom Modifications project is the authority being used for the Corps portion of the Joint Federal Project. The authorized Folsom Dam Raise project will require additional environmental compliance actions and is not scheduled to be implemented for several years. The other features are currently being implemented, and include previously authorized ecosystem restoration work and construction of the permanent Folsom bridge. This decision memo requests approval for Corps participation in the Folsom Joint Federal Plan only.

3. BACKGROUND: The Sacramento District and South Pacific Division have completed the Final Post-Authorization Change and Engineering Documentation Report, which provides the basis for the increase in the estimated total project cost and documents the rationale for recommending Corps participation with the Bureau of Reclamation in construction of the Joint Federal Project and other features, in lieu of previously authorized plans. The enclosed Post Authorization Change Report is summarized in the following paragraphs. HQ review of the final report is complete.

The comprehensive plan for improved flood damage reduction primarily consists of construction of a new gated auxiliary spillway southwest of Folsom Dam, 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 primary

Encl 2

objectives of this comprehensive plan are increased flood damage reduction and improved features for dam safety. This plan would increase the level of flood protection to Sacramento by reducing the probability of flooding from the American River from a 1 in 81 chance in any year to a 1 in 185 chance. Costs and benefits of the plan features are depicted in the following table.

ECONOMIC COSTS AND BENEFITS OF COMPREHENSIVE PLAN ($ MILLIONS)

Item	Folsom Mods (Auxiliary Spillway)	Dam Raise & Other Features	Total
First Cost:			
Flood Damage Reduction	683.0	165.2	848.2
Other		125.5	125.5
Total	**683.0**	**290.7**	**973.7**
Annual Cost (Flood Damage Reduction)	37.9	5.6	43.5
Annual Benefits (Flood Damage Reduction)	89.9	17.2	107.1
Net Benefits	52.0	11.6	63.6
Benefit-Cost Ratio	2.4	3.1	2.5

4. DISCUSSION - Authorities:

a. Folsom Modification Project. Section 101(a) (6) of the Water Resources Development Act (WRDA) of 1999, Public Law (PL) 106-53, provides authorization for the Folsom Modification Project. It directed the Corps to implement a project to modify Folsom Dam and Reservoir generally as described in the March 1996 Supplemental Information Report and as modified by a March 1998 report by the Sacramento Area Flood Control Agency (SAFCA). The total authorized cost was $150 million. This authority must be amended to increase the total project cost.

b. Folsom Dam Raise Project. Section 128 of the Energy and Water Development Appropriations Act of 2004 (PL 108-137) directed the Secretary of the Army to carry out a project for flood damage reduction and environmental restoration, as described in a Report of the Chief of Engineers, dated November 2002, at a total cost of $257.3 million. Ecosystem restoration and the Folsom permanent bridge were included in the Folsom Dam Raise Project authority, and are being implemented as authorized with no proposed changes. There are no changes required to this authority.

c. Project Collaboration. Section 128 of the Energy and Water Development Appropriations Act of 2006 (PL 109-103) directed the Secretary of the Army and the Secretary of the Interior to collaborate on authorized activities to maximize flood damage reduction improvements and address dam safety needs at Folsom Dam. Pursuant to this legislation, the Secretaries are to consider reasonable modifications to existing authorized activities, including an auxiliary spillway.

5. DISCUSSION – 902 limit:

a. The calculated 902 limit for the authorized Folsom Modifications project is $245,600,000. During contract solicitation for the first phase of construction, key elements of high risk placed on contractors, limited competition, and significant escalation of construction material costs were identified that would increase the total project cost well above the maximum allowable limit. The Corps, in collaboration with the Bureau of Reclamation, reconfigured the Folsom Modifications project as part of the Joint Federal Project. The revised total cost for the Corps portion of the joint effort is approximately $683,000,000 which exceeds the 902 limit of the Folsom Modifications authority. Using the authorized cost share formula, the Federal share is $444,000,000 and the non-Federal share is $239,000,000.

6. DISCUSSION – Environmental Compliance:

a. As a companion to the Post-Authorization Change report, the Corps and Bureau of Reclamation cooperated in preparation of the 2007 Final Folsom Dam Safety/Flood Damage Reduction Environmental Impact Statement/Environmental Impact Report (EIS/EIR). Reclamation is the lead Federal agency, with participation by the Corps as a cooperating agency. The document discloses potential environmental impacts of action alternatives meeting Corps flood damage reduction and Reclamation dam safety objectives. The EIS/EIR includes information being developed by Reclamation as part of ongoing designs and construction of dam safety improvements at Folsom Dam under the Reclamation Safety of Dams Program. The Federal Register notice for the Final EIS/EIR was published on 30 March 2007. On 20 April 2007, the Corps filed a notice of intent to adopt the 2007 Final Folsom Dam Safety/Flood Damage Reduction Final EIS/EIR to satisfy the requirements of the National Environmental Policy Act (NEPA) for changes to the originally authorized Folsom Modification project.

b. The Corps and Reclamation cooperatively developed the enclosed Record of Decision for the Folsom Joint Federal Project. We are providing it for review, approval, and execution at this time. At this time we are also providing a draft Record of Decision for the Folsom Dam Raise, for information only. We anticipate additional environmental compliance activities for the Dam Raise portion of the comprehensive plan, which will be accomplished over the next several years. A final Record of Decision for the Dam Raise will be required at that time.

CEMP-SPD
SUBJECT: Post-Authorization Change Report for the American River Watershed, Folsom Modifications and Folsom Dam Raise Projects, California (Folsom Joint Federal Project)

c. The enclosed draft Memorandum of Understanding (MOU) between the Bureau of Reclamation and the Corps of Engineers establishes the mutual framework for the respective responsibilities of the two agencies. This MOU, provided for your information, will be executed between the Bureau of Reclamation regional project officer and the Sacramento District Engineer.

7. RECOMMENDATIONS:

a. That you approve the Post-Authorization Change report for the American River Watershed, Folsom Modifications and Folsom Dam Raise Projects, California.

b. That you transmit the Post-Authorization Change Report to Congress as a basis for authorization of a modification to the project to increase the total project cost of the American River Watershed (Folsom Modifications) to $683,000,000. Draft documents necessary to coordinate this recommendation with the Office of Management and Budget are enclosed for your use.

c. That you approve the Record of Decision for the Folsom Joint Federal Project (Corps of Engineers Folsom Modifications and Bureau of Reclamation Dam Safety). The Bureau of Reclamation requests execution of the joint Record of Decision by 7 May 2007 to maintain their timetable for initiation of work.

DON T. RILEY
Major General, USA
Director of Civil Works

Enclosures:
1. Record of Decision for Joint Federal Project
2. Record of Decision for Folsom Dam Raise
3. Draft letters to OMB and Congress
4. Draft MOU for joint agency implementation
5. Post-Authorization Change Report

Post Authorization Change Report

American River Watershed Project

Folsom Dam Modification and
Folsom Dam Raise Projects



Appendices

US Army Corps
of Engineers

Sacramento District
South Pacific Region

March 2007



Post Authorization Change Report

American River Watershed Project

Folsom Dam Modification and
Folsom Dam Raise Projects

Appendix A
Folsom Modification Project
Engineering Documentation Report



US Army Corps of Engineers

Sacramento District
South Pacific Region

March 2007

EXECUTIVE SUMMARY

This Engineering Documentation Report (EDR) is an engineering refinement and technical implementation document to support the Post Authorization Change (PAC) report of the authorized Folsom Modification Project to be implemented by the United States Army Corps of Engineers, Sacramento District (Corps), which has an objective of improving flood damage reduction on the lower American River through structural modifications to the existing Folsom Dam and appurtenant facilities. Construction bids for the first phase of the original authorized project were higher than estimated, requiring the need to look at alternative design approaches to the original project. The purpose of this EDR is to evaluate design refinement alternatives that provide all the functionality that would have been achieved by the authorized Folsom Modification Project and examine the advantages and disadvantages of each technical alternative, including cost and performance data, in coordination with other programs and efforts at Folsom Dam. The Folsom Modification Project authorization did not have dam safety as a project objective. Therefore, the auxiliary spillway alternatives presented in this EDR reflect achieving only the flood damage reduction objective comparable to the original outlet modification project (six enlarged outlets plus two new outlets plus two existing main dam river outlets).

The primary objective of the authorized Folsom Modification Project is to provide additional flood damage reduction through modifications to the dam to allow for better utilization of the existing flood storage space. The authorized project modifies the main dam river outlet capacity by enlarging the existing main dam river outlets and constructing two new main dam river outlets that together will increase the release capacity to 115,000 cfs with the reservoir pool at spillway crest at 418 feet above mean sea level (elevation 418). The capability of maintaining the flood storage space by early releases of up to 115,000 cfs was calculated to reduce the probability of flooding in any one year from one chance in 81 to one chance in 154.

The Folsom Modification Project was also authorized to modify the emergency spillway release diagram (ESRD) and certain physical features of the dam and dikes to allow the water surface elevation of the reservoir to "surcharge" four feet higher than currently allowed under reservoir operation criteria. This additional surcharge would add approximately 46,200 acre-feet of flood storage space and would allow for controlled emergency releases of up to 160,000 cfs for a longer period of time. However, in the Limited Reevaluation Report (LRR) of November 2003, a recommendation was made to defer the implementation of the surcharge storage feature of this authorization to ensure design compatibility with the associated authorized Folsom Dam Raise Project that also addresses surcharge.

Currently, Folsom Dam has limited capability to make objective flood releases until the reservoir is nearly 75 percent encroached into the flood pool. Flood releases are limited to the existing eight main dam river outlets prior to the reservoir pool rising above the spillway crest at elevation 418. Normal flood operations at Folsom Dam would limit downstream flows to a maximum of 115,000 cfs. Upon completion of the Common Features

Project, outflows from the dam could be increased from 115,000 cfs to the new non-damaging channel capacity of the lower American River of 160,000 cfs. The downstream objective flow of 115,000 cfs is reached when the reservoir level reaches elevation 447, through a combination of flows through the penstocks, main dam river outlets, and the five primary service tainter gates. To avoid potential cavitation problems, the main dam river outlet openings are reduced to 60 percent when the main service tainter gates are in operation.

Key design considerations include constructibility and the environment. Constructibility considerations are: (1) availability of all main dam river outlets for flood releases at 24 hours notice; (2) availability of all service tainter gates for releases at 24 hours notice; (3) avoidance of disturbance of existing utilities and dam operations, if practical; and (4) minimization of potential erosion problems below the emergency spillway chute and adjacent areas. Environmental considerations include: (1) utilization of best management practices to limit disruption of aquatic habitat and turbidity resulting from construction operations; (2) minimization of construction impacts to existing habitat and fish; and (3) optimization of noise and air quality factors from construction activities.

PROJECT DESCRIPTION

The Folsom Modification Project was originally authorized in the 1999 Water Resources Development Act (WRDA 1999). The authorized plan included elements of the Folsom Modification Plan as described in the *American River Watershed Project, California, Supplemental Information Report* (1996 SIR), and subsequently modified in the Sacramento Area Flood Control Agency (SAFCA) Information Paper *Folsom Dam Modification Report, New Outlets Plan*, dated March 1998. Because the project authorized in WRDA 1999 differed from what was presented in the 1996 SIR, Headquarters, United States Army Corps of Engineers provided guidance on the intent of this authorization, directing that a decision document be prepared to support the authorized project. An LRR was prepared in August 2001. The primary purpose of the LRR was to demonstrate that the authorized operational and structural modifications to Folsom Dam are economically justified, are technically sound, are environmentally acceptable and clearly define the project features. As part of the reevaluation effort, the design of the authorized plan was examined to determine if enlarging the eight existing main dam river outlets would result in a cost savings compared to constructing new river outlets beneath the emergency spillway and constructing a new stilling basin downstream of the emergency spillway. As a result of this evaluation, a plan to enlarge the eight existing main dam river outlets was developed, with the outlets designed to allow for concurrent spillway releases. Following the publication of the LRR document in 2001, constructability and operability reviews of the enlarged main dam river outlets proposed in the LRR prompted additional design refinements. At the same time, further studies for yet additional flood protection and for dam safety were being conducted, which were documented in the February 2002 American River Watershed Long-Term Study Final Supplemental Plan Formulation Report (2002 Long-Term Study). To assimilate common features between the 2001 LRR and the 2002 Long-Term Study and to reflect changes in the Folsom Modification Project design since publication of the 2001 LRR, the LRR was revised in a final LRR report dated November 2003, which was submitted to the Assistant Secretary of the Army and approved in January 2004.

Engineering documents were prepared for construction implementation of the project proposed in the 2003 LRR. The Folsom Dam Outlet Works Modification Project Design Documentation Report (DDR) dated February 2004 discussed the Folsom Modification Project in two parts: The Outlet Works Modification Project (with the function to increase release capacity) and the Surcharge Storage Modification Project (with the function to modify the use of surcharge storage).

Implementation of the features of the modified use of surcharge storage function would provide additional flood control storage of 46,200 acre-feet. Under existing conditions, the ESRD and physical features of the dam allow for surcharge storage to elevation 470 without overtopping the existing emergency tainter gates in their closed position. When the reservoir exceeds elevation 470, the emergency tainter gates must be open and the dam would release more than the objective release, potentially causing downstream flooding. The surcharge storage modifications described in the original authorization would require both physical and operational changes to allow the flood pool to surcharge to elevation 474. The features associated with the surcharge storage project would include replacement of the three existing emergency tainter gates, raising the penstock hydraulic control pumps and controls, and increasing the height of the impervious core in Dikes 5 and 7 and the Mormon Island Auxiliary Dam (MIAD).

The features of the increase release capacity function were to include installation of new main dam river outlets through the concrete portion of the existing dam, enlargement of the existing river outlets, and modifications to the existing spillway and stilling basin as necessary. The new and enlarged main dam river outlets were to increase the release capacity to 115,000 cfs with the reservoir pool at spillway crest (elevation 418). The capability of maintaining the flood storage capacity gained by early release would reduce the probability of flooding in any one year from one chance in 81 to one chance in 154. Subsequent to the February 2004 (DDR), it was decided to divide the modification of the ten main dam river outlets into two contracts: an upper tier contract comprised of six river outlets, and a lower tier contract comprised of a maximum of four river outlets. Construction documents were prepared for the six upper tier river outlets. Proposals were received in March 2005 but exceeded the fully funded, updated authorized cost (Section 902 limit). The solicitation was canceled in January 2006.

Without implementation of the Folsom Modification Project, significant flood protection risks remain. In the Energy and Water Development Appropriations Act of 2006, Congress directed the Corps and the United States Department of the Interior, Bureau of Reclamation (Reclamation) to integrate their efforts at Folsom Dam to maximize flood damage reduction improvements, address dam safety, and give consideration to a new auxiliary spillway for the purpose of developing a single project that integrates both agencies' objectives. This project was described in the report entitled *Folsom Dam Raise and Auxiliary Spillway Alternative, Project Alternative Solutions Study (PASS) II* dated June 2006 and presented and engineered evaluation of an auxiliary spillway alternative consisting of four 17 foot 7 inches wide by 33 foot high submerged tainter gates (STGs) and a dam raise of seven feet.

Optimization efforts of the PASS alternative were initiated, the technical evaluations of which are the subject of these EDR appendices. The alternatives to the authorized Folsom Modification Project consist of various combinations of new, enlarged, or existing main dam river outlets, the replacement of some or all of the existing main dam tainter gates, and a new auxiliary spillway. The auxiliary spillway would be a major new structural component of the Folsom Facility, consisting of an excavated approach channel, a concrete control structure housing STGs for flow release, and a rectangular downstream chute and a stilling basin.

The location of the proposed auxiliary spillway would be the same in all the alternatives examined. The approach channel of the auxiliary spillway would be located in the existing parking lot overlook area in the left abutment, and the spillway would extend from near the abutment of the left wing dam west-northwesterly to the American River channel downstream of the main concrete dam.

The following six alternatives are discussed in this EDR:

- Eight enlarged plus two new main dam river outlets (2003 LRR plan – the currently authorized project)
- Six enlarged, two new, and two existing main dam river outlets (baseline alternative for functional equivalence)
- Four-STG auxiliary spillway (least cost alternative that provides all of the functionality of the authorized Folsom Modification Project)
- Four-STG auxiliary spillway with three emergency tainter gates replaced on the main dam
- Six-STG auxiliary spillway (least cost alternative that provides all of the functionality of the authorized Folsom Modification Project that also passes the probable maximum flood [PMF])
- Six-STG auxiliary spillway with three emergency tainter gates replaced on the main dam

The main dam outlets alternatives examined in this EDR consist of two combinations of new or enlarged main dam river outlets. These two alternatives provide different levels of release capacity at significantly different costs.

The new auxiliary spillway alternatives presented in the EDR would be used in conjunction with the existing main dam river outlets and would be implemented either with or without replacing the three existing emergency tainter gates on the main dam.

A tabular summary of the Folsom Modification Project alternatives is presented in **Table ES-1**. The table provides information on whether an alternative provides all the functionality that would have been achieved by the baseline alternative (six enlarged main dam outlets plus two new main dam outlets and two existing main dam outlets) for the Modification authorization, the estimated first cost and the estimated annual cost for each of

the alternatives, the performance for each alternative, and the design flood event that each alternative would pass.

TABLE ES-1
FOLSOM MODIFICATION PROJECT ALTERNATIVES

Alternative Description	Functionality Compared to the Authorized Project	First Cost	Annual Costs	Performance (Inverse of AEP)	Design Event Passed
		(millions)	(millions)	(1:X Chance)	(years)
Eight enlarged and two new main dam river outlets	N/A	$785	$45.8	154	200
Six enlarged, two new and two existing main dam river outlets	Baseline	$630	$36.1	147	180
Four 17'-7" by 33' STG Auxiliary Spillway	Equal	$633	$34.4	149	180
Four 17'-7" by 33' STG Auxiliary Spillway; Three Emergency Tainter Gates Replaced	Equal	$675	$36.8	149	180
Six 23' by 33' STG Auxiliary Spillway*	Greater	$889	$50.0	156	200
Six 23' by 33' STG Auxiliary Spillway; Three Emergency Tainter Gates Replaced*	Greater	$930	$52.4	156	200

*Note : *These alternatives pass the PMF.*

HYDROLOGY AND RESERVOIR OPERATIONS

The Corps' understanding of the hydrology of Folsom Dam and the American River Drainage Basin is presented, including a discussion of design floods and the PMF. Also discussed are reservoir operations based on the Water Control Diagram (WCD) and ESRD as they exist currently, and as they would be modified for various alternatives examined for the Folsom Modification Project.

Table ES-2 outlines some of the basic assumptions adopted as WCD or ESRD operational criteria.

TABLE ES-2
WATER CONTROL DIAGRAM AND EMERGENCY SPILLWAY RELEASE DIAGRAM

Condition	Outflow Restriction
Maximum objective release allowed by WCD (larger releases may be initiated by ESRD)	115,000 cfs
Maximum allowable rate of release change Increases: When discharge is greater than 20,000 cfs and less than or equal to 160,000 cfs When discharge is greater than 160,000 cfs Decreases: When discharge is greater than 20,000 cfs	 15,000 cfs/hour Unlimited 5,000 cfs/hour (decrease)
Maximum outflow allowed by WCD or ESRD	Do not exceed maximum inflow experienced during flood event
Release limitation if the actual or forecasted inflow is greater than 25,000 cfs and less than 150,000 cfs and reservoir is less than 20 percent encroached	Limit outflow to 60 percent of the maximum inflow experienced during the flood event
Maximum power available or relied upon for flood operations	Power penstocks would be assumed to have zero release capacity during all routings
Physical limitation of existing emergency tainter gates	Emergency tainter gates are not used until either the total outflow from the dam exceeds 240,000 cfs or the pool elevation is within 1 foot of overtopping the emergency tainter gates while in the closed position
Release requirements (115,000 cfs to 160,000 cfs) based on Accelerated Transition Zone conditions as outlined on the proposed ESRD: if current inflow is greater than 200,000 cfs and the 12-hour forecasted inflow is greater than 360,000 cfs if current inflow is greater than 250,000 cfs and the 12-hour forecasted inflow is greater than 370,000 cfs if the current inflow is greater than 270,000 cfs and the 12-hour forecasted inflow is greater than 370,000 cfs	 Increase release to 130,000 cfs Increase release to 145,000 cfs Increase release to 160,000 cfs
KEY: WCD – Water Control Diagram ESRD – Emergency Spillway Release Diagram cfs – cubic feet per second cfs/hour – cubit feet per second per hour (flow rate of change)	

Design of the existing ESRD restricts the maximum discharge to 160,000 cfs until the reservoir's pool reaches elevation 470. Once the reservoir water surface exceeds elevation 470, the ESRD allows releases to be increased above the 160,000 cfs limitation. However, releases should not be made through the three emergency tainter gates until discharge in the

stilling basin reaches 240,000 cfs to avoid incurring damages. The contradiction in the ESRD is that it does not take into account the physical and operational limitations of the emergency spillway. When the emergency tainter gates are closed, the top of the gates is elevation 471. The routing model can force operation of the emergency tainter gates. The water surface must be within 1 foot of the top of the gates for this to occur. Sufficient tailwater is required to prevent erosion below the emergency spillway chute and adjacent areas. Although the existing ESRD does not require a discharge of 240,000 cfs until the pool rises above elevation 472, the dam operator can choose to make a larger releases sooner. The effect of delaying operation of the emergency tainter gates is that above elevation 471, water would begin to flow over the top; possibly causing damages, failure, or making the gates inoperable.

A large number of alternatives were screened to determine which one best serves as the with-project condition. The configurations included various combinations of main dam river outlet modifications, auxiliary spillway with STGs, conventional tainter gates, and Reclamation's emergency fuseplug spillway design. The various tainter gate combinations were analyzed at differing sill elevations for the auxiliary spillway. Combinations of modifications to the main dam river outlets were also analyzed, and advance release criteria were incorporated into the release decisions. Of the numerous configurations considered, this document focuses on the with- and without-project conditions listed below:

- Common Features - without-project condition: Section 101(a) (1) of WRDA 1996 authorized construction of features that were common to three candidate plans identified by the Corps, SAFCA, and the State of California Reclamation Board (State Reclamation Board). Those commonalities included the following:
  - Levee modification along both banks of the lower American River
  - Levee modification along the east bank of the Sacramento River downstream from the Natomas Cross Canal
  - Installation of streamflow gages upstream from Folsom Reservoir and modification to a flood warning system along the lower American River
- New main dam river outlets and modification of existing main dam river outlets; no auxiliary spillway; original authorization; with-project condition
- New main dam river outlets and modification of existing main dam river outlets; no auxiliary spillway; adaptation of original authorization; with-project condition
- No main dam river outlet modification; four-submerged 17-foot by 33-foot tainter gate auxiliary spillway; with-project condition
- No main dam river outlet modification, four-submerged 17-foot by 33-foot tainter gate auxiliary spillway, emergency tainter gate replacement, with-project condition
- No main dam river outlet modification; six-submerged 23-foot by 33-foot tainter gate auxiliary spillway; with-project condition

- No main dam river outlet modification, six-submerged 23-foot by 33-foot tainter gate auxiliary spillway, emergency tainter gate replacement, with-project condition

The resultant maximum elevations, obtained through routing the PMF through each of the proposed alternatives is provided in **Table ES-3**.

TABLE ES-3
MAXIMUM PROBABLE MAXIMUM FLOOD ELEVATIONS

Alternative	Maximum El, feet	
Without-Project Condition	**PMF**	**Top of Dam**
Common Features (model run R000_800CF)	483.2[1]	480.5
With-Project Condition		
New main dam river outlets and modification of existing main dam river outlets; no auxiliary spillway;	482.9[1]	480.5
New main dam river outlets and modification of existing main dam river outlets; no auxiliary spillway; Adaptation of original authorization	480.8[1]	480.5
No main dam river outlet modification; four submerged (17- by 33-foot) tainter gate auxiliary spillway;	480.8[1]	480.5
No main dam river outlet modification; four submerged (17- by 33-foot) tainter gate auxiliary spillway; emergency tainter gate replacement	481.3[1]	480.5
No main dam river outlet modification; Six submerged (23- by 33-foot) tainter gate auxiliary spillway	477.4	480.5
No main dam river outlet modification; Six submerged (23- by 33-foot) tainter gate auxiliary spillway; emergency tainter gate replacement	477.9[1]	480.5
KEY: PMF – Probable maximum flood El, feet – Elevation in feet		

Notes:
1 Alternatives do not meet the minimum freeboard space requirement of at least 3 feet.

ENVIRONMENTAL EFFECTS AND MITIGATION

An examination of environmental effects from construction of the Folsom Modification Project is discussed. Several previous environmental documents are relevant to the impact analysis for the main dam river outlet modification alternatives. These documents provided information about existing environmental, socioeconomic, and cultural conditions in the area; the effects of various actions on the resources in the area; and potential measures to avoid, minimize, reduce, or compensate for any significant effects. Resources studied include hydrology, water quality, groundwater, water supply, air quality, aquatic resources, terrestrial vegetation and wildlife, soils, minerals, geological resources, visual resources, agricultural resources, and transportation.

- **Air Quality:** Exhaust and fugitive dust emissions from construction and hauling equipment would cumulatively produce a significant air quality impact. Nitrogen oxide (NOx) emissions would trigger a general conformity evaluation, from which mitigation measures would be developed to reduce air quality impacts.

- **Terrestrial Vegetation and Wildlife:** Construction would have the potential to adversely affect special status plant or animal species, protected oak woodlands, native vegetation, and wetlands. These impacts would require compensatory mitigation as per the U.S. Fish and Wildlife Service biological opinion.

- **Soils, Minerals, and Geological Resources:** Construction activities would result in the loss of topsoil resources that would be mitigated to less than significant levels through the implementation of best management construction practices.

- **Transportation and Circulation:** The hauling of materials and supplies to the project sites would not have a significant impact on the level of service for most local roadways, except for Scott Road north of White Rock, and East of Natoma Street. This impact would be mitigated as feasible.

- **Noise:** Nighttime noise increase at three residential receptor areas would exceed ambient noise criteria creating an unavoidable adverse impact, should mitigation measures not be effective in reducing noise levels.

- **Cultural Resources:** Cultural resources are known to exist at many locations proposed for staging and facility construction and could be disturbed or destroyed under any of the action alternatives. Cultural resources staff would prepare a determination of potential impacts and consult with the State Historic Preservation Office (SHPO). Cultural resource impacts would be evaluated and mitigated under a programmatic agreement in consultation with the SHPO.

- **Recreation**: Contractor staging would emphasize use of areas with no current public access, away from residential areas. Excess materials would be used to create platforms above the normal operating reservoir water surface at elevation of 466.0 and would be placed so as to maintain existing or equivalent public recreation access and use capacity during the peak recreation season. To minimize potential impacts to recreation, staging areas at Beal's Point and Folsom Point would be placed on constructed platforms or on adjacent unimproved areas a safe distance from primary recreational activities. Public safety would be maintained through the use of fencing or other similar measures. There would be nearly continuous public access to recreation areas and trails throughout the construction period through the use of traffic control measures, grade separated vehicular and/or pedestrian crossings, and/or temporary alternate public access detours. Closures could occur while the Partner Agencies are implementing these new measures that allow continued access or to address public safety and facility security objectives. In such cases, temporary closures would be accomplished during off-peak days or the off-season to minimize impacts on recreation activities. Reclamation's Central California Area Office would notify local agencies and the general public and accept input in advance of any possible extended closure(s) that may be necessary due to unforeseen project circumstances.

GEOTECHNICAL INVESTIGATIONS AND CONSIDERATIONS

A summary is presented of engineering geology and geotechnical information that is pertinent to the four-STG auxiliary spillway alternative, which is the least-cost alternative that provides all of the functionality of the authorized Folsom Modification Project. Included are available data, relevant interpretations, and a summary of findings as they apply to the proposed project elements.

The proposed auxiliary spillway and all of its design components are located within a semi-rectangular area beginning at the existing parking area and overlook approximately 3,000 feet east of the dam along the Dam Road, which has been restricted to traffic for the past two years. The western end of the facilities would terminate approximately 600 to 700 feet south of the existing dam stilling basin at the American River. Topographically, this project area begins at approximate upper elevation 525 descending along a gently west-southwest sloping natural ground surface to approximate elevation 115 to 120 at the American River. Although several areas of shallow access road cuts and fills exist throughout this project footprint, the majority of the site consists of annual grass cover and natural vegetation. One area of deeper fills is present at the west end of the project and a 50-foot high, steep road cut was constructed along the former Dam Road. The parking area was created by placement of deep fill extending into the reservoir. No other significant structures are known to be present in this area.

The geologic, seismic, and geotechnical information available within the project area are presented. Geotechnical design considerations for design and construction of the auxiliary spillway include reuse of excavated materials, slope stability; rock cut slope stability, seepage potential, scour potential and foundation criteria. Excavated materials from the auxiliary spillway may be used to accomplish the proposed MIAD remediation and dike raises. Preliminary slope stability analyses for the auxiliary spillway suggest that the deeper portions of cuts could be constructed at steeper gradient and shallower cuts could also be steepened with adequate bench design intervals and vegetation. Rock cut slope stability design considerations include persistent faults, zones of intense fracturing, and/or alteration known to exist in portions of the auxiliary spillway. If adversely oriented, these would be detrimental to the auxiliary spillway and may require mitigation measures.

To date, no seepage analyses or evaluations have been performed; however, the presence of persistent structural features that represent seepage paths perpendicular to the auxiliary spillway and adjacent left wing dam axes would likely require further analysis. Seepage potential during construction has also not been evaluated based on the absence of data currently available. However, of particular concern is the potential for seepage beneath the left wing dam and into the auxiliary spillway or through the proposed cofferdam plug.

It is assumed likely that lateral loads on the proposed control structure will govern the geotechnical design of foundations. It is also anticipated that drilled shafts will be the most economical system to withstand this loading condition. Therefore, the lateral capacity of the shafts will control the design. Despite the current intent to line the entire auxiliary spillway approach channel, control structure, chute, and stilling basin, preliminary evaluations were

performed to assess the potential for leaving portions of the auxiliary spillway exposed where low scour potential may be present.

Additional data acquired during the Phase 2 auxiliary spillway geotechnical explorations will provide updated data characterization models. Analyses relative to each of these and other design considerations will result in better definition of the geotechnical design criteria for the auxiliary spillway, and thus improvement of the corresponding design components and estimated costs.

DESIGN AND CONSTRUCTION CONSIDERATIONS FOR THE FOLSOM MODIFICATION PROJECT

The Folsom Modification Project consists of a proposed auxiliary spillway constructed in the left abutment adjacent to the existing Folsom Dam. The new auxiliary spillway would regulate releases through a concrete gravity control structure with four STGs into a lined spillway chute and stilling basin, discharging directly into the American River. Design considerations and performance are discussed, including hydraulic, civil, structural, mechanical, and electrical design. Also discussed are construction considerations, cost and schedule to implement the project.

- **Hydraulic Design** - The recommended alternative for the Folsom Modification project should have the capability to release objective flow at a lower pool elevation than currently possible. Design considerations include: acceptable hydraulic performance; satisfactory functionality of the auxiliary spillway and stilling basin at design flows and at higher flows without excessive damage; and combined releases from the service spillway, auxiliary spillway, and emergency spillway without complex operational constraints. The four-STG auxiliary spillway alternative is effective because it increases the release capabilities at lower levels in the reservoir. The auxiliary spillway for Folsom Dam would consist of four 17-foot 7-inch wide by 33-foot-high submerged tainter gates and have a head of about 93 feet on the centerline of the gates at maximum pool elevation 477.5. The discharge facilities for the four-STG auxiliary spillway alternative would include a flared approach channel, a concrete gravity control structure, a steep rectangular concrete-lined chute, and a stilling basin. The control structure has a vertical upstream face, an intake/entrance to each of the conduits with a double elliptical roof curve, the submerged tainter gates, and four rectangular concrete conduits (just long enough to house each of the tainter gates and provide an exit to the steep chute). The maximum velocity at the upstream end of the concrete lining in the approach channel and the conduit roof curves are expected to be 16 fps and 50 fps, respectively. Hydraulic model tests and further geotechnical data will be used to confirm the velocities and assess whether or not the extent of the concrete (or other lining) can be reduced or needs to be increased. The stilling basin would be included for energy dissipation at the downstream end of chute. A design discharge of 90,000 cfs was selected for the concrete lined chute and the stilling basin energy dissipator based on a downstream release of 115,000 cfs, the objective release. In addition to designing the chute wall heights to provide full freeboard (meeting both Corps and Reclamation criteria) for the 90,000 cfs water surface profile plus an allowance for waves, the top of walls would be designed to provide freeboard (not including waves) for a discharge of 155,800 cfs ("tainter gates full open" at maximum pool elevation 477.5). The wall heights of the chute would be selected depending on which

approach controls the design. A Type II stilling basin would be used as described in Reclamation's "*Hydraulic Design of Stilling Basins and Energy Dissipators*," Engineering Monograph No. 25 (Peterka, 1974). Physical hydraulic model tests may result in changes to the design of this basin or consideration of other means of energy dissipation such as a stepped energy dissipator. Ongoing studies and future analysis during the next phase of design are required to fully define design requirements.

- **Civil Design -** Continued public access to Folsom Point Recreation Area would require public health and safety measures to allow it to remain open for the duration of the auxiliary spillway and dam safety construction. This area will be used as a staging area for the construction contractor as well as a disposal site for some of the excavated materials from the auxiliary spillway channel. The new Folsom Bridge Road (separate project performed under the Folsom Dam Raise authorization) serves to replace access across Folsom Dam via the existing Folsom Dam Road, with a new bridge that crosses the American River, approximately 1,500 feet downstream from Folsom Dam. The Folsom Bridge project includes an access road to the left wing dam and the area at the toe of the left wing dam. The auxiliary spillway project would include a road across the top of the new spillway structure and would connect to the new bridge access road. A portion of the existing Natomas Pipeline would be relocated where it crosses the auxiliary spillway alignment. Part of the existing access road from Folsom Dam Road to the Corps resident office and the toe of the main concrete dam would need to be realigned because of the presence of the auxiliary spillway control structure, chute alignment and the Folsom Bridge Road embankment. Armoring the existing powerhouse access road may be necessary to prevent erosion of the embankment caused by discharges from the auxiliary spillway.

- **Structural and Mechanical Design -** The auxiliary spillway is a major new structural component of the featured alternative and consists of a concrete gravity control structure housing four-STGs, a rectangular chute downstream from the new spillway structure, and a concrete-lined stilling basin for energy dissipation. Due to time constraints, and to be consistent with the objectives of Folsom Modification Project, the structural engineering effort focuses on "worst-case" loading for the most critical structures. Accordingly, the concrete auxiliary spillway was analyzed for the maximum credible earthquake (MCE)[1], and other structures were sized based on the experience of the design team. The auxiliary spillway control structure was site-adapted from *DWR's Oroville Dam flood control structure* (DWR, 1965) primarily to provide enhanced flood control and hydrologic risk reduction. Site adaptations from the existing control structure at Oroville Dam include using 49-foot-wide independent concrete monoliths, each containing two-STGs similar in size to those at Oroville. A variety of tainter gate sizes and invert elevations were investigated with the two-monolith, four-gate configuration at invert elevation 368.0, approximately 10 feet lower than the equivalent Oroville spillway, providing the best project function at least cost.

The State of California Division of Safety and Dams (DSOD) developed a three-dimensional (3-D) finite element model (FEM) using SAP2000 version 9.14 to include the MCE seismic loading case, which is assumed to govern the stability of the control structure. The seismic load case was determined to govern both the stress and stability of the structure, as expected.

[1] During the feasibility study, technical criteria, standards, and/or guidelines from involved agencies would be considered and designed for (e.g., the Corps MCE and Reclamation probabilistic upper-bound earthquake would be analyzed and considered in the feasibility design).

Sliding stability was analyzed by comparing the calculated base shear to the allowable base shear through each time interval of the acceleration record. Results of the fixed-base, 3-D finite element sliding analyses show that the monoliths would be at the verge of sliding during MCE loading condition, resulting in a factor of safety of 1.0. Based on the conservative oversimplifications assumed for the analyses, further refinement of these analyses should calculate a higher factor of safety.

The model used to evaluate sliding stability was also used for a linear elastic stress analysis, based on the same set of assumptions and load combinations. Based on these linear elastic, and somewhat conservative analyses, DSOD concluded that the auxiliary spillway control structure would be stable and structurally adequate under all loading conditions.

The proposed Folsom Dam auxiliary spillway STGs would be 33 feet tall and 17-foot 7-inches wide. The STGs would be operated by means of hydraulic cylinders, similar to those used at Winfield Dam, Corps Huntington District, as opposed to a traditional gear driven chain or cable type hoist mechanism, as is currently used at Folsom and Oroville dams. The hydraulic cylinders would be mounted above the tainter gates and will pivot about their centerpoint. The cylinders would have a bore of approximately 18 inches, a rod diameter of approximately 7 inches, a stroke of approximately 29.5 feet, and would take approximately 20 minutes to open.

- **Electrical Design** – The proposed new power distribution system is specifically designed for reliability with emergency on-site generation. These features would provide a reliable, fault-tolerant, and easily maintained system. Emergency electrical power would be provided from the existing emergency generator building on the Folsom project site. An additional provision for portable generator plug-in would be provided at the auxiliary spillway.

- **Construction Considerations** – A phased construction approach has been identified for the Folsom Dam auxiliary spillway. A phased construction approach allows for developing and implementing specific "work packages." Designated work packages should be compatible with future contracting/procurement efforts, and should represent major contracts as the program is currently envisioned. Work packages would be sized to take advantage of the strengths of both large and small disadvantaged businesses. Work packages would be coordinated with other ongoing projects at the Folsom Facility to reduce contractor conflicts and maximize available funding.

- **Schedule** – A preliminary construction schedule for the four-STG auxiliary spillway is presented that shows an approximate construction start date of July 2007 for Work Package 1 (interim measures). Work Package 2 (auxiliary spillway excavation and construction) would begin June 2010, and Work Package 3 (miscellaneous projects) would begin in January 2011. All project work is anticipated to be complete by the end of 2013.

- **Cost** – A draft feasibility-level cost estimate for the four-STG auxiliary spillway alternative was developed. The first cost is $633 million. The four-STG auxiliary spillway alternative is economically feasible. The annual cost and the average annual flood control benefits are estimated at $34.4 million and $84.9 million, respectively.

CONCLUSIONS

The following conclusions are based on the results of the analyses contained in this EDR.

- An auxiliary spillway alternative consisting of four STGs with gate dimensions of 17 feet 7 inches wide by 33 feet high and an invert at elevation 368 provides the same flood damage reduction afforded by the authorized Folsom Modification Project that serves as the baseline for comparison of alternatives (six enlarged, two new, and two existing main dam river outlets). Flood routings of the four-STG auxiliary spillway have been performed to demonstrate that the alternative would provide a flood control level of protection computed at one chance in 149. This alternative would provide the capability for Folsom Dam to pass a 180-year design flood event.
- The design and construction of the four-STG auxiliary spillway alternative would take about eight years.
- The four-STG auxiliary spillway alternative does not address the existing dam safety deficiency of inadequate spillway capacity. The additional release capacity provided by the auxiliary spillway increases, but does not fully meet the dam's capability to pass the PMF.
- The four-STG auxiliary spillway alternative is also designed to dissipate energy from high velocity flows before they enter the American River channel. Ongoing studies and future analysis will determine what necessary measures are required to address possible impacts to downstream water surface elevations and channel erosion potential.
- During project development, further study of reservoir operations will be made focusing on reducing the variable space allocated to flood control within the reservoir from the current operating range of 400,000 to 670,000 acre-feet to an operating range of 400,000 to 600,000 acre-feet.
- Construction of the four-STG auxiliary spillway alternative would cause some resource impacts; but mitigation measures would be proposed to reduce these potential impacts to less than significant levels where possible.
- Preliminary geologic, geotechnical, seismic, and hydrogeologic investigations support the viability of locating the auxiliary spillway at this site. Further data and analysis obtained during the ongoing Phase 2 explorations will enhance these data and allow further evaluation of key design considerations, including the following:
    - Cofferdam seepage
    - Sliding block stability
    - Control structure foundation design
    - Long-term seepage

- Structural analyses of the auxiliary spillway alternative indicate that the structure can achieve adequate margins of safety using cost-effective design and construction techniques.
- A draft feasibility-level cost estimate for the four-STG auxiliary spillway alternative was developed. The first cost is $633 million. The four-STG auxiliary spillway alternative is economically feasible. The annual cost and average annual flood control benefits are estimated at $34.4 million and $84.9 million, respectively.

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ACRONYM AND ABBREVIATION LIST

2002 Long-Term Study	American River Watershed Long-Term Study Final Supplemental Plan Formulation Report
2-D	Two dimensional
3-D	Three dimensional
AEP	Annual exceedance probability
amp	Ampere
ASCE	American Society of Civil Engineers
ASP	Available stream power
ATS	Automatic transfer switch
°C	Degrees centigrade
CFR	Code of Federal Regulation
cfs	Cubic feet per second
Corps	United States Army Corps of Engineers
CVP	Central Valley Project
D	Distance
DDR	Design Documentation Report
DPR	State of California Department of Parks and Recreation
DSOD	State of California Division of Safety of Dams
DWR	State of California, Department of Water Resources
E	East
EA/IS	Environmental Assessment / Initial Study
EC	Engineering Circular
EDR	Engineering Documentation Report
EIS/EIR	Environmental Impact Statement / Environmental Impact Report
elevation XXX	elevation, feet above mean sea level
EM	Engineering Manual
ER	Engineering Regulation
ERDC	Engineer Research and Development Center
ESRD	Emergency spillway release diagram
FDR	flood damage reduction
FEM	Finite element model
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulation Commission
FONSI	Finding of no significant impact
fps	Feet per second
ft/min	Feet per minute
g	Acceleration due to gravity
GIS	Geographic Information System
gpm	Gallons per minute
GSI	Geologic Strength Indicies

HEC-RAS	Hydrologic Engineering Centers – River Analysis System
hp	Horsepower
HPU	Hydraulic power unit
IEEE	Institute of Electric and Electronic Engineers
JFP	Folsom Dam Joint Federal Project
Js	Relative ground structure number
K	Erodibility Index (mean value; mean minus 1 standard deviation)
Kb	Particle/block size number
Kd	Discontinuity shear strength number
km	Kilometers
kV	Kilovolt
kVA	Kilovolt-ampere
kW	Kilowatt
LRR	Limited Reevaluation Report
M	Modal magnitude
M-CACES	Microcomputer-Aided Cost Estimating System
MCE	Maximum credible earthquake
MDE	Maximum design earthquake
MIAD	Mormon Island Auxiliary Dam
Mpa	Mega pascals
Ms	Mass strength number
N	North
NA	Not applicable
NC	Not classified
NE	Northeast
NMFS	National Marine Fisheries Service
NO_x	Nitrogen oxides
NW	Northwest
NWS	National Weather Service
OBE	Operating basis earthquake
PAC	Post-Authorization Change
PASS	Project Alternatives Solutions Study
PFP	Probable failure point
PGA	Peak horizontal ground acceleration
PM_{10}	Particulate matter smaller than ten microns
PMF	Probable maximum flood
PNP	Probable non-failure point
psi	Pounds per square inch
R&U	Risk and uncertainty
Reclamation	United States Department of the Interior, Bureau of

	Reclamation
RMR	Rock mass rating
ROG	Reactive organic gasses
rpm	Revolutions per minute
RQD	Rock quality designation
RRFM	Reservoir Release Forecast Model
RSP	Required stream power
RWQCB	Regional Water Quality Control Board
RWS	Reservoir water surface
SAFCA	Sacramento Area Flood Control Agency
SIR	Supplemental Information Report
SMAQMD	Sacramento Municipal Air Quality Management District
SMUD	Sacramento Municipal Utility District
SRA	State Recreation Area
State Reclamation Board	State of California Reclamation Board
STG	Submerged tainter gates
SWP	State Water Project
TAF	Thousand acre-feet
TBD	To be determined
UCS	Unconfined compressive strength
USGS	United States Geological Survey
v:h	Vertical to horizontal ratio
W	West
WES	Waterways Experiment Station
WCD	Water control diagram
WRDA	Water Resources Development Act

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CHAPTER 1.0
INTRODUCTION

This Engineering Documentation Report (EDR) is an engineering refinement and technical implementation document to support the Post-Authorization Change (PAC) report of the currently authorized Folsom Modification Project, which has an objective of implementing flood damage reduction on the lower American River through structural modifications to the existing Folsom Dam and appurtenant facilities. Construction bids for the first phase of the original authorized project were higher than estimated, requiring the need to look at design variations and design approaches to the original project. The purpose of this EDR is to evaluate design refinement alternatives that provide all of the functionality that would have been achieved by the currently authorized Folsom Modification Project by determining the advantages and disadvantages of each technical alternative, including its cost and performance data, in coordination with other programs and efforts at Folsom Dam. The Folsom Modification Project authorization did not have dam safety as a project objective. Therefore, the auxiliary spillway alternatives presented in this EDR reflect achieving only the flood damage reduction objective comparable to the original outlet modification project (six enlarged outlets plus two new outlets plus two existing main dam river outlets).

1.1 SCOPE OF REPORT

This EDR describes the project authorized by the Water Resources Development Act of 1999. The report documents the engineering aspects of the alternatives considered. It focuses on cost, performance, and functionality of the alternatives to the currently authorized project.

1.2 PROJECT AUTHORIZATION AND APPROVAL

Authorization to construct a dam on the American River was included in the Flood Control Act of 1944. Construction of Folsom Dam was initiated in 1948 and completed in 1956. The storms of 1986 raised concerns over the adequacy of the existing flood control system resulting in the December 1991 American River Watershed Investigation Feasibility Report. Congressional guidance was forthcoming in the 1993 Defense Appropriations Act, authorizing additional studies to develop solutions to flood problems. This study was documented in the March 1996 *American River Watershed Project, California, Supplemental Information Report* (United States Army Corps of Engineers, Sacramento District [Corps], 1996) (1996 SIR). The 1996 SIR described multiple alternative plans, of which certain levee and other flood system improvements were "common" to all alternatives. In the 1996 Water Resources Development Act (WRDA), Congress authorized only a portion of the 1996 SIR-recommended plan. The authorized elements became known as "Common Features." While efforts moved forward to further develop and implement the Common Features, discussions continued on ways to achieve higher levels of flood protection for Sacramento.

Under Section 101(a)(6) of the WRDA of 1999 (Public Law 106-53), Congress authorized physical modifications at Folsom Dam, consistent with the descriptions provided

in the 1996 SIR, as modified by the *Folsom Dam Modification Report, New Outlets Plan*, dated March 1998, prepared by the Sacramento Area Flood Control Agency (SAFCA).

Headquarters, United States Army Corps of Engineers, provided guidance on the intent of this authorization directing that a decision document be prepared to support the currently authorized project. The Limited Reevaluation Report (LRR) was prepared (Corps, 2001), the purpose of which was to demonstrate that the authorized operational and structural modifications to Folsom Dam were economically justified, technically sound, and environmentally acceptable, and that they were clearly defined with regard to project features.

As part of the reevaluation effort, the design of the authorized plan was examined to determine if enlarging the eight existing main dam river outlets would result in a cost savings, compared to constructing new main dam river outlets beneath the emergency spillway and constructing a new stilling basin downstream of the emergency spillway. As a result of this evaluation, a plan to enlarge the eight existing river outlets was developed with the outlets designed to allow for concurrent spillway releases.

Following the publication of the LRR in 2001, constructibility and operability reviews of the enlarged gates proposed in the LRR prompted additional design refinements. These refinements were documented in a final LRR dated November 2003, which was submitted to the Assistant Secretary of the Army and approved in January 2004.

1.3 PROJECT OBJECTIVES

The primary objective of the authorized Folsom Modification Project is to provide additional flood damage reduction through modifications to the dam to allow for better utilization of existing flood storage space. The authorized project would modify outlet capacity by enlarging existing main dam river outlets and constructing two new main dam river outlets that together will increase the release capacity to 115,000 cubic feet per second (cfs) with the reservoir pool at spillway crest at an elevation of 417 feet above mean sea level (elevation 418). The capability of maintaining the flood storage space by early releases of up to 115,000 cfs was calculated to reduce the probability of flooding in any one year from 1 chance in 81 to 1 chance in 154.

The Folsom Modification Project was also authorized to modify the emergency spillway release diagram (ESRD) and certain physical features of the dam and dikes to allow water surface elevation of the reservoir to "surcharge" four feet higher than currently allowed under reservoir operation criteria. This additional surcharge would add approximately 46,200 acre-feet of flood storage space and would allow for controlled emergency releases of up to 160,000 cfs for a longer period of time. However, in the LRR of November 2003, a recommendation was made to defer the implementation of the surcharge storage feature of this authorization to ensure design compatibility with the associated authorized Folsom Dam Raise Project, which also addresses the surcharge issue.

1.4 PROJECT SITE AND CONDITIONS

The American River Watershed covers approximately 2,100 square miles northeast of Sacramento, California, including portions of Placer, El Dorado, and Sacramento counties. Runoff from the basin flows through Folsom Reservoir into the lower American River and on through the Sacramento metropolitan area, in a system of levees along both banks and leveed floodways.

Folsom Dam is located at the confluence of the North and South forks of the American River, near the City of Folsom, approximately 29 miles upstream of the City of Sacramento. **Plate 1-1** shows the American River Watershed.

The present Folsom Facility consists of a gravity-type main concrete dam, left and right earth embankment wing dams, an auxiliary earthfill dam (Mormon Island Auxiliary Dam [MIAD]), and eight earth embankment dikes located around the rim of the reservoir. **Plate 1-2** depicts the Folsom Dam and Reservoir area and shows the project features.

The reservoir has a capacity of 977,000 acre-feet at gross pool elevation 466. The top of the main concrete dam is at elevation 480.5 and spillway crest is elevation 418. The current maximum allowable pool elevation under extreme conditions is 475.4 feet. The objective release for flood control from the dam to the lower American River is 115,000 cfs.

The main dam river outlets consist of eight 5-foot by 9-foot rectangular outlets located in the center four monoliths of the main concrete dam. The four upper tier river outlets are at springline elevation 280; the four lower tier river outlets are at a springline elevation 210. The river outlets are capable of passing 24,816 cfs (at 100 percent gate opening) through the dam with the reservoir pool at spillway crest elevation 418. The river outlets are operated primarily to evacuate the flood control space during flood season and, to a lesser extent, to provide colder lower-pool water for fisheries in the fall.

The gated overflow spillway is located in the central gravity section of the main concrete dam with spillway crest elevation 418. The spillway is divided by piers into eight equal sections. The first five sections (westernmost) comprise the service spillway. They are controlled by five 42-foot by 50-foot radial (tainter) gates; discharging into the stilling basin. The three remaining spillway sections are for emergency use when release requirements exceed 300,000 cfs. They are controlled by three 42-foot by 53-foot tainter gates. Water discharges over a flip bucket onto the emergency stilling basin slab. The rated capacity of the entire spillway is 567,000 cfs.

Three 15.5-foot-diameter penstocks pass through the west non-overflow section of the main concrete dam. Normal releases through the penstocks provide power generation and downstream water supply deliveries. The discharge through the penstocks was not considered to contribute to outlet capacity during the analysis of flood routings. The combined capacity of the three penstocks is 8,000 cfs. In addition, there is one 7-foot-diameter intake conduit, located west of the penstocks, which supplies water to several local water districts.

1.5 KEY DESIGN CONSIDERATIONS

Currently, Folsom Dam has limited capability to make objective flood releases until the reservoir is nearly 75 percent encroached into the flood pool. Flood releases are limited to the existing eight main dam river outlets prior to the pool above spillway crest elevation 418. Normal flood operations at Folsom Dam would limit downstream flows to a maximum of 115,000 cfs. Upon completion of the Common Features project, outflows from the dam could be increased from 115,000 cfs to the new non-damaging channel capacity of the lower American River of 160,000 cfs. The downstream objective flow of 115,000 cfs is reached when the reservoir level reaches elevation 447, through a combination of flows through the penstocks, river outlets, and the five service tainter gates. To avoid potential cavitation problems, the river outlet gate openings are reduced to 60 percent when the spillway gates are in operation.

A major concern exists regarding the potential for erosion below the emergency spillway chute and adjacent areas. It has been determined that even small flows could cause severe erosion below the emergency spillway; continuous flows without sufficient tailwater could allow this erosion to migrate towards the stilling basin serving the main service spillway. It is estimated that sufficient tailwater would not be present to operate the emergency spillway until discharges exceed 300,000 cfs. Modifications to the three emergency tainter gates should be consistent with the assumption used in the original design of the emergency stilling basin.

Key design considerations also include constructibility and environmental considerations.

Key constructibility considerations include the following:

- All of the main dam river outlets need to be available for flood releases at 24 hours notice.
- All of the five service tainter gates need to be available for releases at 24 hours notice.
- Disturbance of existing utilities and dam operations is to be avoided if practical.
- Potential erosion problems below the emergency spillway chute and adjacent areas should be minimized.

Key environmental considerations include the following:

- Best management practices are to be implemented to limit disruption of aquatic habitat and turbidity resulting from construction operations.
- Construction impacts to existing habitat and fish are to be minimized.
- Noise and air quality factors from construction activities are to be considered.

CHAPTER 2.0
PROJECT DESCRIPTION

This chapter describes the Folsom Modification Project and summarizes the technical and regulatory history leading to development of alternatives to the currently authorized project.

2.1 DESCRIPTION OF AUTHORIZED PLAN

The Folsom Modification Project was originally authorized in the 1999 WRDA. The authorized plan included elements of the Folsom Modification Plan as described in the 1996 SIR (Corps, 1996), and subsequently modified in the SAFCA Information Paper *Folsom Dam Modification Report, New Outlets Plan* (March 1998). The Folsom Modification Project has two main functions: increase release capacity and modify use of surcharge storage.

The features of the increase release capacity function were to include installation of new main dam river outlets through the concrete portion of the existing dam, enlargement of the existing main dam river outlets, and modifications to the existing spillway and stilling basin as necessary. The new and enlarged river outlets were to increase the release capacity to 115,000 cfs with the reservoir pool at spillway crest (elevation 418). The capability of maintaining the flood storage capacity gained by early release would reduce the probability of flooding in any one year from 1 chance in 81 to 1 chance in 154.

Implementation of the features of the modified use of surcharge storage function would allow better utilization of the existing flood control storage space. Under existing conditions, the ESRD and physical features of the dam allow for surcharge storage to elevation 470 without overtopping the existing three emergency tainter gates in their closed position. When the reservoir exceeds elevation 470, the emergency tainter gates must be open and the dam would release more than the objective release, potentially causing downstream flooding. The surcharge storage modifications described in the original authorization would require both physical and operational changes to allow the flood pool to surcharge to elevation 474. The features associated with the surcharge storage project would include replacement of the three existing emergency tainter gates, raising the penstock hydraulic control pumps and controls, and increasing the height of the impervious core in Dikes 5 and 7 and the MIAD.

2.2 BACKGROUND

Because the project authorized in WRDA 1999 differed from what was presented in the 1996 SIR, the 2001 LRR was prepared. At the same time, additional studies for yet additional flood protection and for dam safety were being conducted, which were documented in the February 2002 *American River Watershed Long-Term Study Final Supplemental Plan Formulation Report* (2002 Long-Term Study) (Corps, 2002). To assimilate common features between the 2001 LRR and the 2002 Long-Term Study, and to

reflect changes in the Folsom Modification Project design since publication of the 2001 LRR, the *Folsom Dam Modification Project LRR* was revised in 2003 (Corps, 2003).

Recommendations from the 2002 Long-Term Study that were authorized in the Water Resources Development Act of 2004 (WRDA, 2004) included raising the dam by 7 feet, known commonly as the "mini-raise;" modifying the spillway at L.L. Anderson Dam, located upstream of Folsom Dam on the Middle Fork of the American River; constructing a permanent bridge downstream of Folsom Dam; and modifying emergency release operations to permit surcharge. These authorized features, which make up the Folsom Dam Raise Project described in a separate EDR, carry design implications for the previously authorized Folsom Modification Project, as described below.

Under the Folsom Dam Raise Project, all eight main dam tainter gates and spillway bridge piers would be modified and the spillway bridge would be replaced. If the Folsom Modification Project were implemented first, as authorized, then gate modifications would need to be made twice. Consequently, the 2003 LRR refined the elements related to increasing release capacity to be consistent with the modifications in the 2002 Long-Term Study, and to reflect changes in the design from what was described in the 2001 LRR. These changes include the following:

- Constructing two new upper tier river outlets, 9.33 feet wide by 14 feet high
- Enlarging the four existing upper tier outlets to 9.33 feet by 14 feet, and the four existing lower tier outlets to 9.33 feet by 12 feet
- Providing additional anchorage for the stilling basin slab and training walls
- Deferring replacement of the three emergency spillway gates, authorized as part of WRDA 1999, since the Folsom Dam Raise Project would address the gates

Since preparation of the 2001 LRR and the authorization of the Folsom Dam Raise Project, design efforts have identified further changes to the Folsom Modification Project as reflected in the 2003 LRR. **Table 2-1** summarizes the 1996 SIR project features, the originally authorized elements, and the features modified in the 2003 LRR.

TABLE 2-1
COMPARISON OF AUTHORIZED AND REFINED PROJECT FEATURES, FOLSOM MODIFICATION PROJECT

Function	Project Features in 1996 SIR	Currently Authorized Project Features (WRDA 1999)	Project Features in 2003 LRR
Increase Release Capacity (115,000 cfs objective release)	Lower spillway crest by 15 feet	In lieu of lowering the spillway, construct five new main dam river outlets under the auxiliary spillway (two 7-foot by 14-foot slide gates per outlet)	Add two new upper tier river outlets (9 feet 4 inches by 14 feet)
	Enlarge 8 existing main dam river outlets to 6 feet by 12 feet	Enlarge 8 existing main dam river outlets to 6 feet by 12 feet	Enlarge 8 existing main dam river outlets to 9 feet 4 inches by 14 feet (four upper tier river outlets), and 9 feet 4 inches by 12 feet (four lower tier river outlets)
		Construct new stilling basin downstream from auxiliary spillway	Use existing stilling basin, but with additional anchorage of apron slab and walls
Modify Use of Surcharge Storage	Raise impervious core in Mormon Island Auxiliary Dam, Dike 5, and Dike 7	No change	No change
	Modify surcharge operation to provide additional flood space	No change	No change
	Construct parapet wall at Newcastle Powerhouse	No change	No parapet wall required
	Raise penstock gate hoists and relocate hydraulic pumps	No change	No change
	Replace 3 emergency tainter gates with 42'x59' tainter gates (new top of gate elevation 476)	No change	Design tainter gate foundations to permit expansion in future, if Folsom Dam Raise Project is implemented
	Top-seal existing tainter gates	No change	Top-seal not used (not technically feasible)
Revise Interim Operation	Reduce variable space allocated to flood control from 400-670 TAF to 400-600 TAF	No change	No change
Update Folsom Dam Flood Management Plan	Revise plan to reflect operational capabilities provided by outlet modifications, surcharge storage space, and improved forecasting	No change	No change

KEY:
LRR – limited reevaluation report
SIR – supplemental information report
TAF – thousand acre-feet
WRDA – Water Resources Development Act

Engineering documents were prepared for construction implementation of the project proposed in the 2003 LRR. The *Folsom Dam Outlet Works Modification Project Design Documentation Report* (DDR) (Corps, 2004) discussed the Folsom Modification Project in two parts: The Outlet Works Modification Project (with the increase release capacity function) and the Surcharge Storage Modification Project (with the modified use of surcharge storage function).

With regards to the Surcharge Storage Modification Project features, the DDR stated that because the project had many features similar in nature to the modifications proposed by the 2002 Long-Term Study, which include raising the dam, the detailed design of the surcharge storage modification features was deferred, following congressional decision granting authorization to raise the dam.

The 2003 LRR presented the following description of the designed Outlet Works Modification Project features.

The primary feature of the increase release capacity function would be the modification of the main dam river outlets. The six upper tier outlets (four modified and two new) would be 9.33 feet wide by 14 feet high; the two new main dam river outlets are skewed 3.5 degrees so that they exit just inside the sidewalls of the existing spillway (**Plate 2-1**). The four lower tier outlets would be 9.33 feet wide by 12 feet high. The main dam river outlets would be over-excavated to allow for a formed concrete surface. The existing slide gates, gate bodies, and gate hoists would be replaced by larger units.

Subsequent to the February 2004 DDR, it was decided to divide the modification of the main dam river outlets into two contracts: an upper tier contract comprised of six river outlets and a lower tier contract comprised of a maximum of four river outlets. Construction documents were prepared for the six upper tier river outlets. Proposals were received in March 2005 but exceeded the fully funded, updated authorized cost (Section 902 limit). The solicitation was canceled in January 2006.

Without implementation of the Outlet Works Modification Project, significant flood risks remain. In the Energy and Water Development Appropriations Act of 2006, Congress directed that expedited action be taken to maximize flood damage reduction improvements and address safety at Folsom Dam. In addition, the existing currently authorized project was expanded to include consideration of an auxiliary spillway.

The Corps and the United States Department of the Interior, Bureau of Reclamation (Reclamation) initiated studies in 2005 and 2006 with the purpose of developing a single project that integrates both agencies' objectives. This project was described in the report entitled *Folsom Dam Raise and Auxiliary Spillway Alternative, Project Alternative Solutions Study (PASS) II* (Corps and Reclamation, 2006) and presented an engineered evaluation of an auxiliary spillway alternative consisting of four submerged tainter gates (STG) and a dam raise of seven feet. Optimization efforts of the PASS alternative identified variations of four- and six-STG-auxiliary spillway alternatives, with and without emergency tainter gate

replacement on the main concrete dam, the technical evaluations of which are the subject of this report.

2.3 OVERVIEW OF ALTERNATIVES

The alternatives to the currently authorized project consist of various combinations of new, enlarged, or existing main dam river outlets, the replacement of some or all of the existing main dam tainter gates, and a new auxiliary spillway. The auxiliary spillway would be a major new structural component of the Folsom Facility, consisting of an excavated approach channel, a concrete control structure housing STGs for flow release, and a rectangular downstream chute and a stilling basin. The location of the auxiliary spillway is the same in all cases. The control structure will extend from near the abutment of the left wing dam west-northwesterly to the American River channel, as depicted on **Plate 2-2**.

The following six alternatives are discussed in Chapter 3, Folsom Modification Project Alternatives. The first alternative shown below represents the currently authorized project:

- Eight-enlarged main dam river outlets plus two new main dam river outlets (2003 LRR plan – the currently authorized project)
- Six-enlarged main dam river outlets plus two new main dam river outlets and two existing main dam river outlets (baseline alternative for functional equivalence)
- Four-STG auxiliary spillway (least cost alternative that provides all of the functionality of the authorized Folsom Modification project)
- Four-STG auxiliary spillway with three emergency tainter gates replaced on the main dam
- Six-STG auxiliary spillway (least-cost alternative that provides all of the functionality of the authorized Folsom Modification project that also passes the PMF)
- Six-STG auxiliary spillway with three emergency tainter gates replaced on the main dam

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CHAPTER 3.0
FOLSOM MODIFICATION PROJECT ALTERNATIVES

The alternatives to the authorized Folsom Modification Project consist of various combinations of new or enlarged main dam river outlets, the replacement of emergency tainter gates, and a new auxiliary spillway. The costs for each of the alternatives were prepared for the purpose of determining concept feasibility and project screening. All of the estimates were prepared by the same team of cost engineers for consistency among the estimates for comparison of the alternatives. The cost estimates are based on generally accepted cost principals. The estimates are considered reconnaissance level, fitting the Corps definition as based on the probable type and size of a project, and include construction features, lands and damages, relocations, environmental compliance and required mitigation, engineering and design, construction management, and contingencies. The cost estimate method establishes reasonable costs sufficient to support a planning evaluation process. The estimates were developed using quotes, calculations, unit prices, and historical data as backup. The estimates have all been factored to an October 2006 price level.

3.1 MAIN DAM RIVER OUTLETS ALTERNATIVES

The following main dam river outlets alternatives consist of two combinations of new or enlarged main dam river outlets. The first alternative would consist of eight enlarged river outlets plus two new river outlets. The second alternative would consist of six enlarged river outlets in conjunction with two new river outlets and two existing unmodified lower tier river outlets. Both alternatives provide different levels of release capacity at significantly different costs. All main dam river outlet alternatives reflect symmetrical modifications so as to be able to achieve as balanced flows as possible through the stilling basin given a particular outlet configuration.

3.1.1 Eight Enlarged Main Dam River Outlets Plus Two New Main Dam River Outlets Alternative

The eight enlarged plus two new main dam river outlets alternative is the project described in the 2003 LRR plan (Corps, 2003). This alternative includes enlarging the eight existing main dam river outlets and adding two upper tier river outlets. The total of ten main dam river outlets would allow a combined discharge of as much as 115,000 cfs into the lower American River prior to the reservoir pool reaching the spillway crest (elevation 418). Elements of this alternative are described below.

3.1.1.1 Outlets

The four existing upper tier 5-foot by 9-foot main dam river outlets would be enlarged and the outlet gate pairs (each pair consisting of one emergency gate and one service gate) would be replaced with 9-foot 4-inch by 14-foot outlet gates. The four existing lower tier river outlets would also be enlarged and the existing gates replaced with tandem 9-foot 4-inch by 12-foot outlet gates. In addition, two new outlets would be constructed – one at each end of the row of the existing upper tier river outlets. They would be of the same size

as the upper tier enlarged river outlets. All main dam river outlets would be over-excavated to allow for a formed concrete surface.

The inlet at each of the main dam river outlets is based on a compound elliptical curve to minimize cavitation potential under all conditions of outlet openings and reservoir heads. The flared intake for the new and enlarged outlets would be constructed of concrete, flush with the face of the dam and integral with the new concrete liner. A new inspection bulkhead would be required for maintenance purposes for use at the enlarged inlet.

3.1.1.2 Conduits

All conduits would be steel-reinforced and concrete-lined and designed for loads expected both during and after construction, including a reservoir water surface elevation 482 (assuming a seven foot dam raise as was authorized).

In the conduit area adjacent to the outlet gates, the existing gate leaves, bodies, and hoists would be removed and the outlet conduit excavation expanded upward to encompass the gate chamber area. All new embedded gate components, namely the gate body, the bonnet, and the expansion, would be moved into position through the downstream portion of the outlet after its excavation. The equipment would then be encased in concrete.

A temporary internal bulkhead would be installed in the existing conduit between the inlet and the outlet gates to provide a redundant bulkhead during removal of the existing gates and installation of the new gates.

3.1.1.3 Gate Chambers

The existing gate chambers would be enlarged to provide sufficient clearance for installation and maintenance around the new, larger gate bonnet assemblies. The installation of the gate leaf in the gate body would require transporting the leaf through the existing inspection galleries to the gate chambers. Alcoves would need to be excavated in half of the gate chambers to house the hydraulic power units (HPUs) used to power the outlet gate hoist. Each HPU would operate two pairs of outlet gates.

At the two new outlets, new gate chambers would be excavated. They would be configured similar to the modified gate chambers. A portion of the existing inspection galleries would be enlarged to match the existing gallery size between the gate chambers to facilitate installation of the new gate leaves. Waterstops would be specified to eliminate or reduce seepage and uplift loads on the new concrete. Drains would be installed behind the new concrete gate chamber lining and between the new and existing concrete in the gate body area. Grouted anchor bars would be used in the gate excavation and the gate chamber areas.

3.1.1.4 Air Intake Manifold

The significant increase in water discharge through the enlarged outlets would lead to an increase in the air demand in the outlet. An enlarged air intake manifold and new, larger, vertical air shafts would be required to provide adequate air to ensure cavitation-free operation and proper hydraulic performance.

3.1.1.5 Construction Adits and Gantry Crane

Two new construction adits would be excavated, one at each gate gallery level. They would provide access to the upper tier and lower tier inspection galleries and would be fitted with a secure entrance door. The door for the lower access adit would be waterproof.

The existing gantry crane would be modified to allow placement of the enlarged inspection bulkhead. The modifications would include replacement of the 25-ton capacity auxiliary hoist and trolley assembly with a 50-ton capacity hoist and trolley assembly of similar configuration, strengthening of the existing hoist boom arms and the upstream bridge girder, and extension of the crane rails onto Monolith 18 in order to service Outlet 10.

3.1.1.6 Stilling Basin

Modifications to the floor and sidewalls of the stilling basin would be required due to the increased outlet flows. Rock anchor tie-downs would be installed and grouted through the stilling basin slab and the L-wall footing. Additional rock anchor tiebacks would be installed on the anchored wall portions of the basin's right and left walls. The gravity wall sections on both the right and left walls would be tied back into rock with grouted rock anchors.

3.1.1.7 Electrical Equipment

The existing power distribution, gate control, lighting, and communication systems would be replaced.

3.1.1.8 Post Construction Considerations

Debris from the original construction and sediments that have accumulated upstream of the dam above elevation 180 would be removed. In addition, stone protection would be required on the reservoir bottom for scour prevention due to higher intake velocities, and on the left abutment wrap fill slope for slope stabilization.

3.1.1.9 Cost Estimate

The estimate of first cost for this alternative is $785 million; the estimate of annual cost is $45.8 million.

3.1.1.10 Performance

This alternative would pass the 200-year design flood event. The performance, inverse of the annual exceedance probability (AEP), of this alternative has a 1 in 154 chance of exceedance in any given year.

3.1.2 Six Enlarged Main Dam River Outlets Plus Two New Main Dam River Outlets and Two Existing Main Dam River Outlets Alternative

The six-enlarged main dam river outlets plus two new main dam river outlets and two existing main dam river outlets alternative serves as the baseline for comparison for functionality of alternatives to the authorized Folsom Modification Project. This alternative is a refined design of the project described in the 2003 LRR (see Section 3.1.1). This alternative was recommended over the eight enlarged plus two new main dam river outlets alternative as a result of a hydraulic, geotechnical, and structural assessment of problems associated with enlarging the two outside lower tier outlets, Outlets 1 and 4.

3.1.2.1 Engineering Considerations

The following list of engineering considerations summarize the decision favoring the six enlarged plus two new and two existing river outlets alternative over the eight enlarged plus two new river outlets alternative.

- Any increase in gate height above the existing 9 feet for Outlet 4 would result in undercutting the wrap fill embankment and necessitate its subsequent stabilization. The depth and conditions at which this slope stabilization would have to be performed precludes assurance of safe construction and the long-term performance of the wrap fill embankment.

- Any increase in the size of Outlet 4 would require scour protection of the wrap fill slope in addition to the slope stabilization measures noted above.

- Rock outcropping near Outlet 1 precludes modifying the outlet without removing the outcropping to prevent undesirable flow conditions in the outlet.

- Constructibility of drilled shafts as a means of slope stabilization would be affected by the great water depth, in excess of 200 feet, likely dark water conditions, and variable subsurface material characteristics ranging in particle sizes from finely grained material to boulders.

- Subsurface conditions in the vicinity of the face of the dam are uncertain. The resistance of a drilled shaft wall to lateral load would be based on passive soil resistance. The resistance due to a 20-foot embedment in fill material of unknown configuration, extent and relative compaction would be difficult to quantify.

- Installation would need to be performed from barge-supported cranes and drill rigs and containment and disposal of drilling fluid and cuttings would be required due to environmental concerns.

- Enlarging of Outlets 1 and 4 for a size other than 9 feet 4 inches by 12 feet would require new hydraulic model studies.

- The total of six enlarged and two new main dam river outlets together with the two unmodified lower tier river outlets would allow a combined discharge of 101,000 cfs into the lower American River, prior to the reservoir pool reaching spillway crest (elevation 418).

The construction of six enlarged upper tier main dam river outlets and two enlarged lower tier river outlets, Outlets 2 and 3, would be as described above in Section 3.1.1 with the following considerations and exceptions:

- Outlets 1 and 4 would not be modified and would retain their original dimensions.

- The air demand for the six enlarged plus two new and two existing main dam river outlets alternative would not be substantially different from the eight enlarged plus two new river outlets alternative. Therefore, the same enlarged air manifold would be included in this alternative.

- The new construction adits at each gallery level would also be required, as they were for the eight enlarged plus two new main dam river outlets alternative, to allow installation of the two new pairs of gate leaves and the gate hoists for Outlets 2 and 3.

- The stilling basin floor and sidewalls would also experience increased outlet flows, very similar to the eight enlarged plus two new main dam river outlets alternative. Only the impact area downstream of Outlets 1 and 4 would have somewhat decreased loadings. Therefore, rock anchor tie-downs and tiebacks would be similar to the eight enlarged plus two new outlets alternative.

- Since only two of the gate pairs for the lower tier river outlets would be replaced under this alternative (the other two remaining in service), a single larger HPU could be used to operate all lower tier gates. The new HPU would be situated in a new alcove carved into the existing dam.

- Under this alternative, lower tier construction is limited to Outlets 2 and 3, therefore the debris removal dredging limits would be confined to the area upstream of these enlarged outlets.

- Stone protection on the reservoir bottom would still be required for abrasion protection of the concrete liner surface of the outlets due to scour of the finer

material lining the reservoir. No stone protection would be required on the wrap fill slopes since the corner of Outlets 1 and 4 would not be enlarged, and the flow velocities would not be increased.

- The reservoir bottom would still be lowered by dredging to help prevent bed material from entering the enlarged river outlets. This would also improve flow conditions in the approach to the outlets.

3.1.2.2 Cost

The estimate of first cost of this alternative is $630 million; the estimate of annual cost is $36.1 million.

3.1.2.3 Performance

This alternative would pass the 180-year design flood event. The performance (inverse of the AEP) of this alternative has a 1 in 147 chance of exceedance in any given year.

3.2 AUXILIARY SPILLWAY ALTERNATIVES

This section presents variations of auxiliary spillway alternatives. These variations of a new proposed auxiliary spillway would be used in conjunction with the existing main dam river outlets and would be implemented either with or without replacing any of the existing tainter gates on the main dam. The auxiliary spillway would be a major new structural component of Folsom Dam.

3.2.1 Common Design Characteristics

For all of the auxiliary spillway alternatives, the spillway would consist of an excavated approach channel, a concrete control structure housing submerged tainter gates for flow release, a rectangular chute downstream from the new control structure, and a stilling basin to serve as an energy dissipater. The location of the auxiliary spillway would be the same in all cases (see **Plate 2-2**).

3.2.1.1 Approach Channel

The approach channel invert and vertical sides would be concrete lined for a distance of 50 feet upstream from the face of the control structure. The invert elevation for this concrete lining would be elevation 368 (sill elevation for the gates). The vertical concrete walls that provide a transition from the control structure to the approach channel would have an elliptical shape using parameters adapted from the spillway at Oroville Dam, owned by the State of California, Department of Water Resources (DWR). A negative invert slope of 0.0100 from elevation 364 towards the lake, and an abrupt rise in the approach invert from elevation 364 to the concrete lining at elevation 368, would be incorporated in the design to minimize the need for erosion protection and the potential for passage of large mineral debris

through the submerged tainter gates. Most of the approach channel geometry would be excavated in rock, providing resistance to erosion. Geotechnical data and physical hydraulic model tests would be used to determine the optimum approach geometry and any needed erosion protection.

3.2.1.2 Control Structure

The control structure would extend from the current overlook area, near the abutment of the left wing dam, approximately 200 feet in a south-southwesterly direction into the adjacent hillside. As shown on **Plate 2-2**, the auxiliary spillway would extend in a west-northwesterly direction at approximately 30 degrees diagonally to the left wing dam, and would be directed into the American River channel approximately 1,200 feet downstream of the main concrete dam. The control structure would be similar for all the alternatives examined, the major differences being the width of the channel and the number of STGs incorporated into the control structure.

The auxiliary spillway control structure was site-adapted from the Oroville Dam spillway control structure. A variety of gate sizes, quantities and invert elevations were investigated. The concrete section for the control structure would be deepened to allow for less competent rock at Folsom Dam as compared to Oroville Dam. A grout curtain and drainage gallery would be installed near the upstream face of the concrete monoliths, and the bottom would be sloped 8 degrees up in the downstream direction. The grout/drain gallery would provide capability for split-spaced grouting in the grout curtain, with increased grout pressures after the concrete control structure is in place to provide confinement. After construction is complete, the gallery would provide access for monitoring and maintaining drains to reduce uplift (reduce risk of structure instability), and would also provide access to address any problems encountered after completion of construction.

The top surface of the invert slab would be reinforced to control cracking and to improve performance as a high-velocity water passage. The piers and breast wall would be adequately reinforced to carry water and seismic loads. The piers would be extended upstream and vortex beaming would be added, similar to that developed in model testing for modifications to Theodore Roosevelt Dam, owned by Reclamation. Continuous reinforced concrete trunnion beams would be used to address problems related to partial trunnion beams used at Oroville Dam. Continuous beams would also reduce pier flexure, which is a concern for thin piers that would be desired at Folsom for hydraulic efficiency. The continuous concrete beams would be used with hydraulic cylinders to control gate opening. These cylinders would provide positive closure force, dampen any flow-induced vibrations, and improve control relative to the cable lifts used at Oroville Dam.

The control structure concrete monoliths would be flanked with non-overflow monoliths that would be trapezoidal in shape. This shape was investigated for use with previous projects at Auburn and Marysville locations, and was found to provide stability and strength for seismic loads while avoiding stress concentrations at the heel and curvature points found with conventional concrete sections.

3.2.1.3 Spillway Chute and Stilling Basin

The auxiliary spillway chute would be a rectangular, reinforced-concrete chute downstream from the control structure, similar to that at Oroville Dam. The invert slope from the gate sill Station 9+89.3 (elevation 368.0) to Station 12+00 (elevation 365.89) would be 0.010. This relatively mild slope would be used to reduce excavation during construction and, along with parallel chute walls, decrease the possibility or magnitude of rapid pulsating flow and/or standing waves. Downstream from Station 12+00, the slope would be increased to 0.020 down to Station 32+00 (elevation 325.89).

At Station 32+00, the invert profile would begin to transition to either a conventional stilling basin or an alternate type of structure to provide necessary energy dissipation. The chute would have a 5-foot-thick reinforced-concrete slab anchored to the rock with 5-foot-long No. 11 reinforcing dowels at 10-foot centers, similar to the existing stilling basin slab at Folsom Dam. Underdrain pipes sloping down to the sides of the chute, similar to those used at Oroville Dam, would be provided to reduce potential uplift forces on the slab. Drain pipes would be provided in pervious backfill on the outside of the walls to carry water away from the drains beneath the dam and additional water from the ladder drains. These pipes would be sized to facilitate inspection and maintenance with appropriate access provided. Actual chute wall height would be determined from hydraulic model results and would vary along the length of the chute. For the purpose of the cost estimate, wall thickness and reinforcing were based on the Oroville Dam spillway and experience with walls of similar height for other projects.

Energy dissipation would be provided by constructing a lined stilling basin (reinforced concrete founded on rock) at the downstream end of the chute, just upstream from the location where the auxiliary spillway flows re-enter the American River. The stilling basin would transition from the invert of the spillway chute at Station 32+00 (elevation 325.89) to the stilling basin floor with a long parabolic drop to ensure positive pressures. Other chute profiles will be evaluated during design. An unlined stilling basin may be considered as an alternative to the lined stilling basin during final design studies.

3.2.2 Four-Submerged-Tainter-Gates Auxiliary Spillway Alternative

This alternative would consist of a four-STG auxiliary spillway. The tainter gate dimensions were patterned after the gates for the Oroville Dam, i.e., 33 feet high by 17 feet 7 inches wide. The invert elevation for the Folsom project is 368 feet. The spillway gates would have a head of approximately 93 feet on the centerline of the gates at maximum pool elevation 477.5, similar to the roughly 90-foot head on the Oroville Dam gates. The four gates would be located in two 49-foot-wide independent concrete monoliths as part of the control structure. The chute width would be 90 feet to accommodate the four gates and the three piers separating the gates, and would transition from 90 feet to 143 feet at the entrance to the stilling basin. The stilling basin length would be 265 feet with 66-foot-high walls. The bottom of the stilling basin would be at elevation 119.

The four-STG auxiliary spillway discharge capacity would be about 78,000 cfs at pool elevation 418. When combined with releases from the eight existing main dam river outlets, the combined discharge provides only slightly less release capacity than the 115,000 cfs for the original project.

The estimate of first cost of this alternative is $633 million; the estimate of annual cost is $34.4 million.

This alternative would pass the 180-year design flood event. The performance (inverse of the AEP) of this alternative has a 1 in 149 chance of exceedance in any given year.

3.2.3 Four-Submerged-Tainter-Gates Auxiliary Spillway with Three Emergency Tainter Gates Replacement Alternative

This alternative would be similar to the alternative described above under Section 3.2.2, except that it would also includes the replacement of the three existing emergency spillway tainter gates on the main dam for the purpose of improving storage utilization for increased flood protection. The existing emergency tainter gates are 42 feet wide and 53 feet 10 inches high, with top of gate at elevation 471. Based on assumed reservoir operations for a three emergency tainter gate replacement with no dam raise alternative, the reservoir could reach a water surface elevation of 475.5 before the emergency tainter gates would be operated. To maintain one foot of freeboard on the gates, the gate height would be increased to elevation 476.5.

The four-STG auxiliary spillway discharge is calculated at 78,000 cfs at pool elevation 418. When combined with the releases from the eight existing river outlets on the main dam, the combined discharge provides only slightly less release capacity than the 115,000 cfs for the original project.

The estimate of first cost of this alternative is $675 million; the estimate of annual cost is $36.8 million.

This alternative would pass the 180-year design flood event. The performance (inverse of the AEP) of this alternative has a 1 in 149 chance of exceedance in any given year.

3.2.4 Six-Submerged-Tainter-Gates Auxiliary Spillway Alternative

This alternative is similar to the alternative discussed in Section 3.2.2, except that it would have six 33-foot-high by 23-foot-wide STGs, with an invert at elevation 368.

The six-STG auxiliary spillway discharge is calculated at 135,000 cfs at approximate pool elevation 416, which would exceed the objective release of 115,000 cfs for the original project.

The estimate of first cost of this alternative is $889 million; the estimate of annual cost is $50.0 million.

This alternative would pass the 200-year design flood event. The performance (inverse of the AEP) of this alternative has a 1 in 156 chance of exceedance in any given year.

3.2.5 Six-Submerged-Tainter-Gates Auxiliary Spillway with Three Emergency Tainter Gates Replacement Alternative

This alternative would be similar to the previous alternative described above under Section 3.2.4, except that it would also include the replacement of the three existing emergency spillway tainter gates on the main dam for the purpose of bettering storage utilization for increased flood protection. The emergency tainter gate replacement is identical to the tainter gate replacement associated with the four-STG auxiliary spillway alternative described in Section 3.2.3.

The six-STG auxiliary spillway discharge is calculated at 135,000 cfs at pool elevation 416, which would exceed the objective release of 115,000 for the original project.

The estimate of first cost of this alternative is $930 million; the estimate of annual cost is $52.4 million.

This alternative would pass the 200-year design flood event. The performance (inverse of the AEP) of this alternative has a 1 in 156 chance of exceedance in any given year.

3.3 SUMMARY OF FOLSOM MODIFICATION PROJECT ALTERNATIVES

A tabular summary of the Folsom Modification Project alternatives is presented in **Table 3-1**. The table provides information on whether an alternative provides all the functionality that would have been achieved by the baseline alternative for the Modification authorization (six enlarged plus two new and two existing main dam river outlets alternative), the estimated first cost and the estimated annual cost for each of the alternatives, the performance (inverse of the AEP) for each alternative, and the design flood event that each alternative would pass.

The least-cost alternative that provides all the functionality of the authorized Folsom Modification Project is the four-STG auxiliary spillway. The design and construction considerations for this alternative are described in **Chapter 7** of this report.

TABLE 3-1

FOLSOM MODIFICATION PROJECT ALTERNATIVES

Alternative Description	Functionality Compared to the Authorized Project	First Cost	Annual Costs	Performance (Inverse of AEP)	Design Event Passed
		(millions)	(millions)	(1:X Chance)	(years)
Eight enlarged and two new main dam river outlets	N/A	$785	$45.8	154	200
Six enlarged, two new and two existing main dam river outlets	Baseline	$630	$36.1	147	180
Four 17'-7" by 33' STG Auxiliary Spillway	Equal	$633	$34.4	149	180
Four 17'-7" by 33' STG Auxiliary Spillway; Three Emergency Tainter Gates Replaced	Equal	$675	$36.8	149	180
Six 23' by 33' STG Auxiliary Spillway*	Greater	$889	$50.0	156	200
Six 23' by 33' STG Auxiliary Spillway; Three Emergency Tainter Gates Replaced*	Greater	$930	$52.4	156	200

*Note : *These alternatives pass the PMF.*

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CHAPTER 4.0
HYDROLOGY AND RESERVOIR OPERATIONS

This chapter presents the Corps' understanding of the hydrology of the American River Drainage Basin and Folsom Dam site. Also discussed are reservoir operations as they exist currently, and as they would be modified for various alternatives examined for the Folsom Modification Project. The Folsom Dam Operations and Planning Model, developed with Microsoft Excel, is used in all the routing and alternative analyses for the various American River Folsom Dam studies.

4.1 HYDROLOGY

This section presents hydrology of the Folsom Dam area including information on design floods and the probable maximum flood (PMF).

4.1.1 Design Floods

Hydrology for the American River Projects has been extensively studied by the Corps. In that process, unregulated flow frequency statistics for the American River at Fair Oaks were developed and have subsequently been updated to include flood data for the years 1905 through 2004. The statistical analysis used for this report followed procedures found in *Bulletin 17B, Guidelines for Determining Flood Flow Frequency* (United States Geologic Survey [USGS], 1981). The resultant statistics adopted for the American River at Fair Oaks are shown in **Table 4-1**. A complete discussion of the development of the adopted statistics is provided in the *Rain Flood Flow Frequency Analysis, American River, California* (Corps, 2004).

TABLE 4-1
AMERICAN RIVER AT FAIR OAKS –
UNREGULATED FLOW STATISTICS

Duration	Log Mean (cfs)	Log Standard Deviation (cfs)	Skew
1 Day	4.453	0.425	-0.05
3 Days	4.326	0.414	-0.05
7 Days	4.162	0.398	-0.13
15 Days	4.015	0.373	-0.26
30 Days	3.897	0.360	-0.42
KEY: cfs – cubic feet per second			

The unregulated flow statistics shown above were used to develop a series of inflow design events (synthetic hydrographs) used in the modeling and analysis of the various conditions and alternatives studied for Folsom Dam. The shape of each inflow design

hydrograph was patterned using the shape adopted for the American River PMF. **Figure 4-1** shows both an inflow design event and the PMF inflow hydrograph. Once the unimpaired (natural) flow hydrographs were developed, they were routed throughout the system, including the upstream reservoirs. This process transformed them into regulated inflow hydrographs, to serve as inflow to Folsom Dam. Baseline or the most likely routings (i.e., with no risk and uncertainty considerations) assumed that upstream reservoirs would be full at the start of the flood routing. This assumption provides the most critical condition for Folsom Dam routings.

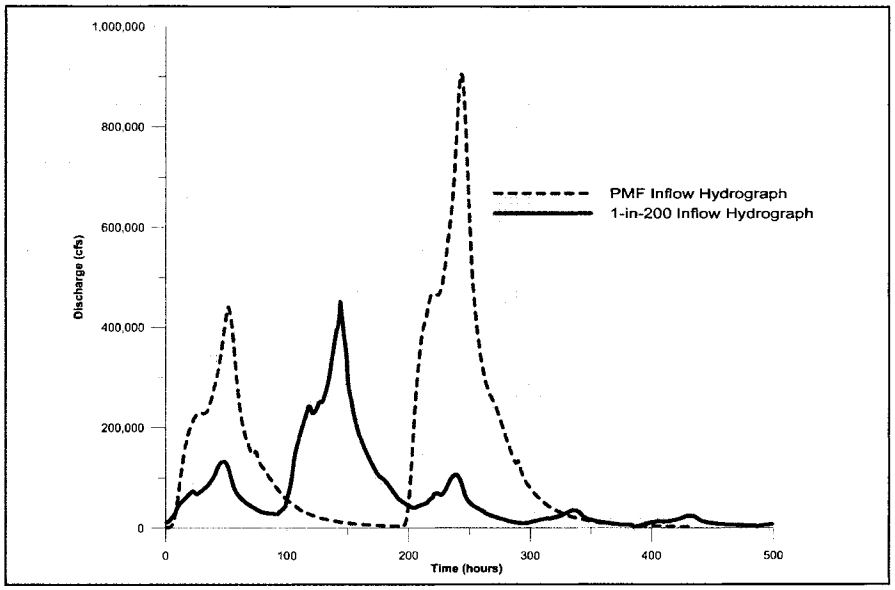


FIGURE 4-1
SHAPES OF PROBABLE MAXIMUM FLOOD AND INFLOW HYDROGRAPH SERIES

Corps guidance (ER 1105-2-101) requires the use of risk analysis in flood damage reduction studies. For risk and uncertainty purposes, the analyses herein cover Folsom Reservoir's response to a range of design. The flood events, routed using the Folsom Dam Operations and Planning Model, range from a 1-in-2-year-chance of being exceeded to those with a 1 in 550 chance of being exceeded. Refer to **Section 4.4.2** to see its application to the operations.

4.1.2 Probable Maximum Flood

By definition, a PMF results from a combination of the most severe meteorological and hydrologic conditions considered reasonably possible in a particular region. The PMF is a flood derived in accordance with procedures developed by the Federal Government (National Weather Service [NWS], 1999) and accepted by the State of California in its dam safety program as a viable method for developing spillway design floods in the United States. The PMF applied in this analysis was jointly developed by the Corps and the Reclamation and is documented in the report *American River Basin, Folsom Dam, Revised PMF* (Corps, 2001). The PMF is used for evaluating dam safety. The PMF is used to design a reservoir to keep a dam from overtopping; it is not used as a measure for developing alternatives to provide downstream flood protection. The following scenarios shown in **Table 4-2** were considered during development of the PMF.

TABLE 4-2
AMERICAN RIVER AT FAIR OAKS –
PROBABLE MAXIMUM FLOOD VOLUMES

	Peak (thousand cubic feet)	72-Hour (thousand acre-feet)
No upstream dam failure		
North Fork PMF	906	2810
South Fork PMF #1	896	2805
South Fork PMF #2	889	2805
Upstream dam failures		
North Fork PMF	1183	2935
South Fork PMF #1	1127	3206
South Fork PMF #2	1322	3205

Notes:
1. North Fork PMF - Storm centering over French Meadows Reservoir (with or without failure of LL Anderson Dam)
2. South Fork PMF #1 - Storm centering near Placerville basin (with or without failure of both LL Anderson Dam and Union Valley Dam)
3. South Fork PMF #2 - Storm centering over Union Valley and Ice House Reservoirs (with or without failure of both LL Anderson Dam and Union Valley Dam)

When upstream dam failures are considered, the South Fork PMF #2 scenario (storm centering over Union Valley and Ice House Reservoirs) produces the largest peak and 72-hour volume. The South Fork scenarios include failures of both Union Valley Dam located on the South Fork of the American River and L.L Anderson Dam located on the Middle Fork of the American River. The dam failure scenarios are considered unlikely to occur. Due to the Federal Energy Regulatory Commission relicensing program, all upstream projects are responsible for safely passing their PMF events and must make the necessary modifications to comply with those requirements. Without any upstream dam failures, the peak and 72-hour volumes are nearly identical for both the North Fork and South Fork storm centerings. The following summarizes the assumptions adopted for this report with regards to the PMF:

- The PMF implemented within this analysis is designed and centered over the North Fork of the American River.
- L.L. Anderson Dam (French Meadows Reservoir, located upstream of Folsom Dam on the Middle Fork of the American River) passes its PMF event, without failure, with the assumption that the existing physical and operational inadequacies would be corrected according to previous studies investigating those issues.

4.2 OPERATIONAL RULES FOR FLOOD CONTROL

Flood control operation of Folsom Dam is governed by two sets of operating criteria: the water control diagram (WCD) and the emergency spillway release diagram (ESRD).

4.2.1 Water Control Diagram

The WCD represents a compilation of regulating criteria, guidelines, guide curves, and specifications that govern the storage and release functions of water resource projects. The diagram indicates pool levels and limiting rates of project releases required during various seasons of the year to meet all functional objectives of a particular project, acting separately or in combination with other projects in a system. The operational rules are expressed in the form of graphs and tables, supplemented by concise specifications, and are used to help determine regulation (release) schedules. The 1986 WCD as presented in the December 1987 *Folsom Dam and Lake Water Control Manual* and interim WCD for Folsom Dam currently in use are provided as **Plates 4-1** and **4-2a**. **Plate 4-2b,** presents further details in the agreement and interim operation of Folsom Dam and Lake as per **Plate 4-2a**. Both diagrams as illustrated in **Plate 4-1** and **Plate 4-2a** maintain a minimum allowable flood control reservation of 400,000 acre-feet; the interim WCD, however, allows for a variable allocation of an additional 270,000 acre-feet of reserved flood control space based on creditable storage available in upstream reservoirs.

4.2.2 Emergency Spillway Release Diagram

The ESRD is applied when circumstances require that a gated spillway be used to meet the release requirements. The ESRD transitions normal low outflows to significantly higher outflows gradually so as not to constitute a major hazard to downstream interests. For Folsom Dam, the transition from normal low outflows to significantly higher flows begins at discharges greater than 115,000 cfs. Because Folsom Dam would rely on the induced surcharge capabilities of its gated spillway(s) to control less frequently occurring events, each alternative proposed herein would require that an ESRD be designed and tailored to that alternative's release capabilities. The ESRD approved for current operations is provided as **Plate 4-3**.

Table 4-3 outlines some of the basic assumptions adopted as WCD or ESRD operational criteria. **Plate 4-4** provides a detailed outline of various operational differences

between the American River Watershed Projects; Folsom Modification, Folsom Dam Raise, and the Folsom Dam Joint Federal Project.

TABLE 4-3
WATER CONTROL DIAGRAM AND EMERGENCY SPILLWAY RELEASE DIAGRAM

Condition	Outflow Restriction
Maximum objective release allowed by WCD (larger releases may be initiated by ESRD)	115,000 cfs
Maximum allowable rate of release change Increases: When discharge is greater than 20,000 cfs and less than or equal to 160,000 cfs When discharge is greater than 160,000 cfs Decreases: When discharge is greater than 20,000 cfs	 15,000 cfs/hour Unlimited 5,000 cfs/hour (decrease)
Maximum outflow allowed by WCD or ESRD	Do not exceed maximum inflow experienced during flood event
Release limitation if the actual or forecasted inflow is greater than 25,000 cfs and less than 150,000 cfs and reservoir is less than 20 percent encroached	Limit outflow to 60 percent of the maximum inflow experienced during the flood event
Maximum power available or relied upon for flood operations	Power penstocks would be assumed to have zero release capacity during all routings
Physical limitation of existing emergency tainter gates	Emergency tainter gates are not used until either the total outflow from the dam exceeds 240,000 cfs or the pool elevation is within 1 foot of overtopping the emergency tainter gates while in the closed position
Release requirements (115,000 cfs to 160,000 cfs) based on Accelerated Transition Zone conditions as outlined on the proposed ESRD: if current inflow is greater than 200,000 cfs and the 12-hour forecasted inflow is greater than 360,000 cfs if current inflow is greater than 250,000 cfs and the 12-hour forecasted inflow is greater than 370,000 cfs if the current inflow is greater than 270,000 cfs and the 12-hour forecasted inflow is greater than 370,000 cfs	 Increase release to 130,000 cfs Increase release to 145,000 cfs Increase release to 160,000 cfs
KEY: WCD – Water Control Diagram ESRD – Emergency Spillway Release Diagram cfs – cubic feet per second cfs/hour – cubic feet per second per hour (flow rate of change)	

4.2.3 Emergency Spillway Release Diagram Operational Contradictions

Spillway tainter gates are not designed for overtopping. According to EM 1110-2-3600, the maximum normal operating pool is limited to allow 2 feet of freeboard when the gates are closed. Due to downstream considerations, the Corps and Reclamation increased the maximum normal operating pool level from elevation 466 to 470 by allowing some use of the surcharge storage space. This minimized downstream impacts for the longest time period possible while lengthening the downstream notification and evacuation period. The vehicle for the operational agreement is the 1986 ESRD. Operation using the 1986 ESRD essentially reduces the design freeboard for the emergency spillway gates from 5 feet to 1 foot when the gates are in the closed position.

Design of the existing ESRD restricts the maximum discharge to 160,000 cfs until the reservoir's pool reaches elevation 470. Once the reservoir water surface exceeds elevation 470, the ESRD allows releases to be increased above the 160,000 cfs limitation. However, releases should not be made through the three emergency tainter gates until discharge in the stilling basin reaches 240,000 cfs to avoid incurring damages. The contradiction in the ESRD is that it does not take into account the physical and operational limitations of the emergency spillway. When the emergency tainter gates are closed, the top of the gates is elevation 471. The routing model can force operation of the emergency tainter gates. The water surface must be within 1 foot of the top of the gates for this to occur. Sufficient tailwater is required to prevent erosion below the emergency spillway chute and adjacent areas. Refer to **Section 4.2.4.3** for additional background on this operational constraint. Although the existing ESRD does not require a discharge of 240,000 cfs until the pool rises above elevation 472, the dam operator can choose to make larger releases sooner. The effect of delaying operation of the emergency tainter gates is that above elevation 471, water would begin to flow over the top, possibly causing damages or failure, or making the tainter gates inoperable.

4.2.4 Reclamation and Corps Variances in Routing Assumptions

During the development of project alternatives and configurations, various differences between Reclamation and Corps routing assumptions were encountered. These differences cause the output generated by Reclamation and the Corps, for the same alternative configuration, to be widely different. The resulting differences impact parameters such as the maximum water surface elevation produced through routing the PMF by as much as several feet. The Corps and Reclamation reached an agreement that Reclamation operating standards and criteria should take precedence due to their jurisdiction over dam safety operations. Per Code of Federal Regulations (CFR) 33 208.11, the project owner (Reclamation) has full responsibility for the safety of the dam/appurtenant facilities and for regulation of the project during surcharge storage utilization. **Attachment A1** includes a summary of the latest routing assumptions above the flood pool and related design criteria developed through on-going discussions between the Corps and Reclamation. The analysis and results provided herein implement the routing assumptions described above in **Table 4-3** and on **Plate 4-4**. At the time of the routings, some of Reclamation's requirements had not

have been fully identified. For differences between the assumptions used in the routings and those adopted after subsequent discussions, compare **Table 4-3** and **Plate 4-4** with **Attachment A1**. Future design studies, such as the hydraulic modeling, should facilitate efforts to refine the selected project. The following discussion highlights some of the assumptions that influence the routing results.

4.2.4.1 Maximum Operating Flood Pool

Generally, dam safety operation commences once the reservoir water surface exceeds the authorized flood control space. Storage space extending above and beyond the authorized flood control space is designated as surcharge storage space. The demarcation at Folsom Dam between the authorized flood control space and surcharge storage space is normal full pool (elevation 466 feet). Surcharge capacity is needed to pass the PMF. Levee breaching flows should occur only when the reservoir is within the surcharge storage space. The maximum surcharge water surface coincides with the maximum PMF pool elevation.

For the Joint Federal Project, achieving flood damage reduction goal requires the use of some of the surcharge storage space. The target elevation within the surcharge storage space is determined by the design flood. Once the reservoir water surface exceeds the specified target elevation, the operation is focused strictly on dam safety. This concept is applied to the routing herein.

4.2.4.2 Rating Curves

The existing main dam spillway rating curves (1997), utilized within the Corps' routing model, were produced by Reclamation based on physical model study results. The Corps' computer program (H3106) was used to generate rating curves for the various alternatives which include modifications to the main and/or emergency tainter gates. A spillway rating curve for the current design was also created. A quick check of the differences indicates that the computer program produces a broader zone of instability than defined in Reclamation's spillway rating table. Refer to **Attachment A2, Section 7-1.5.2** for further discussion. The result of this restriction is higher, more conservative pool elevations and reduced flood damage reduction benefits for any particular configuration. All model results reflect orifice (controlled) spillway flow operation. The routing results herein reflect use of Reclamation's rating curves for alternatives with unmodified spillway gates and computer generated ratings for alternatives with modified spillway gates.

4.2.4.3 Computational Time Interval

The computational time interval utilized in the Corps routings is one hour. Release decisions made within the routings are only allowed to look back at information provided one hour prior (i.e., the previous time-step). Reclamation generally agrees with this same standard. There is one exception. In the routing of the fuseplug auxiliary spillway, Reclamation relies on current hour information. This provides similar results as if the operations were handled with a shorter time step (i.e., 15-minute interval). The Corps and Reclamation have discussed the modeling assumptions and the possibility of coincident

operation of the main dam tainter gates with operation of the fuseplug. Reclamation's premise is that the operators have the data/tools/ability to enact this operation. In this instance, applying the hour look-back standard would only result in higher, more conservative maximum PMF pool elevations. A shorter time step is appropriate for the fuseplug. Since Reclamation has jurisdictional authority regarding dam safety operations, this exception prevails. All routings provided herein, without a fuseplug feature, use a one-hour look-back window.

4.2.4.4 Required In-channel Flows for Emergency Gate Releases

The Corps and Reclamation have had many discussions regarding the prerequisite tailwater discharge required to initiate operation of the emergency gates. The Corps has documentation from the 1950s on the structural design analysis of Folsom Dam and its appurtenant works. The flip bucket is to be used only for spillway discharges above 300,000 cfs. It is undetermined if the 300,000+ cfs criterion includes contributions from the emergency spillway. Since the sole purpose for the emergency tainter gates is dam safety, Reclamation has jurisdiction over its prescribed operation. Reclamation maintains that 240,000 cfs is the appropriate threshold for operation of the emergency tainter gates. Therefore, the Corps routings herein incorporate 240,000 cfs as the in-channel flow requirement. This in-channel flow requirement is needed to provide a pool of water at a certain depth within the stilling basin, deep enough to dissipate the force exhibited by flows coming down the emergency spillway. Without sufficient "padding" the force of flow discharging through the emergency spillway may damage structures within the stilling basin, potentially causing greater damage to the sidewalls and foundation of the dam.

4.2.4.5 Physical Constraints in Operations

Restrictions in operation are required to avoid jeopardizing the integrity of the dam and its appurtenances during high pool conditions. A constraint incorporated within the Corps' routings avoids pool elevations overtopping main dam tainter gates. Various alternative configurations proposed herein, recommend modifications or enlargements to either the emergency tainter gates or emergency and service tainter gates. Maximum operating pool elevations will change according to the alternative configuration proposed. **Table 4-4** presents the critical elevations corresponding to the gate modification proposed by any particular alternative configuration.

TABLE 4-4
PARAMETERS APPLIED IN MODELING

Configuration [1]	Emergency Tainter Gates (El, feet)		Main Dam Tainter Gates (El, feet)
	Operating Constraint [2]	Top of Closed Gates	Top of Open Gates
No raise No gate modification	470.0	471.0	480.0
No raise Three-gate modification	475.5	476.5	480.0
No raise Eight-gate modification	475.5	476.5	491.5
3.5-foot raise Three-gate modification	479.0	480.0	480.0
3.5 foot raise Eight-gate modification	479.0	480.0	491.5
7.0-foot raise Eight-gate modification	482.5 (bridge replaced)	483.5	497.0
KEY: El, feet – Elevation in feet			

Notes:

1. *The parameter assumptions are dependent solely on the dam height configuration and whether or not a given alternative includes modifications to either the three emergency spillway gates or both the emergency and main dam service spillway gates.*
2. *Minimum operating pool requirement based on 1 foot of remaining freeboard when the emergency tainter gates are in the closed position.*

The Corps recognizes that Reclamation's jurisdictional authority takes precedence in the decision to operate the emergency spillway gates once the pool level exceeds the top of flood control pool.

4.2.4.6 Discharge Rate of Increase

A rapid rate of flow increase downstream is of great concern, especially when the discharge is expected to exceed 160,000 cfs (emergency objective release). Emergency evacuations will generally take place while the discharge is held to 160,000 cfs or less. Corps guidance EM 1110-2-1420 clearly indicates that project operation plans should ensure that release rates-of-change should be gradual and not exceed the historical maximum rates of increase. Also, the operations should ensure that the resultant peak discharge is no greater

than peak inflow. The Corps recognizes that Reclamation's jurisdictional authority takes precedence in this decision. At the time of the routings, Reclamation's requirements were unknown. The routings provided herein use an unlimited rate-of-increase once the discharge exceeds 160,000 cfs. The discharge is limited so as not to exceed previous hour inflow. When releases greater than 160,000 cfs are required, any delays will only increase the magnitude of the dam safety release requirement.

4.3 OPERATIONS AND ALTERNATIVE DESCRIPTIONS

Past routings and alternative analyses were performed using the Utah State University's Reservoir Release Forecast Model (RRFM). The current analyses were conducted with a different model. This should be considered when comparing previous results to current output. Also, note that advance release or forecast based operations (FBO) results are not covered in the PAC/EDR reports. FBO is connected to directives to update the Flood Management Plan under the Folsom modification authorization. Current efforts do not preclude consideration of FBO.

There are two versions of RRFM. The latest version of RRFM is more robust than the one used during the American River Long-Term Study. RRFM provides the user with a choice between two modes of operation – planning/study mode and real-time operations mode. RRFM is able to generate probabilistic distributions of outflow based on statistically defined inflow parameters for study or planning purposes. It is also able to forecast releases based on hydrometeorological input parameters for day-to-day real-time operations. The primary interface of RRFM is through input windows or screens much like most software packages. Adaptation of the earlier version of RRFM was extensive. However, the challenges and complexities presented in the American River Watershed Projects (i.e., Folsom Modification and Folsom Dam Raise projects) require a deeper technical interface with software code and scripting and an ability to automate complex and iterative processes. No efforts were made to further adapt the earlier version or to use the latest version for study purposes. Uncertainties with what exactly would be required of the Folsom Dam model, today and in the future, dictated the use of another piece of software. RRFM did not provide the necessary adaptability. It was decided that the flexibility offered by Microsoft Excel - with its Visual Basic for Applications, macros, and spreadsheet functions - provided the flexibility and adaptability that is required to fully explore any potential alternatives and configurations. Thus, the Folsom Dam Operations and Planning Model, developed with Excel, is currently used in all the routing and alternative analyses for the various American River studies.

A comprehensive listing of alternatives for various tainter gate, river outlet, and auxiliary spillway configurations analyzed for this project are provided in **Plate 4-5**. The initial screening of what configurations would move forward was determined from this initial list. The configurations included various combinations of an auxiliary spillway with STGs, conventional tainter gates, and fuseplug. The various gate combinations were analyzed at differing sill elevations. Combinations of modifications to the main dam river outlets were also analyzed, and advance release criteria were incorporated into the release decisions. Of

the configurations in **Plate 4-5**, this document focuses on the with- and without-project conditions listed below:

- Common Features (model run R000_800CF) – without-project condition
- New main dam river outlets and modification of existing main dam river outlets, no auxiliary spillway, (model run R000_0102FM), original authorization, with-project condition
- New main dam river outlets and modification of existing main dam river outlets, no auxiliary spillway, (model run R000_282FM), adaptation of original authorization, with-project condition
- No main dam river outlet modification, four-submerged 17-foot by 33-foot tainter gate auxiliary spillway, (model run R040 800FM), with-project condition
- No main dam river outlet modification, four-submerged 17-foot by 33-foot tainter gate auxiliary spillway, (model run R040 800 FM), emergency tainter gate replacement, with-project condition
- No main dam river outlet modification, six-submerged 23-foot by 33-foot tainter gate auxiliary spillway, (model run R060_800FM), with-project condition
- No main dam river outlet modification, six-submerged 23-foot by 33-foot tainter gate auxiliary spillway, (model run R040 800 FM), emergency tainter gate replacement, with-project condition

4.3.1 Existing Operations – Without-Project Conditions

The Folsom Modification Project was first authorized in 1996; its currently proposed configuration serves as the without-project condition for the Folsom Dam Raise for comparative purposes. A summary comparison of key operational differences is provided as **Plate 4-6.**

4.3.1.1 Outlet Efficiency

Prior to the Reclamation and SAFCA *Interim Operations Plan* (2004) shown in **Plates 4-2a and 4-2b**, releases from Folsom Dam's eight main dam river outlets were limited to 60 percent of their capacity when used in conjunction with the service spillway. This outflow restriction was adopted to prevent cavitation from damaging the face of the dam. The current interim operations agreement, however, allows all main dam river outlets to be fully opened while the service spillway is in operation. The increased discharge capability improves the ability of the dam to discharge flood waters at controlled rates downstream from the dam. Mitigation of damages due to cavitation is outlined in the Interim Operations Plan. The alternatives proposed herein do not address approaches to remedy this issue; consequently, any with-project condition assumes the eight main dam river outlets are functioning at 60 percent of their capacity.

4.3.1.2 Interim Operation Measures

The water control diagram (WCD) for Folsom Dam was originally designed in 1986 with a seasonally allocated flood control storage space of 400,000 acre-feet (**Plate 4-1**). However, the interim operation agreement between Reclamation and SAFCA was executed in 1994. In that interim operation plan, flood control storage in the reservoir was changed to a variable space allocation ranging from 400,000 acre-feet to 670,000 acre-feet (**Plate 4-2a and Plate 4-2b**), depending on the amount of creditable vacant space in three existing upstream reservoirs. In the *Water Resources Development Act of 1996* (WRDA, 1996), Congress directed Reclamation to continue that interim operation indefinitely. Following improvements and project completion, the variable space allocated to flood control within the reservoir would be reduced from the current operating range of 400,000 to 670,000 acre-feet (**Plate 4-2a**) to 400,000 to 600,000 acre-feet, as shown in the proposed flood control diagram (**Plate 4-7**).

4.3.1.3 Common Features

Section 101(a) (1) of WRDA 1996 authorized construction of features that were common to three candidate plans identified by the Corps, SAFCA, and the State Reclamation Board. Those commonalities included the following:

- Levee modification along both banks of the lower American River
- Levee modification along the east bank of the Sacramento River downstream from the Natomas Cross Canal
- Installation of streamflow gages upstream from Folsom Reservoir and modification to a flood warning system along the lower American River

All analyses and routings performed assume complete implementation of Common Features.

4.3.2 Future Operations – With-Project Conditions

This section presents a discussion of Folsom Dam operations as they would be affected in the future under with-project conditions.

4.3.2.1 Outlet Efficiency

One of the intended benefits of any outlet modification would be to eliminate damages that occur as discharge is made concurrently through the main dam river outlets and over the service spillway. Main dam river outlets being redesigned would be capable of releasing 100 percent of their capacity. Main dam river outlets that are not modified would still be operated at 60 percent their capacity.

4.3.2.2 Interim Operation Measures

Following improvements and project completion, the variable space allocated to flood control within the reservoir would be reduced from the current operating range of 400,000 to 670,000 acre-feet (**Plate 4-2a**) to 400,000 to 600,000 acre-feet as shown in the proposed flood control diagram (**Plate 4-7**).

4.3.2.3 Outlet Modifications

The Folsom Dam outlet modification components consist primarily of enlarging the four existing upper tier river outlets from 5 feet by 9 feet to 9 feet 4 inches by 14 feet, and the inner two existing lower tier river outlets from 5 feet by 9 feet to 9 feet 4 inches by 12 feet, and adding two new outlets on the upper tier. These two new main dam river outlets would be constructed with the same dimensions as the other upper tier outlets. Outer Outlets 1 and 4 on the lower tier might not be modified due to economic and physical constraints. Ideally, the main dam river outlets would be able to release 115,000 cfs (normal objective release) at or before reaching water-surface elevation 418 (spillway crest). At water-surface elevation 418 (spillway crest), the outlet modification would increase the release capacity from 24,800 to 101,000 cfs. With modifications extended to outer main dam river Outlets 1 and 4, the total main dam river outlet capacity increases to about 120,000 cfs at the spillway crest. The primary goal of the proposed outlet modifications is to maximize the total main dam river outlet capacity. Additional flood storage gained by allowing releases to occur earlier would reduce the probability of flooding.

4.3.2.4 No Main Dam River Outlet Modifications – Auxiliary Spillway

This auxiliary spillway configuration is intended to satisfy dam safety concerns and provide an incremental flood control benefit. In this configuration, the auxiliary spillway sill invert is set at elevation 368. The four-submerged-tainter gate auxiliary spillway alternative achieves roughly the same performance as the Folsom Modification Project. It is the least cost alternative. The six-submerged-tainter-gate auxiliary spillway alternative is intended to pass the unlikely occurrence of the PMF and allow Folsom Dam to release objective flow at lower pool elevations.

The routing model does not require the user to pre-define a gate operation sequence. The routing model only specifies the total discharge requirement throughout each event. By examining this information, one can deduce the best method of splitting or distributing the flow amongst the outlet works and spillway features. The following provides an idea of how the auxiliary spillway might be integrated into the gate operation sequence. Generally, the outlet works would be brought on line, followed by the auxiliary spillway. Together, the outlets and auxiliary spillway can maintain the normal objective release (115,000 cfs) once the pool reaches elevation 411. While releases of 115,000 cfs are being made, the use of the outlet works and/or auxiliary spillway could be reduced as the main spillway is given control of the discharge. The main spillway could take over fully while a release of 160,000 cfs is maintained. As soon as sufficient tailwater of 240,000 cfs is achieved in the main stilling basin, the emergency spillway gates would be primed for operation.

4.3.2.5 Addition of Surcharge Storage Space

With the increased release capacity at the project, the original maximum surcharge storage space at elevation 475.5 increases to elevation 477.0. Although the revised PMF event presented in the *American River Basin, Folsom Dam, Revised PMF* (Corps, 2001) is substantially larger than the event used for the original sizing of the project, the additional surcharge storage space allows for the revised PMF event to be contained. Given the additional goal of controlling discharge of a specific design event to non-damaging flows, flood control operations might need to extend into the surcharge storage space. The maximum pool elevation attained by routing the desired design event is labeled flood damage reduction (FDR) flood pool in **Figure 4-2**. Thus to attain desired project performance, an alternative might include appropriation of some of the surcharge storage space for FDR purposes. This would occur if the authorized flood storage reservation was not sufficient in containing the specified design event.

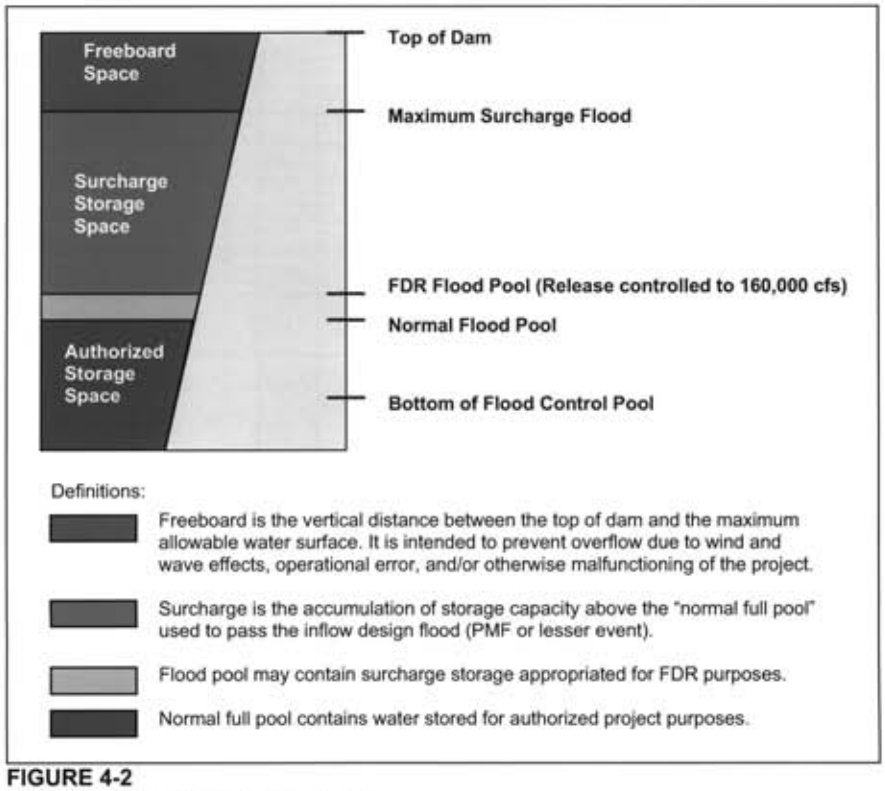


FIGURE 4-2
STORAGE SPACE ALLOCATIONS

Figure 4-2 describes how space is allocated within the reservoir. The authorized storage space remains constant and independent of any modifications to the project. The surcharge storage space is used to contain extreme events within the reservoir. The surcharge space requirement is greatly affected by the inflow design flood volume, the total discharge capacity of the project, and the plan of operation. Freeboard space above the maximum allowable surcharge storage is needed to prevent overtopping mainly by wind or wave action. Refer to **Table 4-5** below for key water surface elevations associated with the various alternatives.

TABLE 4-5
PERTINENT INFORMATION

Alternative	Top of Dam	Maximum Surcharge Flood Pool[1]	Freeboard[3]	FDR Flood Pool[4]	Normal Full Pool	Normal Flood Control Reservation Range[5]
	El, feet	El, feet	El, feet	El, feet	El, feet	El, feet (acre-feet)
Pre-Common Features	480.5	475.5[2]	5	470.0	466.0	425.8 (400,000)
Common Features	480.5	475.5[2]	5	470.0	466.0	425.8 to 388.3 (400,000 – 670,000)
Folsom Modifications (Joint Federal Project)	480.5	477.5	3	468.0	466.0	425.8 to 399.7 (400,000 – 600,000)
Folsom Raise 3.5 Feet	484.0	481.0	3	474.0	466.0	425.8 to 399.7 (400,000 – 600,000)
Folsom Raise 7.0 Feet	487.0	484.5	3	477.0	466.0	425.8 to 399.7 (400,000 – 600,000)
KEY: El, feet – Elevation in feet						

Notes:

1. *These values reflect the highest allowable pool elevation given both freeboard and top of dam height requirements. The maximum surcharge flood pool is established by routing a PMF through the reservoir. The PMF has been updated or revised periodically (e.g. 1946, 1980, 1991, and 2001)*
2. *The existing project requires more surcharge storage than is available under the original project design. Under the without-project conditions, the 2001 PMF event would overtop Folsom Dam.*
3. *Reclamation has determined that 3 feet provides sufficient freeboard for the with-project alternatives.*
4. *The FDR flood pool is established by routing the single design 1-in-200 chance event through Folsom Dam. The release from Folsom Dam will not exceed 160,000 cfs as long as the water surface remains at or below the FDR flood pool. The antecedent event for the PMF is roughly equivalent in volume to the 1-in-200 chance event and should also be taken into consideration when establishing the FDR flood pool elevation requirement. Optimization using Reclamation standards/criteria is necessary to firmly establish the FDR flood pool.*
5. *The authorized storage space allocation for flood control differs with the alternatives. The flood space requirement itself varies seasonally. The maximum space would be needed only during the most critical flood period (December through February).*

4.4 FLOOD ROUTING RESULTS

This section presents a discussion of PMF routings for various with- and without-project conditions alternatives.

4.4.1 Probable Maximum Flood Routings

Any adopted alternative for Folsom Dam must be capable of controlling a PMF event to a maximum reservoir elevation without encroaching into the prescribed freeboard. For this analysis, some assumptions made in routing the PMF through the Folsom Dam

operations and planning model were different from those routings performed in the development of flood damage reduction alternatives. These differences, which are unique to the PMF routings, are described below.

- A reduced efficiency is assumed on discharge through the main dam river outlets. Lower tier outlets are functioning at 50 percent operability and the upper tier outlets at 75 percent. An alternate practice would be to assume non-functioning main dam river outlets.
- The PMF is routed with an antecedent event, which sets the initial starting condition for the PMF. The initial starting storage for the antecedent event is 377,000 acre-feet (bottom of the flood control space). An alternate practice would be to route the PMF alone starting at 977,000 acre-feet (normal full [gross] pool).

The resultant maximum elevations, obtained through routing the PMF through each of the proposed alternatives is provided in **Table 4-6**.

TABLE 4-6
MAXIMUM PROBABLE MAXIMUM FLOOD ELEVATIONS

Alternative[1]	Maximum El, feet	
Without-Project Condition	**PMF**	**Top of Dam**
Common Features (model run R000_800CF)	483.2[2]	480.5
With-Project Condition		
New main dam river outlets and modification of existing main dam river outlets; no auxiliary spillway; (model run R000_0102FM)	482.9[2]	480.5
New main dam river outlets and modification of existing main dam river outlets; no auxiliary spillway; (model run R000_282FM) – Adaptation of original authorization	480.8[2]	480.5
No main dam river outlet modification; four submerged (17- by 33-foot) tainter gate auxiliary spillway; (model run R040_800FM_17x33)	480.8[2]	480.5
No main dam river outlet modification; four submerged (17- by 33-foot) tainter gate auxiliary spillway; emergency tainter gate replacement (model run R040_800FMe_17x33)	481.3[2]	480.5
No main dam river outlet modification; Six submerged (23- by 33-foot) tainter gate auxiliary spillway; (model run R060_800FM)	477.4	480.5
No main dam river outlet modification; Six submerged (23- by 33-foot) tainter gate auxiliary spillway; emergency tainter gate replacement (model run R060_800FMe)	477.9[2]	480.5

KEY:
PMF – Probable maximum flood
El, feet – Elevation in feet

Notes:
1 An explanation of nomenclature is provided in Plate 4-5.
2 Alternatives do not meet the minimum freeboard space requirement of at least 3 feet.

4.4.2 Uncertainty in Operations

Uncertainty considered in this analysis includes attempts to account for estimating relationships such as discharge-frequency, reservoir inflows versus outflow (i.e., unregulated versus regulated flow values), and rating curves. Previous analyses determined this uncertainty using the MONTE™ software package to perform Monte Carlo simulations, integrating the uncertainty associated with any of these relationships. The current analysis uses the Flood Damage Analysis software developed by the Corps, Hydrologic Engineering Center. The resulting output is a measure of flood risk associated with a particular project configuration.

Uncertainty in hydrology and reservoir operations is described via a band of uncertainty around paired data relationships or ranges of possible values. In hydrology, this uncertainty band is described by the confidence limits around unregulated flow-frequency curves. In reservoir operations, this band resembles a range of maximum and minimum outflow estimates around a reservoir inflow/outflow relationship. This analysis incorporates a reasonable range in reservoir operations, determined through various scenarios, to describe the range of uncertainty of the maximum and minimum reservoir releases associated with any given flood event. These risk analysis scenarios reflect the operating conditions ranging from the most likely to occur (base) to the most extreme operating conditions likely to produce the largest (maximum) or smallest (minimum) expected release. The criterion for operation is based on actual flood operations and analysis of historical data, resulting from coordinated effort by representatives of the Corps, SAFCA, and Reclamation. The operating criteria and assumptions associated with each scenario are summarized below in **Table 4-7**.

TABLE 4-7
OPERATING CRITERIA AND ASSUMPTIONS

Factor	Scenario		
	Base (cfs)	Maximum Outflow (cfs)	Minimum Outflow (cfs)
Initial Encroachment (acre-feet)	0	50,000	0
Extra Space in Folsom Lake (acre-feet)	0	0	100,000
Upstream Reservoir Space (acre-feet)	0	0	150,000
Starting Storage (acre-feet)	377,000	427,000	440,000
Initial Delay in Releases (hours)	4	8	0
Main Dam River Outlets Operation During Concurrent Spillway Operation (percent open)	60	0	60
KEY: cfs – cubic feet per second			

The following figures **(Figures 4-3** through **4-9)** represent output from the Folsom Dam operations and planning model, as outlined in the operations and alternative descriptions presented in **Section 4.3**. Represented are the inflow/outflow relationships for each alternative configuration. Given a fixed inflow, the uncertainty in operation is shown through the shaded band residing above and below the base outflow. The inflow/outflow relationships for key events are noted by vertical dashed lines.

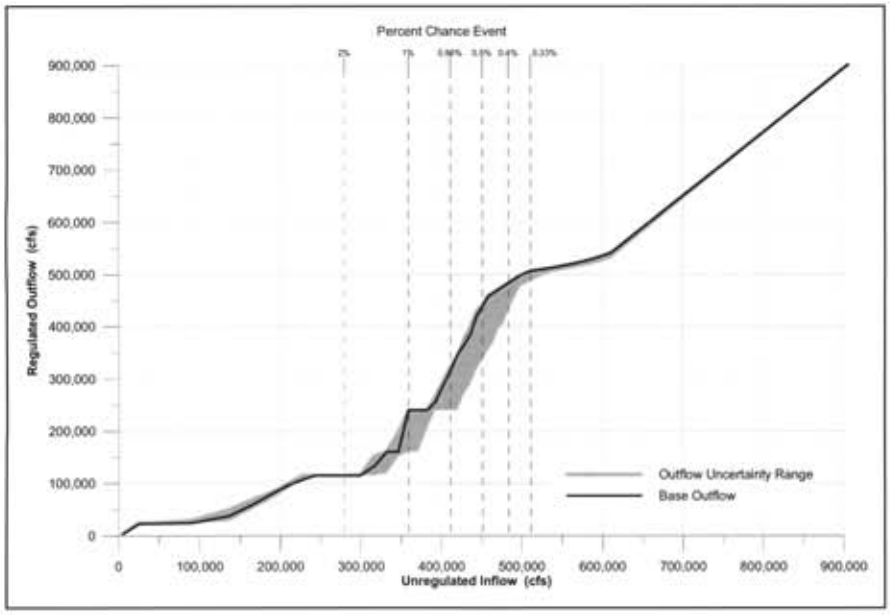


FIGURE 4-3
INFLOW VS. OUTFLOW RELATIONSHIP FOR EXISTING OPERATIONS WITHOUT PROJECT CONDITION – COMMON FEATURES

Common Features
Model Run R000_800CF

Water Control Diagram	400/670 SAFCA/Reclamation Interim Operation
Outlet Configuration	Eight existing main dam river outlets unmodified
Main Spillway Gates	Unmodified
Emergency Gates	Unmodified
Auxiliary Spillway	None
Dam Raise	None
PMF Peak Elevation	483.2

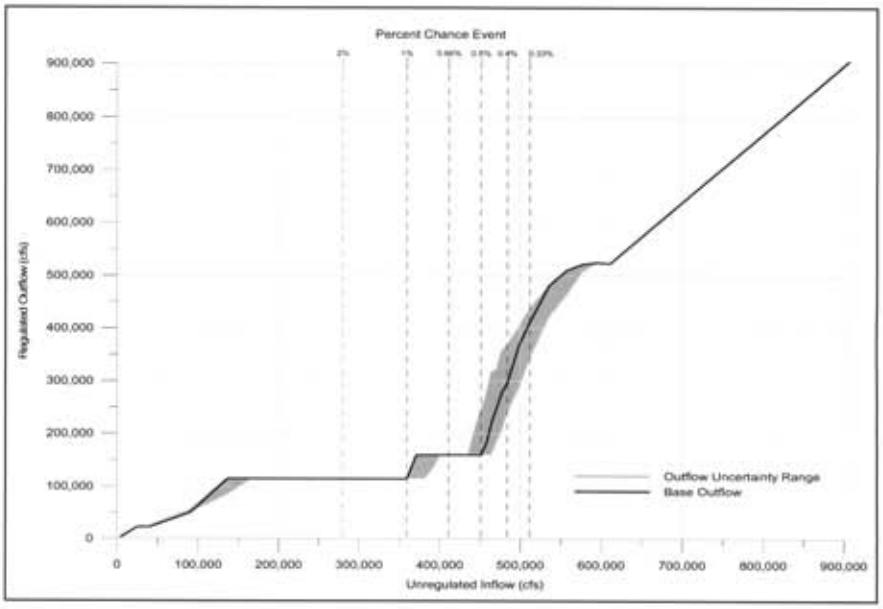


FIGURE 4-4
INFLOW VS. OUTFLOW RELATIONSHIP FOR FUTURE OPERATIONS WITH-PROJECT CONDITION – TEN OUTLETS

Original Authorization – Ten Outlets
Model Run R000_0102FM

Water Control Diagram	400/600 Reoperation
Outlet Configuration	Four existing, modified lower tier river outlets Four existing, modified upper tier river outlets Two new upper tier river outlets
Main Spillway Gates	Unmodified
Emergency Gates	Unmodified
Auxiliary Spillway	None
Dam Raise	None
PMF Peak Elevation	482.9

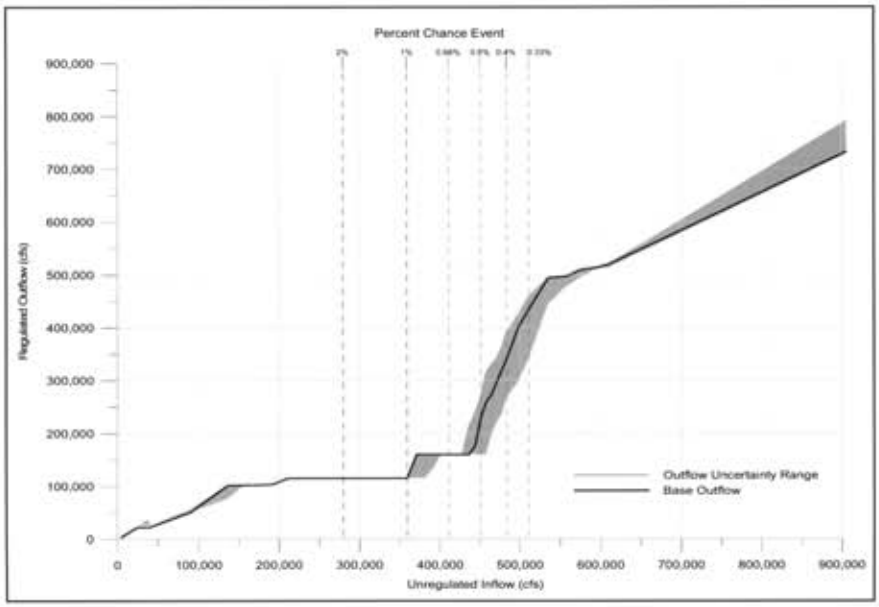


FIGURE 4-5
INFLOW VS. OUTFLOW RELATIONSHIP FOR FUTURE OPERATIONS WITH-PROJECT CONDITIONS – EIGHT OUTLETS

Adaptation of Original Authorization – Eight Outlets
Model Run R000_282FM

Water Control Diagram	400/600 Reoperation
Outlet Configuration	Two existing, unmodified, outer lower tier river outlets Two existing, modified, inner lower tier river outlets Four existing, modified upper tier river outlets Two new upper tier river outlets
Main Spillway Gates	Unmodified
Emergency Gates	Unmodified
Auxiliary Spillway	None
PMF Max Pool Elevation	481.8

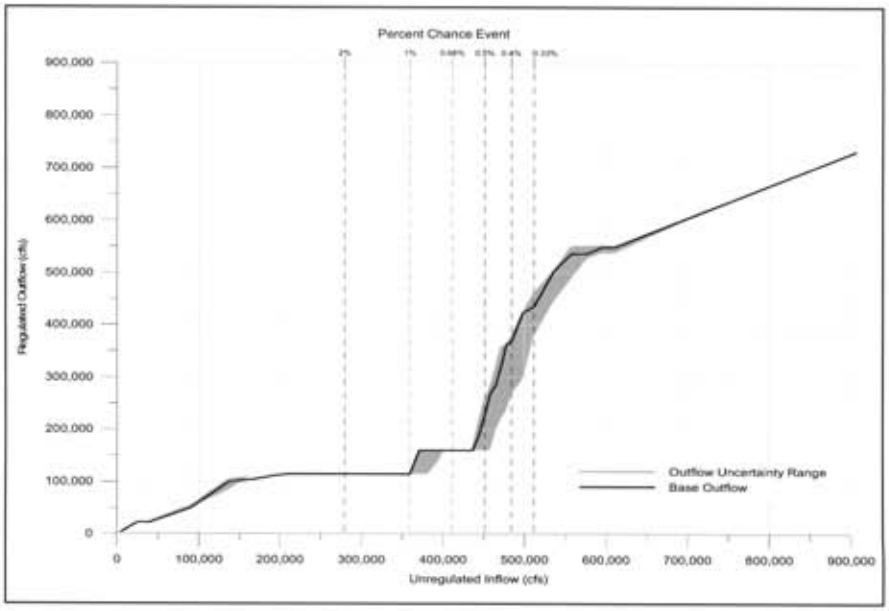


FIGURE 4-6
INFLOW VS. OUTFLOW RELATIONSHIP FOR FUTURE OPERATIONS WITH-PROJECT CONDITION - FOUR-SUBMERGED (17- BY 33-FOOT) TAINTER-GATE AUXILIARY SPILLWAY

No Outlet Modifications - Four-Submerged (17- By 33-Foot) Tainter-Gate Auxiliary Spillway
Model Run R040_800FM 17x33

Water Control Diagram	400/600 Reoperation
Outlet Configuration	Eight existing main dam river outlets, unmodified
Main Spillway Gates	Unmodified
Emergency Spillway Gates	Unmodified
Auxiliary Spillway	Four submerged (17- by 33-foot) tainter gates
PMF Max Pool Elevation	480.8

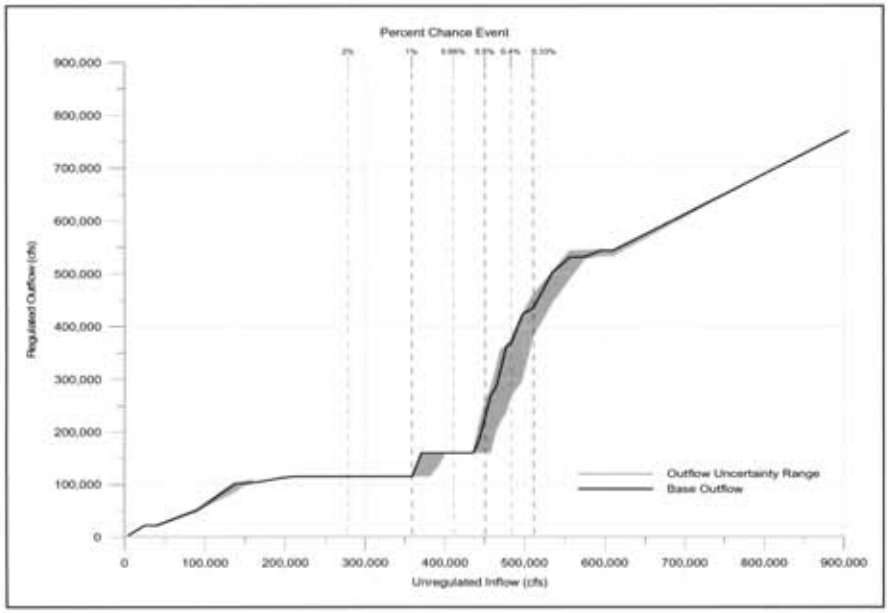


FIGURE 4-7
INFLOW VS. OUTFLOW RELATIONSHIP FOR FUTURE OPERATIONS WITH-PROJECT CONDITIONS - FOUR-SUBMERGED (17- BY 33-FOOT) TAINTER-GATE AUXILIARY SPILLWAY

No Outlet Modifications - Four-Submerged (17- By 33-Foot) Tainter-Gate Auxiliary Spillway
Model Run R040_800FMe 17x33

Water Control Diagram	400/600 Reoperation
Outlet Configuration	Eight existing main dam river outlets, unmodified
Main Spillway Gates	Unmodified
Emergency Spillway Gates	Modified
Auxiliary Spillway	Six submerged (17- by 33-foot) tainter gates
PMF Max Pool Elevation	481.3

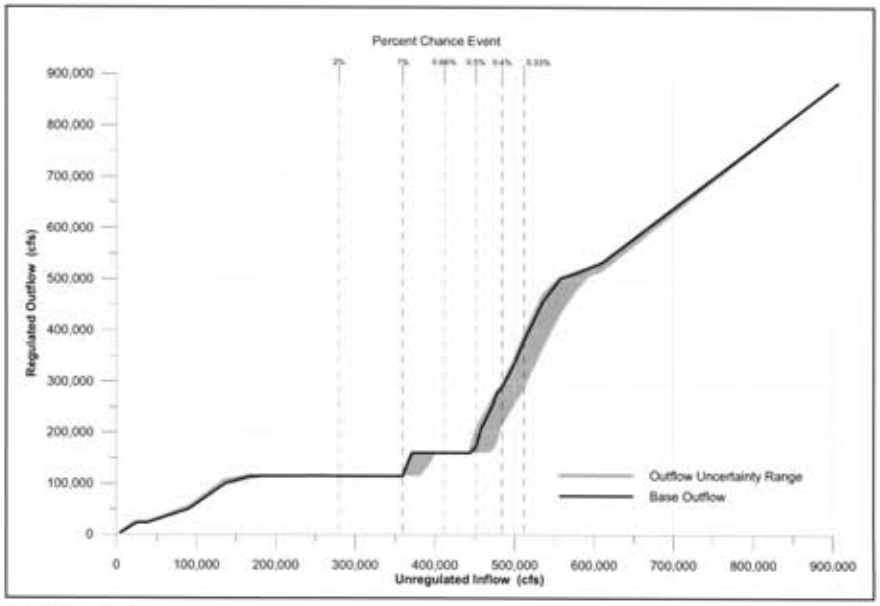


FIGURE 4-8
INFLOW VS. OUTFLOW RELATIONSHIP FOR FUTURE OPERATIONS WITH-PROJECT CONDITION - SIX-SUBMERGED (23- BY 33-FOOT) TAINTER-GATE AUXILIARY SPILLWAY

No Outlet Modifications - Six-Submerged (23- By 33-Foot) Tainter-Gate Auxiliary Spillway
Model Run (R060_800FM)

Water Control Diagram	400/600 Reoperation
Outlet Configuration	Eight existing main dam river outlets, unmodified
Main Spillway Gates	Unmodified
Emergency Spillway Gates	Unmodified
Auxiliary Spillway	Six submerged (23- by 33-foot) tainter gates
PMF Max Pool Elevation	477.4

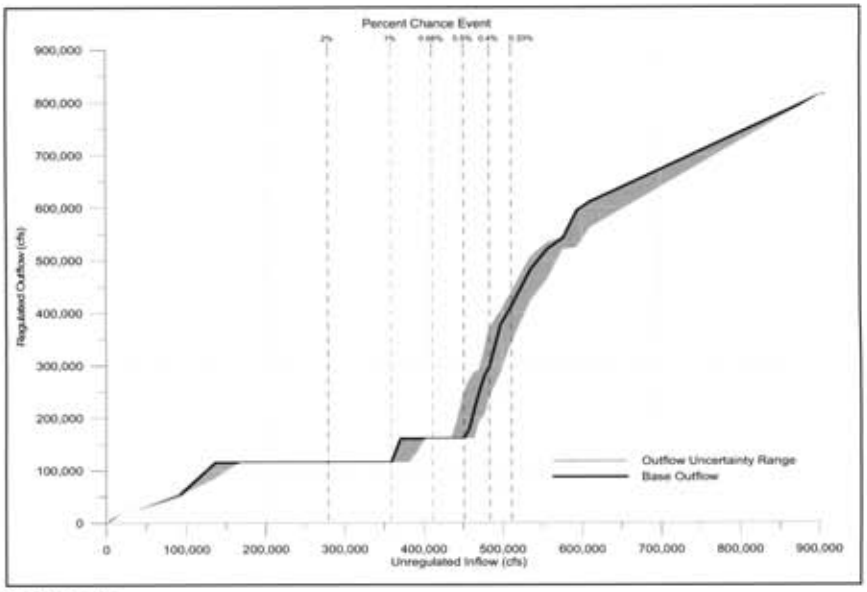


FIGURE 4-9
INFLOW VS. OUTFLOW RELATIONSHIP FOR FUTURE OPERATIONS WITH-PROJECT CONDITION - SIX-SUBMERGED (23- BY 33-FOOT) TAINTER-GATE AUXILIARY SPILLWAY; EMERGENCY TAINTER GATE REPLACEMENT

No Outlet Modifications - Six-Submerged (23- By 33-Foot) Tainter-Gate Auxiliary Spillway; Emergency Tainter Gate Replacement
Model Run R060_800fm

Water Control Diagram	400/600 Reoperation
Outlet Configuration	Eight existing main dam river outlets, unmodified
Main Spillway Gates	Unmodified
Emergency Spillway Gates	Unmodified
Auxiliary Spillway	Six submerged (23- by 33-foot) tainter gates
PMF Max Pool Elevation	477.9

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CHAPTER 5.0
ENVIRONMENTAL EFFECTS AND MITIGATION

Several previous environmental documents are relevant to the impact analysis for the main dam river outlet modification alternatives. These documents provided information about existing environmental, socioeconomic, and cultural conditions in the area; the effects of various actions on the resources in the area; and potential measures to avoid, minimize, reduce, or compensate for any significant effects.

5.1 EIGHT MAIN DAM RIVER OUTLETS MODIFICATION

A final *Environmental Assessment/Initial Study* (EA/IS) (State Reclamation, 2001) was prepared in August 2001, which discussed the environmental conditions and evaluated the potential effects of the original project design (enlarging the eight existing river outlets on the main dam) for the American River Watershed, California, Folsom Modification Project. The Corps determined that the proposed modifications would not have any significant long-term adverse effects on the environmental resources within the project footprint or along the lower American River. As a result, a finding of no significant impact (FONSI) and negative declaration accompanied the final 2001 EA/IS.

Following the issuance of the 2001 EA/IS, the project design was revised to include improvement of approximately 4,100 feet of existing access roads by paving and widening from 16 to 24 feet maximum and construction of approximately 3,000 feet of additional access roads and a Corps resident office facility. A final EA/IS was prepared for these activities in 2005. The Corps determined that with the proposed mitigation measures, these proposed construction activities would not have any significant long-term adverse effects on the environmental resources within the project footprint or along the lower American River. As a result, a FONSI and negative declaration accompanied the final 2005 EA/IS. These improvements were completed in 2006.

Also since the issuance of the 2001 EA/IS, additional information regarding technical feasibility and cost of modifying all eight of the existing main dam river outlets have led to further refinements to the project design. For current planning purposes, the Folsom Dam river outlet modifications would consist primarily of enlarging the four existing upper tier river outlets from 5 feet by 9 inches to 9 feet 4 inches by 14 feet, the inner two existing lower tier river outlets from 5 feet by 9 inches to 9 feet 4 inches by 12 feet, and adding two new river outlets on the upper tier. The two new outlets would be constructed of the same dimensions as the other upper tier river outlets. The enlarged main dam river outlets would increase the release capacity from 24,800 to 115,000 cfs (the objective release) at water-surface elevation 418 (the spillway crest elevation).

Modification of the main dam river outlets would not have any potentially significant impacts related to the resource categories of agricultural land use, geology and soils, topography, socioeconomics, recreation, or traffic and circulation.

Impacts would be as disclosed in the 2001 and 2005 EA/ISs with the following additional potential impacts due to design refinements.

5.1.1 Vegetation and Wildlife

Approximately 9.3 acres of waters of the United States would be temporarily affected by construction activities that modify the main dam river outlets. This area primarily would consist of the stilling basin and downstream channel.

5.1.2 Fisheries

Improvements to the existing stilling basin would be made during the non-flood season from approximately June until November over a two-year period. Construction activities would involve dewatering the stilling basin and installing rock anchors in the basin floor and sidewalls. The basin would be temporarily unavailable as habitat for fish and other aquatic species during these months until the stilling basin work is completed; however, the aquatic habitat would be available during flood season from November through May, and additional habitat would be available downstream and in Lake Natoma. Due to the relatively small area of the stilling basin as compared to downstream areas and Lake Natoma, the project would not substantially diminish habitat for fish or significantly displace fish to reduce year class strength of any fishes occupying the stilling basin. In addition, there would be no significant effects on the movement of resident or migratory fish because there is suitable habitat downstream and in Lake Natoma.

Approximately 8.7 acres of habitat would be unavailable during periods of dewatering. A 450-foot long by 15-foot wide access road would be constructed in the riffle pool complex downstream of the stilling basin to facilitate access to the stilling basin and ensure the possibility of rapid removal of personnel and equipment if necessary. This access road would require permanent or temporary filling of approximately 0.15 acre of the riffle/pool complex. The road would be constructed of 1,000 cubic yards lean mix concrete (permanent road) or clean gravel/cobbles (temporary road). Should a permanent road be constructed using lean mix concrete it would result in the filling of 0.15 acres of habitat, resulting in a significant adverse impact to fisheries. However, should a temporary road be constructed resulting in the filling of 0.15 acres with gravel/cobbles, the action would have a long-term beneficial effect on fisheries and invertebrate production downstream of the stilling basin because it would be expected that the gravel/cobble mix would be moved downstream and contribute to spawning areas, and riffle pool complexes as this is a sediment-starved area. Placement of gravel/cobbles in the amount of 1,000 cubic yards per year during stilling basin modification would have beneficial effects.

Prior to dewatering the stilling basin for construction, a fish salvage operation would be conducted, as necessary, to relocate fish downstream. In addition, the contractor would use best management practices to ensure that construction-related materials are not discharged downstream during construction. These best management practices would include cleaning and washing the stilling basin prior to allowing the stilling basin to be flooded. This water would then be disposed of at an appropriate facility to handle such materials contained in the stilling basin.

5.1.3 Water Quality

Construction activities within the interior of the dam would not be directly exposed to the environment but could affect downstream water quality through the drainage system within the dam. Excavation or fill activities would take place in approximately 0.13 acre of seasonal wetlands, and cause temporary disturbance to 9.3 acres of open water (0.15 permanent or temporary fill) and drainages (0.6 permanent).

Appropriate best management practices to control construction-related contamination and to reduce construction-related and operation effects to less-than-significant levels would be as follows:

- Sediment control methods would be used in the interior of the dam to limit the discharge of construction materials into the interior drainage system of the dam. Best management practices could include the use of silt fences or other barriers at drainage inlets.
- Major equipment cleaning and maintenance would not be conducted within the construction area at the face of the dam or near the stilling basin.
- A dewatering permit would be obtained from the Regional Water Quality Control Board (RWQCB) and water quality monitoring conducted for stilling basin dewatering.
- Sediment curtains and water quality monitoring would be completed to ensure that turbidity limits and other RWQCB water quality parameters are not exceeded during marine construction and stilling basin modification.

5.1.4 Air Quality

Potential air pollutants generated during construction include particulate matter smaller than ten microns (PM_{10}) emissions from debris-moving activities and vehicle travel on unpaved roads, and exhaust emissions from operation of construction equipment, delivery and haul trucks, and employee vehicles. Tailpipe exhaust emissions include ozone precursors (nitrogen oxides [NO_x] and reactive organic gasses [ROG]) and PM_{10}.

Sacramento Municipal Air Quality Management District (SMAQMD) thresholds and Federal thresholds of significance would be exceeded for NOx under the proposed action in all years with main dam river outlet modification construction activities. In general, air quality effects would be less than significant for ROG and PM_{10}. Federal conformity for NO_x would be exceeded. Federal conformity for ROG, PM_{10}, and CO_2 would not be exceeded. However, no sensitive receptors (residences and schools) are located in the project area. Therefore, no sensitive receptors would be affected by short-term increases in dust and other air pollutants.

The analysis summarized above should be considered preliminary, with the possibility of fewer or greater effects than calculated. This is possible since the analysis is a maximum daily average of emissions and not an average emission analysis. The Corps does not have the ability to conduct an accurate average daily emission analysis since the Corps

does not control contractor production rates, schedule, equipment inventory, source material, and employee housing locations. Therefore, mitigation measures have been developed in coordination with SMAQMD to minimize exceeding State and Federal thresholds.

Potentially significant air quality effects have been identified, and the Corps would implement mitigation measures as described in the 2005 EA/IS for NO_x emissions in years where SMAQMD thresholds and Federal thresholds of significance are exceeded. With the implementation of these mitigation measures, the project would not exceed SMAQMD thresholds and Federal thresholds of significance for the project. As a result, potential emissions due to the project would be below the level of significance for air quality.

5.1.5 Visual Resources

Effects on visual resources are changes in viewer response as a result of project construction and operation. Multiple types of construction equipment would be visible at the project area. Boaters, pedestrians, and bicyclists, would be able to see the construction equipment, as well as workers and visitors to Reclamation and Corps offices. The construction equipment would be visible for approximately seven years. The presence of construction equipment would have an adverse impact on the visual quality of scenic vistas. Views of Folsom Dam would not be permanently altered by construction of the main dam river outlet modifications and the addition of two new river outlets. Outlet modification would be generally confined to the interior of Folsom Dam; therefore, it is considered less than significant. Also, because this effect would be temporary during construction, it is considered less than significant.

5.1.6 Cultural Resources

Since preparation of the previous environmental documentation for main dam river outlet modification work, Folsom Dam has become eligible for listing as a historic resource. Prior to construction activities, cultural resources staff would prepare a determination of potential impacts and consult with the State Historic Preservation Office.

5.2 FOUR-SUBMERGED-TAINTER-GATE AUXILIARY SPILLWAY AND REPLACEMENT OF THREE EMERGENCY TAINTER GATES

Separate impact analyses have not been performed for two- or four-STG auxiliary spillway alternatives. It is assumed that impacts for these alternatives would be similar in nature, but of lesser magnitude than a six-STG auxiliary spillway, which is analyzed in the *Folsom Dam Safety and Flood Damage Reduction Environmental Impact Statement / Environmental Impact Report (EIS/EIR),* which was scheduled for public review in December 2006 (Reclamation, 2006). The following sections provide a summary of the impacts, organized by resource category, for the STG auxiliary spillway and replacement of three emergency tainter gates, along with proposed mitigation measures to minimize potential impacts to less-than-significant levels when possible.

5.2.1 Hydrology, Water Quality, and Groundwater

Construction of this alternative in itself would not change the hydrology of the American River nor alter current operations of the reservoir. The proposed modifications to the Folsom Facility could ultimately lead to revisions of Folsom Dam operations that would provide for greater releases of reservoir water prior to the reservoir reaching the main dam spillway crest elevation. Construction of this alternative would allow for the release of 115,000 cfs (the existing objective release) sooner than is now possible, with sufficient capability for a maximum release of 160,000 cfs (existing emergency release) reflecting the emergency channel capacity of the American River downstream of Folsom Dam. These larger, earlier releases from Folsom Reservoir would better utilize the existing flood storage space. However, the proposed modifications would be operated using existing criteria until the completion of the revised water control manual and supporting supplemental environmental compliance documentation. These would be completed one year prior to completion of the proposed modifications, at which time the full potential benefits of the proposed modifications would be realized.

Construction of this alternative would not affect local or Central Valley Project water supplies developed at Folsom Reservoir.

5.2.2 Air Quality

Air quality would be significantly impacted by cumulative emissions from exhaust from construction equipment and materials hauling trucks, fugitive dust produced by excavators and haul trucks on dirt roads, and fugitive dust emissions from materials processing facilities and concrete batch plants. NO_x emissions would trigger a general conformity evaluation, from which mitigation measures would be developed to reduce air quality impacts.

5.2.3 Aquatic Resources

Construction of this alternative would have less than a significant impact on in-reservoir aquatic resources. The majority of the fish species inhabiting the reservoir are introduced game or prey species, and special status species are not known to inhabit the immediate vicinity of the project sites. Construction near Dike 6 could potentially result in removal of a seasonal wetland. Loss of the wetland would be significant, requiring compensation.

5.2.4 Terrestrial Vegetation and Wildlife

Construction of this alternative would have the potential to adversely affect special status plant or animal species and protected oak woodlands, and could result in loss of native vegetation, and result in a permanent loss of project area wetlands. All vegetation impacts would be mitigated to less-than-significant levels. Construction activities could result in the alteration or loss of habitat for wildlife special status species. Construction activities would result in direct and indirect impacts to a number of elderberry shrubs, which are habitat for the Valley Elderberry Longhorn Beetle *(Desmocerus californicus)*, which is Federally listed as a threatened species and protected by the Endangered Species Act. These impacts would

require compensatory mitigation in accordance with the United States Fish and Wildlife Service biological opinion.

5.2.5 Soils, Minerals, and Geological Resources

Construction activities would result in the loss of topsoil resources. This impact would be mitigated to less-than-significant levels through the implementation of best management construction practices.

5.2.6 Visual Resources

Construction work on the auxiliary spillway would result in a temporary visual impact to visitors of the Folsom Lake State Recreation Area (SRA). The visual resource impairment is expected to be temporary during construction, and less than significant.

5.2.7 Agricultural Resources

This alternative would not impact local or regional agricultural resources.

5.2.8 Transportation and Circulation

The hauling of materials and supplies to the project sites would not have a significant impact on the level of service for most local roadways, except for Scott Road north of White Rock, and East of Natoma Street. This impact would be mitigated as feasible.

5.2.9 Noise

Construction equipment, materials processing facilities, and haul trucks all would increase noise levels within the project area. During the day time, there would be a perceptible increase in noise for the project area, but due to the distance between sensitive noise receptors and noise sources, the increase would not be considered as significant. However, nighttime noise increase at three residential receptor areas would exceed ambient noise criteria creating an unavoidable adverse impact, should mitigation measures not be effective in reducing noise levels.

5.2.10 Cultural Resources

Since preparation of the previous environmental documentation for main dam river outlet modification work, Folsom Dam has become eligible for listing as a historic resource. Prior to construction activities, cultural resources staff would prepare a determination of potential impacts and consult with the State Historic Preservation Office. Cultural resources are known to exist at many locations proposed for staging and facility construction. Cultural resource impacts would be evaluated and mitigated for under a programmatic agreement in consultation with the State Historic Preservation Office.

5.2.11 Land Use, Planning, and Zoning

Construction of this alternative would be conducted in compliance with local planning and zone rules.

5.2.12 Recreation

Contractor staging would emphasize use of areas with no current public access, away from residential areas. Excess materials would be used to create platforms above the normal operating reservoir water surface at elevation of 466.0 and would be be placed so as to maintain existing or equivalent public recreation access and use capacity during the peak recreation season.

To minimize potential impacts to recreation, staging areas at Beal's Point and Folsom Point would be placed on constructed platforms or on adjacent unimproved areas a safe distance from primary recreational activities. Public safety would be maintained through the use of fencing or other similar measures. There would be nearly continuous public access to recreation areas and trails throughout the construction period through the use of traffic control measures, grade separated vehicular and/or pedestrian crossings, and/or temporary alternate public access detours. Closures could occur while the Partner Agencies are implementing these new measures that allow continued access or to address public safety and facility security objectives. In such cases, temporary closures would be accomplished during off-peak days or the off-season to minimize impacts on recreation activities. Reclamation's Central California Area Office would notify local agencies and the general public and accept input in advance of any possible extended closure(s) that may be necessary due to unforeseen project circumstances.

5.2.13 Utilities

Construction planning and sequencing would be performed so that existing utilities would not be impacted by construction activities. The 42-inch water main would be rerouted to accommodate any auxiliary spillway alternative.

5.2.14 Hydropower

Construction of this alternative would not impact hydropower operations at Folsom or Nimbus dams.

5.2.15 Population and Housing

Construction of this alternative would not impact local or regional population or housing.

5.2.16 Public Health and Safety

This alternative would include construction planning and implementation elements providing safety considerations for local public and visitors to the Folsom Lake SRA.

5.2.17 Indian Trust Assets

There are no Indian Trust Assets within the project area that would be affected by construction activities.

5.2.18 Environmental Justice

There are no ethnic or low income groups defined by environmental justice guidance within the project area that would be disproportionately impacted by construction activities.

5.3 FOUR-SUBMERGED-TAINTER-GATE AUXILIARY SPILLWAY

Environmental impact analysis was not performed specifically for this alternative. In general, impacts for this alternative would be similar to those described above, but to a lesser degree, especially for air quality and transportation, due to the shorter construction time and need for less equipment, workers, and materials if no gate replacement work would be done.

CHAPTER 6.0
GEOTECHNICAL INVESTIGATIONS AND CONSIDERATIONS

This chapter provides a summary of available engineering geology and geotechnical information that is pertinent to the proposed Folsom Modification Project. An aerial photographic view of the entire Folsom Reservoir and Dam area is provided as **Plate 1-2**. This chapter describes the available data and relevant interpretations, and a summary of these findings as they apply to the proposed project elements.

The project being considered as the least-cost alternative that provides all of the functionality of the authorized Folsom Modification Project is the four-STG auxiliary spillway as shown on **Plate 2-1**. This plate also shows the proposed Folsom Dam Road realignment project that is immediately adjacent and to the south.

The proposed auxiliary spillway and all of its design components are located within an area beginning at the existing parking area and overlook about 3,000 feet east of the dam along the Dam Road, which has been restricted to traffic for the past two years. The western end of the facilities will terminate approximately 600 to 700 feet south of the existing dam stilling basin at the American River. Topographically, this project area begins at approximate upper elevation 525, descending along a gently west-southwest sloping natural ground surface to approximate elevation 115 to 120 at the American River. Although several areas of shallow access road cuts and fills exist throughout this project footprint, the majority of the site consists of annual grass cover and natural ground. One area of deeper fills is present at the west end of the project and an approximate 50-foot high, steep road cut was constructed along the former Dam Road. The parking area was created by placement of deep fill extending into the reservoir. No other significant structures are known to be present in this area.

The following sections describe the available geologic, seismic, and geotechnical information within the project area and a summary of those findings. These discussions are followed by a summary of these conditions as they relate to potential design considerations for the auxiliary spillway project.

6.1 SUMMARY OF GEOTECHNICAL INVESTIGATIONS

Available geologic and geotechnical data within the project area consists of geologic mapping, site-specific geotechnical explorations, and detailed laboratory testing and analyses. This summary describes this information and is followed by a summary of findings. A complete list of applicable geologic and geotechnical references is provided in Chapter 9, References.

6.1.1 Geologic Mapping

Regional geologic mapping has been performed by a number of geologists that provides crucial geologic unit descriptions and contact locations for the Folsom Reservoir and Dam area. Geologic mapping was performed by George Kiersch (Kiersch, 1950) during

initial foundation investigations for Folsom Dam and Reservoir. Ralph Loyd performed bedrock mapping of the Folsom Quadrangle at a scale of 1:24,000 (Loyd, 1984). A regional geologic compilation of multiple geologic maps was prepared by David Wagner (Wagner, 1981) for the Sacramento 2-degree sheet. As-built foundation excavation mapping was performed (Corps, 1952 and 1954) at the main dam, left and right wing dams, and MIAD. More recently, geologic mapping and rock discontinuity mapping has been performed by the Reclamation (Reclamation, 1999 and 2001) and Kleinfelder (2005 and 2006) for the main dam stilling basin scour analysis and auxiliary spillway, respectively. Collectively, these data provide a strong basis for surface interpretation of the nature and extent of surficial and geologic earth units.

The major geologic earth units in the Folsom Reservoir region are shown on **Plate 6-1**. The primary earth unit in the area is the Mesozoic diorite of Rocklin-Penryn Pluton, a late stage igneous intrusion associated with the emplacement of the Sierra Nevada Batholith. The eastern boundary of this pluton occurs between the main dam and MIAD, a little over one-half mile east of the auxiliary spillway project area. East of this contact, northwest striking and steeply dipping foliated Jurassic metamorphic rocks prevail. Tertiary volcanics of the Mehrten Formation cap these two primary bedrock formations, forming isolated ridgelines and peaks throughout this area. One such peak occurs within the eastern portion of the auxiliary spillway forming the highest hilltop along the southeast of the proposed inlet and gate structure cuts. Shallow alluvium and fill also form thin veneers over this sequence of units throughout the project area. These geologic mapping efforts are shown collectively on **Plate 6-2**.

Faulting has also been mapped largely on the basis of field geologic mapping and interpretation of aerial photographs. Faults have been mapped in the project area by Kiersch (1950), Wagner (1981), Woodward-Clyde (1983), Loyd (1984), Jennings (1994), URS Corporation (URS, 2004), and Reclamation (2004). No active faults are mapped or otherwise known to exist within the immediate vicinity of Folsom Reservoir and Dam. Several faults have been mapped that occur within the auxiliary spillway and main and left wing dam areas, but none are suspected to be young enough to be capable of generating design earthquakes. These faults are significant in that they represent potential zones of intense fracturing and persistent discontinuities along which low shear strength exists, and thus may influence design considerations. These faults include the channel and subsidiary faults dipping gently to the northwest and outcropping in the main dam and spillway area, the east-west fault mapped beneath the left wing dam, and the penstock faults represented by steeply dipping structures outcropping near the penstocks. These fault locations are shown on **Plate 6-3**.

Surface discontinuity mapping and statistical analyses were also performed (Corps, 2005; Kleinfelder, 2006). These data identified two structural blocks of differing discontinuity orientations and characteristics referred to as the north and south blocks. These blocks are separated by the mapped east-west fault, as shown on **Plate 6-4**. The south structural block coincides with the entire auxiliary spillway project footprint. A stereonet showing the orientations of these south block discontinuities is provided as **Figure 6-1a**. **Figure 6-1b** shows the results of a preliminary assessment of the Norcal (2005) televiewer data for the Corps Phase I explorations (Corps, 2006) and (Kleinfelder, 2006). These

stereonets suggest that discontinuities represented by joints, fractures, faults, and foliation within the auxiliary spillway project area may be generally consistent and represented by the following structural sets presented in **Table 6-1**, below.

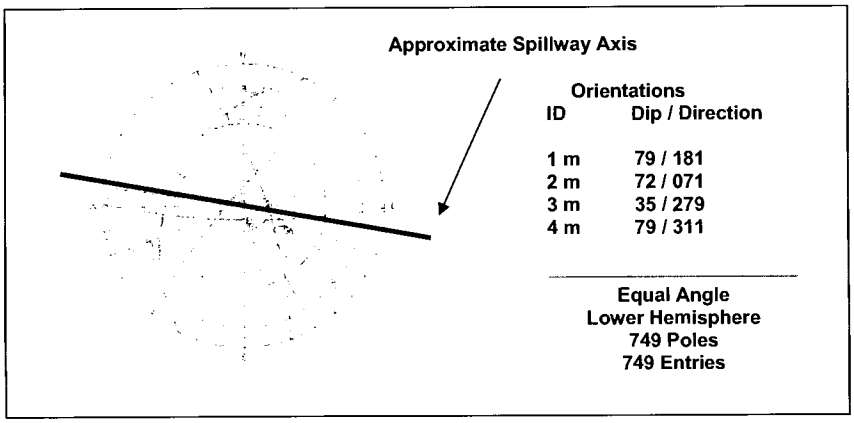


FIGURE 6-1a
CONTOURED POLE PLOT STEREONET SHOWING DISCONTINUITY SETS FOR STRUCTURAL BLOCK II

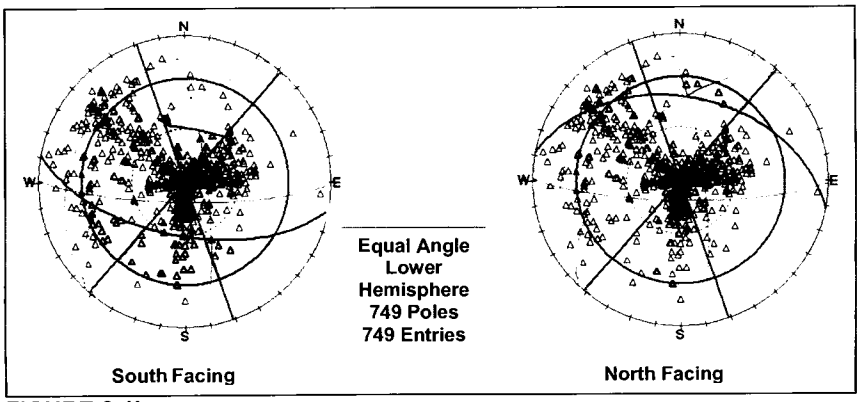


FIGURE 6-1b
MARKLAND EVALUATION FOR SOUTH FACING AND NORTH FACING SLOPES

TABLE 6-1
SOIL AND ROCK PROFILE AND CHARACTERISTICS

Set	Strike	Dip	Relation to Auxiliary Spillway	Comments
1	N89°W	79°SW	Approximately parallel, steeply dipping	
2	N7°W	78°NE	Approximately perpendicular, steeply dipping	Foliation Parallel to Penstock Faults, if present;
3	N41°E	82°NW	Approximately subparallel, steeply dipping	Parallel to East-West Fault
4	N37°E	25-55°NW	Approximately subparallel, low angle dip out of southern cut slope	Parallel to channel fault

KEY:
N – North
W – West
E – East
NE – Northeast
NW – Northwest

6.1.2 Geotechnical Explorations

Geotechnical explorations have been performed in the auxiliary spillway area during the initial foundation investigations (Corps, 1950), overwater explorations at the heel of the main dam (Kleinfelder, 2002), below the main dam (Reclamation, 1999 and 2001), for the alternate Dam Road and bridge alignment (URS, 2005), and jointly for the auxiliary spillway Phase I exploration program (Corps, 2006; Reclamation, 2006). Seismic refraction studies were also performed in the auxiliary spillway footprint for the auxiliary spillway and alternative road alignment (Norcal, 2005; URS, 2005).

These data have been compiled in plan and profile view relative to the proposed auxiliary spillway. Locations of all available borings and refraction lines are shown on **Plate 6-2**. Borings and refraction data have also been captured in the geographic information system (GIS) (shapefile) format. In general, the auxiliary spillway is underlain by dioritic (i.e. granitic) rock with weathering, hardness, and discontinuity spacing that varies with depth. Zones of discontinuity and rock mass characteristics have been classified into five zones with increasing depth, as described in **Table 6-2**.

TABLE 6-2
SOIL AND ROCK PROFILE AND CHARACTERISTICS

Zone	Name	Description	Weathering Grade	Strength
A	Soil and Fill	Soil and loose rock; Residual soil profiles and fills	VI	R0
B	Weak Rock	Highly weathered to decomposed; Highly to intensely fractured	IV – V	R1 – R2
C	Moderate Rock	Slightly to moderately weathered; Slightly to moderately fractured	II – III	R3 – R4
D	Hard Rock	Fresh or unweathered; Slightly to unfractured	I	R5 – R6
E	Mehrten Formation	NC	NC	NC

KEY:
NC – Not classified
Note: All values rock mass rating (RMR) system

Rock mass ratings (RMRs) and geologic strength indices (GSIs) were developed for the zones based upon the available data described above. These values are generally described in **Table 6-3**.

TABLE 6-3
ROCK MASS RATING AND GEOLOGIC STRENGTH INDEX VALUES

Zone	Name	RQD Rating	Groundwater Rating	Discontinuity Condition Rating	UCS Rating	RMR	GSI
A	Soil and Fill	NA	NA	NA	NA	NA	NA
B	Weak Rock	7	15	10	1	39	34
C	Moderate Rock	14	15	10	4	50	45
D	Hard Rock	18	15	0	9	59	54
E	Mehrten Formation	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

KEY:
RQD – Rock quality designation
UCS – Unconfined compressive strength
RMR – Rock mass rating
GSI – Geologic strength index
NA – Not applicable

Seismic refraction velocities were developed by Norcal for the auxiliary spillway and for excavations associated with the nearby proposed alternate Dam Road alignment and bridge construction, and are outlined in **Table 6-4**.

TABLE 6-4
SEISMIC REFRACTION VELOCITIES

Zone	Norcal, 2005a	Norcal, 2005b	Weathering Grade
A	V1: 1,100-1,400 fps	V1: 1,200-2,100 fps	VI
B	V2: 2,900-3,700 fps	V2: 2,000-5,000 fps	IV – V
C	V3: 4,800-10,400 fps	V3: 12,600-14,900 fps	II – III
D	Not differentiated	Not differentiated	I
E	Not differentiated	Not differentiated	NC
KEY: fps – feet per second			

Although Norcal was the geophysical consultant for both of these adjacent projects, the three identified velocity layers are not consistent. The velocities for the bridge project to the south of the auxiliary spillway were somewhat lower. Norcal is in the process of reviewing these data utilizing the existing boring information as ground truthing and will revise these velocity profiles accordingly.

Plates 6-5 through **6-7** are geologic profiles and cross-sections of the proposed auxiliary spillway design components relative to these subsurface zones. These subsurface interpretations are prepared on the basis of the available data only and are subject to variation depending upon future subsurface exploration findings.

6.1.3 Geotechnical Testing and Analysis

Extensive geotechnical field and laboratory testing and analysis were performed on rock samples obtained from explorations outlined above. These studies largely focused on the sliding block stability evaluations for the main dam in the present configuration as well as the revised pool elevation for a proposed Folsom Dam Raise Project.

Large-scale direct shear testing was performed by Anders Bro (Bro, 2004 and 2005), Fuller, Mossbarger (2003), URS (2003 and 2004), Reclamation (2005). Shear strength estimates using these values and considering the roughness coefficients of rock discontinuities were performed by Greene (2002), Goodman (2005), Quest Structures (2005a and 2005b), and URS (2001 and 2003). Engineer Research and Development Center (ERDC), formerly known as Waterways Experiment Station (WES) also estimated in-situ geophysical properties in 2005. Concrete strength testing was also performed (Reclamation, 2002; Reclamation, 2005; Reclamation, 2006). Goodman Jack testing and rock mass modulus estimates were perfumed by Woodward-Clyde (1983). Stability evaluations utilizing these data were performed by the Corps (Corps, 1989) and Kleinfelder (2006), and 3-D block analyses by Reclamation (USBR, 2004). Geotechnical foundation design criteria were developed for the alternative Dam Road Bridge by URS (2006) and for the auxiliary spillway project by Kleinfelder (2006).

These laboratory tests and parameters developments were primarily focused on the main dam and foundation materials. In general, these studies developed shear strengths and

rock mass moduli for the concrete, concrete-foundation rock interface, and for the foundation rock.

6.1.4 Ground Motions

Ground motion studies for this project were performed by URS and results were presented in three reports (URS, 2001, 2002, and 2003). The 2001 report developed horizontal ground motions for operating basis earthquake (OBE), maximum design earthquake (MDE), and maximum credible earthquake (MCE). The OBE and the MDE have been defined probabilistically as ground motions having 10 percent and 0.5 percent probability of exceedance in a design life of 50 years, respectively (return periods of 500 and 10,000 years, respectively). The MCE is defined as the 84th percentile motion estimated deterministically from a magnitude 6.5 event on the nearby branch of Bear Mountain fault zone (source to site distance of 14 kilometers). The 2002 report presented the design criteria for a seismic event appropriate during the construction period (about seven years) defined as 6.76 percent probability of exceedance in seven years (return period of about 100 years). The 2001 and 2002 reports provided recommendations to take vertical ground motions as two-thirds of horizontal motions at all periods. However, based on some recent research, period-dependent vertical ground motions were provided in the 2003 report.

A summary of the peak horizontal and vertical accelerations in terms of 'g' for different seismic events is provided in **Table 6-5**. **Table 6-6** presents the results of deaggregation in terms of mean and modal magnitude (M) and distances (D) for probabilistic events. These are the controlling magnitudes and distances for each probabilistic seismic event. The mean values are the average of the parameters contributing and the modal values are the most commonly occurring value contributing to the hazard. The MCE is a deterministic event and represents M6.5 at a distance of 14 kilometers. Horizontal and vertical spectral acceleration values at other periods for each seismic event as well as a suite of spectra-matched time histories were also presented in these reports.

TABLE 6-5
SEISMIC DESIGN GROUND MOTIONS

Seismic Event	Probability of Exceedance	Peak Ground Acceleration, PGA (g)	
		Horizontal	Vertical
OBE	10% in 50 years	0.10	0.0704
MDE	0.5% in 50 years	0.28	0.2374
MCE	84th percentile deterministic	0.38	0.3220
Construction Loads	6.76% in 7 years	0.057	0.0401

KEY:
OBE – Operating Basis Earthquake
MDE – Maximum Design Earthquake
MCE – Maximum Credible Earthquake
g – Acceleration due to gravity

TABLE 6-6
DEAGGREGATION RESULTS

Seismic Event	Mean		Modal	
	M	D (km)	M	D (km)
OBE	5.7	41	5.1	14
MDE	5.7	13	5.3	8
Construction Loads	5.7	65	5.3	37.5

KEY:
OBE – Operating Basis Earthquake
MDE – Maximum Design Earthquake
M – Modal magnitude
D – Distance
km - kilometers

6.2 GEOTECHNICAL DESIGN CONSIDERATIONS

The geotechnical design considerations revolve around the proposed design components to construct the auxiliary spillway. These generally include the excavation, suitability of exporting materials to other sites, temporary and long-term stability of excavated slopes, temporary and long-term seepage potential, seismic design, geotechnical foundation design criteria, and scour potential at exposed sections of the auxiliary spillway. The following sections provide a summary of the referenced data relative to these potential design considerations.

6.2.1 Excavation Characteristics

Excavation characteristics at the proposed auxiliary spillway will vary with depth and are generally defined by the fracture spacing and seismic velocity data summarized in **Section 6.2**. These data are summarized in **Table 6-7**.

TABLE 6-7
EXCAVATION CHARACTERISTICS

Zone	Material	Average Velocity	Average Fracture Spacing	Caterpillar Handbook Designation (2001)
A	Soil and Fill	<2,000 fps	NA	Rippable
B	Soft Rock	2,000-5,000 fps	<2 feet	Rippable
C	Moderate Rock	5,000-8,000 fps	2-6.5 feet	Marginally rippable
D	Hard Rock	8,000-12,000 fps	>6.5 feet	Marginally to non-rippable
E	Mehrten Formation	<12,000 fps	Unknown	Marginally rippable

KEY:
fps – feet per second

6.2.2 Reuse of Excavated Materials

Potential reuse opportunities for the excavated soil and rock generated from the auxiliary spillway project include the proposed remediation of MIAD and dike raises. The MIAD remediation is proposed to involve stripping of downstream slope and placing an estimated one million cubic yards of shell material. General specifications have not been established but material having an internal angle of friction of 33 degrees was used in the initial analyses with a maximum of 10 percent fines. Although material properties have not been evaluated through extensive laboratory testing of physical properties, it is likely that the rock zones C and D would generate material for reuse in this application but would require processing. The volume of these zones has not been estimated at this time.

Should an embankment raise alternative for the dike raises proceed, they may also represent a source of reuse for the auxiliary spillway excavated materials. Detailed specifications of the material properties for the raised dikes is not available but is generally proposed to consist of a filter and bedding layer beneath the riprap on the waterside slope and the placement of shell material on the downstream slope. This would require the import of shell materials and filter materials. Both materials could likely be produced by processing the zone C and D rock materials from the auxiliary spillway excavation but may not be feasible given the need for transportation across the reservoir. These material applications are summarized in **Table 6-8**.

TABLE 6-8
EXCAVATED MATERIAL REUSE POTENTIAL

Zone	Material	Shell Material Potential	Filter Material Potential	General Embankment Material Potential
A	Soil and Fill	Poor	Poor	High
B	Soft Rock	Low	Low	High
C	Moderate Rock	Moderate	Moderate	Moderate
D	Hard Rock	High	High	Low
E	Mehrten Formation	Moderate	Moderate	Moderate

6.2.3 Excavated Slope Stability (Temporary and Permanent)

All of the proposed excavations for the approach channel, control structure, chute, and stilling basin are proposed as permanent slopes with the exception of the 1:1 false cut that is proposed for the control structure, leaving the approach channel cut for later excavation to leave a cofferdam plug until the remaining auxiliary spillway construction is complete. **Plates 6-5** through **6-7** show the approach channel, control structure, and chute in profile and cross-sectional view with the interpreted soil and rock zones described above. Markland analyses have been performed based on preliminary rock mass and discontinuity data from Reclamation and Corps auxiliary spillway explorations to date, and initial interpretations of downhole televiewer orientation information. These analyses provided

preliminary conclusions that the cut slopes could be constructed at allowable gradients as outlined in **Table 6-9**.

TABLE 6-9
ALLOWABLE SLOPE GRADIENTS

Zone	Material	Allowable Gradient (South-Facing)	Allowable Gradient (North-Facing)	Comments
A	Soil and Fill	28°; 1:2 (v:h)	28°; 1:2 (v:h)	Presently designed at 1:3 (v:h)
B	Soft Rock	28°; 1:2 (v:h)	28°; 1:2 (v:h)	Presently designed at 1:1.5 (v:h)
C	Moderate Rock	53°; 1:0.75 (v:h)	43°; 1:1 (v:h)	Presently designed at 1:0.5 (v:h)
D	Hard Rock	53°; 1:0.75 (v:h)	43°; 1:1 (v:h)	Presently designed at 1:0.5 (v:h)
E	Mehrten Formation	45°; 1:1 (v:h)	45°; 1:1 (v:h)	Presently designed at 1:3 (v:h)
KEY: v:h – vertical to horizontal				

Table 6-9 also shows the present slope geometries proposed for the auxiliary spillway cut slopes. Preliminary slope stability analyses suggest that the deeper portions of cuts could be constructed at a steeper gradient (i.e. 1:0.5 versus 1:1 as proposed) and shallower cuts could also be steepened from 1:3 as proposed to 1:2 with adequate bench design intervals and vegetation. Ongoing studies for the Phase 2 exploration of the auxiliary spillway will provide substantial new data that will allow re-evaluation of rock kinematics and thus allowable slope gradients.

Persistent faults, zones of intense fracturing and/or alteration are known to exist in portions of the auxiliary spillway and, if adversely oriented, may represent a sliding block potential that would be detrimental to the rock cut slope stability and potentially the stability of the adjacent left wing dam embankment. Evaluation of this potential has not been possible given the lack of oriented core data until very recently. If unstable, this would require stabilization methods beyond any rock bolting or stabilization of adversely oriented localized discontinuities described above. Mitigation of sliding block potential would likely require offloading and/or layback that would significantly influence the project design especially on the south side where it is adjacent to the proposed Folsom Dam Road realignment project. The ongoing Phase 2 explorations will also provide valuable data for reconsideration of this potential as well. An allowance has been included in the cost estimate for mitigation of this potential.

6.2.4 Seepage (Temporary and Permanent)

To date, no seepage analyses or evaluation has been performed. Permeability values need to be developed for the soil and rock profile (i.e. zones A through E) described above. As discontinuities will control rock permeability beneath the soil and fill zones, characterization of the aperture, infilling material, orientation, persistence, and spacing of discontinuities will become essential to seepage analysis. The presence of persistent structural features that represent seepage paths perpendicular to the auxiliary spillway and

adjacent left wing dam axes would likely require seepage controls such as grouting and/or placement of filter blankets and/or relief wells to alleviate excessive hydrostatic forces on the proposed rock cut slopes and approach channel, control structure, and chute concrete liner. This potential can be further evaluated as permeability data is developed from pressure/packer testing proposed as part of the Phase 2 auxiliary spillway explorations.

Seepage potential during construction has also not been evaluated because of the absence of data. Seepage beneath the left wing dam and into the auxiliary spillway during construction is a consideration. Of particular concern is the potential for seepage through the proposed cofferdam plug. As shown on **Plate 6-5**, this temporary excavation is proposed at a gradient of 1:1 and would expose rock zones B and C. Again, the permeability of these zones has not been evaluated because of the lack of available data but will be addressed as data becomes available during the Phase 2 auxiliary spillway explorations.

6.2.5 Seismic Design

The design of structures and consideration of seismic stability of permanent slopes will require the application of dynamic loading described previously in **Section 6.2.4** and summarized in **Tables 6-5** and **6-6**.

6.2.6 Geotechnical Foundation Design Criteria

It is assumed likely that lateral loads on the proposed control structure will govern the geotechnical design of foundations. It is also anticipated that drilled shafts will be the most economical system to withstand this loading condition. Therefore, the lateral capacity of the shafts will control the design. Preliminary correlations were performed during evaluation of the Phase 1 exploration data (Kleinfelder, 2006). These correlations suggest that the side shaft resistance available to provide axial or downward capacity is on the order of 2.2 mega pascals (Mpa). Therefore, using a safety factor of 2.5 to account for unknown contraction techniques, the allowable capacity of the shafts in sidewall shear is about 1.5 Mpa, or about 200 pounds per square inch (psi). The lateral loading on the shafts will dictate the shaft tip elevation and can provide either values for input into the computer program LPILE^{TM}, or spring constants for structural design. The diameter of the shafts will be required for this additional information. These data and further geotechnical foundation design criteria can be developed based on data provided from the ongoing Phase 2 auxiliary spillway explorations.

6.2.7 Scour Potential

Despite the intent to line the entire auxiliary spillway approach channel, control structure, chute, and stilling basin, preliminary evaluations were performed to assess the potential for leaving portions of the auxiliary spillway exposed where low scour potential may be present. Preliminary analyses were performed using the Annandale (1995) rock scour method based on initial results from the Phase 1 auxiliary spillway exploration data. Rock mass and discontinuity data were converted to the Annandale model parameters to develop erodibility indices, as summarized in **Table 6-10**, below.

TABLE 6-10
ROCK SCOUR POTENTIAL

Zone	Material	Ms	Kb	Kd	Js	K
A	Soil and Fill	2.04	7.05	2.02 (1.92)	0.67	19.5 (18.5)
B	Soft Rock	30	17.3	1.72 (1.55)	0.67	598 (539)
C	Moderate Rock	100	21.6	1.81 (1.51)	0.67	2619 (2185)

KEY:
Ms – Mass strength number
Kb – Particle/block size number
Kd – Discontinuity shear strength number
Js – Relative ground structure number
K – Erodibility Index (mean value; mean minus 1 standard deviation)

These values can be converted to required stream power (RSP) values using the Annandale (1995) empirical relationships and then compared to available stream power (ASP) derived from hydraulic modeling for the auxiliary spillway. If RSP values are found to be significantly higher than ASP values for portions of the auxiliary spillway, further consideration could be given to the frequency and consequence of these flows and whether it would be feasible to leave these portions of the auxiliary spillway unlined. Ongoing Phase 1 Explorations for the auxiliary spillway will provide more definitive data and subsequent analyses in this regard.

6.3 CONCLUSIONS

Preliminary geologic, geotechnical, seismic, and hydrogeologic data have been developed that is directly applicable to the auxiliary spillway design. Further data and analysis obtained during the ongoing Phase 2 auxiliary spillway explorations will enhance these data and allow further evaluation of key design considerations. Several critical design considerations have been identified during these previous geotechnical studies, including the following:

- Cofferdam seepage
- Sliding block stability
- Control structure foundation design
- Long-term seepage

Additional data, updated data characterization models, and analyses relative to each of these and other design considerations will result in better definition of the geotechnical design criteria for the auxiliary spillway and thus improvement of the corresponding design components and estimated costs. As these data and findings are developed, close coordination between the geotechnical engineers and the design team will be essential.

CHAPTER 7.0
FOLSOM MODIFICATIONS LEAST-COST FUNCTIONALLY EQUIVALENT ALTERNATIVE

The least-cost alternative that provides all of the functionality that would have been achieved by the authorized Folsom Modification Project for flood damage reduction only would be a four-STG auxiliary spillway adjacent to the existing Folsom Dam. The auxiliary spillway would regulate releases through a concrete gravity control structure into a lined spillway chute and stilling basin. The stilling basin would discharge directly into the American River. Plan and profile views of the proposed auxiliary spillway are shown in **Plates 7-1** through **7-3**. The design aspects and construction considerations associated with this alternative are described in the following sections.

7.1 PERFORMANCE

The four-STG auxiliary spillway alternative would provide a level of flood protection that meets or exceeds the protection afforded by the authorized Folsom Modification Project at the least-cost. The project most representative of the Folsom Modification authorization consists of the construction of six enlarged river outlets plus two new river outlets along with two of the existing river outlets in the main concrete dam. The performance of this project, once fully implemented, would reduce the probability of flooding in any one year from 1 chance in 81 to 1 chance in 147 and provide the capability to pass a 180-year design flood event. The four-STG auxiliary spillway alternative would provide a flood control level of protection computed at 1 chance in 149 in any given year. This alternative would provide the capability for Folsom Dam to pass a 180-year design flood event.

The four-STG auxiliary spillway alternative does not address the existing dam safety deficiency of inadequate spillway capacity. The additional release capacity provided by the auxiliary spillway increases, but does not fully meet, the capability for Folsom Dam to pass the PMF.

7.2 COST

The cost estimate presented in this EDR for the four-STG auxiliary spillway alternative is considered a reconnaissance-level estimate by Corps definition based on the probable type and size of the project, and includes construction features, lands and damages, relocations, environmental compliance and required mitigation, engineering and design, construction management, and contingencies. As described in **Chapter 3**, Folsom Modification Project Alternatives, the cost estimate was prepared for the purpose of determining concept feasibility and project screening of various alternatives. All of the screening estimates were prepared by the same team of cost engineers for consistency among the estimates for comparison of the alternatives. The cost estimate was based on generally accepted cost principals. The cost estimate method established reasonable costs sufficient to support a planning evaluation process. The estimate was developed using quotes,

calculations, unit prices and historical data as backup. The estimate has been factored to an October 2006 effective price level.

The estimated first cost for the four-STG auxiliary spillway alternative is $633 million.

Annual cost was developed based on 50-year life of the project and 4.875 percent interest rate. The estimated annual cost for the four-STG auxiliary spillway alternative is $34.4 million.

Key assumptions made in the preparation of the cost estimate are shown below:

- The design of the gates would be similar to the existing tainter gates at Oroville Dam.
- Concrete required for the auxiliary spillway would be batched on site and would be temperature controlled to control the heat of hydration.
- Stripping and excavated material would be hauled 2.25 miles for stockpiling or disposal at Folsom Point and/or site D-2 near the right abutment of MIAD.
- Temporary roads, 80-feet wide, would be constructed for the hauling of excavated material.
- The weight of reinforcing steel is based on 150 pounds/cubic yard of concrete.
- All construction would be on Federal land; therefore no real estate cost has been included in the cost of this project.
- The mitigation cost provided by the Corps' Environmental Resource Branch would be used for implementation of habitat mitigation at a US Fish and Wildlife approved site in the American River Parkway.
- A contingency varying between 20 and 35 percent was applied to the various construction features depending on the level of information provided. The average contingency for the total field costs was about 30 percent.
- A 3 percent compounded projected inflation factor was added to the contingencies to capture a higher unrealized inflation rate above what is provided in the Civil Works Construction Cost Index System.

7.3 HYDRAULIC DESIGN

This section describes the recommended alternative for the Folsom Modification Project and the variables that determine the capability of the project to release objective flow at a lower pool elevation than currently possible. The recommended alternative includes the construction of an auxiliary spillway near the left abutment of the main dam that incorporates four 17 feet 7 inches wide by 33 feet high submerged tainter gates at invert elevation 368.0. The dam, as it currently exists, has two major problems: flood control and dam safety. The existing main dam tainter gates and river outlets cannot pass the PMF without overtopping the dam. Also, the amount of flood control storage in the reservoir is insufficient and the

existing sluices through the dam are not large enough to pass significant flood flows during the early part of large floods. The existing sluices can only release a maximum of 24,800 cfs at spillway crest elevation 418.0. The downstream channel has an objective or target flood release of 115,000 cfs and releases above that are allowed only for dam safety purposes during very large floods. Since large flood flows can only be passed with the existing main dam tainter gates, a significant amount of flood control space must be filled before the objective downstream flows can be attained.

Other design alternatives have also been investigated and are described in the hydraulic design engineering attachment (**Attachment A2**). These alternatives increase the flood control capability of Folsom Dam by increasing the outflow capacity at lower reservoir levels, resulting in reduced maximum pool elevations when large storms occur and proper reservoir operations are followed. The studies determined the project's capability to discharge flows (outflow capacity) and dissipate energy from high-velocity flows before they enter the American River channel. Possible impacts to downstream water surface elevations, channel capacity stability and definition of the floodplain are briefly described. Ongoing studies and future analysis during the next phase of design are required to fully define design requirements.

7.3.1 Project Description and Historical Record of Hydraulic Design

This section identifies previous studies that relate to the least-cost alternative that provides all of the functionality that would have been achieved by the authorized Folsom Modification Project. This section also discusses the project objectives and details of the alternative.

7.3.1.1 Previous Studies

The following are studies that have been performed relative to the Folsom Modification Project:

- Corps, Original Design of Folsom Dam
- DWR, Original Design of Oroville Dam
- Reclamation, Recommended Flood Operations for Folsom Dam, TM FD-8130-FD-TM-97-3, September 1997
- Corps, Long-Term Study
- Corps, Folsom Modification Project – Design Document Report (original draft for outlet works with 10 main dam river outlets and most recent draft for six 9-foot 4-inch by 14 foot upper tier river outlets) and the project Design Plans and Specifications for the Upper Tier Conduits
- Corps, Reclamation, SAFCA, DWR, and State Reclamation Board, Folsom Dam Raise and Auxiliary Spillway Alternative, PASS II, June 2006

7.3.1.2 Project Objectives

The main objectives of the alternative for the authorized Folsom Modification Project as related to hydraulic design are to ensure the following:

- Hydraulic performance is acceptable.
- The auxiliary spillway and the stilling basin(s) function satisfactorily at design flows and at higher flows without excessive damage.
- Combined releases from the service spillway, auxiliary spillway, and emergency spillway can be made without complex operational constraints.

7.3.1.3 Least-Cost Functionally Equivalent Alternative

This section describes the least-cost alternative that provides all of the functionality that would have been achieved by the authorized Folsom Modification Project.

Without-Project Condition

The without-project condition includes construction of the Common Features Project for the lower American River. Folsom Dam currently has three methods of discharging flows from the reservoir: three power penstocks, eight 5-foot by 9-foot main dam river outlets (four upper tier and four lower tier), and eight tainter(radial) gates set near the spillway crest (five service and three emergency). To ensure adequate tailwater for releases from the three emergency tainter gates to prevent damage to the emergency stilling basin, the three emergency tainter gates should not be used unless the total outflow from the dam exceeds 300,000 cfs. However, the ESRD indicates that the emergency tainter gates will be overtopped unless opened when total releases exceed about 240,000 cfs. Therefore, damage to the emergency stilling basin could occur by operating the emergency tainter gates at less than 300,000 cfs. Because of the restriction on use of the emergency tainter gates, they are unusable for normal flood control purposes and use of the gates is limited to dam safety outflows. The current spillway capacity is insufficient to pass the PMF. Therefore, an auxiliary spillway or dam raise is required for dam safety to avoid overtopping the dam during extreme storm events.

Table 7-1 summarizes the capability of each outflow method at the selected pool elevations.

TABLE 7-1
SUMMARY OF FOLSOM DAM DISCHARGE OUTLET CAPACITY

Outlet Feature	Lake Elevation 400 feet Bottom of Maximum Flood Space	Lake Elevation 426 feet Bottom of Normal Flood Space	Lake Elevation 466 feet Normal Gross/Full Pool	Lake Elevation 477.5 feet Spillway Design Pool
	(cfs)	(cfs)	(cfs)	(cfs)
Three Power Penstocks	7,000	7,000	7,000	0
Four Lower Tier River Outlets	13,000	13,800	14,900	15,200
Four Upper Tier River Outlets	10,500	11,500	12,900	13,200
Five Service Tainter Gates[1]	0	12,500	209,500	300,000
Three Emergency Tainter Gates[1]	0	0	0	180,000
Total Existing Flood Control Capability	**30,500**	**44,800**	**244,300**	**508,400**
Four 17 foot 7 inch by 33-foot STGs at invert El 368 auxiliary spillway	**38,000**	**90,000**	**145,000**	**155,000**
KEY: cfs – cubic feet per second El – elevation				

Notes:
[1] *Regulated flow capability*

Four-STG Auxiliary Spillway

The least-cost alternative that provides all of the functionality that would have been achieved by the original authorization is an auxiliary spillway that provides flood control and has a discharge capacity of about 78,000 cfs at pool elevation 418. When combined with releases from the outlet works, this alternative actually provides only slightly less release capacity than the project associated with the original authorization. The combined capacity of the service spillway and auxiliary spillway is well over 300,000 at pool elevation 470, where the emergency tainter gates would need to be opened to avoid overtopping. The tainter gate design is very similar to that of the auxiliary spillway at Oroville Dam. The tainter gates for the new four-STG auxiliary spillway at Folsom Dam would be of similar size and the structural configuration and maximum head on the gates are similar. The alternative would include a four-STG auxiliary spillway on the left abutment (at the current overlook area). The auxiliary spillway would consist of an approach channel, a concrete gravity control structure with four top-seal STGs that are 17-feet, 7-inches wide by 33-feet high with the sill at elevation 368, and a 90-foot wide rectangular, concrete-lined chute that

leads into an energy dissipation area and exit channel. This alternative is effective because it increases the release capabilities at lower levels in the reservoir. A discharge chute would run from the outlet works towards the downstream end of the exit channel for the main dam (entering the American River in almost a direct line). A hydraulic jump stilling basin would be constructed to provide energy dissipation of the high velocity flows in the chute.

7.3.2 Criteria

The following list of documents provides applicable hydraulic design criteria for the project:

- Engineering Regulation (ER) 1110-2-1150 Engineering and Design for Civil Works Projects
- ER 1110-2-1156 Dam Safety – Organization, Responsibilities, and Activities
- Engineering Manual (EM) 1110-2-1601 Hydraulic Design of Flood Control Channels
- EM 1110-2-1602 Hydraulic Design of Reservoir Outlet Works
- EM 1110-2-1603 Hydraulic Design of Spillways
- EC 1110-2-6061 Safety of Dams – Policy and Procedures
- Federal Emergency Management Agency (FEMA) Publication 64, "Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners"
- Peterka, A. J. 1974. "Hydraulic Design of Stilling Basins and Energy Dissipators," Engineering Monograph No. 25, US Bureau of Reclamation, Denver, Colo.
- Boes and Hager. September 2003 "Two Phase Flow Characteristics of Stepped Spillways", American Society of Civil Engineers (ASCE), HY Journal

7.3.3 Hydraulic Design Elements & Parameters

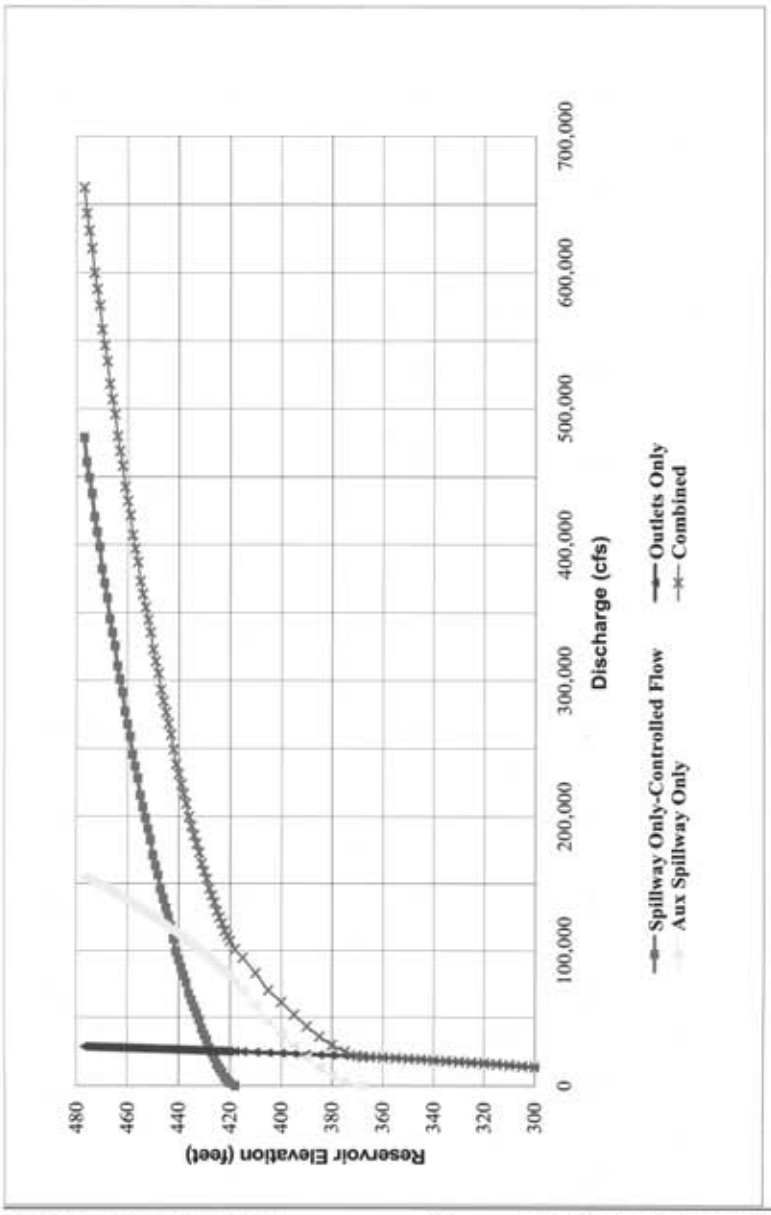
The discharge facilities for the four-STG auxiliary spillway alternative include a flared approach channel, a concrete gravity control structure, a steep rectangular concrete-lined chute, and a stilling basin. The control structure has a vertical upstream face, an intake/entrance to each of the conduits with a double elliptical roof curve, the submerged tainter gates, and four rectangular concrete conduits (just long enough to house each of the tainter gates and provide an exit to the steep chute). The stilling basin will be included for energy dissipation at the downstream end of chute.

7.3.3.1 Hydraulic Roughness

A Manning's "n" value of 0.035 was assumed for the channel roughness in the auxiliary spillway approach channel and in the exit channel downstream of the energy dissipator. Manning's "n" values of 0.012 and 0.016 were used for establishing maximum velocities and depths of flow, respectively, in the chute. More discussion of hydraulic roughness values is contained in the hydraulic design **Attachment A2**.

7.3.3.2 Stage-Discharge Relationships

The discharge rating curves (pool stage versus discharge) for the auxiliary spillway were patterned after the Oroville Dam service spillway. The auxiliary spillway for Folsom Dam would be 17 feet 7 inches wide and have a head of about 93 feet on the centerline of the tainter gates at maximum pool elevation 477.5. These dimensions are the same as the Oroville spillway STGs, but the Oroville Dam Spillway has a head of about 90 feet on the centerline of the tainter gates at maximum pool. The discharge rating curve for the Folsom Dam auxiliary spillway control structure, with gates fully opened is shown on **Figure 7-1.** **Figure 7-1** also show discharge rating curves for the existing river outlets in the main dam and the existing tainter gates for the main dam. See **Attachment A2** for more information.



Note: Objective Release of 115,000 cfs can be attained at about elevation 426

FIGURE 7-1 FOLSOM DAM -
DISCHARGE RATING CURVES - AUXILIARY SPILLWAY AND EXISTING DISCHARGE FACILITIES

7.3.3.3 Water Surface Profiles

Water surface profiles for the auxiliary spillway were computed for the approach channel from the reservoir to the control structure, the chute from the control structure to the stilling basin, and the American River from the proposed bridge to the existing main dam stilling basin. For more discussion, see the hydraulic design **Attachment A2.**

7.3.3.4 Design Discharge Capacities & Velocities

The design discharge for the auxiliary spillway control structure is the discharge that can be passed at the spillway design pool (maximum flood pool). Average velocities through the tainter gates and river outlets with the gates fully open will be as high as 68 feet per second (fps) at maximum pool elevation 477.5. Velocities in the approach channel would vary greatly, increasing steadily with proximity to the auxiliary spillway control structure. The maximum velocity at the upstream end of the concrete lining in the approach channel is expected to be approximately 16 fps. The maximum at the upstream end of the conduit roof curves of the control structure is approximately 50 fps. Hydraulic model tests and further geotechnical data will be used to confirm the velocities and assess whether or not the extent of the concrete (or other lining) can be reduced or needs to be increased.

A design discharge of 90,000 cfs was selected for the concrete-lined chute and the stilling basin energy dissipator based on a downstream release of 115,000 cfs, the objective release. The operational scenario assumed that about 25,000 cfs would be released from the main dam sluices concurrent with about 90,000 cfs from the auxiliary spillway. In addition to designing the chute wall heights to provide full freeboard (meeting both Corps and Reclamation criteria) for the 90,000 cfs water surface profile plus an allowance for waves, the top of walls would be designed to provide freeboard (not including waves) for a discharge of 155,000 cfs ("tainter gates full open" at maximum pool elevation 477.5). Computed depths of flow within the 90 feet wide chute for a flow of 155,000 cfs varied from about 31 feet exiting the control structure to about 24 feet near the upstream end of the chute to about 21 feet at station 32+00 (the beginning of the parabolic drop), the flow depths would decrease rapidly as the invert slope increases along the parabolic drop into the stilling basin. The wall heights of the chute would be selected depending on which approach controls the design. A design discharge of 90,000 cfs was also selected for the energy dissipator, although, it should function with increasing degrees of damage as flows increase above the design discharge. A Type II stilling basin would be used as described in Reclamation's "*Hydraulic Design of Stilling Basins and Energy Dissipators*," Engineering Monograph No. 25 (Peterka, 1974) (See **Figure 7-2**). Physical hydraulic model tests may result in changes to the design of this basin or consideration of other means of energy dissipation such as a stepped energy dissipator.

Total Discharge Capacity

Figure 7-3 shows the maximum calculated discharge capacity for Folsom Dam with the proposed auxiliary spillway with four 17-foot 7-inch wide 33-foot high STGs at invert elevation 368.0.

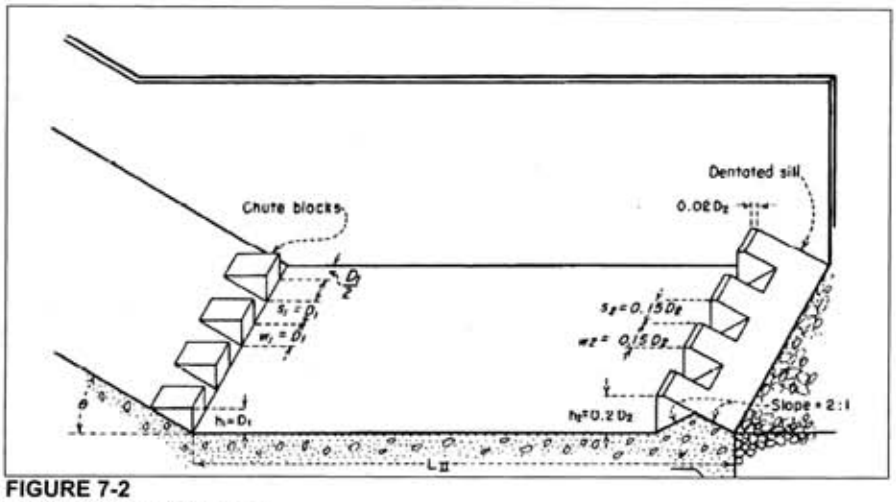


FIGURE 7-2
TYPE II STILLING BASIN

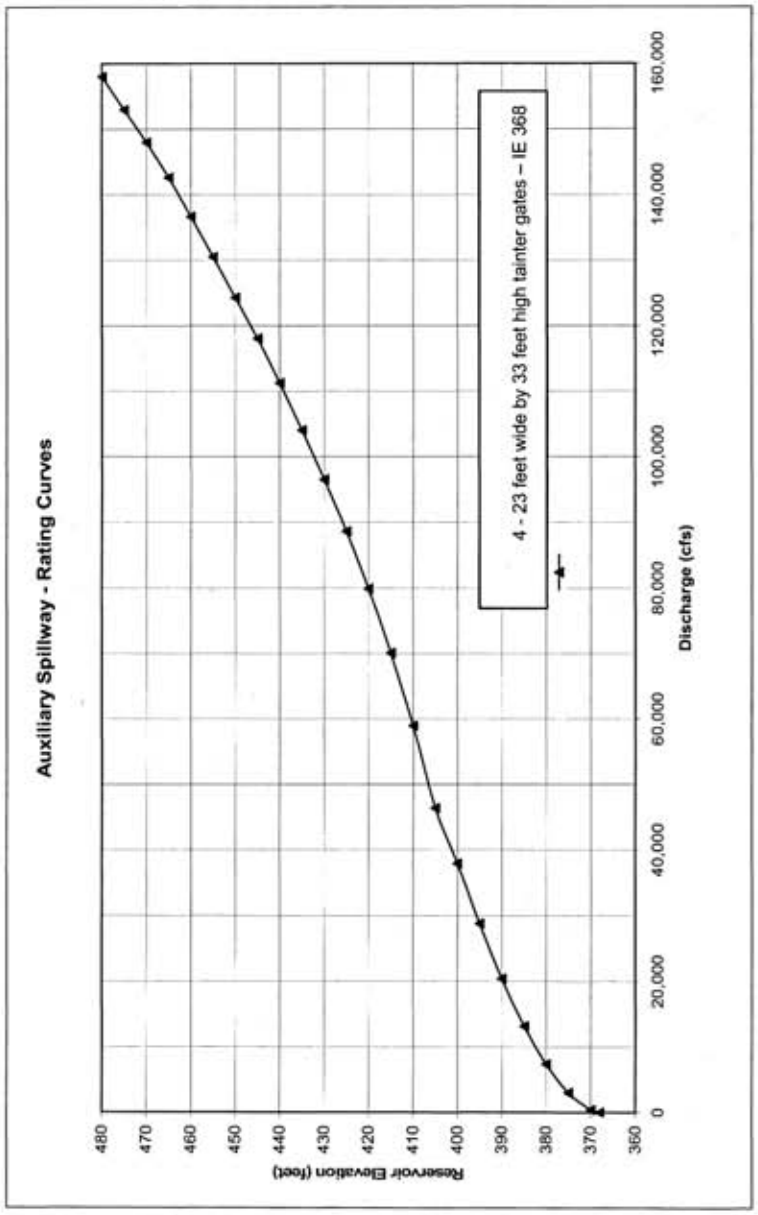


FIGURE 7-3
FOLSOM DAM AUXILIARY SPILLWAY DISCHARGE RATING -- TAINTER GATES FULL OPEN

7.3.3.5 *Structure Sizing to Meet Design Capacity*

The flood reduction objective release from Folsom Dam is currently 115,000 cfs so the initial approach was to size the discharge facilities from Folsom Dam to pass 115,000 cfs at the main dam spillway crest elevation 418.0. A second objective was to be able to pass the 200-year inflow design event without flooding downstream and pass the PMF without overtopping the dam. The selected alternative for the Folsom Dam Modification Project described in this chapter only passes about 78,000 cfs from the auxiliary spillway and 24,800 cfs from the existing sluices for a total of about 103,000 cfs at spillway crest elevation 418.0. It does provide the capacity to control larger floods approaching the 200-year inflow design event to within the downstream American River channel capacity, but does not provide safe passage of the PMF. A larger auxiliary spillway would be required to pass the PMF. See **Attachment A2**.

7.3.3.6 *Conditions That May Effect Design Capacity and Other Spillway Design Considerations*

Vortices that may develop and areas that may suffer cavitation damage are two areas of concern that would possibly affect design capacity of the auxiliary spillway control structure. See **Attachment A2** for further information on these and other design considerations.

7.3.4 Chute Hydraulics

The four tainter gates and the three piers separating the gates in the auxiliary spillway control structure require a width of 90 feet. This same width was adopted for the rectangular, concrete chute downstream from the gated control structure. Manning's n-values of 0.012 and 0.016 were used for establishing maximum velocities and establishing depths of flow, respectively.

To determine appropriate wall heights, additional vertical depth to account for possible flow bulking and waves, and a reasonable freeboard would need to be added to the computed depths. An initial conservative nominal chute wall height of 30 feet was selected. Walls would need to be a few feet higher for a short distance downstream of the conduit exits. Wall heights would be refined during physical model testing and future studies by considering the waves produced in the model, flow bulking, and considering progressively higher discharges in the model. The goal is to contain all possible flows from the auxiliary spillway in the chute if waves are not considered. For further detail on chute hydraulics, see **Attachment A2**.

7.3.5 Energy Dissipation Features

For energy dissipation, water surface profiles were computed assuming minimum losses. Results of these computations were utilized in designing the stilling basin.

7.3.5.1 Stilling Basin Design

Two approaches to energy dissipation for flows from the auxiliary spillway chute were considered during design studies for this report. The first and most predictable approach would be to provide a stilling basin (either unlined or lined with reinforced concrete) at the downstream end of the chute, just upstream from where auxiliary spillway flows re-enter the American River. The estimate for this report assumes construction of the stilling basin will be of reinforced concrete (founded on rock). The second approach would be to provide an energy dissipation area similar to that provided for the Oroville Dam service spillway. This would include spreading the flows at the end of the chute and providing an excavated chute/plunge pool area.

For the first approach, two types of stilling basins were considered: (1) a lined stilling basin (reinforced concrete founded on rock), and (2) an unlined stilling basin excavated in sound rock. Both stilling basins were designed for 90,000 cfs in their respective chutes with sequent depth from flows entering the basin and the tailwater produced from 115,000 cfs in the American River. This would allow adequate energy dissipation for flows somewhat greater than 90,000 cfs in the auxiliary spillway. The tailwater elevation for 115,000 cfs in the American River would be approximately elevation 185.0. A Hydrologic Engineering Centers – River Analysis System (HEC-RAS) (Corps, 2005) model of the American River from Nimbus Dam upstream to Folsom Dam has been developed to compute water surface elevations for project design. Both of the stilling basin designs included transitioning the invert of the chute from station 32+00 (elevation 325.89) to the stilling basin floor with a long approximately parabolic drop. For both designs, this parabolic drop curve would be conservatively designed to provide positive pressures. At a later design stage, it may be desirable to break this invert curve into chords. Both of the stilling basin designs also include 1:30 sidewall expansions from station 32+00 to the stilling basin. Water surface profile computations assumed an expansion loss coefficient of 0.3 to account for transition losses. Because of relatively high Froude numbers (varying from about 6 to 10), both stilling basin designs were generally patterned after the Type II basin as documented in Reclamation EM No. 25 titled *Hydraulic Design of Stilling Basins and Energy Dissipators* (Peterka, 1974).

Physical model studies will be required to best determine the final energy dissipation method to use and to ensure that flows blending together from the auxiliary spillway and service spillway merge well as they enter the American River, that forces on the auxiliary spillway stilling basin walls are taken into account for wall design, and that the flow regime in the American River does not change dramatically over a broad range of conditions (this could lead to scour of the banks downstream of the confluence of these flows). The model studies will address adequacy of energy dissipation in the immediate vicinity, and overall hydraulics from Folsom Dam downstream to the proposed new bridge on the American River. Preparation for the physical models will consider as much geological data as is practical to obtain.

For more information on energy dissipation, see **Attachment A2**.

7.3.6 Operations

Model testing from previous studies has led to observations that must be considered in operating procedures that govern releases through the outlet works or spillways. Of major importance is that balanced gate operations lead to uniform discharges across the width of the stilling basin and minimizes the formation of recirculation currents that can draw abrasive material into the stilling basin.

7.3.6.1 Gate Sequencing During Flood-Control Operations

Design considerations include the following:

- The peak (unregulated) PMF inflow would be about 902,000 cfs. Discharges would always be regulated so that peak inflows are never exceeded.
- With an auxiliary spillway, the existing main dam river outlets would be the sole release capacity until the pool reaches elevation 368.0 (seal invert elevation of the auxiliary spillway). Power releases would likely be made during this time but (conservatively) were not included in the continuing scenario.
- As pool elevation 368.0 is exceeded, the auxiliary spillway tainter gates would begin to discharge, and before the pool reaches elevation 418 (main concrete dam spillway crest), total combined discharge from the main dam river outlets and the auxiliary spillway could reach the objective release of 115,000 cfs. The transition can be made from combined releases to release through the auxiliary spillway only.
- The auxiliary spillway, by itself, would be able to hold the objective release, but flows must be transitioned to the service spillway before those tainter gates are overtopped. The top of closed service spillway tainter gates is at elevation 468.0. Because of this requirement, during the pool elevation's rise to elevation 467.0, the auxiliary spillway tainter gates would transition to the closed position and the five service tainter gates would open as necessary to maintain the 115,000 cfs objective release. From pool elevations 467.0 to 470.0, discharges would be from the five main dam service tainter gates, and would be limited to 160,000 cfs or less. Above pool elevation 470 the emergency tainter gates must be opened to avoid overtopping (top of closed gates are at elevation 471.0). Opening the main dam emergency tainter gate requires a release of 300,000 cfs. Therefore, the dam releases must be ramped up to 300,000 cfs before the gates are opened. This can best be accomplished by opening the auxiliary spillway tainter gates to supplement flows from the main dam service tainter gates.

7.3.7 Erosion Control Requirements

Upon completion of the Common Features Project on the American River, the levees should be capable of passing 160,000 cfs with freeboard. Although an exact discharge for overtopping of the American River levees is not available, the overtopping discharge is probably 190,000 cfs +/-. The erosion potential of flows exiting the auxiliary spillway and sequencing of combined flows from the existing main dam outlets and service tainter gates

and the auxiliary and emergency spillways must be considered and minimized as practical for flows up to the level when the levees are overtopped. This is especially true of the "tainter gates full open" discharges as the pool elevations approach maximum pool elevations. It is also desirable to minimize erosion potential for higher discharges but not a priority since the levees on the American River that protect the Sacramento area are expected to fail if flows reach 160,000 to 190,000 cfs. Model tests will evaluate higher flows from all sources of discharge capability and recommend operational changes if practical.

7.3.7.1 Potential for Downstream Scour

Scour is the result of the erosive action of flowing water that attacks the bed and banks of streams and the piers and abutments of bridges. Different materials scour at different rates. Loose granular soil is rapidly eroded by flowing water, while cohesive/cemented soil and rock are more scour-resistant. Ultimately, over a long period of time, scour can be as deep for rock as for sand-bed streams.

Altered flow patterns due to the auxiliary spillway may impact the river channel as it exits the stilling basin, and for some distance downstream. Combined flow from the main spillway area and the auxiliary spillway could also result in an alteration of current flow patterns. Potential maximum discharge from the dam would increase with an auxiliary spillway, although frequent flood discharges would remain essentially unchanged. An important design consideration is to determine if the altered flow patterns and increased potential discharges (and discharge duration) would attack the rock and result in excessive scour. The powerhouse road area and the new Folsom Dam Road Bridge are areas of concern.

If the model studies indicate that high velocity flows could attack and scour rock to an extent that is not acceptable, further assessment of rock scour potential would be performed by expanding on the previous studies by Kleinfelder (2005-2006 study on rock scour potential in the exit channel) to include other areas, such as below the auxiliary spillway exit and the chute area, if it is unlined. As in the 2005 study, *Annandale's Erodibility Index* methodology would be used for evaluation.

The cost estimate includes costs for grouting (stabilizing) existing rock in the powerhouse road area under the assumption that additional scour could result from the project.

7.3.8 Downstream Channel Capacity

The physical capacity of the American River to safely transport flows depends on the downstream levee system. In the past, Folsom Dam has been operated to control flood releases to 115,000 cfs. This is defined as the objective flood release, the maximum release for normal flood operations. Since completion of Folsom Dam, the objective flood release of 115,000 cfs was exceeded once in 1986. The maximum flow during the 1986 flood was 134,000 cfs.

With construction of the proposed auxiliary spillway, Folsom Dam outflows would not exceed 115,000 cfs for all historic floods of record, and also for a design flood that has a one percent chance of being exceeded in a given year (100-year design flood). For floods larger than the 100-year design flood, maximum outflows would increase. For the 200-year design flood, Folsom Dam maximum outflows would increase to, but not exceed 160,000 cfs.

The Common Features Project (Federal Legislation, 1996) involves strengthening and raising American River levees to safely pass a flow of 160,000 cfs. Most of this work has been completed. Specifically, the levees are being improved to be structurally sound and competent to pass flows of 160,000 cfs. For purposes of the current studies, the maximum safe discharge capacity of the American River was assumed to be 160,000 cfs. Once flows reach this threshold, downstream areas that could flood would commence evacuation procedures.

There is some concern about possible lateral erosion of the American River channel if flows of 160,000 cfs occur for an extended duration (up to four days). A study has been initiated to determine measures required to safely pass a flow of 160,000 cfs for up to 48 hours. This study is assessing the stability of grass-lined levee slopes, critical bank erosion sites, and erosion-resistant geologic formations in the channel bed. It also will identify long-term monitoring and maintenance required to sustain the lower American River's ability to convey 160,000 cfs for an extended duration. For more information, see **Attachment A2**.

7.3.9 Potential for Levee Breaching

Investigation of potential levee breaching is currently underway. Levee breaching is most likely to occur at the locations where the rising water surface attains an elevation equal to that of the predicted probable non-failure point (PNP) and then continues rising towards the probable failure point (PFP), the elevation where the levee is very likely to have failed. These locations and determination of the PNP and PFP are based on site investigations, models, and engineering and geotechnical judgment, as are the levee breaching scenarios, the extents of the potential levee breaks, and the judgment of existing levee reliability.

7.3.10 Hydraulic Impact on Downstream Water Surface

Investigation using numerical models will be required for the design storm events to determine whether new operations implemented due to the increased discharge of the project will cause significant changes to the maximum water surfaces downstream. Some of the concerns that may or may not be addressed in the models are changes in bank and bed erosion/deposition, changes in channel roughness due to sedimentation processes, and the effect on vegetation that could possibly lead to increased debris loading. These concerns will be considered in more detail after one alternative is selected and authorized to go forward.

7.3.11 Construction Contract Considerations

The primary area of concern during construction of the auxiliary spillway would be the impact as large storm events pass through the system. Even moderate releases from the main spillway could have impacts on construction of the auxiliary spillway stilling basin. Furthermore, high reservoir water surfaces would impact excavation of the approach channel.

7.3.12 Model Studies (Requirements and Results)

Hydraulic features of the auxiliary spillway that would require physical model tests include the main concrete dam spillway (overflow crest and downstream chute, stilling basin/flip bucket, exit channel, and exit of sluices) and auxiliary spillway features (approach channel, control structure, chute, and energy dissipation area). Model tests to allow lifting of the 60 percent restriction currently in place and allowing 100 percent gate openings for the existing main dam river outlets or enlarged river outlets when the service spillway is releasing flows are not planned. The plan selected for this project, which is described in this paragraph, includes an auxiliary spillway with submerged tainter gates but no enlargement of the existing main dam river outlets. The increase in discharge capability possible by allowing 100 percent openings for the existing main dam river outlets is not significant compared to the discharge capability of the submerged tainter gates.

7.3.12.1 Numerical Model

It would be impractical to construct a physical model at a suitable scale that would include enough of the reservoir to establish whether satisfactory approach conditions to the structure occur. Therefore, a three-dimensional numerical model will be performed in addition to a reasonably-sized physical model, providing boundary conditions to implement in Full Model 1 described below.

7.3.12.2 Full Model 1

A full physical model is required for ensuring hydraulic performance. The model will be of the auxiliary spillway structure (approach channel, control structure, upper chute). Model data that leads to inconclusive results may subsequently require development of a sectional model of the control structure intake and gate passage.

7.3.12.3 Full Model 2

A second full physical model of the converging flows from the service spillway, auxiliary spillway and emergency spillway is also required for ensuring hydraulic performance. If the scale of comprehensive coverage flows model is not sufficient to provide good results for the stilling basin and chute leading up to the stilling basin, a separate physical model study with an adequate scale will be performed.

7.3.12.4 Sectional Model 1 (to be Considered)

A third physical model that will be considered if the project alternative described in this paragraph goes forward for more detailed studies is a sectional model that would include service tainter gate #5, the three emergency gates, and the existing flip bucket. An operational restriction that now appears to be necessary is to open the emergency tainter gates as soon as possible to 10 feet when total dam discharges reach 300,000 cfs so as to minimize a wave that forms when the service gates are releasing flows and the emergence gates are opened at a lesser gate opening. One scenario to minimize the sudden increase in discharge adverse effects would be to open only the emergency gate (#6) next to service gate #5 before opening emergency gates #7 and #8. This would be investigated in "Full Model 2" discussed above to see if it would give reliable results and evaluate the potential benefits before constructing this sectional model.

7.3.13 Prototype Auxiliary Spillway Testing and Monitoring

Consideration will be given to installing instrumentation in the prototype auxiliary spillway, with suitable monitoring to verify key hydraulic performance parameters used in the hydraulic model studies. Given the size and public visibility of the project, installing instrumentation during construction would provide a useful tool to verify the performance of the prototype. Locations that are accessible in the prototype will be instrumented to compare with instrumentation in the model studies.

7.3.14 Inundation Maps for Flood Emergency Action Plans

The inundation maps for emergency action plans should be updated based upon the increased release capacity of Folsom Dam.

FEMA Publication 64, "*Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners,*" indicates that three inundation maps should be developed for the area below dams:

(1) Dam failure at the normal everyday pool elevation (sunny day failure)

(2) Maximum spillway discharge at a full flood pool

(3) Maximum discharge at the PMF condition

Also, in some cases, the spillway or outlet works discharge for which flooding commences should be indicated.

7.4 CIVIL DESIGN

This section addresses civil design as it pertains to the four-STG auxiliary spillway, including roads and utilities.

7.4.1 Roads

The four-STG auxiliary spillway alternative does not include a dam raise, so most of the existing access roads around the reservoir are not affected by the project. The Folsom Point recreation area and its access road, however, would require some public health and safety measures such as fencing and traffic separation. Only roads and utilities affected by construction of this alternative are addressed below.

7.4.1.1 Auxiliary Spillway Access Road

The Folsom Bridge project (separate project performed under the Folsom Dam Raise authorization) would include an access road extending from the new Folsom Dam Road alignment to the existing Folsom Dam Road in the vicinity of the existing Folsom Dam Overlook area, to provide access to the left wing dam and the area at the toe of the left wing dam. The auxiliary spillway project would include an access road across the top of the new spillway structure and would connect to the new bridge access road. Because of the proximity of the auxiliary spillway control structure to the bridge road alignment, the access road is likely to be bench-cut into the slope of the spillway inlet channel, merging into the cut of the bridge access road. This road must accommodate semi-trucks with oversized loads.

7.4.1.2 Access Turnout to Relocated Natomas Pipeline

A portion of the Natomas Pipeline would be situated between the auxiliary spillway channel and the new Folsom Bridge Road, between stations 52 + 00 and 55 + 00 of the road. The Folsom Bridge Road in this area is on an embankment. Need for access to the pipeline would be infrequent and normally limited to City of Folsom employees but could be accommodated by providing a turnout and shoulder turn lane on the north side of Folsom Bridge Road near station 55 + 00. This turnout or shoulder turn lane should be accessible to westbound traffic only.

7.4.1.3 Access Road to Left Wing Dam Toe and Stilling Basin

Part of the existing access road from Folsom Dam Road to the Corps resident office and the toe of the main concrete dam would have to be realigned because of the presence of the auxiliary spillway control structure, chute alignment and the Folsom Bridge Road embankment. For the eastern portion of the access road, the new alignment would be located near the toe of the left wing dam, connecting to the resident office access road. For access to the toe of the main concrete dam and the stilling basin, the new alignment would extend from the resident office vicinity to the beginning of the existing concrete pavement, about 700 feet downstream from the dam. Some or all of the road would be paved with asphalt-concrete.

7.4.1.4 Powerhouse Access Road

Armoring the existing powerhouse access road may be necessary to prevent erosion of the embankment caused by discharges from the auxiliary spillway. Hydraulic model studies and geotechnical site investigations may be needed to determine the extent of any armoring required. The road that may be at risk is approximately 400 feet long.

7.4.1.5 Folsom Point Recreation Area Access Road

Access to Folsom Point recreation facilities is provided by a paved two-lane road crossing over the reservoir divide east of the Dike 8 left abutment. An area adjacent to Folsom Point is a potential staging site and/or a potential material disposal site for material from the auxiliary spillway excavation. Access to Folsom Point would be maintained for the duration of the auxiliary spillway and dam safety projects but some modifications involving fencing and traffic separation would be required for public health and safety.

7.4.1.6 Folsom Bridge Road

The new Folsom Bridge Road would serve to replace access across Folsom Dam via the existing Folsom Dam Road, with a new bridge that crosses the American River, approximately 1,500 feet downstream from Folsom Dam. The road would be constructed on a new alignment from Folsom-Auburn Road to the Folsom Dam Overlook and reconstructed or widened along the existing road alignment from the overlook to East Natomas Street, a total distance of approximately 2 miles. The road is being designed as a four-lane road with an asphalt-concrete surface.

The proposed alignment for the new Folsom Bridge Road interferes with a portion of the existing access road to the stilling basin. The bridge project would maintain access to the stilling basin by constructing a temporary graveled alignment alongside the toe of the fill for the new Folsom Bridge Road. A permanent alignment would be provided as part of the auxiliary spillway project. This alignment would be located between the new auxiliary spillway chute and the left wing dam.

The proposed Folsom Bridge Road alignment does not directly interfere with the auxiliary spillway control structure (invert at elevation 368) or the spillway chute or terminal structure, although the hillside excavation for the road in the vicinity of the control structure partially coincides with the excavation required for the auxiliary spillway.

7.4.2 Utilities

Several utilities would be impacted by construction of the proposed four-STG auxiliary spillway alternative. The Natomas Pipeline, a raw water pipeline, would need to be relocated. The realigned pipeline section would need to be installed prior to any outage, and a very short-term water supply interruption would be coordinated with all downstream water users while the new pipeline section is put into service. Additionally, a number of power lines and telephone lines would require relocation, as would some of the utilities servicing the Corps resident office building. Each of these potential relocations is discussed below.

7.4.2.1 Existing Natomas Pipeline

Reclamation operates and maintains the existing aboveground raw water pipeline (Natomas Pipeline) that provides water from Folsom Reservoir to the City of Folsom, the California Department of Corrections water treatment plants, and the Corps resident office fire protection system. The pipeline is 42 inches in diameter, and is approximately 2,800 feet

long from where the pipeline exits the dam at Adit 4 to the Folsom standpipe. The aboveground raw water pipeline is made of American Water Works Association C200 welded steel with a coal tar enamel interior lining. The chute alignment for the auxiliary spillway would cross a portion of the aboveground raw water pipeline. Approximately 300 feet of the existing Natomas Pipeline would be relocated in kind as an aboveground pipeline. It would extend from an existing anchor block on the dam side of the chute to an anchor block on the far side of the chute, and incorporate a high-level ring girder supported pipe segment spanning the proposed chute. The pipe relocation would be constructed, and then cut into the pipeline at each of the anchor blocks, limiting the disruption of water supply to the amount of time to make the change over at the anchor blocks. The chute would be excavated beneath the relocated pipeline after its completion. In addition, the 8-inch-diameter fire protection pipeline and the metering station that services the Corps resident office would need to be relocated. The City of Folsom has stated that it can only accept outage for a few hours; therefore, all new pipeline features must be in place and ready prior to disrupting service. The change-over would be conducted at both ends of the pipeline simultaneously.

7.4.2.2 Future Redundant Pipeline

The cities of Roseville and Folsom and the San Juan Water District need a reliable, redundant system supplying raw water from Folsom Dam. Currently, water purveyors, the Corps, and Reclamation are evaluating a range of conceptual alternatives for meeting the purveyors' water needs.

Only one of the conceptual alternatives under study for the pipeline would have an impact on the proposed auxiliary spillway design: a required pipeline intake structure and provision in the auxiliary spillway approach channel for a pipeline intake. While the impact would be minor, the alternative would require connecting an 84-inch-diameter inlet pipe to the proposed auxiliary spillway side approach channel. All engineering design and construction costs associated with this alternative would be the responsibility of the water purveyors.

7.4.2.3 Power Lines

The dam's left abutment area is criss-crossed by aerial power lines, all of which would require either partial or complete realignment. These are discussed in the following paragraphs.

The Corps resident office receives power from the Sacramento Municipal Utility District (SMUD) for a 12-kilovolt (kV) service that was formerly an abandoned 115-kV Pacific Gas and Electric Company power line. Five wood poles and approximately 1,500 feet of conductor would require relocation if the office building remains in use during the spillway construction. If the building is relocated, the power line would be decommissioned.

The 4,160-volt power line that serves Reclamation's yard on the right abutment would require relocation of seven poles and approximately 2,000 feet of conductor.

SMUD's 230-kV high voltage power line would require partial relocation. The existing trussed towers would be replaced by three steel poles. The extent of the relocation would be a distance of approximately 2,000 feet.

7.4.2.4 Telephone Lines

Telephone and other communication lines will be affected by implementation of the four-STG auxiliary spillway project. These are described in the following paragraphs.

Telephone and internet needs for the Corps resident office are served by AT&T. The actual alignment has yet to be determined. An alignment is being studied that would avoid relocation if the office building remains in use following the completion of the new Folsom Bridge Road.

A telephone line services a Reclamation station located near the City of Folsom's standpipe, and is routed on the 4,160-volt power poles. Two telephone poles would need to be relocated in addition to the power poles and about 500 feet of wire.

7.4.2.5 Corps Resident Office Utilities

The proposed auxiliary spillway chute alignment would necessitate relocation of some of the utilities servicing the Corps resident office building if the office building remains in use following the completion of the new Folsom Bridge Road. These utilities include the 8-inch-diameter fire protection pipeline connected to the 42-inch-diameter Natomas Pipeline, a mounded leach field, and the power and communication lines noted in the preceding paragraphs. The fire protection pipeline relocation work would include a valved connection to the 42-inch-diameter pipeline, a metering station, shut-off valve, and approximately 200 feet of below-grade 8-inch-diameter pipe. The mounded leach field is about 7,500 square feet in area and would be relocated to another site adjacent to the existing septic tank.

7.5 STRUCTURAL AND MECHANICAL DESIGN

This section addresses structural features and components of the least-cost alternative that provides all of the functionality that would have been achieved by the authorized Folsom Modification Project, namely the four-STG auxiliary spillway. The project design team recognizes that differences exist in operational criteria and analysis/design methods and standards among the project stakeholders. Therefore, it has been agreed upon that routings and decisions of dam modifications to accommodate these routings will be conducted based on the criteria of the agency which has jurisdiction; however, the design of new structural components should accommodate the most stringent criteria.

The auxiliary spillway is a major new structural component of the featured alternative and consists of a concrete gravity control structure housing four-STGs, a rectangular chute downstream from the new spillway structure, and a concrete-lined stilling basin for energy dissipation. Due to time constraints, and to be consistent with the objectives of Folsom Modification Project, the structural engineering effort focuses on "worst-case" loading for the most critical structures. Accordingly, the concrete auxiliary spillway was analyzed for

the MCE[1], and other structures were sized conservatively, based on the experience of the design team. The MCE is a deterministically defined (Corps) event that can be described as a moment magnitude 6.5 on the east branch of the Bear Mountain Fault zone, at a distance of 14 kilometers from the site, with a peak horizontal ground acceleration of 0.38 gravity (g) (84^{th} percentile MCE).

The following paragraphs provide details of the structural features of the proposed alternative. **Plate 7-4** contains an overview of Folsom Dam.

7.5.1 Auxiliary Spillway

Plan and profile views of the proposed auxiliary spillway are shown in **Plates 7-1** through **7-3**. The following sections discuss the structural and mechanical components of the auxiliary spillway.

7.5.1.1 Auxiliary Spillway Control Structure

The auxiliary spillway control structure was site-adapted from *DWR's Oroville Dam flood control structure* (DWR, 1965) primarily to provide enhanced flood control and hydrologic risk reduction. The Oroville Dam flood control structure is a reinforced concrete gravity structure socketed into the sound rock of its site. It provides eight-STGs 17-feet 7-inches-wide by 33.08-feet high, to control flood releases in two 94.33-foot-wide concrete monoliths.

Site adaptations from the existing control structure at Oroville Dam include using 49-foot-wide independent concrete monoliths, each containing two-STGs similar in size to those at Oroville (**Plates 7-5** through **7-7**). A variety of gate sizes and invert elevations were investigated with the two-monolith, four-gate configuration at invert elevation 368.0, approximately 10 feet lower than the equivalent Oroville spillway, providing the best project function at least cost. The concrete section for the control structure was deepened to add a grout drain gallery near the upstream face of the monoliths, and the bottom was sloped 8 degrees up in the downstream direction. These changes were made to allow for less competent rock at Folsom as compared to Oroville. The grout/drain gallery (**Plate 7-7**) would provide capability for split-spaced grouting in the grout curtain, with increased grout pressures after the concrete control structure is in place, to provide confinement. The gallery would provide access for post-construction monitoring and maintaining drains to reduce uplift (reduce risk of structure instability) and for access to address any problems encountered after completion of construction.

The invert slab would be reinforced in its top surface to control cracking and to improve its performance as a high-velocity water passage. The piers and breast wall would be adequately reinforced to carry water and seismic loads. The piers were extended upstream and vortex beaming added similar to that developed in model testing for Theodore Roosevelt Dam modifications. Continuous reinforced concrete trunnion beams would be used to

[1] During the feasibility study, technical criteria, standards, and/or guidelines from involved agencies would be considered and designed for (e.g., the Corps MCE and Reclamation probabilistic upper-bound earthquake would be analyzed and considered in the feasibility design).

address problems experienced with the partial trunnion beaming used at Oroville. Continuous beaming would also reduce pier flexure, a concern with the thin piers normally desired for hydraulic efficiency. In addition, continuous concrete beaming would be used with hydraulic cylinders to control gate opening. These cylinders would provide positive closure force, dampen any flow-induced vibrations, and improve control relative to the cable lifts used at Oroville.

Flanking non-overflow concrete monoliths would be trapezoidal in shape. This shape was investigated for use with the Auburn and Marysville projects and found to provide stability and strength for seismic loads while avoiding stress concentrations at the heel and curvature points found with conventional concrete sections.

7.5.1.2 Auxiliary Spillway Control Structure Stability Analysis

Preliminary two dimensional 2-D stability analyses were performed for the auxiliary spillway control structure with invert elevation 368.0. For evaluating gross pool and PMF pool conditions, 2-D hydrostatic models were used while a pseudostatic analysis was used for preliminary seismic stability. The stability of the structure was evaluated based on two basic loading conditions:

- Usual load condition, which represents the normal operating pool
- Extreme load conditions, which represent the PMF pool or an earthquake during normal operating conditions

Stability Criteria and Assumptions

The required factor of safety for sliding, and the limit on resultant location, were taken from *Engineering Circular (EC) 1110-2-6058* (Corps, 2003); the selected factors of safety are applicable to both critical and normal structures. Per EC 1110-2-6058, the required sliding factor of safety used in the analysis was 2.0 for the usual load condition and 1.1 for both extreme loading conditions. The limits on the location of the resultant were 100 percent of the base in compression for the normal operating condition, and the resultant within the base for extreme loading conditions.

Material properties and strength parameters used for the analyses were conservatively estimated until further explorations of the foundation materials can be completed. For the sliding analysis, the internal shear angle used for the rock was 45 degrees, and the cohesion value was assumed to be zero. The weight of the concrete was assumed to be 155 pounds per cubic foot, considering the weight of the concrete in the existing dam and the fact that a similar mix design would be specified.

The weight of the control structure was calculated for a 49-foot concrete monolith, which included a prestressed concrete bridge with 6-inch slab, vortex breaker, tainter gate, shear wall covering the gate and lifting equipment, and the applicable mass of water on the invert. The total weight of the structure also accounted for voids attributable to the 8-foot by 8-foot grout gallery through the invert and the 2-foot-diameter air vent through the breast

wall. The base of the invert was sloped at 8 degrees from horizontal to increase the structure's resistance to sliding.

For normal operating conditions, a headwater elevation of 466.0 was used. Tailwater was not considered for uplift or resisting hydrostatic force calculations because the gates will be closed during normal operating conditions and a drainage system exists under the chute slab that begins at the toe of the concrete control structure. The uplift pressures along the base were reduced by placing a drainage gallery and foundation drains approximately 12 feet from the upstream face of the control structure, and the effectiveness of the drainage system was taken as 50 percent. In addition, flow to the drains would be controlled by a grout curtain. It also was taken into consideration that while sustaining a pool elevation of 466.0, the bulkheads would be in place and the tainter gates would be in the lowered position with water between the bulkhead and tainter gate removed. This preliminary operation plan was intended to safeguard the STGs against any potential damage. Subsequently, only the mass of the water on the invert upstream of the bulkhead could be used for stability. To accommodate these details, and for the structure to remain stable, it was necessary to increase the amount of mass concrete in the breastwall. The PMF condition was evaluated using a headwater elevation of 487.5, and tailwater to the top sill of the auxiliary spillway. For this condition, all STGs would be open and the mass of water flowing over the invert could be used for stability calculations. As with normal operating conditions, uplift pressures along the base were reduced by using a drainage gallery and foundation drains with 50 percent effectiveness, and a grout curtain to control flow to the drains.

The pseudostatic analysis, or the seismic coefficient method, was used for preliminary seismic evaluation. This analysis considered the MCE and the normal operating pool. In addition to hydrostatic forces from the reservoir's normal pool, an inertia force due to the horizontal acceleration of the dam, and hydrodynamic forces resulting from the reaction of the reservoir water against the dam, were considered. Inertia forces were calculated using the determined weight of the structure multiplied by a seismic coefficient. The seismic coefficient was determined by taking two thirds of the peak horizontal ground acceleration (PGA) for Folsom Dam, given in a 2001 report by URS titled *Probabilistic and Deterministic Seismic Hazard Analyses, Folsom Dam*. The PGA selected from this analysis was 0.38 g. Hydrodynamic forces were calculated using Westergaard's parabolic approximation, given in *EM 1110-2-2200* (Corps , 1995). The seismic coefficient method was used only to determine the resultant location and sliding stability. In strong seismic areas, a stress analysis should be performed to determine the magnitude and distribution of stresses throughout the structure under static and dynamic load conditions.

The State of California Division of Safety of Dams (DSOD) provided an independent check on sliding stability of the control structure with a summary of the work provided herein. DSOD performed independent stress and sliding stability analyses based on DSOD safety guidelines. Additional analyses are required to confirm compliance with the Corps and Reclamation criteria. DSOD developed a 3-D finite element model (FEM) using SAP2000 version 9.14 to include the MCE seismic loading case, which is assumed to govern the stability of the control structure. A fixed-base model was developed, with the base aligned to the proposed upstream slope, using a hydrostatic load based on a reservoir water surface (RWS) elevation of 466, and added mass to model hydrodynamic forces. The model

neglects the separation of the two central concrete monoliths. The trapezoidal monoliths were not modeled, which is assumed to be conservative because the central monoliths would receive additional sliding resistance through contact with the trapezoidal monoliths. The central gravity section also has the least weight, and the reinforced piers at the base of the structure are the smallest cross section in the structure, which results in the highest stress concentrations. Individual structural components and 3-D finite element mesh for the central monolith are shown in **Plates 7-8** and **7-9**.

Loading conditions shown in **Table 7-2** were combined as appropriate, and used to calculate the vertical stress distribution and sliding stability. Uplift pressure was assumed to vary linearly from two thirds of the hydrostatic head at the upstream heel to zero at the downstream toe. The gate bays were considered to be dry (gates closed). Other operational combinations of hydrostatic head and uplift will be examined for follow-up analyses.

TABLE 7-2
SUMMARY OF LOADING CONDITIONS

Loading Condition	Reservoir Elevation	Uplift	Gravity	Time History
Dead	Not applicable	Not applicable	Yes	Not applicable
Normal	466.0 feet	Yes	Yes	Not applicable
Flood	487.5 feet*	Yes	Yes	Not applicable
Seismic	466.0 feet	Yes	Yes	Yes

*Note: *Top of the parapet wall*

The seismic load case was determined to govern both the stress and stability of the structure, as expected. Three site-specific spectrally-matched acceleration time histories were used in the SAP2000 dynamic analyses, based on a PGA of 0.38 g. The modified records are the same three developed for the existing main concrete dam, less than a kilometer away. No vertical acceleration was included in the analysis.

Sliding stability was analyzed by comparing the calculated base shear to the allowable base shear through each time interval of the acceleration record, as shown in **Plate 7-10**. The allowable base shear is calculated as the vertical reaction, derived from SAP2000 output, minus the uplift pressure, times the coefficient of friction. The foundation exploration program was in progress at the time of the analyses; thus, a friction angle of 45 was assumed. The horizontal base shear is output directly from SAP2000, and includes hydrostatic force. This model neglects foundation flexibility, which is considered conservative for sliding stability.

Results of the fixed-base, 3-D finite element sliding analyses show that the monoliths would be at the verge of sliding during MCE loading condition, resulting in a factor of safety of 1.0. Based on the conservative oversimplifications assumed for the analyses, further refinement of these analyses should calculate a higher factor of safety. In addition, foundation improvements can be included, such as grouting, dental concrete, caissons, or drains to improve the friction angle and reduce the assumed uplift. These standard

foundation preparations are included in the cost estimate. DSOD analyses conclude that this structure is marginally stable under the MCE loading condition, but a larger margin of safety easily can be obtained using standard cost-effective design and construction techniques.

7.5.1.3 Proposed Auxiliary Spillway Control Structure Stress Analysis

The model used to evaluate sliding stability also was used for a linear elastic stress analysis, based on the same set of assumptions and load combinations. Peak stresses occur in the piers at the upstream of the structure, as expected. The magnitude of maximum compressive stress is approximately 1,000 psi, as shown in **Plate 7-11**, which is far below the expected allowable compressive strength. Maximum tensile stresses occur at the location, and are in the range of 600 psi, as shown in **Plate 7-12**. These brief transient peaks of tensile stress are well within the expected allowable tensile strength of the reinforced piers.

Based on these linear elastic,.and somewhat conservative analyses, DSOD concluded that the auxiliary spillway control structure would be stable and structurally adequate under all loading conditions. The cost estimate should include reasonable foundation preparation items to improve the margin of safety, and it should include significant vertical reinforcement in the piers that is fully developed above and below the piers. These recommendations should be consistent with typical design criteria for any similar structure.

7.5.1.4 Proposed Auxiliary Spillway Chute and Energy Dissipater

A reinforced concrete, rectangular chute would be used, similar to that at Oroville Dam (**Plates 7-13** and **7-14**). It would have a 5-foot reinforced concrete slab anchored to the rock with 20- to 30-foot-long No. 11 reinforcing dowels at 10-foot centers to anchor the slab. Underdrain pipes sloping down to the sides similar to those used at Oroville would be provided to reduce uplift forces on the slab. Drain pipes would be provided in pervious backfill on the outside of the walls to carry away water from the drains beneath the dam and additional water from the ladder drains. These pipes would be sized to facilitate inspection and maintenance with appropriate access provided. An average wall height of 30 feet was used for the cost estimate; actual wall height would be determined from hydraulic physical model results and would vary along the length of the chute. Wall thickness and reinforcing were based on the Oroville flood control outlet and experience with walls of similar height for other projects.

7.5.1.5 Concrete-Lined Stilling Basin

A section through the concrete-lined stilling basin is shown in **Plate 7-15**. The wall and slab thickness, anchorage pattern, and reinforcing were based on the Folsom Dam stilling basin walls and experience with walls of similar height for other projects. The 143-foot width of the stilling basin was determined from Reclamation's Type II stilling basin and an average wall height of 66 feet over a length of 265 feet was determined from preliminary hydraulic modeling. The stilling basin design is considered to be adequate for energy dissipation; however, it will be overtopped during high release events. The stilling basin dimensions used in this estimate will be optimized once physical modeling has been completed.

7.5.2 Auxiliary Spillway Tainter Gates and Operating System

The auxiliary spillway would feature four STGs similar in design to the gates used at Oroville Dam, which features eight STGs 33 feet tall and 17 feet 7 inches wide. The proposed Folsom Dam auxiliary spillway STGs would also be 33 feet tall and 17 feet 7 inches wide. The STGs would be operated by means of hydraulic cylinders, similar to those used at Winfield Dam, Corps Huntington District, as opposed to a traditional gear driven chain or cable type hoist mechanism, as is currently used at Folsom and Oroville dams. The hydraulic cylinders would be mounted above the gates and will pivot about their centerpoint. The cylinders would have a bore of approximately 18 inches, a rod diameter of approximately 7 inches, a stroke of approximately 29.5 feet, and would take approximately 20 minutes to open.

Another concept that was investigated was the use of bottom mounted cylinders, similar to those used at Table Rock Dam, Corps Little Rock District. This approach was rejected when it was determined that it would necessitate an additional 3 to 4 feet in pier thickness (resulting in an unacceptable 15 to 20 additional feet of spillway width).

Each of the 12 cylinders would have its own dedicated HPU. The HPUs would feature a 40 horsepower (hp) motor, a 25-gallon-per-minute (gpm) pump, and a 300-gallon reservoir. The cylinders will be oversized so that only one will be required to operate a gate. The gate design will feature a roller assembly which will prevent binding of the gate in the event of a hydraulic cylinder failure.

An additional benefit of the hydraulic cylinder hoist system will be its ability to provide sufficient damping to overcome any flow induced vibration, which is considered to be a potential problem on tainter gates which operate under such high heads. As an added precaution, a computer model study will be performed Dr. Noriaki Ishii of the Osaka Electro-Communication University to check the dynamic stability of the design.

Similar to the main dam spillway gates, consideration will be given to the use of self-lubricated composite trunnion bearings. Regardless of which type of trunnion materials are used, an auto-lube system will be provided. It is anticipated that the size of the trunnions will be somewhat smaller diameter than that used on the existing tainter gates. The forensic report of the tainter gate failure on the main dam in 1995 determined that the large diameter of the existing trunnions was a contributing factor to the gate failure. The trunnion binding forces were transferred to the endframe. Most tainter gates at other facilities utilize much smaller trunnions than were used at Folsom. A notable example is Theodore Roosevelt Dam, which actually had a trunnion bearing seize and rotate in place rather than fail the endframe.

At the present time, it is intended, for security reasons, that each tainter gate would be protected by a dedicated bulkhead gate weighing approximately 40 tons. A traditional gear driven cable hoist mechanism, similar to the existing chain hoist mechanisms used on the existing tainter gates, will be used for raising the bulkhead gates. The hoist will consist of a 7 ½ hp, 1150 revolutions per minute (rpm) motor which will connect to a 50:1 worn gear speed reducer (Falk Model 1700 Omnibox) by means of a 1-inch Wrapflex elastomer coupling. The twin 2.5 inch output shafts of the Omnibox speed reducer will each connect to

a 105:1 parallel shaft triple reduction speed reducer (Falk Model 465) by means of a gear coupling and a 6- to 8-foot long connecting shaft. The 7 ½ inch output shafts of the parallel shaft speed reducers will each connect to a cable drum by means of a 7 ½ inch gear coupling. Each cable drum will also be supported by a 4-inch-diameter pillow block bearing. The cable drums will be 14-inch diameter (for a lifting speed of approximately 0.9 feet per minute (ft/min) and will each have two 1-inch cables. The system is designed so that each of the two cable pairs can support 60 percent (approximately 80,000 pounds) of the gate weight. The lifting speed is predicated on the fact that the bulkheads would be operated on a seasonal basis rather than each time the tainter gates are operated. The hoist assembly will also feature an electric solenoid operated braking device, as well as an automated positive dogging mechanism which will be used to hold the bulkheads in the open position.

All mechanical systems on the new spillway will incorporate redundant features. The hoist mechanism for the new spillway tainter gates will utilize two hydraulic cylinders per gate. Either of the cylinders will be capable of operating the gate by itself in the event that the other cylinder fails. A dedicated HPU will be provided for each cylinder. Adjacent HPUs would be interconnected for redundancy. In addition, a portable HPU will be provided as a backup. The hoist mechanisms for the bulkhead gates will include a total of seven motors for the six gates. The system will be designed so that each gate hoist can be coupled to one of two motors (similar to the system used for the tainter gate hoists at the existing spillway).

The proposed auxiliary spillway design will utilize permanent hoist mechanisms for operating the tainter gates and bulkhead gates, and a mobile crane could be used to perform routine maintenance. Therefore, no permanent crane would be necessary for this design. However, as previously noted, a less costly alternative may be investigated that would necessitate the addition of a permanent crane.

7.6 ELECTRICAL DESIGN

This section addresses electrical changes at Folsom Dam associated with the addition of an auxiliary spillway with four STGs. Topics addressed include electrical power distribution, backup power, and redundant systems.

7.6.1 Electrical Power Distribution

Existing power distribution overhead conductors, feeding from 4,160-volt switchboard UHA in the Western Area Power Administration switchyard, will have to be upgraded to carry its current electrical load and the added load of the new auxiliary spillway (per Bob Beingessner of Reclamation). This 4,160-volt feeder is called "Dam East Abutment" and crosses over the river several hundred yards downstream of the dam.

7.6.2 New Power Distribution System

The proposed new power distribution system is specifically designed for reliability with emergency on-site generation. These features would provide a reliable, fault-tolerant, and easily maintained system.[2]

7.6.2.1 Power Supply

A new single-ended substation would be located at the new spillway. This substation will be fed from the existing switchyard breaker Dam East Abutment via the upgraded 4,160-volt overhead pole line crossing the river. The switchyard is connected to the Folsom power plant, Nimbus Dam generators, and transmission grid. Consequently, several primary power sources exist for the 5-kV switchgear, and therefore for the new substation. The reused breaker in the 5-kV switchgear would be fully reconditioned (and upgraded if necessary); no other work is anticipated on the 5-kV switchgear. However, these improvements are contingent on results of a load study and evaluation being performed by Reclamation.

7.6.2.2 Substation

The single-ended substation will be fitted with a 4160-volt (delta connected) to 480-volt (resistance-grounded wye-connected) 225-kilovolt-ampere (kVA) transformer. The transformer would be of epoxy cast coil construction for maximum reliability. They would be designed for an 80-degrees-centigrade (°C) rise above a 30°C average ambient (40°C maximum ambient) temperature.[3] The single-ended substation would be fully sized at 400 amperes (amps). All systems within the auxiliary spillway would be able to start and run at the same time without overloading the system.

7.6.2.3 480-Volt Distribution

The 480-volt power would be distributed from the substation to a 600-amp automatic transfer switch (ATS). The ATS would supply a local 400-amp motor control center/switchboard providing power to the local systems.

7.6.3 Emergency Electrical Power

Emergency electrical power would be provided from the existing emergency generator building on the Folsom project site. An additional provision for portable generator plug-in will be provided at the auxiliary spillway.

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[2] Distributed redundancy is discussed in Redundancy Provides the Key to Data Center Reliability, CEE News, September 2000.

[3] The Connected Load is ~1,425-kVA (April 2002), including the assumed future upsizing of the spillway gate motors from 5- to 10-hp. The estimated minimum coincident demand load is ~450-kVA with two hydraulic power units, two spillway gates, the sump pumps, one penstock hoist, the elevator running and all non-motor loads on line at 0.8 load factor.

7.6.4 Existing Emergency Electrical Power System

The existing 480-volt emergency power system (generator building project) is designed in accordance with National Fire Protection Association 110, for a Level 1 system. It would supply emergency power for the entire spillway. The system includes two existing 500-kilowatt (kW) (625 kVA), generators, either of which can start sequentially and run the minimum coincident demand load.[4] These generators would provide reliable emergency power even when one unit is out of service for maintenance or repair, or because of failure.[5] Combined, the two units would provide emergency power for the entire combined spillway and dam load at approximately 50 percent of their rated capacity. These generators would enable indefinite full operation during a catastrophic failure of the primary system, such as might be caused by an earthquake [6] or sabotage. The emergency power system also would provide sufficient emergency power for the enlarged spillway gates that would be installed when the top of the dam is raised.

7.6.5 New Emergency Electrical Power Distribution

Emergency power would be distributed to the ATS via a route through the existing dam. Several empty conduits were provided from the generator building to the dam under the generator building contract. These conduits will be extended through the dam, using the utility shaft in part, and then routed out of the control tower and along the top of the dam feeding towards the auxiliary spillway. The feeder to the auxiliary spillway would be stepped up/down to 4,160 volts with 225 kVA dry-type transformers at the tower and at the auxiliary spillway to limit voltage drop over the lengthy 3625-foot run.

7.6.6 Uninterruptible Power Supplies

All existing systems that could not "live" through the 10-second delay before emergency power comes on would be fitted with battery-powered uninterruptible power supplies. This measure would be applied to all new systems.

7.7 CONSTRUCTION CONSIDERATIONS

This section summarizes the anticipated approach to project construction of the four-STG auxiliary spillway, including means and methods and proposed scheduling.

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[4] See Footnote 3 for the minimum coincident demand load.
[5] The advantages of multiple generators are addressed in Section 4.6.2 of the Institute of Electric and Electronic Engineers (IEEE) Standard 446 (1987), IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications (IEEE Orange Book) and in an article Paralleled On-Site Generators Increase Reliability and Cost Savings, in the "on-peak," supplement to Consulting-Specifying Engineer, November 2000.
[6] Appendix B, Lifeline Report No. 1, Systems at Risk from Earthquakes, Hydroelectric Power Plant Facilities, Corps ETL 1110-2-533 (1994).

7.7.1 Phased Construction and Work Packages

A phased construction approach has been identified for the Folsom Dam auxiliary spillway. Other non-integrated Federal projects to be constructed in conjunction with the auxiliary spillway would have a similar sequenced or phased nature. A phased construction approach allows for developing and implementing specific "work packages." For purposes of this report, a work package is considered to be a grouping of work elements defined either by an area or a specific program feature. Designated work packages should be compatible with future contracting/procurement efforts and should represent major contracts as the program is currently envisioned. Work packages would be sized to take advantage of the strengths of both large and small disadvantaged businesses. Work packages would be coordinated with other ongoing projects at the Folsom Facility to reduce contractor conflicts and maximize available funding. Other major non-integrated proposed construction features include the Folsom Dam Bridge and Road project, the City of Folsom Redundant Pipeline, the downstream foundation treatment at MIAD, and various interim construction measures currently underway by the Corps and Reclamation.

Work package development would continue as the auxiliary spillway is brought forward through the design stage. For the purposes of this report, the following work packages have been identified, and are consistent with cost estimate development for the auxiliary spillway:

- **Work Package 1** – Interim Measures. This work package includes any interim measures associated with modifications to the existing main concrete dam tainter gates, including tainter gate-opening modifications, and similar measures for incremental flood protection benefits in the near term.
- **Work Package 2** – Auxiliary Spillway Excavation and Construction. This work package covers the entire costs of excavation and construction for the auxiliary spillway project, including the approach channel, control structure, chute and stilling basin. All common and rock excavation materials would be trucked via an in-reservoir haul road to a stockpile/disposal site near MIAD.
- **Work Package 3** – Miscellaneous Projects. This work package includes implementing various miscellaneous project elements: (1) relocations, (2) erosion protection, (3) mitigating recreation impacts, (4) new fencing and access roads, and (5) security improvements.

Additional benefits can be realized through optimization of the design process, materials excavation and distribution, and construction scheduling. These issues will be thoroughly evaluated in follow-on design efforts.

7.7.2 Bid-Ability

"Bid-ability" is the ease with which contract documents can be understood, bid, administered, and executed. To facilitate bid-ability for this project, the contractor will need to be able to accurately verify quantities for each construction line from the plans and specifications in order to propose a reliable bid. If plans and specifications are incomplete or

vague, the overall project risk is transferred to the contractor. Often this translates into the contractor not being able to adequately estimate the project needs, which at minimum, results in bids being significantly elevated to cover the uncertainties. When complete and accurate information is included in plans and specifications, and the contractor is able to quantify or place boundaries on this risk, bid-ability is greatly improved. Review of the construction documents during the design phases with emphasis on incorporating bid-ability is essential.

7.7.3 Constructibility and Construction Risk Overview

"Constructibility" can generally be described as the extent to which the project design provides for ease of construction and still meets the overall requirements of the completed facility. Establishing constructibility begins with the initial planning phase and extends into the detailed design, procurement, and field construction phases. A critical factor is determining if means and methods of construction can be employed to allow the project to be completed using industry standard practices, or innovative construction techniques that have been used successfully by the reviewer or company bidding the project.

In determining constructibility, a construction risk overview would be conducted. This is a review to determine if the major risks associated with the project can be identified and quantified. If the reviewer is able to accurately assess the risks primarily from a review of the available contract documentation, the project is determined to be constructible and the risks reasonable. As with bid-ability, if this can not be completed, realistic constructibility or construction risk assumptions would not be achieved. Proposed risk reduction considerations include discussions with contractors during the design phase, limiting the means and methods in plans and specification documentation, adequate construction funding, use of local and regional cost indices to track as-bid or as-constructed prices, use of an equitable price adjustment clause in the contract, and accurate unit pricing.

On the basis of a preliminary risk overview by the design team, it is believed that one potential risk issue that may affect constructibility is the post-9/11 security requirements. If requirements are stringent to the point that construction workers' access to the site is greatly restricted, the ability to accurately assess constructibility is limited, resulting in a potentially large increase in cost and time for completing the work.

7.7.4 Construction Means and Methods

Construction means and methods primarily refer to construction equipment, operations, practices, procedures, and related activities. Below is a general description of means and methods that have been initially identified. It should be noted, however, that the means and methods provided below are only one set of possibilities for achieving the desired results; construction documents should not limit bidders from using their own means and methods, and taking advantage of resources within their respective companies, provided those means and methods reflect the requirements of the plans and specifications documentation.

This discussion of means and methods below is organized by major work item, not by work package, because many of the work packages are assumed to employ similar means and methods.

7.7.4.1 Spillway Excavation and Material Processing

The decomposed granite and superficial soils in the spillway excavation area can be loosened using a 400 hp dozer (Cat D-9) with either a single shank or multiple shanks. Using standard excavation equipment, push dozers, and off-highway haulers, the material would be taken for processing or spread at a stockpile site. The underlying competent bedrock would be broken, employing industry standard drill and blast techniques. Loosened materials would be loaded into off-highway haulers using a 190,000-pound excavator (Cat 375).

Excavation materials would be transported to one or more disposal sites, including, but not limited to, the Folsom Point area, the water-side of Dike 7, and a disposal site near the MIAD right abutment.

7.7.4.2 Access and Haul Roads

Public access to all park facilities would be maintained, including Folsom Point, either via existing park roads or temporary relocated roads. Public access would be restricted from the construction areas, the processing areas, and haul roads.

To reduce construction traffic on city streets and to allow the use of oversized construction equipment, internal haul roads would be developed adjacent to the reservoir. The internal haul roads would be graded into the weathered granite and have an earthen road base installed. The internal roadways would be sized to allow passage of oversized equipment. The crests of the wing dams and MIAD would be included as part of the internal road network. Given the space limitations of the crests, only conventional equipment would use the wing dams or MIAD. A construction haul road would be constructed from the auxiliary spillway site to the Dike 7 stockpile area and then on to Folsom Point and MIAD (R1 and D2 borrow/stockpile sites). This would allow transport of material between these project facilities. At this time, there is no consideration being given to using the main concrete dam as a haul road.

7.7.4.3 Construction Field Office, Heavy Equipment Maintenance Yard, and Laydown Areas

Following is a preliminary locations for the construction field office, heavy equipment maintenance yard, and laydown (construction staging) areas for each of the work packages:

- **Work Package 1** – Interim Measures. Field office and laydown areas could be located near the main concrete dam adjacent to the Corps field office facilities and the overlook area just east of the left wing dam.
- **Work Package 2** – Auxiliary Spillway Excavation and Construction. Material processing and load out operations would be located in the overlook area just east of

the left wing dam. Some field office and laydown area is available near the auxiliary spillway and a substantial area is available near Folsom Point. The area required to erect and operate a concrete batch plant, including adequate aggregate storage areas, is available at Folsom Point and possibly near the LWD. The LWD site has the advantage of being in very close proximity to the work site and from removed from housing and recreation sites. Folsom Point, on the other hand, has an advantage of minimizing security concerns compared to staging areas near the main dam. A heavy equipment maintenance yard could be located at Folsom Point or at Dike 7, in the vicinity of the haul road.

- **Work Package 3** – Miscellaneous Projects. Multiple field office and laydown areas of various sizes would be required. Potential locations remain to be determined.

7.7.4.4 Concrete Batch Plant

The construction of the new control structure, spillway, and stilling basin will require large quantities of temperature controlled concrete. This will necessitate the use of a contractor-provided, on-site concrete batch plant and deliveries of large quantities of concrete aggregates, concrete sand, and cement. It is estimated that the concrete batch plant and material stockpiles will require about ten acres of land. An area near Folsom Point can accommodate this requirement. The in-reservoir haul road would be used for concrete transport from Folsom Point to keep truck traffic off local roads. Another potential batch plant site is the area at the toe of the LWD, potentially in combination with part of the paved overlook area at the east end of the LWD, for use as aggregate storage. With the relocation of the 42-inch Natomas pipeline and the Corps' office building, the LWD site could increase by several acres.

7.7.4.5 Concrete Materials and Placement

Delivery of concrete aggregate, sand, and cement will involve a large volume of truck traffic. Due to the quantities involved and operating hours of aggregate and cement suppliers, the delivery scheduling would not be restricted solely to traffic off-peak hours. Deliveries are not expected to cause a significant impact on traffic.

The construction of the new control structure, spillway and stilling basin will require large quantities of temperature controlled concrete. It is likely unavoidable that some concrete batching and placements will have to occur during the night-time hours. This is especially true for large volume placements and placements that occur in the hot summer season. Night-time placements will be included in the design considerations and allowed in the construction contract documents.

7.7.5 Construction Schedule

A preliminary schedule for the four-STG auxiliary spillway alternative is presented in **Plate 7-16** and is presented by work package. The construction cost estimate is based on this

preliminary schedule and was used to derive escalation allowances in determining the mid-point of construction for each work package.

7.7.6 Contracting and Procurement

As stated previously, the work packages described above are preliminary. As the auxiliary spillway design and schedule progress, refinement of these work packages would likely be required because of various issues, including availability of funding. Minor changes to work packages should not have a significant impact to the overall program cost at this stage of estimate if the overall duration of the program schedule does not change. However, the impact on the cost estimate should be reviewed for any significant changes to work packages development and major scheduling assumptions.

CHAPTER 8.0
CONCLUSIONS

The following conclusions are based on the results of the analyses contained in this EDR for the Folsom Modification Project.

- An auxiliary spillway alternative consisting of four STGs with gate dimensions of 17 feet 7 inches wide by 33 feet 1 inch tall and an invert at elevation 368 provides the same flood damage reduction afforded by the currently authorized Folsom Modification Project that serves as the baseline for comparison of alternatives (six enlarged main dam river outlets plus two new main dam river outlets and two existing main dam river outlets). Flood routings of the four-STG auxiliary spillway have been performed to demonstrate that the alternative would provide a flood control level of protection computed at 1 chance in 149. This alternative would provide the capability for Folsom Dam to pass a 180-year design event.
- The design and construction of the four-STG auxiliary spillway alternative would take about eight years.
- The four-STG auxiliary spillway alternative does not address the existing dam safety deficiency of inadequate spillway capacity. The additional release capacity provided by the auxiliary spillway increases, but does not fully meet, the dam's capability to pass the PMF.
- The four-STG auxiliary spillway alternative is designed to dissipate energy from high velocity flows before they enter the American River channel. Ongoing studies and future analysis will determine what measures are required to address possible impacts to downstream water surface elevations and channel erosion potential.
- During project development, further study of reservoir reoperation will be performed, focusing on reducing the variable space allocated to flood control within the reservoir. The variable space may be reduced from the current operating range of 400,000 to 670,000 acre-feet to an interim operating range of 400,000 to 600,000 acre-feet.
- Construction of the four-STG auxiliary spillway alternative would cause some resource impacts; but mitigation measures would be proposed to reduce these potential impacts to less-than-significant levels where possible.
- Preliminary geologic, geotechnical, seismic, and hydrogeologic investigations of the auxiliary spillway site support the geotechnical viability of locating the auxiliary spillway at this site. Further data and analysis obtained during the ongoing Phase 2 explorations will enhance these data and allow further evaluation of key design considerations, including the following:
    - Cofferdam seepage
    - Sliding block stability

  - Control structure foundation design
  - Long-term seepage

- Structural analyses of the auxiliary spillway alternative for stability and stress indicate that the structure can achieve adequate margins of safety using cost-effective design and construction techniques.
- A draft feasibility-level cost estimate for the four-STG auxiliary spillway alternative was developed. The first cost is $633 million. The four-STG auxiliary spillway alternative is economically feasible. The annual cost and average annual flood control benefits are estimated at $34.4 million and $84.9 million, respectively.

CHAPTER 9.0
REFERENCES

CHAPTER 1

Sacramento Area Flood Control Agency (SAFCA). 1998. Folsom Dam Modification Report, New Outlets Plan, Prepared by Murray, Burns and Kienlen, Sacramento, California.

U.S. Army Corps of Engineers, (Corps). 1996. American River Watershed Project, California, Supplemental Information Report and Final Supplemental Environmental Impact Statement/Environmental Impact Report. Sacramento District. Sacramento, California, March.

Corps. 2001. Folsom Dam Modification Project, Limited Reevaluation Report and Environmental Assessment/Initial Study, American River Watershed, California. August.

Corps. 2003. Folsom Dam Modification Project, Final Limited Reevaluation Report and Environmental Assessment/Initial Study, American River Watershed, California, November.

Water Resources Development Act (WRDA 1996), (Public Law 104-303), Section 101 (a)(1), American River Watershed, California.

Water Resources Development Act of 1999 (WRDA 1999) (Public Law 106-53), Section 101 (a)(6), American and Sacramento Rivers, California.

CHAPTER 2

Corps. 1996. American River Watershed Project, California, Supplemental Information Report and Final Supplemental Environmental Impact Statement/Environmental Impact Report. Sacramento District. Sacramento, California. March.

Corps. 2002. American River Watershed, California: Long Term Study, Final Supplemental Plan Formulation Report/Environmental Impact Statement/Environmental Impact Report. February.

Corps. 2003. Folsom Dam Modification Project, Final Limited Reevaluation Report and Environmental Assessment/Initial Study, American River Watershed, California. November.

Corps. 2004. Design Documentation Report (DDR), Folsom Dam Outlet Works Modification Project, Volumes I and II. August.

Corps. Reclamation, SAFCA, DWR and State of California Reclamation Board. 2006. Project Alternative Solutions Study II (PASS II), Final Report, Folsom Dam Flood Control and Hydrologic Risk Reduction Alternatives. October.

SAFCA. 1998. Folsom Dam Modification Report New Outlets Plan. February.

CHAPTER 3

Corps. 2003. Folsom Dam Modification Project, Final Limited Reevaluation Report and Environmental Assessment/Initial Study, American River Watershed, California. November.

CHAPTER 4

Corps. Sacramento District. 1987. Water Control Manual, Folsom Dam and Lake, American River, California. Appendix VIII to Master Water Control Manual, Sacramento River Basin, California. December 1987.

Corps. 2001. "American River Basin, California, Folsom Dam and Lake Revised PMF Study, Hydrology Office Report," Sacramento District, U.S. Army Corps of Engineers, October 2001.

Corps. 2004. "American River, California, Rain Flood Flow Frequency Analysis, Office Report" Sacramento District, U.S. Army Corps of Engineers, August 2004.

National Weather Service [NWS]. 1999. Hydrometeorological Report (HMR) No.59 (includes HMR No. 58), "Probable Maximum Precipitation for California," Hydrometeorological Branch of the National Weather Service, February 1999.

SAFCA & Reclamation. 2004. "Folsom Dam Interim Operations Plan (2004), American River, California," September

USGS. 1981. "Guidelines for Determining Flood Flow Frequency, Bulletin #17B," Interagency Advisory Committee on Water Data, U.S. Geological Survey, revised September 1981.

Water Resources Development Act of 1996. (Public Law 104-303), Section 101 (a) (1), American River Watershed, California.

CHAPTER 5

Corps. State of California Reclamation Board, 2001, Final Environmental Assessment/Initial Study, American River Watershed, California, Folsom Dam Modification Project, August.

Reclamation, 2006, Folsom Dam Safety and Flood Damage Reduction Draft Environmental Impact Study / Environmental Impact Report (DEIS/EIR), (Document prepared by CDM), December.

CHAPTER 6

Annandale. 1995. Scour Technology, McGraw-Hill Professional. November.

Bro. 2004. Large Scale Direct Shear Testing of Monolith 15 Concrete/Foundation Contact. 2005.

Bro. 2005. Skewed Brazilian Splitting Tensile Strength Testing to Correlate Tests with Orientation of Healed Fractures.

Corps. 1950. Definite Project Report, Folsom Project, American River, CA. Part IV – Dam and Appurtenances.

Corps. 1952. Foundation Report, Left Wing Dam, Folsom Project, American River, CA. 1952.

Corps. 1954. Roddy, Russell, Foundation Report, Part "D", Main Concrete Dam, Monoliths 7-23, Folsom Project, American River, California.

Corps. 1989. Seismic Stability Evaluation of Folsom Dam – Dam Safety Assurance Program.

Corps. 2004. SPK, Folsom Dam Resident Office, Staging Areas, and Access Roads, Specification No. 1410; Final Geotechnical Report. July.

Corps. 2005. WES, In Situ Geophysical Surveys for Estimation of Foundation Rock Properties, Concrete Gravity Section, Folsom Dam; ERDC/GSL TR-05-18. August.

Corps. 2006a. SPK – J. Bolton – Top of Dam Explorations and Permeability Testing, Dikes 5 &7 and Mormon Island, Draft Permeability Report. 2006 (in progress).

Corps. 2006b. Auxiliary Spillway. Drilled 15 rock core holes and conducted optical televiewer surveys. April.

Corps. 2006c. DRAFT – American River Watershed Project, California, Folsom Modifications and Folsom Dam Raise Projects. October.

Fuller. 2003. Rock Testing (Shear, sliding friction, unconfined compressive strength of holes TH-G through TH-P from drain gallery drilling) for URS. March 2003.

Goodman. 2005. Shear Strength of a Foundation with Two-dimensional Roughness; Paper submitted for the 2005 American Rock Mechanics Association Conference.

Greene. 2002. Memo – Rock Properties for Folsom Dam MODS. September.

Jennings. 1994. Fault Activity Map of California and Adjacent Areas with Location and Ages of Recent Volcanic Eruptions. California Division of Mines and Geology, Geologic Data Map Series, Map No. 6.

Kiersch. 1950. Folsom Dam Regional Geology Map – 1 inch = 1 mile. January 1950.

Kiersch. 1955. Kiersch and Treasher, Investigation, Corps Aerial and Engineering Geology – Folsom Dam Project, Central CA, May.

Kleinfelder. 2002. Geotechnical Investigation Report – Folsom Dam Subsurface Exploration, November.

Kleinfelder. 2005. Spillway Scour Analysis, January.

Kleinfelder. 2006. Geologic and Geotechnical Evaluation, Downstream Rock Scour Potential, Folsom Dam, Folsom, CA.

Loyd. 1984. General Geology of the Auburn 15-minute Quadrangle, Division of Mines and Geology, Open File Report, 1984.

Norcal. 2005a. Seismic Refraction Survey of Auxiliary Spillway – Draft Letter Report. The refraction was never verified and correlated with Phase 1 drilling. October.

Norcal. 2005b. Geophysical – Seismic Refraction Survey of Dam Road Realignment for URS.

Norcal. 2005c. Geophysical for URS – DRAFT Preliminary Roadway Materials Report for Folsom Dam Bridge, Folsom, CA. October.

Quest. 2005a. Summary Report on Shear Strength of Monolith 15. Discusses results of the direct shear testing of the 6-inch concrete and bedrock samples. January.

Quest. 2005b. Report of Bond Strength of the Rock/Concrete Interface of Monoliths 15-19, Folsom Dam – Observations, findings, and recommendations, October.

Reclamation. 1999. Hydraulic Model Study of Folsom Dam Spillway Performance and Stilling Basin Abrasion. September.

Reclamation. 2001. Technical Report of Construction – Folsom Dam Spillway Rehabilitation. February.

Reclamation. 2002. Tech Service Center, Concrete Coring – Laboratory Testing program, Folsom Dam Modifications. April.

Reclamation. 2004. Static and Dynamic Foundation Analysis – 3D Block Analysis. August 2004.

Reclamation. 2005. Results of Direct Shear Tests. October 2005.

Reclamation. 2006. Auxiliary Spillway. Drilled 5 rock core holes, geologic drill hole logs and field notes. January.

URS. 2001a. Final Report, Folsom Dam Modifications, Evaluation of Rock Mass Properties. June (draft) – December (final). December.

URS. 2001b. Deterministic and Probabilistic Seismic Hazard Analysis for Folsom Dam, California. 2001.

URS. 2002. Supplemental Report, Deterministic and Probabilistic Seismic Hazard Analysis, Folsom Dam. July.

URS. 2003b. Final Report, Supplemental Report II, Deterministic and Probabilistic Seismic Hazard Analysis, Folsom Dam. June.

URS. 2003a. Tech Memo, Folsom Dam Foundation Characterization. August 8, 2003 Addressed differences in rock mass properties in the May 2003 Rock Testing report with those from the 1989 DSAP report. August.

URS. 2003b. Tech Memo, Rock Testing Report. Testing done by FMS&M. May.

URS. 2003c. Final Report, Supplemental Report II, Deterministic and Probabilistic Seismic Hazard Analysis, Folsom Dam. June.

URS. 2004a. Memo, Evaluation of Potential for Surface Faulting at Folsom Dam. Mapping and field investigation by URS to estimate age of last movement of Channel Fault. February.

URS. 2004b. Direct Shear Testing of Scale Models for Folsom Dam Monolith 15. July 2004.

URS. 2005. DRAFT Preliminary Roadway Materials Report for Folsom Dam Bridge; Folsom CA. October.

URS. 2006. DRAFT Foundation Report for Folsom Bridge, Folsom, CA. May.

Wagner. 1981. Geologic Map of the Sacramento Quadrangle, California – 1:250,000.

Woodward-Clyde. 1983. Investigation of Concrete and Foundation Conditions (Fault Study) at Folsom Dam. Drilled holes TH-A through TH-F in drain gallery, conducted Goodman Jack testing, calculated rock mass modulus. August.

CHAPTER 7

Annandale. 2005. Scour Technology, McGraw-Hill Professional, November Annandale's Erodibility Index.

Boes and Hager. 2003. Two Phase Flow Characteristics of Stepped Spillways, ASCE, HY Journal, September.

Corps. Sacramento District, American River Watershed, CA, Folsom Dam Modification Project, Gate Size Decision Technical Memorandum.

Corps. 2002. American River Watershed, California: Long Term Study, Final Supplemental Plan Formulation Report/Environmental Impact Statement/Environmental Impact Report, February.

Corps. Reclamation, SAFCA, DWR and State of California Reclamation Board. 2006. Project Alternative Solutions Study (PASS) II, Final Report, Folsom Dam Raise and Auxiliary Spillway Alternative, June

Corps. Reclamation, SAFCA, DWR, State Board of Reclamation, 2006, Folsom Dam Raise and Auxiliary Spillway Alternative, Project Alternative Solution Study (PASS) II, Final Report, June.

Corps. 1980. Hydraulic Design of Reservoir Outlet Works, Engineering Manual 1110-2-1602, 15 October 1980.

Corps. 1987. Hydraulic Design Criteria, November 1987.

Corps. 1990. Hydraulic Design of Spillways, Engineering Manual 1110-2-1603, 16 Jan 1990.

Corps. 1992. Dam Safety – Organization, Responsibilities, and Activities, Engineering Regulation ER 1110-2-1156, 31 July 1992.

Corps. 1994. Hydraulic Design of Flood Control Channel, Change 1, ENG 4794-R, 30 June 1994.

Corps. 1995. Gravity Dam Design, Engineering Manual EM 1110-2-2200, 30 June 1995.

Corps. 1999. American River Watershed, California, Information Paper, August 1999.

Corps. 1999. Engineering and Design for Civil Works, Engineer Regulation 1110-2-1150, 31 August 1999.

Corps. 2001. Sacramento District, American River Watershed, CA, Folsom Dam Modification Project, Final Limited Reevaluation Report, August 2001.

Corps. 2003. Engineering and Design: Stability Analysis of Concrete Structures, Engineering Circular EC 1110-2-6058, 30 November 2003.

Corps. 2004. Engineering and Design, Safety of Dams – Policy and Procedures, Engineering Circular EC 1110-2-6061, 30 April 2004.

Corps. 2004. Design Documentation Report, Folsom Dam Outlet Works Modifications Project, Volumes I and II, August.

DWR. Original Design of Oroville Dam.

DWR. 1965. Oroville Dam Flood Control Structure.Corps. 1999, Engineering Regulation ER 1110-2-1150, Engineering and Design for Civil Works Projects, 31 August 1999.

ESA Consultants, Inc. 1994. Folsom Dam Improvements, Mini Raise, Preliminary, August

FEMA. Publication 64, Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners.

Murray, Burns, and Kienlen (MBK) Consulting Civil Engineers. 1998. Folsom Dam Modification Report New Outlets Plan, February

Peterka, A. J. 1974. Hydraulic Design of Stilling Basins and Energy Dissipators, Engineering Monograph No. 25, US Bureau of Reclamation, Denver, Colorado.

Pinto, N.L. de S., and Neidert, S.H. 1992. Model Prototype Conformity in Aerated Spillway Flow, International Conference on Hydraulic Modeling of Civil Engineering Structures, BHRA, Coventry

Reclamation. 1971. Hydraulic Model Studies of the Folsom Spillway-Outlet Junction, REC-ERC-71-12, Reclamation. (Isbester, T.J.)

Reclamation. 1980. Air-Water Flow in Hydraulic Structures, Engineering Monograph No. 41, December 1980.

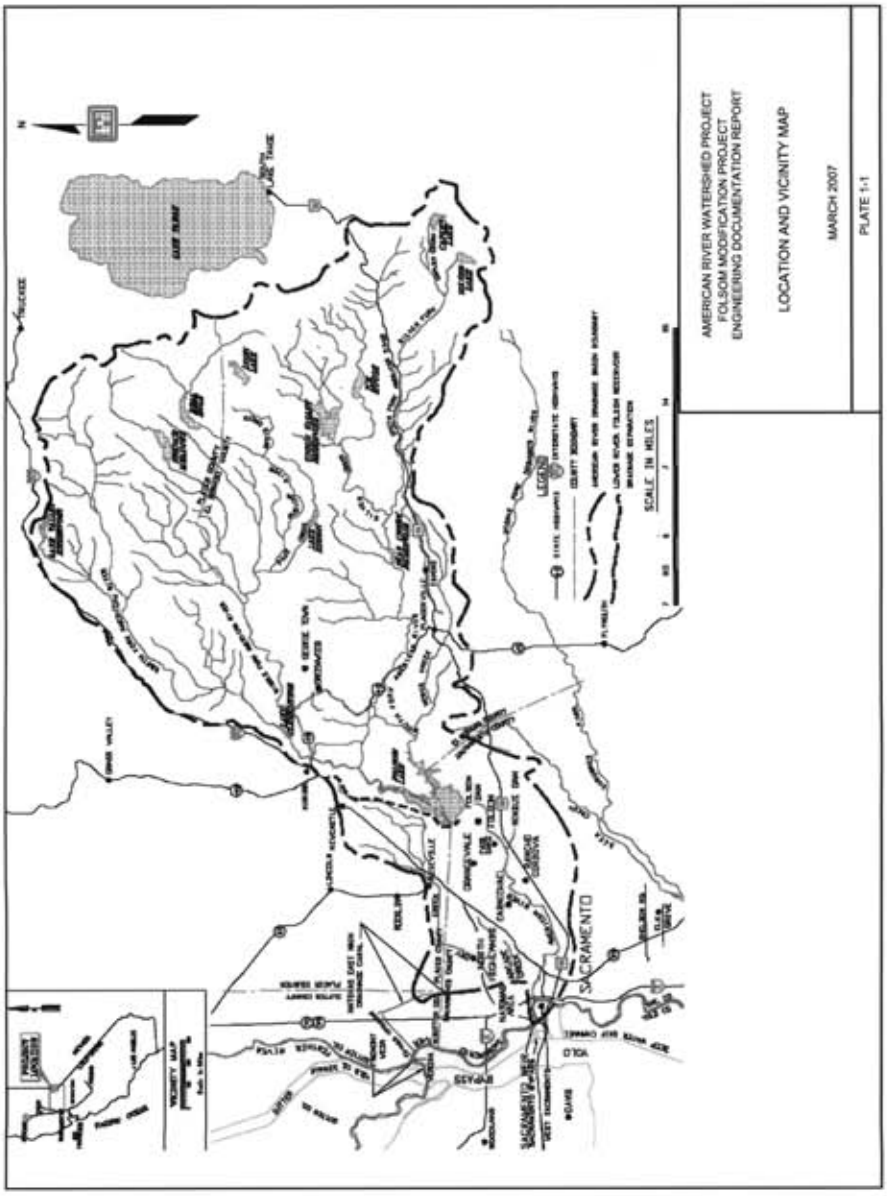
Reclamation. 1990. Cavitation in Chutes and Spillways, Engineering Monograph No. 42, April 1990.

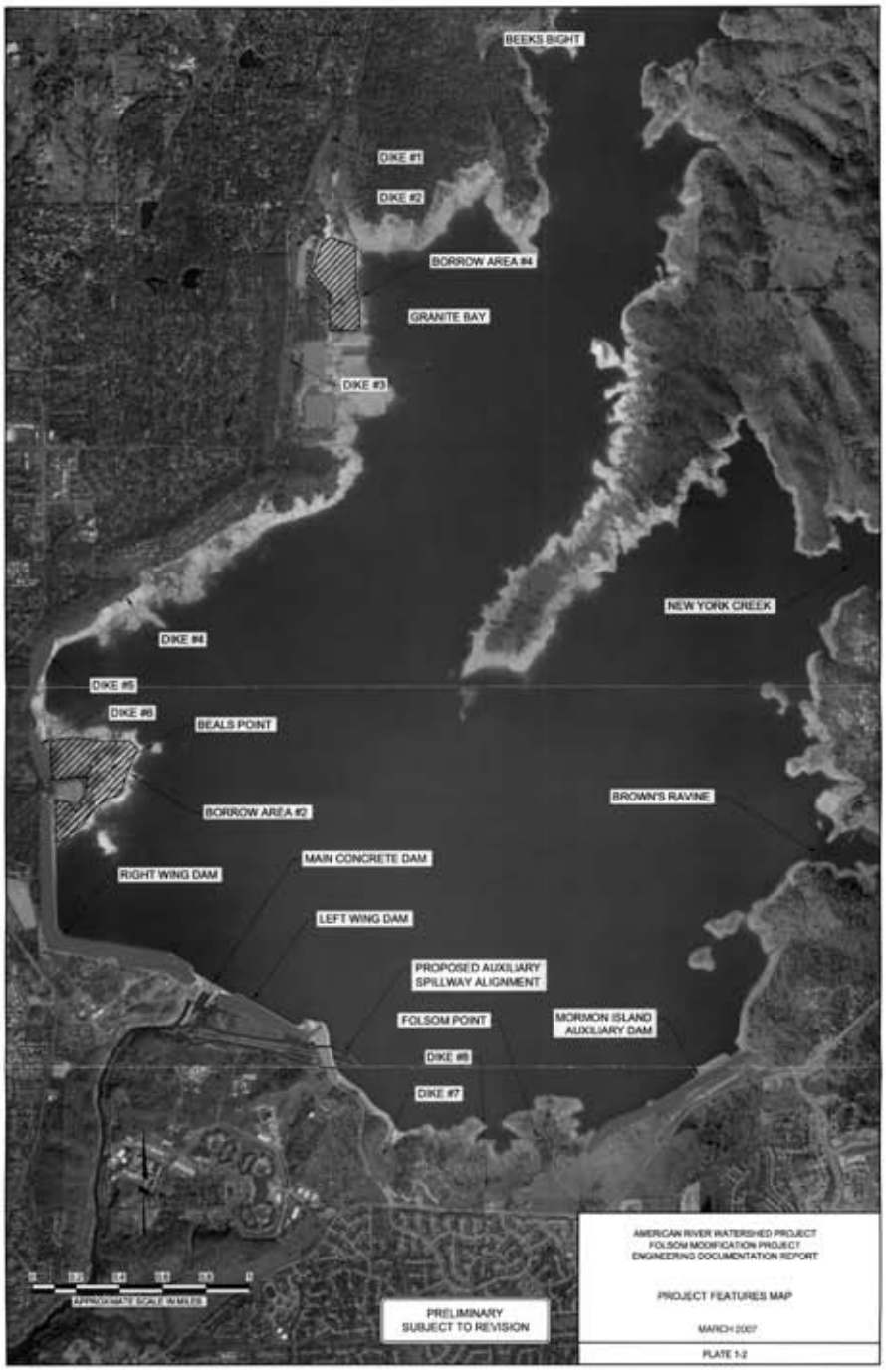
Reclamation. 1996. Folsom Dam Spillway Stilling Basin Rehabilitation, TM No. FOL-8130-REH-96-1, September 1996.

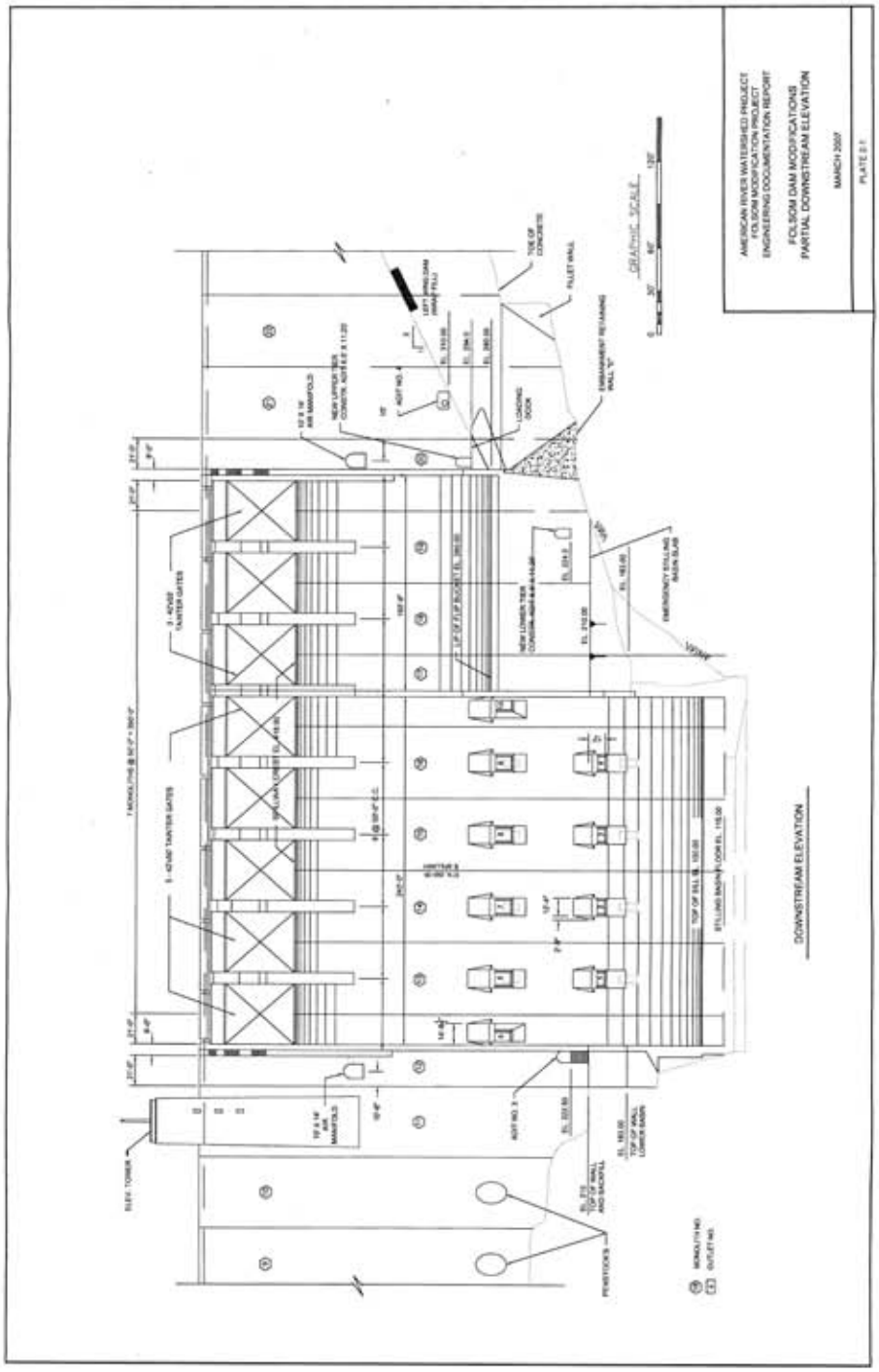
Reclamation. 1997. Recommended Flood Operations for Folsom Dam, TM FD-8130-FD-TM-97-3, September

Reclamation. 1998. Aeration Enhancements at the Folsom Dam Outlet Works: Reducing Cavitation Damage Potential, April 1998.

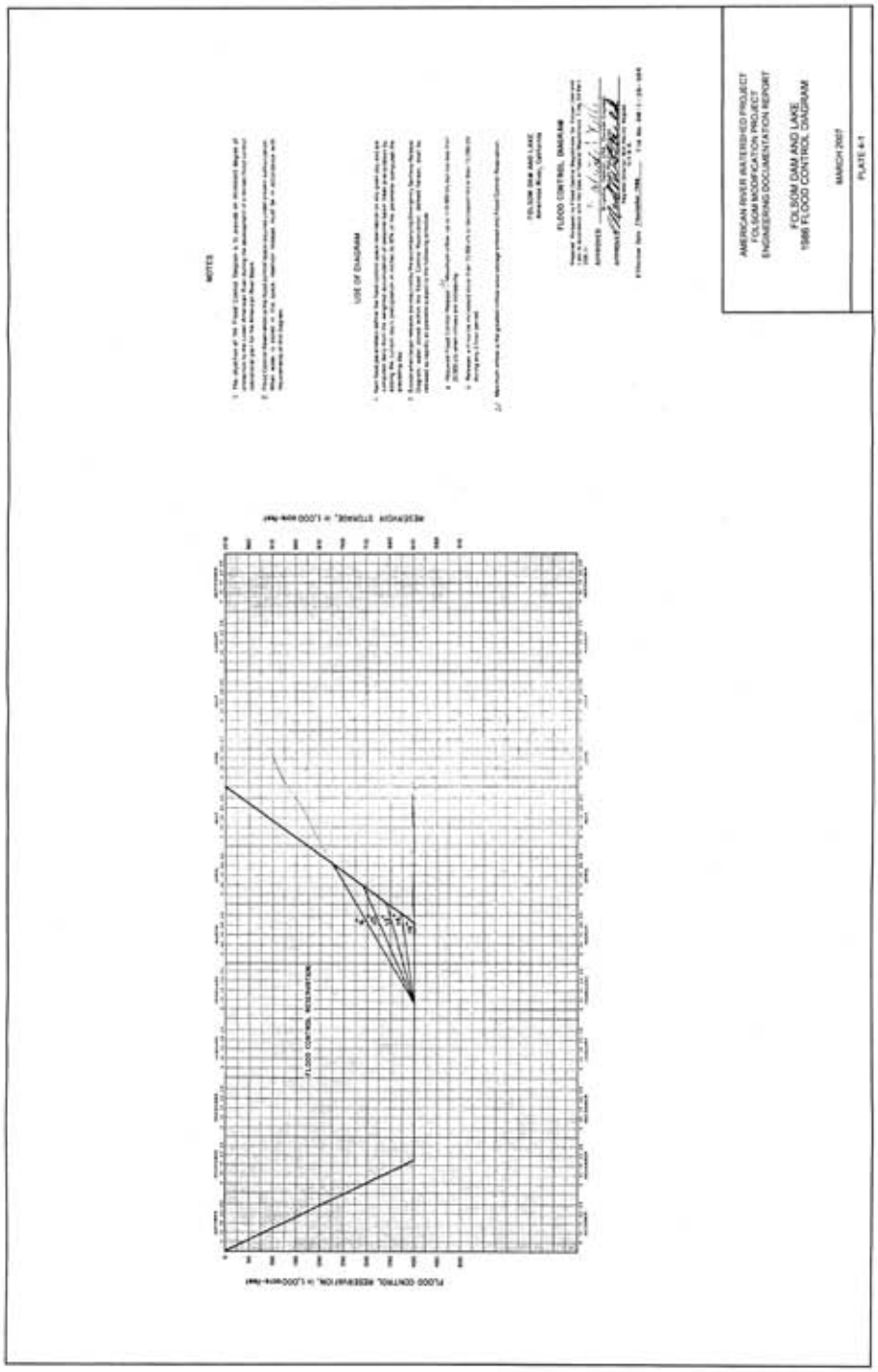
URS. 2001. Probabilistic and Deterministic Seismic Hazard Analyses, Folsom Dam, Central California, Final Report, July 5.

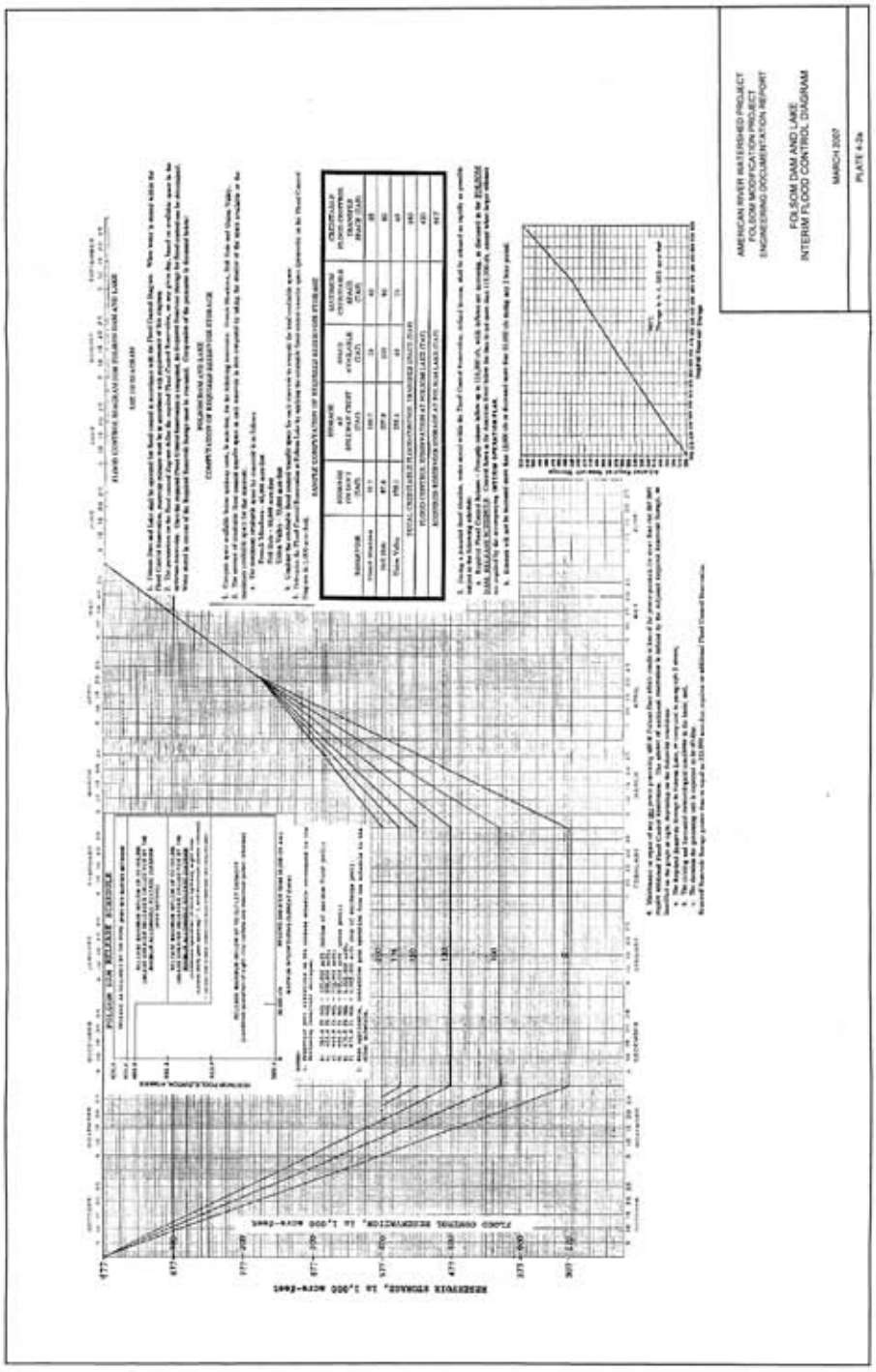

AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
LOCATION AND VICINITY MAP
MARCH 2007
PLATE 1-1
SACRAMENTO
SCALE IN MILES


BEEKS BIGHT
DIKE #1
DIKE #2
BORROW AREA #4
GRANITE BAY
DIKE #3
NEW YORK CREEK
DIKE #4
DIKE #5
DIKE #6
BEALS POINT
BROWN'S RAVINE
BORROW AREA #2
MAIN CONCRETE DAM
RIGHT WING DAM
LEFT WING DAM
PROPOSED AUXILIARY SPILLWAY ALIGNMENT
FOLSOM POINT
MORMON ISLAND AUXILIARY DAM
DIKE #8
DIKE #7
APPROXIMATE SCALE IN MILES
PRELIMINARY SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
PROJECT FEATURES MAP
MARCH 2007
PLATE 1-2


AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
FOLSOM DAM MODIFICATIONS
PARTIAL DOWNSTREAM ELEVATION
MARCH 2007
PLATE E-1
GRAPHIC SCALE
DOWNSTREAM ELEVATION


RIGHT WING DAM
FUTURE FOLSOM BRIDGE (SEPARATE PROJECT)
STILLING BASIN
MAIN CONCRETE DAM
LEFT WING DAM
FUTURE USACE RESIDENT OFFICE
FUTURE PARKING
CONTROL STRUCTURE
APPROACH CHANNEL
PROPOSED AUXILIARY SPILLWAY ALIGNMENT
CHUTE
FUTURE FOLSOM BYPASS ROADWAY (SEPARATE PROJECT)
PRELIMINARY SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM, CALIFORNIA
ENGINEERING DOCUMENTATION REPORT
MAIN CONCRETE DAM AND
AUXILIARY SPILLWAY PLAN VIEW
MARCH 2017
PLATE 2-2


AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
FOLSOM DAM AND LAKE
1986 FLOOD CONTROL DIAGRAM
MARCH 2007
PLATE E-1
NOTES
USE OF DIAGRAM
FLOOD CONTROL RESERVATION



AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT

FOLSOM DAM AND LAKE
INTERIM FLOOD CONTROL DIAGRAM

MARCH 2007

PLATE 4-3a

Folsom Dam

Interim Operations Plan (2004)

What is the Plan

The plan is a modification to the Folsom Dam Flood Control Diagram that has been adopted by Sacramento Area Flood Control Agency (SAFCA) and the Bureau of Reclamation. The Corps has endorsed these flood operation rules. The modification consists of a set or rules that would accomplish the following:

A. Limit the outflow from Folsom Dam to a maximum of 145,000 cfs while the lake level is below elevation 470 feet. Outflows greater than 115,000 cfs would be limited to extreme flood events that occur very infrequently.

B. Utilize 160% gate openings for the eight 5-foot by 9-foot outlet gates in conjunction with the use of the service spillway, if required. This operation would be limited to extreme flood events that occur very infrequently.

Why is the Plan being implemented

The plan is necessary to provide an important increment of flood protection to areas downstream from Folsom Dam. These areas do not have protection from the FEMA Base Flood (1% Annual Exceedance Probability) without the implementation of the Interim Operating Plan.

How does the Plan work

The Interim Operation Plan is based on increasing the outlet capacity from the dam during the early stages of the flood and by limiting outflows above 115,000 cfs to the downstream channel capacity. Each feature of the plan is discussed below:

Limit Outflow to 145,000 cfs. The existing flood control rules call for a flood release from the dam of 160,000 cfs while the lake elevation is well below the normal full pool at elevation 466 feet. The current American River levee evaluations find that that 145,000 cfs can be safely carried by the levees for up to 36 hours. Therefore, the existing limit of 160,000 cfs is being modified to limit outflows to 145,000 cfs until the lake level increases to the maximum elevation that would not require the opening of the emergency spillway gates (elevation 470 feet). This modification reduces the frequency of flood discharges from the dam that exceed 145,000 cfs.

Allow Use of Maximum Outlet Capacity. The current operation plan limits the utilization of the outlet works gates to 60% open during periods when the spillway is also discharging water. This requirement has a detrimental affect on the ability of the dam to manage flood waters. The reason for the limit is that the potential for cavitation to damage the face of the dam is considered to be less if the gates are not fully opened. Cavitation has occurred in the past on the face of the spillway and is not considered a threat to the integrity of the dam if prompt maintenance actions to repair the damage are implemented. The Interim Plan allows the gates to be fully opened while the service spillway is in operation given a sufficiently large event. The gate operation allowed by the Interim Plan could potentially increase the cavitation damage to the spillway face. This is considered an acceptable risk and a plan has been developed whereby SAFCA will fund the work required to repair damage that might be sustained by the dam as a result of this operation. The increased outlet capacity that is achieved by this operation significantly improves the capability of the dam to discharge flood waters at controlled rates downstream from the dam. This capability is an important element in limiting the FEMA Base Flood to outflows of 145,000 cfs or less downstream from the dam.

Under What Conditions do the Provisions of the Plan Take Effect

The provisions of the plan are designed to be used very infrequently for short periods of time. For instance, none of the provisions would be activated for floods that have occurred in the last 100 years. It is estimated that in any given year there may be a 2% chance that the outlets will be operated at maximum gate opening while the spillway is operating. And a 1% chance that flows would exceed 115,000 cfs. The provisions that lead to implementation of the Interim Plan are the forecast of a very large flood in the next 24 hours (325,000 cfs peak inflow or 400,000 acre-feet inflow volume) or reservoir pool to exceed elevation 466 feet, either of which are extremely rare occurrence.

What operations are not affected by the Interim Plan

The Water Supply, Power, Recreation and Fishery operations are not changed by the Interim Plan.

What is changed by the Interim Plan?

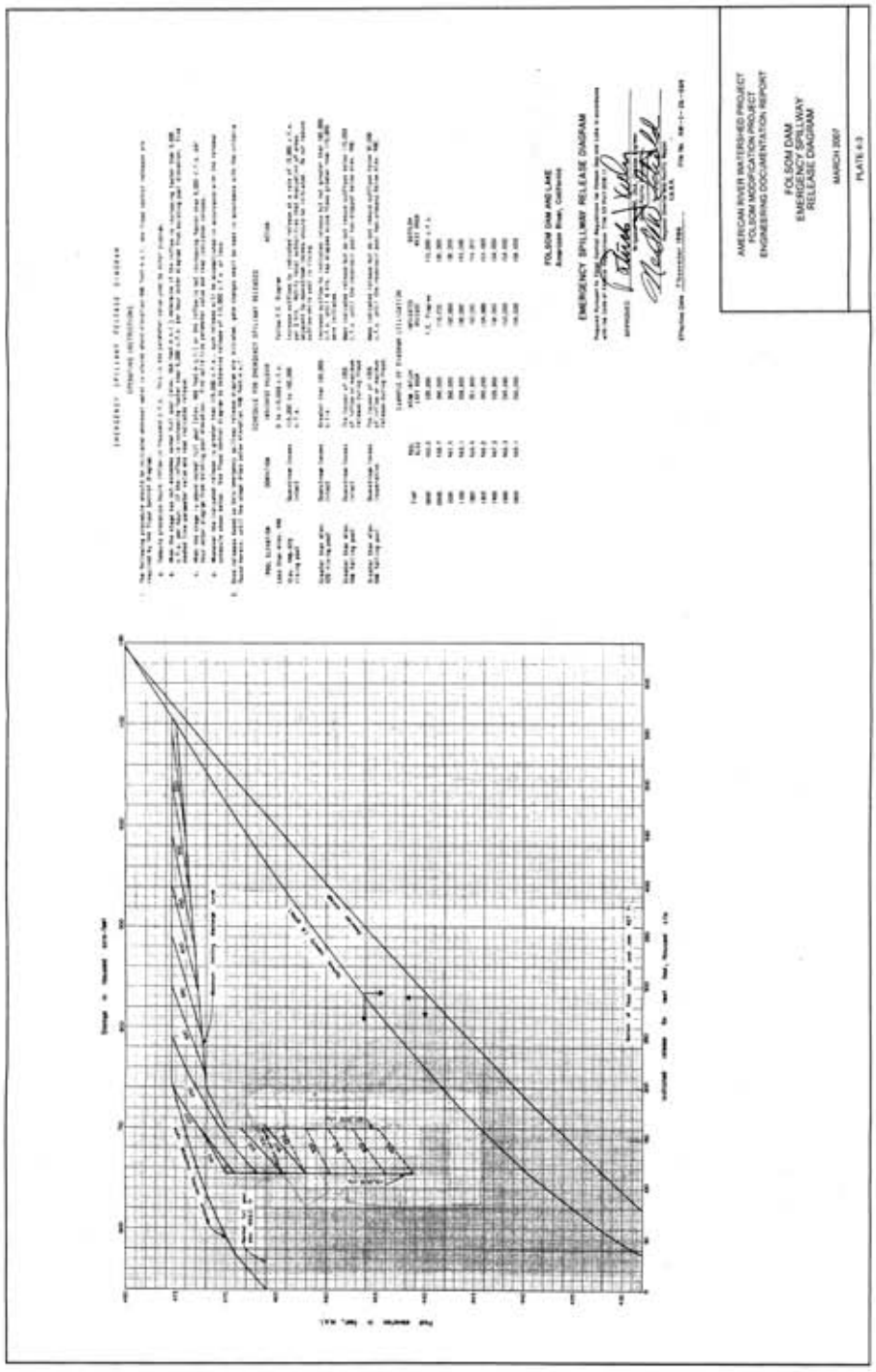
The maximum flood release from the dam is limited to 145,000 cfs instead of 160,000 cfs at the 1% flood level. The potential for cavitation damage to the face of the dam is slightly increased by maximum use of the existing outlets.

AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT

FOLSOM DAM
INTERIM OPERATIONS PLAN (2004)

MARCH 2007

PLATE 4-2b



AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT

FOLSOM DAM
EMERGENCY SPILLWAY
RELEASE DIAGRAM

MARCH 2007

PLATE 6-3

COMPARISON OF KEY OPERATIONAL DIFFERENCES BETWEEN PROJECTS

With-project comparisons made to existing SAFCA/Reclamation re-operation

Feature	Existing SAFCA/Reclamation Re-operation	Folsom Modification Project (six-STG)	Folsom Dam Raise Project (six-STG with raise)	Joint Federal Project
TOP OF DAM ELEVATION DAM RAISE INCREMENT	480.5 feet No Change	No Change	484.5 feet 487.5 feet 3.5 feet 7 feet	480.5 feet 484.5 feet 487.5 feet No Change 3.5 feet 7 feet
GROSS POOL ELEVATION	466.0 feet (977,000 acre-feet)	No Change	No Change	No Change
TOP SURCHARGE (PMF) POOL	475.4 feet (1,094,760 acre-feet)	477.5 feet	481.0 feet 484.5 feet	477.5 feet 481.0 feet
OBJECTIVE RELEASE				
Normal	115,000 cfs	No Change	No Change	No Change
Emergency	160,000 cfs	No Change	No Change	No Change
SERVICE & EMERGENCY GATE CONFIGURATION	3-42 feet x 60 feet service gates 3-42 feet x 53-feet emergency gates[1]	No Change	3-42 feet x 66 feet service gates[2] 3-42 feet x 66 feet emergency gates[2]	TBD
OUTLET CONFIGURATION	4-Upper Tier 9-feet x 9 feet 4-Lower Tier 9-feet x 9-feet	No Change	No Change	No Change
OUTLET CAPACITY (w/o power) @ Elevation 418.0	24,800 cfs	No Change	No Change	No Change
AUXILIARY SPILLWAY CONFIGURATION	None	six-STG Sill elevation – 388 feet	six-STG Sill elevation – 388 feet[2]	four-STG to six-STG Sill elevation – 388 feet[2]
VARIABLE FLOOD CONTROL SPACE	400,000 – 670,000 acre-feet	400,000 – 600,000 acre-feet	400,000 – 600,000 acre-feet	400,000 – 600,000 acre-feet
RATE OF RELEASE CHANGE				
Increase Outflow ≤ 25 kcfs Outflow ≥ 25 kcfs Outflow ≥ 160 kcfs Outflow ≥ 240 kcfs	5,000 cfs/hour 7,500 cfs/hour Unlimited	No Change 15,000 cfs/hour 15,000 cfs/hour Unlimited	No Change 15,000 cfs/hour 15,000 cfs/hour Unlimited	No Change 15,000 cfs/hour Unlimited Unlimited
Decrease	5,000 cfs/hour	No Change	No Change	No Change
Aggressive Ramping 12-hour Forecast Window	145,000 cfs-FEMA base flood 240 kcfs < Inflow < 360 kcfs	Target 160,000 cfs 270 kcfs < Inflow < 370 kcfs Target 145,000 cfs 250 kcfs < Inflow < 370 kcfs Target 130,000 cfs 200 kcfs < Inflow < 360 kcfs	Target 160,000 cfs 270 kcfs < Inflow < 370 kcfs Target 145,000 cfs 250 kcfs < Inflow < 370 kcfs Target 130,000 cfs 200 kcfs < Inflow < 360 kcfs	Target 160,000 cfs 270 kcfs < Inflow < 370 kcfs Target 145,000 cfs 250 kcfs < Inflow < 370 kcfs Target 130,000 cfs 200 kcfs < Inflow < 360 kcfs
CONDITIONS FOR LIMITATION				
Concurrent operation of Outlet Works and Spillway	60 percent Outlet Opening	60 percent Outlet Opening	60 percent Outlet Opening	60 percent Outlet Opening
Spillway Gate Operation	Controlled	Controlled	Controlled	Controlled
Mitigation to reduce impact to spawning gravels	None	95 percent of Inflow Rule Outflow = 60 percent of actual or forecasted Inflow (25 kcfs < Inflow < 150 kcfs) Disperse with rule if flood encroachment ≥ 20 percent	95 percent of Inflow Rule Outflow = 60 percent of actual or forecasted Inflow (25 kcfs < Inflow < 150 kcfs) Disperse with rule if flood encroachment ≥ 20 percent	95 percent of Inflow Rule Outflow = 60 percent of actual or forecasted Inflow (25 kcfs < Inflow < 150 kcfs) Disperse with rule if flood encroachment ≥ 20 percent
Vortices operation to prevent Formation	None	No Change	No Change	No Change
Spray operation to prevent impacts to powerhouse	None	No Change	No Change	No Change

Key:
@ - at
cfs - cubic feet per second
FEMA - Federal Emergency Management Agency
PMF - probable maximum flood
SAFCA - Sacramento Area Flood Control Agency
STG - submerged-sidetr-gate
TBD - to be determined
kcfs - thousand cubic feet per second
w/o - without
< - less than
≥ - greater than or equal to

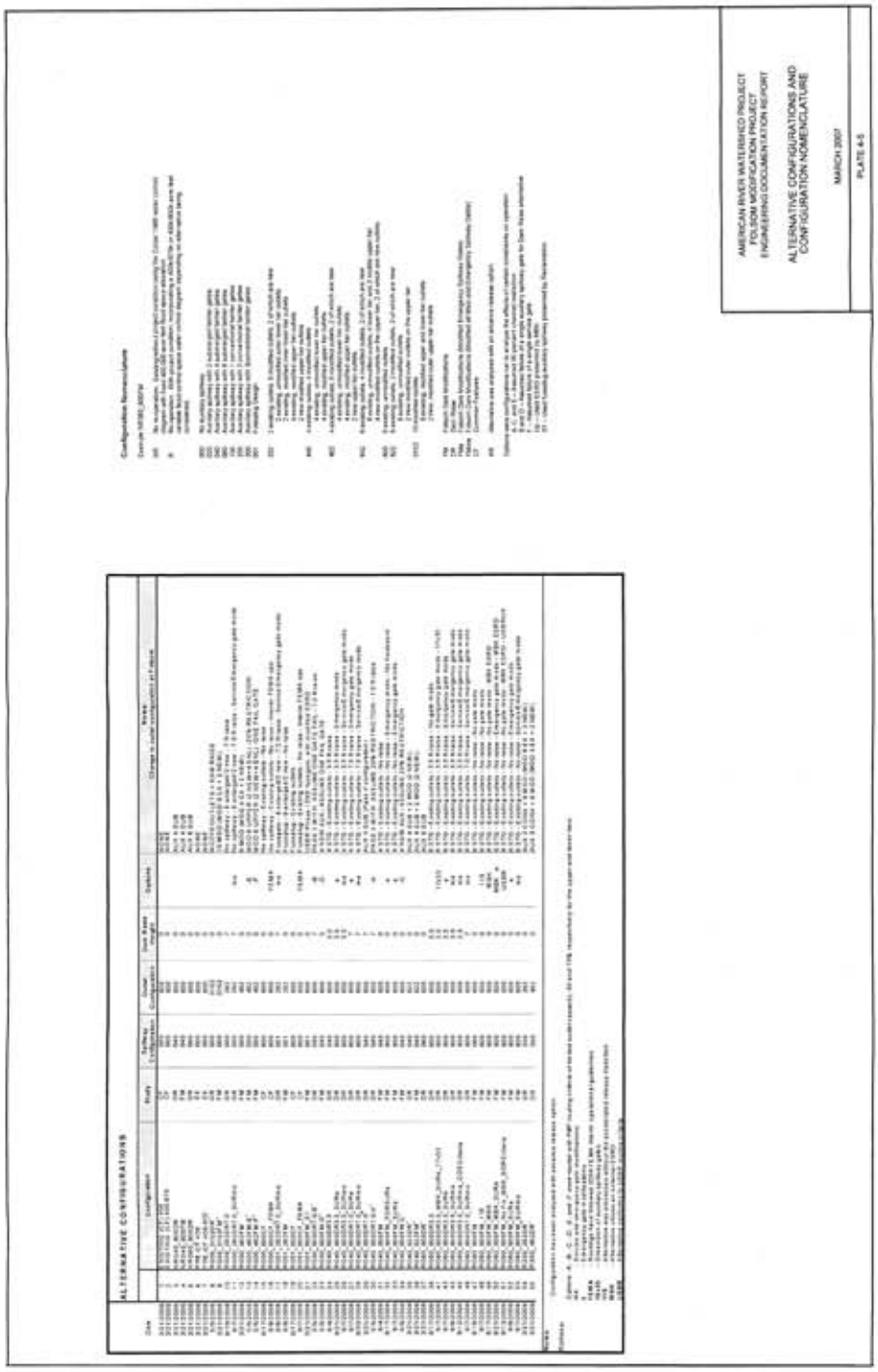
Notes:
1 T-foot dam raise is only associated with the four-STG configuration proposed as part of the Joint Federal Project with project condition.
2 Utilization of emergency gates is limited to discharges greater than 240,000 cfs.
3 Final configuration of the main spillway gates has not yet been determined, this analysis assumes a potential resizing of the gates to 42 feet x 66 feet exists only with a dam raise of 7 feet or higher.

AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT

COMPARISON OF KEY OPERATIONAL DIFFERENCES BETWEEN PROJECTS

MARCH 2007

PLATE 4-4

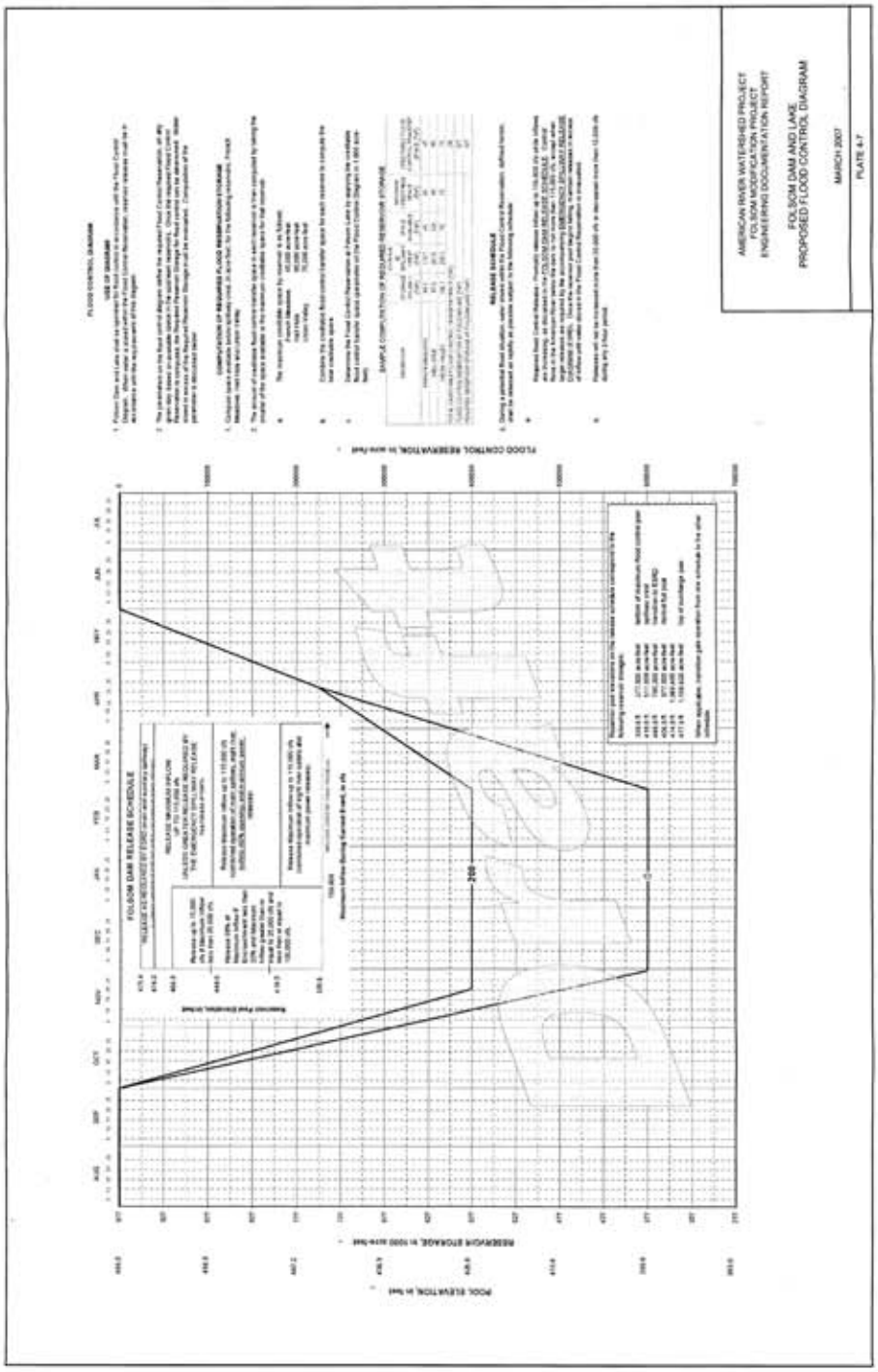

ALTERNATIVE CONFIGURATIONS
Configuration Nomenclature
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
ALTERNATIVE CONFIGURATIONS AND
CONFIGURATION NOMENCLATURE
MARCH 2007
PLATE 4-5

AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT

COMPARISON OF KEY OPERATIONAL DIFFERENCES
(WITH - PROJECT COMPARISONS MADE TO
IMMEDIATELY PRECEDING STUDY)

MARCH 2007

PLATE E-6

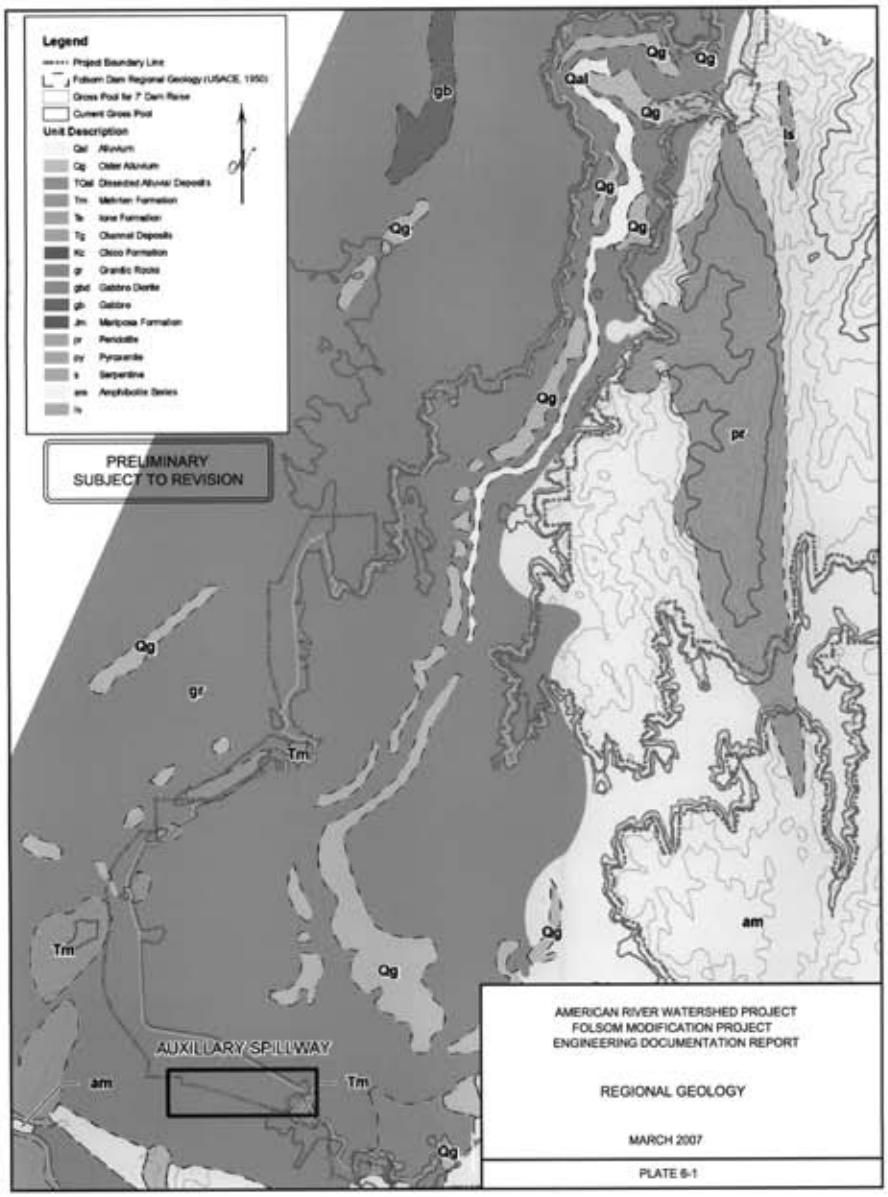


AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT

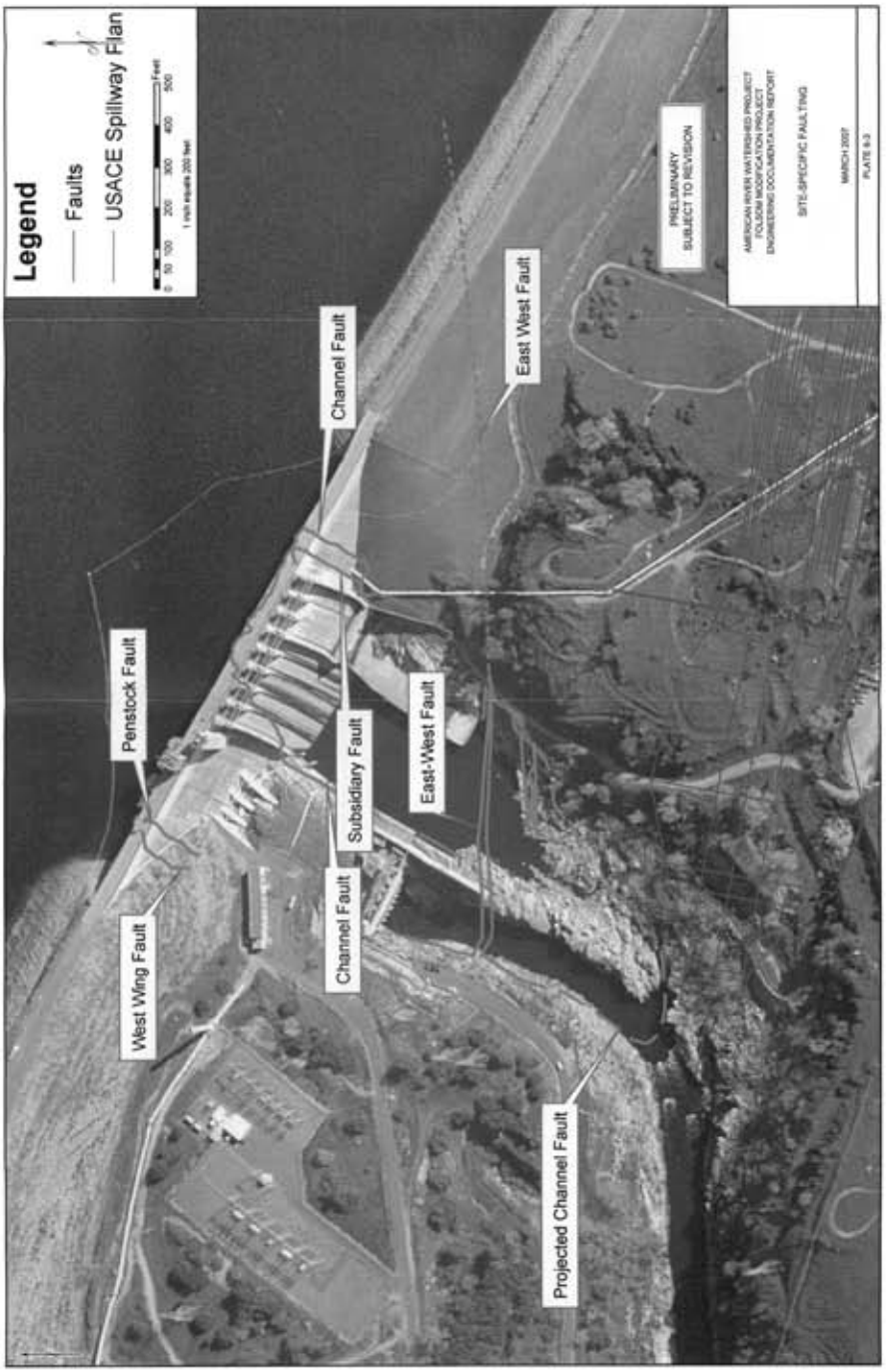
FOLSOM DAM AND LAKE
PROPOSED FLOOD CONTROL DIAGRAM

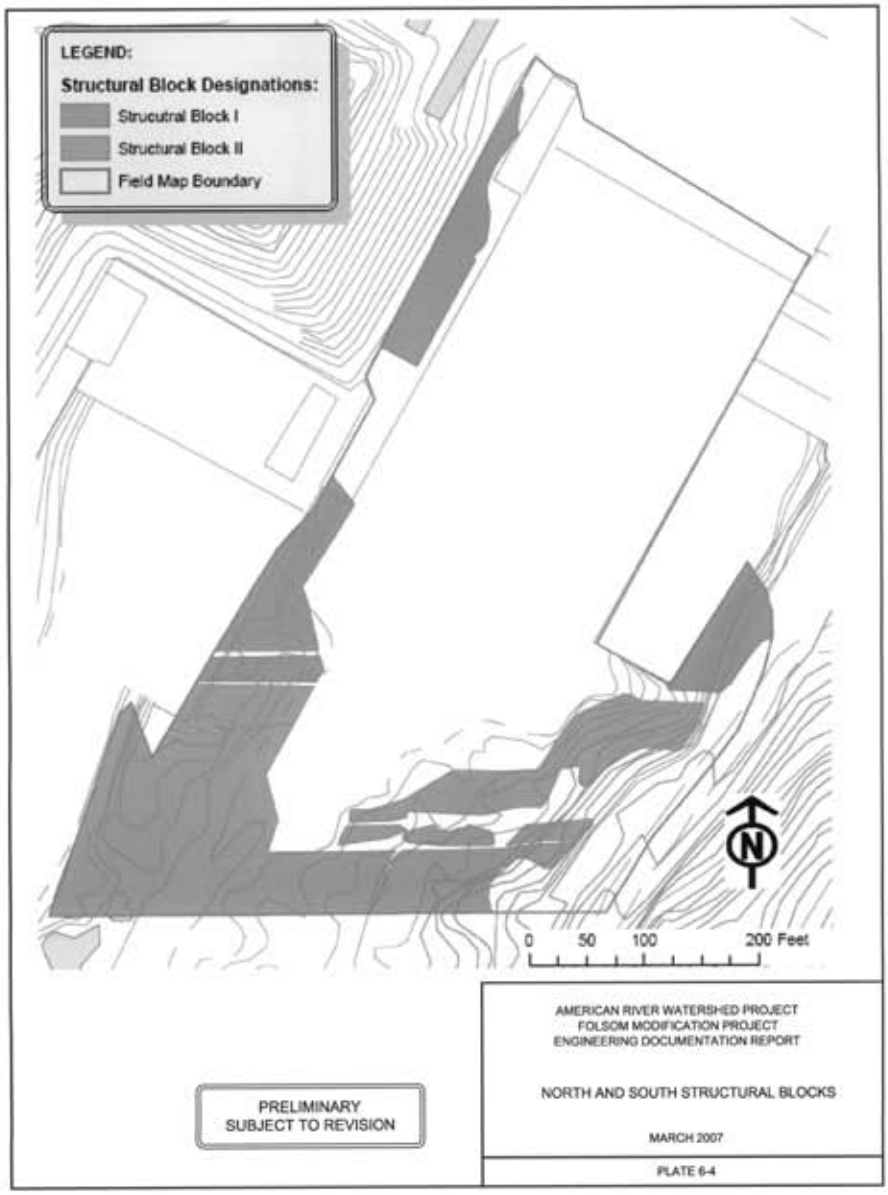
MARCH 2007

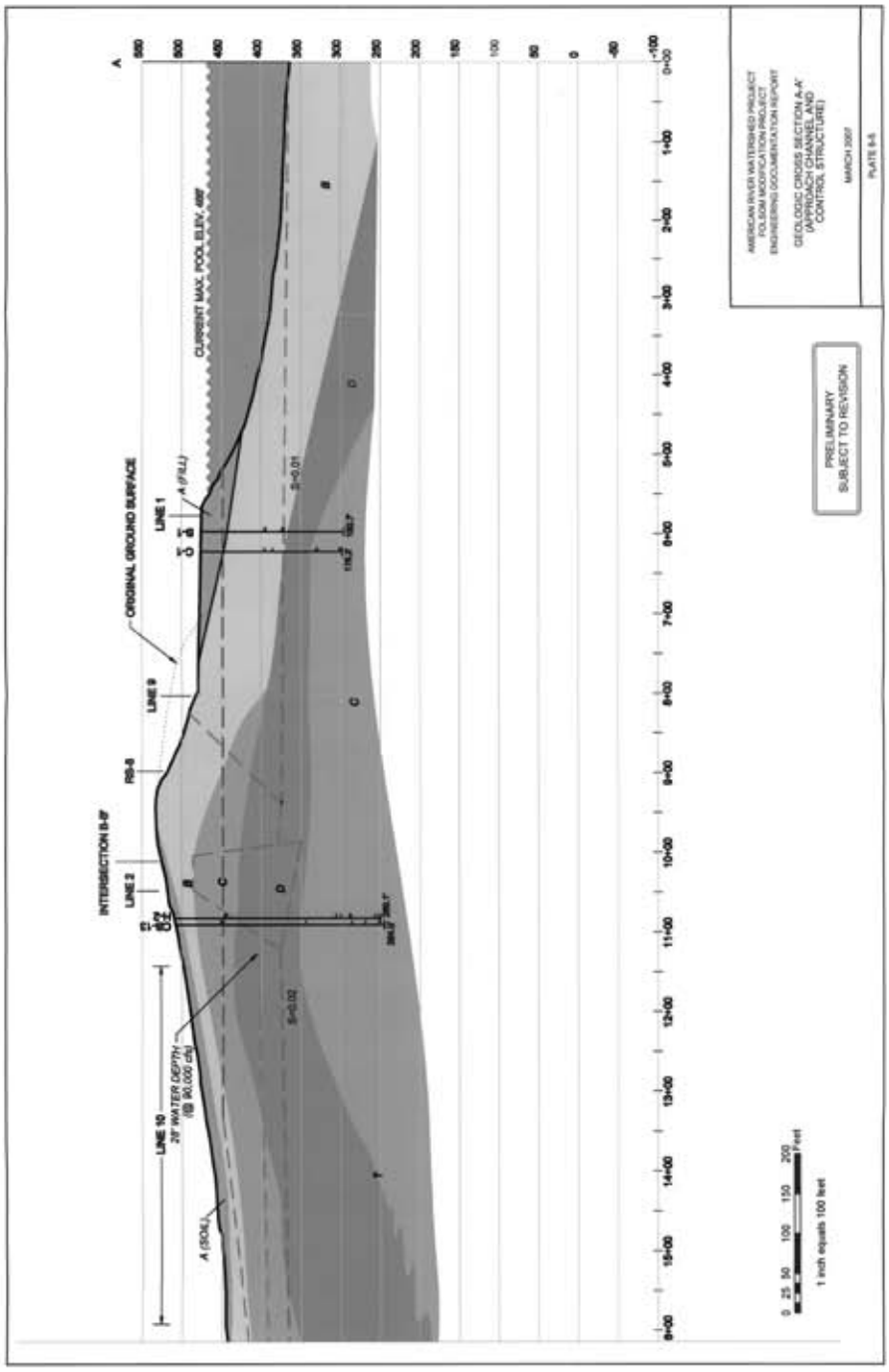
PLATE E-7

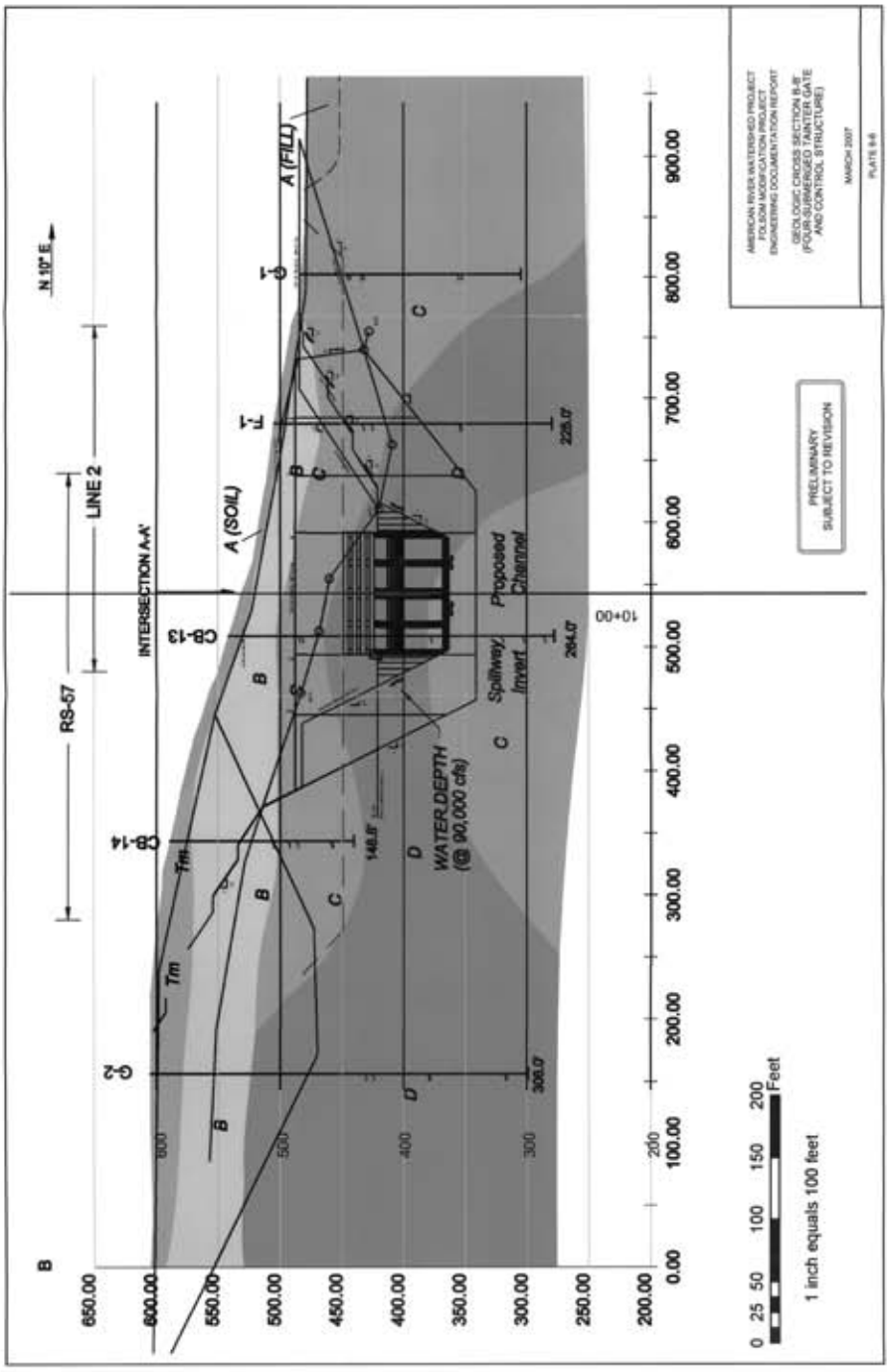

Legend
Project Boundary Line
Folsom Dam Regional Geology (USACE, 1950)
Gross Pool for 7' Dam Raise
Current Gross Pool
Unit Description
Qal Alluvium
Qg Older Alluvium
TQal Dissected Alluvial Deposits
Tm Mehrten Formation
Ta Ione Formation
Tc Channel Deposits
Kc Cleco Formation
gr Granitic Rocks
gbd Gabbro Diorite
gb Gabbro
Jm Mariposa Formation
pr Peridotite
py Pyroxenite
s Serpentine
am Amphibolite Series
ls
PRELIMINARY
SUBJECT TO REVISION
AUXILLARY SPILLWAY
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
REGIONAL GEOLOGY
MARCH 2007
PLATE 6-1

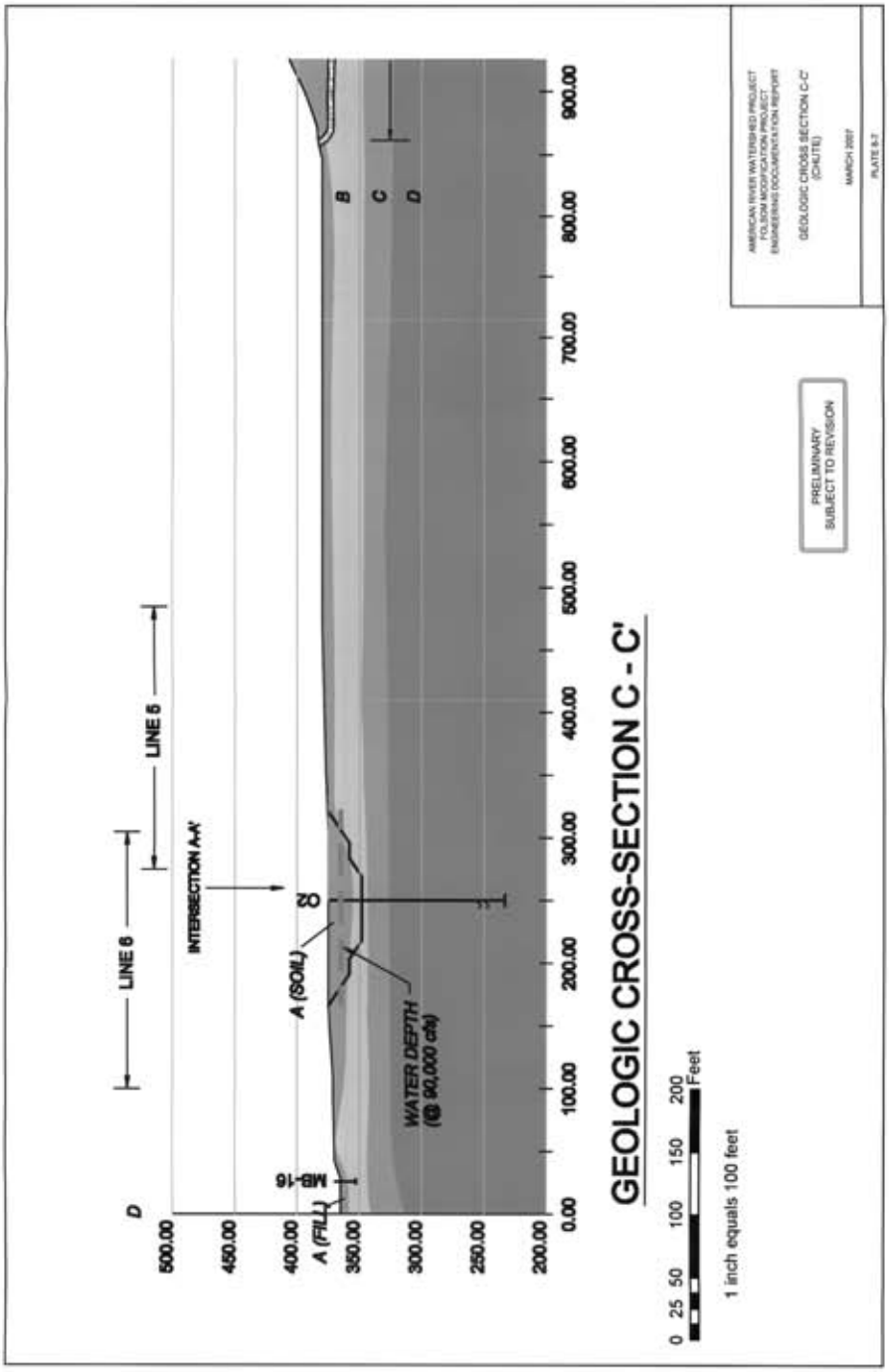

Legend
DH-9 USBR Borings (2005-2006)
C2 USACE Borings (2005-2006)
Phase II Proposed Borings
CS-14 URS Coreholes (2005)
MB-19 URS Hollow/Solid Stem Auger/Borings (2009)
H-84 Horizontal Drill Hole (USACE, 1950)
V-96 Vertical Drill Hole (USACE, 1950)
BF-2 Auger Hole (USACE, 1950)
JF-6 Churn Drill Hole (USACE, 1950)
204 Coreholes (USACE, 1950)
ESTG Plan
Artificial Fill (KleinRieder 2005)
Mehrten Conglomerate (KleinRieder 2005)
Granodiorite Outcrops (KleinRieder 2005)
Folsom Dam Regional Geology (USACE, 1950)
0 500 1,000 Feet
1 inch equals 500 feet
PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATIONS PROJECT
ENGINEERING DOCUMENTATION REPORT
AUXILIARY SPILLWAY GEOLOGY
AND EXPLORATIONS
MARCH 2007
PLATE 6-2

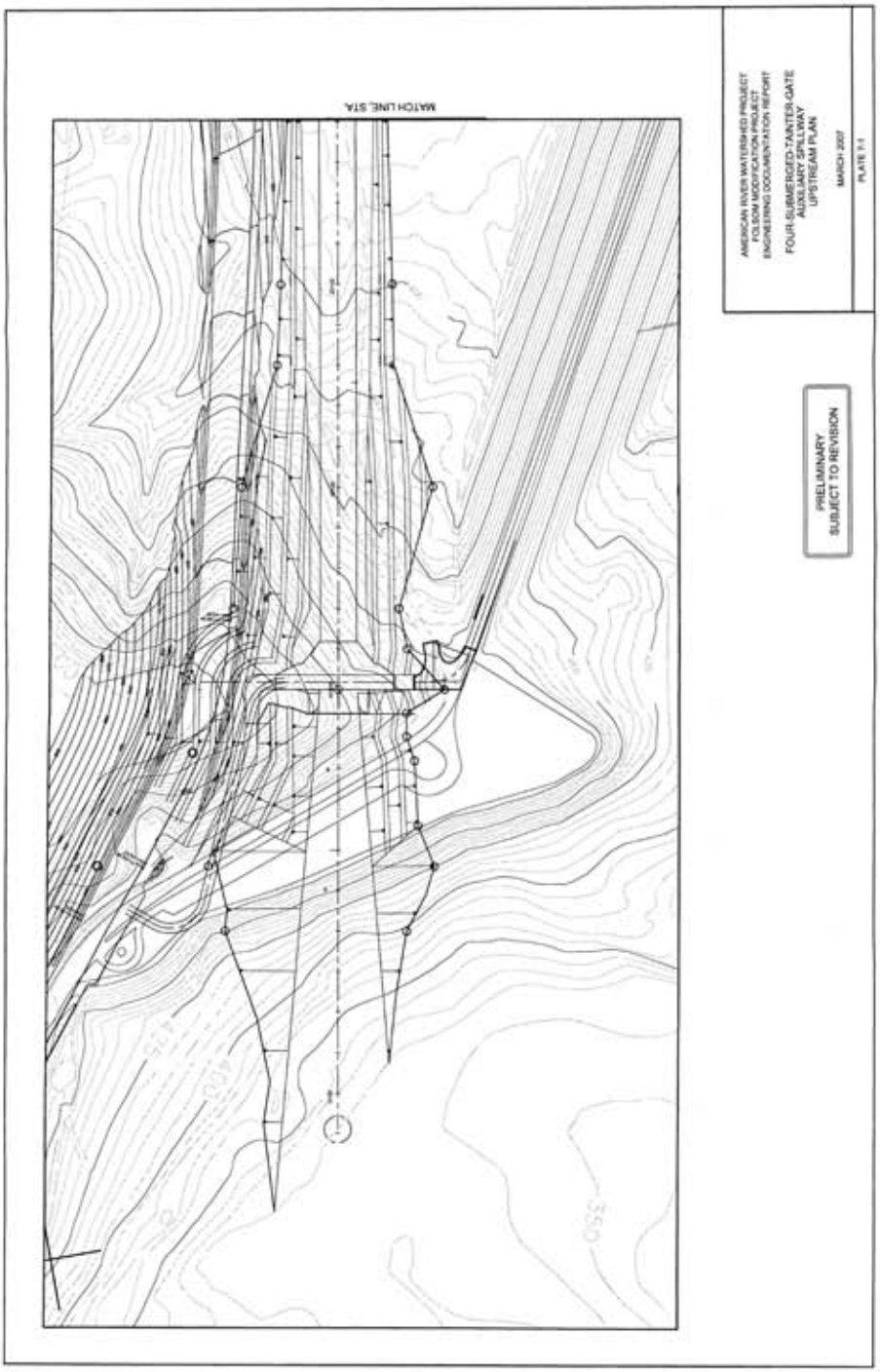

Legend
Faults
USACE Spillway Plan
Penstock Fault
West Wing Fault
Channel Fault
Subsidiary Fault
Channel Fault
East-West Fault
East West Fault
Projected Channel Fault
PRELIMINARY
SUBJECT TO REVISION
SITE-SPECIFIC FAULTING
MARCH 2007
PLATE 6-3

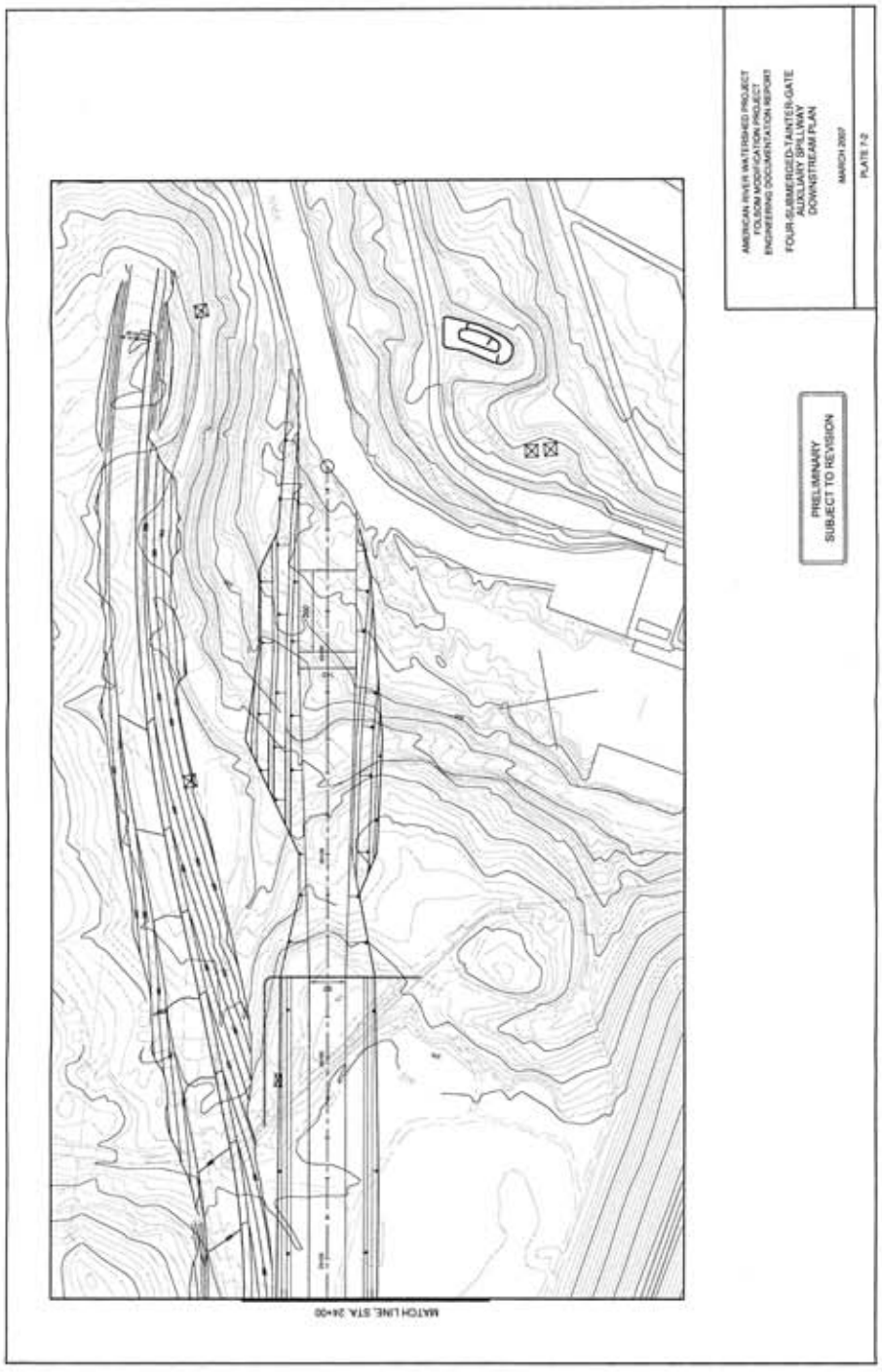

LEGEND:
Structural Block Designations:
Strucutral Block I
Structural Block II
Field Map Boundary
N
0 50 100 200 Feet
PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
NORTH AND SOUTH STRUCTURAL BLOCKS
MARCH 2007
PLATE 6-4

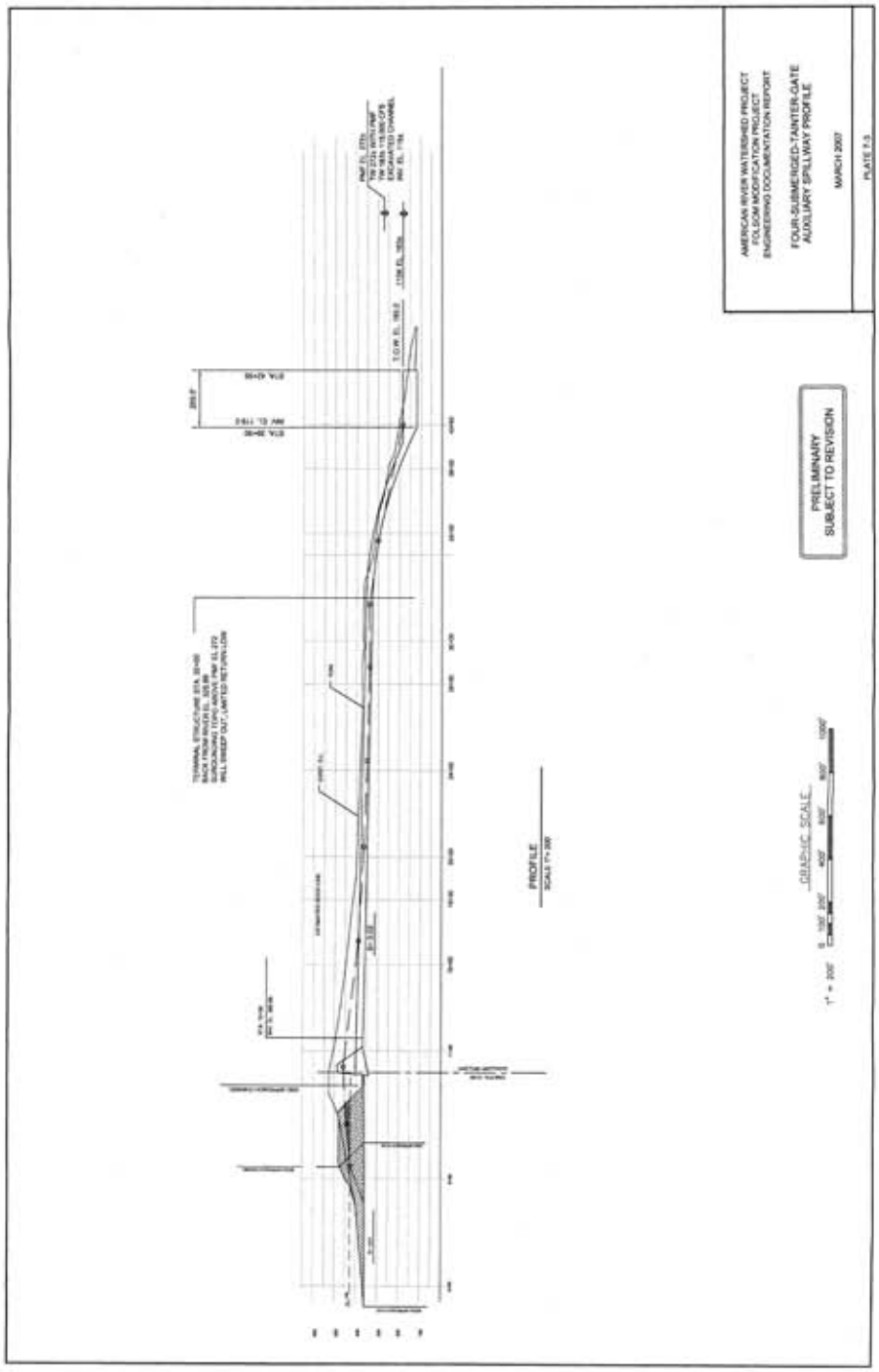

A
A'
ORIGINAL GROUND SURFACE
CURRENT MAX. POOL ELEV. 466'
LINE 1
LINE 2
LINE 9
LINE 10
RS-8
INTERSECTION B-B'
A (FILL)
A (SOIL)
S=0.01
S=0.02
29' WATER DEPTH
(@ 80,000 cfs)
PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
GEOLOGIC CROSS SECTION A-A'
(APPROACH CHANNEL AND
CONTROL STRUCTURE)
MARCH 2007
PLATE B-5
1 inch equals 100 feet
Feet

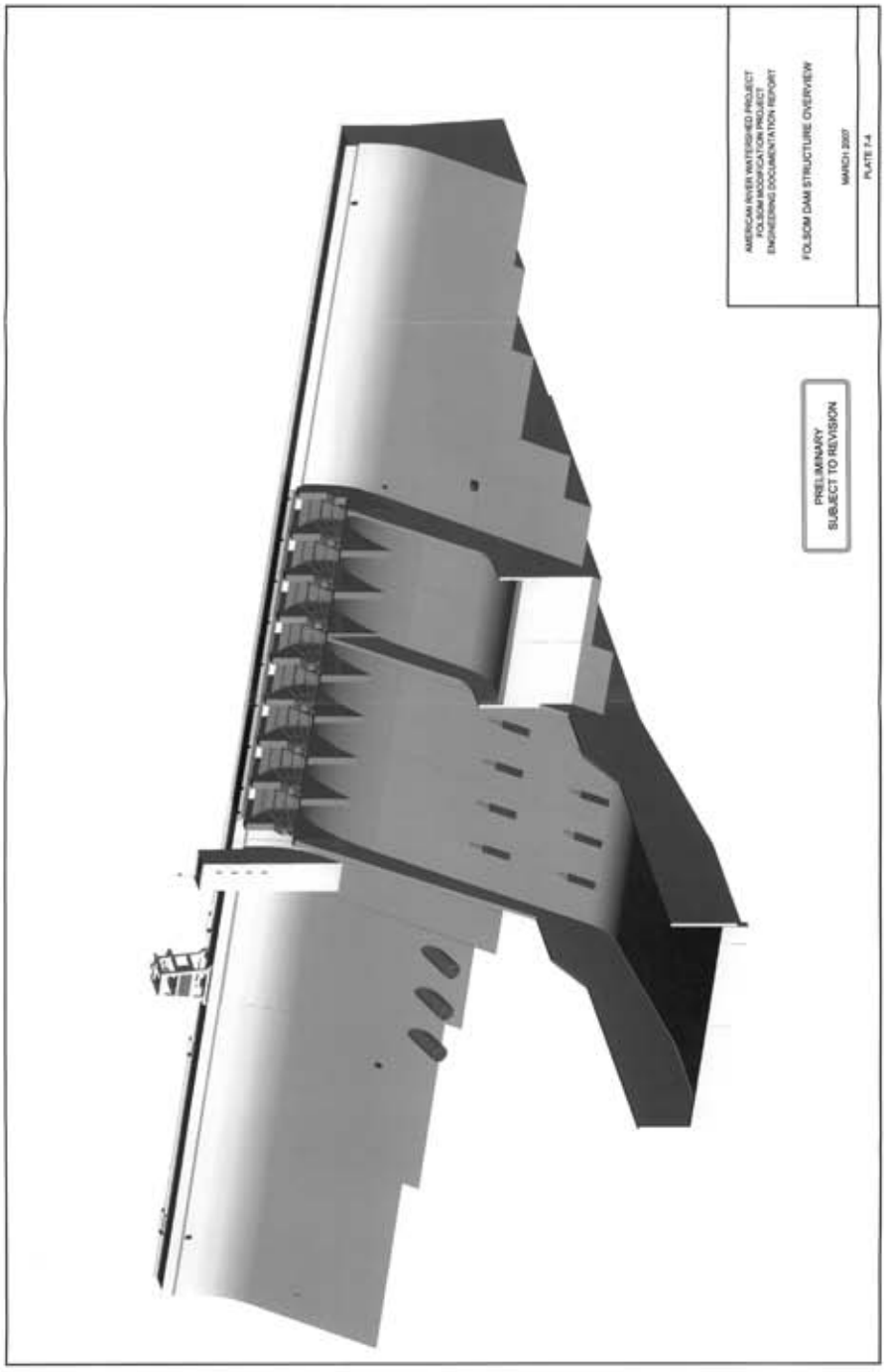

B
650.00
600.00
550.00
500.00
450.00
400.00
350.00
300.00
250.00
200.00
0.00
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
N 10° E
RS-57
LINE 2
INTERSECTION A-A'
CB-13
CB-14
G-2
T-1
A (SOIL)
A (FILL)
Tm
B
C
D
WATER DEPTH
(@ 90,000 cfs)
Spillway
Invert
Proposed
Channel
10+00
264.0'
225.0'
308.0'
140.8'
0 25 50 100 150 200 Feet
1 inch equals 100 feet
PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM SOUTH CANAL UNIT
ENGINEERING DOCUMENTATION REPORT
GEOLOGIC CROSS SECTION B-B'
(FOUR-SUBMERGED TAINTER GATE
AND CONTROL STRUCTURE)
MARCH 2007
PLATE B-8

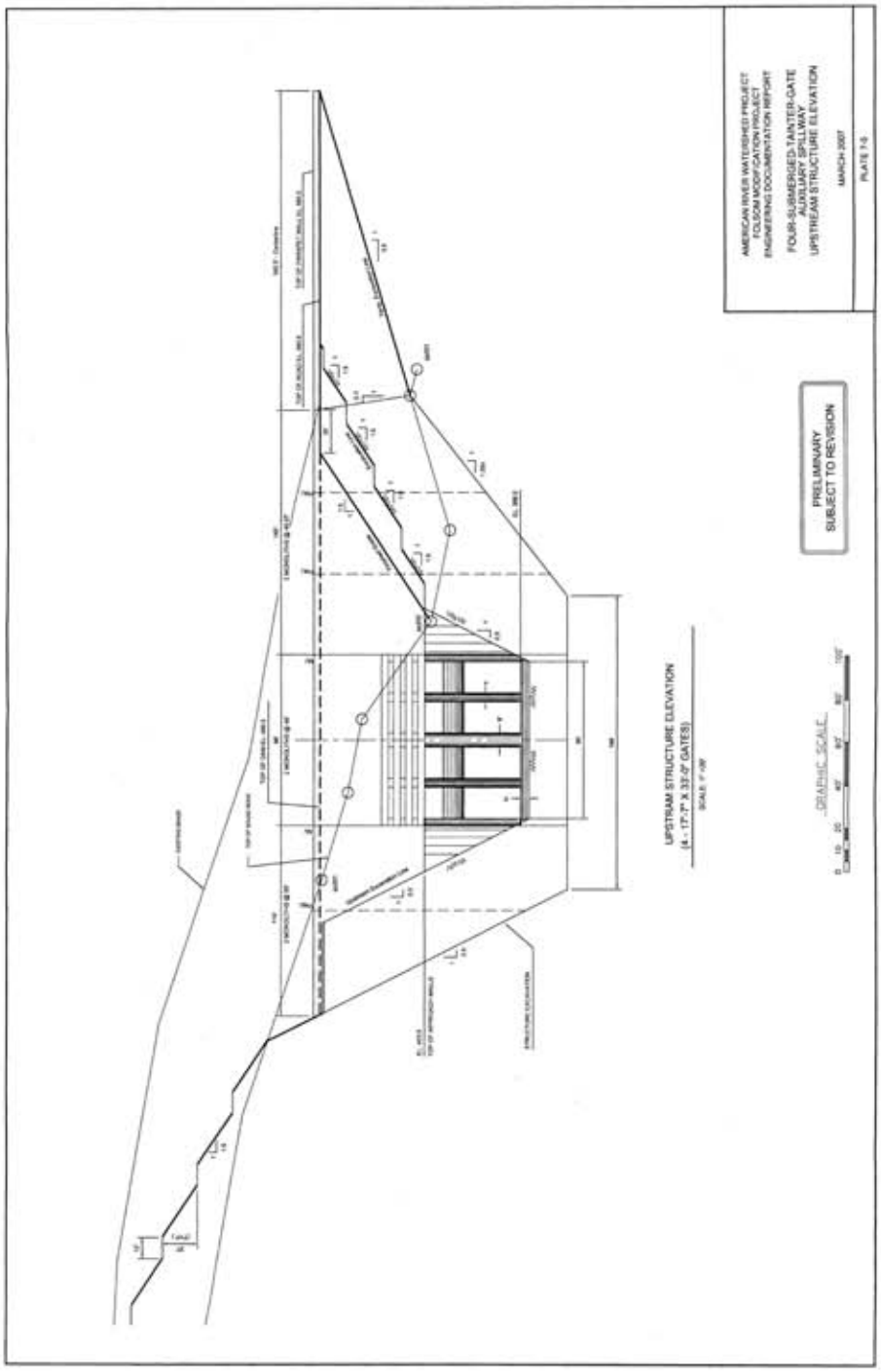

GEOLOGIC CROSS-SECTION C - C'
LINE 6
LINE 6
INTERSECTION A-A'
A (SOIL)
A (FILL)
MB-16
WATER DEPTH
(@ 90,000 cfs)
B
C
D
500.00
450.00
400.00
350.00
300.00
250.00
200.00
0.00
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
0 25 50 100 150 200 Feet
1 inch equals 100 feet
PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
GEOLOGIC CROSS SECTION C-C'
(CAUTE)
MARCH 2007
PLATE B-7

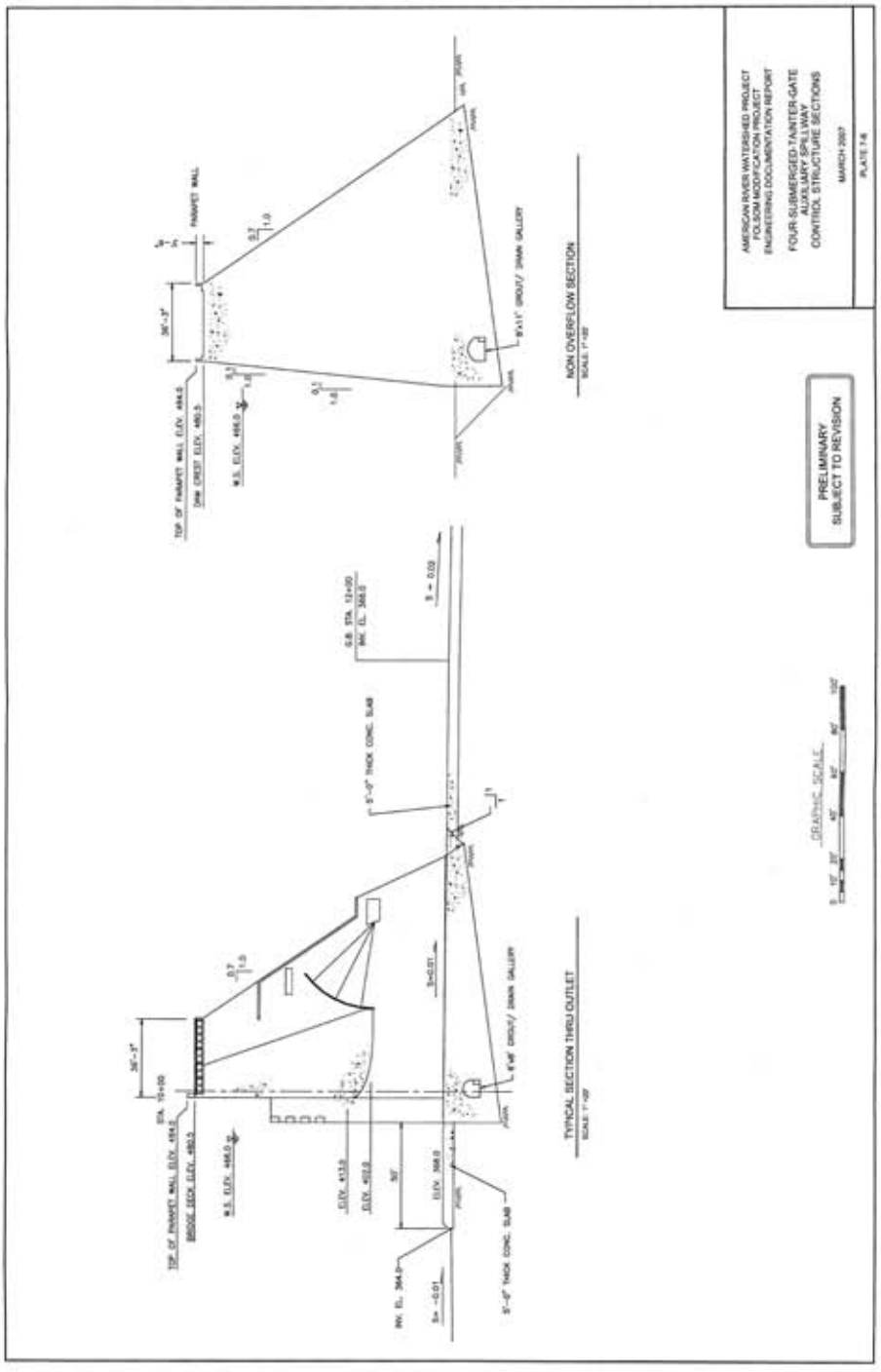

MATCH LINE STA
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
FOUR-SUBMERGED-TAINTER-GATE
AUXILIARY SPILLWAY
UPSTREAM PLAN
MARCH 2007
PLATE 7-1
PRELIMINARY
SUBJECT TO REVISION

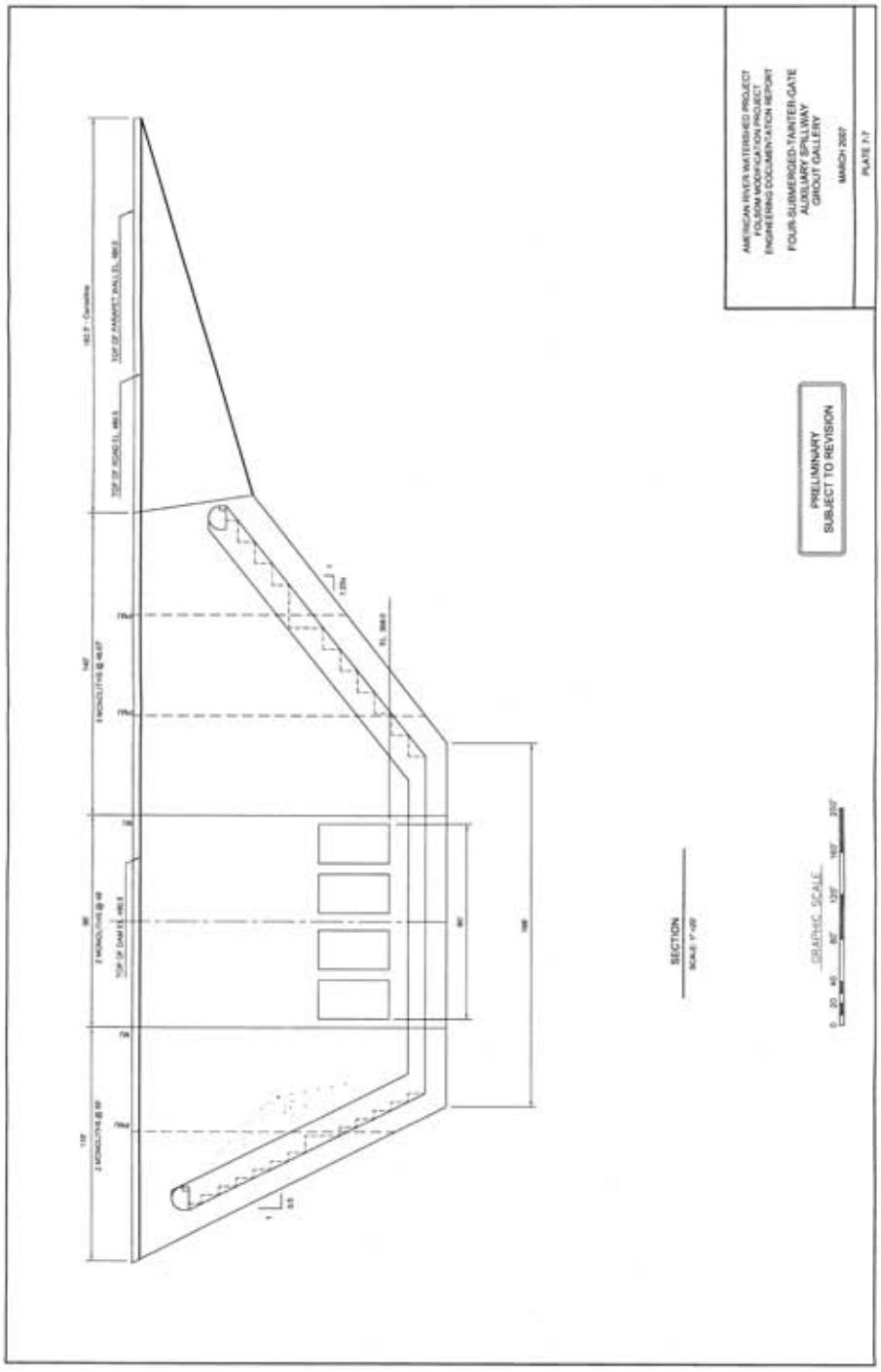

AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
FOUR-SUBMERGED-TAINTER-GATE
AUXILIARY SPILLWAY
DOWNSTREAM PLAN
MARCH 2007
PLATE 7-2
PRELIMINARY
SUBJECT TO REVISION
MATCH LINE STA. 24+00

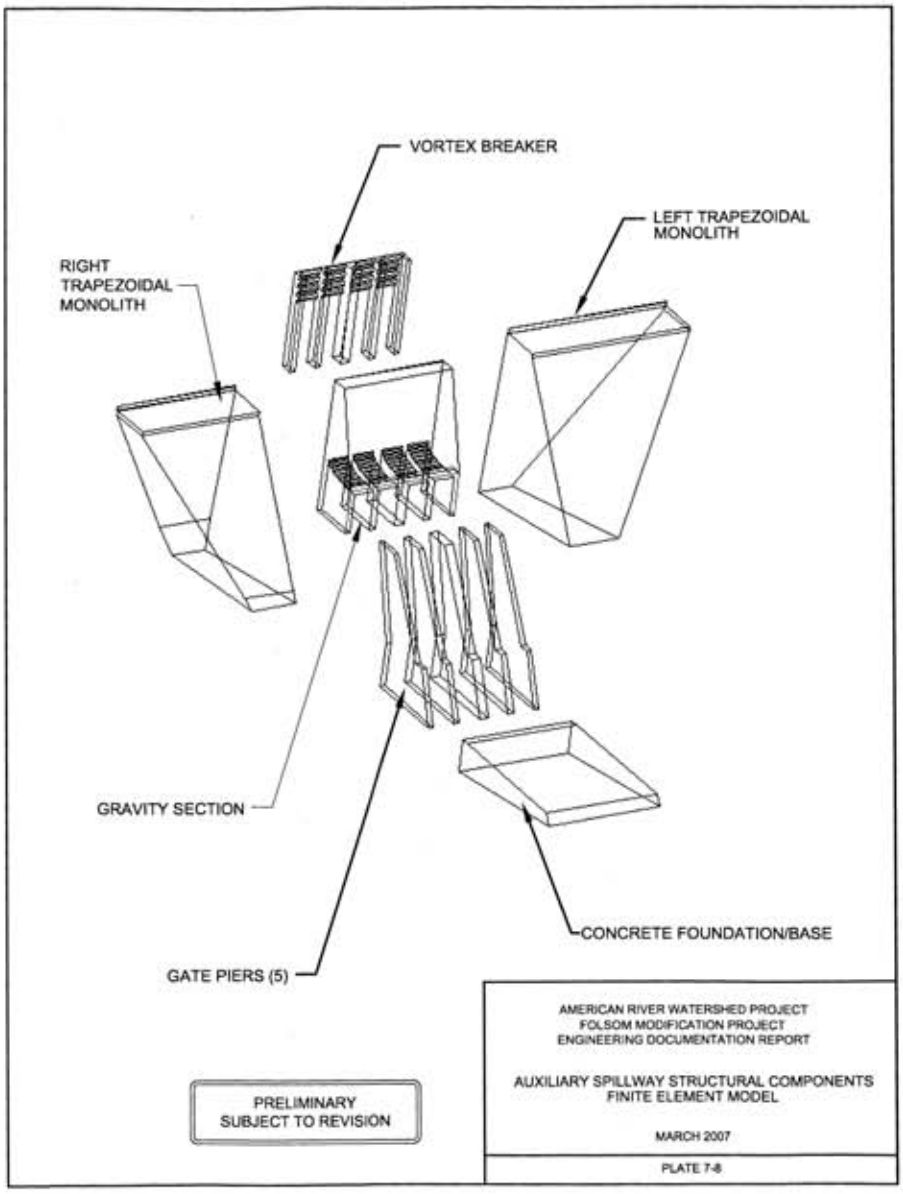

AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
FOUR-SUBMERGED-TAINTER-GATE
AUXILIARY SPILLWAY PROFILE
MARCH 2007
PLATE F-3
PRELIMINARY
SUBJECT TO REVISION
PROFILE
GRAPHIC SCALE

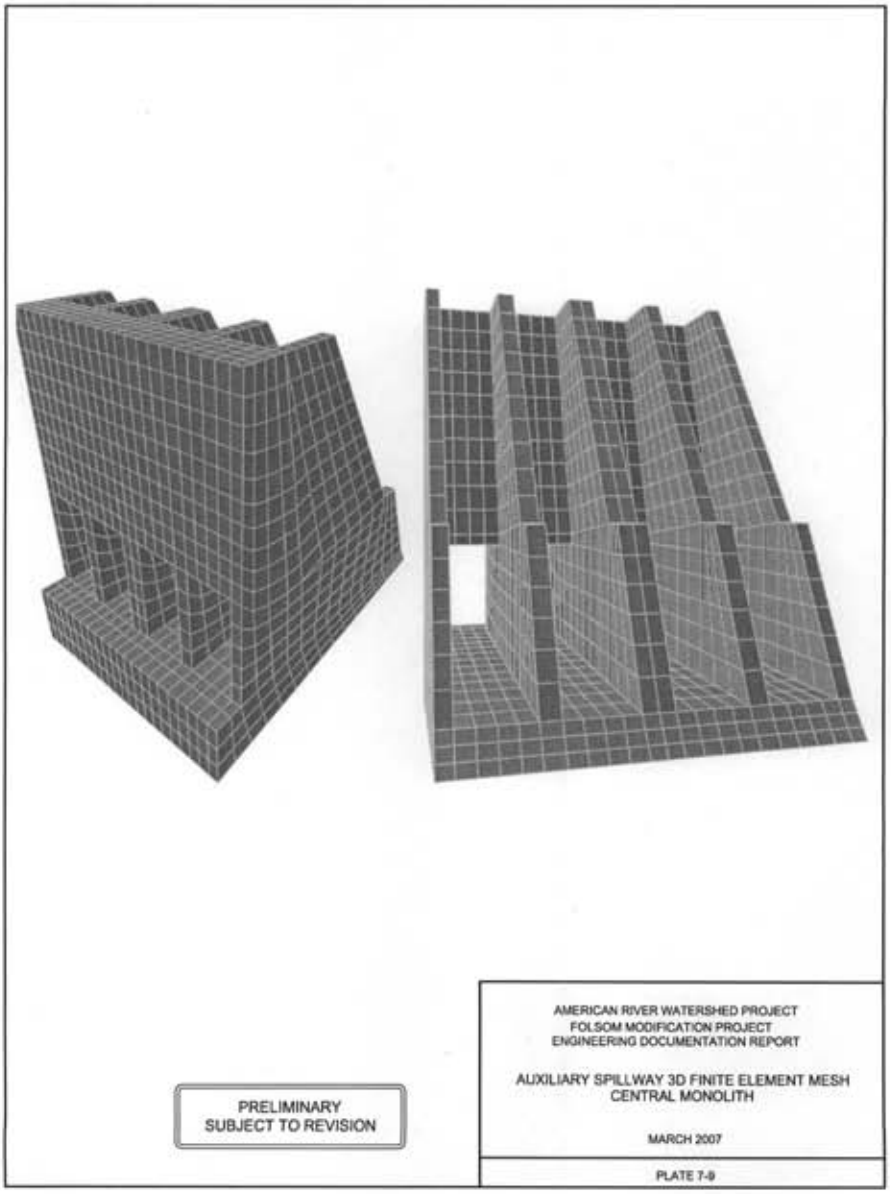

AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
FOLSOM DAM STRUCTURE OVERVIEW
MARCH 2007
PLATE F-4
PRELIMINARY
SUBJECT TO REVISION

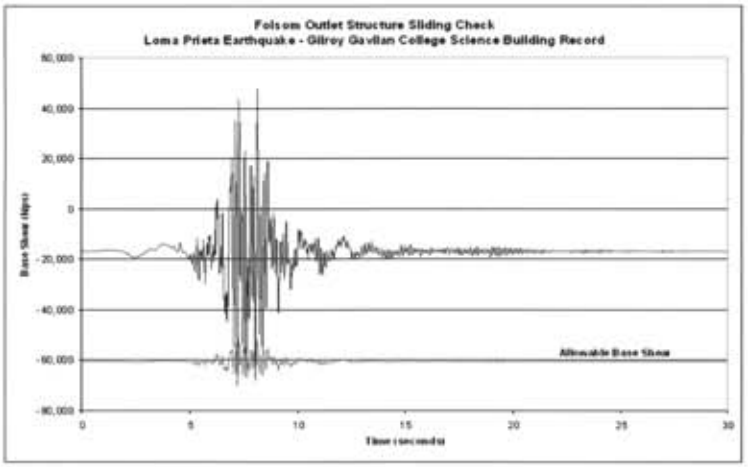

AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
FOUR-SUBMERGED TAINTER-GATE
AUXILIARY SPILLWAY
UPSTREAM STRUCTURE ELEVATION
MARCH 2007
PLATE 7-3
PRELIMINARY
SUBJECT TO REVISION
UPSTRAM STRUCTURE ELEVATION
(4 - 17'-7" X 33'-0" GATES)
GRAPHIC SCALE


AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
FOUR SUBMERGED TAINTER GATE
AUXILIARY SPILLWAY
CONTROL STRUCTURE SECTIONS
MARCH 2007
PLATE 7-6
PRELIMINARY
SUBJECT TO REVISION
NON OVERFLOW SECTION
TYPICAL SECTION THRU OUTLET
GRAPHIC SCALE


AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
FOUR-SUBMERGED-TAINTER-GATE
AUXILIARY SPILLWAY
GROUT GALLERY
MARCH 2007
PLATE 7-7
PRELIMINARY
SUBJECT TO REVISION
SECTION
GRAPHIC SCALE


VORTEX BREAKER
LEFT TRAPEZOIDAL MONOLITH
RIGHT TRAPEZOIDAL MONOLITH
GRAVITY SECTION
GATE PIERS (5)
CONCRETE FOUNDATION/BASE
PRELIMINARY SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
AUXILIARY SPILLWAY STRUCTURAL COMPONENTS FINITE ELEMENT MODEL
MARCH 2007
PLATE 7-8


PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
AUXILIARY SPILLWAY 3D FINITE ELEMENT MESH
CENTRAL MONOLITH
MARCH 2007
PLATE 7-9



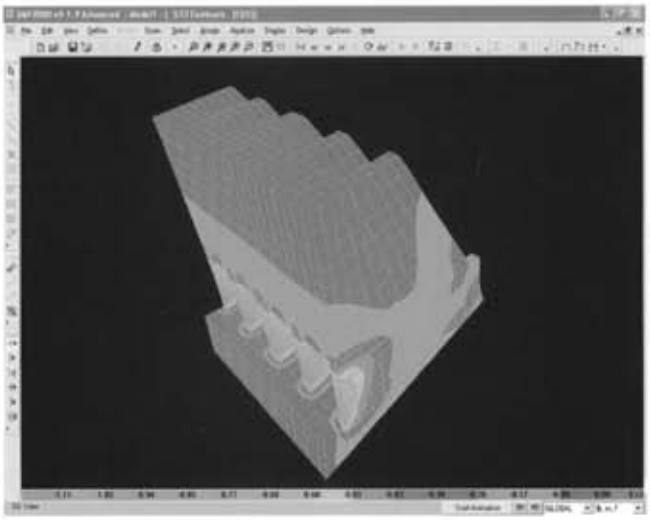
PRELIMINARY
SUBJECT TO REVISION

AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT

AUXILIARY SPILLWAY BASE SHEAR VERSUS ALLOWABLE BASE SHEAR THROUGH TIME INTERVALS FOR LOMA PRIETA EARTHQUAKE ACCELERATION RECORD

MARCH 2007

PLATE 7-10



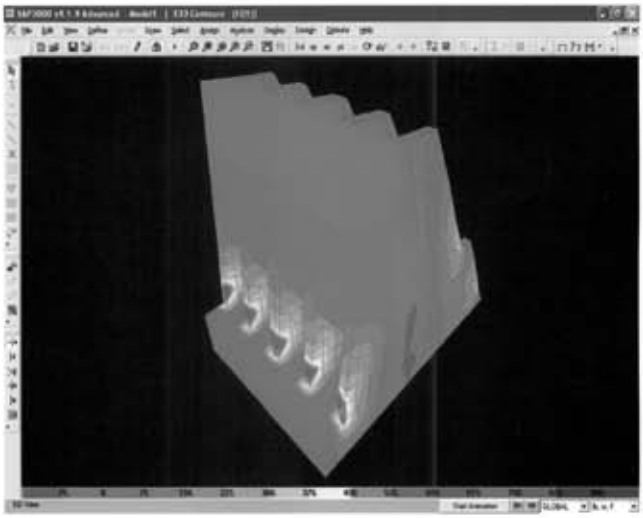
PRELIMINARY
SUBJECT TO REVISION

AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT

MAXIMUM COMPRESSIVE STRESS
FROM LINEAR ELASTIC
MODEL FOR AUXILIARY SPILLWAY

MARCH 2007

PLATE 7-11



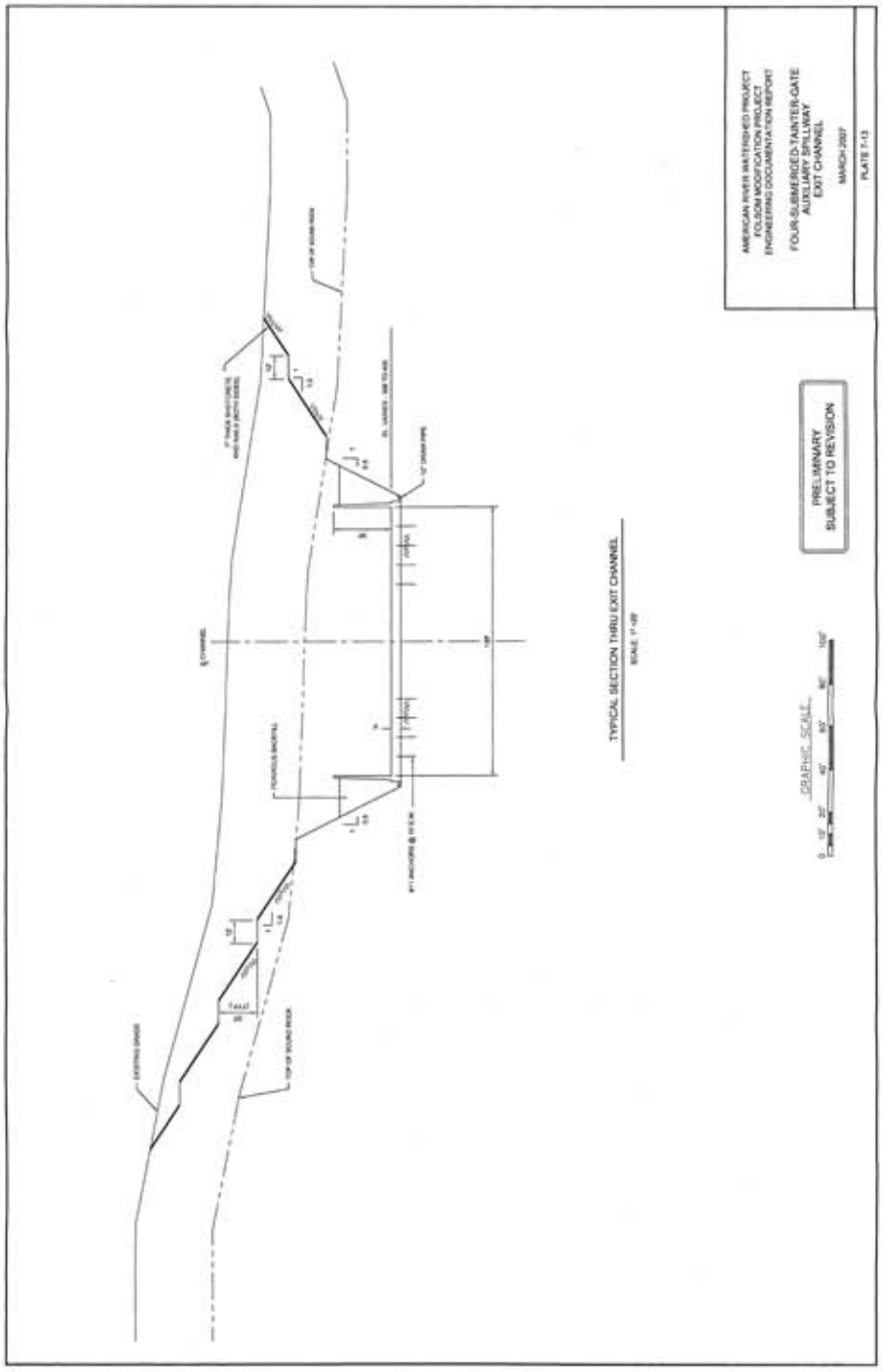
PRELIMINARY
SUBJECT TO REVISION

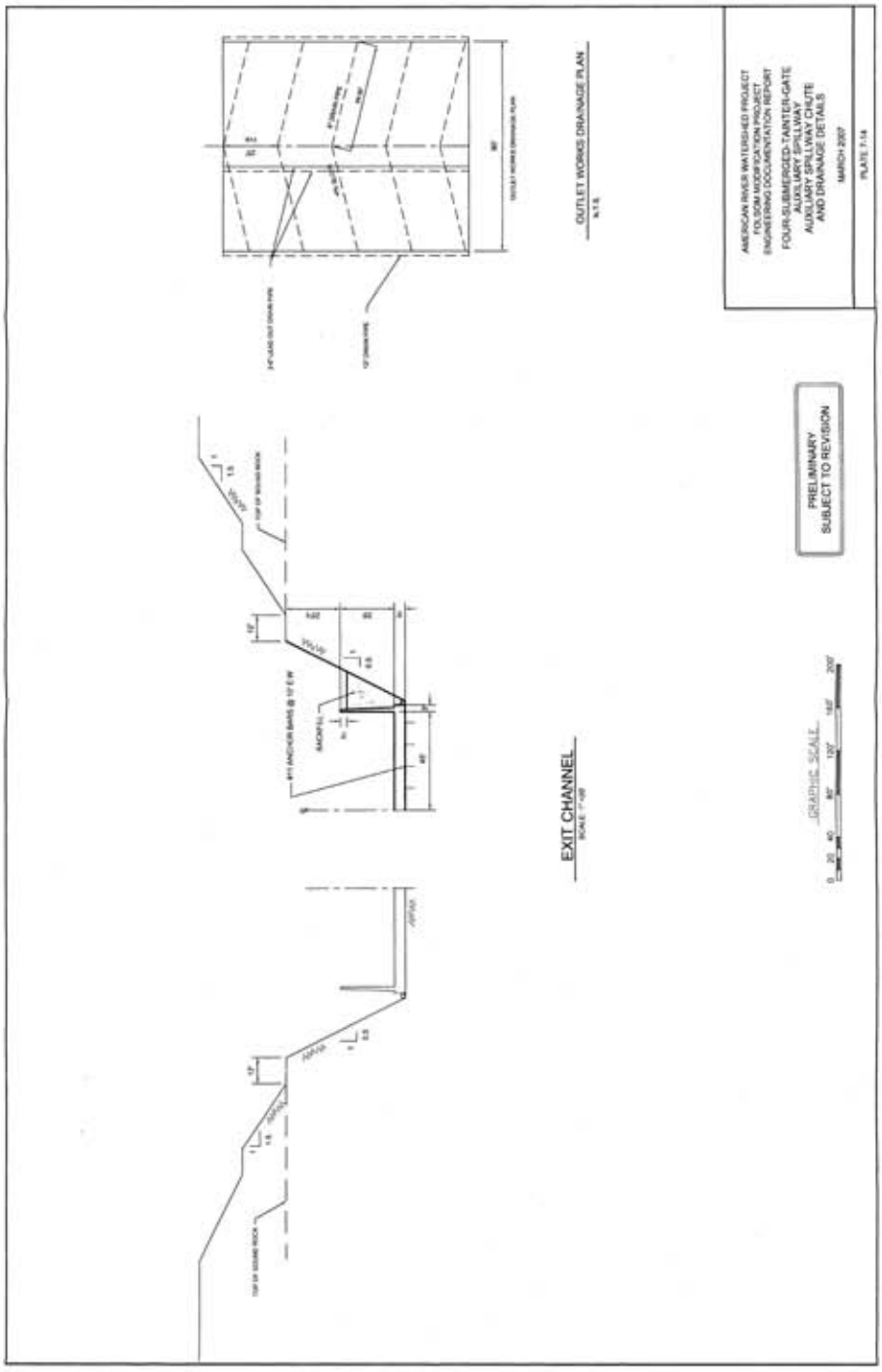
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT

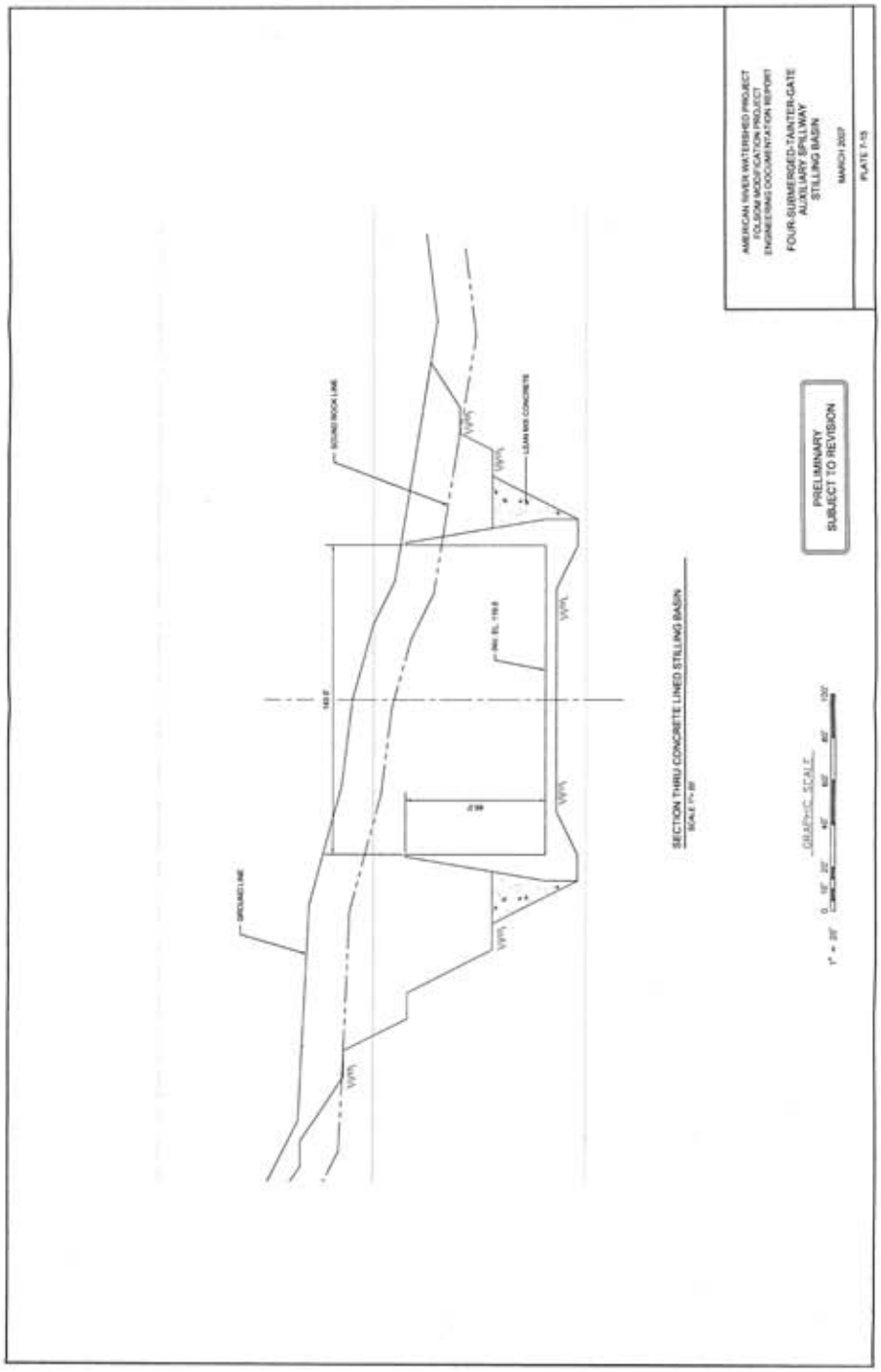
MAXIMUM TENSILE STRESS
FROM LINEAR ELASTIC
MODEL FOR AUXILIARY SPILLWAY

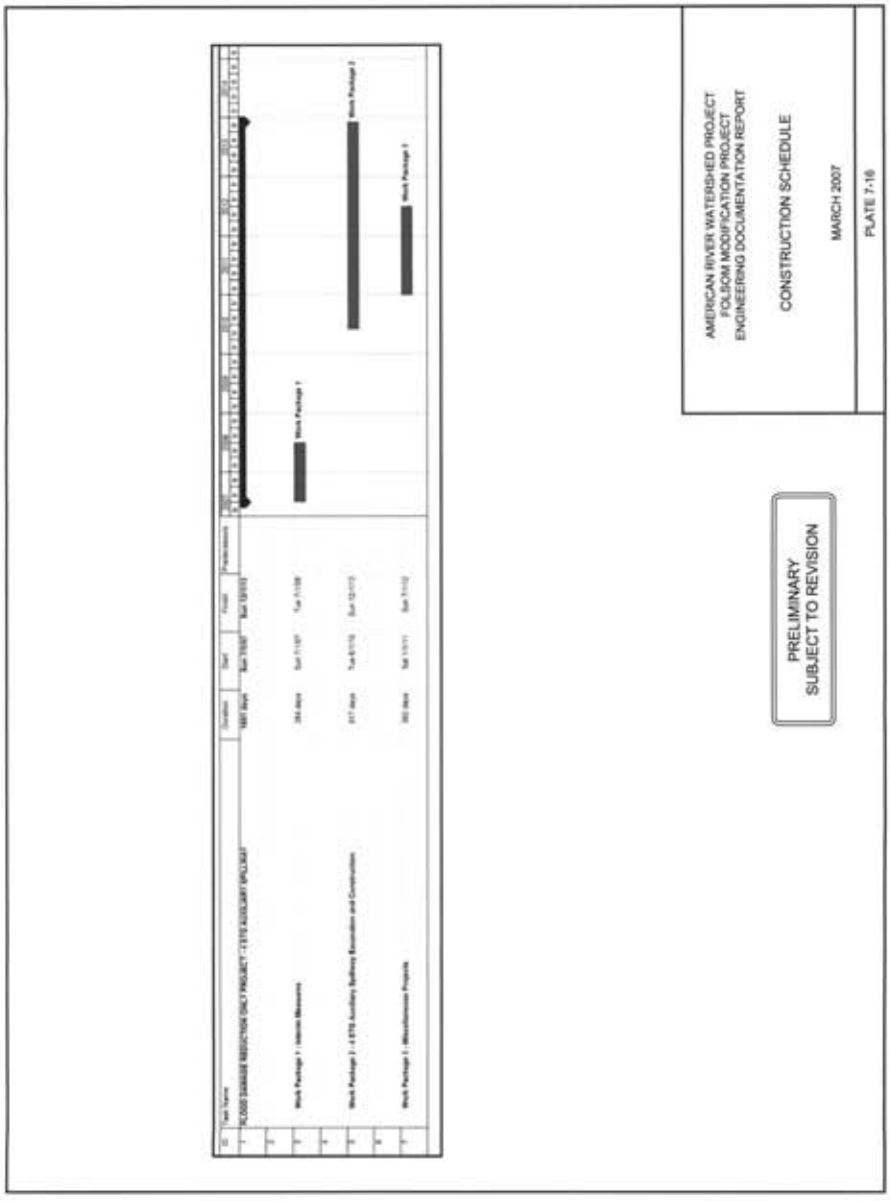
MARCH 2007

PLATE 7-12


AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
FOUR-SUBMERGED-TAINTER-GATE
AUXILIARY SPILLWAY
EXIT CHANNEL
MARCH 2007
PLATE T-13
PRELIMINARY
SUBJECT TO REVISION
TYPICAL SECTION THRU EXIT CHANNEL
GRAPHIC SCALE


AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
FOUR-SUBMERGED-TAINTER-GATE
AUXILIARY SPILLWAY
AUXILIARY SPILLWAY CHUTE
AND DRAINAGE DETAILS
MARCH 2007
PLATE 7-14
OUTLET WORKS DRAINAGE PLAN
N.T.S.
PRELIMINARY
SUBJECT TO REVISION
EXIT CHANNEL
SCALE: 1"=40'
GRAPHIC SCALE
0 20 40 80 120 160 200'


AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
FOUR-SUBMERGED-TAINTER-GATE
AUXILIARY SPILLWAY
STILLING BASIN
MARCH 2007
PLATE T-15
PRELIMINARY
SUBJECT TO REVISION
SECTION THRU CONCRETE LINED STILLING BASIN
GRAPHIC SCALE
1" = 20'
0
10'
20'
40'
60'
80'
100'
GROUND LINE
BOUND ROCK LINE
LEAN MIX CONCRETE
EL. 119.0


PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION PROJECT
ENGINEERING DOCUMENTATION REPORT
CONSTRUCTION SCHEDULE
MARCH 2007
PLATE 7-16

Attachment A1 – PMF Routing Assumtions, Guidelines and Criteria
Folsom Modification Project
Engineering Documentation Report

PMF ROUTING ASSUMPTIONS, GUIDELINES, AND CRITERIA

General Assumptions

- Flood control operation is prescribed by the U.S. Army Corps of Engineers (Corps). Although the current authorized Top of Flood Control Reservation is at reservoir elevation 466, a joint agreement between the U.S. Army Corps of Engineers (Corps) and the U.S. Bureau of Reclamation (Reclamation) had extended flood control operations into the surcharge storage space up to pool elevation 470.
- ***Any changes to the formally allocated flood control space should be documented and requested in writing.***
- Above pool elevation 466, the releases within the surcharge storage space are controlled by the Reclamation.
- The PMF event for Folsom Dam and Lake was developed in 2001 using Hydrometeorological Report (HMR) 59. The hydrograph was developed based on a North Fork storm centering with no upstream failures. LL Anderson Dam is presumed fixed so as to pass its PMF.
- The PMF event is preceded 8-days in advance by an antecedent flood (72-hours of rainfall) immediately followed by the main flood with a peak inflow of 905,770 ft^3/s and a 5-day volume of 3,206,000 acre-feet. The antecedent flood (50 percent PMF hydrograph) was derived using an HEC-1 model. This process required that each sub-area hydrograph ordinate be reduced by half and routed through the upstream reservoirs and reaches down to Folsom.
- Section 101(a)(6) of the Water Resources Development Act (WRDA) 1999 (Public Law 106-53) specifies that the Secretary of the Army and Secretary of the Interior shall coordinate. Upon completion and improvements to Folsom Dam, the variable space allocated to flood control within the reservoir shall be reduced from the current interim operating range of 400-670,000 acre-feet to 400,000-600,000 acre-feet.

Description of Alternatives

- Joint Federal Project
  - No Dam Raise
  - Existing spillway service/emergency gates <u>not</u> replaced.
  - Controlled spillway flows are maintained throughout operation (no free flow operation).
  - Discharges do not exceed 160,000 ft^3/s until the pool elevation rises above the Flood Pool elevation target set by routing the 0.05 probability flood event. Note that the antecedent event for the PMF is roughly equivalent in volume to the 0.05 probability flood event and should be taken into consideration when establishing the flood pool elevation requirement.
- Selected (Joint Federal) Project
  - 3.5 ft Dam Raise
  - Existing <u>emergency</u> spillway gates are replaced **and**/or increased in height.
  - Existing <u>service</u> spillway gates are not replaced.
  - Controlled spillway flows are maintained throughout (no **planned** free flow operation).
  - Discharges do not exceed 160,000 ft^3/s until the pool elevation rises above the Flood Pool elevation target ***at which enhanced flood protection can be provided.***
  - The service spillway gates**, while fully open,** could be overtopped for floods approaching the PMF. The following is as noted in Reclamation's 2004 Folsom Dam Hydrologic Corrective Action Study report: *Although the gates could fail under this condition, any failed gates would likely wash downstream. This is not viewed as a dam safety issue since they would not impede flows through the spillway. Any additional flow generated by failed gates would be relatively small compared to the total flow being discharged.* ***Recent model studies have shown the gates begin to overtop at a reservoir water surface of about 481.0. Given a 3.5 foot dam raise the maximum reservoir water surface should not be greater than 481.0. The BOR notes that if the gates are overtopped it will be by minimal depths.*** **Under different circumstances, a notable gate failure occurred at Folsom Dam on 17 July 1995. A spillway tainter gate broke as it was being raised. This is an example where a failed or malfunctioning gate partially impeded flows because it did not wash downstream.**

PMF ROUTING ASSUMPTIONS, GUIDELINES, AND CRITERIA

Summary of Physical Constraints

- All existing-sized (5' x 9') river outlets retain their 60% gate opening restriction during concurrent spillway gate operation. **Once flows exceed 115,000 cfs, the outlets should not be operated concurrently with the main dam spillway gates under normal flood operations.**
- Any power units that are assumed operating would become non-functional once the tailwater discharge exceeds 250,000 ft^3/s.
- Emergency tainter gate operations can begin once the tailwater discharge reaches 240,000 ft^3/s or water surface is within 1 ft of overtopping closed emergency gates
- **It is physically impossible to open the main dam service spillway gates beyond 457.0 feet. Therefore, it is physically impossible to operate the service spillway gates in "free flow" conditions. Gate tests were performed *on November 15, 2006 to determine the current and maximum spillway gate openings. The gate was reportedly opened to 40 feet (elevation 457) where it contacted the first limit switch. Operators at the dam believe the gates can be easily modified to be opened to the full opening height of 459.0. Reclamation prefers that orifice flow be maintained.* The final design of the new emergency tainter gates will determine how high they can be opened.**
- The safe long-term channel capacity of the downstream levees was assumed to be 160,000 ft^3/s.

Operation Criteria

- The freeboard requirement is set at 3 ft per Reclamation (Denver).
- No power units are available for use in the routings per Reclamation (Folsom). All power units are off-line.
- Releases from Folsom Dam must **not** be greater than the flows produced without the project in place.
- The dam was assumed to be releasing a minimum 2,000 ft^3/s at the start of the routing.
- Two methods are available for routing the PMF:
    - 1) use an antecedent flood starting routed at the bottom of the flood control pool. (The initial reservoir water surface was assumed to be at elevation 399.63). This established the initial starting conditions for the PMF (around pool elevation El 401) or
    - 2) route the PMF alone starting at normal full pool (466 ft). The second option is appropriate for projects with limited release capabilities.
- All routings reflect the first method which provides 600,000 acre-feet of Flood Control Reservation (also referred to as Flood Control Space) between the initial water surface and the top of joint use at elevation 466
- The PMF event was routed assuming a 4-hour delay in determining outflows until the releases reached 115,000 ft^3/s. This simulates initial delays in computing inflow, scheduling/performing gate changes, solving mechanical problems, or delays in staffing the facility. Once releases reached 115,000 ft^3/s outflows were adjusted based on 1-hour intervals until reaching the top of the surcharge storage space.
- Discharge must **not** exceed 160,000 ft^3/s while the water surface elevation is less than the storage space elevation, ***which provides the desired level of flood protection***.
- The downstream levees were assumed to remain intact throughout the antecedent event.

PMF ROUTING ASSUMPTIONS, GUIDELINES, AND CRITERIA

Operation Criteria (continued)

- Ramp up Rate Limitations.

Discharge is less than or equal to 20,000 ft^3/s	no more than 10,000 ft^3/s during any 2-hour period
Discharge is less than or equal to 160,000 ft^3/s	no more than 30,000 ft^3/s during any 2-hour period
Discharge is greater than or equal to 160,000 ft^3/s	***no more than 100,000 ft^3/s during any 1-hour period for discharges below 360,000 ft^3/s.***

Ramp down Rate Limitation:

Outflow is less than or equal to 115,000 ft^3/s	no more than 10,000 ft^3/s during any 2-hour period.
Outflow is greater than 115,000 ft^3/s	Lesser of maximum peak release or 125 percent of inflow while pool elevation greater than 448 feet.

- Above storage elevation (468 for the JFP routing) at which the desired level of flood protection is reached.~***Discharge should be increased by no more than 100,000 ft^3/s during any 1-hour period for discharges below 360,000 ft^3/s.*** (Note that the antecedent event for the PMF is roughly equivalent in volume to the 0.05 probability flood event and should be taken into consideration when establishing the flood pool elevation requirement. The maximum pool elevation for the antecedent event is slightly higher than the 0.05 probability flood event.)
- ***For discharges greater than 360,000 ft^3/s*** releases are limited to inflow.
- ***Discharge should be increased by no more than 100,000 ft^3/s during any 1-hour period for discharges below 360,000 ft^3/s. See above.***
- Releases cannot exceed discharge capacity.
- A ramp-down rate of 10,000 ft^3/s in one hour and no ramp down the next hour is considered acceptable
- The Accelerated Transition rule maximizes use of the downstream capacity. Releases were increased from 115,000 ft^3/s to 160,000 ft^3/s as soon as the requirements of the accelerated transition zone were met. The requirements of the accelerated transition zone are as follows. Releases may be increased from 115,000 ft^3/s to 130,000 ft^3/s when the current inflow is greater than 200,000 ft^3/s and the 12-hour forecasted inflow is greater than 360,000 ft^3/s. Releases may be increased from 130,000 ft^3/s to 145,000 ft^3/s when the current inflow is greater than 250,000 ft^3/s and the 12-hour forecasted inflow is greater than 370,000 ft^3/s. Releases may be increased from 145,000 ft^3/s to 160,000 ft^3/s when the current inflow is greater than 270,000 ft^3/s and the 12-hour forecasted inflow is greater than 370,000 ft^3/s. The requirement to limit the ramp-up rate to 15,000 ft^3/s per hour or no more than 30,000 ft^3/s during any 2-hour period still applies. Ramping rate requirements still apply.
- Fish and Wildlife Service Mitigation Rule. For inflows greater than or equal to 25,000 ft^3/s, less than or equal to 150,000 ft^3/s, limit the release to 60 percent of previous hour inflow. Discontinue this rule once the 12-hour forecast exceeds 150,000 ft^3/s or the reservoir rises above elevation 416.15 (20 percent encroachment).
- For a falling reservoir below elevation 448, releases were computed using an USACE drawdown algorithm which attempts to evacuate the Flood Control Reservation plus inflow in 1 day for each iteration while at the same time reduce the releases from 115,000 ft^3/s in 5,000 ft^3/s increments. The drawdown algorithm succeeds in evacuating most of the Flood Control Reservation below elevation 448 in a little more than 3 days.
- For a falling reservoir with releases at or below 15,000 ft^3/s, the ramp-down rate was limited to 1,000 ft^3/s per hour as defined in the USACE drawdown algorithm.

Attachment A2 - Hydraulic Design
Folsom Modification Project
Engineering Documentation Report

7-1.1 GENERAL INTRODUCTION

This attachment describes variables that determine the capability of the Folsom Modification Project alternatives to manage floods and to safely pass the accepted probable maximum flood (PMF) for Folsom Dam. It addresses the existing dam's deficiency in flood damage reduction capability, the dam safety inadequacies, and discusses alternative solutions. The dam (as it currently exists) has two major problems. These are flood control and dam safety. The existing spillway and outlet works cannot pass the PMF without overtopping the Dam. Also, the amount of flood damage reduction storage in the lake is insufficient and the existing sluices through the dam are not large enough to pass significant flood flows during the early part of large floods. The existing sluices can only release a maximum of 24,800 cubic feet per second (cfs) at the spillway crest elevation 418.0. The downstream channel has an objective or target flood release of 115,000 cfs and releases above 115,000 cfs must be made only during very large floods for dam safety purposes. Large flood flows can only be passed with the existing spillway tainter gates and therefore, a significant amount of flood damage reduction space must be filled with water before objective downstream release flows can be attained. The design alternatives investigated and described herein increase the flood control capability of Folsom Dam by increasing the outflow capacity at lower lake levels, resulting in reduced maximum flood pool elevations when large storms occur and proper reservoir operations are followed. Studies described below determine the (with and without) project's capability to discharge flows (outflow capacity) and dissipate energy from high-velocity flows before they enter the American River channel. Possible impacts to downstream water surface elevations, channel capacity stability and definition of the floodplain are briefly described. Ongoing studies and future analysis during the next phase of design are required to fully define the design requirements.

7-1.2 PROJECT DESCRIPTION/HISTORICAL RECORD OF HYDRAULIC DESIGN

7-1.2.1 Previous Studies

The following studies previously performed are relative to the Folsom Modification project:

- Original Design of Folsom Dam, by the Corps of Engineers
- Original Design of Oroville Dam, by the USBR
- Recommended Flood Operations for Folsom Dam, TM FD-8130-FD-TM-97-3, September 1997 by the USBR
- Long-Term Study, by the Corps of Engineers
- Folsom Dam Modifications Project – DDR (original draft for outlet works with 10 outlets and most recent draft for six 9'-4" x 14' upper tier outlets) and the project Design Plans and Specifications for the Upper Tier Conduits, by the Corps of Engineers

- PASS II Study, by the Corps of Engineers, USBR, and SAFCA (Sacramento Area Flood Control Agency)

7-1.2.2 Project Objectives – Relative to Hydraulic Design

The main objectives of the Folsom Modification project are to ensure that:

- Hydraulic performance is acceptable.
- The auxiliary spillway and the stilling basin(s) function satisfactorily at design flows and at higher flows without excessive damage.
- Combined releases from the service spillway, auxiliary spillway (alternative scenarios described herein), and the emergency spillway can be made without complex operational constraints.

7-1.2.3 Overview of Alternatives

The "With-Out Project Condition" includes construction of the Common Features project for the lower American River. Folsom Dam currently has three methods of discharging flows from the reservoir: three power penstocks, eight flood control outlets (four upper tier and four lower tier, all 5 ft x 9 ft), and eight tainter/radial spillway gates set near the spillway crest (five service and three emergency). To insure adequate tailwater for releases from the three emergency spillway gates, they should not be used unless the total outflow from the dam exceeds 300,000 cfs. This condition can only be achieved by free-flow through the service spillway due to the top elevation of the emergency spillway gates. To maintain controlled release by the gates, the emergency gates must be opened at a total outflow of about 240,000 cfs, For this extreme condition where flooding has already occurred downstream due to channel capacity (levees will be overtopped and/or breached), damage caused by operating the emergency spillway gates at less than 300,000 cfs must be considered acceptable. Because of the restriction on use of the emergency gates they are unusable for normal flood control purposes and use of the gates is limited to dam safety outflows. The current spillway capacity is insufficient to pass the probable maximum flood (PMF), and therefore an auxiliary spillway or a dam raise is required for dam safety to avoid overtopping the dam during extreme storm events.

Following is a brief summary of the flood control alternatives presented in Chapter 3. All but the first two include an auxiliary spillway near the left abutment. All the alternatives would provide increased flood control at Folsom Dam by greatly increasing flow capacity at much lower pool elevations, allowing the rate of change in reservoir pool to be controlled more effectively during large storm events, and the maximum pool reached during these storms to be lower as well. An auxiliary spillway would provide Folsom Dam with four methods of discharging flows from the reservoir: three power penstocks, the flood control outlets, the tainter/radial spillway gates set near the main spillway crest (five service and three emergency), and the submerged tainter gates (STGs) provided as part of the auxiliary spillway. Table 7-1.1 summarizes the capability of each outflow method and a few of the alternatives considered.

TABLE 7-1.1
SUMMARY OF FOLSOM DAM OUTLET CAPACITY

Outlet Feature	Lake Elevation 400 feet Bottom of Maximum Flood Space	Lake Elevation 426 feet Bottom of Normal Flood Space	Lake Elevation 466 feet Normal Gross/Full Pool	Lake Elevation 477.5 feet Spillway Design Pool/Maximum Flood Pool
	(cfs)	(cfs)	(cfs)	(cfs)
3 Power Penstocks	7,000	7,000	7,000	0
4 Lower Outlets	13,000	13,800	14,900	15,200
4 Upper Outlets	10,500	11,500	12,900	13,200
5 Operating Spill Gates[1]	0	12,500	209,500	300,000
3 Emergency Spill Gates[1]	0	0	0	180,000
Total Existing Flood Control Capability	**30,500**	**44,800**	**244,300**	**508,400**
Alternative - Outlet Works Modifications[2]	**69,000**	**75,700**	**85,200**	**86,100**
Alternative - 6 23'X33' STG Auxiliary Spillway	**70,600**	**174,000**	**280,000**	**304,000**
Alternative - 4 - 17'-7" 'X33' STG Auxiliary Spillway	**38,000**	**90,000**	**145,000**	**155,000**

Notes:
[1] Regulated flow capability
[2] Capacity of 10 Outlets, 6 Large/Enlarged Upper Tier, 2 Enlarged Lower Tier, 2 existing Lower Tier
cfs – cubic feet per second

7-1.2.3.1 10 Main Dam Outlets; All Enlarged or New

This alternative is the original authorized plan for the Folsom Modification Project. The plan consisted of modification of the eight existing outlets and adding two others in the half monoliths for the service spillway. This alternative provided flood control with a discharge capacity of 115,000 cfs at pool elevation 418.0, the spillway crest. There would have been 10 outlets. The gate sizes would be as follows: Upper Tier (9'- 4" x 14'), Lower Tier (9'-4" x 12'). The sluiceways for the modified outlets would require complete demolition and reconstruction. The intakes, gate chamber and passage, air vent system, exit tunnel, and exit portal would be much larger. The intakes would now be lower on the upstream face of the dam. The exit portals on the other hand, would be higher on the downstream face. This would require the eyebrows above the exit portals to be reconstructed also. The stilling basin needed to be anchored more effectively, due to the impact forces from the jets issuing from the exit portals and to meet current design criteria (criteria updated since the dam was designed and constructed). Dam Safety would be provided by the emergency fuse plug spillway designed by USBR. The hydraulic design elements for this alternative have been extensively described previously in previous DDRs for the Folsom Modification project.

7-1.2.3.2 10 Main Dam Outlets; 8 Enlarged or New, 2 Existing

This alternative is a slight modification of the previous one and is the baseline plan for functional equivalency. The alternative includes modifications to six of the existing outlets and the addition of two new upper tier outlets in the half monoliths for the service spillway. This alternative provides flood control with slightly less discharge capacity than the original authorization indicated (104,500 cfs at pool elevation 418.0, the spillway crest; the original design was 115,000 cfs at this pool elevation for the modified outlet works). There would still be 10 outlets, but only 8 would be large. There would be 6 enlarged outlets (4 upper tier, 2 lower tier), 2 new large outlets (upper tier), and 2 existing outlets (lower tier). The cost for construction to enlarge the outer two lower tier outlets is extremely high and so those outlets would not be enlarged. The gate sizes would be as follows: Upper Tier (9'-4" x 14'), Enlarged Lower Tier (9'-4" x 12'), and existing Lower Tier (5' x 9'). All information indicated in the previous alternative relative to demolition and construction of the modified outlets still applies. Dam Safety would again be provided by the fuse plug designed by USBR. The hydraulic design elements for this alternative have been extensively described previously in previous DDRs for the Folsom Modification project. Some clarifications for the alternatives that enlarge the existing sluices are described herein, but the remainder of this appendix primarily describes alternatives that provide an auxiliary spillway.

7-1.2.3.3 Four 17' – 7" Wide by 33' High STGs Auxiliary Spillway

This alternative is an auxiliary spillway that provides flood control and has a discharge capacity of about 78,000 cfs at pool elevation 418.0. For the purposes of this report, it is considered the least-cost functional equivalent of the original authorization and is the featured alternative in the main body of the report. When combined with releases from the outlet works, this alternative has the capability to pass about 103,000 cfs at spillway crest elevation 418.0. The combined capacity of the service spillway and auxiliary spillway is well over 300,000 at pool elevation 470, where the emergency gates would still need to be opened to avoid overtopping. The gate design is very similar to that of the auxiliary spillway at Oroville Dam. The gates for the spillway at Folsom Dam would be the same size and the structural configuration and maximum head on the gates would be just a few feet larger for Folsom Dam. This alternative would include an auxiliary spillway near the left abutment (at the current overlook area). The auxiliary spillway would consist of an approach channel, an Auxiliary Spillway Control Structure with four top-seal radial gates that are 17'-7" wide by 33' high with the sill at elevation 368, and a 90-foot wide rectangular, concrete-lined chute that leads into an energy dissipation area and exit channel. This alternative is effective because it increases the flood control capabilities at lower levels in the reservoir. A discharge chute would run from the outlet works towards the downstream end of the exit channel for the main dam (entering the American River in almost a direct line). A hydraulic jump stilling basin would be constructed to provide energy dissipation of the high velocity flows in the chute.

7-1.2.3.4 4 STG Auxiliary Spillway plus Replacement of Three Emergency Spillway Tainter Gates

This alternative would add to the previous one by replacing the three existing emergency gates with taller gates. This increases flood protection by allowing the emergency spillways to

remain closed until much higher pool elevations are achieved. The emergency gates no longer must be opened at pool elevation 470 to avoid overtopping. This allows more flexibility in dam operations.

7-1.2.3.5 Six 23' Wide by 33' HIgh STGs Auxiliary Spillway- Joint Federal Project

This alternative is an auxiliary spillway that provides for dam safety as well as flood control. The discharge capacity of this auxiliary spillway alone is about 150,000 cfs at pool elevation 418.0, greater than the original authorization called for, and greatly increases discharge capacity for dam safety at higher pools. The design is similar in many ways to the auxiliary spillway at Oroville Dam. The gates for the spillway at Folsom Dam would be wider (23' vs. 17'-7"), but the structure configuration and maximum head on the gates are very much the same. The alternative would again be an auxiliary spillway on the left abutment. The auxiliary spillway would consist of an approach channel, an Auxiliary Spillway Control Structure with six top-seal radial gates that are 23 feet wide by 33 feet high with the sill at elevation 368, and a 169-foot wide rectangular, concrete-lined chute that leads into an energy dissipation area and exit channel. This alternative is very effective because it both increases the flood control capabilities at lower levels in the lake and also provides increased dam safety by allowing Folsom Dam to safely pass very large storm events without overtopping. A discharge chute would again run from the outlet works towards the downstream end of the exit channel for the main dam (entering the American River in almost a direct line) and a hydraulic jump stilling basin would be constructed to provide energy dissipation of the high velocity flows in the chute

7-1.2.3.6 Six 23' Wide by 33' High STGs Auxiliary Spillway plus Replacement of Three Emergency Spillway Tainter Gates

This alternative would add to the previous one by replacing the three existing emergency gates with taller gates. Again, replacing these gates increases flood protection by allowing the emergency spillways to remain closed until much higher pool elevations are achieved and allows more flexibility in dam operations.

7-1.3 CRITERIA

The following list of documents provides applicable hydraulic design criteria for the project:

ER 1110-2-1150 Engineering and Design for Civil Works Projects

ER 1110-2-1156 Dam Safety – Organization, Responsibilities, and Activities

EM 1110-2-1601 Hydraulic Design of Flood Control Channels

EM 1110-2-1602 Hydraulic Design of Reservoir Outlet Works

EM 1110-2-1603 Hydraulic Design of Spillways

EC 1110-2-6061 Safety of Dams – Policy and Procedures

FEMA Publication 64, "Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners"

Peterka, A. J. 1974. "Hydraulic Design of Stilling Basins and Energy Dissipators," Engineering Monograph No. 25, US Bureau of Reclamation, Denver, CO.

Two Phase Flow Characteristics of Stepped Spillways" by Boes and Hager, ASCE, HY Journal, Sep 2003.

7-1.4 HYDRAULIC DESIGN ELEMENTS & PARAMETERS

As mentioned above in paragraph 7–1.2.3.2, unless otherwise indicated, discussions through the rest of this attachment are pertinent to the alternatives that include an auxiliary spillway and not to the alternatives that include providing additional or enlarging main dam outlets. The discharge facilities for the auxiliary spillway alternatives includes a flared approach channel, a concrete structure with a vertical upstream face, a double elliptical roof entrance to each of the conduits that houses the tainter gates, the tainter gates, and a rectangular concrete conduit (just long enough to house each of the tainter gates and provide an exit to a steep chute; a concrete-lined, rectangular channel). At the downstream end of the chute a stilling basin will be constructed for energy dissipation.

7-1.4.1 Hydraulic Roughness

Hydraulic roughness values were selected for the rock/earth excavation in the approach channel to the auxiliary spillway structure, the rock excavated exit channel from the auxiliary spillway energy dissipator to the American River, the American River from the Folsom Dam to the Folsom Dam Road Bridge currently being designed, and for the concrete surfaces within the auxiliary spillway structure, the chute extending from the control structure to the energy dissipator, and the energy dissipator. A Manning's "n" value of 0.035 was assumed for the channel roughness in the auxiliary spillway approach channel and in the exit channel downstream of the energy dissipator. Manning's "n" values of 0.012 and 0.016 were used for establishing maximum velocities (maximum energy dissipation required) and depths of flow (maximum wall heights required), respectively, in the chute. These "n" values were checked against recommended roughness heights (Ks) of 0.002 and 0.007 for concrete flood control channels in EM 1110-2-1601 (USACE 1994) and found to be reasonably consistent with that guidance.

7-1.4.2 Discharge Rating Curves and Stage-Discharge Relationships

The discharge rating curves (pool stage versus discharge) for the auxiliary spillway alternatives were patterned after the Oroville Dam Service Spillway and adjusted for the number of gates and the gate width. The Oroville Dam spillway has eight 17-feet, 7-inch wide by 33-feet high tainter gates with a maximum head on the gates of about 90 feet. The auxiliary spillway gates for Folsom Dam would be either 17 ft – 7 inches wide by 33 ft high or 23 ft wide by 33 ft high and have a head of about 93 feet on the centerline of the gates at maximum flood pool elevation 477.5. Model studies will be used to confirm the ratings and/or develop more accurate discharge ratings. Two types of flow (weir flow and orifice flow) will occur over the range of

reservoir pools at which discharges will be made. Weir-type flow would occur until the roof of the rectangular opening is reached or the lip of the tainter gate (if the gates are partially opened), and would still be applicable for a short vertical distance above this. Above the outlet roof or valve lip, a transition zone to orifice flow control would exist. Under orifice flow conditions, the tainter gate is fully submerged and acts as a valve. The rectangular openings that house the submerged tainter gates would continue a short distance before flows would exit to a steep concrete chute/channel where open channel flow occurs. The minimum distance would be governed by structural considerations. Since the distance would be so short, pressure flow downstream of the tainter gates was not a consideration for computing the ratings. The weir-type flow scenarios would only occur at the lower pools. The water surface of the flow through the auxiliary spillway outlet works would be open channel at these lower pools. A discharge rating curve for the "6 STG Auxiliary Spillway - Joint Federal Project" alternative discussed in paragraph 7-1.2.3.5 is shown on Figure 7-1.1, with gates fully opened. These values are adapted from those for the Oroville Dam Control Structure, adjusted for elevation, the number of gates, and the area of the gates. Physical model tests will be utilized to determine the "part gate open" discharge rating curves. This rating would also apply to the alternative discussed in paragraph 7–1.2.3.6. To obtain discharge rating values for the four STG alternatives described in paragraphs 7–1.2.3.3 and 7–1.2.3.4, the discharges at selected pool elevations would need to multiplied by 0.5097 (ratio of the gate widths times ratio of number of STGs) to account for four 17' – 7" wide gates instead of six 23 feet wide gates.

7-1.4.3 Water Surface Profiles

For the alternatives with an auxiliary spillway, water surface profiles were computed for the Auxiliary Spillway approach channel from the reservoir to the control structure, the Auxiliary Spillway chute from the control structure to the stilling basin, and the American River from the new Folsom Dam Road Bridge (currently under design) to the existing main dam stilling basin.

7-1.4.3.1 Approach Channel to Auxiliary Spillway

A simple HEC-RAS model was developed primarily to assess velocities that might be experienced in the approach channel to the auxiliary spillway. The invert slope of 0.020 passing through the concrete structure housing the tainter gates is supercritical (assuming a maximum Manning's "n" value of 0.016 to allow for some roughening by mineral debris). However, this slope begins at the upstream end of the double-elliptical flared entrance. This model assumed critical depth at the downstream end of the elliptical intake curves and HEC-RAS backwater computations were performed from that point to the upstream end of the approach channel to obtain lake elevations corresponding to assumed discharges. Manning's "n" values of 0.035 (rock cut) and 0.016 (concrete) were used to account for frictional losses in the backwater computations. A contraction loss coefficient of 0.1 was used for the approach channel contraction. Computations for the lower pool elevations were made using the entire approach channel, including all of the tainter gates, piers between the gates, and abutment walls. A physical hydraulic model and/or numerical model will be used to determine the final design water surface profiles.

7-1.4.3.2 Auxiliary Spillway Chute

The WASP2 water surface profile program (Twiss and Sarvary, 1985) was used in computing water surface profiles for the Auxiliary Spillway chute for all auxiliary spillway alternatives discussed in this report. This program was specifically developed for high velocity prismatic channels, and allows the user to rapidly compute profiles and other pertinent hydraulic data, such as Froude numbers, sequent depths, and stream power. A HiVel2D program will be developed for final design.

7-1.4.3.3 American River Channel below Folsom Dam

A HEC-RAS model has also previously been developed for the American River from downstream of Folsom Dam to Nimbus Dam for the Bridge project. New topography was obtained to construct this model. The primary reasons for developing this model was for the detailed bridge design, however, it was also needed for tailwater considerations in designing the auxiliary spillway energy dissipator and in analyzing the energy dissipation and the adequacy of the existing main dam spillway stilling basin. The tailwater rating curve used in original design of the main dam stilling basin / flip bucket energy dissipator is close to the tailwater curve developed using the new topography. At the higher discharges, the tailwater elevation at the auxiliary spillway energy dissipator is expected to be two to three feet lower than the tailwater elevation at the main dam. The tailwater rating curve for the auxiliary spillway energy dissipator will be refined for the final report and in time for use in the physical model tests. This refinement will include incorporating the auxiliary spillway stilling basin exit channel into the HEC-RAS model.

7-1.4.4 Head Losses

Hydraulic head losses that will occur as flows pass through the auxiliary spillway will include frictional and form losses. As discussed in paragraph 7-1.4.1 above, frictional losses for concrete surfaces were calculated using Manning's "n" values of 0.012 for minimum losses and 0.016 for maximum losses. Manning's "n" values of 0.035 were used for rock cut areas. Form losses for expansions, contractions, piers, roof and side curves, invert offsets, etc. will also occur as flows are passed. A contraction loss coefficient of 0.1 was used for the approach channel contraction. An expansion head loss coefficient of 0.3 was used to account for expansions in the concrete chute downstream of the control structure.

7-1.4.5 Design Discharge Capacities & Velocities

The Auxiliary Spillway Control Structure will be designed for all discharges that could occur with all combinations of pool elevation and gate openings. Average velocities through the gates and conduits with the gates fully open will be as high as 68 fps at this pool (elevation 477.5). Velocities in the approach channel vary greatly, increasing steadily closer to the auxiliary spillway structure. The maximum at the upstream end of the conduit roof curves is about 50 fps. The maximum velocity at the upstream end of the concrete lining in the approach channel is expected to be about 16 fps. Hydraulic model tests and further geotechnical data will be used to confirm the velocities that will be experienced and assess whether or not the extent of the concrete (or other lining) can be reduced or needs to be increased.

The downstream channel has an objective or target flood release of 115,000 cfs. Therefore, a design discharge of 90,000 cfs (combined with 25,000 cfs from the main dam sluices) was selected for the concrete lined chute and stilling basin. However, there are a myriad of discharges and combinations of greater discharges that the chute and stilling basin could be exposed to during the project life. Upon completion of the JFP project and the Common Elements project, the auxiliary spillway would probably become the first choice (after the existing sluices) for flood releases. An auxiliary spillway release of 135,000 cfs concurrent with a release of 25,000 cfs from the main dam sluices could be made without failure of the upgraded levees on the American River. The chute wall heights will be designed to provide full Corps and USBR freeboard requirements for the 90,000 cfs water surface profile plus an allowance for waves. In addition to the 135,000 cfs mentioned above, another scenario to be considered in the final design process is the maximum discharge of slightly greater than 300,000 cfs that could occur under PMF conditions. One solution would be to design the top of chute walls to contain the PMF discharge without considering waves and freeboard. This will be investigated in more detail as the design proceeds. The stilling basin will be designed for optimal performance at the design discharge but also function satisfactorily at higher discharges up to PMF magnitude. However, some damages (not catastrophic in nature) are acceptable as flows increase above the downstream channel capacity.

7-1.4.5.1 Maximum Discharge Capacity

Figure 7-1.2 shows the maximum calculated discharge capacity for Folsom Dam Auxiliary Spillway with 6 – 23 ft wide STGs. To obtain like rating curves for the auxiliary spillway alternatives with 4 – 17'-7" STGs, the discharge values at a selected pool elevation for the auxiliary spillway curve would need to be multiplied by 0.5097 and the total discharge curve revised accordingly. The pool elevation range is from 300' to 477.5' and assumes the outlet works from the main dam are fully open for the full range of reservoir pool elevations. Maximum discharge capacities are shown for the outlet works (for all 8 conduits combined), the service and emergency spillways (for all 8 radial gates combined), the auxiliary spillway (6 STGs), and combined operation of the three. Maximum discharge capacity assumes no operational constraints on releases from the outlet works.

7-1.4.6 Structure Sizing to Meet Design Capacity

The flood reduction objective release from Folsom Dam is currently 115,000 cfs so the initial approach was to size the discharge facilities from Folsom Dam to pass 115,000 cfs at the main dam spillway crest elevation 418.0. A second objective was to be able to pass the 200-year event without flooding downstream and pass the PMF without overtopping the dam (dam safety). The alternative that provides 8 large outlets and 2 existing outlets can pass only about 104,500 cfs at pool elevation 418 and cannot pass the 200-year event, nor does it add enough discharge capacity to allow passage of the PMF. An auxiliary spillway or raising of the dam is required to do that. All of the alternatives with auxiliary spillways except the four 17'-7" wide by 33' high STGs exceed the flood reduction objective release at pool elevation 418.0 with the combined discharge (sluices and STGs) equaling or exceeding 115,000 cfs. The auxiliary spillways with six STGs allow control of larger floods up to the 200-year + event to remain within the downstream American River channel capacity and provides for passage of the PMF (satisfies dam safety requirements).

7-1.4.7 Conditions That May Effect Design Capacity

7-1.4.7.1 Vortices

Vortices can affect intake efficiency and possibly create a debris and safety hazard. The intensity of the vortex is a function of the submergence of the intake, the discharge, and the intake and approach channel geometry. Plate C-35 (Figure 7-1.3) of EM1110-2-1602 (USACE, 1980) indicates that planned operations of the auxiliary spillway could result in problems with vortices. For this reason, a vortex suppressor similar to the structure at Theodore Roosevelt Dam (on the Salt River in Arizona) has been incorporated into the design. This structure comprises a set of beams placed above the intake opening that disrupts vortices. Model tests of the Oroville Dam Auxiliary Spillway structure (after which the Folsom Dam Auxiliary Spillway is patterned) showed that when a near vertical wall above the inlet for the gates was used, a vortex suppressor was not needed. However, a vortex suppressor, patterned after the one used for the Theodore Roosevelt Dam, has been included. Physical hydraulic model tests would be used to determine whether a vortex suppressor is needed.

7-1.4.7.2 Cavitation

Cavitation is the successive formation and collapse of vapor pockets in low-pressure areas associated with high-velocity flow. It results from the sudden reduction of the local pressure at any point to the vapor pressure of water. The collapse of the pockets sets up high-pressure shock waves that cause damage to the nearby boundary. Cavitation often causes severe damage to steel or concrete and it can occur at the conduit entrance, downstream from gate slots, in the conduit downstream from the gates, and anywhere that high velocity flows tend to separate from the flow boundary and the piezometric head approaches the vapor pressure of water.

Any alternative auxiliary spillway at Folsom Dam would have a similar configuration to the one at Oroville Dam. The intake also is very similar. The Oroville design is a simple ellipse for the "roof" curve of the intake of length D (33 feet) and height 1/3D (11 feet). The model study for Oroville Dam indicated that, for a discharge of 277,000 cfs (approximately 35,000 cfs per gate at Oroville Dam) and piers of 5 feet in width, pressures as low as -31.7 feet were recorded at the upper corner of the intake. Pressures below -20 feet typically indicate a strong possibility of cavitation. The design for Folsom Dam uses a 5-foot pier between gates within a monolith, with a design discharge of about 15,000 cfs per gate, a total design discharge of 90,000 cfs (objective discharge of 115,000 cfs includes about 25,000 cfs from the main dam outlet works) and a maximum discharge of about 50,600 cfs per gate (PMF discharge of 304,000 cfs). Therefore, the potential definitely exists for cavitation, especially at the higher pool elevations. The Folsom design would include a double elliptical roof curve to assist in reducing the potential for negative pressures. Although some cavitation will be acceptable at the higher pool elevations, the design goal will be to decrease the potential for cavitation to the extent practical. Potential for cavitation will be investigated in more detail as the design process proceeds. Physical hydraulic model tests will be used to investigate cavitation potential, and modifications made as needed to eliminate and/or minimize cavitation. Extension of the piers separating the gates and eliminating the curvature on the outside walls may also be helpful in minimizing the potential for cavitation and would be tested in the model.

Other areas of any auxiliary spillway alternative where cavitation problems could potentially occur include the area where the control structure becomes an exit chute, offsets at joints (either as constructed or developing after construction), imperfections in the concrete finish, abrasion damage from mineral or other debris, damage to the concrete due to vandalism, transitions both laterally in the chute side walls and the invert, and the approach to, and within, the energy dissipator at the downstream end of the chute. To the extent practical, these potential cavitation areas would be investigated with model tests. Elimination of and/or minimization of cavitation potential for most of these areas can best be addressed by a conservative/clear design and specifications of transitions, offsets, and construction tolerances, etc., followed by detailed, thorough, and firm inspections with departures from specifications rigidly corrected. Specifications, instructions to field personnel, and the operations manual also would need to be clear regarding after-construction developments that represent potential cavitation problems, and the maintenance procedures to be performed to minimize potential cavitation. At locations where the invert slope changes significantly, a large radius circular curve or a parabolic invert transition, assuming velocities at least 25 percent higher than maximum design velocities, would be incorporated into the design to maintain positive pressures on the invert.

7-1.5 OTHER SPILLWAY DESIGN CONSIDERATIONS

7-1.5.1 Approach Channel

The plan and profile for the 6 STG Auxiliary Spillway Control Structure and the approach channel are shown in Plates 7-1, 7-2 and 7-3. Concrete lining of the invert and (vertical) sides would be provided for a distance of 50 feet upstream from the face of the Control Structure. The invert elevation for this concrete lining would be at sill elevation 368. The vertical concrete walls that provide a transition from the Control Structure to the approach channel will have an elliptical shape using the Oroville Dam spillway parameters. An abrupt rise in the approach channel invert from elevation 364 to elevation 368 at the start of the concrete lining and a negative invert slope of 0.01 from that point towards the lake would be incorporated in the design to discourage debris material from migrating toward the structure and thus minimize the need for erosion protection and reduce the potential for passage of large mineral debris through the submerged tainter gates. Most of the approach channel geometry would be excavated in rock and be resistant to erosion. Further, geotechnical data and physical hydraulic model tests would be used to determine the optimum approach geometry and needed erosion protection. At the design discharge, approach velocities are expected to be about 9 to 11 fps at about 100 feet from the intake based on a simple HEC-RAS model assuming a Manning's "n" value of 0.035 and a contraction loss coefficient of 0.10. These velocities are based on the gates being full open. The approach velocity would accelerate to about 30 fps at the intake entrance for the design discharge. A boom would be provided upstream from the Auxiliary Spillway Control Structure to catch floating debris. Trash racks or log racks upstream from the STGs also were considered but it was decided that the racks would probably not be needed. The openings are large and the boom should catch a considerable amount of the debris that would cause concern. The drainage basin upstream from Folsom Dam is fairly similar to that above the Oroville Dam, and no racks were provided for the Oroville Dam project. This will be checked with the physical model (passage of debris).

7-1.5.2 Modification of Existing Spillway Gates

There are operational constraints when operating the existing service and emergency tainter gates at Folsom Dam. The emergency gates are not to be opened until 300,000 cfs is being released into the American River. The top of the emergency gates in the closed position is at elevation 471 so that dam operators have to begin opening the emergency gates at pool elevation 470. This effectively limits the current flood control operation to elevation 471. Since the service gates are already open, the emergency gates need to be opened up at least 10 feet almost immediately so that a wave coming around the pier between the service gate and emergency gate will not impact the service gate trunnion. Operation of the service gates is also sensitive because the service gates must follow the pool up once the pool comes within about two feet of the top of gate. Another problem in operation of the existing tainter gates is that they should not be operated in the transitional zone from orifice flow (part gate) to full open and should not be lowered to go from full open (gates out of the water) to part gate operation. The Corps computer program H3106 computes part gate open discharge rating curves for tainter gates, indicates when the transitional zone is entered, and states that "gate control uncertain – avoid operation at above pool and gate opening" for a particular calculated discharge based on gate opening and pool elevation/head. The USBR also has also noted this transitional zone. Model reports describe the transition zone as where model data was inconsistent with both the gated-discharge rating and the free-flow rating as a zone of instability where control can shift rapidly between two regimes. Measurements of discharge and pool elevation vary widely in this transition zone. At the higher pool elevations, the existing tainter gates cannot physically be opened enough that free-flow will occur. This decreases the potential maximum spillway flow by greater than 100,000 cfs.

The three existing emergency spillway gates would be replaced with taller gates as part of two of the alternatives. Installation of the larger gates would require modification of the piers to raise the trunnion axis to prevent spillway flows from impacting the trunnion tie beams. Structural design investigations indicate that the piers would not need to be widened. The gates would be taller, and the new trunnions would be out of the flow stream for large floods. Final gate design would allow free-flow thru the emergency spillway for very large events. Replacing the emergency spillway gates would allow water to be stored against the closed emergency gates up to lake elevation 475.5, two feet below maximum flood pool. This equates to a top-of-gate at 476.5 with one foot of freeboard on the gate. The gate radius for the new gates would be 54.5 ft and the new trunnion would be located about 10.4 ft farther downstream and about 6 ft higher. The new gate "seat" would be about 13.3 ft downstream of the crest. The piers bordering the gates would be extended downstream about 12 ft.

Figure 7-1.4 shows computed rating curves for the main dam spillway with the emergency gates replaced. Examination of the figure shows that the controlled-discharge rating curves and the uncontrolled discharge (free-flow) rating curve are separated by a transition zone. In this zone surging can occur as the flow is unstable and can rapidly shift between controlled-discharge and free-flow. Operating in the transition zone is not recommended. When free flow would be required for very large storm events, the emergency gates should be raised out of the flow as quickly as possible. Free-flow currently is not physically possible for the existing service gates at high pools.

7-1.5.3 Spillway Bridge at the Main Concrete Dam

Where spillway gates are replaced a new spillway bridge would also be placed at the top of the piers on the upstream side of the new spillway gates to replace the existing bridge. The bridge deck would be 4 feet thick and the low chord of the bridge would be lower than the maximum flood pool (elevation 477.5). The drawdown curve for flow over the spillway was computed using the procedures in Engineering Manual (EM) 1110-2-1603, Hydraulic Design of Spillways (USACE, 1992), to determine if the bridge deck would intersect spillway flows. Should pressure flow occur because flows impinge on the bridge, the spillway discharge would decrease and the reservoir pool elevation would increase. At maximum flood pool, the center line nappe elevation would be only about one-tenth of a foot below the girder elevation. The girder would therefore be chamfered to provide a freeboard of at least 0.5 feet. At the piers, flow would slightly impinge on the bridge deck; however, it is not likely that pressure flow would occur. This will be further investigated during more detailed studies.

7-1.5.4 Modification of Sluice Exit Portals and Eyebrow Deflectors

Operating experience at Folsom Dam has shown that concurrent operation of the five service spillway gates and the outlet works creates a condition that results in cavitation damage to the dam. This damage can be minimized if the full capacity of the outlets is not used. Previous model studies by Isbester indicated that the existing conduits should not be operated above 60 percent gate opening when spillway flows are occurring. This is the current operation procedure. This restriction could possibly be eliminated by modifying the spillway in the vicinity of the sluice exit portals. If confirmed by model tests, this modification would allow 100 percent gate openings for the outlet gates with the service spillway gates discharging. The operation studies contained in this EDR assumed that full use of the new and enlarged outlet gates would be available if needed for the alternatives that include enlarging the existing outlets. However, for the alternatives incorporating an auxiliary spillway with STGs, the increased discharge capacity gained by lifting the 60 percent restriction would be very small compared to the auxiliary spillway capacity and the 60 percent restriction is assumed to still be part of planned operations.

7-1.5.5 Advance Release

The term "advance release" refers to increasing releases from Folsom Dam to draw down the reservoir in advance of a predicted storm. For example, a peak inflow of 300,000+ cfs is anticipated to occur within the 3-day forecast window. Releases would then be ramped up to the objective flow (115,000 cfs) as quickly as possible. Since the flow would be maximized as soon as possible, vortices may form at low lake level elevations. It is believed that any operations required to alleviate vortex formation will have minimal impact on advance release performance. Determining the details on the implementation of advanced release is not directly part of the Folsom Dam Outlet Works Modification project, but is a design consideration.

7-1.5.6 Gate Vibration

The auxiliary spillway control structure is very similar to the gated structure at Oroville Dam (near Oroville, California). Although no significant vibration problems have been reported at Oroville Dam, the gates at Oroville Dam haven't experienced hydraulic heads near the

maximum design heads. Gate vibration problems are not anticipated with the proposed gates for the Folsom Dam Auxiliary Spillway.

7-1.5.7 Chute Hydraulics

The six gates and the five piers separating the gates in the Auxiliary Spillway Control Structure for the six 23' wide by 33' high STGs require a width of 169 feet. This width was also adopted for the rectangular, concrete chute downstream from the gated control structure. The invert slope from the gate sill Station 9+89.3 (elevation 368.0) to Station 12+00 (elevation 365.89) would be 0.010. This relatively mild slope was used to reduce excavation during construction, and with parallel chute walls, decreases the probability of rapid pulsating flow and/or standing waves. Downstream from station 12+00, the slope would be increased to 0.020 down to station 32+00 (elevation 325.89). At station 32+00, the invert profile would begin to transition to either a conventional stilling basin (for this design) or another method of energy dissipation (later design refinement, if possible). Manning's "n" values of 0.012 and 0.016 were used for establishing maximum velocities and establishing depths of flow, respectively. These "n" values were checked against recommended roughness heights (Ks) of 0.002 and 0.007 for concrete flood control channels in EM 1110-2-1601 (USACE, 1994), and found to be slightly conservative at both the low and high ends. The initial depth leaving the short conduit housing the gates varied with discharge and was computed by applying Bernoulli's Equation and assuming a minimal head loss from the approach channel to the downstream end of the control structure conduits.

The flow in the chute downstream of Station 9-89.3 is hydraulically steep and the Froude number is greater than 2. Therefore, roll waves and cross waves (rapid pulsating flow and/or standing waves) are likely to form in the chute. To determine appropriate wall heights, additional vertical depth to account for possible flow bulking and waves, and a reasonable freeboard would need to be added to the computed depths. An initial conservative nominal chute wall height of 30 feet was selected and the estimate for this report reflects this. Walls would have to be a few feet higher for a short distance downstream of the conduit exits. Wall heights would be refined during physical model testing and future studies by considering the waves produced in the model, flow bulking, and considering progressively higher discharges in the model.

160,000 cfs is the target release to hold for as long as possible while evacuating downstream for extreme flood events. The minimum pool elevation to discharge 135,000 cfs with auxiliary spillway gates full open would be about elevation 415.5. This corresponds to a flow of 160,000 cfs when combined with about 25,000 cfs from the outlet works. The flow depth as flow exits the downstream end of the conduits would be about 29 feet, dropping to about 20.0 feet a relatively short distance downstream. For maximum loss conditions, flow depths would vary from 20.0 feet near the upstream end of the chute to about to 13.9 feet at station 32+00. Depths then decrease rapidly as the invert becomes even steeper towards the energy dissipator.

The goal is to contain all possible flows from the Auxiliary Spillway in the chute if waves are not considered. The "gates full open" discharge through the auxiliary spillway structure at maximum flood pool elevation 477.5 would be about 304,000 cfs. For this scenario, the flow depth exiting the conduits would be about 32 feet, decreasing to about 26 feet a short distance downstream. Flow depths would continue to decrease down the chute to about 23 feet at station

32+00. Depths then decrease rapidly as the invert becomes even steeper towards the energy dissipator.

7-1.6 ENERGY DISSIPATION FEATURES

Water surface profiles were computed assuming minimum losses. Results of these runs were utilized in designing the stilling basins.

7-1.6.1 Service Spillway – Stilling Basin

The stilling basin is the energy-dissipating device for flows from the outlet works and service spillway. The hydraulic jump is the basic feature used to dissipate excess hydromechanical energy in a stilling basin such as at Folsom Dam. Five of the eight spillway bays discharge into the main stilling basin and the remaining three emergency spillway bays discharge over a flip bucket. The stilling basin for Folsom Dam acts as a hydraulic jump basin when flows are from the main spillway. The tailwater curve near the end of the stilling basin is shown as Figure 7-1.5.

7-1.6.2 Emergency Spillway – Flip Bucket

Flows from the emergency flip bucket spillway act in a very different manner than those from the service spillway. Flow follows a trajectory (like a ski jump) where the energy is mainly dissipated in the plunge pool that develops when discharges are high. Because the energy is not dissipated effectively except when a plunge pool exists, the emergency spillway is not utilized until the service spillway reaches its maximum release capacity at pool elevation 470, which is one foot below the top of the closed emergency gates (releases of 240,000 are being made through the main stilling basin). The pressures on the toe curve of the flip bucket for the emergency spillway were investigated, using Plate 112-7 of HDC. See Figures 7-1.6 and 7-1.7.

7-1.6.3 Auxiliary Spillway – Stilling Basin

During design studies for this report, two basic approaches to energy dissipation for flows from the auxiliary spillway chute were considered. The first and most predictable approach would be to provide a conventional stilling basin (either lined with reinforced concrete, unlined, or preceded by a steeped chute) The estimate for this report assumes construction of a reinforced concrete, conventional stilling basin (without the stepped chute). The second approach was to provide an energy dissipation area similar to that provided for the Oroville Dam service spillway. This would include spreading the flows at the end of the chute and providing an excavated chute/plunge pool area. However, the second approach was rejected because the spray from such an energy dissipator could cause problems for the existing power plant at Folsom Dam.

Three types of stilling basins were considered: (1) a conventional lined stilling basin (reinforced concrete founded on rock), (2) an unlined stilling basin excavated in sound rock, and (3) a conventional, concrete lined stilling basin preceded by a stepped concrete lined chute. The auxiliary spillway stilling basins for (1) and (2) above were designed for 90,000 cfs in their respective chutes with sequent depth from flows entering the basin and the tailwater produced from 115,000 cfs in the American River. The designs would also allow for adequate energy

dissipation for flows greater than 90,000 cfs in the auxiliary spillway. The tailwater elevation for 115,000 cfs in the American River would be approximately elevation 185.0. A HEC-RAS (USACE, 2005) model of the American River from Nimbus Dam upstream to Folsom Dam has been developed to compute water surface elevations for project design. Both of the stilling basin designs included transitioning the invert of the chute from station 32+00 (elevation 325.89) to the stilling basin floor with a long approximately parabolic drop. For both designs, this would be conservatively designed to provide positive pressures on the invert. At a later design stage, it may be desirable to break this invert curve into chords. Each of the stilling basin designs also included a 1:30 sidewall expansion from station 32+00 to the stilling basin floor. Water surface profile computations assumed an expansion loss coefficient of 0.3 to account for transition losses. Because of relatively high Froude numbers (varying from about 6 to 10), both stilling basin designs were generally patterned after the Type II basin (see Reclamation EM No. 25 titled Hydraulic Design of Stilling Basins and Energy Dissipators (Paterka, 1974)). See Figure 7-1.8 for a sketch of a Type II basin. Conservatively low Manning's "n" values of 0.012 for concrete and 0.035 for rock excavation were selected for energy dissipation considerations.

For the alternatives with six STGs, the bottom width would transition from 169 feet at station 32+00 to 222.3 feet at the beginning of the stilling basin, station 40+00. At a discharge thru the chute of 90,000 cfs, the flow depth entering the stilling basin would be about 3.65 feet with a velocity of about 111 fps. The Froude number entering the basin would be approximately 10.2. The sequent depth would be 51 feet, which would require wall heights of about 53 feet and a stilling basin length of about 204 feet. However, consideration was given to the likelihood of discharges up to 135,000 cfs concurrent with 25,000 cfs from the main dam sluices being part of the flood reduction package and the length and wall heights in this report are reflective of that scenario. This would require wall heights of 66 feet and a basin length of 280 feet (about four times the sequent depth). The basin floor was set at elevation 130.2. Energy dissipation is optimal for the design discharge with the D2 for 90,000 cfs and the tailwater elevation for 115,000 cfs in the American River matching. However, the basin dimensions set for this report use the more conservative auxiliary spillway discharge of 135,000 cfs concurrent with 25,000 cfs from the main dam sluices. The "height of the tailwater over the end sill" versus the sequent depth for higher discharges (up to the gates full open discharge at maximum pool) indicates that adequate energy dissipation should occur at the maximum discharges. However, the stilling basin walls would be overtopped and damage to the stilling basin would be expected at auxiliary spillway discharges exceeding 135,000 cfs. Further analyses and physical model studies will be utilized to optimize the stilling basin length and other dimensions.

For the alternatives with four STGs, the bottom width would transition from 90 feet at station 32+00 to 143 feet at the beginning of the stilling basin, station 39+90. The flow depth for 90,000 cfs entering the stilling basin would be about 5.5 feet with a velocity of about 115 fps. The Froude number entering the basin would be approximately 8.7. The sequent depth would be 64.5 feet, requiring wall heights of at least 66 feet in the stilling basin. A stilling basin length of 265 feet would be provided, which is a little more than four times the sequent depth. The basin floor was set at elevation 119.0.

Although the current cost estimate assumes a lined stilling basin would be used, the quality of the rock in the vicinity of the energy dissipation area is very good and may allow for an unlined design to be considered. The ability to shape a rock excavation into the form of a

stilling basin is somewhat limited but results should be sufficient for adequate energy dissipation to occur. Dimensions of the parabolic drop leading to the basin and the basin proper do not have to be exact to achieve the desired energy dissipation. Although the stilling basin approach to energy dissipation is the most predictable, and would result in far less cleanup and maintenance of the stilling area and around the Main Concrete Dam powerhouse and stilling basin, the option of spreading the flow similar to the Oroville Dam Auxiliary Spillway, and providing a plunge pool was considered; however, the use of a plunge pool has been removed from further consideration due to potential negative impacts to the power plant.

Prior to physical modeling of the auxiliary spillway energy dissipator, more detailed designs will be accomplished for the conventional spillway alternatives and for the conventional stilling basin preceded by the stepped spillway chute. Cost estimates will also be done for each energy dissipation alternative. The costs as well as other considerations will determine which alternative is actually physically modeled.

7-1.6.4 Merging Flows from the Stilling Basins

Physical model studies will be required to insure that flows blending together from the auxiliary spillway and service spillway merge well as they enter the American River, that forces on the auxiliary stilling basin walls are accounted for in wall design, and that the flow regime in the American River does not change dramatically over a broad range of conditions (this could lead to scour of the banks downstream of the confluence of these flows).

7-1.7 OPERATIONS

From a hydraulic viewpoint, the preferred order of making releases (not considering power releases) is the main dam sluices, the auxiliary spillway, the main dam service tainter gates, and finally the main dam emergency tainter gates. The sluices generally should be closed (or at least limited to 60% open) when the service tainter gates on the main dam are opened.

7-1.7.1 General

Model testing from previous studies has led to some observations that must be considered in operating procedures that govern releases through the outlet works or spillways. Of major importance is that balanced gate operations lead to uniform discharges across the width of the stilling basin and minimizes the formation of recirculating currents that can draw abrasive material into the stilling basin.

7-1.7.2 Gate Sequencing during Flood-Control Operations

Design considerations include the following:

- The peak (unregulated) PMF inflow would be about 902,000 cfs. Discharges would always be regulated so that peak inflows are never exceeded.
- For alternatives that modify the outlet works, the existing outlets and powerhouse provide sole release capacity until pool elevation 418.0 (spillway crest), is reached. Even with the

much larger outlets, the objective release of 115,000 cfs sometimes cannot be attained at pool elevation 418. The objective release can only be made when the pool has risen high enough to enable combined releases from the outlet works and service spillway to meet or exceed 115,000 cfs. As the pool rises above pool elevation 418, the service gates would continue to open while the outlets transition to the closed position, thus conserving the cold-water pool.

- As the pool rises to 470.0, discharges would be from the service spillway gates, and would be limited to 160,000 cfs or less. Above pool elevation 470 the emergency spillway gates must be opened, else they would overtop (top of closed gates are at elevation 471.0). Prior to opening of the emergency gates, a tailwater needs to build up to prevent excessive damage to the area just downstream of the flip bucket. The Corps has been assuming that a tailwater from a total discharge of 300,000 cfs needs to be obtained. This would require free flow thru the service gates and this cannot currently occur due to physical operating constraints on the gates. Therefore, the dam releases can only be ramped up to 240,000 cfs before the gates are opened, and any damage below the flip bucket must be considered acceptable. The Corps' assumption that a tailwater buildup from 300,000 cfs is being re-assessed. However, for alternatives that include an auxiliary spillway with STGs, the 300,000 cfs can easily be attained before opening the emergency gates.

- For alternatives with an Auxiliary Spillway, the existing outlets in the dam would be the sole release capacity until pool elevation 368.0 (sea invert elevation of the Auxiliary Spillway) is reached. Power releases likely would be made during this time but (conservatively) were not included in the continuing scenario.

- As pool elevation 368.0 is exceeded, the Auxiliary Spillway gates would begin to discharge, and before the pool reaches elevation 418 (Main Concrete Dam spillway crest), total combined discharge from the outlets and the Auxiliary Spillway could exceed 100,000 cfs. The transition can then be made from combined existing outlets and auxiliary spillway STGs releases to combined releases through the main dam service tainter gates and the auxiliary spillway STGs.

- The service spillway gates must be opened partially before they are overtopped. The top of closed service spillway gates is at elevation 468.0. Because of this requirement, during the pool elevation's rise to elevation 467.0, the Auxiliary Spillway gates would transition to the closed position and the five service tainter gates would open as necessary to maintain a 115,000 cfs objective release. From pool elevations 467.0 to 470.0, discharges would be from the service spillway gates, and would be limited to 160,000 cfs or less. Above pool elevation 470 the emergency spillway gates must be opened, else they would overtop (top of closed gates are at elevation 471.0). Utilizing the 300,000 cfs figure operating criteria above, opening the emergency gate requires a total release of 300,000 cfs. Therefore, the dam releases must be ramped up to 300,000 cfs before the gates are opened. This can best be accomplished by opening the Auxiliary Spillway gates to supplement flows from the service gates. At maximum flood pool elevation 477.5, discharges from the dam would be about 365,000 cfs from the Main Concrete Dam services gates, 220,000 cfs from the Main Concrete Dam emergency gates, and 155,000 cfs from the Auxiliary Spillway gates. It is conservatively assumed that the outlet works and powerhouse would not provide discharges for extreme events. The alternative with an auxiliary spillway control structure housing four

17'-7" by 33' STGs in this report would not be capable of passing the PMF without overtopping the dam. The PMF has a peak inflow of about 903,000 cfs.

7-1.8 EROSION CONTROL REQUIREMENTS

The erosion potential of flows exiting auxiliary spillway and sequencing of combined flows from service/auxiliary/emergency spillways has to be considered and minimized as practical. This is especially true of the "gates full open" discharges as the pool elevations approach maximum pool elevations. Physical model tests will serve as an aid to assess erosion potential, problems, and solutions.

7-1.8.1 Potential for Downstream Scour

Scour is the result of the erosive action of flowing water that attacks the bed and banks of streams and the piers and abutments of bridges. Different materials scour at different rates. Loose granular soil is rapidly eroded by flowing water, while cohesive/cemented soil and rock are more scour-resistant. Ultimately, over a long period of time, scour can be as deep for rock as for sand-bed streams.

Altered flow patterns due to the auxiliary spillway may impact the river channel as it exits the stilling basin(s), and for some distance downstream. Potential maximum discharge from the dam would increase with an auxiliary spillway, although frequent flood discharges would remain essentially unchanged. An important design consideration is to determine if the altered flow patterns and increased potential discharges (and discharge duration) would attack the rock and result in excessive scour. The powerhouse road area and the new Folsom Dam Road Bridge are areas of concern.

If the model studies indicate that high velocity flows could attack and scour rock to an extent that is not acceptable, further assessment of rock scour potential would be done by expanding on the previous studies done by Kleinfelder (2005-2006 study on rock scour potential in the exit channel) to include other areas, such as below the auxiliary spillway exit and the chute area, if it is unlined. Annandale's Erodibility Index methodology would again be used for evaluation (2005).

The cost estimate includes costs for grouting (stabilizing) existing rock in the powerhouse road area under the assumption that additional scour could result from the project.

7-1.9 DOWNSTREAM CHANNEL CAPACITY

The physical capacity of the American River to safely transport flows depends on the downstream levee system. Prior to 1956 (completion of construction of Folsom Dam), the north levee of the American River extended upstream from the Sacramento River to approximately the Cal Expo area, a distance of about 5 miles. This levee and the south levee of the American River were designed to pass a flow of 180,000 cfs (USACE, 1957). The south levee of the American River extended upstream from Cal Expo at that time but did not have a defined capacity because the north levee was not yet constructed. Presumably, flows up to and greater than 180,000 cfs diverted to the north and the south levees would have been able to protect against very high

flows. In conjunction with completion of the Folsom Dam project, USACE extended the north levee of the American River upstream approximately 8 miles to high ground. This levee was designed to equalize protection for areas north and south of the American River. The levees were designed to pass the most severe conditions of either a flow of 115,000 cfs with 5 feet of freeboard on the levee, or 152,000 cfs with 3 feet of freeboard on the levee. The former condition (115,000 cfs) controlled the levee heights downstream from the H Street bridge while the latter condition (152,000 cfs) controlled levee heights upstream from the H Street bridge (USACE, 1957). Regardless of levee design criteria, Folsom Dam has in the past been operated to control flood releases to 115,000 cfs. This is defined as the "objective" flood release for the project. Since completion of Folsom Dam, the "objective" flood release of 115,000 cfs was exceeded only in 1986. The maximum flow during that flood was 134,000 cfs.

The "objective" release remains 115,000 cfs, that is, normal flood operations would limit downstream flows to 115,000 cfs. With construction of the alternatives discussed herein, Folsom Dam outflows would not exceed 115,000 cfs for all historic floods of record, and also for a Design Flood that has a 1 percent chance of being exceeded in a given year (100-Year Design Flood). For floods larger than the 100-Year Design Flood, maximum outflows would increase. For the 200-Year Design Flood, Folsom Dam maximum outflows would increase to, but not exceed 160,000 cfs.

The Common Features Project (Federal Legislation, 1996) involves strengthening and raising American River levees to safely pass a flow of 160,000 cfs. Most of this work has been completed. Specifically, the levees are being improved to be structurally sound and competent to pass flows of 160,000 cfs. The maximum safe discharge capacity of the American River was assumed to be 160,000 cfs by the PASS Study team, for which downstream areas which could flood would commence evacuation procedures.

Some members of the project design team have expressed concern about possible lateral erosion of the river channel if flows of 160,000 cfs were made for an extended duration (up to 4 days). A study has been initiated to determine the measures required to safely pass the occurrence of a flow of 160,000 cfs for duration of up to 48 hours. This study will assess the stability of grass-lined levee slopes, critical bank erosion sites, and erosion-resistant geologic formations in the channel bed. It also will identify long-term monitoring and maintenance required to sustain the lower American River's ability to convey 160,000 cfs for an extended duration in any given year.

To understand the impact a reduced maximum safe flow would have on project performance, maximum capacities of 115,000 cfs and 145,000 cfs also were analyzed by the PASS Team. These flood routings are contained in the PASS report, Appendix B, Tables B4-1 through B4-5.

7-1.9.1 Potential for Levee Breaching

Investigation of potential levee breaching in currently underway but has not been completed. Potential levee breaching is most likely to occur at the locations where the rising water surface attains an elevation equal to that of the predicted Probable Non-Failure Point (PNP) and then continues rising towards the Probable Failure Point (PFP), the elevation where

the levee is very likely to have failed. These locations and determination of the PNP and PFP are based on site investigations, models, and engineering and geotechnical judgment, as are the levee breaching scenarios, the extents of the potential levee breaks and the judgment of existing levee reliability.

7-1.10 HYDRAULIC IMPACT ON DOWNSTREAM WATER SURFACE

This requires investigation by utilizing existing or new numerical models to investigate whether new operations implemented due to the increased discharge capacity of the project will cause any changes to the maximum water surfaces downstream for the design storm events.

7-1.11 CONSTRUCTION CONTRACT CONSIDERATIONS

The primary area of concern in construction of the auxiliary spillway is the impact as large storm events pass through the system. Even moderate releases from the main spillway could have impacts on construction of the auxiliary stilling basin. High reservoir water surfaces effect excavation of the approach channel.

7-1.12 MODEL STUDIES (REQUIREMENTS & RESULTS)

Hydraulic features of the auxiliary spillway that would require physical model tests include the Folsom Main Concrete Dam spillway (overflow crest and downstream chute, stilling basin/flip bucket, exit channel, and exit of sluices) and the auxiliary spillway (approach channel, control structure, chute, and energy dissipation area).

7-1.12.1 Numerical Model

A physical model at a suitable scale that would include enough of the reservoir to establish whether satisfactory approach conditions to the structure occur would be impractical. Therefore, a 2D numerical model will be performed as well, providing boundary conditions to implement in Full Model 1 described below.

7-1.12.2 Full Model 1

A full physical model is required for ensuring hydraulic performance. The model will be of the auxiliary spillway structure (approach channel, structure, upper chute). Model data that leads to inconclusive results may require a later sectional model and/or numerical model of intake and gate passage.

7-1.12.3 Full Model 2 and Possible Full Model 3

A full model of the converging flows from the service spillway, auxiliary spillway and emergency spillway is also required for ensuring hydraulic performance. If the auxiliary spillway energy dissipator is a conventional spillway, the scale of this model be such that both the merging flows and the auxiliary stilling basin can be accurately modeled. If a stepped

spillway leading to a conventional stilling basin is the selective energy dissipation alternative, a separate model may be required for the energy dissipator.

7-1.12.4 Possible Sectional Model 1

A sectional model test of at least one existing outlet exit portal with at least two spillway gates will be performed if an alternative incorporating the existing outlets is selected. This would be for the purpose of lifting the current 60% opening restriction on the outlet gates when the service gates are operating. For any of the alternatives incorporating an auxiliary spillway with submerged tainter gates, this model will not be necessary since the gain in outlet discharge capacity isn't significant compared to the capacity of the auxiliary spillway.

7-1.13 PROTOTYPE TESTING & MONITORING

Consideration will be given to installing instrumentation in the prototype, with suitable monitoring to verify key hydraulic performance parameters used in the hydraulic model studies. Given the size and public visibility of the project, installing instrumentation during construction would provide a useful tool to verify the performance of the Prototype. Locations that are accessible in the prototype will be instrumented to compare with instrumentation in the model studies.

7-1.14 INUNDATION MAPS FOR FLOOD EMERGENCY ACTION PLANS

The inundation maps for emergency action plans should be updated based upon the increased release capacity of Folsom Dam.

FEMA Publication 64, "Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners", indicates that three (3) inundation maps should be developed for the area below dams.

(1) Dam failure at the normal everyday pool elevation (Sunny Day Failure)

(2) Maximum spillway discharge at a maximum flood pool

(3) Maximum discharge at the PMF condition

Also, in some cases, the spillway or outlet works discharge where flooding starts should be indicated.

7-1.15 REFERENCES

- ESA Consultants, Inc., Folsom Dam Improvements, Mini Raise, Preliminary, 24 August 1994.

- Murray, Burns, and Kienlen (MBK) Consulting Civil Engineers, Folsom Dam Modification Report New Outlets Plan, February 1998.

- Pinto, N.L. de S., and Neidert, S.H., Model Prototype Conformity in Aerated Spillway Flow, International Conference on Hydraulic Modeling of Civil Engineering Structures, BHRA, Coventry, 1982.

- U.S. Army Corps of Engineers, American River Watershed, California, Information Paper, August 1999.

- U.S. Army Corps of Engineers, Hydraulic Design Criteria, November 1987.

- U.S. Army Corps of Engineers, Hydraulic Design of Reservoir Outlet Works, Engineering Manual 1110-2-1602, 15 October 1980.

- U.S. Army Corps of Engineers, Sacramento District, American River Watershed, CA, Folsom Dam Modification Project, Final Limited Reevaluation Report, August 2001.

- U.S. Army Corps of Engineers, Sacramento District, American River Watershed, CA, Folsom Dam Modification Project, Gate Size Decision Technical Memorandum.

- U.S. Bureau of Reclamation, Air-Water Flow in Hydraulic Structures, Engineering Monograph No. 41, December 1980.

- U.S. Bureau of Reclamation, Aeration Enhancements at the Folsom Dam Outlet Works: Reducing Cavitation Damage Potential, April 1998.

- U.S. Bureau of Reclamation, Cavitation in Chutes and Spillways, Engineering Monograph No. 42, April 1990.

- U.S. Bureau of Reclamation, Folsom Dam Spillway Stilling Basin Rehabilitation, TM No. FOL-8130-REH-96-1, September 1996.

- U.S. Bureau of Reclamation, Hydraulic Model Studies of the Folsom Spillway-Outlet Junction, REC-ERC-71-12, USBR, 1971. (Isbester, T.J.)

- Twiss, Donald E., and Sarvary, David J. March 1985. "Water-Surface Profiles, Rectangular and Trapezoidal channels," USDA Soil Conservation Service, Davis, CA.

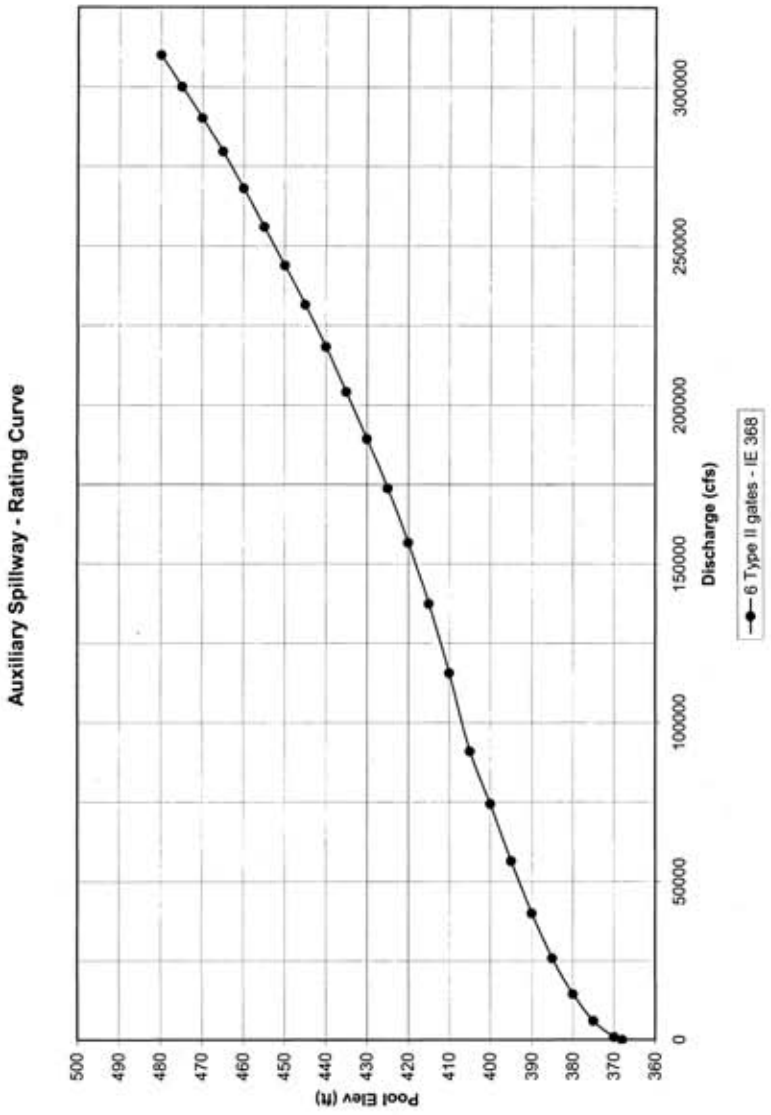


Figure 7-1.1 Folsom Dam – Discharge Capacity – Auxiliary Spillway

A2-24

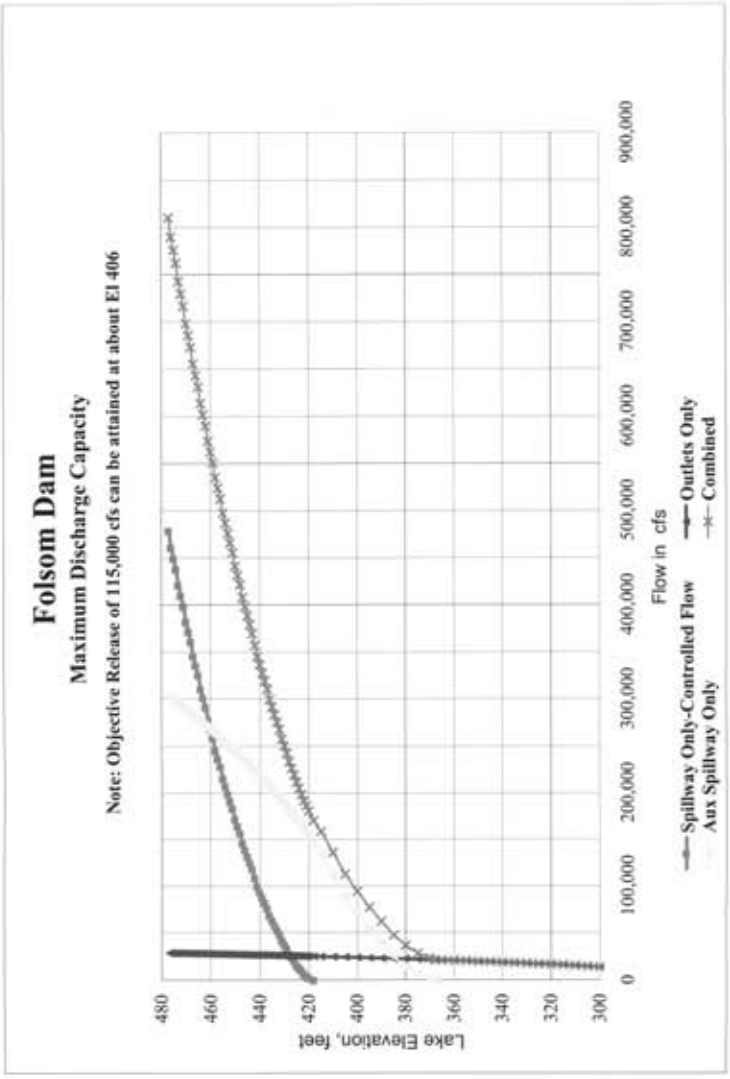


Figure 7-1.2 Folsom Dam - Maximum Discharge Capacity

A2-25

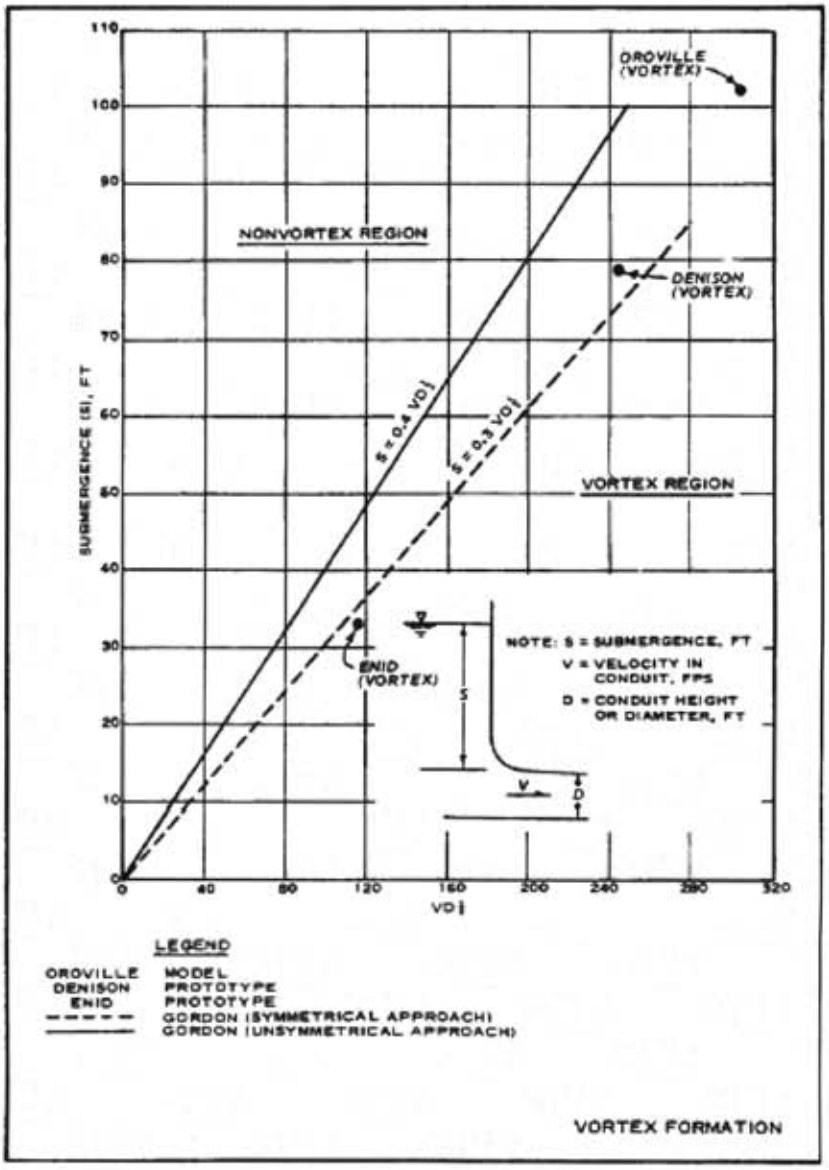


Figure 7-1.3 Plate C-35, EM1110-2-1602 Hydraulic Design of Reservoir Outlet Works.

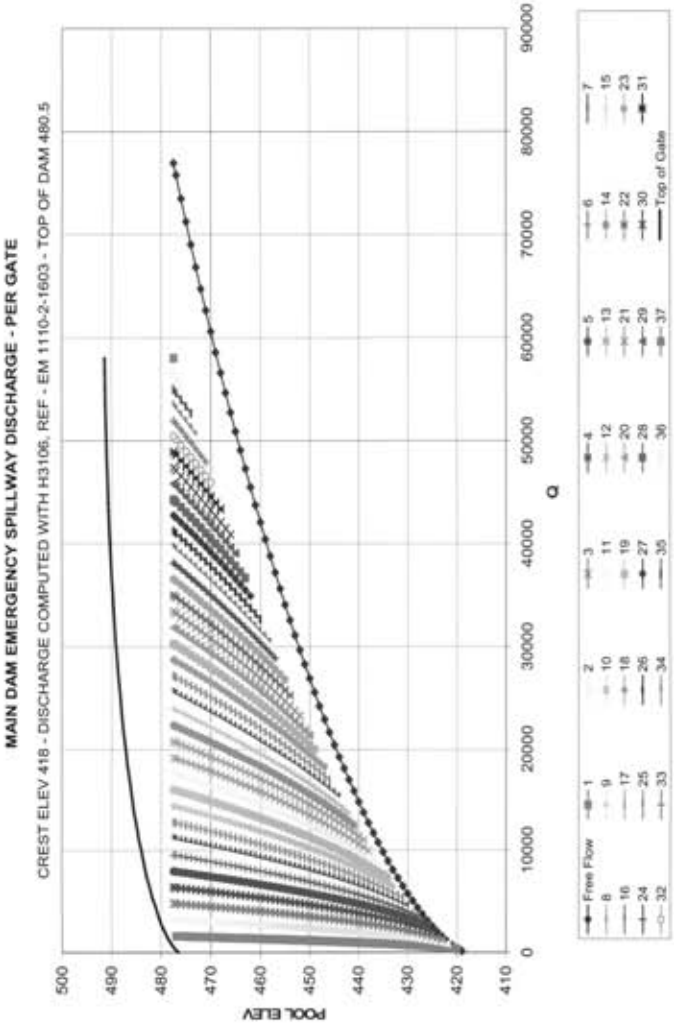


Figure 7-1.4 Emergency Spillway Gate Rating Curve.

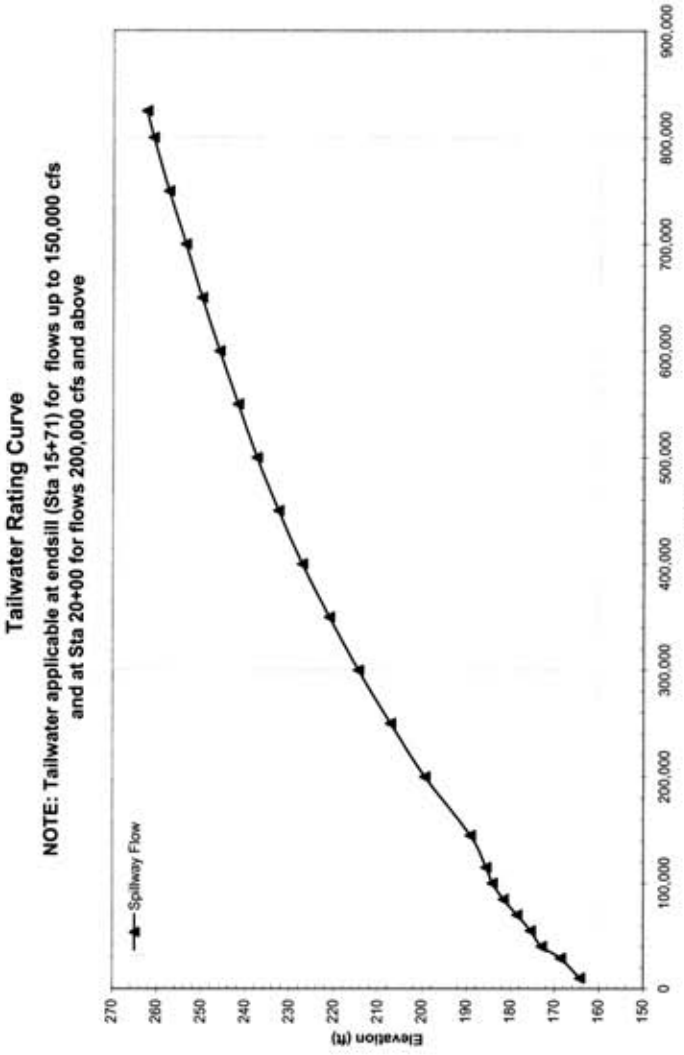


Figure 7-1.5 Tailwater curve, Combination of CORPS curve and data taken from 1:36 model.

A2-28

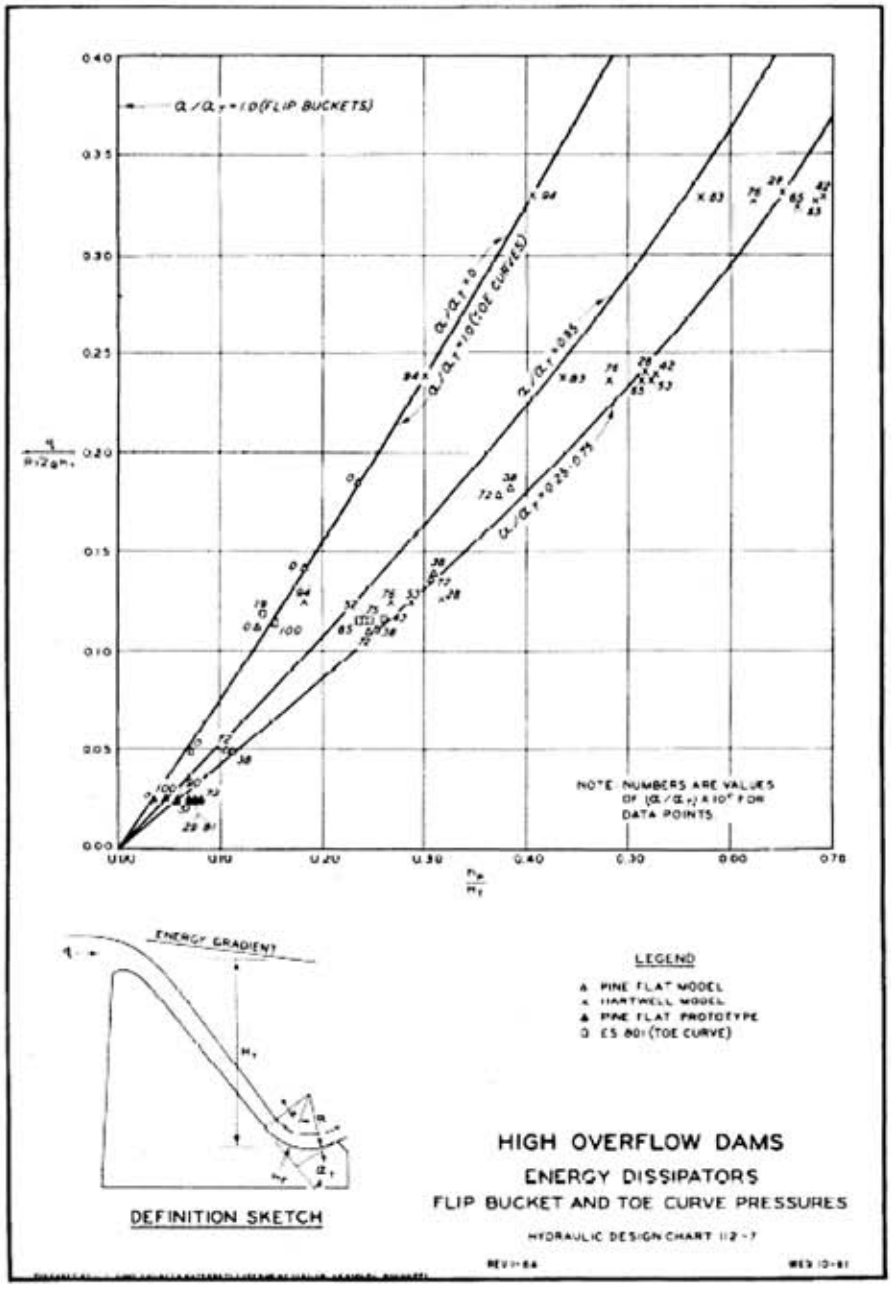


Figure 7-1.6 – HDC Plate 112-7 – Flip Bucket and Toe Curve Pressures

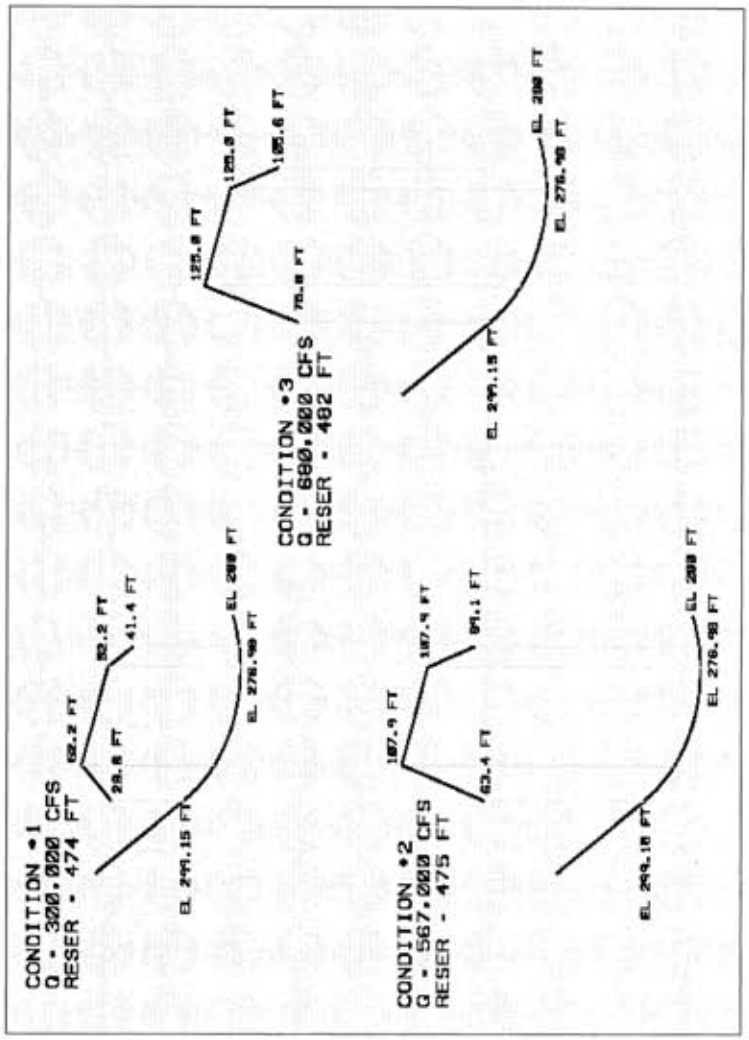


Figure 7-1.7 Flip bucket pressures for emergency spillway, based on Chart HDC 112-7.

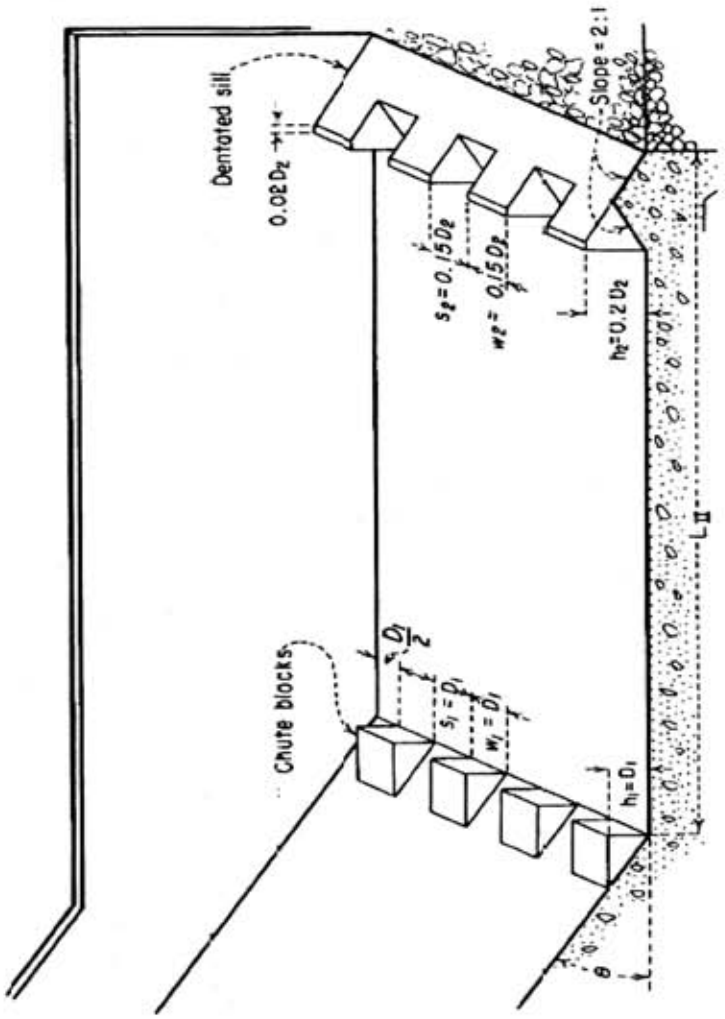
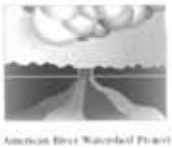


Figure 7-1.8 Type II Basin.

A2-31



Post Authorization Change Report

American River Watershed Project

Folsom Dam Modification and
Folsom Dam Raise Projects

Appendix B
Folsom Dam Raise Project
Engineering Documentation Report



US Army Corps of Engineers

Sacramento District
South Pacific Region

March 2007

EXECUTIVE SUMMARY

This Engineering Documentation Report (EDR) is an engineering refinement and technical implementation document to support the Post-Authorization Change (PAC) report of the authorized Folsom Modification and Folsom Dam Raise Projects to be implemented by the United States Army Corps of Engineers, Sacramento District (Corps). This EDR focuses on the flood damage reduction features for the authorized Folsom Dam Raise Project. The Folsom Dam Raise Project is premised upon the Folsom Modification Project being in place. Proposed changes to the Folsom Modification flood damage reduction project features, along with recent changes in dam safety priorities of the United States Department of the Interior, Bureau of Reclamation (Reclamation), necessitate a re-evaluation and coordination of the flood damage reduction features of the Folsom Dam Raise Project to ensure compatibility and greater efficiency between the two flood damage reduction project authorities and Reclamation's dam safety objectives. This report documents re-evaluation of the engineering aspects of the authorized Folsom Dam Raise Project and other flood damage reduction alternatives considered in conjunction with the proposed changes to the Folsom Modification Project. This EDR focuses on cost efficiency and performance of the alternatives that best integrate the proposed Folsom Modification Project and Folsom Dam Raise Project authorities.

The primary objectives of the Folsom Dam Raise Project are: (1) flood damage reduction, (2) ecosystem restoration, and (3) construction of a permanent bridge. The flood damage reduction elements of the Folsom Dam Raise Project enhance the utilization of the existing flood storage capacity as well as increase the flood storage capacity of the reservoir.

Key design considerations include constructibility and environmental considerations. Constructibility considerations include: (1) availability of all service spillway gates for releases at 24 hours notice; and (2) avoidance of disturbance of existing utilities and dam operations to the extent practical. Environmental considerations include: (1) utilization of best management practices to limit disruption of aquatic habitat and turbidity resulting from construction operations; (2) construction impacts on existing habitat and fish should be minimized; (3) habitat restoration should be designed to provide more extensive shaded riverine aquatic habitat; (4) installation of in-channel woody structures, boulders, and other in-channel elements should be considered to reduce flow velocities and/or to create eddies, scour holes, or pools to restore fish habitat; (5) environmental restoration along the top of banks should include the use of native trees, shrubs, and grasses; and (6) noise and air quality factors from construction activities should be considered.

PROJECT DESCRIPTION

The Folsom Dam Raise Project was authorized in the Energy and Water Development Appropriation Act of 2004 based on recommendations contained in the November 2002 Chief of Engineers' Report that were based on findings in the 2002 Long-Term Study. Under the original authorized plan, the main concrete dam, the left and right embankment wing dams, Mormon Island Auxiliary Dam (MIAD), and the eight dikes would be raised 7

feet, adding approximately 93,000 acre-feet of flood storage capacity to the reservoir. In addition, the five main dam service tainter gates and the three main dam emergency tainter gates would be replaced.

Since authorization, the Folsom Dam Raise Project has been subject to cost increases due to increases in construction material costs, a decrease in the availability of contractors, and safety and security considerations at the dam. Efforts are moving forward on design and advanced implementation of the Folsom Bridge, which is scheduled for completion in December 2008. Efforts to raise Folsom Dam have continued, but at a slower pace; any dam raise needs to be considered concurrently with other features required to modify the dam and appurtenances for both flood damage reduction and dam safety. Recent studies related to the Folsom Dam Raise Project focus on compatibility and greater efficiency for the flood damage reduction projects and Reclamation's dam safety objectives.

An engineering *Project Alternative Solutions Study (PASS)* was conducted jointly by the Corps and Reclamation in 2005 as well as other stakeholders including the Sacramento Area Flood Control Agency (SAFCA), State of California Department of Water Resources (DWR), and the State of California Reclamation Board (State Reclamation Board). A follow-up study, PASS II, was completed in 2006 as documented in the *Folsom Dam Raise and Auxiliary Spillway Alternative, Project Alternative Solutions Study (PASS) II*, dated June 2006. This study presented an engineered evaluation of an auxiliary spillway alternative consisting of four submerged tainter gates (STGs) along with a 7-foot dam raise. Optimization efforts of the PASS II alternative identified additional alternative variations of the four- and six-STG auxiliary spillway and dam raise, with and without emergency spillway gate replacement.

The six-STG auxiliary spillway is assumed to be a without-project condition for the Folsom Dam Raise Project as an assumption that it will have been previously implemented under the new Folsom Modification Project. The alternatives considered in this report consist of various combinations of the Folsom Dam Raise Project flood damage reduction features of a raise and the replacement of spillway gates. Replacement of the main dam spillway gates would provide increased flood protection and raising the top of dam would add flood storage capacity to the reservoir creating increased flood protection. The following six alternatives are discussed in this EDR.

- Six-enlarged main dam outlets plus two new main dam outlets and two existing main dam outlets; seven-foot dam raise; all eight spillway gates replaced (baseline for functionality comparison)
- Six-STG auxiliary spillway with three emergency spillway gates replaced
- Six-STG auxiliary spillway with 3.5-foot dam raise
- Six-STG auxiliary spillway, a 3.5-foot dam raise, and three emergency spillway gates replaced
- Six-STG auxiliary spillway, 3.5-foot dam raise, and all eight spillway gates replaced
- Six-STG auxiliary spillway; 7-foot dam raise and all eight spillway gates replaced

A tabular summary of the Folsom Dam Raise Project alternatives is presented in **Table ES-1**. The table provides information on the array of alternatives representing both the modification and the raise authorizations, the first cost and the annual cost for each of the alternatives, the performance for each, and the design flood event that the alternative passes. Please note that the costs provided in the table below are for cost screening purposes only. The first cost and annual costs presented in the table do not match the MCACES estimates provided for the same alternatives. The alternative that demonstrates approximately equal or greater performance, at an equal or lesser cost to the baseline plan, is the 3.5-foot raise along with replacement of the three emergency tainter gates. The design aspects and construction considerations of this alternative are described in this report.

TABLE ES-1
FOLSOM DAM RAISE PROJECT ALTERNATIVES

Alternative Description	Functionality Compared to the Authorized Projects	First Cost	Annual Costs	Performance (Inverse of AEP)	Design Event Passes
		(millions)	(millions)	(1:X chance)	(years)
Six Enlarged plus Two New and Two Existing Main Dam River Outlets; 7-foot Raise; Eight Main Dam Tainter Gates Replaced (Baseline)	Baseline	$1,236	$67.0	189	250
Six-STG Auxiliary Spillway; Three Emergency Tainter Gates Replaced	Significant, but not quite equal	$930	$52.4	156	200
Six-STG Auxiliary Spillway; 3.5-foot Raise	Significant, but not quite equal	$962	$52.9	167	220
Six-STG Auxiliary Spillway; 3.5-foot Raise; Three Emergency Tainter Gates Replaced	About Equal	$1,005	$55.6	185	240
Six-STG Auxiliary Spillway; 3.5-foot Raise; all Eight Main Dam Tainter Gates Replaced	About Equal	$1,073	$59.5	182	240
Six-STG Auxiliary Spillway; 7-foot Raise; all Eight Main Dam Tainter Gates Replaced	Greater	$1,457	$85.3	213	275

HYDROLOGY AND RESERVOIR OPERATIONS

This report presents the Corps' understanding of the hydrology of the Folsom Dam area, including a discussion of design floods and probable maximum floods (PMFs). Also discussed are reservoir operations currently, and as they would be modified for various alternatives examined for the Folsom Dam Raise Project.

Table ES-2 outlines some of the basic assumptions adopted as water control diagram (WCD) or emergency spillway release diagram (ESRD) operational criteria.

TABLE ES-2
WATER CONTROL DIAGRAM AND EMERGENCY SPILLWAY RELEASE DIAGRAM

Condition	Outflow Restriction
Maximum objective release allowed by WCD (larger releases may be initiated by ESRD)	115,000 cfs
Maximum allowable rate of release change Increases: When discharge is greater than 20,000 cfs and less than or equal to 160,000 cfs When discharge is greater than 160,000 cfs Decreases: When discharge is greater than 20,000 cfs	 15,000 cfs/hour Unlimited 5,000 cfs/hour (decrease)
Maximum outflow allowed by WCD or ESRD	Do not exceed maximum inflow experienced during flood event
Release limitation if the actual or forecasted inflow is greater than 25,000 cfs and less than 150,000 cfs and reservoir is less than 20 percent encroached	Limit outflow to 60 percent of the maximum inflow experienced during the flood event
Maximum power available or relied upon for flood operations	Power penstocks would be assumed to have zero release capacity during all routings
Physical limitation of existing emergency spillway gates	Emergency spillway gates are not used until either the total outflow from the dam exceeds 240,000 cfs or the pool elevation is within 1 foot of overtopping the emergency gates while in the closed position
Release requirements (115,000 cfs to 160,000 cfs) based on Accelerated Transition Zone conditions as outlined on the proposed ESRD: if current inflow is greater than 200,000 CFS and the 12-hour forecasted inflow is greater than 360,000 cfs if current inflow is greater than 250,000 cfs and the 12-hour forecasted inflow is greater than 370,000 cfs if the current inflow is greater than 270,000 cfs and the 12-hour forecasted inflow is greater than 370,000 cfs	 Increase release to 130,000 cfs Increase release to 145,000 cfs Increase release to 160,000 cfs
KEY: WCD – Water Control Diagram ESRD – Emergency Spillway Release Diagram cfs – cubic feet per second cfs/hour – cubic feet per second per hour	

Design of the existing ESRD restricts a maximum discharge of 160,000 cfs when the reservoir's pool reaches elevation 470. Once the reservoir water surface exceeds elevation 470, the ESRD allows releases to be increased above the 160,000 cfs limitation. However, releases cannot be made through the three emergency spillway gates until discharge in the stilling basin reaches 240,000 cfs, at least not without incurring damages. The contradiction

in the ESRD is that it prohibits obtaining a discharge of 240,000 cfs until the pool rises above elevation 472. When the emergency tainter gates are closed, the top of the gates is elevation 471. The routing model can force operation of the emergency tainter gates. The water surface must be within 1 foot of the top of the gates for this to occur. Sufficient tailwater is required to prevent erosion below the emergency spillway chute and adjacent areas. Although the existing ESRD does not require a discharge of 240,000 cfs until the pool rises above elevation 472, the dam operator can choose to make larger releases sooner. The effect of this is that above elevation 471, water will begin to flow over the top of the emergency spillway gates if they are not opened; possibly causing damages, failure, or making the gates inoperable.

A large number of alternatives were screened to determine which alternative best serves as the with-project condition. The configurations included various combinations of outlet modifications, an auxiliary spillway with STGs, conventional tainter gates, a fuseplug, and a dam raise. The various gate combinations were analyzed at differing sill elevations. Combinations of modifications to the main dam outlets were also analyzed, and advance release criteria were incorporated into the release decisions. Of the numerous configurations considered, this document focuses on the with- and without-project conditions listed below:

- Folsom Modification Project as outlined in Appendix A without-project condition
- No auxiliary spillway, 7.0-foot dam raise, emergency and service gate replacement, original authorization, with-project condition
- 3.5-foot dam raise, emergency gate replacement, with-project condition
- 7.0-foot dam raise, emergency and service gate replacement, with-project condition

The resultant maximum elevations, obtained through routing the PMF through each of the proposed alternatives is provided in **Table ES-3**.

TABLE ES-3
MAXIMUM PROBABLE MAXIMUM FLOOD ELEVATIONS

Without-Project Condition		
	Maximum Elevation	
Alternative	**PMF**	**Top of Dam**
Folsom Modification Project as outlined in Appendix C	477.4	480.5
With-Project Condition		
No auxiliary spillway; 7.0-foot dam raise; emergency and service gate replacement; original authorization	484.5	487.5
3.5-foot dam raise; emergency gate replacement	478.8	484.0
7.0-foot dam raise; emergency and service gate replacement	484.1	487.5
Key: PMF – Probable maximum flood El, feet – Elevation in feet		

ENVIRONMENTAL EFFECTS AND MITIGATION

An examination of environmental effects from construction of the Folsom Dam Raise Project are discussed. Several previous environmental documents are relevant to the impact analysis for the main dam outlet modification alternatives. These documents provided information about existing environmental, socioeconomic, and cultural conditions in the area; the effects of various actions on the resources in the area; and potential measures to avoid, minimize, reduce, or compensate for any significant effects using best management practices. Resources studied include hydrology, water quality, groundwater, water supply, air quality, aquatic resources, terrestrial vegetation and wildlife, soils, minerals, geological resources, visual resources, agricultural resources, and transportation.

Environmental effects were found to be less than significant with the following exceptions:

- **Air Quality:** Exhaust and fugitive dust emissions from construction and hauling equipment would cumulatively produce a significant air quality impact. Nitrogen oxide (NOx) emissions would trigger a general conformity evaluation, from which mitigation measures would be developed to reduce air quality impacts.
- **Terrestrial Vegetation and Wildlife:** Construction would have the potential to adversely affect special status plant or animal species, protected oak woodlands, native vegetation, and wetlands. These impacts would require compensatory mitigation as per the U.S. Fish and Wildlife Service biological opinion.
- **Soils, Minerals, and Geological Resources**: Construction activities would result in the loss of topsoil resources that would be mitigated to less than significant levels through the implementation of best management construction practices. Use of

granitic material from within the reservoir for raising the dikes and MIAD would represent a long-term commitment of this resource. The schist-based bedrock comprising the borrow material east of Dike 7 contains low levels of asbestos, and if utilized, would be managed to reduce air borne release of asbestos fibers.

- **Transportation and Circulation:** The hauling of materials and supplies to the project sites would not have a significant impact on the level of service for most local roadways except for Scott Road north of White Rock, and East of Natoma Street. This impact would be mitigated as feasible.
- **Noise:** Nighttime noise increase at three residential receptor areas would exceed ambient noise criteria creating an unavoidable adverse impact, should mitigation measures not be effective in reducing noise levels.
- **Cultural Resources:** Cultural resources are known to exist at many locations proposed for staging and facility construction, and could be disturbed or destroyed under any of the action alternatives. Cultural resources staff would prepare a determination of potential impacts and consult with the State Historic Preservation Office (SHPO). Cultural resource impacts would be evaluated and mitigated for under a programmatic agreement in consultation with the SHPO.
- **Recreation**: Contractor staging would emphasize use of areas with no current public access, away from residential areas. Excess materials would be used to create platforms above the normal operating reservoir water surface at elevation of 466.0 and would be placed so as to maintain existing or equivalent public recreation access and use capacity during the peak recreation season.

  To minimize potential impacts to recreation, staging areas at Beal's Point and Folsom Point would be placed on constructed platforms or on adjacent unimproved areas a safe distance from primary recreational activities. Public safety would be maintained through the use of fencing or other similar measures. There would be nearly continuous public access to recreation areas and trails throughout the construction period through the use of traffic control measures, grade separated vehicular and/or pedestrian crossings, and/or temporary alternate public access detours. Closures could occur while the Partner Agencies are implementing these new measures that allow continued access or to address public safety and facility security objectives. In such cases, temporary closures would be accomplished during off-peak days or the off-season to minimize impacts on recreation activities. Reclamation's Central California Area Office would notify local agencies and the general public and accept input in advance of any possible extended closure(s) that may be necessary due to unforeseen project circumstances.

GEOTECHNICAL INVESTIGATIONS AND CONSIDERATIONS

A summary is presented of engineering geology and geotechnical information available that is pertinent to the proposed Folsom Dam Raise Project. Included are the available data, the relevant interpretations, and a summary of these findings as they apply to

the proposed project elements. This report describes geologic, seismic, and geotechnical information available within the project area, along with a summary of those findings.

Two methods are being considered to accomplish the authorized 7-foot raise of Folsom Dam. The first method would be to raise the earthfill dams and dikes through placement of fill derived from the auxiliary spillway excavation and/or from borrow areas situated within and bordering on the perimeter of the reservoir. The second method would be construction of a 3.5-foot high reinforced concrete flood wall in combination with a 3.5-foot embankment raise. An alternative to the combination flood wall/embankment raise method would be to construct a dual wall system with engineered fill placed between the wall sections. For this report the dual wall system would be limited to the left and right wing dams while a conventional earthfill raise would be used for all other dikes and MIAD. The cost estimate will include a combination of the two methods based on assumptions about the most likely method to be used for each dike or dam site. Processed materials for riprap, road base, and fine and coarse filters would be obtained either from commercial sources in the area, or from an on-site processing plant that may be established if found to be economically feasible. The current cost estimate assumes these materials would be obtained commercially.

The proposed auxiliary spillway represents a major component of the Folsom project and would consist of an approach channel, a six-STG control structure, a concrete lined rectangular chute downstream from the new control structure, and an energy dissipater (either a concrete-lined stilling basin or an unlined plunge pool). Assuming the auxiliary spillway represents the without-project condition, a smaller (3.5-foot) raise was investigated. Two methods are being considered to accomplish the 3.5-foot raise. The first method would be to raise the earthfill dams and dikes through placement of fill derived from the auxiliary spillway excavation and/or from borrow areas situated within the reservoir. The second method would be to construct a 3.5-foot high reinforced concrete floodwall that would be placed near the waterside edge of the existing embankment crests.

To date, geotechnical studies have concentrated on type, source, and quantity of materials required for raising the left and right wing dams, Dikes 1 through 8, and MIAD based on preliminary raise design concepts. A comprehensive investigation is currently underway for the auxiliary spillway, including exploratory boreholes, laboratory testing, geological mapping, and geophysical testing.

DESIGN AND CONSTRUCTION CONSIDERATIONS FOR THE FOLSOM DAM RAISE ALTERNATIVE

The proposed Folsom Dam Raise alternative consists of a 3.5-foot dam raise and the replacement of the three existing emergency tainter gates on the main concrete dam. This alternative provides much of the functionality that would have been achieved by the authorized Folsom Dam Raise Project. The 3.5-foot dam raise component would consist of a cast-in-place, reinforced concrete wall located near the reservoir side of the crest of each of the dikes, the left and right wing dams and MIAD. The existing access ramps crossing the dikes would be raised 3.5 feet to match the concrete crest wall height. The three new tainter gates would be 42 feet wide by 56 feet 10 inches tall and would include extension of the piers supporting the trunnions and relocating the trunnions. Design considerations and

performance are discussed, including hydraulic, civil, structural, mechanical, and electrical design. Also discussed are construction considerations, cost and schedule to implement the project.

- **Hydraulic Design -** The main objectives of the Folsom Dam Raise project are to ensure that hydraulic performance is acceptable, adequate design provisions are made for the additional head and increased flow capacity of the spillway, the stilling basin(s) function satisfactorily at design flows and without excessive damage at higher flows, and combined releases from the service spillway, auxiliary spillway, and emergency spillway can be made without complex operational constraints.

  The dam discharge facilities include the powerhouse, main dam river outlet works, service spillway and emergency spillway, in addition to the (assumed pre-project condition) auxiliary spillway. Flows from any or all of these facilities merge together downstream of the dam and provide the majority of flow for the lower American River. The design discharge for a spillway is the discharge that can be passed at the maximum pool. Discharges would be controlled by the gates for the full range of reservoir head unless all eight tainter gates on the main dam crest are replaced, in which case free-flow will be allowed for extreme discharges.

  For the main dam spillway, average velocities through the gates would be over 40 feet per second (fps) for controlled releases at the maximum pool elevation 481. For the auxiliary spillway, the average velocities through the gates and conduits with the gates fully open will be as high as 68 fps. Velocities in the chute and drop to the stilling basin would also have supercritical flow and velocities would be very high. Certain hydraulic elements that may require modification include the existing tainter gates, the existing bridge over the main dam spillway, the existing spillway crest, the existing flood control river outlet exit portals, and the main dam stilling basin. The main dam stilling basin is the energy-dissipating device for flows from the main dam outlet works and spillway service gates. Physical model studies would be required to ensure that flows blending together from the auxiliary spillway and service spillway merge well as they enter the American River, that forces on the auxiliary stilling basin walls would be taken into account for in wall design, and that the flow regime in the American River would not change dramatically over a broad range of conditions (this could lead to scour of the banks downstream of the confluence of these flows). It appears that the existing main dam stilling basin length would be adequate if releases from the main dam service gates and the proposed auxiliary spillway are coordinated and optimized for hydraulic jump action in the existing basin. However, model tests may show that some lengthening of the stilling basin is desirable. During earlier studies for the Folsom Dam Raise Project, a conservative stilling basin extension of 60 feet was selected based on preliminary computations and engineering judgment. For this report, a 60-foot lengthening is assumed, but more detailed studies, additional geotechnical data currently being gathered, and model tests will be used in subsequent design studies to determine whether the existing stilling basin needs to be lengthened and by how much.

- **Civil Design** - The crest of dams and dikes currently being used as access roads and bike trails would continue with the same functionality following the dam raise. Roadway surfacing materials that are disturbed would be reinstalled in-kind after the raise. To reduce construction traffic on city streets and to allow the use of oversized construction equipment during construction of the auxiliary spillway, internal haul roads would be developed within the reservoir from the auxiliary spillway site to Folsom Point and MIAD. Access roads servicing the Folsom Lake SRA facilities would require in-kind reconstruction because of dike raises. Folsom Point would serve as a potential staging site and/or a potential disposal site for material from the auxiliary spillway excavation. Continued public access to Folsom Point would require some public health and safety measures to allow it to remain open for the duration of the auxiliary spillway and dam safety construction.

  Raising the dam and dikes 3.5 feet will have a minor impact on existing utilities. Impacted utilities include electricity, water, and waste water facilities.

- **Structural and Mechanical Design** – The existing main concrete dam is a straight gravity section with a structural height of 340 feet, and a crest length of 1,400 feet. The dam has 28 concrete monoliths, each 50 feet in length, with a crest width of 36 feet. All upstream faces have a 0.1:1 (horizontal to vertical ratio [h:v]) batter. The 20 non-overflow monoliths have a downstream slope of 0.7:1 below a near-vertical neck region at the crest. The eight spillway monoliths are sloped at 0.67:1 downstream, after transitioning from an ogee crest spillway. The eight spillway bays are 42 feet wide, measured between 8-foot-thick piers.

  Proposed structural modifications to the existing main concrete dam for a 3.5 foot raise include work in the emergency spillway: replacement or modification of three emergency tainter gates, modifications to increase the maximum gate opening for the five service/main tainter gates, and possible vertical and/or downstream extension of the spillway piers for the emergency spillway.

  The five service gates require modifications with the dam raise. The three emergency tainter gates would require significant enhancements or total replacement for the dam raise to increase the gate height from 53 feet 10 inches to 56 feet 10 inches. Both sets of gates have existing inadequacies that would need to be addressed.

  The three existing emergency tainter gates on the main concrete dam emergency spillway may require replacement with the dam raise. Therefore, the piers would be raised and extended downstream to anchor the new larger tainter gates, and locate the trunnions above the PMF nappe. The pier extensions would vary in the main spillway and the emergency spillway, since the gates would not be replaced in the main spillway.

  The proposed alternative would increase maximum hydrologic conditions by approximately 5 feet. The elevated reservoir water surface (RWS) would increase from the original design maximum RWS of elevation 475.4 to elevation 480.4. Therefore, a concern has been identified about the stability of the main concrete dam monoliths relative to sliding at the contact (between the dam and foundation).

Additionally, stability under seismic loading has been considered. Different agencies involved in the project addressed either seismic or hydrologic concerns, the results are summarized below:

- A stability analysis performed by Reclamation has been completed to evaluate any potential instability of the main concrete dam monolith contacts due to an elevated RWS, and to assess whether modifications are needed to stabilize the main concrete dam. Analyses were based on a normal static pool of elevation 466 and a flood (hydrologic) pool of elevation 484.5. Based on results from these analyses, all monoliths would appear to be stable for static and hydrologic loading conditions using contact friction angles that are likely to exist. Considering these analyses were conducted for a higher PMF pool than the current PMF pool of the 3.5-foot raise, it can reasonably be concluded the stability results would only improve.

- The State of California Division of Safety of Dams reanalyzed the seismic stability of the main dam for the PASS II Report (Corps, Reclamation, SAFCA, DWR, State Reclamation Board, 2006) using best-estimate shear strengths from the 2005 report by Goodman and Ghanaat, in combination with the forced vibration study results (Corps, 2005). However, their results focused only on seismic stability and did not address hydrologic stability concerns. Their findings concluded that the main dam monoliths are unstable for seismic loading and supported the need for modifications.

- Stability analyses were completed by the Corps in 2005. These studies indicated a need to stabilize the dam for hydrologic conditions in its existing condition. The Corps will be running new stability analyses based on modifications of the main dam proposed as part of the dam raise project. These analyses will be conducted using SAP2000 and/or GT Strudel.

Although discrepancies exist amongst the agencies involved in the project regarding stability of the main concrete dam monoliths under hydrologic conditions, the general consensus is that modifications must be completed to address either seismic or hydrologic instabilities. However, it should be noted that modifications developed to address sliding instability of the main concrete dam monoliths due to seismic loading are anticipated to address any uncertainties associated with potential displacement due to static and/or hydrologic loadings.

- **Electrical Design** – Existing power distribution equipment and cables, from substation 5-kilovolt (kV) feeders to the existing utilization equipment are still functional and would be reused. Backup electrical power would be provided from the existing emergency generator Building on the Folsom Facility site.

- **Construction Considerations** – A phased construction approach has been identified for the 3.5-foot crest-wall raise based on completion of the dam safety static and seismic modifications to the dikes, both wing dams and MIAD, and on the location of the individual sites relative to each other. A phased construction approach allows for

developing and implementing specific "work packages." Designated work packages should be compatible with future contracting/procurement efforts, and should represent major contracts as the program is currently envisioned. Work packages would be sized to take advantage of the strengths of both large and small disadvantaged businesses. Work packages would be coordinated with other ongoing projects at the Folsom Facility to reduce contractor conflicts and maximize available funding. The replacement of the three emergency tainter gates as part of the Folsom Dam Raise Project will be a separate work package from the crest-wall work packages. Other major non-integrated proposed construction features include the Folsom Dam Bridge and Road Project, City of Folsom Redundant Pipeline, downstream foundation treatment at MIAD, and various interim construction measures currently underway by the Corps and Reclamation.

- **Schedule** – A preliminary schedule for the Folsom Dam Raise alternative is presented that shows an approximate construction start date of January 2014 for Work Package 1 (crest wall raise at right wing dam and Dikes 4, 5 and 6). Work Package 2 (crest wall raise at left wing dam, Dikes 7 and 8, and MIAD) would begin January 2015, and Work Package 3 (crest wall raise at Dikes 1, 2 and 3) would begin in June 2016. Work Package 4 (emergency tainter gate replacements) would begin in July 2014. All project work is anticipated to be complete by 2016.

- **Cost** – The 3.5-foot crest wall raise and the replacement of the main dam emergency tainter gates are economically feasible. The first cost for these features of the Folsom Dam Raise Project is approximately $115.3 million. The annual cost and the average annual flood control benefits are estimated at $5.6 million and $17.2 million, respectively.

ADDITIONAL FOLSOM DAM RAISE PROJECT FEATURES

The primary objectives of the Folsom Dam Raise Project are 1) flood damage reduction, 2) environmental restoration, and 3) construction of a permanent bridge downstream of the dam. Under the original authorized plan, the main concrete dam, the two wing dams, MIAD, and the eight dikes would all be raised. In addition, the L.L. Anderson Dam spillway at the upstream French Meadows Reservoir would be modified to allow safe passage of the PMF. Additional project features including a change in status of modifications to L.L. Anderson Dam, construction of Folsom Bridge, and ecosystem restoration and habitat improvement along the American River are summarized below.

- **LL Anderson Dam Spillway** – L.L. Anderson Dam located at French Meadows Reservoir is primarily a water supply facility owned by the Placer County Water Agency (PCWA). Plans called for enlarging the spillway and making other modifications to L.L. Anderson Dam, so that it can contain the PMF and thereby reduce potential flood flows into Folsom Reservoir. Recently, an agreement was reached between the Federal Energy Regulatory Commission (FERC) and PCWA regarding the responsibility for repairs to the dam related to a PMF. With this agreement and concurrence from the Corps, L.L. Anderson Dam will be considered

completed and not part of this project by the Corps and Reclamation. Documentation will be included in the PAC report to support this change.

- **Folsom Bridge** - The project authorized in 2004 differs from the project recommended in the *2002 Long-Term Study* in that Congress approved construction of a permanent bridge rather than a temporary bridge. A permanent bridge would mitigate for the closure of Folsom Dam Road during construction, while also providing greater security for the dam. The September 2006 *Final Post Authorization Decision Document/EIS-EIR, American River Watershed Project, Folsom Dam Raise, Folsom Bridge* (Corps, 2006) documents the change from a temporary to a permanent bridge feature. Folsom Bridge construction is anticipated to be complete by December 2008.
- **Ecosystem Restoration** - The lower American River flood plain has significant natural ecosystem assets that have become increasingly valued in California. Ecosystem restoration features of the Folsom Dam Raise Project are construction of automated temperature shutters; planting of native riparian, upland, wetland, and woodland vegetation; terracing riverbanks; and controlling non-native plants at two sites totaling about 620 acres.

CONCLUSIONS

The following conclusions are based on the results of the analyses contained in this EDR for the Folsom Dam Raise Project.

- The primary objectives of the Folsom Dam Raise Project are flood damage reduction and ecosystem restoration and the construction of a permanent bridge downstream of the dam.
- The Folsom Dam Raise Project alternative presented in this EDR, includes a 3.5-foot cast-in-place concrete crest-wall on each of the eight dikes, both wing dams and on MIAD, and replacement of the three emergency tainter gates on the main dam. The currently authorized Folsom Dam Raise Project includes a 7-foot dam raise and replacement of the eight existing main dam tainter gates. Flood routings of the 3.5-foot raise and the emergency tainter gate replacement, along with the six-STG auxiliary spillway, were performed to demonstrate that the alternative would provide flood damage reduction computed at one chance in 185 in any given year. This alternative would provide the capability for Folsom Dam to pass a 240-year design flood event.
- The purpose of this project is the reduction of flood damages. The 3.5-foot raise increases the flood damage reduction capability of Folsom Dam and Reservoir by increasing the flood storage capacity. Replacement of the three emergency tainter gates enhances the utilization of the existing flood storage capacity. The proposed change to the Folsom Dam Raise Project flood damage reduction objective or element, integrated with the six-STG auxiliary spillway (as a without-project condition assuming the new Folsom Modification Project is in place), provides much

of the functionality that would have been achieved by the authorized project and passes the PMF. The combined elements are identified in the PAC report as the Selected Plan (SP).

- Hydrologic dam safety (safely passing the PMF) is addressed by the Joint Federal Project as described in Appendix C as the proposed project of the Folsom Modification authorization. The Folsom Dam Raise Project does not address existing dam safety static or seismic deficiencies associated with the dikes, wing dams, or MIAD. Those deficiencies would be corrected under separate actions initiated by Reclamation.
- The design and construction of the raise components could be completed within 5 years, although the projects would be coordinated with other construction at Folsom Dam that could delay a part of the construction as much as 3 years.
- The Folsom Dam Raise Project is strongly supported by the local partners, including the State Reclamation Board and SAFCA. Formulation of the Folsom Dam Raise Project has been coordinated with the partners and Reclamation.
- Construction of the 3.5-foot wall raise and the replacement of the main dam emergency tainter gates would cause some environmental resource impacts; but mitigation measures are proposed to reduce potential impacts to less than significant levels where possible.
- The 3.5-foot crest-wall raise and the replacement of the main dam emergency tainter gates are economically feasible. The first cost for these features of the Folsom Dam Raise Project is approximately $115.3 million. The annual cost and the average annual flood control benefits are estimated at $5.6 million and $17.2 million, respectively.

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ACRONYM AND ABBREVIATION LIST

ADA	Americans with Disabilities Act
AEP	Annual exceedance probability
AWS	American Welding Society
CFR	Code of Federal Regulation
cfs	Cubic feet per second
CO_2	Carbon dioxide
Corps	United States Army Corps of Engineers
CSR	Combined stress ratio
CVACS	Central Valley Automated Control System
CVP	Central Valley Project
CWCCIS	Civil Works Construction Cost Index System
D	Distance
DPR	State of California Department of Parks and Recreation
DS	Downstream
DSOD	State of California Division of Safety of Dams
DWR	State of California, Department of Water Resources
EA/IS	Environmental Assessment / Initial Study
EC	Engineering Circular
EDR	Engineering Documentation Report
EIS/EIR	Environmental Impact Statement / Environmental Impact Report
elevation XXX	elevation, feet above mean sea level
EM	Engineering Manual
EPA	Equitable price adjustment
ER	Engineering Regulation
ERDC	Engineer Research and Development Center
ESRD	Emergency spillway release diagram
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulation Commission
FONSI	Finding of no significant impact
fps	Feet per second
ft	Feet
g	Acceleration due to gravity
gpm	Gallons per minute
h:v	Horizontal to vertical ratio
HDC	United States Army Corps of Engineers Hydraulic Design Criteria

hp	Horsepower
HPU	Hydraulic power unit
in	Inches
JFP	Folsom Dam Joint Federal Project
km	Kilometers
kV	Kilovolt
kVA	Kilovolt-ampere
kW	Kilowatt
LRR	Limited Reevaluation Report
M	Modal magnitude
MCC	Motor control center
MCE	Maximum credible earthquake
MDE	Maximum design earthquake
MGE	MGE Engineering
MIAD	Mormon Island Auxiliary Dam
NFPA	National Fire Protection Association
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
NO_X	Nitrogen oxides
NWS	National Weather Service
O&M	Operation and Maintenance
OBE	Operating basis earthquake
PAC	Post-Authorization Change
PASS	Project Alternatives Solutions Study
pcf	Pounds per cubic foot
PCWA	Placer County Water Agency
PFP	Probable failure point
PGA	Peak horizontal ground acceleration
PL	Public Law
PM_{10}	Particulate matter smaller than ten microns
PMF	Probable maximum flood
PNP	Probable non-failure point
R&U	Risk and uncertainty
Reclamation	United States Department of the Interior, Bureau of Reclamation
ROG	Reactive organic gasses
rpm	revolutions per minute

RRFM	Reservoir Release Forecast Model
RWQCB	Regional Water Quality Control Board
RWS	Reservoir water surface
SAFCA	Sacramento Area Flood Control Agency
SIR	Supplemental Information Report
SMAQMD	Sacramento Municipal Air Quality Management District
SP	Selected plan
SRA	State Recreation Area
State Reclamation Board	State of California Reclamation Board
STG	Submerged tainter gates
SWP	State Water Project
UPS	Uninterruptible power supplies
US	Upstream
USGS	United States Geological Survey
WCD	Water control diagram
WES	Waterways Experiment Station
WRDA	Water Resources Development Act

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CHAPTER 1.0
INTRODUCTION

This Engineering Documentation Report (EDR) is an engineering refinement and technical implementation document to support the Post Authorization Change (PAC) report of the currently authorized Folsom Modification and Folsom Dam Raise Projects. The purpose of this EDR is to present alternative designs for the authorized Folsom Dam Raise Project and to present advantages and disadvantages of each alternative, including cost and functional data.

1.1 SCOPE OF REPORT

This EDR focuses on the flood damage reduction features authorized for the Folsom Dam Raise Project; the ecosystem restoration features of the authorization require no re-evaluation. The Folsom Dam Raise Project is authorized and premised upon the Folsom Modification Project being in place. Proposed changes to the Folsom Modification flood damage reduction project features, along with recent changes in dam safety priorities of the United States Department of the Interior, Bureau of Reclamation (Reclamation), necessitate a re-evaluation and coordination of the flood damage reduction features of the Folsom Dam Raise Project to ensure compatibility and greater efficiency between the two flood damage reduction projects authorities and Reclamation's dam safety objectives. This report documents re-evaluation of the engineering aspects of the authorized Folsom Dam Raise Project and other flood damage reduction alternatives considered in conjunction with the proposed changes to the Folsom Modification Project. This EDR focuses on cost efficiency and performance of the alternatives that best integrate the proposed Folsom Modification Project and Folsom Dam Raise Project authorities.

1.2 PROJECT AUTHORIZATION AND APPROVAL

Authorization to construct a dam on the American River was included in the Flood Control Act of 1944. Construction of Folsom Dam was initiated in 1948 and completed in 1956. The storms of 1986 raised concerns over the adequacy of the existing flood control system resulting in the December 1991 *American River Watershed Investigation, Feasibility Report.* Congressional guidance was forthcoming in the 1993 Defense Appropriations Act, authorizing additional studies to develop solutions to the flood problems. This study effort was documented in the March 1996 *American River Watershed Project, California, Supplemental Information Report* (1996 SIR) (United States Army Corps of Engineers, Sacramento District [Corps], 1996). The 1996 SIR described multiple alternative plans, of which certain levee and other flood system improvements were "common" to all alternatives. In the 1996 Water Resources Development Act (1996 WRDA), Congress authorized only a portion of the 1996 SIR-recommended plan. The authorized elements became known as "Common Features." While efforts moved forward to further develop and implement the Common Features, discussions continued on ways to achieve higher levels of flood protection for Sacramento.

Based on the findings of the *2002 Long Term Study Final Supplemental Plan Formulation Report* (Corps, 2002a), a Chief of Engineers Report (Corps, 2002b)was signed on 5 November 2002 that recommended a 7-foot raise in the height of Folsom Dam. Under Section 128 of the Energy and Water Resources Development Act of 2004 (Public Law [PL] 108-137), Congress authorized the Folsom Dam Raise Project based on the recommendations contained in the November 2002 Chief of Engineers Report.

1.3 PROJECT OBJECTIVES

The primary objectives of the Folsom Dam Raise Project are (1) flood damage reduction, (2) ecosystem restoration, and (3) construction of a permanent bridge downstream of Folsom Dam. The dual flood damage reduction elements of the Folsom Dam Raise Project enhance the utilization of the existing flood storage capacity as well as increase the flood storage capacity of the reservoir.

1.4 PROJECT SITE AND CONDITIONS

The American River Watershed encompasses approximately 2,100 square miles northeast of Sacramento, California, including portions of Placer, El Dorado, and Sacramento counties. Runoff from the basin flows through Folsom Reservoir into the lower American River and through the Sacramento metropolitan area. The river has a system of levees along both banks and leveed floodways.

Folsom Dam is located at the confluence of the North and South forks of the American River, near the City of Folsom, approximately 29 miles upstream from the City of Sacramento. **Plate 1-1** shows the American River Watershed.

The present Folsom Facility consists of a gravity-type main concrete dam, left and right earth embankment wing dams, an auxiliary earthfill dam Mormon Island Auxiliary Dam (MIAD), and eight earth embankment dikes. **Plate 1-2** depicts the Folsom Dam and Reservoir area and shows the project features.

The reservoir has a capacity of 977,000 acre-feet at its gross pool elevation of 466 feet above mean sea level (elevation 466). The top of the main concrete dam is at elevation 480.5 and spillway crest is at elevation 418. Under extreme conditions, the current maximum allowable pool elevation is 475.4 feet. The objective release for flood control from the dam to the lower American River is 115,000 cubic feet per second (cfs).

The main dam river outlets consist of eight 5-foot by 9-foot rectangular outlets located in the center four monoliths of the concrete gravity section. The four upper tier river outlets are at a springline elevation of 280; the four lower tier river outlets are at a springline elevation of 210. The main dam river outlets are capable of passing 24,816 cfs (at 100 percent gate opening) through the dam with the reservoir pool at spillway crest elevation 418. The outlets are operated primarily to evacuate the flood control space during flood season and, to a lesser extent, to provide colder lower-pool water for fisheries in the fall.

The gated overflow spillway is located in the central concrete gravity section of the main concrete dam with spillway crest at elevation 418. The spillway is divided by piers into eight equal sections. The first five sections (westernmost) comprise the service spillway. They are controlled by five 42-foot by 50-foot tainter (radial) gates; discharging into the stilling basin. The three remaining spillway sections are for emergency use only. They are controlled by three 42-foot by 53-foot tainter gates; flow discharges over a flip bucket onto the emergency stilling basin slab. The rated capacity of the entire spillway is 544,000 cfs at pool elevation 473.8. This capacity is based on the original model study with all tainter gates fully open (free-flow under the gates).

Three 15.5-foot-diameter penstocks pass through the west non-overflow section of the main conerete dam. Normal releases through the penstocks provide power generation and downstream water deliveries, however these were not considered during the analysis of flood routings. The combined capacity of the three penstocks is 8,000 cfs. In addition, one 7-foot diameter intake conduit located west of the penstocks, which supplies water to several local water districts.

1.5 KEY DESIGN CONSIDERATIONS

A major concern exists regarding the potential for erosion below the emergency spillway chute and adjacent areas. It has been determined that even small flows could cause severe erosion below the emergency spillway; continuous flows without sufficient tailwater could allow this erosion to migrate towards the stilling basin serving the main service spillway. It is estimated that sufficient tailwater would not be present to operate the emergency spillway until discharges exceed 300,000 cfs. Modifications to the three emergency tainter gates should be consistent with the assumptions used in the original design of the emergency stilling basin.

Normal flood operations at Folsom Dam would limit downstream flows to a maximum of 115,000 cfs. On completion of the Common Features, outflows from the dam could be increased from 115,000 cfs to the new non-damaging channel capacity of the lower American River of 160,000 cfs.

Other key design considerations include constructibility and environmental considerations.

Constructibility considerations include the following:

- All of the service tainter gates need to be available for releases at 24 hours notice.
- Disturbance of existing utilities and dam operations should be avoided to the extent practical.

Environmental considerations include the following:

- Best management practices are to be implemented to limit disruption of aquatic habitat and turbidity resulting from construction operations.
- Construction impacts on existing habitat and fish should be minimized. It is expected that project in-channel construction should be timed to minimize impacts to endangered fish species.
- Habitat restoration should be designed to provide more extensive shaded riverine aquatic habitat.
- Installation of in-channel woody structures, boulders, and other in-channel elements should be considered to reduce flow velocities and/or to create eddies, scour holes, or pools to restore fish habitat.
- Environmental restoration along the top of banks should include the use of native trees, shrubs, and grasses.
- Noise and air quality factors from construction activities are to be considered.

CHAPTER 2.0
PROJECT DESCRIPTION

This chapter describes the Folsom Dam Raise Project and summarizes the technical and regulatory history leading to development of alternatives to the currently authorized project.

2.1 DESCRIPTION OF AUTHORIZED PLAN

The Folsom Dam Raise Project was authorized in the Energy and Water Development Appropriation Act of 2004. The project, as authorized, consisted of the following major elements:

- Raise Folsom Dam, the two wing dams, MIAD, and the eight dikes, by 7 feet.
- Construct a permanent bridge downstream from the dam.
- Modify the spillway of L.L. Anderson Dam at French Meadows Reservoir.
- Implement ecosystem restoration features to benefit the lower American River.

Some of these elements are depicted on **Plates 1-2** and **2-1**. L.L. Anderson Dam is located at French Meadows Reservoir, on the Middle Fork of the American River, about 50 miles upstream from Folsom Dam.

Raising the dam 7 feet requires that all eight of the existing main dam tainter gates be replaced with larger gates. In addition, the spillway bridge piers would be modified, the spillway bridge would be replaced, and the existing stilling basin would be extended approximately 60 feet to provide adequate energy dissipation. The modifications would add approximately 93,000 acre-feet of flood storage capacity to the reservoir.

A permanent bridge located downstream from the dam (**Plate 2-1**) would accommodate rerouted traffic from Folsom Dam Road during and after construction of the dam raise. The currently authorized project differs from the project recommended in the 2002 Long-Term Study (USACE, 2002a) in that Congress approved construction of a permanent bridge in lieu of a temporary one. A permanent bridge would both mitigate closure of Folsom Dam Road during construction, and provide greater long-term security for the dam.

Modifications to L.L. Anderson Dam would involve enlarging the spillway to allow safe passage of the probable maximum flood (PMF). Under present conditions, the spillway is unable to pass the PMF without overtopping the embankment. A failure of L.L. Anderson Dam would significantly increase the PMF at Folsom Dam.

Ecosystem restoration features of the authorized project include construction of automatic temperature control shutters at Folsom Dam to benefit American River fisheries

(the existing shutters are operated manually) and active habitat restoration at the Woodlake Restoration Site and Bushy Lake Restoration Site, both located on the lower American River.

2.2 BACKGROUND

The Folsom Dam Raise Project was authorized in the Energy and Water Development Appropriation Act of 2004 based on recommendations contained in the November 2002 Chief of Engineers' Report (Corps, 2002b) that were based on findings in the 2002 Long-Term Study (USACE, 2002a).

Since authorization, the Folsom Dam Raise Project has been subject to cost increases due to increases in construction material costs, decreases in the availability of contractors, and safety and security considerations at the dam. Modifications of the spillway at L.L. Anderson Dam are no longer being considered as part of the Folsom Dam Raise Project since the owner, Placer County Water Agency, is responsible to resolve all dam safety issues separately. Efforts are moving forward on design and advanced implementation of the Folsom Bridge, which is scheduled for completion in December 2008. Efforts to raise Folsom Dam have continued, but at a slower pace; any dam raise needs to be considered concurrently with other features required to modify the dam and appurtenances for both flood damage reduction and dam safety. Recent studies related to the Folsom Dam Raise Project focus on compatibility and greater efficiency for the flood damage reduction projects and Reclamation's dam safety objectives.

An engineering *Project Alternative Solutions Study (PASS)* was conducted jointly by the Corps and Reclamation in 2005 as well as other stakeholders including the Sacramento Area Flood Control Agency (SAFCA), State of California Department of Water Resources (DWR), and the State of California Reclamation Board (State Reclamation Board). A follow up study, PASS II, was completed in June 2006 as documented in the report entitled *Folsom Dam Raise and Auxiliary Spillway Alternative, PASS II.* This study presented an engineered evaluation of an auxiliary spillway alternative consisting of four submerged tainter gates (STGs) along with a 7-foot dam raise. Optimization efforts of the PASS II alternative identified additional alternative variations of the four- and six-STG auxiliary spillway and dam raise, with and without emergency spillway gate replacement.

The Folsom Dam Raise Project, in combination with other flood control and dam safety projects being considered for Folsom Dam, may present additional opportunities to reduce the current flood risks.

2.3 OVERVIEW OF ALTERNATIVES

The six-STG auxiliary spillway with 23-foot wide by 33-foot tall tainter gates is assumed to be a without-project condition for the Folsom Dam Raise alternatives as an assumption that it will have been previously implemented under the Folsom Modification Project. The raise alternatives considered in this report consist of various combinations of the Folsom Dam Raise Project flood damage reduction features of a raise and the replacement of main dam tainter gates. Replacement of the main dam tainter gates would

provide increased flood protection and raising the top of the dam would add flood storage capacity to the reservoir, creating increased flood protection. The following six alternatives are discussed and evaluated in **Chapter 3** of this EDR. The first alternative represents the project features associated with the original authorizations to establish a baseline for functionality comparison and does not include an auxiliary spillway as a without-project condition.

- Six-enlarged, two new, and two existing main dam river outlets; 7-foot dam raise; and all eight main dam tainter gates replaced (baseline for functionality comparison)
- Six-STG auxiliary spillway and three emergency tainter gates replaced
- Six-STG auxiliary spillway and 3.5-foot dam raise
- Six-STG auxiliary spillway, 3.5-foot dam raise, and three emergency tainter gates replaced
- Six-STG auxiliary spillway; 3.5-foot dam raise and all eight main dam tainter gates replaced
- Six-STG auxiliary spillway, 7-foot dam raise, and all eight main dam tainter gates replaced

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CHAPTER 3.0
FOLSOM DAM RAISE PROJECT ALTERNATIVES

The alternatives considered in this chapter consist of various combinations of a dam raise and the replacement of main dam tainter gates. The description of these alternatives will include engineering aspects by which they may be evaluated to provide greater flood protection by adding flood storage capacity.

The six-STG auxiliary spillway is assumed to be a without-project condition for the Folsom Dam Raise Project as the auxiliary spillway would have been previously implemented under the Folsom Modification Project authorization and is included in the alternative description to show all the project features for the Folsom facility. A description of the six-STG auxiliary spillway is included in the Folsom Dam Joint Federal Project EDR.

The costs for each of the alternatives were prepared for the purpose of determining concept feasibility and project screening. All of the estimates were prepared by the same team of cost engineers for consistency among the estimates for comparison of the alternatives. The cost estimates are based on generally accepted cost principals. The estimates are considered reconnaissance-level, fitting the Corps definition as based on the probable type and size of a project, and include construction features, lands and damages, relocations, environmental compliance and required mitigation, engineering and design, construction management, and contingencies. The cost estimate method establishes reasonable costs sufficient to support a planning evaluation process. The estimates were developed using quotes, calculations, unit prices, and historical data as backup. The estimates have all been factored to an October 2006 price level.

3.1 SIX ENLARGED PLUS TWO NEW AND TWO EXISTING MAIN DAM RIVER OUTLETS WITH 7-FOOT RAISE WITH EIGHT MAIN DAM TAINTER GATES REPLACEMENT ALTERNATIVE

This alternative is the baseline plan for functionality comparison of alternatives to the authorized Folsom Modification and the Folsom Dam Raise projects.

The six enlarged plus the two new and the two existing main dam river outlets portion of this alternative was recommended over the ten new or enlarged main dam river outlet project described in the 2003 Limited Reevaluation Report (LRR). This decision is a result of a hydraulic, geotechnical, and structural assessment of problems associated with enlarging Outlets 1 and 4 of the lower tier river outlets. A detailed description of the outlet modification is contained in the Folsom Modification Project EDR.

The Folsom Dam Raise authorization recommended a 7-foot raise of Folsom Dam including the main concrete dam, the left and right embankment wing dams, MIAD, and eight dikes. Included in the project is the replacement of all eight existing main dam tainter gates. Together, these modifications would add approximately 93,000 acre-feet of flood storage capacity to the reservoir.

The estimate of first cost for this alternative is $1,236 million; the estimate of annual cost is $67.0 million.

This alternative would pass the 250-year design flood event. The performance (inverse of the annual exceedance probability [AEP]) of this alternative has a 1 in 189 chance of exceedance in any given year.

3.2 SIX-SUBMERGED-TAINTER-GATES AUXILIARY SPILLWAY WITH THREE EMERGENCY TAINTER GATES REPLACEMENT ALTERNATIVE

This alternative includes the six-STG auxiliary spillway as a without-project condition, along with the replacement of the three emergency tainter gates for the purpose of improving storage utilization for increased flood protection. The existing emergency tainter gates are 42 feet wide by 53 feet 10 inches high, with top-of-gate at elevation 471. The emergency stilling basin was not designed for emergency tainter gate openings for main dam releases less than 300,000 cfs. The reservoir water service elevation for releases less than 300,000 cfs must be within the freeboard of the emergency tainter gates. Based on assumed reservoir operations for a three-emergency-tainter-gate replacement with-no-dam-raise alternative, the reservoir would reach water surface elevation 475.5 before the emergency tainter gates would be operated. To maintain 1 foot of freeboard on the gates, the gate height would be increased under this alternative to elevation 476.5.

The replacement of the three emergency tainter gates does not add flood storage capacity to the reservoir, but does enhance the utilization of the existing storage capacity.

The estimated first cost of this alternative, including the six-STG auxiliary spillway feature, is $930 million; the annual cost is $52.4 million. The stand-alone first cost for the three emergency tainter gate replacement component only is $42 million; the annual cost is $2.4 million.

The combined six-STG auxiliary spillway and the three emergency tainter gate replacement alternative will pass the 200-year design flood event. The performance (inverse of the AEP) of this alternative has a 1 in 156 chance of exceedance in any given year.

3.3 SIX-SUBMERGED-TAINTER-GATES AUXILIARY SPILLWAY WITH 3.5-FOOT RAISE ALTERNATIVE

This alternative includes the six-STG auxiliary spillway as a without-project condition, along with a 3.5-foot raise of Folsom Dam, including the main concrete dam, the left and right wing dams, MIAD, and eight dikes. The 3.5-foot raise feature assumes a reinforced concrete wall located near the reservoir side of the crest for each of the eight dikes, both wing dams, and MIAD for the purpose of increasing reservoir storage capacity for additional flood protection. Access to recreation facilities on the reservoir side of the dikes would require raising the embankments 3.5 feet at the crossings and ramping back down on the sides to the top of the dikes.

A 3.5-foot raise component would increase the flood storage capacity to the reservoir by approximately 46,200 acre-feet above the current flood pool storage of 1,022,185 acre-feet associated with pool elevation 470.

The first cost of this alternative, including the six-STG auxiliary spillway feature, is $962 million; the annual cost is $52.9 million. The stand-alone first cost for only the 3.5-foot raise component is $74 million; the annual cost is $3.2 million.

The combined six-STG auxiliary spillway and the 3.5-foot raise alternative will pass the 220-year design flood event. The performance (inverse of the AEP) of this alternative has a 1 in 167 chance of exceedance in any given year.

3.4 SIX-SUBMERGED-TAINTER-GATES AUXILIARY SPILLWAY WITH 3.5-FOOT RAISE WITH THREE EMERGENCY TAINTER GATES REPLACEMENT ALTERNATIVE

This alternative includes the six-STG auxiliary spillway as a without-project condition, a 3.5-foot raise of Folsom Dam, including the main concrete dam, the left and right wing dams, MIAD, and eight dikes, along with the replacement of the three emergency tainter gates, all as previously described. For extreme events approaching the PMF, the existing gates on the service spillway would be overtopped by as much as 1 foot, not including wave action.

A 3.5-foot raise component would increase the flood storage capacity of the reservoir by approximately 46,200 acre-feet above the current flood pool storage of 1,022,185 acre-feet associated with pool elevation 470.

The estimated first cost of this alternative, including the six-STG auxiliary spillway feature, is $1,005 million; the annual cost is $55.6 million. The stand-alone first cost for only the 3.5-foot raise plus the three emergency tainter gates replacement components is $116 million; the annual cost is $5.6 million.

The combined six-STG auxiliary spillway and the 3.5-foot raise with the three emergency tainter gate replacement alternative will pass the 240-year design flood event. The performance (inverse of the AEP) of this alternative has a 1 in 185 chance of exceedance in any given year.

3.5 SIX-SUBMERGED-TAINTER-GATES AUXILIARY SPILLWAY WITH 3.5-FOOT RAISE WITH EIGHT MAIN DAM TAINTER GATES REPLACEMENT ALTERNATIVE

This alternative includes the six-STG auxiliary spillway as a without-project condition, a 3.5-foot raise of Folsom Dam, including the main concrete dam, left and right wing dams, MIAD, and eight dikes, all as previously described, along with the replacement of all eight main dam tainter gates. The three emergency tainter gates are as previously described. The five remaining service tainter gates are located above the service spillway on

the main dam. These tainter gates are all 42 feet wide by 50 feet 10 inches high, with top-of-gate elevation 468. As the tainter gates currently exist, to maintain a minimum of 1 foot of freeboard on the gates, they must be opened when the reservoir rises above water surface elevation 467. The five service tainter gates can limit flood control releases to 160,000 cfs or water surface elevation 475.5. The emergency stilling basin was not designed for emergency tainter gate openings for main dam releases less than 300,000 cfs. The reservoir water surface elevation for releases between 160,000 cfs and 300,000 cfs must be within the freeboard of the emergency tainter gates. The 300,000 cfs release threshold equates to a tentative reservoir water surface elevation 479.0. A minimum 1 foot of freeboard would require minimum emergency tainter gate top elevation 480.0. With a top of dam at elevation 484, given a 3.5-foot raise, and maintaining a minimum of 3 feet of freeboard, the reservoir operation routings for this configuration shows maximum reservoir water surface elevation 473. The five service tainter gates have top of arc elevation 480.0. To maintain a minimum freeboard on the gates of 1 foot, the top of the tainter gate would need to be at elevation 474. In addition, PMF releases would impinge on the trunnion tie beams. The trunnion and trunnion tie beams must be elevated above the nappe of the flow to avoid gate failure, requiring extension of the spillway piers.

A 3.5-foot raise component would increase the flood storage capacity to the reservoir by approximately 46,200 acre-feet above the current flood pool storage of 1,022,185 acre-feet associated with pool elevation 470.

The estimate of first cost of this alternative, including the six-STG auxiliary spillway feature, is $1,073 million; the annual cost is $59.5 million. The stand-alone first cost for the 3.5-foot raise plus the eight service tainter gates replacement components only is $184 million; the annual cost is $9.5 million.

The combined six-STG auxiliary spillway and the 3.5-foot raise with the eight main dam tainter gates replacement alternative will pass the 240-year design flood event. The performance (inverse of the AEP) of this alternative is a 1 in 182 chance of exceedance in any given year.

3.6 SIX-SUBMERGED-TAINTER-GATES AUXILIARY SPILLWAY WITH A 7-FOOT RAISE WITH EIGHT MAIN DAM TAINTER GATES REPLACEMENT ALTERNATIVE

This alternative includes the six-STG auxiliary spillway as a without-project condition and replacement of all eight main dam tainter gates, both as previously described, along with a 7-foot raise of Folsom Dam, including the main concrete dam, left and right wing dams, MIAD, and eight dikes. The cost and performance information for this alternative reflect a 7-foot dam raise component as this would be indicative of the costs associated with raising the height of the main concrete dam, not simply affecting a "raise" by increasing a parapet wall height.

A 7-foot raise component would increase the flood storage capacity of the reservoir by approximately 93,000 acre-feet above the current flood pool storage of 1,022,185 acre-feet associated with pool elevation 470.

The first cost of this alternative, including the six-STG auxiliary spillway feature, is $1,457 million; the annual cost is $85.3. The stand-alone first cost for the 7-foot raise plus the eight main dam tainter gates replacement components only is $568 million; the annual cost is $35.3 million.

This alternative will pass the 275-year design flood event. The performance (inverse of the AEP) of this alternative has a 1 in 213 chance of exceedance in any given year.

3.7 SUMMARY OF FOLSOM DAM RAISE PROJECT ALTERNATIVES

A tabular summary of the Folsom Dam Raise Project alternatives is presented in **Table 3.1**. The table provides information on how an alternative compares functionally to the project represented by both the modification and the raise authorizations, the first cost and the annual cost for each of the alternatives, the performance (inverse of the AEP) for each, and the design flood event that the alternative passes.

The alternative that demonstrates approximately equal performance, at an equal or lesser cost to the baseline plan, is the 3.5-foot dam raise along with replacement of the three emergency tainter gates. The design aspects and construction considerations of this alternative are described in detail in Chapter 7 of this report.

TABLE 3-1

FOLSOM DAM RAISE PROJECT ALTERNATIVES

Alternative Description	Functionality Compared to the Authorized Projects	First Cost	Annual Costs	Performance (Inverse of AEP)	Design Event Passes
		(millions)	(millions)	(1:X Chance)	(years)
Six Enlarged plus Two New and Two Existing Main Dam River Outlets; 7-foot Raise; Eight Main Dam Tainter Gates Replaced (Baseline)	Baseline	$1,236	$67.0	189	250
Six-STG Auxiliary Spillway; Three Emergency Tainter Gates Replaced	Significant, but not quite equal	$930	$52.4	156	200
Six-STG Auxiliary Spillway; 3.5-foot Raise	Significant, but not quite equal	$962	$52.9	167	220
Six-STG Auxiliary Spillway; 3.5-foot Raise; Three Emergency Tainter Gates Replaced	About Equal	$1,005	$55.6	185	240
Six-STG Auxiliary Spillway; 3.5-foot Raise; all Eight Main Dam Tainter Gates Replaced	About Equal	$1,073	$59.5	182	240
Six-STG Auxiliary Spillway; 7-foot Raise; all Eight Main Dam Tainter Gates Replaced	Greater	$1,457	$85.3	213	275

CHAPTER 4.0
HYDROLOGY AND RESERVOIR OPERATIONS

This chapter presents the Corps' understanding of the hydrology of the American River Drainage Basin and Folsom Dam site. Also discussed are reservoir operations as they exist currently, and as they would be modified for various alternatives examined for the Folsom Modification Project. The Folsom Dam Operations and Planning Model, developed with Microsoft Excel, is used in all the routing and alternative analyses for the various American River Folsom Dam studies.

4.1 HYDROLOGY

This section presents hydrology of the Folsom Dam area including information on design floods and the PMF.

4.1.1 Design Floods

Hydrology for the American River projects has been extensively studied by the Corps. In that process, unregulated flow frequency statistics for the American River at Fair Oaks were developed and have subsequently been updated to include flood data for the years 1905 through 2004. The statistical analysis used for this report followed procedures found in *Bulletin 17B, Guidelines for Determining Flood Flow Frequency* (United States Geologic Survey [USGS], 1982). The resultant statistics adopted for the American River at Fair Oaks are shown in **Table 4-1**. A complete discussion of the development of the adopted statistics is provided in the *Rain Flood Flow Frequency Analysis, American River, California* (Corps, 2004).

TABLE 4-1
AMERICAN RIVER AT FAIR OAKS –
UNREGULATED FLOW STATISTICS

Duration	Log Mean (cfs)	Log Standard Deviation (cfs)	Skew
1 Day	4.453	0.425	-0.05
3 Days	4.326	0.414	-0.05
7 Days	4.162	0.398	-0.13
15 Days	4.015	0.373	-0.26
30 Days	3.897	0.360	-0.42
KEY: cfs – cubic feet per second			

The unregulated flow statistics shown above were used to develop a series of inflow design (synthetic hydrograph) events for Folsom Dam used in the modeling/analysis of the various conditions and alternatives studied. The shape of each inflow design hydrograph was

patterned using the shape adopted for the American River PMF. **Figure 4-1** shows both an inflow design event and the PMF inflow hydrograph. Once the unimpaired (natural) flow hydrographs were developed, they were routed throughout the system including the upstream reservoirs. This process transformed them into regulated inflow hydrographs, to serve as inflow to Folsom Dam. Baseline or the most likely routings (i.e., with no risk and uncertainty considerations) assumed that upstream reservoirs would be full at the start of the flood routing. This assumption provides the most critical condition for Folsom Dam routings.

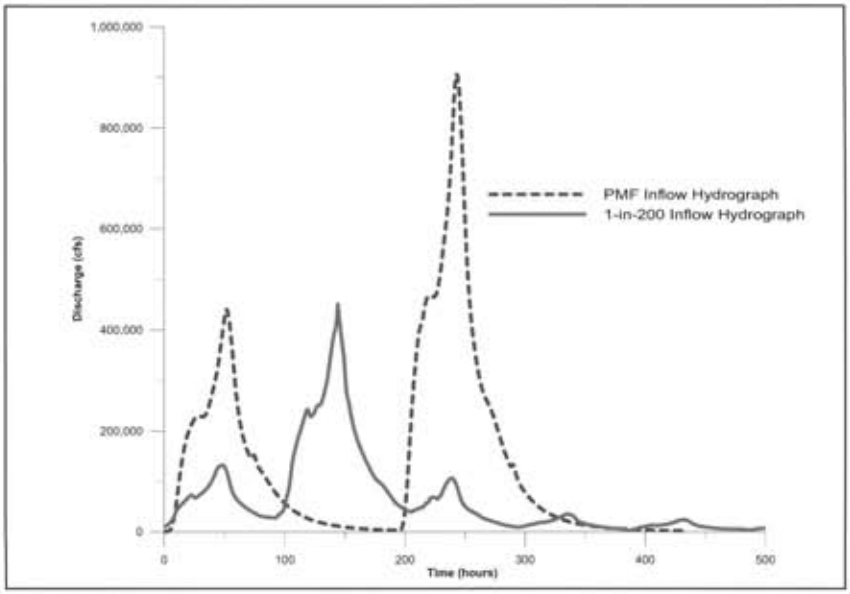


FIGURE 4-1
SHAPES OF PROBABLE MAXIMUM FLOOD AND INFLOW HYDROGRAPH SERIES

Corps guidance (ER 1105-2-101) requires the use of risk analysis in flood damage reduction studies. For risk and uncertainty purposes, the analyses herein cover Folsom Reservoir's response to a range of design. The flood events, routed using the Folsom Dam Operations and Planning Model, range from a 1-in-2-year-chance of being exceeded to those with a 1 in 550 chance of being exceeded. Refer to **Section 4.4.2** to see its application to the operations.

4.1.2 Probable Maximum Flood

By definition, a PMF results from a combination of the most severe meteorological and hydrologic conditions considered reasonably possible in a particular region. The PMF is

a flood derived in accordance with procedures developed by the Federal Government (National Weather Service [NWS], 1999) and accepted by the State of California in its dam safety program as a viable method for developing spillway design floods in the United States. The PMF applied in this analysis was jointly developed by the Corps and Reclamation and is documented in the report *American River Basin, Folsom Dam, Revised PMF* (Corps, 2001). The PMF is needed for evaluating dam safety. The PMF is used to design a reservoir to keep a dam from overtopping; it is not used as a measure for developing alternatives to provide downstream flood protection. The following scenarios shown in **Table 4-2** were considered during development of the PMF.

TABLE 4-2
AMERICAN RIVER AT FAIR OAKS –
PROBABLE MAXIMUM FLOOD VOLUMES

	Peak (thousand cubic feet)	72-Hour (thousand acre-feet)
No upstream dam failure		
North Fork PMF	906	2810
South Fork PMF #1	896	2805
South Fork PMF #2	889	2805
Upstream dam failures		
North Fork PMF	1183	2935
South Fork PMF #1	1127	3206
South Fork PMF #2	1322	3205

Notes:
1. North Fork PMF - Storm centering over French Meadows Reservoir (with or without failure of LL Anderson Dam)
2. South Fork PMF #1 - Storm centering near Placerville basin (with or without failure of both LL Anderson Dam and Union Valley Dam)
3. South Fork PMF #2 - Storm centering over Union Valley and Ice House Reservoirs (with or without failure of both LL Anderson Dam and Union Valley Dam)

When upstream dam failures are considered, the South Fork PMF #2 scenario (storm centering over Union Valley and Ice House Reservoirs) produces the largest peak and 72-hour volume. The South Fork scenarios include failures of both Union Valley Dam on the South Fork of the American River and L.L Anderson Dam on the Middle Fork of the American River. The dam failure scenarios are considered unlikely to occur. Due to the Federal Energy Regulatory Commission relicensing program, all upstream projects are responsible for safely passing their PMF events and must make the necessary modifications to comply with those requirements. Without any upstream dam failures, the peak and 72-hour volumes are nearly identical for both the North Fork and South Fork storm centerings. The following summarizes the assumptions adopted for this report with regards to the PMF:

- The PMF implemented within this analysis is designed and centered over the North Fork of the American River.
- L.L. Anderson Dam (French Meadows Reservoir, located upstream of Folsom Dam on the Middle Fork of the American River) passes its PMF event, without failure,

with the assumption that the existing physical and operational inadequacies would be corrected according to previous studies investigating those issues.

4.2 OPERATIONAL RULES FOR FLOOD CONTROL

Flood control operation of Folsom Dam is governed by two sets of operating criteria: the water control diagram (WCD) and the emergency spillway release diagram (ESRD).

4.2.1 Water Control Diagram

The WCD represents a compilation of regulating criteria, guidelines, guide curves, and specifications that govern the storage and release functions of water resource projects. The diagram indicates pool levels and limiting rates of project releases required during various seasons of the year to meet all functional objectives of a particular project, acting separately or in combination with other projects in a system. The operational rules are expressed in the form of graphs and tables, supplemented by concise specifications, and are used to help determine regulation (release) schedules. The 1986 WCD as presented in the December 1987 Folsom Dam and Lake Water Control Manual and interim WCD for Folsom Dam currently in use are provided as Plates 4-1 and 4-2a. Plate 4-2b, presents further details in the agreement and interim operation of Folsom Dam and Lake as per Plate 4-2a. Both diagrams as illustrated in Plate 4-1 and Plate 4-2a maintain a minimum allowable flood control reservation of 400,000 acre-feet; the interim WCD, however, allows for a variable allocation of an additional 270,000 acre-feet of reserved flood control space based on creditable storage available in upstream reservoirs.

4.2.2 Emergency Spillway Release Diagram

The ESRD is applied when circumstances require that a gated spillway be used to meet the release requirements. The ESRD transitions normal low outflows to significantly higher outflows gradually so as not to constitute a major hazard to downstream interests. For Folsom Dam, the transition from normal low outflows to significantly higher flows begins at discharges greater than 115,000 cfs. Because Folsom Dam would rely on the induced surcharge capabilities of its gated spillway(s) to control less frequently occurring events, each alternative proposed herein would require that an ESRD be designed and tailored to that alternative's release capabilities. The ESRD approved for current operations is provided as **Plate 4-3**.

Table 4-3 outlines some of the basic assumptions adopted as WCD or ESRD operational criteria. **Plate 4-4** provides a detailed outline of various operational differences between the American River Watershed Projects; Folsom Modifications, Folsom Dam Raise, and the Folsom Dam JFP.

TABLE 4-3
WATER CONTROL DIAGRAM AND EMERGENCY SPILLWAY RELEASE DIAGRAM

Condition	Outflow Restriction
Maximum objective release allowed by WCD (larger releases may be initiated by ESRD)	115,000 cfs
Maximum allowable rate of release change Increases: When discharge is greater than 20,000 cfs and less than or equal to 160,000 cfs When discharge is greater than 160,000 cfs Decreases: When discharge is greater than 20,000 cfs	 15,000 cfs/hour Unlimited 5,000 cfs/hour (decrease)
Maximum outflow allowed by WCD or ESRD	Do not exceed maximum inflow experienced during flood event
Release limitation if the actual or forecasted inflow is greater than 25,000 cfs and less than 150,000 cfs and reservoir is less than 20 percent encroached	Limit outflow to 60 percent of the maximum inflow experienced during the flood event
Maximum power available or relied upon for flood operations	Power penstocks would be assumed to have zero release capacity during all routings
Physical limitation of existing emergency tainter gates	Emergency tainter gates are not used until either the total outflow from the dam exceeds 240,000 cfs or the pool elevation is within 1 foot of overtopping the emergency tainter gates while in the closed position
Release requirements (115,000 cfs to 160,000 cfs) based on Accelerated Transition Zone conditions as outlined on the proposed ESRD: if current inflow is greater than 200,000 CFS and the 12-hour forecasted inflow is greater than 360,000 cfs if current inflow is greater than 250,000 cfs and the 12-hour forecasted inflow is greater than 370,000 cfs if the current inflow is greater than 270,000 cfs and the 12-hour forecasted inflow is greater than 370,000 cfs	 Increase release to 130,000 cfs Increase release to 145,000 cfs Increase release to 160,000 cfs
KEY: WCD – Water Control Diagram ESRD – Emergency Spillway Release Diagram cfs – cubic feet per second cfs/hour – cubic feet per second per hour (flow rate of change)	

4.2.3 Emergency Spillway Release Diagram Operational Contradictions

Spillway tainter gates are not designed for overtopping. According to EM 1110-2-3600, the maximum normal operating pool is limited to allow 2 feet of freeboard when the gates are closed. Due to downstream considerations, the Corps and Reclamation raised the maximum normal operating pool level from elevation 466 to 470 by allowing some use of the surcharge storage space. This minimized downstream impacts for the longest time period possible while lengthening the downstream notification and evacuation period. The vehicle for the operational agreement is the 1986 ESRD. Operation using the 1986 ESRD essentially reduces the design freeboard for the emergency spillway gates from 5 feet to 1 foot when the gates are in the closed position.

Design of the existing ESRD restricts the maximum discharge to 160,000 cfs until the reservoir's pool reaches elevation 470. Once the reservoir water surface exceeds elevation 470, the ESRD allows releases to be increased above the 160,000 cfs limitation. However, releases should not be made through the three emergency tainter gates until discharge in the stilling basin reaches 240,000 cfs to avoid incurring damages. The contradiction in the ESRD is that it does not take into account the physical and operational limitations of the emergency spillway. When the emergency tainter gates are closed, the top of the gates is elevation 471. The routing model can force operation of the emergency tainter gates. The water surface must be within 1 foot of reaching the top of the gates for this to occur. Sufficient tailwater is required to prevent erosion below the emergency spillway chute and adjacent areas. Refer to **Section 4.2.4.3** for additional background on this operational constraint. Although the existing ESRD does not require a discharge of 240,000 cfs until the pool rises above elevation 472, the dam operator can choose to make larger releases sooner. The effect of delaying operation of the emergency tainter gates is that above elevation 471, water would begin to flow over the top; possibly causing damages or failure, or making the tainter gates inoperable.

4.2.4 Reclamation and Corps Variances in Routing Assumptions

During the development of project alternatives and configurations, various differences between Reclamation and Corps routing assumptions were encountered. These differences cause the output generated by Reclamation and the Corps, for the same alternative configuration, to be widely different. The resulting differences impact parameters such as the maximum water surface elevation produced through routing the PMF by as much as several feet. The Corps and Reclamation reached an agreement that Reclamation operating standards and criteria should take precedence due to their jurisdiction over dam safety operations. Per Code of Federal Regulations (CFR) 33 208.11, the project owner (Reclamation) has full responsibility for the safety of the dam/appurtenant facilities and for regulation of the project during surcharge storage utilization. **Attachment B1** includes a summary of the latest routing assumptions above the flood pool and related design criteria developed through on-going discussions between the Corps and Reclamation. The analysis and results provided herein implements the routing assumptions described above in **Table 4-3** and on **Plate 4-4**. At the time of the routings, some of Reclamation's requirements had not have been fully identified. For differences between the assumptions used in the routings and those adopted after subsequent discussions, compare **Table 4-3** and **Plate 4-4** with

Attachment B1. Future design studies, such as the hydraulic modeling, should facilitate efforts to refine the selected project. The following highlights some of the assumptions that influence the routing results.

4.2.4.1 Maximum Operating Flood Pool

Generally, dam safety operation commences once the reservoir water surface exceeds the authorized flood control space. Storage space extending above and beyond the authorized flood control space is designated as surcharge storage space. The demarcation at Folsom Dam between the authorized flood control space and surcharge storage space is normal full pool (elevation 466 feet). Surcharge capacity is needed to pass the PMF. Levee breaching flows should occur only when the reservoir is within the surcharge storage space. The maximum surcharge water surface coincides with the maximum PMF pool elevation.

For the Folsom Dam Raise Project, achieving flood damage reduction goal requires the use of some of the surcharge storage space. The target elevation within the surcharge storage space is determined by the design flood. Once the reservoir water surface exceeds the specified target elevation, the operation is focused strictly on dam safety. This concept is applied to the routing herein.

4.2.4.2 Rating Curves

The existing main dam spillway rating curves (1997), utilized within the Corps' routing model, were produced by Reclamation based on physical model study results. The Corps' computer program (H3106) was used to generate rating curves for the various alternatives, which include modifications to the main and/or emergency tainter gates. A spillway rating curve for the current design was also created. A quick check of the differences indicates that the computer program produces a broader zone of instability than defined in Reclamation's spillway rating table. Refer to **Attachment A2, Section 7-1.4.3** for further discussion. The result of this restriction is higher, more conservative pool elevations and reduced flood damage reduction benefits for any particular configuration. All model results reflect orifice (controlled) spillway flow operation. The routing results herein reflect use of Reclamation's rating curves for alternatives with unmodified spillway gates and computer generated ratings for alternatives with modified spillway gates.

4.2.4.3 Computational Time Interval

The computational time interval utilized in the Corps routings is one hour. Release decisions made within the routings are only allowed to look back at information provided one hour prior (i.e., the previous time-step). Reclamation generally agrees with this same standard. There is one exception. In the routing of the fuseplug auxiliary spillway, Reclamation relies on current hour information. This provides similar results as if the operations were handled with a shorter time step (i.e., 15-minute interval). The Corps and Reclamation have discussed the modeling assumptions and the possibility of coincident operation of the main dam tainter gates with operation of the fuseplug. Reclamation's premise is that the operators have the data/tools/ability to enact this operation. In this instance, applying the hour look-back standard would only result in higher, more

conservative maximum PMF pool elevations. A shorter time step is appropriate for the fuseplug. Since Reclamation has jurisdictional authority regarding dam safety operations, this exception prevails. All routings provided herein, without a fuseplug feature, use a one-hour look-back window.

4.2.4.4 Required In-channel Flows for Emergency Gate Releases

The Corps and Reclamation have had many discussions regarding the prerequisite tailwater discharge required to initiate operation of the emergency gates. The Corps has documentation from the 1950s on the structural design analysis of Folsom Dam and its appurtenant works. The flip bucket is to be used only for spillway discharges above 300,000 cfs. It is undetermined if the 300,000+ cfs criterion includes contributions from the emergency spillway. Since the sole purpose for the emergency tainter gates is dam safety, Reclamation has jurisdiction over its prescribed operation. Reclamation maintains that 240,000 cfs is the appropriate threshold for operation of the emergency tainter gates. Therefore, the Corps routings herein incorporate 240,000 cfs as the in-channel flow requirement. This in-channel flow requirement is needed to provide a pool of water at a certain depth within the stilling basin, deep enough to dissipate the force exhibited by flows coming down the emergency spillway. Without sufficient "padding" the force of flow discharging through the emergency spillway may damage structures within the stilling basin, potentially causing greater damage to the sidewalls and foundation of the dam.

4.2.4.5 Physical Constraints in Operations

Restrictions in operation are required to avoid jeopardizing the integrity of the dam and its appurtenances during high pool conditions. A constraint incorporated within the Corps' routings avoids pool elevations overtopping main dam tainter gates. Various alternative configurations proposed herein, recommend modifications or enlargements to either the emergency tainter gates or emergency and service tainter gates. Maximum operating pool elevations will change according to the alternative configuration proposed. **Table 4-4** presents the critical elevations corresponding to the gate modification proposed by any particular alternative configuration.

TABLE 4-4
PARAMETERS APPLIED IN MODELING

Configuration	Emergency Tainter Gates (El, feet)		Main Dam Tainter Gates (El, feet)
	Operating Constraint	Top of Closed Gates	Top of Open Gates
No raise No gate modification	470.0	471.0	480.0
No raise Three-gate modification	475.5	476.5	480.0

Configuration	Emergency Tainter Gates (El, feet)		Main Dam Tainter Gates (El, feet)
	Operating Constraint	Top of Closed Gates	Top of Open Gates
No raise Eight-gate modification	475.5	476.5	491.5
3.5-foot raise Three-gate modification	479.0	480.0	480.0
3.5 foot raise Eight-gate modification	479.0	480.0	491.5
7.0-foot raise Eight-gate modification	482.5 (bridge replaced)	483.5	497.0
KEY: El, feet – Elevation in feet			

Notes:

1. *The parameter assumptions are dependent solely on the dam height configuration and whether or not a given alternative includes modifications to either the three emergency spillway gates or both the emergency and main dam service spillway gates.*
2. *Minimum operating pool requirement based on 1 foot of remaining freeboard when the emergency tainter gates are in the closed position.*

The Corps recognizes that Reclamation's jurisdictional authority takes precedence in the decision to operate the emergency spillway gates once the pool level exceeds the top of flood control pool.

4.2.4.6 Discharge Rate of Increase

A rapid rate of flow increase downstream is of great concern, especially when the discharge is expected to exceed 160,000 cfs (emergency objective release). Emergency evacuations will generally take place while the discharge is held to 160,000 cfs or less. Corps guidance EM 1110-2-1420 clearly indicates that project opcration plans should ensure that release rates-of-change should be gradual and not exceed the historical maximum rates of increase. Also, the operations should ensure that the resultant peak discharge is no greater than peak inflow. The Corps recognizes that Reclamation's jurisdictional authority takes precedence in this decision. At the time of the routings, Reclamation's requirements were unknown. The routings provided herein use an unlimited rate-of-increase once the discharge exceeds 160,000 cfs. The discharge is limited so as not to exceed previous hour inflow. When releases greater than 160,000 cfs are required, any delays will only increase the magnitude of the dam safety release requirement.

4.3 OPERATIONS AND ALTERNATIVE DESCRIPTIONS

Past routings and alternative analyses were performed using the Utah State University's Reservoir Release Forecast Model (RRFM). The current analyses were conducted with a different model. This should be considered when comparing previous results to current output. Also, note that advance release or forecast based operations (FBO) results are not covered in the PAC/EDR reports. FBO is connected to directives to update the Flood Management Plan under the Folsom modification authorization. Current efforts do not preclude consideration of FBO.

There are two versions of RRFM. The latest version of RRFM is more robust than the one used during the American River Long-Term Study. RRFM provides the user with a choice between two modes of operation – planning/study mode and real-time operations mode. RRFM is able to generate probabilistic distributions of outflow based on statistically defined inflow parameters for study or planning purposes. It is also able to forecast releases based on hydrometeorological input parameters for day-to-day real-time operations. The primary interface of RRFM is through input windows or screens much like most software packages. Adaptation of the earlier version of RRFM was extensive. However, the challenges and complexities presented in the American River Watershed Projects (i.e., Folsom Modifications and Folsom Dam Raise projects) require a deeper technical interface with software code and scripting and an ability to automate complex and iterative processes. No efforts were made to further adapt the earlier version or to use the latest version for study purposes. Uncertainties with what exactly would be required of the Folsom Dam model, today and in the future, dictated the use of another piece of software. RRFM did not provide the necessary adaptability. It was decided that the flexibility offered by Microsoft Excel, with its Visual Basic for Applications, macros, and spreadsheet functions, provided the flexibility and adaptability that is required to fully explore any potential alternatives and configurations. Thus, the Folsom Dam Operations and Planning Model, developed with Excel, is currently used in all the routing and alternative analyses for the various American River studies.

A comprehensive listing of alternatives for various tainter gate, river outlet, and auxiliary spillway configurations analyzed for this project are provided in **Plate 4-5**. The initial screening of configurations that would move forward was determined from this initial list. The configurations included various combinations of an auxiliary spillway with STGs, conventional tainter gates, and fuseplug. The various gate combinations were analyzed at differing sill elevations. Combinations of modifications to the main dam river outlets were also analyzed, and advance release criteria were incorporated into the release decisions. Of the configurations in **Plate 4-5**, this document focuses on the with- and without-project conditions listed below:

- Folsom Modification Project as outlined in Appendix A (model run R060_800FM); without-project condition
- No auxiliary spillway; 7.0-foot dam raise; emergency and service tainter gate replacement (model run R000_0102DR7.0_SURme); original authorization; with-project condition

- 3.5-foot dam raise; emergency tainter gate replacement (model run R060_800DR3.5_SURe); with-project condition
- 7.0-foot dam raise; emergency and service tainter gate replacement (model run R060_800DR7.0_SURme); with-project condition

4.3.1 Existing Operations – Without-Project Conditions

The Folsom Modification Project was first authorized in 1996; its currently proposed configuration serves as the without-project condition for the Folsom Dam Raise Project. As the Folsom Modification project has evolved, design changes and refinements have been investigated and incorporated into the analysis. For further discussion with respect to the Folsom Modification project components; reoperation measures, outlet configuration, or the auxiliary spillway please reference *Appendix A to the Post Authorization Change (PAC) Report - Folsom Modification Project, Engineering Documentation Report.* In addition, a summary comparison of key operational differences is also provided as **Plate 4-6.**

4.3.1.1 Outlet Efficiency

Prior to the Reclamation and SAFCA *Interim Operations Plan* (2004) shown in **Plates 4-2a** and **4-2b**, releases from Folsom Dam's eight main dam river outlets were limited to 60 percent of their capacity when used in conjunction with the service spillway. This outflow restriction was adopted to prevent cavitation from damaging the face of the dam. The current operations agreement, however, allows all main dam river outlets to be fully opened while the service spillway is in operation. The increased discharge capability improves the ability of the dam to discharge flood waters at controlled rates downstream from the dam. Mitigation of damages due to cavitation is outlined in the Interim Operations Plan. The alternatives proposed herein do not address approaches to remedy this issue; consequently, any with-project condition assumes the eight main dam river outlet are functioning at 60 percent of their capacity.

4.3.1.2 Interim Operation Measures

The water control diagram (WCD) for Folsom Dam was originally designed in 1986 with a seasonally allocated flood control storage space of 400,000 acre-feet (**Plate 4-1**). However, the interim operation agreement between Reclamation and SAFCA was executed in 1994. In that interim operation plan, flood control storage in the reservoir was changed to a variable space allocation ranging from 400,000 acre-feet to 670,000 acre-feet (**Plates 4-2a and 4-2b**), depending on the amount of creditable vacant space in three existing upstream reservoirs. In the *Water Resources Development Act of 1996* (WRDA, 1996), Congress directed Reclamation to continue that interim operation indefinitely. Following improvements and project completion, the variable space allocated to flood control within the reservoir would be reduced from the current operating range of 400,000 to 670,000 acre-feet (**Plate 4-2a**) to 400,000 to 600,000 acre-feet, as shown in the proposed flood control diagram (**Plate 4-7**).

4.3.1.3 Outlet Modifications

The Folsom Dam outlet modification components consist primarily of enlarging the four existing upper tier river outlets from 5 feet by 9 feet to 9 feet 4 inches by 14 feet, and the inner two existing lower tier river outlets from 5-feet by 9-feet to 9-feet 4-inches by 12-feet, and adding two new outlets on the upper tier. These two new main dam river outlets would be constructed with the same dimensions as the other upper tier outlets. Outer Outlets 1 and 4 on the lower tier might not be modified due to economic and physical constraints. Ideally, the main dam river outlets would be able to release 115,000 cfs (Normal Objective Release) at or before reaching water-surface elevation 418 (spillway crest). At water-surface 418 (spillway crest), the outlet modification would increase the release capacity from 24,800 to 101,000 cfs. With modifications extended to outer main dam river Outlets 1 and 4, the total outlet capacity increases to about 120,000 cfs at the spillway crest. The primary goal of the proposed outlet modifications is to maximize the total main dam river outlet capacity. Additional flood storage gained by allowing releases to occur earlier, would reduce the probability of flooding.

4.3.1.4 No Main Dam River Outlet Modifications - Six-Submerged-Tainter-Gate Auxiliary Spillway

This configuration is intended to satisfy the concerns of both dam safety and flood control. In this configuration, the auxiliary spillway sill invert is set at elevation 368. This alternative is intended to pass the unlikely occurrence of the PMF and allow Folsom Dam to release objective flow at lower pool elevations.

The routing model does not require the user to pre-define a gate operation sequence. The routing model only specifies the total discharge requirement throughout each event. By examining this information, one can deduce the best method of splitting or distributing the flow amongst the outlet works and spillway features. The following provides an idea of how the auxiliary spillway might be integrated into the gate operation sequence. Generally, the outlet works would be brought on-line first followed by the auxiliary spillway. Together, the outlets and auxiliary spillway can maintain the normal objective release (115,000 cfs) once the pool reaches elevation 411. While releases of 115,000 cfs are being made, the use of the outlet works and/or auxiliary spillway could be reduced as the main spillway is given control of the discharge. The main spillway could take over fully while a release of 160,000 cfs is maintained. As soon as sufficient tailwater of 240,000 cfs is achieved in the main stilling basin, the emergency spillway gates would be primed for operation.

4.3.2 Future Operations – With-Project Conditions

This section presents a discussion of Folsom Dam operations as they would be affected in the future under with-project conditions. The analysis and discussion provided herein assumes the structural and operational components of the Folsom Modification Project (reoperation measures, outlet modifications, and auxiliary spillway) have been implemented. For further discussion on these components please refer to *Appendix A to the Post Authorization Change (PAC) Report - Folsom Modification Project, Engineering Documentation Report.*

4.3.2.1 Outlet Efficiency

One of the intended benefits of any outlet modification would be to eliminate damages that occur as discharge is made concurrently through the main dam river outlets and over the service spillway. Main dam river outlets being redesigned would be capable of releasing 100 percent of their capacity. Main dam river outlets that are not modified would still be operated at 60 percent their capacity.

4.3.2.2 Dam Raise – 3.5 or 7.0 feet

The dam raise component of the Folsom Dam Raise Project is intended to satisfy the flood damage reduction portion of the overall project objective. A dam raise, however, whether 3.5 feet or 7.0 feet will also provide an incremental dam safety benefit. The additional volume provided through raising the dam permits the reservoir to sustain non-damaging release for a longer duration. The next section discusses surcharge storage.

4.3.2.3 Addition of Surcharge Storage Space

Extra volume gained via a raise is added to the surcharge storage space. For dam safety purposes, Folsom Reservoir's surcharge storage space is sized to handle a PMF event. Given the additional goal of controlling discharge of a specific design event to non-damaging flows, flood control operations must extend into the surcharge storage space. Thus to attain a desired project performance, an alternative might include appropriation of some of the surcharge storage space for flood damage reduction (FDR) purposes. This would occur if the authorized flood storage reservation was not sufficient in containing the specified design event.

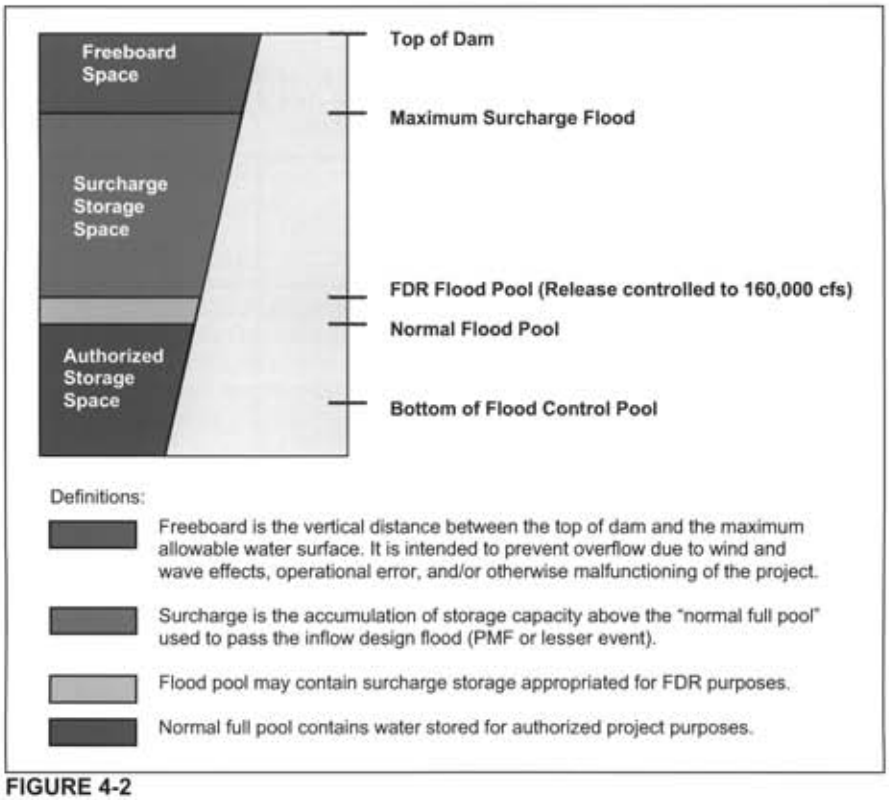


FIGURE 4-2
STORAGE SPACE ALLOCATIONS

Figure 4-2 describes how space is allocated within the reservoir. The authorized storage space remains constant and independent of any modifications to the project. The surcharge storage space is used to contain extreme events within the reservoir. The surcharge space requirement is greatly affected by the inflow design flood volume, the total discharge capacity of the project, and the plan of operation. Freeboard space above the maximum allowable surcharge storage is needed to prevent overtopping mainly by wind or wave action. Refer to **Table 4-5** below for key water surface elevations associated with the various alternatives.

TABLE 4-5
PERTINENT INFORMATION

Alternative	Top of Dam	Maximum Surcharge Flood Pool[1]	Freeboard [3]	FDR Flood Pool [4]	Normal Full Pool	Normal Flood Control Reservation Range [5]
	El, feet	El, feet	El, feet	El, feet	El, feet	El, feet (acre-feet)
Pre-Common Features	480.5	475.5[2]	5	470.0	466.0	425.8 (400,000)
Common Features	480.5	475.5[2]	5	470.0	466.0	425.8 to 388.3 (400,000 – 670,000)
Folsom Modifications (JFP)	480.5	477.5	3	468.0	466.0	425.8 to 399.7 (400,000 – 600,000)
Folsom Raise 3.5 Feet	484.0	481.0	3	474.0	466.0	425.8 to 399.7 (400,000 – 600,000)
Folsom Raise 7.0 Feet	487.0	484.5	3	477.0	466.0	425.8 to 399.7 (400,000 – 600,000)
KEY El, feet – Elevation in feet						

Notes:

1. *These values reflect the highest allowable pool elevation given both freeboard and top of dam height requirements. The maximum surcharge flood pool is established by routing a PMF through the reservoir. The PMF has been updated or revised periodically (e.g. 1946, 1980, 1991, and 2001).*
2. *The existing project requires more surcharge storage than is available under the original project design. Under the without-project conditions, the 2001 PMF event would overtop Folsom Dam.*
3. *Reclamation has determined that 3 feet provides sufficient freeboard for the with-project alternatives.*
4. *The FDR flood pool is established by routing the single design 1-in-200 chance event through Folsom Dam. The release from Folsom Dam will not exceed 160,000 cfs as long as the water surface remains at or below the FDR flood pool. The antecedent event for the PMF is roughly equivalent in volume to the 1-in-200 chance event and should also be taken in to consideration when establishing the FDR flood pool elevation requirement. Optimization using Reclamation standards/criteria is necessary to firmly establish the FDR flood pool.*
5. *The authorized storage space allocation for flood control differs with the alternatives. The flood space requirement itself varies seasonally. The maximum space would be needed only during the most critical flood period (December through February).*

4.3.2.4 Spillway Tainter Gate Modification

Spillway tainter gate modifications are being proposed as part of the Folsom Dam Raise Project. Modifications are being proposed for the three emergency tainter gates on the emergency spillway portion of the main spillway. Gate modifications, in combination with the dam raise component, allows operations to reach higher water surface elevations without overtopping the gates.

4.4 FLOOD ROUTING RESULTS

This section presents a discussion of PMF routings for various with- and without-project conditions alternatives.

4.4.1 Probable Maximum Flood Routings

Any adopted alternative for Folsom Dam must be capable of controlling a PMF event to a maximum reservoir elevation without encroaching into the prescribed freeboard. For this analysis, some assumptions made in routing the PMF through the Folsom Dam operations and planning model were different from those routings performed in the development of flood damage reduction alternatives. These differences, which are unique to the PMF routings, are described below.

- A reduced efficiency is assumed on discharge through the main dam river outlets. Lower tier outlets are functioning at 50 percent operability and the upper tier outlets at 75 percent. An alternate practice would be to assume non-functioning main dam river outlets.
- The PMF is routed with an antecedent event, which sets the initial starting condition for the PMF. The initial starting storage for the antecedent event is 377,000 acre-feet (bottom of the flood control space). An alternate practice would be to route the PMF alone starting, at 977,000 acre-feet (normal full [gross] pool).

The resultant maximum elevations, obtained through routing the PMF through each of the proposed alternatives is provided in **Table 4-6**.

TABLE 4-6
MAXIMUM PROBABLE MAXIMUM FLOOD ELEVATIONS

Alternative[1]		
	Maximum El, feet	
Without-Project Condition	**PMF**	**Top of Dam**
Folsom Modification Project as outlined in Appendix C (model run R060_800FM)	477.4	480.5
With-Project Condition		
No auxiliary spillway; 7.0-foot dam raise; emergency and service tainter gate replacement (model run R000_0102DR7.0_SURme); original authorization	484.5	487.5
3.5-foot dam raise; emergency tainter gate replacement (model run R060_800DR3.5_SURe)	478.8	484.0
7.0-foot dam raise; emergency and service tainter gate replacement (model run R060_800DR7.0_SURme)	484.1[1]	487.5
Key: PMF – Probable maximum flood El, feet – Elevation in feet		

Notes:
1 An explanation of nomenclature is provided in Plate 4-5.

4.4.2 Uncertainty in Operations

Uncertainty considered in this analysis includes attempts to account for estimating relationships such as discharge-frequency, reservoir inflows versus outflow (i.e., unregulated versus regulated flow values), and rating curves. Previous analyses determined this uncertainty using the MONTE™ software package to perform Monte Carlo simulations,

integrating the uncertainty associated with any of these relationships. The current analysis uses the Flood Damage Analysis software developed by the Corps, Hydrologic Engineering Center. The resulting output is a measure of flood risk associated with a particular project configuration.

Uncertainty in hydrology and reservoir operations is described via a band of uncertainty around paired data relationships or ranges of possible values. In hydrology, this uncertainty band is described by the confidence limits around unregulated flow-frequency curves. In reservoir operations, this band resembles a range of maximum and minimum outflow estimates around a reservoir inflow/outflow relationship. This analysis incorporates a reasonable range in reservoir operations, determined through various scenarios, to describe the range of uncertainty of the maximum and minimum reservoir releases associated with any given flood event. These risk analysis scenarios reflect the operating conditions ranging from the most likely to occur (base) to the most extreme operating conditions likely to produce the largest (maximum) or smallest (minimum) expected release. The criterion for operation is based on actual flood operations and analysis of historical data, resulting from coordinated effort by representatives of the Corps, SAFCA, and Reclamation. The operating criteria and assumptions associated with each scenario are summarized below in **Table 4-7**.

TABLE 4-7
OPERATING CRITERIA AND ASSUMPTIONS

Factor	Scenario		
	Base (cfs)	Maximum Outflow (cfs)	Minimum Outflow (cfs)
Initial Encroachment (acre-feet)	0	50,000	0
Extra Space in Folsom Lake (acre-feet)	0	0	100,000
Upstream Reservoir Space (acre-feet)	0	0	150,000
Starting Storage (acre-feet)	377,000	427,000	440,000
Initial Delay in Releases (hours)	4	8	0
Outlet Works Operation During Concurrent Spillway Operation (percent open)	60	0	60
KEY cfs – cubic feet per second			

The following figures (**Figures 4-3** through **4-6**) represent output from the Folsom Dam operations and planning model, as outlined in the operations and alternative descriptions presented in **Section 4.3**. Represented are the inflow/outflow relationships for each alternative configuration. Given a fixed inflow, the uncertainty in operation is shown through the shaded band residing above and below the base outflow. The inflow/outflow relationships for key events are noted by vertical dashed lines.

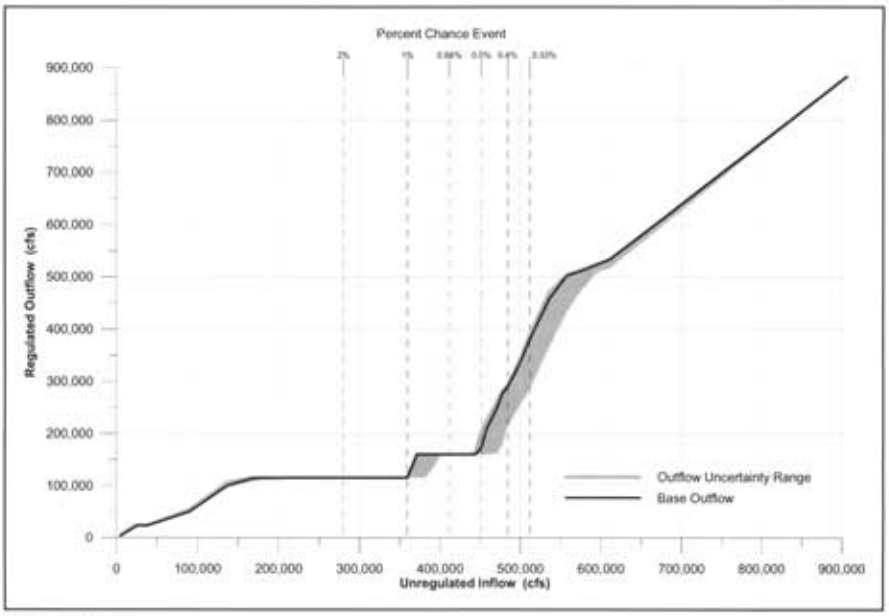


FIGURE 4-3
INFLOW VS. OUTFLOW RELATIONSHIP FOR EXISTING OPERATIONS WITHOUT-PROJECT CONDITION - SIX-SUBMERGED (23- BY 33-FOOT) TAINTER-GATE AUXILIARY SPILLWAY

No Outlet Modifications - Six-Submerged (23- By 33-Foot) Tainter-Gate Auxiliary Spillway
Model Run R060_800FM

Water Control Diagram	400/600 Reoperation
Outlet Configuration	Eight existing main dam river outlets, unmodified
Main Spillway Gates	Unmodified
Emergency Gates	Unmodified
Auxiliary Spillway	Six submerged (23- by 33-foot) tainter gates
Dam Raise	None
PMF Peak Elevation	477.4

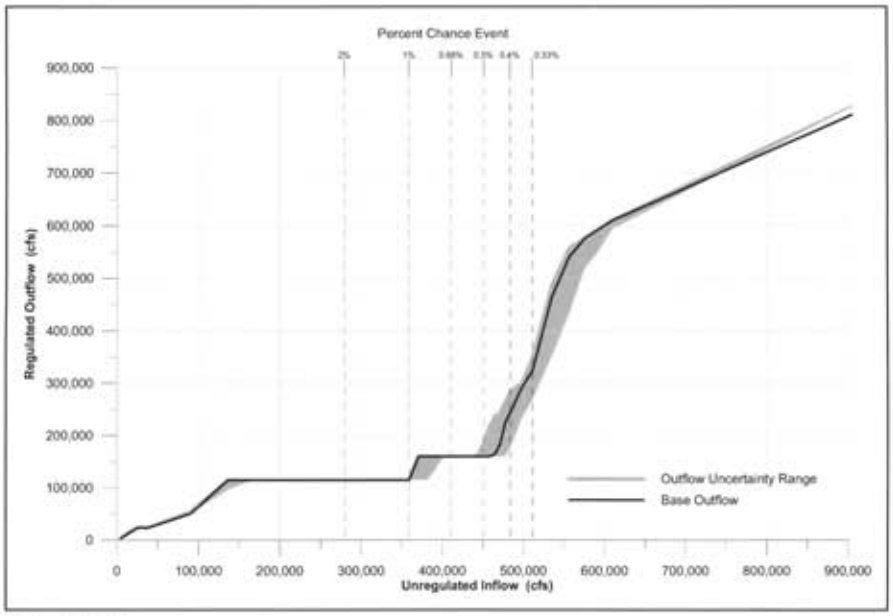


FIGURE 4-4
INFLOW VS. OUTFLOW RELATIONSHIP FOR EXISTING OPERATIONS WITH-PROJECT CONDITION - TEN OUTLETS; 7.0 FOOT DAM RAISE; MAIN AND EMERGENCY TAINTER GATE REPLACEMENT

Original Folsom Dam Raise Authorization - Ten Outlets; 7.0 Foot Dam Raise; Main And Emergency Tainter Gate Replacement
Model Run R000_0102DR7.0_SURme

Water Control Diagram	400/600 Reoperation
Outlet Configuration	Four existing, modified lower tier outlets Four existing, modified upper tier outlets Two new upper tier outlets
Main Spillway Gates	Modified
Emergency Spillway Gates	Modified
Auxiliary Spillway	None
Dam Raise	7.0 feet
PMF Max Pool Elevation	484.5

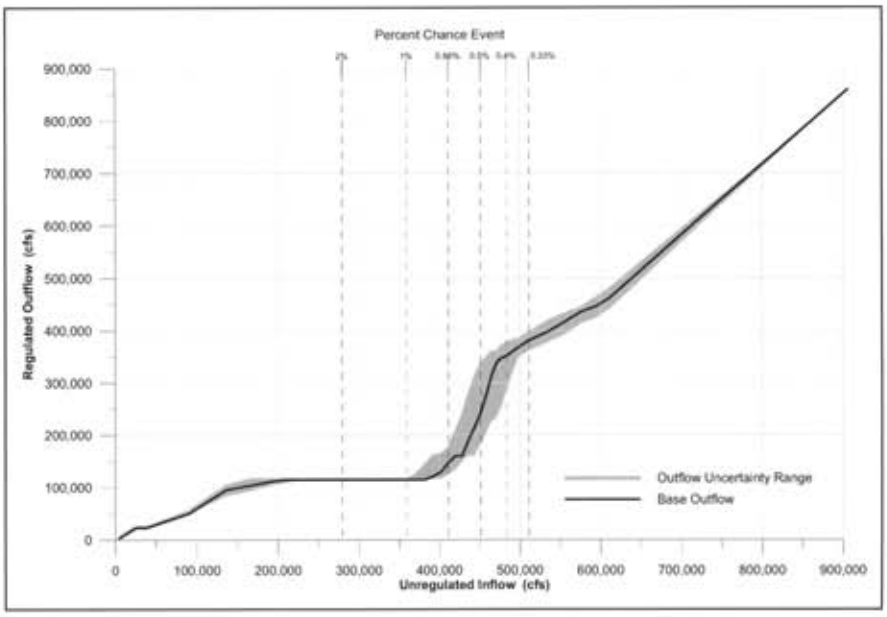


FIGURE 4-5
INFLOW VS. OUTFLOW RELATIONSHIP FOR EXISTING OPERATIONS WITH-PROJECT CONDITION - SIX-SUBMERGED (23- BY 33-FOOT) TAINTER-GATE AUXILIARY SPILLWAY; 3.5 FOOT DAM RAISE; EMERGENCY TAINTER GATE REPLACEMENT

No Outlet Modifications - Six-Submerged (23- By 33-Foot) Tainter-Gate Auxiliary Spillway; 3.5 Foot Dam Raise; Emergency Tainter Gate Replacement
Model Run R060_800DR3.5_SURme

Water Control Diagram	400/600 Reoperation
Outlet Configuration	Eight existing main dam river outlets, unmodified
Main Spillway Gates	Unmodified
Emergency Spillway Gates	Modified
Auxiliary Spillway	Six submerged (23- by 33-foot) tainter gates
Dam Raise	3.5 feet
PMF Max Pool Elevation	478.8

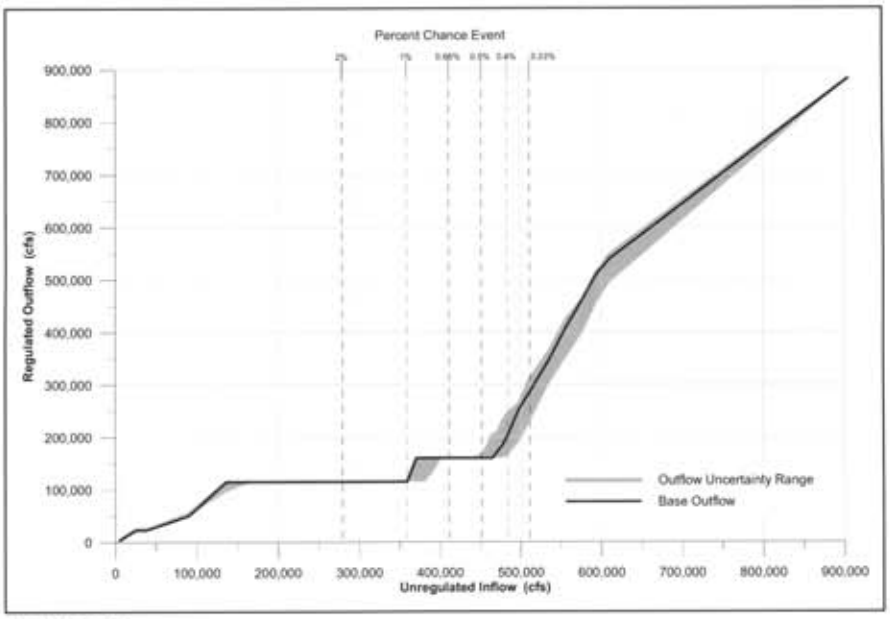


FIGURE 4-6
INFLOW VS. OUTFLOW RELATIONSHIP FOR EXISTING OPERATIONS WITH-PROJECT CONDITION - SIX-SUBMERGED (23- BY 33-FOOT) TAINTER-GATE AUXILIARY SPILLWAY; 7.0 FOOT DAM RAISE; MAIN AND EMERGENCY TAINTER GATE REPLACEMENT

No Outlet Modifications – Six-Submerged (23- By 33-Foot) Tainter-Gate Auxiliary Spillway; 7.0 Foot Dam Raise; Main And Emergency Tainter Gate Replacement
Model Run R060_800DR7.0_SURme

Water Control Diagram	400/600 Reoperation
Outlet Configuration	Eight existing main dam river outlets, unmodified
Main Spillway Gates	Modified
Emergency Spillway Gates	Modified
Auxiliary Spillway	Six submerged (23- by 33-foot) tainter gates
Dam Raise	7.0 feet
PMF Max Pool Elevation	484.1

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CHAPTER 5.0
ENVIRONMENTAL EFFECTS AND MITIGATION

Several previous environmental documents are relevant to the impact analysis for the dam raise alternatives. These documents provided information about existing environmental, socioeconomic, and cultural conditions in the area; the effects of various actions on the resources in the area; and potential measures to avoid, minimize, reduce, or compensate for any significant effects.

5.1 SIX-SUBMERGED-TAINTER-GATE AUXILIARY SPILLWAY, 3.5-FOOT RAISE, AND REPLACEMENT OF THREE EMERGENCY TAINTER GATES

The six-STG auxiliary spillway is assumed to be a without-project condition for the Folsom Dam Raise Project, as the auxiliary spillway would have been previously implemented under the Folsom Modification Project authorization and is included in the alternative description to show all project features for the Folsom facility. A description of the six-STG auxiliary spillway is included in the Folsom Dam Joint Federal Project EDR.

A 3.5-foot-dam raise for flood damage reduction would be accomplished by construction of either a reinforced concrete parapet (flood) wall or an embankment raise. The parapet wall would be located along the waterside edge of the existing crest for all facilities except the main concrete dam, which has an existing parapet wall that is sufficient. Embankment raises would be accomplished by raising the dam and dike crests through placement of suitably graded materials from the auxiliary spillway and/or borrow areas.

Flood wall construction or embankment raises would involve the removal and disposal of material necessary to facilitate placement of the new construction features. Due to various types of material involved, i.e. riprap, fine and course filter materials, road base asphaltic pavement and common embankment fill, it is anticipated that the relatively small quantities of these materials would be disposed of at a Federally-owned site in the local area (within ½ mile). New riprap, filter material and backfill would be imported from a local source. Borrow and stockpile sites would be developed on Federal property within and immediately outside of the reservoir. The number and extent of borrow sites would be dependent on the amount of earthen material required to accomplish the various raise alternatives. Several potential borrow sites have been investigated by the Reclamation and the Corps, as discussed in **Chapter 6**.

The environmental impact analysis for this alternative, assuming the 3.5-foot raise would be accomplished by constructing a flood wall, is fully discussed in the *Folsom Dam Safety Flood Damage Reduction EIS/EIR* as Alternative 3. In the event that the 3.5-foot raise would be accomplished by an earthen embankment, the environmental impact analysis for that feature is included in Alternative 2 of the EIS/EIR. A summary of potential impacts for this alternative follows.

5.1.1 Hydrology

Construction of this alternative in itself would not alter the hydrology of the American River nor current reservoir operations; however, modifications to the operation of the Folsom Dam facilities to take advantage of proposed features (spillway) would alter downstream hydrology. These changes in operations are not known at this time, and are anticipated to be complete one year prior to completion of construction of the spillway. Agency and public coordination and environmental compliance documentation will accompany these changes in operation. Construction of any of the alternatives would result in improved hydrologic control of the American River Watershed flood flows, providing flood control benefits to the Sacramento region. The reservoir would be operated under existing criteria until completion of a new water control manual and supporting environmental compliance documentation, which is scheduled for completion one year prior to completion of construction.

Construction of raises would result in the potential for temporarily increasing the surcharge elevation of the reservoir. This would result in the potential for flooding of additional shoreline property, which would be further surveyed and addressed once a plan is selected and further design is completed. These impacts would likely be addressed in supplemental environmental compliance documentation.

5.1.2 Water Quality

Construction of any of the alternatives would have the potential for significant water quality impacts. The greatest potential for this alternative would result from soil erosion during blasting and excavation of the auxiliary spillway approach channel. These impacts would be minimized as much as possible with the use of best management practices such as sediment curtains.

5.1.3 Air Quality

Exhaust emissions from construction equipment and materials-hauling trucks, fugitive dust produced by excavators and haul trucks on disturbed soils, and fugitive dust emissions from materials processing facilities and concrete batch plants would cumulatively produce a significant air quality impact. Nitrogen oxide (NO_x) emissions would trigger a general conformity determination as required by the Clean Air Act. In this evaluation, mitigation measures would be developed to reduce air quality impacts.

5.1.4 Aquatic Resources

Construction of this alternative would have potentially significant impacts on in-reservoir aquatic resources. However, the majority of fish species inhabiting the reservoir are introduced game or prey species, and special status species are not known to inhabit the immediate vicinity of the project sites. Construction near Dike 6 could have adverse impacts on a seasonal wetland, which would require compensatory mitigation.

5.1.5 Terrestrial Vegetation and Wildlife

Construction of any of the alternatives would have the potential to adversely impact special status species, protected oak woodlands, native vegetation, and wetlands. Construction activities would result in direct and indirect impacts to a number of elderberry shrubs, which are habitat for the Valley Elderberry Longhorn Beetle (*Desmocerus californicus),* a Federally-listed threatened species and is protected by the Endangered Species Act. These impacts would require compensatory mitigation as per the U.S. Fish and Wildlife Service biological opinion. All impacts to terrestrial vegetation and wildlife could be mitigated to less than significant levels with compensatory mitigation.

5.1.6 Soils

Construction activities would result in loss of topsoil resources. This impact would be mitigated to less than significant levels through the implementation of best management practices. Use of granitic material from within the reservoir for raising the dikes and MIAD would represent a long-term commitment of this resource. The schist-based bedrock comprising the borrow material east of Dike 7 contains low levels of asbestos, and if utilized, would be managed to reduce air borne release of asbestos fibers.

5.1.7 Visual Resources

Establishment of material processing facilities, excavation of borrow sites, and construction work on Folsom Dam and the dikes would result in a significant but temporary visual impact to Folsom Lake State Recreation Area (SRA) visitors and to the homeowners surrounding the reservoir. The impact to visual resources would be an unavoidable adverse impact until construction was completed at each facility.

5.1.8 Transportation

The hauling of materials and supplies to the construction sites would have a less than significant impact on the level of service for most local roadways, with the exception of Scott Road north of White Rock, and East Natoma Street. This impact would be mitigated as feasible.

5.1.9 Noise

Construction equipment, materials processing facilities, and haul trucks all would increase noise levels within the project area. During the day, there would be a perceptible increase in noise for the project area, but due to the distance between sensitive noise receptors and noise sources, the increase would not be considered as significant. However, nighttime noise increase at three residential receptor areas would exceed ambient noise criteria, creating an unavoidable adverse impact, should mitigation measures not be effective in reducing noise levels.

5.1.10 Cultural Resources

Cultural resources are known to exist at many locations proposed for staging and facility construction. Cultural resources could be disturbed or destroyed under any of the action alternatives. Cultural resource impacts would be evaluated and mitigated for under a programmatic agreement in consultation with the State Historic Preservation Office.

5.1.11 Recreation

Contractor staging would emphasize use of areas with no current public access, away from residential areas. Excess materials would be used to create platforms above the normal operating reservoir water surface at elevation of 466.0 and would be be placed so as to maintain existing or equivalent public recreation access and use capacity during the peak recreation season.

To minimize potential impacts to recreation, staging areas at Beal's Point and Folsom Point would be placed on constructed platforms or on adjacent unimproved areas a safe distance from primary recreational activities. Public safety would be maintained through the use of fencing or other similar measures. There would be nearly continuous public access to recreation areas and trails throughout the construction period through the use of traffic control measures, grade separated vehicular and/or pedestrian crossings, and/or temporary alternate public access detours. Closures could occur while the Partner Agencies are implementing these new measures that allow continued access or to address public safety and facility security objectives. In such cases, temporary closures would be accomplished during off-peak days or the off-season to minimize impacts on recreation activities. Reclamation's Central California Area Office would notify local agencies and the general public and accept input in advance of any possible extended closure(s) that may be necessary due to unforeseen project circumstances.

5.1.12 Utilities

Construction planning and sequencing would be performed so that existing utilities would not be impacted by construction activities. Mitigation measures would be implemented to reduce interruptions in service. A 42-inch water main would be relocated for construction of the auxiliary spillway. All roads and other utilities damaged by construction activities would be repaired or replaced.

5.2 MODIFICATION OF SIX PLUS TWO NEW MAIN DAM RIVER OUTLETS, 7-FOOT RAISE, AND REPLACEMENT OF EIGHT MAIN DAM TAINTER GATES

This section presents environmental effects related to (1) main dam river outlet modification and to (2) a 7-foot dam raise plus replacement of eight tainter gates on the main dam.

5.2.1 Main Dam River Outlet Modification

Several previous environmental documents are relevant to the impact analysis for the main dam river outlet modification alternatives. These documents provided information about existing environmental, socioeconomic, and cultural conditions in the area; the effects of various actions on the resources in the area; and potential measures to avoid, minimize, reduce, or compensate for any significant effects.

A final *Environmental Assessment/Initial Study* (EA/IS) was prepared in August 2001, which discussed the environmental conditions and evaluated the potential effects of the original project design (enlarging the eight existing main dam river outlets) for the American River Watershed, California, Folsom Modification Project. The Corps determined that the proposed modifications would not have any significant long-term adverse effects on the environmental resources within the project footprint or along the lower American River. As a result, a finding of no significant impact (FONSI) and negative declaration accompanied the final 2001 EA/IS.

Following the issuance of the 2001 EA/IS, the project design was revised to include improving approximately 4,100 feet of existing access roads by paving and widening from 16 to 24 feet maximum, constructing approximately 3,000 feet of additional access roads, and constructing a Corps resident office facility. A final EA/IS was prepared for these construction activities in 2005. The Corps determined that these proposed construction activities would not have any significant long-term adverse effects on the environmental resources within the project footprint or along the lower American River. As a result, a FONSI and negative declaration accompanied the final 2005 EA/IS. These staging area improvements were completed in 2006.

Also since the issuance of the 2001 EA/IS, additional information regarding technical feasibility and cost of modifying all eight of the existing main dam river outlets have led to further refinements to the project design. For current planning purposes, the Folsom Dam outlet modifications would consist primarily of enlarging the four existing upper tier river outlets from 5 feet by 9 feet to 9 feet 4 inches by 14 feet, the inner two existing lower tier river outlets from 5 feet by 9 feet to 9 feet 4 inches by 12 feet, and adding two new outlets on the upper tier. The two new outlets would be constructed to the same dimensions as the other upper tier outlets. The enlarged river outlets would increase the release capacity from 24,800 to 115,000 cfs (the objective release) at water-surface elevation 418 (the spillway crest elevation).

Modification of the main dam river outlets would not have any potentially significant impacts related to the resource categories of agricultural land use, geology and soils, topography, socioeconomics, recreation, or traffic and circulation.

Impacts would be as disclosed in the 2001 and 2005 EA/ISs with the following additional potential impacts due to design refinements.

5.2.1.1 Vegetation and Wildlife

For construction activities modifying the main dam river outlets, approximately 9.3 acres of waters of the United States would be temporarily affected, which primarily consist of the stilling basin and downstream channel.

5.2.1.2 Fisheries

Improvements to the existing stilling basin would be made during the non-flood season from approximately June until November over a two-year period. Construction activities would involve dewatering the stilling basin and installing rock anchors in the basin floor and sidewalls. The basin would be temporarily unavailable as habitat for fish and other aquatic species during these months until the stilling basin work is completed. However, the aquatic habitat would be available during flood season from November through May, and additional habitat would be available downstream and in Lake Natoma. Due to the relatively small area of the stilling basin as compared to downstream areas and Lake Natoma, the project would not substantially diminish habitat for fish or significantly displace fish to reduce year class strength of any fishes occupying the stilling basin. In addition, there would be no significant effects on the movement of resident or migratory fish because there is suitable habitat downstream and in Lake Natoma.

Approximately 8.7 acres of habitat would be unavailable during periods of dewatering. A 450-foot long by 15-foot wide access road would be constructed in the riffle pool complex downstream of the stilling basin to facilitate access to the stilling basin and ensure the possibility of rapid removal of personnel and equipment if necessary. This access road would require permanent or temporary filling of approximately 0.15 acre of the riffle/pool complex. The road would be constructed of 1000 cubic yards lean mix concrete (permanent road) or clean gravel/cobbles (temporary). Should a permanent road be constructed using lean mix concrete it would result in the filling 0.15 acres of habitat, resulting in a significant adverse impact to fisheries. However, should a temporary road be constructed resulting in the filling of 0.15 acres with gravel/cobbles, the action would have a long term beneficial effect on fisheries and invertebrate production downstream of the stilling basin. It would be expected that the gravel/cobble mix would be moved downstream and contribute to spawning areas, and riffle pool complexes in this sediment starved area. Placement of gravel/cobbles in the amount of 1000 cubic yards per year during stilling basin modification would have beneficial effects.

Prior to dewatering the stilling basin for construction, a fish salvage operation would be conducted, as necessary, to remove fishes and relocate them downstream. In addition, the contractor would use best management procedures to ensure that construction-related materials are not discharged downstream during construction. These best management practices would include cleaning and washing the stilling basin prior to allowing the stilling basin to be flooded. This water would then be disposed of at an appropriate facility to handle such materials contained in the stilling basin.

5.2.1.3 Water Quality

Construction activities within the interior of the dam would not be directly exposed to the environment, but could affect downstream water quality through the drainage system within the dam. Excavation or fill activities would take place in approximately 0.13 acre of seasonal wetlands, and temporary disturbance to 9.3 acres of open water (0.15 acre permanent or temporary fill) and drainages (0.6 acre permanent).

Appropriate best management practices to control construction-related contamination and to reduce construction-related and operation effects to less-than-significant levels would be as follows:

- Sediment control methods would be used in the interior of the dam to limit the discharge of construction materials into the interior drainage system of the dam. Best management practices could include the use of silt fences or other barriers at drainage inlets.
- Major equipment cleaning and maintenance would not be conducted within the construction area at the face of the dam or near the stilling basin.
- A dewatering permit would be obtained from the Regional Water Quality Control Board (RWQCB) and water quality monitoring completed for stilling basin dewatering.
- Water quality monitoring would be completed to ensure that turbidity limits and other RWQCB water quality parameters are not exceeded during marine construction and stilling basin modification.

5.2.1.4 Air Quality

Potential air pollutants generated during construction include particulate matter smaller than ten microns (PM_{10}) emissions from debris-moving activities and vehicle travel on unpaved roads, and exhaust emissions from operation of construction equipment, delivery and haul trucks, and employee vehicles. Tailpipe exhaust emissions include ozone precursors (NO_X and reactive organic gasses [ROG]) and PM_{10}.

Sacramento Municipal Air Quality Management District (SMAQMD) thresholds and Federal *Thresholds of Significance* would be exceeded for NO_x under the proposed action in all years with main dam river outlet modification construction activities. In general, air quality effects would be less than significant for ROG and PM_{10}. Federal conformity for NO_x would be exceeded. Federal conformity for ROG, PM_{10}, and carbon dioxide (CO_2) would not be exceeded. However, no sensitive receptors (residences and schools) are located in the project area. Therefore, no sensitive receptors would be affected by short-term increases in dust and other air pollutants.

This analysis should be considered preliminary, with the possibility of fewer and greater effects than calculated. This is possible since the analysis is a maximum daily

average of emissions and not an average emission analysis. The Corps does not have the ability to conduct an accurate average daily emission analysis since the Corps does not control contractor production rates, schedule, equipment inventory, source material, and employee housing locations. Therefore, mitigation measures have been developed in coordination with SMAQMD to minimize exceedence of State and Federal thresholds.

Potentially significant air quality effects have been identified, and the Corps would implement mitigation measures as described in the 2005 EA/IS for NO_x emissions in years where SMAQMD thresholds and Federal *Thresholds of Significance* are exceeded. With the implementation of these mitigation measures, the project would not exceed SMAQMD thresholds and Federal *Thresholds of Significance* for the project. As a result, potential emissions due to the project would be below the level of significance for air quality.

5.2.1.5 Visual Resources

Effects on visual resources are changes in viewer response as a result of project construction and operation. Multiple types of construction equipment would be visible at the project area. Boaters, pedestrians and bicyclists, would be able to see the construction equipment, as well as workers and visitors to the Reclamation and Corps offices. The construction equipment would be visible for approximately 7 years. The presence of construction equipment would degrade the visual quality of scenic vistas to low vividness, intactness, and unity. Views of Folsom Dam would not be permanently altered by construction of the main dam outlet modifications and the addition of two new main dam outlets. River outlet modification would generally be confined to the interior of Folsom Dam; therefore, it is considered less than significant. Also, because this effect would be temporary during construction, it is considered less than significant.

5.2.2 Seven-Foot Raise and Replacement of Eight Main Dam Tainter Gates

A 7-foot raise of the Folsom facilities would be accomplished through a combination of parapet walls and earthen embankment raises. See **Chapter 6** for a description of construction activities and quantities.

5.2.2.1 Hydrology, Water Quality, and Groundwater

Any raise of the Folsom facilities would allow for an increase in the surcharge storage capacity of the reservoir for flood control. The increased capacity in the reservoir would result in rare potential flooding of areas along Mooney Ridge, north of Beal's Point, which would be addressed by supplemental investigations and environmental compliance documentation with potential recommendations for flood easements for impacted properties. Flood easements at Mooney Ridge could result in the conversion of land from open space or residential to flood control purposes.

5.2.2.2 Air Quality

Exhaust emissions from construction equipment and materials hauling trucks, fugitive dust produced by excavators and haul trucks on dirt roads, and other fugitive dust emissions would cumulatively produce a significant air quality impact. Cumulative NOx emissions

could trigger a general conformity evaluation, from which mitigation measures would be developed to reduce air quality impacts.

Air quality impacts would be greater for a 7-foot raise alternative than for a 3.5-foot raise alternative, in that there would be additional emissions from borrow material processing, hauling and placement.

5.2.2.3 Aquatic Resources

Construction activities for either raise alternative near Dike 6 would have the potential to remove a seasonal wetland. Loss of the wetland would be considered to be significant requiring compensatory mitigation.

5.2.2.4 Terrestrial Vegetation and Wildlife

Construction of either of the raise alternatives would have the potential to adversely affect special status plant species, protected oak woodlands, result in losses of native vegetation, result in a permanent loss of project area wetlands, and impact elderberry shrubs, which host to the endangered Valley Elderberry Long-Horn Beetle. All vegetation impacts can be mitigated to non-significant levels, considering that dam raise work would be done on the crest of the dam, with some construction activity within the construction easement, which is considered to be 150 feet from the toe of the dam/dikes as a worse-case scenario. This construction easement would be adjusted as appropriate for construction activities at each facility, avoiding adverse impacts vegetation and wildlife, including special status species

5.2.2.5 Soils, Minerals, and Geological Resources

Construction activities for either raise alternative would result in the loss of topsoil resources, as disturbance of existing soils would be necessary for installation of parapet walls on the crests of the dams/dikes. This impact would be mitigated to non-significant levels through the implementation of best management construction practices.

5.2.2.6 Visual Resources

Establishment of the material processing facilities, excavation of borrow sites, and construction work on the dams and dikes would result in a significant but temporary visual impact to Folsom Lake SRA visitors and to the home owners bordering the reservoir. The visual resource impairment would be an unavoidable adverse impact until construction work was completed at each facility.

5.2.2.7 Transportation and Circulation

The hauling of materials and supplies to the work sites would not have a significant impact on the level of service for most local roadways except for Scott Road north of White Rock, and East of Natoma Street. This impact would be mitigated as feasible.

5.2.2.8 Noise

Construction equipment, materials processing facilities, and haul trucks all would increase noise levels within the project area. During the day time, there would be a perceptible increase in noise for the project area, but due to the distance between sensitive noise receptors and noise sources, the increase would not be considered as significant. However, nighttime noise increase at three residential receptor areas would exceed ambient noise criteria creating an unavoidable adverse impact, should mitigation measures not be effective in reducing noise levels.

5.2.2.9 Cultural Resources

Cultural resources are known to exist at many locations proposed for staging, borrow development, and facility construction. Cultural resources could be disturbed or destroyed under either of the raise alternatives, but potential for cultural resources impacts would be greater for a 7-foot raise, due to the need for borrow excavation for earthen embankment raises at certain facilities. Cultural resource impacts would be mitigated for under a programmatic agreement in consultation with the State Historic Preservation Office.

5.2.2.10 Land Use, Planning, and Zoning

Construction of Folsom staging, borrow site, and facility improvements would be conducted in compliance with local planning and zone rules. Any raise of the Folsom facilities would allow for an increase in the temporary storage capacity of the reservoir for flood control. The increased capacity in the reservoir would result in potential flooding of areas along Mooney Ridge, north of Beal's Point, which would be addressed by supplemental investigations and environmental compliance documentation with potential recommendations for flood easements for impacted properties. Flood easements at Mooney Ridge could result in the conversion of land from open space or residential to flood control purposes.

5.2.2.11 Recreation

The establishment of staging areas and borrow sites within existing recreational use areas coupled with construction work at Folsom facilities and haul truck traffic would have significant and unavoidable adverse impacts to recreation at Folsom. State Parks, the entity managing the recreational aspects of Folsom, would be impacted by losing all public access at the Folsom Point recreation area, and portions of Beal's Point and Granite Bay recreation facilities. This would result in significant loss of recreation revenue to the State.

CHAPTER 6.0
GEOTECHNICAL INVESTIGATIONS AND CONSIDERATIONS

This chapter presents the results of on-going geotechnical investigations and studies for raising Folsom Dam. While numerous geological and geotechnical investigations have been completed in the past, the details of these investigations will not be presented in this section of the report but are contained in the references listed in **Chapter 10**. Neither the reports nor the data contained within these reference reports are reproduced herein. Rather this chapter describes the data, the relevant interpretations, and a summary of these findings as they apply to the proposed project elements.

Presently, two methods are being considered to accomplish the authorized 7-foot raise of Folsom Dam. The first method would be to raise the earthfill dams and dikes through placement of fill derived from the auxiliary spillway excavation and/or from borrow areas situated within and bordering on the perimeter of the reservoir. The second method would be construction of a 3.5-foot high reinforced concrete flood wall in combination with a 3.5-foot embankment raise. An alternative to the combination flood wall/embankment raise method would be to construct a dual-wall system with engineered fill placed between the wall sections. For this report the dual-wall system would be limited to the left and right wing dams while a conventional earthfill raise would be used for all other dikes and MIAD. The cost estimate will include a combination of the two methods based on assumptions about the most likely method to be used for each dike or dam site. Processed materials for riprap, road base, and fine and coarse filters would be obtained either from commercial sources in the area, or from an on-site processing plant that may be established if found to be economically feasible. The current cost estimate assumes these materials would be obtained commercially.

The proposed auxiliary spillway represents a major component of the Folsom project and would consist of an approach channel, a six-STG control structure, a concrete lined rectangular chute downstream from the new control structure, and an energy dissipater (either a concrete-lined stilling basin or an unlined plunge pool). Assuming the auxiliary spillway represents the without-project condition, a smaller (3.5-foot) raise was investigated. Two methods are being considered to accomplish the 3.5-foot raise. The first method would be to raise the earthfill dams and dikes through placement of fill derived from the auxiliary spillway excavation and/or from borrow areas situated within the reservoir. The second method would be to construct a 3.5-foot high reinforced concrete floodwall that would be placed near the waterside edge of the existing embankment crests.

To date, geotechnical studies have concentrated on type, source, and quantity of materials required for raising the left and right wing dams, Dikes 1 through 8, and MIAD, based on preliminary raise design concepts. A comprehensive investigation is currently underway for the auxiliary spillway, including exploratory boreholes, laboratory testing, geological mapping, and geophysical testing. Pertinent information for critical embankment features, selected engineering design parameters, and the results of analytical studies conducted as part of the 2002 Long-Term Study are summarized in this chapter.

6.1 EXISTING DESIGN DATA/ANALYSES

This section presents existing data used in design for the right and left wing dams, dikes, and MIAD.

6.1.1 Embankment Geometry

Pertinent design information for existing project embankment features is summarized in **Table 6-1**.

TABLE 6-1
GENERALIZED EMBANKMENT GEOMETRY

Feature[a]		Max Height (feet)	Crest Length (feet)	Crest Width (feet)	Upstream Slope H:1V	Downstream Slope H:1V
Left wing dam		167	2100	30	2.25	2.0
Right wing dam		145	6700	30	2.25[b] 3.25[b1]/3.75[b2]	2.0
MIAD		165	4820	30	2.0[c] 3.0[c1]/4.5[c2]	2.0/3.5[d]
Dikes	1	26.5	1980	20	2.25/3.25[d]	2.25
	2	17.5	1765	20	2.25/3.25[d]	2.25
	3	14.5	1100	20	2.25/3.25[d]	2.25
	4	20.5	1325	20	2.25/3.25[d]	2.25
	5	110	1920	20	2.25/3.25[d]	2.25
	6	48.5	1418	20	2.25/3.25[d]	2.25
	7	55	740	20	2.25/3.25[d]	2.25
	8	18.5	639	20	2.25/3.25[d]	2.25

KEY:
ft – feet
MIAD – Mormon Island Auxiliary Dam

Notes:
[a] *All crest elevations are 480.5 (NGVD, 1929)*
[b] *Continuous slope from right end of dam to Sta. 219+50 and from Stas. 240+60 to 264+75; From Stas. 219+50 to 240+60, elevation 480.5 to 450.0*
[b1] *From Stas. 219+50 to 238+60, elevation 450.0 to 427.0*
[b2] *From Stas. 219+50 to 238+60, below elevation 427.0*
[c] *From top of dam to elevation 466.0*
[c1] *From elevation 466.0 to 427.0*
[c2] *Below elevation 427.0*
[d] *Flatter slope occurs below gross pool elevation 466.0*

6.1.2 Engineering Parameters

Shear strength, permeability, and unit weight data for embankment and foundation materials are presented in the following tables. Material properties for the left and right wing dams are summarized in **Table 6-2.**

TABLE 6-2
MATERIAL PROPERTIES – LEFT AND RIGHT WING DAMS

Material Types (Zones)	Unit Weights (pcf)		Strength		k_{design} (fpd)		Notes
	Moist	Saturated	φ' (deg.)	c' (psf)	k_v	k_h	
Foundation							
Upper Zone (A)	117	130	31	0	10.0	10.0	1,3
Lower Zone (B)	150	151	45	0	7.0	7.0	2,3
Right Wing Dam							
A – Shell	146	152	43	0	200	400	
B - Transition	146	152	43	0	200	400	
C – Core	136	142	37/31[5]	0	0.5	2.0	4
Left Wing Dam							
E – Shell	146	152	43	0	200	400	
F – Filter	146	152	43	0	-	-	
G – Core	136	142	37	0	0.5	2.0	

KEY:
pcf – pounds per cubic foot
k_{design} – selected design permeability, in feet per day (fpd)
k_v – vertical permeability
k_h – horizontal permeability
φ' – effective angle of internal friction, in degrees (deg)
c' – effective cohesion, in pounds per square foot (psf)

Notes:
1. *The upper foundation zone consists of topsoil and decomposed granite. This layer is approximately 5 feet thick.*
2. *The underlying foundation zone consists of dense disintegrated granite.*
3. *No consistent relationship between the horizontal and vertical permeabilities was observed for those samples for which the coefficient of permeability was determined in both directions. Therefore, an average coefficient of permeability in both the horizontal and vertical directions was adopted for use in design.*
4. *Permeability is based on the testing of undisturbed materials obtained from embankment test fill sections and therefore is expected to be more representative of actual conditions. Although there is no apparent consistent relationship between the permeability in the horizontal and vertical directions, construction procedures are conducive to stratification; therefore, the horizontal permeability is assumed to be four times greater than the vertical.*
5. *Strength (tan φ') reduced by 20 percent for material below the piezometric line*

Material properties for MIAD are summarized in **Table 6-3**.

TABLE 6-3
MATERIAL PROPERTIES – MORMON ISLAND AUXILIARY DAM

Zone	Material	Unit Weights (pcf)		Strength		k_{design} (fpd)		Notes
		Moist	Saturated	φ'	c' (psf)	k_v	k_h	
1	Shell (minus 2" dredge tailings)	146	152	43°	0	200	400	
2	Transition (dredge tailings)	136	142	37°	0	25	100	
3[1,2]	Filter (silty gravelly sand)	125	135	35°	0	0.035	0.15	1,2
4	Core (clayey sand)	125	135	35/29°[3]	0	0.01	0.05	
A	Foundation (tailings)	-	136	41°	0	-	-	
B	Foundation (weathered bedrock)	-	147	41°	0	-	-	

KEY:
pcf – pounds per cubic foot
k_{design} – selected design permeability, in feet per day (fpd)
k_v – vertical permeability
k_h - horizontal permeability
φ' – effective angle of internal friction
c' – effective cohesion, in pounds per square foot (psf)

Notes:
1. *Zone 3 filter is assumed to have the same unit weights and strength as Zone 4.*
2. *Zone 3 filter consists of decomposed granite. Permeability was derived from tests on materials ranging from silty gravel to sandy clay. Permeability ranged from 0.0004 to 0.035 feet per day (Corps, 1950). Construction procedures are conducive to stratification; therefore, the horizontal permeability is assumed to be four times greater than the vertical.*
3. *Strength (tan φ') reduced by 20 percent for material below the piezometric line*

Material properties for the dikes are based on properties derived for Dike 5. **Table 6-4** summarizes the material properties for Dike 5.

TABLE 6-4
MATERIAL PROPERTIES – DIKE 5

Zone[1]	Material	Unit Weights (pcf)		Strength		k_{design} (fpd)	
		Moist	Saturated	φ' (deg)	c' (psf)	k_v	k_h
1	Shell	146	152	38/32[2]	0	0.5	2
2	Core	125	135	38/32[2]	0	0.1	0.5

KEY:
pcf – pounds per cubic foot
k_{design} – selected design permeability, in feet per day (fpd)
k_v – vertical permeability
k_h - horizontal permeability
φ' – effective angle of internal friction
c' – effective cohesion, in pounds per square foot (psf)

Notes:
1. *Core and shell materials were obtained from the same source but the core was compacted to a higher density.*
2. *Strength (tan φ') reduced by 20 percent for material below the piezometric line*

6.1.3 Embankment Design Analyses (2002 Long-Term Study)

Seismic stability analyses were conducted as part of the *American River Watershed Long-Term Study* to evaluate the stability of a raise that is higher than what is currently planned for the left and right wing dams, MIAD, and the eight dikes. The raise height that was investigated during this study was 12 feet, or nearly twice the maximum height of raise that is now proposed. The raised section consisted of a 3.5-foot concrete parapet (flood) wall with 8.5 feet of earth fill. The Long-Term Study designs were based on maintaining seismic deformations for the raised embankment sections equal to or less than the values reported for the existing embankment sections analyzed by the Engineer Research and Development Center (ERDC), formerly known as Waterways Experiment Station (WES) (Corps, 1988, 1989, 1990 and 1992). The ERDC seismic stability evaluation utilized a peak horizontal ground acceleration of 0.35g. It was determined that no capable faults underlie any of the water-retaining structures or the main body of the reservoir. The tectonic and seismicity studies also indicated that it is unlikely that Folsom Lake can induce major seismicity. Since the faults that underlie the water retaining structures were found to be non-capable, seismic fault displacement is judged to be highly unlikely. The closest capable fault to Folsom Dam is the east branch of the Bear Mountain fault zone, which is capable of generating a maximum magnitude M = 6.5 earthquake. A brief description for each of the embankment features and the analyses that have been performed is described in the following paragraphs.

6.1.3.1 Right Wing Dam

The right wing dam consists of three zones, as shown in **Plate 6-1a** and **6-1b**. Zone A is constructed of a fairly dirty rock fill and forms the upstream and downstream shells over most of the length of the dam. Zone B is a transition zone constructed of gravel obtained from the American River. Zone C is the impervious core constructed of compacted decomposed granite derived from borrow sources located in what is now the reservoir.

Seismic Stability

The computer program UTEXAS4 was used for analyzing the right wing dam at Station 260+00. The existing crest width is 30 feet but the raised section was analyzed for a crest width of 25 feet so as to minimize the effect of additional loading at the top of dam. As recommended in the ERDC study (Corps, 1989), the core strength (tan φ') was reduced by 20 percent for materials below the piezometric line due to the probable development of excess pore pressures resulting from earthquake shaking. The stability model was checked against the yield acceleration results (Corps, 1989) and excellent comparative results were obtained.

Deformations were computed using the Makdisi-Seed method to evaluate the impacts of the raised sections. An embankment period of 0.855 seconds, a peak horizontal ground acceleration of 0.35 times acceleration due to gravity (g), and a peak crest acceleration of 0.54 g were selected. Embankment periods, peak ground accelerations, and crest accelerations were assumed not to change dramatically from that determined for the 12-foot raise; therefore, the parameters given in the ERDC study were used. To compute and compare deformations, slip surfaces were selected such that they were tangent to elevation 456.5 (1/5 of embankment height) and passed through the opposite crest hinge point. Deformation calculations are shown in **Table 6-5**.

TABLE 6-5
DEFORMATION ANALYSIS – RIGHT WING DAM, MORMON ISLAND AUXILIARY DAM, AND DIKE 5

Case [1]	Slope	Pool Elev.	y/h	u_{max} (g)	k_y (g)	k_{max}/u_{max}	k_{max}	k_y/k_{max}	M =6.5 $U/k_{max}gT_o$	U (ft)	U (in)	α	Uα (in)
Right Wing Dam[2]													
1	US	466	0.200	0.54	0.387	0.88	0.475	0.814	0.0018	0.024	0.28	1.3	0.37
2	US	466	0.273	0.54	0.328	0.84	0.454	0.723	0.0040	0.050	0.60	1.3	0.78
1	DS	466	0.200	0.54	0.465	0.88	0.475	0.979	n/a	n/a	n/a	n/a	n/a
2	DS	466	0.273	0.54	0.371	0.84	0.454	0.818	0.0020	0.025	0.30	1.3	0.39
Mormon Island Auxiliary Dam[3]													
1	US	466	0.200	0.67	0.342	0.88	0.590	0.580	0.014	0.197	2.36	1.3	3.07
2	US	466	0.273	0.67	0.335	0.84	0.563	0.595	0.012	0.161	1.93	1.3	2.51
1	DS	466	0.200	0.67	0.437	0.88	0.590	0.741	0.0035	0.049	0.59	1.3	0.77
2	DS	466	0.273	0.67	0.396	0.84	0.563	0.704	0.004	0.054	0.64	1.3	0.84
Dike 5[4]													
1	US	466	0.200	1.27	0.301	0.88	1.118	0.269	0.080	0.979	11.75	1.22	14.33
2	US	466	0.279	1.27	0.257	0.81	1.029	0.250	0.090	1.014	12.16	1.22	14.84
1	DS	466	0.200	1.27	0.379	0.88	1.118	0.339	0.059	0.722	8.66	1.22	10.57
2	DS	466	0.279	1.27	0.312	0.81	1.029	0.303	0.065	0.732	8.78	1.22	10.72

KEY:
US – upstream
DS – downstream
u_{max} - crest PGA
k_y – yield horizontal acceleration (g)
k_{max} – induced maximum horizontal acceleration (g)
U – displacement along failure plane
α – initial stress ratio correction factor
g – acceleration due to gravity
T_o – predominant natural period of embankment (sec)
PGA – peak ground acceleration (g)
n/a – not applicable

Notes:
1. Case 1: Existing embankment section
Case 2: Raised embankment section
2. Calculated deformations based on the following parameters: M=6.5, u_{max}=0.35g, crest PGA=0.54g, T_o=0.855 sec
3. Calculated deformations based on the following parameters: M=6.5, u_{max}=0.35g, crest PGA=0.67g, T_o=0.74 sec
4. Calculated deformations based on the following parameters: M=6.5, u_{max}=0.35g, crest PGA=1.27g, T_o=0.34 sec

The resulting seismic deformations for the right wing dam are summarized in **Table 6-6.** All deformations are less than 1 inch and considered acceptable for the maximum credible earthquake (MCE).

TABLE 6-6
SEISMIC SLOPE STABILITY RESULTS

Case[1]	Slope	Height	Yield Acceleration (g)	Seismic Deformation (in)
Right Wing Dam				
1	US	1/5	0.387	0.37
1	DS	1/5	0.465	n/a
2	US	1/5	0.328	0.78
2	DS	1/5	0.371	0.39
Mormon Island Auxiliary Dam				
1	US	1/5	0.342	3.07
1	DS	1/5	0.437	0.77
2	US	1/5	0.335	2.51
2	DS	1/5	0.396	0.84
Dike 5				
1	US	1/5	0.301	14.33
1	DS	1/5	0.379	10.57
2	US	1/5	0.257	14.84
2	DS	1/5	0.312	10.72

KEY:
US – upstream
DS – downstream
g – gravity
in – inches

Notes:
1. Case 1: Existing embankment section
2..Case 2: Raised embankment section

Other trial failure surfaces (i.e., 2/5 through 5/5 embankment height) were analyzed and found acceptable.

Seepage

Seepage analyses were conducted using computer program GMS/SEEP2D for reservoir water surface (RWS) elevations 474, 478, and 482. Although the duration of these maximum pool elevations would not produce steady state seepage, the assumption of a steady state condition was made for conservatism. In all cases the piezometric surface does not significantly penetrate the downstream transition zone, and thus does not adversely affect the stability of the downstream section. Permeability values of the embankment materials were obtained from the *Definite Project Report* and are indicated in **Table 6-2.**

6.1.3.2 Left Wing Dam

The left wing dam consists of three zones, as shown in **Plate 6-2**. Zone E consists of compacted gravel dredged tailings and forms the upstream and downstream shells. Zone F is the minus 2-inch fraction of the Zone E gravel and was used as a filter zone between the impervious core and the gravel shells. Zone G, the impervious core, is constructed of compacted decomposed granite utilizing borrow sources located in what is now the reservoir. Although the left wing dam has slightly different zoning characteristics than the right wing dam, when the material properties are taken into account, the cross sections between the right

and left wings are essentially the same. Therefore, the raise design for the right wing dam is applicable to the left wing dam.

6.1.3.3 Dikes

Typical cross sections for the dikes are shown in **Plate 6-3**. Dike 5 is the largest of the of the saddle dikes and is founded on weathered rock as are all of the other dikes. Dikes 1, 2, 3, 4, 6, 7, and 8 span low topographic saddles and are much lower in height than Dike 5. As the largest, Dike 5 is more likely to have water against its upstream slope and have saturated zones than the other dikes, which are typically dry. Since all the dikes are essentially homogeneous and constructed of compacted decomposed granite similar to that of Dike 5, Dike 5 represents the most critical case for all the dikes. Dike 5 was analyzed using the embankment and seismic properties listed in **Table 6-4** and (Corps, 1988).

Deformation calculations are shown in **Table 6-5**. An embankment period of 0.34 seconds, a peak horizontal ground acceleration of 0.35 g and a peak crest acceleration of 1.27 g were selected based on recommendations contained in Corps, 1988. Computed deformations for Dike 5 are summarized in **Table 6-6**. The larger seismic deformations indicated for Dike 5 are primarily due to the higher density (stiffer) core section which results in a higher peak crest acceleration (1.27 g). Although indicated deformations are higher at Dike 5 as compared to the right wing dam and MIAD, they are still considered acceptable for the MCE.

6.1.3.4 Mormon Island Auxiliary Dam

MIAD consists of 4 zones, as shown in **Plate 6-4**. Zone 1 is constructed of dredged gravel and forms the upstream and downstream shells. Zone 2 consists of the minus 2-inch fraction of the dredge tailings. Zone 3 consists of impervious decomposed granite and was added due to the fact that insufficient clayey material was available from borrow to construct Zone 4 as wide as originally planned. Zone 4, the impervious core, is a well compacted clayey mixture founded directly on rock over the entire length of the dam to provide a positive seepage cutoff.

MIAD was analyzed at station 446+00 for the 12-foot raise. Material properties are as reported in **Table 6-3**. Deformations were computed based on an embankment period of 0.74 seconds, a peak horizontal ground acceleration of 0.35 g, and a peak crest acceleration of 0.67 g as provided in the ERDC study (Corps, 1992). Computed deformations for the raised embankment are approximately 3 inches for the upstream upper 1/5 failure surface and less than 1 inch for the downstream upper 1/5 failure surface (**Table 6-6**). These deformations assume Reclamation's seismic remediation treatment of the foundation materials underlying the downstream shell of MIAD is complete.

6.2 SUMMARY OF GEOTECHNICAL INVESTIGATIONS

Geologic and geotechnical data in the project area generally consists of geologic mapping, site-specific geotechnical explorations, and detailed laboratory testing and analyses. This summary describes this information and is followed by a summary of the

collective findings. A complete list of applicable geologic and geotechnical references is provided in **Chapter 10**.

6.2.1 Geologic Mapping

Regional geologic mapping has been performed by a number of geologists in the region and within the Folsom Reservoir and Dam area that provide crucial geologic unit descriptions and contact locations. Geologic mapping was performed by George Kiersch (Kiersch, 1950) during initial foundation investigations for Folsom Dam and Reservoir. In 1984, Ralph Loyd (Loyd, 1984) performed bedrock mapping of the Folsom Quadrangle at a scale of 1:24,000. A regional geologic compilation of multiple geologic maps was prepared by David Wagner (Wagner, 1981) for the Sacramento 2-degree sheet. As-built foundation excavation mapping was performed (Corps, 1952 and 1954) at the main dam, wing dams and MIAD. More recently, geologic mapping and rock discontinuity mapping has been performed by Reclamation (Reclamation, 1999 and 2001) and also by Kleinfelder (2006) for the main dam stilling basin scour analysis and auxiliary spillway, respectively. Collectively, these data provide a strong basis for surface interpretation of the nature and extent of surficial and geologic earth units.

The major geologic earth units in the Folsom Reservoir region are shown on **Plate 6-5**. The primary earth unit in the area is the Mesozoic diorite of Rocklin-Penryn Pluton, a late stage igneous intrusion associated with the emplacement of the Sierra Nevada Batholith. The eastern boundary of this pluton occurs between the main dam and MIAD. East of this contact, northwest striking and steeply dipping foliated Jurassic metamorphic rocks prevail. Tertiary volcanics of the Mehrten Formation cap these two primary bedrock formations forming isolated ridgelines and peaks throughout this area. One such peak occurs within the eastern portion of the proposed auxiliary spillway forming the highest hilltop along the southeast of the proposed inlet and gate structure cuts. Shallow alluvium and fill also form thin veneers over this sequence of units throughout the project. These geologic mapping efforts are shown collectively on **Plate 6-6**.

Faulting has also been mapped largely on the basis of field geologic mapping and interpretation of aerial photographs. Faults have been mapped in the project area by Kiersch (1950), Wagner (1981), Woodward-Clyde (1983), Loyd (1984), Jennings (1994), URS (2004a), and Reclamation (2004). No active faults are mapped or otherwise known to exist within the immediate vicinity of Folsom Reservoir and Dam. Several faults have been mapped that occur within the auxiliary spillway and main and left wing dam areas but none are suspected to be young enough to be capable of generating design earthquakes. These faults are significant in that they represent potential zones of intense fracturing and persistent discontinuities along which low shear strength exists and thus may influence design considerations. These faults include the channel and subsidiary faults dipping gently to the northwest and outcropping in the main dam and spillway area, the east-west fault mapped beneath the left wing dam, and the penstock faults represented by steeply dipping structures outcropping near the penstocks. These fault locations are shown on **Plate 6-7**.

6.2.2 Geotechnical Testing and Analysis

Extensive geotechnical field and laboratory testing and analysis have been performed on rock samples obtained from explorations within the project area. These studies largely focused on the sliding block stability evaluations for the main dam in the present configuration as well as the revised pool elevation for a proposed reservoir raise project.

Large-scale direct shear testing was performed by Anders Bro (Bro, 2004 and 2005), Fuller, Mossbarger (2003), URS (2003 and 2004b) and Reclamation (2005). Shear strength estimates using these values and considering the roughness coefficients of rock discontinuities were performed by Greene (2002), Goodman (2005), Quest Structures (2005a, 2005b), and URS (2001a, 2003a and 2003b). ERDC also estimated in-situ geophysical properties in 2005. Concrete strength testing was also performed (Reclamation, 2002, 2005 and 2006). Goodman Jack testing and rock mass modulus estimates were performed by Woodward-Clyde (1983). Stability evaluations utilizing these data were performed by the Corps (1989) and Kleinfelder (2006), and 3-D block analyses by the Reclamation (2004).

These laboratory tests and development of parameters were primarily focused on the main dam and foundation materials. In general, these studies developed shear strengths and rock mass moduli for the concrete, concrete-foundation rock interface, and for the foundation rock.

6.2.3 Ground Motions

Ground motion studies for this project were performed by URS Corporation. Results of the ground motion studies were presented in three reports (URS, 2001b, 2002 and 2003c). The 2001 report developed horizontal ground motions for operating basis earthquake (OBE), maximum design earthquake (MDE), and MCE. The OBE and the MDE have been defined probabilistically as ground motions having 10 percent and 0.5 percent probability of exceedance in a design life of 50 years, respectively (return periods of 500 and 10,000 years, respectively). The MCE is defined as the 84th percentile motion estimated deterministically from a M6.5 event on the nearby branch of Bear Mountain fault zone (source to site distance of 14 km). The 2002 report presented the seismic design criteria for a seismic event appropriate during the construction period (approximately 7 years) defined as 6.76 percent probability of exceedance in 7 years (return period of approximately 100 years). The 2001 and the 2002 reports provided the recommendations to take vertical ground motions as two-thirds of the horizontal motions at all periods. However, based on some recent research, period-dependent vertical ground motions were provided in the 2003 report.

A summary of the peak horizontal and vertical accelerations in terms of "g" for different seismic events is provided in **Table 6-7**. **Table 6-8** presents the results of deaggregation in terms of mean and modal magnitude (M) and distances (D) for probabilistic events. These are the controlling magnitudes and distances for each probabilistic seismic event. The mean values are the average of the parameters contributing and the modal values are the most commonly occurring value contributing to the hazard. The MCE is a deterministic event and represents M6.5 at a distance of 14 km. Horizontal and vertical

spectral acceleration values at other periods for each seismic event as well as a suite of spectra-matched time histories were also presented in these reports.

TABLE 6-7
SEISMIC DESIGN GROUND MOTIONS

Seismic Event	Probability of Exceedance	Peak Ground Acceleration, PGA (g)	
		Horizontal	Vertical
OBE	10 percent in 50 years	0.10	0.0704
MDE	0.5 percent in 50 years	0.28	0.2374
MCE	84th percentile deterministic	0.38	0.3220
Construction Loads	6.76 percent in 7 years	0.057	0.0401

KEY:
OBE – Operating basis earthquake
MDE – Maximum design earthquake
MCE – Maximum credible earthquake
g – acceleration due to gravity

TABLE 6-8
DEAGGREGATION RESULTS

Seismic Event	Mean		Modal	
	M	D (km)	M	D (km)
OBE	5.7	41	5.1	14
MDE	5.7	13	5.3	8
Construction Loads	5.7	65	5.3	37.5

KEY:
Km – kilometer
D - distance
OBE – Operating basis earthquake
M – modal magnitude
MDE – Maximum design earthquake

6.2.4 Geotechnical Design Considerations

The geotechnical design considerations for the Folsom Dam project primarily revolve around the proposed design components for the auxiliary spillway but also include the excavation, exporting, and suitability of materials should an embankment raise alternative for the dike raises proceed. The following paragraphs provide a summary of the referenced data relative to these potential design considerations.

6.2.4.1 Excavation Characteristics

Excavation characteristics for the proposed auxiliary spillway would vary with depth and are generally defined by the fracture spacing and seismic velocity of the in-situ materials. These data are summarized in **Table 6-9**.

TABLE 6-9
EXCAVATION CHARACTERISTICS

Zone	Material	Average Velocity	Average Fracture Spacing	Caterpillar Handbook Designation (2001)
A	Soil and Fill	<2,000 fps	NA	Rippable
B	Soft Rock	2,000-5,000 fps	<2 feet	Rippable
C	Moderate Rock	5,000-8,000 fps	2-6.5 feet	Marginally rippable
D	Hard Rock	8,000-12,000 fps	>6.5 feet	Marginally to non-rippable
E	Mehrten Formation	<12,000 fps	Unknown	Marginally rippable
KEY: fps – feet per second				

6.2.4.2 Reuse of Excavated Materials

Potential reuse opportunities for the excavated soil and rock generated from the auxiliary spillway include Reclamation's proposed dam safety remediation of MIAD and the Corps' dike raise should the Folsom Raise project proceed. MIAD remediation involves stripping of the downstream slope and placing an estimated one million cubic yards of shell material. General specifications have not been established but a material strength having an internal angle of friction of 33 degrees was used in initial analyses assuming a maximum of 10 percent fines. Although material properties have not been evaluated through extensive laboratory testing of physical properties, it is likely that the rock zones C and D would generate material for reuse in this application but would require processing.

Should an embankment raise alternative for the dike raises proceed, they may also represent a source of reuse for the auxiliary spillway excavated materials. Detailed specifications of the material properties for the raised dikes is not available but is generally proposed to consist of a filter and bedding layer beneath riprap on the waterside slope and the placement of shell material and filter on the downstream slope. This would require the import of shell materials and filter materials. Both materials could likely be produced by processing the zone C and D rock material from the auxiliary spillway excavation but may not be feasible given the need for transportation across the reservoir.

6.3 EMBANKMENT RAISES

Geotechnical issues pertaining to this report are related to raising the left and right wing dams, MIAD and Dikes 1 through 8. Presently, two embankment raise alternatives are being considered:

- Seven-foot raise: The authorized 7-foot raise would be accomplished by raising the embankments using a combination of three methods: (a) through placement of embankment fill only – Dikes 1, 2, 3, 4, 7 and 8; (b) raising the embankments through placement of 3.5 feet of embankment fill and a 3.5-foot reinforced concrete parapet (flood) wall – Dikes 7 and 8 and the left and right wing dams, or; (c) the construction

of a dual-wall system. The dual crest wall system, if used, would only be used for raising the left and right wing dams.

- Three and one-half-foot raise: The 3.5-foot raise would be supplemented with an appropriately sized auxiliary spillway to ensure the safe passage of the PMF with 3 feet of freeboard. The 3.5-foot raise would be accomplished through either the placement of 3.5 feet of fill or the construction of a 3.5-foot flood wall which would be located near the waterside edge of the existing embankment crests.

6.3.1 Earth Raises

The left and right wing dams, MIAD and Dikes 1 though 8 would be raised to elevation 487.5 (National Geodetic Vertical Datum [NGVD], 1929) for a 7-foot raise or to elevation 484.0 (NGVD, 1929) for a 3.5-foot raise. Materials required for the dam and dike raises would include shell material, slope protection and fine and course filter materials. Earth raises would be accomplished by raising the dam and dike crests through placement of suitably graded materials from the auxiliary spillway and/or borrow areas. The upstream slope face and crest width design would not be changed; thus, the upstream erosion protection at each dike would be extended to the raised crest. Due to the placement of undersized cobbles on Dikes 2 and 3, these materials would be removed and replaced with suitably sized slope protection. Each earth raise alternative would have the same construction techniques; therefore, the only difference would be the height of raise for each alternative. The first stage of construction would be to clear existing material from the side slope of the dam (or dike) from the raised embankment toe of fill, up the side slopes, and onto the crest of the embankment a horizontal distance of 10 feet. This is to allow access for a dozer with blade or dump bucket to remove material. Prior to this excavation the slopes would be stripped a minimum of one foot normal to the surface to remove vegetation. The waterside slope protection for the existing wing dams and dikes generally consists of a 2-foot layer of riprap. Two 1-foot layers of dredge tailings (a fine- and a course-grained material) are located immediately under the riprap and serve as filter and bedding material, respectively. The amount of riprap and dredge tailings to be removed and stockpiled may be determined from the as-built plans. It is assumed that the riprap would be re-processed and supplemented with slope protection obtained from commercial sources in the area. The filter and bedding layer materials would be returned as common embankment fill and new processed materials would be obtained either from commercial sources in the area, or from an on-site processing plant that may be established if found to be economically feasible.

The crest of the dams and dikes would be excavated, creating a crest width of 20 feet to allow for the movement of equipment. The wing dams, which have a wider crest, would be lowered approximately 2 feet, and the dikes would be lowered approximately 4 feet, to obtain the 20-foot width after both the land side and water side slopes have been excavated. The dams and dikes would then be raised in lifts and compacted, importing new material for the raise and using existing material that was removed and stockpiled. The interior zones of material would be constructed to conform as much as possible to the original design of the dams and dikes. Material placed downstream from the select (impervious core) material would not be required to be impermeable, but because of the prevalence of decomposed granitic material in the area, it is assumed that this decomposed granite is adequately

impervious and would be used for both core and shell zones. Excavation of the existing dam and dike embankments would need to be coordinated with reservoir operations so that the safety of the existing embankments is not threatened. Existing aggregate base and asphalt pavement would be removed from the top of the dams and dikes. Some dams and dikes are presently being used as access roads and bike trails. Where this situation occurs the crest roads would be replaced in kind.

6.3.2 Wall Raises

For the authorized 7-foot raise a 3.5-foot crest wall in combination with an embankment crest raise is a cost effective dam raising method. For the 3.5-foot raise alternative the use of a crest wall has many advantages over a conventional embankment raise. For example, the crest wall is a much simpler feature to design and construct, construction could begin sooner and take less time and there would be fewer environmental issues/impacts to address. Although higher walls may be theoretically possible, 3.5 feet reflects the greatest height that would not interfere with visual observation of the upstream side of the dam or dike from a vehicle on the crest.

6.3.2.1 Dual-wall System

To reduce the amount of earth excavation and preparation, it is anticipated that a dual-wall system that focuses only on crest excavation construction would be a viable alternative, particularly for the left and right wing dams. By allowing random pervious fill materials between the walls the creation of excessive and/or non-uniform hydraulic gradients would be eliminated. Furthermore, by focusing only on crest excavation and construction, the embankments would be exposed to less risk during construction if a flood event were to occur.

Dikes would be constructed with earth only on the downstream slope while the larger embankments (left and right wing dams) would use the dual-wall system or a combination of a 3.5-foot parapet wall with 3.5 feet of earth fill.

Plate 6-8 shows a conceptual cross section of the dual-wall embankment raise. The details for the left wing dam and the right wing dam may be slightly different.

6.3.2.2 Single-parapet Wall

The single parapet wall would be used in combination with the placement of embankment fill for the 7-foot raise. For the 7-foot raise the single parapet wall would be used for the taller dikes (Dikes 5 and 6). For the left and right wing dams it would be an alternative to the dual-wall system. The recommended method for accomplishing a 3.5-foot dam raise would be construction of a single parapet wall. For the 3.5-foot raise flood wall construction would involve the removal and disposal of material necessary to facilitate placement of the wall. Due to the embankment zoning in the immediate vicinity of where the wall would be located (upstream edge of crest) several types of material will be removed. Excavated materials will be disposed of off-site. It would not be practical to reconstitute these materials for reuse. Instead, suitably graded materials will be imported for backfill

since several different types of material are needed at the crest. Concrete will be supplied by commercial sources. For the 7-foot raise the crest wall would be constructed as an integral part of the raise. **Plate 6-9** shows a typical section of the crest wall.

6.3.3 Borrow Material

Borrow sites would be developed on Federal property within and immediately outside of the reservoir. The number and extent of borrow site development would be dependent on the amount of earthen material required to accomplish the various raise alternatives.

6.3.3.1 Potential Borrow Sites

Several potential borrow sites have been investigated by Reclamation and the Corps. A brief description of each site follows.

Granite Bay

Borrow material development would occur along the low water shoreline north of the Granite Bay recreation site. The amount of material to be excavated would vary by alternative. Excavated material would be processed locally including screening for sizing and crushing. Borrow material would be temporarily stored at the processing facility site prior to transport to project sites.

Beal's Point

Borrow material development would occur along the low water shoreline opposite the Beal's Point recreation site and to the north along Mooney Ridge. The amount of material to be excavated would vary by alternative. Other factors would also determine the amount of material that needs to be excavated and processed. Beal's Point, for instance, has an existing supply of beach sand that may serve as filter material. If on-site processing is not found to be economically feasible filter materials would be obtained from commercial sources in the area.

Auxiliary Spillway

Excavation at the auxiliary spillway would produce between 2 and 3.2 million cubic yards of earthen materials (soil and rock). The material would be processed locally (screened and crushed) prior to transport to MIAD, Dike 7 or Folsom Point. Much, but not all, of this material would be utilized by Reclamation to construct MIAD downstream overlay.

MIAD Right Abutment (Folsom Point)

This borrow site is adjacent to Folsom Point. Borrow at this location would be processed (screen and crushed) prior to being stockpiled with materials from the Folsom Point and Dike 8 areas.

MIAD Left Abutment (Brown's Ravine)

This site is located along the reservoir shoreline north of MIAD. Borrow at this location would be transported to Folsom Point for processing.

D1 and D2 Borrow Sites

The D1 borrow site is within Federal property outside of the reservoir south of MIAD. This area would be developed to support construction of Reclamation's MIAD downstream overlay. Staging, including a materials processing facility, would occur at D2.

The D2 borrow site is within Federal property outside of the reservoir south of MIAD. This area contains one of the better sources for impermeable (clay-like soil) materials for raising and strengthening the cores of all earthen facilities. It would be used primarily to support construction of Reclamation's MIAD downstream overlay.

6.3.3.2 Stockpile Sites

Stockpile sites for temporary storage of raw or processed borrow material would be established adjacent to each processing facility. The major exception would be the Dike 7 stockpile site, which could receive material from the auxiliary spillway excavation. In-reservoir sites may require construction of a cofferdam within the reservoir, behind which stockpile material would be placed. In some instances, stockpiles would be temporarily used as processing site platforms. This is most likely to occur at Beal's Point, Folsom Point, and at the overlook parking lot. Following processing, the borrow material would be removed for placement at the dikes, wing dams and MIAD.

6.4 EMBANKMENT SECTIONS AND QUANTITIES

Typical embankment sections are shown in the plates listed below and are the basis for calculating quantities for the 7-foot raise.

- **Plate 6-10**: Typical Raise Section Dikes 1, 2, 3, 4, 7 and 8
- **Plate 6-11**: Typical Raise Section Dikes 5 and 6
- **Plate 6-12**: Typical Raise Section Left Wing Dam
- **Plate 6-13**: Typical Raise Section Right Wing Dam
- **Plate 6-14**: Typical Raise Section MIAD

Materials quantities are shown in the tables listed below for the indicated raise alternatives:

- **Table 6-10**: Estimate Summary of Materials Required for 7-Foot Raise
- **Table 6-11**: Estimate Summary of Materials Required for 3.5-Foot Embankment Raise
- **Table 6-12**: Estimate Summary of Materials Required for 3.5-Foot Parapet Wall Raise

TABLE 6-10
ESTIMATE SUMMARY OF MATERIALS REQUIRED FOR 7-FOOT RAISE

Material	Dikes 1-3	Dike 4	Dike 5	Dike 6	Dike 7	Dike 8	LWD		RWD		MIAD	Total[3]
							SW[1]	DW[2]	SW[1]	DW[2]		
Stripping & Excavation (cy)	27,000	4,450	23,200	16,100	4,400	2,700	24,300	2,700	88,300	13,300	54,650	245,100
Shell Material (cy)	112,000	27,800	23,200	16,900	37,200	20,400	38,500	13,500	101,000	48,600	77,200	454,200
Fine Filter (cy)	4,350	1,000	3,600	2,700	700	600	-	-	-	-	-	12,950
Course Filter (cy)	4,350	1,000	6,200	2,700	700	600	3,200	-	-	-	-	18,750
Filter-Transition Mtrl. (cy)	-	-	-	-	-	-	-	-	21,600	-	-	21,600
Drain Material (cy)	-	-	-	-	4,300	-	-	-	-	-	-	4,300
U/S Riprap (cy)	8,700	2,000	7,150	5,350	1,400	1,200	6,400	3,300	-	7,700	25,000	57,200
D/S Riprap (cy)	-	-	-	-	800	-	-	-	-	6,600	-	800
Reinforced Concrete	-	-	980	735	-	-	960	1,605	3,180	4,320	2,080	7,935
Reinforcement Steel (lb)	-	-	113,200	85,300	-	-	110,700	186,000	368,000	677,000	241,000	918,200
Road Surfacing Mtrl. (cy)	420	250	-	-	150	135	-	-	1,400	1,400	750	3,105
Stabilized Aggregate Base	1,000	-	450	400	-	-	920	920	600	600	-	3,370
AC Paving, 2" Thick (cy)	350	-	150	130	-	-	310	310	250	250	-	1,190
Seeding (acres)	15.5	4	1.5	1	2	1	-	-	-	-	-	25.0

KEY:
cy – cubic yards
lb – pound
- not applicable
SW – single wall
U/S – upstream
D/S – downstream
LWD – Left Wing Dam
DW – dual-wall
RWD – Right Wing Dam
MIAD – Mormon Island Auxiliary Dam
AC – asphaltic concrete

Notes:
[1] Quantities are for a 3.5-foot embankment raise with a single parapet wall.
[2] Quantities are for a 3.5-foot embankment raise with a dual-wall system.
[3] Total does not include quantities for the dual-wall system (LWD & RWD). The double wall system is considered a secondary alternative.

TABLE 6-11
ESTIMATE SUMMARY OF MATERIALS REQUIRED FOR 3.5-FOOT EMBANKMENT RAISE

Material	Dike 1	Dike 2	Dike 3	Dike 4	Dike 5	Dike 6	Dike 7	Dike 8	LWD	RWD	MIAD	Total
Stripping & Excavation (cy)	5,250	4,140	3,130	4,050	5,090	2,700	3,470	2,200	18,510	72,790	32,150	153,480
Shell Material (cy)	19,840	13,880	8,780	16,440	19,410	10,200	12,620	8,400	23,500	69,440	58,950	261,460
Fine Filter (cy)	750	1,600	670	530	690	545	310	310	2,525	-	1,640	9,570
Course Filter (cy)	870	1,615	775	610	715	660	320	320	2,530	-	1,640	10,055
Filter-Transition Material (cy)	-	-	-	-	-	-	-	-	-	23,460	-	23,460
Drain Material (cy)	-	-	-	-	-	-	1,740	-	-	-	-	1,740
U/S Riprap (cy)	1,740	5,490	1,550	1,220	1,570	1,250	750	740	5,060	16,110	3,310	38,790
D/S Riprap	-	-	-	-	-	-	660	-	-	12,690	-	13,350
Road Surfacing Material (cy)	-	300	-	220	400	-	180	135	-	1,350	970	3,555
Stabilized Aggregate Base (cy)	750	-	670	-	-	480	-	-	960	-	-	2,860
AC Paving, 3" Thick (cy)	160	-	140	-	-	160	-	-	320	-	-	780
Seeding (acres)	1.8	1.1	0.7	1.4	1.8	1.0	1.1	0.7	1.3	-	5.1	16.0

KEY:
cy – cubic yards
lb – pound
- not applicable
U/S – upstream
D/S – downstream
LWD – Left Wing Dam
RWD – Right Wing Dam
MIAD – Mormon Island Auxiliary Dam
AC – asphaltic concrete

TABLE 6-12
ESTIMATE SUMMARY OF MATERIALS REQUIRED FOR 3.5-FOOT PARAPET WALL RAISE

Material	Dike 1	Dike 2	Dike 3	Dike 4	Dike 5	Dike 6	Dike 7	Dike 8	LWD	RWD	MIAD	Total
Stripping & Excavation (cy)	3,750	5,770	2,740	2,020	3,030	2,320	1,320	1,310	3,100	9,890	7,100	42,350
Shear Key Excavation (cy)	190	150	140	100	160	120	70	70	160	510	360	2,030
Fine Filter (cy)	-	740	-	-	-	-	-	-	-	-	-	740
Course Filter (cy)	320	940	230	170	260	200	110	110	260	840	600	4,040
Riprap (cy)	1,350	2,400	980	730	1,090	840	470	470	1,110	3,550	2,550	15,540
Common Backfill (cy)	1,490	1,140	1,090	800	1,200	920	520	520	1,230	3,920	2,820	15,650
Reinforced Concrete (cy)	1,200	930	880	650	970	740	420	420	990	3,170	2,280	12,650
Reinforcement Steel (lb)	139,200	107,900	102,100	75,400	112,500	85,800	48,700	48,700	114,800	367,700	264,500	1,467,300

KEY:
cy – cubic yard
lb – pound
LWD – left wing dam
RWD – right wing dam

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CHAPTER 7.0
FOLSOM DAM RAISE ALTERNATIVE

7.1 DESCRIPTION

The proposed Folsom Dam Raise alternative consists of a 3.5-foot dam raise component along with replacement of the three existing emergency tainter gates on the main concrete dam. This alternative provides much of the functionality that would have been achieved by the authorized Folsom Dam Raise Project. The 3.5-foot dam raise component would consist of a cast-in-place, reinforced concrete wall located near the reservoir side of the crest of each of the dikes, the left and right wing dams and MIAD. The existing access ramps crossing the dikes would be raised 3.5 feet to match the concrete crest wall height. The three new emergency tainter gates would be 42 feet wide by 56 feet 10 inches tall and would include an extension of the pier supporting the trunnion and relocating the trunnion itself. The design aspects and construction considerations associated with this alternative are described in the following sections.

7.2 PERFORMANCE

This raise alternative, in conjunction with the Joint Federal Project to provide a six-STG auxiliary spillway, would provide a flood control level of protection computed at 1 chance in 185. This alternative would provide the capability for Folsom Dam to pass a 240-year design flood event.

7.3 COST

The cost estimate prepared for this dam raise alternative is considered a draft feasibility level cost estimate. The estimate was developed using the Corps estimating program, MCACES, backed up with detailed labor, equipment and material cost for each construction item. The estimated first cost for the 3.5-foot dam raise element along with replacement of the three existing emergency tainter gates on the main concrete dam element of the Folsom Dam Raise alternative is $115.3 million, not including costs associated with Ecosystem Restoration and the Folsom Bridge. See **Attachment B2** for a project cost summary, detailed estimate of first cost and a summary of the MCACES estimates. The effective price level for the estimate is October 2006.

Annual cost was developed based on 50-year life of the project and 4.875 percent interest rate. The estimated annual cost for the 3.5-foot dam raise element along with replacement of the three existing emergency tainter gates on the main concrete dam element is $5.6 million, not including costs associated with Ecosystem Restoration and the Folsom Bridge. See **Attachment B3** for detail of the annual costs.

Some of the assumptions made in the preparation of the cost estimate are:

- The crest wall is considered to be a cast-in-place reinforced concrete wall. The exposed stem would be 3.5 feet tall. See **Plate 6-9** for illustration.
- All required concrete, riprap, and filter material would be from commercial sources.
- The weight of reinforcing steel is based on 150 pounds per cubic yard of concrete.
- The existing access ramps crossing embankment features are assumed to be raised 3.5 feet to match the concrete crest wall height. The surface of the raised embankment would match the existing surfacing. The raised sections would be graded to the top of dam or dike elevation in accordance with Americans with Disabilities Act requirements.
- Where necessary, the existing hydraulic bollard-type barricades would be removed and replaced, utilizing the existing solar panels for energy source. For this estimate it has been assumed that the graded access ramps would not interfere with the existing barricades and that they would not require replacement.
- Paved road sections, if disturbed, would be replaced in kind. The assumed replacement section shall consist of 2 inches of asphalt concrete over 6 inches of stabilized aggregate base course.
- The design of the new main dam tainter gates would be similar to the existing main dam tainter gates. All construction would be on Federal land; therefore no real estate cost has been included in the cost estimate of this project.
- The mitigation cost provided by the Corps Environmental Section would be used for banking buyout.
- A line-item contingency varying between 20 and 38 percent was applied to the various construction features depending on the level of information provided.
- A 3 percent compounded projected inflation factor was added to the contingencies to capture a higher unrealized inflation rate above what is provided in the Civil Works Construction Cost Index System.

7.4 HYDRAULIC DESIGN

7.4.1 General Introduction

This section describes variables that determine the capability of the Folsom Dam Raise project alternative to manage floods and to safely pass the accepted probable maximum flood. It addresses the existing dam's deficiency in flood damage reduction capability, the dam safety inadequacies, and discusses alternative solutions.

The existing main dam tainter gates and river outlets cannot pass the PMF without overtopping the dam. Also, the existing sluices through the dam are not large enough to pass significant flood flows during the early part of large floods. The existing sluices can only

release a maximum of 24,800 cfs at spillway crest elevation 418.0. The downstream channel has an objective or target flood release of 115,000 cfs and releases above 115,000 cfs must be made only during large floods for dam safety purposes. Large flood flows can only be passed with the existing spillway tainter gates and therefore, a significant amount of flood control space must be filled with water before objective downstream release flows can be attained. The design alternatives investigated and described in this paragraph increase the flood control capability of Folsom Dam by increasing the available reservoir storage. This study assumes an auxiliary spillway would be constructed near the left abutment. The spillway would control flow discharges using top-seal tainter gates (also called submerged tainter gates or STGs). Possible impacts to downstream water surface elevations, channel capacity stability and definition of the floodplain are briefly described. Ongoing studies and future analysis during the next phase of design are required to fully define these parameters.

Other design alternatives have also been investigated and are described in the hydraulic design engineering attachment herein (**Attachment B4**). Some of these alternatives described in the attachment increase the flood control capability of Folsom Dam by increasing the outflow capacity at lower lake levels, resulting in reduced maximum pool elevations when large storms occur and proper reservoir operations are followed. The studies determined the project's capabilities to discharge flows (outflow capacity) and dissipate energy from high-velocity flows before they enter the American River channel. Possible impacts to downstream water surface elevations, channel capacity stability and definition of the floodplain are briefly described. Ongoing studies and future analysis during the next phase of design are required to fully define design requirements.

7.4.2 Project Description

7.4.2.1 Previous Studies

The following previous studies are relative to the Folsom Dam Raise Project:

- Corps, Original Design of Folsom Dam
- ESA Consultants, Inc., Folsom Dam Improvements, Mini Raise, Preliminary, 24 August 1994
- Corps, American River Watershed, California, Information Paper, August 1999
- Reclamation, Folsom Dam Spillway Stilling Basin Rehabilitation, Technical Manual (TM) No. FOL-8130-REH-96-1, September 1996
- Recommended Flood Operations for Folsom Dam, TM FD-8130-FD-TM-97-3, September 1997 by Reclamation
- Long-Term Study, by the Corps
- Folsom Dam Modifications Project - DDR, Design Plans and Specifications for the Upper Tier Conduits, by the Corps of Engineers

- Corps, Folsom Dam Raise and Auxiliary Spillway Alternative, PASS II, Reclamation, SAFCA, DWR, and State Reclamation Board, June 2006

7.4.2.2 Project Objectives – Relative to Hydraulic Design

The main objectives of the Folsom Dam Raise project are to ensure that:

- Hydraulic performance is acceptable.
- Adequate design provisions are made for the additional head and increased flow capacity of the spillway.
- The stilling basin(s) function satisfactorily at design flows and without excessive damage at higher flows.
- Combined releases from the service spillway, auxiliary spillway, and emergency spillway can be made without complex operational constraints.

7.4.2.3 Overview of Alternatives

Without Project Condition – The "without project condition" for the alternatives discussed below assumes completed construction of the Common Features Project and an auxiliary spillway previously implemented under the Folsom Modifications Project authorization. The auxiliary spillway provides for dam safety as well as flood control and as currently envisioned has a discharge capacity of 145,500 cfs at pool elevation 418.0. The auxiliary spillway would be constructed on the left abutment (at the current overlook area) and would consist of an approach channel, a control structure with six STGs that are 23 feet wide by 33 feet high with the sill at elevation 368, and a 169-foot wide rectangular, concrete-lined chute that leads into an energy dissipation area and exit channel. The discharge chute would run from the auxiliary spillway control structure towards the downstream end of the exit channel for the main dam (entering the American River in almost a direct line).

Folsom Dam would then have four methods of discharging flows from the reservoir: three power penstocks, eight main dam river outlets in the main concrete dam (four upper tier and four lower tier, all 5- by 9-foot), tainter gates set near the main spillway crest (five service and three emergency), and six STGs in the auxiliary spillway.

To ensure adequate tailwater for releases from the three emergency tainter gates to prevent damage to the emergency stilling basin, the three emergency tainter gates should not be used unless the total outflow from the dam exceeds 300,000 cfs. However, the ESRD indicates that the emergency tainter gates will be overtopped unless opened when total releases exceed about 240,000 cfs. Therefore, damage to the emergency stilling basin could occur by operating the emergency tainter gates at less than 300,000 cfs. Because of the restriction on use of the emergency tainter gates they are unusable for normal flood control purposes and use of the emergency tainter gates is limited to dam safety outflows. Under the "without project condition" assumed for this report, Folsom Dam and the American River

ean safely pass the PMF without overtopping the dam, however, operational restrictions on making releases through the existing service and emergency tainter gates are very complex and do not leave much room for operator error or equipment malfunctions. **Table 7-1** summarizes the capability of each outflow method, assuming free-flow capability from the main dam emergency tainter gates.

TABLE 7-1
SUMMARY OF FOLSOM DAM DISCHARGE CAPACITY

Outlet Feature	Lake Elevation 400 feet Bottom of Maximum Flood Space (cfs)	Lake Elevation 426 feet Bottom of Normal Flood Space (cfs)	Lake Elevation 466 feet Normal Full Pool (cfs)	Lake Elevation 481.0 feet Spillway Design Pool for 3.5-foot Dam Raise (cfs)	Lake Elevation 484.5 feet Spillway Design Pool for 7-foot Dam Raise (cfs)
Three Power Penstocks	7,000	7,000	7,000	0	0
Four Lower Tier Outlets	13,000	13,800	14,900	10,300[2]	10,400[2]
Four Upper Tier Outlets	10,500	11,500	12,900	9,100[2]	9,200[2]
Five Service Tainter Gates	0	12,500	209,500	332,500[3]	467,000[1]
Three Emergency Tainter Gates	0	0	0	256,500[3]	280,500[1]
Six STG 23-foot wide by 33-foot tall Auxiliary Spillway	70,600	174,000	279,000	312,400	319,400
Total Discharge Capability	**101,100**	**218,800**	**523,300**	**920,800[2]**	**1,086,500[2]**

KEY:
cfs – cubic feet per second

Notes:
[1] *Includes free flow capability for the main dam emergency tainter gates*
[2] *Includes 60 percent opening restriction*
[3] *Includes free flow capability for all main dam tainter gates*

Described below is a series of progressive changes to the dam features designed to systematically increase project performance, flexibility, and dam safety. Specific alternatives are also described, but do not necessarily follow the progression.

Replacement of Tainter Gates on Emergency Spillway

The top of the three existing emergency tainter gates, when closed, is at elevation 471. This effectively limits the flood control operation to elevation 470 (allowing for one foot freeboard on gate). The existing tainter gates also are restricted in their maximum opening. The maximum elevation the tainter gate lip can be raised to is elevation 454.5.

Replacing these gates with taller gates (set at about one foot below the maximum pool) leads to increased project performance because releases of 115,000 to 160,000 cfs can continue to be made above pool elevation 470 (without risk of overtopping the emergency tainter gates). Replacing the "spillway bridge" over the tainter gates and designing the new tainter gates to allow free flow under them effectively increases the maximum discharge capacity of the emergency spillway for large flood events. The proposed auxiliary spillway size could be optimized accordingly.

Replacement of Tainter Gates on Service Spillway

The top of the five existing main dam service tainter gates, when closed, is at elevation 468 feet. Note that for any combination of projects constructed, if the pool elevation is allowed to exceed elevation 480, these tainter gates would be overtopped (maximum height of the gate arc is about elevation 480). These tainter gates are also restricted in their maximum opening, similar to the existing emergency tainter gates. Replacing these tainter gates with taller gates would no longer require the service tainter gates to be opened at the relatively low pool elevation 467 (allowing one foot freeboard to remain on the tainter gate). Replacing the "spillway bridge" over the tainter gates and designing the new gates to allow free flow under the gates would effectively increase the maximum discharge capacity of the service spillway for large flood events. The proposed auxiliary spillway size could be optimized accordingly.

Dam Raise

A minor dam raise coupled with replacement tainter gates on the spillway (either the three emergency tainter gates or both the service and emergency tainter gates) may provide additional flood control and if paired with reducing the size of the auxiliary spillway, be cost effective as well. Any dam raise and corresponding increase in height of the replaced tainter gates on the main dam crest can be balanced with a narrower auxiliary spillway (narrower gates, or possibly fewer gates). The size of the auxiliary spillway and its tainter gates can be refined in final design.

Following is a brief summary of the featured alternative.

Selected Plan (SP) for the Dam Raise Project: Six-STG Auxiliary Spillway Plus Replacement of Three Emergency Tainter Gates Plus 3.5-foot Dam Raise

This alternative would include replacing the three tainter gates on the emergency spillway crest with taller gates, replacing/raising the bridge above the gates, and adding a dam raise of 3.5 feet to the dam using a parapet wall for added flood protection benefits. Raising the spillway training walls on the main dam spillway may also be required. The top of dam would then be at elevation 484. With 3 feet of freeboard, the maximum allowable pool would be elevation 481. The service tainter gates would overtop during extreme events.

7.4.3 Criteria

The following list of documents provides applicable hydraulic design criteria for the project:

- Engineering Regulation (ER) 1110-2-1150 Engineering and Design for Civil Works Projects
- ER 1110-2-1156 Dam Safety – Organization, Responsibilities, and Activities
- Engineering Manual (EM) 1110-2-1601 Hydraulic Design of Flood Control Channels
- EM 1110-2-1602 Hydraulic Design of Reservoir Outlet Works
- EM 1110-2-1603 Hydraulic Design of Spillways
- Engineering Circular (EC) 1110-2-6061 Safety of Dams – Policy and Procedures
- Federal Emergency Management Agency (FEMA) Publication 64, "Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners"
- Peterka, A. J. 1974, "Hydraulic Design of Stilling Basins and Energy Dissipators," Engineering Monograph No. 25, US Bureau of Reclamation, Denver, CO

7.4.4 Hydraulic Design Elements and Parameters

The dam discharge facilities include the powerhouse, main dam river outlet works, service spillway and emergency spillway, in addition to the (assumed pre-project condition) auxiliary spillway. Flows from any or all of these facilities merge together downstream of the dam and provide the majority of flow for the lower American River.

7.4.4.1 Hydraulic Roughness

Hydraulic roughness values selected are indicated in **Attachment B4.**

7.4.4.2 Design Head/Discharge Coefficients

The existing ogee crest was designed to increase discharge coefficients at higher pool elevations. It is assumed that the final design will utilize the existing ogee crest. The existing spillway crest elevation is at 418.0. For more information, see **Attachment B4**.

7.4.4.3 Discharge Rating Curves and Stage-Discharge Relationships

The discharge rating curves (pool stage versus discharge) have been extended to encompass the full range of reservoir pool elevations due to the proposed dam raise.

There are operational constraints when operating the existing service and emergency tainter gates at Folsom Dam. The emergency stilling basin was designed assuming a minimum flow of 300,000 cfs is being released into the American River. The top of the emergency tainter gates in the closed position is at elevation 471; therefore, dam operators need to begin opening the emergency tainter gates at pool elevation 470. Because the service gates would already be open, the emergency tainter gates would need to be raised at least 10 feet as rapidly as possible so that a wave coming around the pier between the service and

emergency tainter gates would not impact the service gate trunnion. Operation of the service tainter gates is also sensitive because the service gates must be raised to follow the pool elevation once the pool comes within about two feet of the top of gate.

Another problem in operation of the existing tainter gates is that they should not be operated in the transitional zone from orifice flow (partial gate opening) to full open and should not be lowered to go from full open (gates out of the water) to orifice flow operation. The Corps computer program H3106 computes partial gate open discharge rating curves for tainter gates, indicates when the transitional zone is entered, and states that "gate control uncertain – avoid operation at above pool and gate opening" for a particular calculated discharge based on tainter gate opening and pool elevation/head. Reclamation also noted this transitional zone. Model reports describe the transition zone to be where model data is inconsistent with both the gated-discharge rating and the free-flow rating, revealing a zone of instability where control can shift rapidly between two regimes. Measurements of discharge and pool elevation vary widely in this transition zone.

Discharge rating curves for the existing emergency tainter gates are shown on **Figure 7-1**. The rating curve for the service tainter gates is similar but the gate top of gate is lower (elevation 468 vs. elevation 471). Examination of **Figure 7-1** shows that the controlled-discharge rating curves and the uncontrolled discharge (free-flow) rating curve are separated by the transition zone. In this zone surging can occur as the flow is unstable and can rapidly shift between controlled-discharge and free-flow. Operating in the transition zone is not recommended. It is not physically possible to open the existing tainter gates enough to go to free-flow. Reservoir routings described elsewhere in this EDR use controlled-flow gate operations unless all tainter gates on the main dam crest are assumed to be replaced.

Discharge rating curves for the new main dam tainter gates that would replace the existing gates are shown on **Figure 7-2**. These rating curves also show a transition zone (blank area) between to controlled-discharge rating curves and the free flow rating curve. Installation of the new tainter gates would require modification of the piers to raise the trunnion axis to prevent spillway flows from impacting the trunnion tie beams. The piers would not need to be widened. The replaced tainter gates would be taller, and the new trunnions would be out of the flow stream for large floods.

Discharge rating curves for the proposed auxiliary spillway control structure, with tainter gates fully open, are shown on **Figure 7-3**. Discharge rating curves for the existing upper tier river outlets are shown on **Figure 7-4** and those for the existing lower tier river outlets are shown on **Figure 7-5**.

7.4.4.4 Water Surface Profiles

Water surface profiles were computed for the auxiliary spillway approach channel from the reservoir to the control structure, the auxiliary spillway chute from the control structure to the stilling basin, and the American River from the new bridge to the existing main dam stilling basin. For more information, see **Attachment B4**.

7.4.4.5 Design Discharge Capacities and Velocities

The design discharge for a spillway is the discharge that can be passed at the maximum pool. Discharges would be controlled by the tainter gates for the full range of reservoir head unless all eight tainter gates on the main dam crest are replaced, in which case free-flow will be allowed for extreme discharges. See **Figures 7-1** through **7-5.**

For the main dam spillway, average velocities through the tainter gates would be over 40 fps for controlled releases at the maximum pool elevation 481. For the auxiliary spillway, the average velocities through the tainter gates and conduits with the gates fully open will be as high as 68 fps. Velocities in the supercritical chute and drop to the stilling basin would also be very high.

Maximum Discharge Capacity

Figure 7-6 shows the maximum calculated discharge capacity from pool elevation 300 to pool elevation 481, assuming the outlet works are fully open for the full range of reservoir pool elevations. Maximum discharge capacities are shown for the main dam river outlets (for all eight outlets combined to pool elevation 418 only), the spillway (for controlled releases from all eight tainter gates combined), the auxiliary spillway, and combined operation of the three. Note that the maximum release capacity would exceed the objective release of 115,000 cfs over a broad range of reservoir pools. Maximum discharge capacity for the outlets assumes no operational constraints due to vortex formation.

7.4.4.6 Conditions Affecting Design Capacity

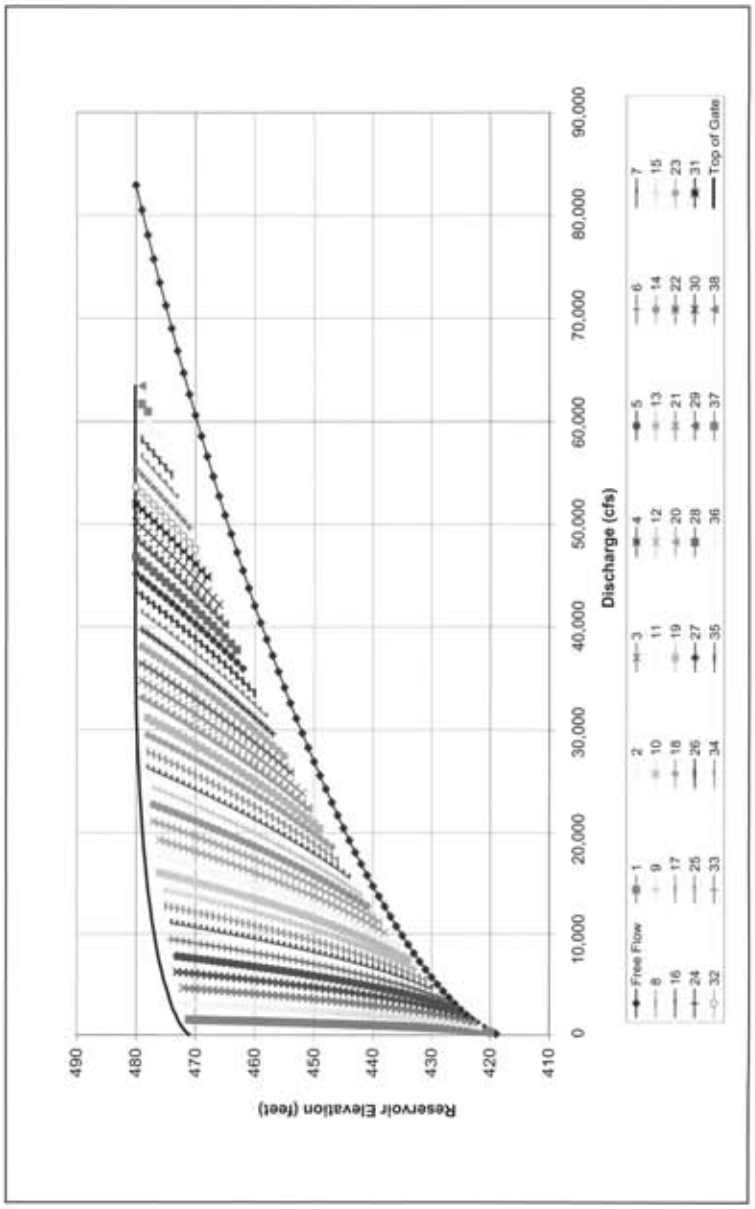
Areas that may suffer cavitation damage would possibly affect design capacity. See **Attachment B4** for further information.

7.4.5 Other Design Considerations Relative to Dam Raise

Other design considerations relative to the proposed dam raise are outlined below. Certain hydraulic elements that may require modification include the existing tainter gates, the existing bridge over the main dam spillway, the existing spillway crest, the existing flood control river outlet exit portals, and the main dam stilling basin.

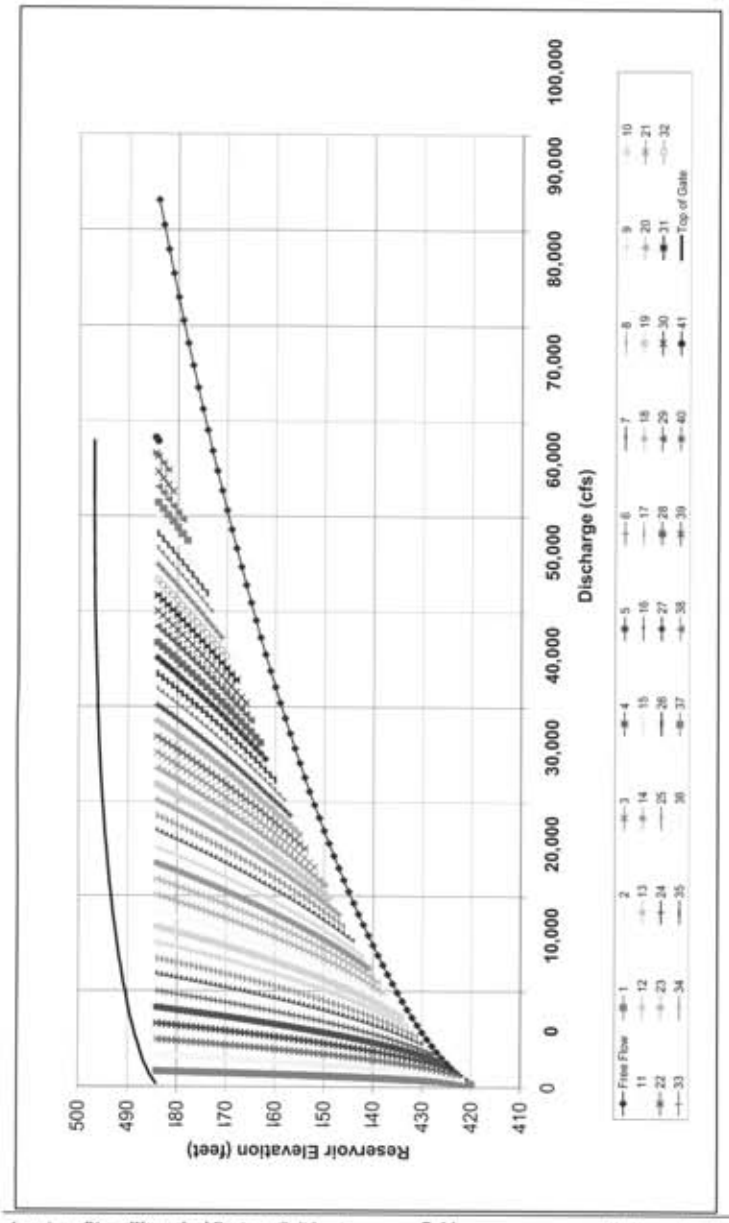
7.4.5.1 Modification of Existing Emergency Tainter Gates

The three existing emergency tainter gates would be replaced with taller gates. Installation of the larger tainter gates would require modification of the piers to raise the trunnion axis to prevent spillway flows from impacting the trunnion tie beams. Structural design investigations indicate the piers would not need to be widened. The replaced tainter gates would be taller, and the new trunnions would be out of the flow stream for large floods. For more information, see **Attachment B4**.



Note: Crest elevation 418 – discharge computed with H3106, Reference EM 1110-2-1603 – top of dam 480.5

FIGURE 7-1
FOLSOM MAIN DAM – DISCHARGE CAPACITY – EXISTING EMERGENCY SPILLWAY – PER GATE



Note: Crest elevation 418 – discharge computed with H3106, Reference EM 1110-2-1603 – top of dam 487.5

FIGURE 7-2
FOLSOM DAM – DISCHARGE CAPACITY-NEW SPILLWAY-PER TAINTER GATE

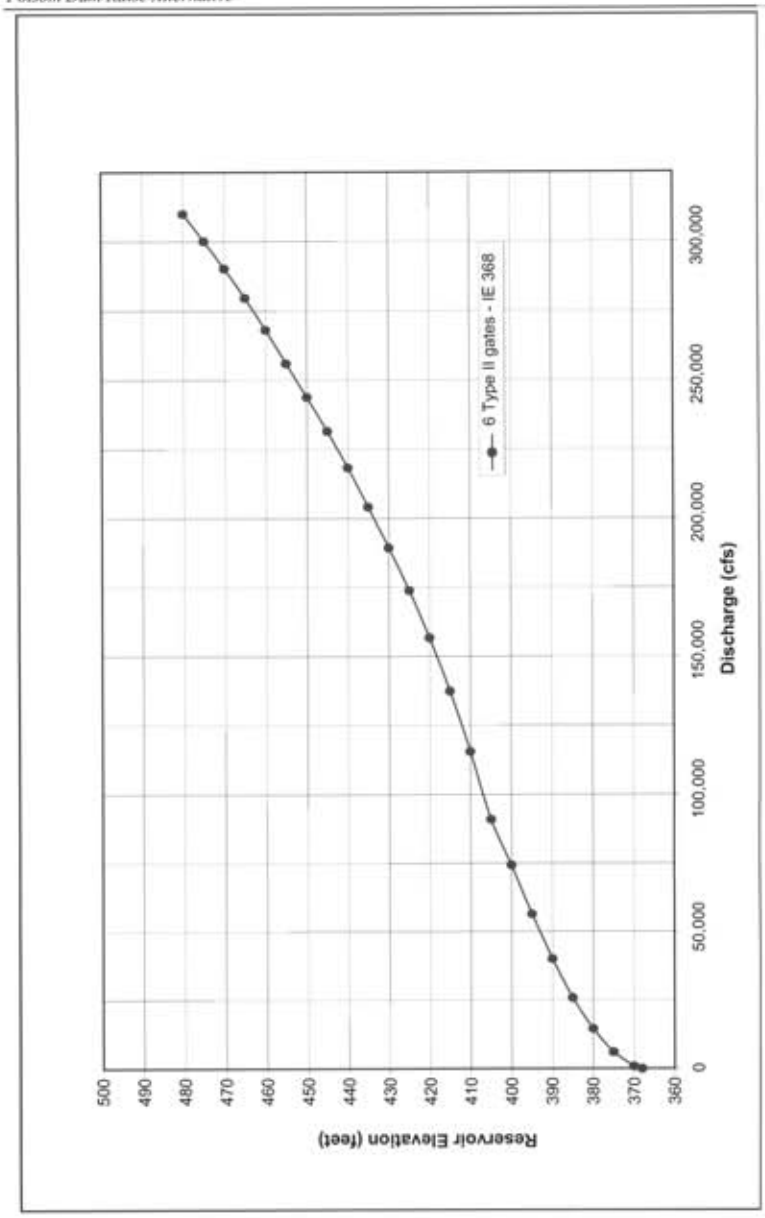


FIGURE 7-3
FOLSOM MAIN DAM – DISCHARGE CAPACITY – AUXILIARY SPILLWAY RATING CURVE

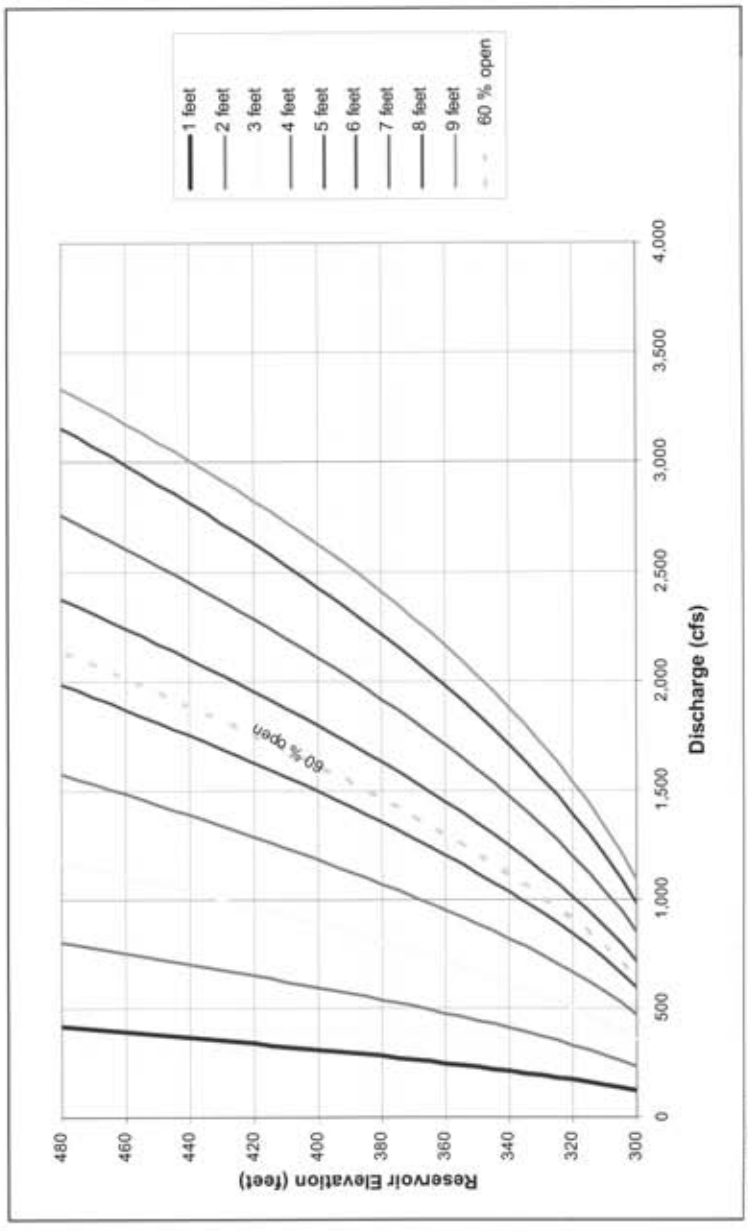


FIGURE 7-4
FOLSOM DAM – DISCHARGE CAPACITY – UPPER TIER OUTLET WORKS – 5 FEET BY 9 FEET GATE RATING

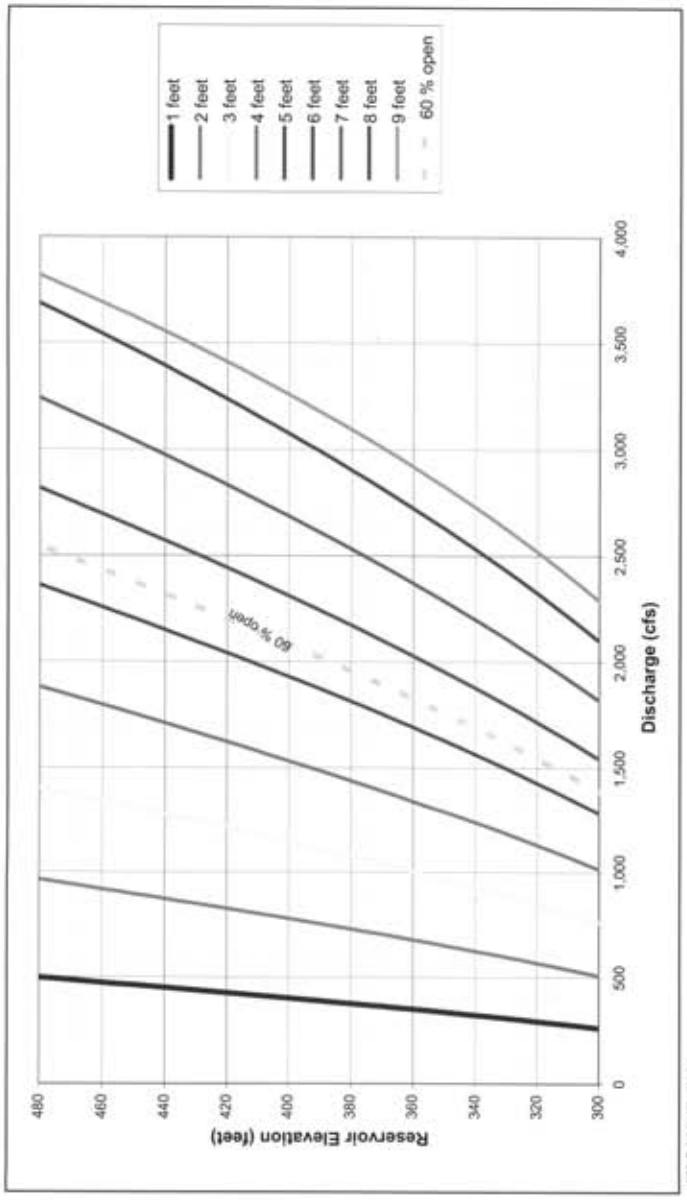
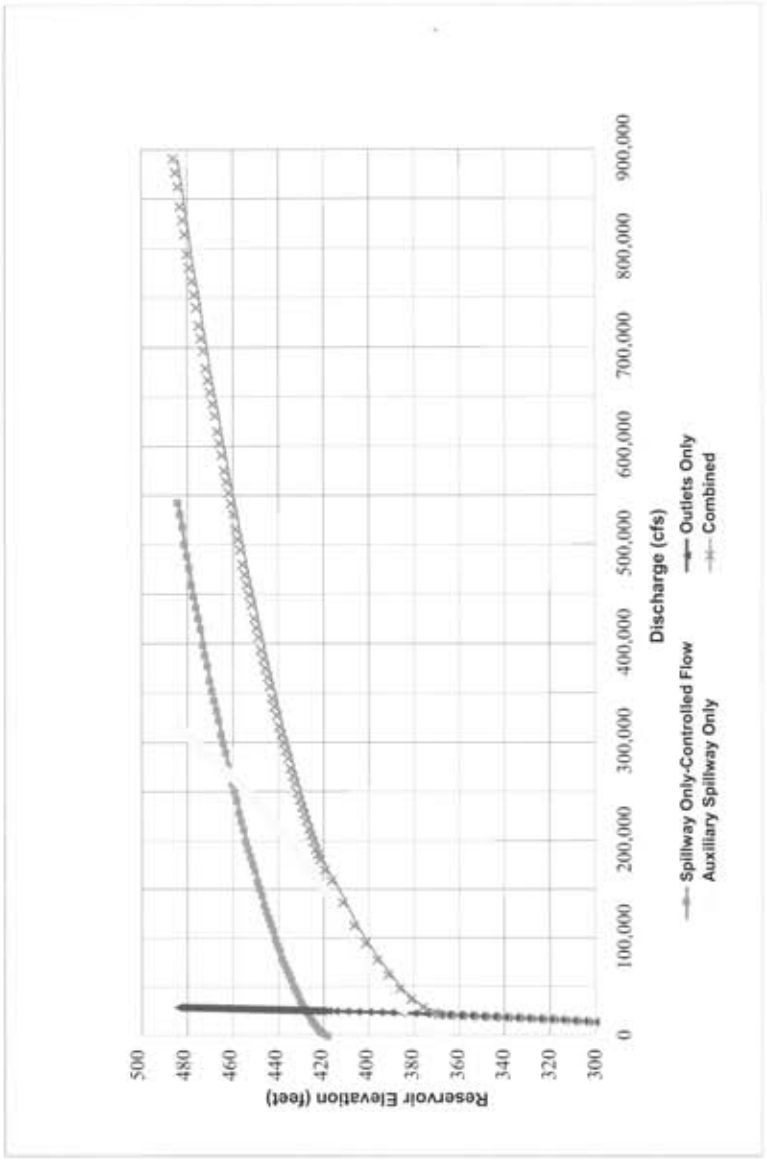


FIGURE 7-5
FOLSOM DAM – DISCHARGE CAPACITY – LOWER TIER OUTLET WORKS – 5 FEET BY 9 FEET TAINTER GATE RATING



Note: Objective release of 115,000 cfs can be attained at about elevation 406.

FIGURE 7-6
FOLSOM MAIN DAM - MAXIMUM DISCHARGE CAPACITY

7.4.5.2 New Spillway Bridge at the Main Concrete Dam

Where tainter gates are replaced, a new spillway bridge would be located at the top of the piers to replace the existing bridge. **Attachment B4** provides more information on the details of flows through the replaced bridge.

7.4.5.3 Cavitation Potential at Existing Dam Spillway Crest

Modifications of the main dam spillway crest shape are not anticipated at this time and would be made only if model studies and/or prototype data from other dams show that potential cavitation damage would be significant.

7.4.5.4 Modification of Sluice Exit Portals and Eyebrow Deflectors

Operating experience at Folsom Dam has shown that concurrent operation of the five service tainter gates and the main dam river outlets creates a condition that results in cavitation damage to the dam. This damage can be minimized if the full capacity of the river outlets is not used. Previous model studies indicated that the existing main dam river outlets should not be operated above 60 percent when spillway flows are occurring. This is the current operation procedure and would continue to be followed for this project. Elimination of the 60 percent restriction would require improved sluice exit portal designs and physical model studies to confirm that the improved designs work to eliminate cavitation concerns.

7.4.6 Energy Dissipation Features

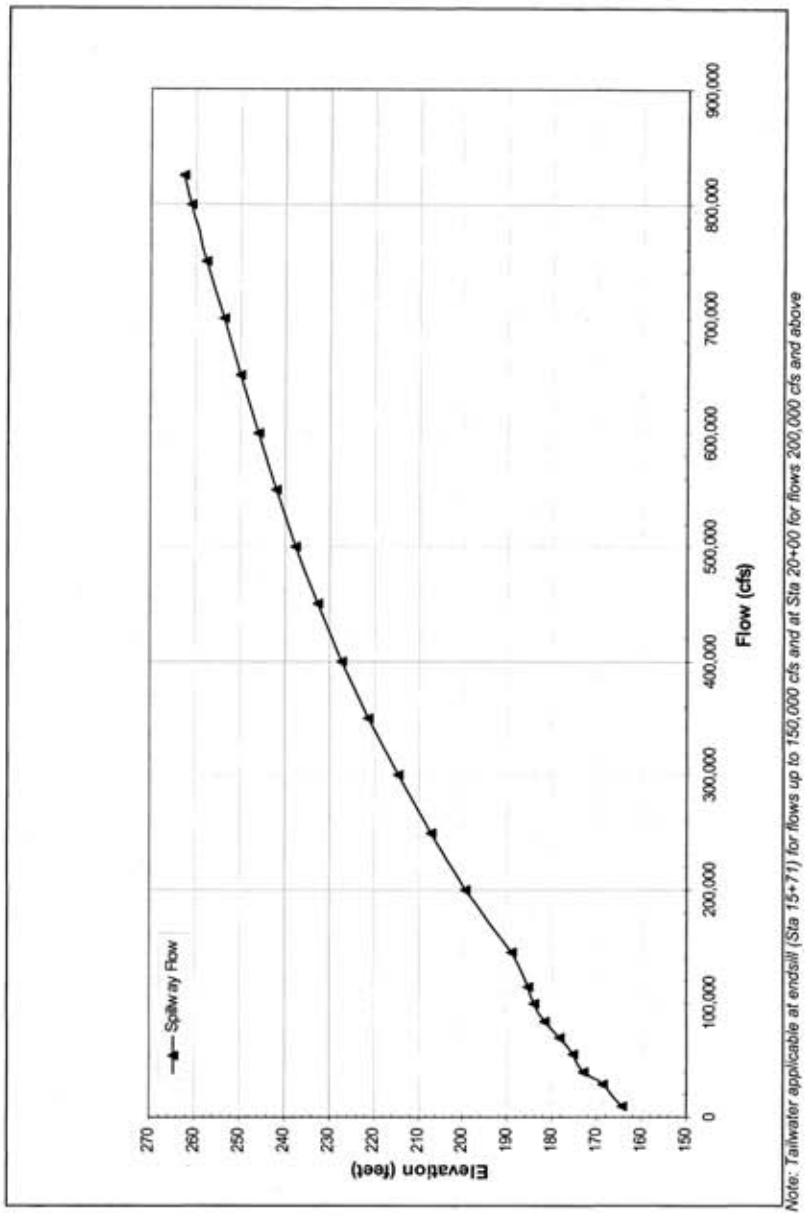
Water surface profiles computations to address energy dissipation were computed assuming minimum losses. Results of these runs were utilized in designing the stilling basins.

7.4.6.1 Service Spillway Required Modifications

The main dam stilling basin is the energy-dissipating device for flows from the main dam river outlets and service tainter gates. The hydraulic jump is the basic feature used to dissipate excess hydromechanical energy in a stilling basin such as that for the service spillway at Folsom Dam. The tailwater curve near the end of the stilling basin and within the exit channel from the main dam spillway area is shown as **Figure 7-7**.

The existing main dam stilling basin was designed so that fully developed and contained hydraulic jump action would exist in the stilling basin for flows up to 200,000 cfs, and to prevent failure (major damage) during passage of the spillway design flood, which at the time of design included a peak outflow from all eight spillway bays of 544,000 cfs at lake elevation 473.8. This included free-flow under the tainter gates and no flow through the 5-foot by 9-foot river outlets. Above 200,000 cfs, hydraulic jump action is only partially effective, with the jump extending further downstream into the exit channel as flows

increase. Increased pool elevations associated with the raised dam should not significantly change jump action in the existing stilling basin for flows up to 200,000 cfs. The addition and operation of the proposed auxiliary spillway may be used as a positive influence on the characteristics of the hydraulic jump in the existing stilling basin. The increase in tailwater due to combined flows with the auxiliary spillway should cause the hydraulic jump to remain more within the stilling basin at higher discharges. Key design considerations are discussed in **Attachment B4** and will be evaluated in detail during future studies, which will include physical hydraulic modeling. A preliminary estimate has been made of how much (if any) the existing stilling basin would need to be lengthened for satisfactory functioning during passage of the PMF.



Note: Tailwater applicable at endsill (Sta 15+71) for flows up to 150,000 cfs and at Sta 20+00 for flows 200,000 cfs and above

FIGURE 7-7
TAILWATER RATING CURVE, COMBINATION OF CORPS CURVE AND DATA TAKEN FROM 1:36 MODEL

7.4.6.2 Emergency Spillway – Flip Bucket

Flows from the emergency flip bucket spillway act in a very different manner than those from the service spillway. Flow follows a trajectory (like a ski jump) where the energy is mainly dissipated in the plunge pool that develops when discharge flows are high. The energy is not dissipated effectively except when a plunge pool exists. The original design of the emergency stilling basin was based on combined releases from the dam being at least 300,000 cfs.

7.4.6.3 Auxiliary Spillway – Stilling Basin

The stilling basin for the proposed auxiliary spillway would be expected to be a concrete lined hydraulic jump type similar to that of the stilling basin for the service spillway. The stilling basin design was generally patterned after the Type II basin (Peterka, 1974). See **Figure 7-8** for a sketch of a Type II basin.

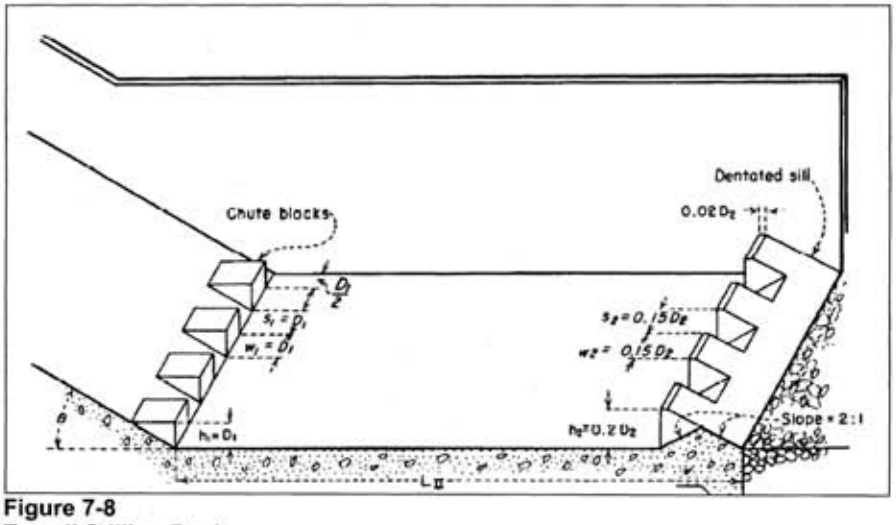


Figure 7-8
Type II Stilling Basin

7.4.6.4 Merging Flows from the Stilling Basins

Physical model studies would be required to ensure that flows blending together from the auxiliary spillway and service spillway merge well as they enter the American River, that forces on the auxiliary stilling basin walls would be taken into account for in wall design, and that the flow regime in the American River would not change dramatically over a broad range of conditions (this could lead to scour of the banks downstream of the confluence of these flows).

Preliminary Findings

It appears that the existing main dam stilling basin length would be adequate if releases from the main dam service tainter gates and the proposed auxiliary spillway are coordinated and optimized for hydraulic jump action in the existing basin. However, model tests may show that some lengthening of the stilling basin is desirable. During earlier studies for the Folsom Dam Raise Project, a conservative stilling basin extension of 60 feet was selected based on preliminary computations and engineering judgment. For this report, a 60-foot lengthening is assumed, but more detailed studies, additional geotechnical data currently being gathered, and model tests will be used in subsequent design studies to determine whether the existing stilling basin needs to be lengthened and by how much.

7.4.7 Operations

From a hydraulic viewpoint, the preferred order of making releases (not considering power releases) is the main dam river outlets, the auxiliary spillway, the main dam service tainter gates, and finally the main dam emergency tainter gates. The river outlets generally should be closed (or at least limited to 60 percent open) when the service tainter gates on the main dam are opened.

7.4.7.1 General

Model testing from previous studies has led to some observations that must be considered in operating procedures that govern releases through the spillways. Of major importance is that balanced gate operations that lead to uniform discharges across the width of the stilling basin minimize the formation of recirculating currents which can draw abrasive material into the stilling basin.

7.4.7.2 Gate Sequencing during Flood-Control Operations

Design considerations include the following:

- The peak (unregulated) PMF inflow would be about 902,000 cfs. Discharges would always be regulated so that peak inflows are never exceeded.
- The existing outlets in the dam would be the sole release capacity until pool elevation 368.0 is reached (sill invert elevation of the auxiliary spillway). Power releases likely would be made during this time but (conservatively) were not included in the scenario described.
- Once pool elevation 368.0 is exceeded, the auxiliary spillway tainter gates would begin to discharge, and before the pool reaches elevation 418 (main concrete dam spillway crest), total combined discharge from the outlets and the auxiliary spillway would reach the objective release of 115,000 cfs. When the reservoir is high enough, releases may be made through the auxiliary spillway only, helping to conserve the cold-water pool. The transition can be made from combined releases to release through the auxiliary spillway only.

- The auxiliary spillway can hold the objective release of 115,000 cfs equal to and above pool elevation 418 by itself, however, flows must be transitioned to the service spillway before the main dam tainter gates are overtopped. The top of the closed service spillway tainter gates is at elevation 468.0. During the pool elevation's rise to elevation 467.0, the auxiliary spillway gates would transition to the closed position and the five service tainter gates would open as necessary to maintain the 115,000 cfs objective release. For pool elevations above 467.0, discharges would be from the service spillway gates, and would be limited to 160,000 cfs or less. The top of the replaced emergency tainter gates is dependent on the dam raise. The tainter gates would typically be opened when pool elevation is one foot below the top of the gate. Opening the emergency tainter gates requires a minimum release of 300,000 cfs. Therefore, the dam releases must be ramped up to 300,000 cfs before the emergency tainter gates are opened. This can best be accomplished by opening the auxiliary spillway tainter gates to supplement flows from the service tainter gates. It is anticipated that the emergency tainter gates would be utilized only for very extreme events when both the service tainter gates and auxiliary spillway tainter gates are making releases much greater than 300,000 cfs. At maximum PMF pool elevation 481, discharges from the main dam tainter gates would be about 332,000 cfs from the five service tainter gates, 198,000 cfs from the three emergency tainter gates, and 312,000 cfs from the auxiliary spillway tainter gates for a total of 842,000 cfs. If the new emergency tainter gates are allowed to go to free-flow, this total could be increased to 890,000 cfs. The existing top of the service gates is about elevation 480.0 so that the service gates would overtop at maximum PMF pool level 481.0.

7.4.8 Erosion Control Requirements

The erosion potential of flows exiting the auxiliary spillway and sequencing of combined flows from the service, auxiliary, and emergency spillways has to be considered and minimized as practical. This is especially true of the "tainter gates full open" discharges as the pool elevations approach maximum pool elevations. Physical model tests will serve as an aid to assess erosion potential, problems, and solutions.

7.4.8.1 Potential for Downstream Scour

Scour is the result of the erosive action of flowing water that attacks the bed and banks of streams and the piers and abutments of bridges. Different materials scour at different rates. Loose granular soil is rapidly eroded by flowing water, while cohesive/cemented soil and rock are more scour-resistant. Ultimately, over a long period of time, scour can be as deep for rock as for sand-bed streams.

Altered flow patterns may impact the river channel as flow exits the stilling basin(s), and for some distance downstream. Potential maximum discharge from the dam would increase with the dam raise and auxiliary spillway, although frequent flood discharges would remain essentially unchanged. An important design consideration is to determine if the altered flow patterns and increased potential discharges (and discharge duration) would

attack the rock and result in excessive scour. The powerhouse road area and the new Folsom Dam Road Bridge are areas of concern.

If the model studies indicate that high velocity flows could attack and scour rock to an extent that is not acceptable, further assessment of rock scour potential would be done by expanding on the previous studies by Kleinfelder (2005-2006 study on rock scour potential in the exit channel) to include other areas, such as below the Auxiliary Spillway exit and the chute area, if it is unlined. As in the 2005 study, *Annandale's Erodibility Index* methodology would be used for evaluation.

The cost estimate includes costs for grouting (stabilizing) existing rock in the powerhouse road area under the assumption that additional scour could result from the project.

7.4.9 Downstream Channel Capacity

The physical capacity of the American River to safely transport flows depends on the downstream levee system. Folsom Dam has in the past been operated to control flood releases to 115,000 cfs. This is defined as the "objective" flood release for this design. Since completion of Folsom Dam, the "objective" flood release of 115,000 cfs was exceeded only in 1986. The maximum flow during the 1986 flood was 134,000 cfs.

With construction of the proposed features discussed herein, Folsom Dam outflows would not exceed 115,000 cfs for all historic floods of record, and also for a design flood that has a 1 percent chance of being exceeded in a given year (100-year design flood). For floods larger than the 100-year design flood, maximum outflows would increase. For the 200-year design flood, Folsom Dam maximum outflows would increase to, but not exceed 160,000 cfs.

The *Common Features Project* (Federal Legislation, 1996) involves strengthening and raising American River levees to safely pass a flow of 160,000 cfs. Most of this work has been completed. Specifically, the levees are being improved to be structurally sound and competent to pass flows of 160,000 cfs. For the current studies, the maximum safe discharge capacity of the American River was assumed to be 160,000 cfs. Once flows reach this threshold, downstream areas which could flood would commence evacuation procedures.

Some members of the project design team have expressed concern about possible lateral erosion of the river channel if flows of 160,000 cfs were made for an extended duration (up to 4 days). A study has been initiated to determine the measures required to safely pass the occurrence of a flow of 160,000 cfs for duration of up to 48 hours. This study will assess the stability of grass-lined levee slopes, critical bank erosion sites, and erosion-resistant geologic formations in the channel bed. It also will identify long-term monitoring and maintenance required to sustain the lower American River's ability to convey 160,000 cfs for an extended duration.

For more information, see **Attachment B4**.

7.4.9.1 Potential for Levee Breaching

Investigation of potential levee breaching is currently underway but has not been completed. Potential levee breaching is most likely to occur at the locations where the rising water surface attains an elevation equal to that of the predicted probable non-failure point (PNP) and then continues rising towards the probable failure point (PFP), the elevation where the levee is very likely to have failed. These locations and determination of the PNP and PFP are based on site investigations, models, and engineering and geotechnical judgment, as are the levee breaching scenarios, the extents of the potential levee breaks and the judgment of existing levee reliability.

7.4.10 Hydraulic Impact on Downstream Water Surface

Investigation utilizing existing or new numerical models will be required for the design storm events to determine whether new operations implemented due to the increased discharge capacity of the project will cause any changes to the maximum water surfaces downstream.

7.4.11 Model Studies (Requirements and Results)

For a raise of Folsom Dam, a physical model study is needed to evaluate pressures on the spillway crest for controlled and free-flow operation, to determine the effect of the bridge on spillway flows from higher pools, and to determine the flow characteristics in the stilling basin for increased head and discharge. Hydraulic features related to a dam raise that would require physical model tests include the main concrete dam spillway (overflow crest and downstream chute, stilling basin/flip bucket, exit channel, and exit of sluices) and the auxiliary spillway (approach channel, control structure, chute, and energy dissipation area).

7.4.11.1 Numerical Model

It would be impractical to construct a physical model at a suitable scale that would include enough of the reservoir to establish whether satisfactory approach conditions to the structure exist. Therefore, a multi-dimensional numerical model would be performed in addition to a reasonably-sized physical model, providing boundary conditions to implement in the full model described below.

7.4.11.2 Full Model

A full physical model of the converging flows from the service spillway, auxiliary spillway and emergency spillway is required for ensuring hydraulic performance. This would also include the stilling basin for the auxiliary spillway. Since the auxiliary spillway is considered a pre-project condition, this model would have already been accomplished.

7.4.11.3 Sectional Model

The dam raise and replacement of the tainter gates requires a sectional model to establish gate rating curves and cavitation potential of the existing spillway crest due to increased pools.

7.4.12 Inundation Maps for Flood Emergency Plans

The inundation maps for emergency action plans should be updated based upon the increased release capacity of Folsom Dam.

FEMA Publication 64, *Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners*, indicates that three inundation maps should be developed for the area below dams:

(1) Dam failure at the normal everyday pool elevation (sunny day failure)

(2) Maximum spillway discharge at a full flood pool

(3) Maximum discharge at the PMF condition

Also, in some cases, the spillway or outlet works discharge for which flooding commences should be indicated.

7.5 CIVIL DESIGN

The currently authorized project includes a 7-foot dam raise; however, due to the proposed implementation of the auxiliary spillway, a 3.5-foot dam raise is expected to meet the release capacity, reservoir storage and dam safety objectives. The dam raise alternatives for all of the embankment features are included in Chapter 6, Geotechnical Investigations and Considerations. The crest elevation of all existing dams and dikes is 480.5. The earthen dams and dikes to be enlarged or raised include Dikes 1 through 8, the left and right wing dams and MIAD. The crest elevation of the raised dams/dikes would be elevation 487.5 for a 7-foot raise or elevation 484.0 for a 3.5-foot raise.

7.5.1 Roads

Currently, Folsom Dam lands are divided into two general categories: (1) the Reclamation Central California Area Office administration area (industrial area), which directly supports Operation and Maintenance (O&M) of the main concrete dam, power plant, and pumping plant, and which has limited to no public access, and (2) the State of California Department of Parks and Recreation (DPR) Folsom Lake SRA, to which the public enjoys virtually unlimited access for either a daily fee or no fee. Public roads also are present in the area.

Some of the dams and dikes currently are being used as access roads and bike trails. These uses would continue following the dam raise. Some of the embankments are topped

with aggregate base course while others are topped with a road surfacing material (i.e., a well-graded gravel containing a fine-grained binder material). These materials would be removed prior to the dam raise and reinstalled "in kind" after the raise.

7.5.1.1 Access Within Central California Area Office Administration Area

Within the industrial area, Reclamation requires O&M access at all times to the main concrete dam, power plant, and pumping plant. The main concrete dam can be accessed for personnel and equipment from the first floor adit, third floor adit (both the downstream right and left side), and from the crest of the dam. Access to the stilling basin and the left wing dam seepage-monitoring weir currently is provided by a part-gravel, part-paved road accessible from Folsom Dam Road at the left abutment of the left wing dam. During construction, access to these locations or accepted substitutes must be provided at all times. Future permanent access to the main concrete dam must be functionally equivalent to existing conditions.

Right Wing Dam Approach Road

Folsom Dam Road traverses the downstream slope of the right wing dam at a grade of about 4 percent and merges onto the crest of the right wing dam several hundred feet west of the main concrete dam. For the 7-foot raise alternative, the grade of the road would have to be increased about one percent to accommodate the placement of 3.5 feet of fill on the crest of the right wing dam and would begin approximately 430 feet west of where the road merges onto the raised dam. It may be necessary to construct a retaining wall near the intersection of the road and the crest on the upstream side of the road to accommodate the embankment raise. For a 3.5-foot raise, a 3.5-foot crest wall on the right wing dam, which would be positioned near the waterside hinge point of the crest, would not require alteration of the access road. Using a crest wall to effect a dam raise eliminates a crest elevation difference from occuring between the right wing dam embankment and the main concrete dam.

Road on Left Wing Dam

The road on top of the left wing dam would be removed and replaced in kind. The existing road has a metal beam guardrail on both sides. The new road would have a metal guardrail on the downstream side and a 3.5-foot high concrete parapet wall on the upstream side (3.5-foot raise alternative). Using a crest wall to effect a dam raise eliminates a crest elevation difference from occuring between the left wing dam embankment and the main concrete dam. For a 7-foot raise, the left wing dam embankment would be raised 3.5 feet and then topped with a crest wall and metal guardrail similar to the 3.5-foot raise alternative.

Internal Roadways

To reduce construction traffic on city streets and to allow the use of oversized construction equipment during the excavation for the auxiliary spillway, internal haul roads would be developed within the reservoir from the auxiliary spillway site to Folsom Point and MIAD. The internal haul roads would be graded into the weathered granite and have an earthen road base installed. The internal roadways would be sized to allow passage of oversized equipment. For the construction of the crest wall on the dikes, wing dams and

MIAD, the crests of the dikes, wing dams and MIAD would be included as part of the internal road network. Given the space limitations of the crests, only conventional equipment would be used. At this time, there is no consideration being given to using the main concrete dam as a haul road. The internal haul road route being considered includes a route called "Auxiliary Spillway to MIAD." This route consists of a construction haul road that would be constructed from the auxiliary spillway site to the Dike 7 stockpile area and then on to Folsom Point and MIAD (R1 and D2 borrow/stockpile sites). This would allow transport of material between these project features.

7.5.1.2 Folsom Lake State Recreation Area Access

Surrounding Folsom Lake are seven access roads to established facilities of the Folsom SRA; three of the access roads cross the axes of dams or dikes at the following high points between abutments and natural grade; Beal's Point, Granite Bay, and Folsom Point.

Public access to the recreation facilities would need to be maintained during construction. Future permanent access to these recreation facilities must be equivalent to existing conditions. Alternatives for future access could include (1) leaving the existing crossing roads (from outside the reservoir basin to inside), and installing gate structures that operate and close when the reservoir reaches a certain elevation, or (2) re-grading the roads to suit the new crest elevation. Roads located on the crest of a dam or dike would need to be removed during the raise process and reinstalled in kind for future use.

Beal's Point

The Beal's Point portion of the Folsom SRA is located on the west shore of Folsom Lake and provides equestrian and cycling trails and camping, picnicking, and swimming facilities. These recreation facilities are accessed by a two-lane paved road, which crosses the dam/dike axis between the right wing dam and Dike 6. A paved spur from this road forms the crest of Dikes 4, 5 and 6 and serves as a bike trail and O&M access to monitoring devices at Dikes 5 and 6. This bike trail/access road becomes a gravel road on Dike 5 and continues past Dike 4 to Granite Bay recreation facilities. Additionally, improved gravel road spurs branch off from the crest roads at the left abutment of both Dike 5 and Dike 6 to access seepage toe drains and monitoring weirs.

Granite Bay

The Granite Bay portion of the Folsom SRA is located on the west shore of Folsom Lake and offers five boat launch areas, a beach and swim area, camping and day-use facilities, two concession buildings, an activity center, a play area, and a trail staging area. Several access roads service the Granite Bay recreation facilities and would require reconstruction because of raised Dikes 1, 2 and 3. A two-lane main access road runs parallel to Dikes 2 and 3 near the toe. This road is distant enough from the toe to preclude relocation. From this main two-lane road, a paved spur road crosses the current left abutment of Dike 3 and leads to a parking lot at a boat launching site. A second lake access to the Granite Bay facilities is provided by an existing paved road that crosses near the center of Dike 3, and which also leads to parking lots serving boat launching ramps. A paved spur road from the

second lake access forms part of the crest of Dikes 2 and 3 and proceeds to the lake and lake facilities. This spur is 1,395 feet long and would have to be at least temporarily relocated and then reconstructed on the crest or permanently relocated. A third lake access is provided by an existing paved road that crosses Dike 2 near the right abutment, and proceeds to the lake and lake facilities. Lake access also is provided by a paved road that forms the crest of Dike 1 and wraps around the right abutment of the dike to the lake. The crest of this dike is 2,060 feet long; the crest road would have to be at least temporarily relocated and then reconstructed on the crest or permanently relocated.

Folsom Point Recreation Area Access Road

Access to Folsom Point recreation facilities is provided by a paved two-lane road crossing over the reservoir divide east of the Dike 8 left abutment. Folsom Point is a potential staging site and/or a potential disposal site for material from the auxiliary spillway excavation. Folsom Point and its access road would require some measures such as fencing and traffic separation for public health and safety purposes so that it could remain open to the public for the duration of the auxiliary spillway and dam safety construction.

Brown's Ravine

The Brown's Ravine portion of the Folsom SRA is located on the southeast shore of Folsom Lake and offers two boat launch facilities, a floating concessions stand, refueling station, restroom, camping and picnicking facilities, and an equestrian trail staging area. It also supports Folsom Lake Marina, which is protected by a breakwater at its west end. Above reservoir elevation 466, the road leading to Brown's Ravine from Green Valley Road is closed and all facilities are inaccessible. At reservoir elevation 476, all facilities become inundated.

7.5.1.3 Folsom Bridge Road

The Folsom Bridge Road, a public access road, would serve to replace the existing Folsom Dam Road across Folsom Dam with a new bridge crossing the American River approximately 1,500 feet downstream from Folsom Dam. The road would be constructed on a new alignment from Folsom-Auburn Road to the Folsom Dam Overlook and reconstructed/widened along the existing road alignment from the overlook to East Natoma Street, a total distance of approximately 2 miles. The road is being designed as a four-lane road with an asphalt-concrete surface.

The proposed Folsom Bridge Road alignment does not interfere with the dam raise. Excess excavation from the Folsom Bridge Road contract will be disposed or stockpiled at sites R1, D2 and/or near Dike 7 for later use in Dikes 7 and 8 and MIAD.

7.5.1.4 Salmon Falls Road

Salmon Falls Road, a public access road, crosses the South Fork of the American River. Vehicle parking, restroom facilities, and trail access points are located immediately east of the river crossing and become inundated at reservoir elevation 475. Above reservoir elevation 482, a short length of Salmon Falls Road and the bridge surface may become

flooded. It is currently unknown whether structural modification would be required for the bridge. An alternative route is available.

7.5.2 Utilities

Raising the dam and dikes, whether for a 3.5-foot or a 7-foot raise, will have a minor impact on existing utilities. Impacted utilities include electricity, water, and waste water facilities.

Electricity

Several power lines and utility poles may require relocation during construction including power lines running beneath the boat launch area in front of Dike 3.

Several overhead power lines cross the entrance of Granite Bay. During construction large vehicles may need to have these power lines raised in order to safely pass under them. In instances where overhead lines could create obstacles for construction vehicles, agencies will likely temporarily raise the power lines with large poles in order to avoid utility relocations and interruptions in service.

Water

Construction activities may require the relocation of existing water infrastructure including:

- An existing 3-inch water main that serves the entrance kiosk and restroom facilities at the boat launch at Folsom Point.
- Water pipelines running beneath the boat launch area in front of Dike 3 that provide water service to the restrooms at the boat launch.

Waste Water

Construction activities to provide crest protection at Dike 4 could require the relocation of an existing sewer pipeline that runs through the upper right abutment of Dike 4 and out toward Auburn-Folsom road. Borrow activities in the vicinity of Folsom Point could require the relocation of an existing sewer line that serves the restroom facilities at the boat launch.

A raise of 7 feet to the dams and dikes could result in a maximum water surface elevation of 482.5. If water in the reservoir reaches this elevation, waste water infrastructure and facilities would be inundated including:

- Two El Dorado Irrigation District sewage lift stations in Brown's Ravine
- Two vault toilets at Skunks Hollow
- Two vault toilets at Salmon Falls

7.6 STRUCTURAL AND MECHANICAL DESIGN

This section addresses structural and mechanical features and components of the Folsom Dam Raise Project, with an emphasis on a 3.5-foot dam raise of the existing main concrete dam. The reinforced concrete wall and embankment raise alternatives for the embankment structures are included in Chapter 6, Geotechnical Investigations and Considerations. The dam raise team recognizes that differences exist in operational criteria and analysis/design methods and standards among the project stakeholders including the Corps, Reclamation, and DWR. Therefore, it has been agreed upon that routings and decisions of dam modifications to accommodate these routings will be conducted based on the criteria of the agency which has jurisdiction, but the design of new structural components should accommodate the most stringent criteria.

The existing main concrete dam is a straight gravity section with a structural height of 340 feet, and a crest length of 1,400 feet. The dam has 28 concrete monoliths, each 50 feet in length, with a crest width of 36 feet. All upstream faces have a 0.1:1 batter. The 20 non-overflow monoliths have a downstream slope of 0.7:1 (horizontal to vertical ratio [h:v]) below a near-vertical neck region at the crest. The eight spillway monoliths are sloped at 0.67:1 downstream, after transitioning from an ogee crest spillway. The eight spillway bays are 42 feet wide, measured between 8-foot-thick piers. **Plate 7-1** contains an overview of Folsom Dam.

Proposed structural modifications to the existing Main Concrete Dam for a 3.5 foot raise include work in the emergency spillway: replacement or modification of three emergency tainter gates, modifications to increase the maximum gate opening for the five service tainter gates, and possible vertical and/or downstream extension of the spillway piers for the emergency spillway.

The following paragraphs provide details of the structural features of the proposed 3.5-foot raise alternative.

7.6.1 Existing Spillway Bridge

The existing spillway bridge on the main concrete dam is a 50 year old, fracture critical, built-up, riveted plate girder. The bridge consists of eight spans of two riveted steel plate girders with a composite concrete deck; each span is approximately 34 feet wide by 50 feet long. Shear keying does not meet current standards, but provides some composite action to the floor beams and top girder flanges. The two built-up riveted plate girders are simple spans between pin and rocker supports on alternate spillway piers. Flanges are narrow, constructed of built-up riveted plate sections with more, thicker, and wider plates added to match the increasing moment demand near the center of each span. The existing bridge was designed for HS20-15 highway loads or the load from the gantry crane moving and placing the outlet conduit bulkhead.

For orifice flow releases with nappe profiles above 473.62 at the bridge (**Plate 7-3**), the girders would be submerged in a somewhat static pool, so that equal and opposite pressures would exist on each side of the girder webs. The bridge would not be endangered

in this scenario. Since current routings include orifice flow up to the PMF pool, the existing bridge should not be impacted by the dam raise. In addition, the PMF pool is in the jurisdiction of Reclamation, which has indicated a preference to keep the existing bridge.

7.6.2 Tainter Gates

The five service gates require modifications with the dam raise. The three emergency tainter gates would require significant enhancements or total replacement for the dam raise to increase the tainter gate height. Both sets of tainter gates have existing inadequacies that would need to be addressed.

The O&M requirements of the tainter gates will consist of an annual inspection of the hoist systems, trunnions, lubrication system, seals, air boxes, and the mobile crane. Major rehabilitation of the tainter gates and air boxes will take place on a 25 year cycle.

7.6.2.1 Five Service Tainter Gates

The five service tainter gates, in the main spillway, would be modified slightly with a dam raise. Field measurements have revealed that the actual maximum opening of the existing tainter gates has been restricted by means of a limit switch to elevation 454.5, rather than the design elevation 459.0 indicated on as-constructed drawings (sheet 411/6). The inability of the tainter gates to achieve the design opening is also due to the fact that the point of connection for the hoist chain is near the third frame (strut), rather than the design location of the fourth frame (bottom strut). To achieve an increase in the tainter gate opening and increase release capacity, the chain connection would be moved to the location as specified in the original design. For each gate, this will necessitate adding a total of 20 links of 1 foot pitch chain (10 links per side), 20 feet of 12 inch channel, removal and reattachment of the lifting lugs, and adjustment of the limit switches.

Numerical and physical models demonstrate that, for RWS between 474 and 477.5, the nappe profile of spillway releases is depressed by the bottom of the gate (orifice flow) such that the trunnion tie beams are not impinged by the flow at the maximum opening. While it is logical to assume that the tainter gates will be subject to orifice flow at higher pool elevations, this must be validated before modifying the gate opening for the existing tainter gates. Otherwise, flow impingement on the trunnion tie beams could lead to failure of the gates.

The five service tainter gates would be strengthened as necessary to overcome existing deficiencies. If flood routings demonstrate that these gates would be overtopped, further modifications may be necessary. This would include structural enhancements and elevation of the operating machinery to avoid submergence, all subject to Reclamation dam safety requirements and funding. No further discussion on addressing overtopping of these gates is presented in this report, since any overtopping operation would be outside the scope of Corps criteria or jurisdiction.

7.6.2.2 Three Emergency Tainter Gates

Many geometric constraints were considered for the emergency tainter gates, related to the prevention of overtopping or submerging of the tainter gates, piers, and spillway bridge, per Corps criteria. These constraints, as applicable to the pool elevations for the current routings, are discussed in detail in the following section, "Existing Constraints." As described in "Condition of Existing Tainter Gates" below, modification of the existing emergency tainter gates to meet these demands was considered and determined to be viable but not necessarily preferable. Thus, the cost estimate for the dam raise includes new gates constructed with extended piers, based on conservative assumptions of spillway flow.

Existing Constraints

Plate 7-2 shows the existing spillway cross section with the gates opened and closed, highlighting the constraints imposed on new flood operations. The existing tainter gates are 42 feet wide with an outside radius of 47.0 feet. The main spillway tainter gates are 50.83 feet high, top elevation 468.0, providing at least 2 feet of freeboard up to pool elevation 466.0. The emergency tainter gates are 53.83 feet high, top elevation 471.0, providing at least 1 foot of freeboard up to pool elevation 470.0.

Flow between piers is an overtopping possibility in the existing state of the dam. Flows can only be contained to a pool elevation of 476.25 near the gate, beyond which water will overtop the pier between the gates, impinging on the trunnions and endangering the gates. The nappe profile would be expected to drop below 476.25 at the intermediate piers for certain pool elevations, but may not drop at the end piers. As flows wrap around the end piers, they may not drop sufficiently to avoid impinging on the lower cord of the bridge or to avoid overtopping the pier. The nappe of these flows and the extent of their draw down at the end piers should be hydraulically modeled.

An additional constraint at elevation 476.25 is the gate operating machinery. The machinery is set on the upper catwalk, directly above the gate. This machinery must be protected from submergence to prevent damage and insure reliable operation.

Additional constraints on gate operations include the elevations of the upstream bridge girder, the trunnion elevation, and the trunnion tie beam elevation. If the pool elevation or the nappe resulting from free flow spillway releases exceeds the elevation of one of these constraints, the existing configuration of the piers, bridge, and/or gates is insufficient and must be modified.

Condition of Existing Tainter Gates

Recent static analyses of the existing tainter gates indicate that modifications required to maintain the existing emergency tainter gates for a dam raise would be significant, potentially meriting total gate replacement. The controlling static load case for the tainter gates is an operational load case, so the gate is subject to full hydrostatic pressure while being opened or closed. Following current Corps criteria, which are more stringent than American Institute of Steel Construction (AISC) criteria, the emergency tainter gates are overstressed throughout in their existing state for existing dam operations. The results of the

recent static analyses were quantified in terms of an allowable combined stress ratio (CSR), which should be less than or equal to 1.0 to meet criteria:

$$CSR = \frac{\text{applied stress}}{\text{allowable stress}}$$

TABLE 7-2
COMBINED STRESS RATIOS FOR EXISTING TAINTER GATES

Gate Component	Combined Stress Ratio	
	Emergency Tainter Gates	Service Tainter Gates
Girders	0.90 to 1.40	0.36 to 1.08
Struts	0.82 to 1.34	0.51 to 0.96
Skin Plate	0.42 to 1.68	0.22 to 0.90
Braces	0.02 to 0.50	0.04 to 0.55
Anchorage	0.09 to 1.14	0.09 to 0.67

The results of the CSR analyses shown in **Table 7-2** demonstrate the extent of overstress in the emergency tainter gates due to full hydrostatic head on an operating gate, which produces excessive trunnion pin friction. When considering potential residual stresses in the gates, the gates become more severely overstressed.

Nearly all tainter gate members were hot-rolled during fabrication, which leads to residual stresses throughout. Many components of the gates have been welded, either during original construction or during the 1996 retrofit, leading to further residual stresses, possibly additive with those due to hot-rolling. Therefore the gates were analyzed to include residual stresses generally equal to average maximum values determined by historical research. No measurements have been taken at the tainter gates to provide actual values. For wide-flange sections, the magnitude of residual stresses due to hot-rolling can typically be as high as $0.3F_y$ (compression) in flange tips. Residual stresses due to improper temperature differential before and after welding can result in even higher residual stresses - as high as or exceeding yield in or near welds. The tainter gate rehabilitation performed after the gate failure in 1995 involved field welding for the remaining seven tainter gates, and shop welding for the replaced gate. Therefore, the plates welded to the strut flanges in the retrofit may have introduced residual stresses as high as F_y (tension) into the flange tips and similar compressive stresses in the middle of the plates and flanges.

The plastic deformation that has occurred in the struts over time is expected to have redistributed the residual stresses in the struts, making the stresses more uniform but not necessarily reduced. For the sensitivity analyses that included residual stresses, it was assumed that locations with residual stress near yield are small, localized, and somewhat negligible. As a result, the amount of residual stress included in the analyses included $0.1F_y$,

0.2F_y, and 0.33F_y. This range was used interchangeably for both weld-induced and rolling-induced residual stresses. Results of the CSR values for residual stresses (added to those computed for the load case described above) are summarized in **Table 7-3** below:

TABLE 7-3
COMBINED STRESS RATIOS WITH ASSUMED RESIDUAL STRESS VALUES INCLUDED

Gate Component	Combined Stress Ratio for Emergency Tainter Gates		
	With RS of 0.1F_y	With RS of 0.2F_y	With RS of 0.33F_y
Girders	1.10 to 1.83	1.30 to 2.30	1.51 to 2.77
Struts	1.45 to 1.97	2.07 to 2.59	2.70 to 3.23
Skin Plate	0.82 to 1.36	0.96 to 1.43	1.22 to 1.86
KEY: F_y – Yield Stress RS – Residual Stress			

The specifications for the tainter gate repair and replacement required the contractor to follow American Welding Society (AWS) D1.1, whose procedures minimize residual stresses, through minimum preheating and interpass temperatures for specific electrode type and welding process. Furthermore, vibration stress relief was performed after construction. No measurements have been taken to indicate the effectiveness of either stress-minimizing process, however. The actual residual stress levels could be determined, using non-destructible means, such as ultrasonic methods. Until then, it is prudent and sensible to assume residual stresses exist and conclude the extent of their impacts further justifies gate replacement.

Tainter Gate Replacement vs. Tainter Gate Modification

This section outlines the considerations given to modification of the existing tainter gates to accommodate the increased pool, concluding that replacement may be more advantageous. Thus, costs defined for this report include new tainter gates with extended piers to accommodate a raised trunnion and subsequently increase release capacity.

To meet current standards, mitigate for existing residual stresses, and heighten the existing emergency gates, the skin plate assembly, girders, struts, and anchorage would all require modification. The added gate height may not constitute major additional stresses, but addressing existing structural deficiencies would be quite involved.

A conservative estimate of work required for gate modification follows. An additional frame with associated heavier skin plate assembly at the bottom rather than at the top of the gate. The tainter gate assembly would need to be rotated upward and the top cantilever reduced. The new frame and struts would need to align to the existing trunnion, necessitating cutting back the existing struts and totally replacing the trunnion assembly area. Modifications would need be constructed in place on the existing tainter gates and would have similar limitations to gate replacement, i.e., scheduled after a substantial increase in

PMF capacity is obtained and limited to the number bays for which stop logs are available. Due to the constraints of construction in the existing bays together with the extent of modification required, cost of modification may be similar to that for gate replacement.

The additional loads due to the higher tainter gates require anchorage modifications, which would be similar for gate modification or gate replacement. To increase tensile capacity of the anchors, additional rods would be placed in holes drilled to the same depth as the existing anchors and epoxy end anchored at that depth. The additional anchor rods would be yoked to the existing anchors and, being similar in length, would act elastically similar to existing anchor bar. For a replacement tainter gate, a reinforced anchor bar would extend downstream from the yoke, along the line of the existing anchor, to the new trunnions, downstream and vertically upward. The new trunnion location would ensure the trunnions and trunnion tie beams are clear of free flow nappe for all possible RWS elevations, including possible freeboard encroachment. As a result, overall gate height for replacement gates would be the same as for modified gates, but with a larger gate radius.

It is possible that simpler modification of the existing tainter gates would be an acceptable solution for heightening the emergency gates - an extension of the upper cantilever of the skin plate. A key consideration in a simple tainter gate modification is the nappe profile. If it indeed intersects the trunnion tie beams, as would be expected for free flow, trunnion relocation and subsequent pier extension would be necessary. Because of the age of the tainter gates, the unknown actual level of residual stress, and possibility of trunnion tie beam impingement, the cost estimate includes total gate replacement.

Exclusive of pier extensions, construction timing, duration and costs would be similar for modified or replaced tainter gates. The existing spillway piers would be extended downstream to accommodate the new trunnion location. The gate operating equipment would be elevated above the PMF pool elevation. Pier extensions can be constructed prior to gate construction without interference with operations or delay to gate construction. Gate sections would be prefabricated either in a construction shop at the dam or at the gate manufacturer's plant. Construction in the gate bays would be limited to gate demolition and assemblage of prefabricated sections.

New Tainter Gates

The mitigation of constraints for the existing emergency tainter gates by constructing new gates is addressed in this section. Refer to **Plate 7-3** for the proposed details of new emergency gates.

Dam raise flood routings require that the three existing emergency tainter gates be opened once the pool reaches elevation 470. Corps criteria discourages overtopping of tainter gates; therefore, to maintain 1 foot of freeboard for new operations, the elevation of the top of the emergency tainter gates in the closed position would be elevated with a dam raise to allow pool elevations greater than 470 while maintaining flood releases of 160,000 cfs. Similarly, the top arc of the gates on new gates would be elevated as necessary.

The new tainter gates would include a relocated trunnion, so that releases would avoid impinging the trunnion tie beams to avoid gate failure in the event of free flow. The

nappe profiles at the pier and at the spillway centerline were computed for a pool elevation of 481, and the new trunnion location was determined by placing it downstream of and higher than the nappe. The trunnion would be moved 10.4 feet in the downstream direction and 6.5 feet upward. New tainter gates, therefore, would be 56.83 feet high with a 54.5-foot radius. Final determination will be made concerning PMF releases and their possible impingement on the trunnion tie beams and, therefore, necessitate elevation of the trunnion and trunnion tie beams above the nappe to avoid gate failure. The cost estimate of the dam raise includes relocation of the trunnions and extension of the piers, to envelope the most demanding scenario of spillway flow.

Similar to that described for the service tainter gates, the actual maximum opening of the existing tainter gates has been restricted and would be modified with new or modified gates, increasing spillway release capacity.

Based on proportioning weight of existing Folsom Dam gates to modified geometry and design head, new gate weight was estimated to be approximately 250 kips per gate. This estimate was confirmed through the use of a gate weight estimating curve based on design head, gate width, and gate height, resulting in a less conservative estimate of 215 kips. (Ref. Erbiste, P.C., "Estimating Gate Weights", Water Power and Dam Construction, May 1984).

Consideration will be given to the use of self-lubricated composite trunnion bearings, such as are used on the replacement tainter Gate 3. The existing auto-lube systems will be retained. Although the main configuration of the tainter gate should be similar to the existing gates, new design features that optimize the overall tainter gate design will be considered, including catwalks that function as struts between piers, reinforced concrete trunnion beams (extending from each pier toward the centerline of each spillway) that decrease strut angle and, ultimately, strut size, plus miscellaneous improvements that would minimize vibration concerns relating to dynamic loading.

With a dam raise, the gate operating machinery for the emergency tainter gates, which is located directly above the gate on the upper catwalk, would be elevated. Related work may include modification of the stairwells at each pier, designing around the discontinuous drive shaft at pier 5 (since gate 5 machinery does not need relocation), and possible relocation of the catwalks at machinery level.

The hoist systems for the replacement gates would be traditional gear driven hoist mechanisms similar to the existing design, except that cables would be provided in lieu of the chains as used in the existing system. Consideration has been given to a hydraulic cylinder hoist mechanism, as is proposed for the new auxiliary spillway; however, the existing structure does not lend itself to the mounting of cylinders.

7.6.2.3 Stop Logs

Dam raise construction in the emergency spillway would consist of modification to the piers and trunnion anchorage, existing gate removal, and new gate placement. Hence, stop logs in adjacent bays must be in place for the entire duration of the work, to provide and maintain dry conditions. The existing stop logs do not provide for closure of two complete

bays, so additional stoplogs would need to be constructed. Seven stoplogs are required per bay, and Folsom Dam currently owns 12 stoplogs – a complete set of seven and some spares. To obtain two complete sets, four new stoplogs would have to be constructed, for a total weight of 350 kips.

The existing storage rack at monoliths 3 to 5 would continue to store nine stoplogs plus the lifting beam. Due to the increased pool elevation, consideration should be given to modifying or reconfiguring the storage rack so that no stop logs are submerged at high pool, because this may inhibit accessibility to the stop logs. The new stoplogs would be stored on the ground, perhaps at the maintenance facilities at the dam while not in use.

The existing gantry crane does not facilitate stop log placement in the emergency spillway. The existing gantry crane is a riveted steel structure that rides on crane rails and features both a variable 25-ton and a limited-travel 140-ton hoist. The 25-ton hoist currently is used to place the bulkhead at the eight existing river outlets and the 84-inch water intake. The 140-ton hoist currently is used to raise the penstock fixed-wheel intake gate assemblies and for placing tainter gate stop logs on the main spillway. Currently, the crane rails do not extend to the emergency spillway. The crane rails would be extended as part of the dam raise to permit placement of stop logs at the three emergency spillway tainter gates. The total load for placing the stop logs would be as high as 140 kips (between 55 and 120 kips for the various-sized stop log sections and 20 kips for the lifting beam). This lift exceeds the load capacity of the 25-ton hoist and the travel capability of the 140-ton hoist.

As part of the Folsom Modification Project, MGE Engineering (MGE) did a preliminary design for increasing the capacity of the 25-ton hoist to a 55-ton hoist. As part of its design effort, MGE weighed the crane and determined the center of gravity to prevent overturning from being a problem. To accommodate placement of the new stop logs, modification of the bridge crane as per the MGE design would be investigated to a capacity somewhat greater than 55 tons.

7.6.3 Modify Existing Piers

The three existing emergency tainter gates on the Main Concrete Dam emergency spillway may require replacement with the dam raise. Therefore, the piers would be raised and extended downstream to anchor the new larger tainter gates, and locate the trunnion above the PMF nappe. The pier extensions would vary in the main spillway and the emergency spillway, since the gates would not be replaced in the main spillway. Refer to **Plate 7-3** for details of the emergency spillway modifications.

On the downstream side of the piers, anchorage, pier strength, and pier/monolith stability would govern the modifications. Preliminary engineering analyses presented in the *American River Long Term Study* concluded that, although the existing pier width is sufficient for a gate up to 66-foot-high, the piers must be strengthened because of existing deficiencies (current design criteria more stringent than those used for the original design) and additional static loading from the new gates (transferred through the pier extensions) (Corps, 2002a). The analyses also concluded that severe concrete cracking and weakening of the reinforcing steel in the pier can be expected during large earthquake ground motions in

the cross-canyon direction, which could lead to overstressing of the trunnion anchorage once the pier concrete cracks and steel yields. In addition, the new, larger tainter gates increase the demand on the trunnion anchorage and piers. Thus, anchorage needs exist on two levels:

- Improving Trunnion anchorage for the new gates. Install new mild steel bars in drilled holes that are polyethylene-sleeved and grouted in place. The additional anchors rods would be yoked to the existing anchors through the use of a transfer girder and, being similar in length, would act elastically similar to the existing anchor bar. The transfer girder would connect to the new trunnion through a single mild steel bar and would be located above the PMF nappe (**Plate 7-3**).
- Improving the stability of each pier for resistance to cross-canyon seismic loading. The solution to the trunnion anchorage deficiencies that would be introduced with the new gates could aid, but not completely solve, pier seismic stability needs. Therefore, additional anchorage would be necessary to completely address pier stability deficiencies. Prestressed tendons, independent of Trunnion anchorage, embedded in the mass concrete of the overflow are an option. The extensions of the pier to accommodate the new gates would be anchored with new reinforcement into the mass concrete as well, providing additional stabilization benefits. Addressing these stability needs would be a dam safety issue, subject to Reclamation design and funding. As such, no cost was included in the estimate.

Other viable design considerations exist, which were neither included in the *American River Long Term Study* (Corps, 2002a) nor evaluated/included in this report, exist and are listed below as methods of strengthening the piers for seismic purposes:

- New spillway bridge superstructure constraining piers
- Trunnion beams
- Catwalks that function as struts between piers

If trunnion beams are used in the new tainter gates, the effects of unbalanced operating conditions (dissimilar gate openings in adjacent gates) would need to be addressed in the design of the beams and the piers.

The following issues remaining from preliminary seismic analyses would need to be addressed:

- Hydrodynamic interaction should be included in the analyses.
- Due to the coarse nature of the model, element strains were calculated 12 inches from the edge of the concrete. The centroid of the existing steel is probably closer than this distance to the edge of the concrete. Including more layers of elements in the model through the thickness would result in more accurate steel strains.
- Recently revised probabilistic ground motions and historically applied deterministic ground motions should be included in the analysis.

Ground motions applied to the base of the spillway gate piers (particularly the upstream/downstream direction) would be magnified compared to bedrock ground motions. Calculating the amount of this magnification was beyond the scope of the preliminary analyses, which concentrated on the cross-canyon behavior of the piers.

It should be noted that after more detailed design efforts or model studies are completed, the proposed preliminary design may be modified. For example, significant modifications may be required to the crest curve due to the increase in design head and associated cavitation problems. Crest improvements would be required to address this problem, but pier improvements would be justifiable to concurrently improve spillway flow. Therefore, the upstream ends of the piers would be reshaped, and extended upstream. For the feasibility level, however, neither crest modifications nor upstream pier extensions with stop log slots are justifiable.

7.6.4 Main Concrete Dam Monolith Stability Analysis

The proposed alternative would increase maximum hydrologic conditions by approximately 5 feet. The elevated RWS would increase from the original design maximum RWS of elevation 475.4 to elevation 480.4. Therefore, a concern has been identified about the stability of the main concrete dam monoliths relative to sliding at the contact (between the dam and foundation). Additionally, stability under seismic loading has been considered.

Because of extensive work regarding stability analysis of the main concrete dam conducted by Reclamation, State of California Division of Safety of Dams (DSOD), and the Corps (Corps, 2002b, 2004) over the past several years, and because of differences in criteria and analysis methods, summaries for each agency are presented. This is in keeping with the stated goal of the dam raise project, which is to address all the criteria of all stakeholders. A significant difference is Reclamation's risk analysis approach compared to the Corps and DSOD deterministic approach.

7.6.4.1 Stability Evaluation by Reclamation

A stability analysis has been completed to evaluate any potential instability of the main concrete dam monolith contacts due to an elevated RWS, and to assess whether modifications are needed to stabilize the main concrete dam. The analyses conducted were based on a normal static pool of elevation 466 and a flood (hydrologic) pool of elevation 484.5. Based on results from these analyses, all monoliths would appear to be stable for static and hydrologic loading conditions using contact friction angles that are likely to exist. Therefore, it is not recommended by Reclamation that modifications be implemented to address these loading conditions. Considering these analyses were conducted for a higher PMF pool than the current PMF pool of the 3.5-foot raise, it can reasonably be concluded the stability results would only improve. However, it should be noted that modifications have been developed to address sliding instability of the main concrete dam monoliths due to seismic loading. These seismic modifications are anticipated to address any uncertainties associated with potential displacement due to static and/or hydrologic loadings.

7.6.4.2 Stability Evaluation by Division of Safety of Dams

DSOD reanalyzed the seismic stability of the main dam for the PASS II Report (Corps, Reclamation, SAFCA, DWR, State Reclamation Board, 2006) using best-estimate shear strengths from the 2005 report by Goodman and Ghanaat, in combination with the forced vibration study results (Corps, 2005). However, their results focused only on seismic stability and did not address hydrologic stability concerns. Their findings concluded that the main dam monoliths are unstable for seismic loading and supported the need for modifications.

7.6.4.3 Stability Evaluation by the Corps

Stability analyses were completed by the Corps in 2005. These studies indicated a need to stabilize the dam for hydrologic conditions in its existing condition. Approximately $30 million was included in the Corps-authorized dam raise project (Corps, 2002a, 2002b) for dam stabilization measures. The Corps has updated previous stability analyses based on recommendations in the *Report on Bond Strength of the Rock/Concrete Interface of Monoliths 15-19. Folsom Dam* (Goodman and Ghanaat, 2005) and will be running new stability analyses based on modifications of the main dam proposed as part of the dam raise project. These analyses will be conducted using SAP2000 and/or GT Strudel.

7.6.4.4 Folsom Dam Raise Project Proposed Stability Modifications

Although discrepancies exist amongst the agencies involved in the project regarding stability of the main concrete dam monoliths under hydrologic conditions, the general consensus is modifications must be completed to address either seismic or hydrologic instabilities. However, it should be noted that modifications developed to address sliding instability of the main concrete dam monoliths due to seismic loading are anticipated to address any uncertainties associated with potential displacement due to static and/or hydrologic loadings.

7.6.5 Auxiliary Spillway

The existing condition for the Folsom Dam Raise Project assumes that an auxiliary spillway would be constructed. The preliminary design for the proposed auxiliary spillway was site-adapted from State of California DWR's Oroville Dam flood control structure (DWR, 1965) primarily to provide enhanced flood control, hydrologic risk reduction, and safe passage of the PMF. Site adaptations from the existing structure at Oroville Dam include using 59-foot wide independent monoliths, each containing two STGs similar in size to those at Oroville. A variety of gate sizes and invert elevations were investigated with the three-monolith, six-gate configuration at invert elevation 368.0, approximately 10 feet lower than the equivalent Oroville spillway, providing the best project function at least cost. A description of the control structure, stability analyses, and plan and profiles are provided in the PASS II Report, Chapter 6, Structural Design (Corps, Reclamation, SAFCA, DWR, State Reclamation Board, 2006).

7.6.6 Auxiliary Spillway Tainter Gates and Operating System

The auxiliary spillway would feature six STGs similar in design to the gate used at Oroville Dam, which features eight STGs 33 feet tall and 17 feet 7 inches wide. The proposed Folsom Dam tainter gates would be 33 feet tall and up to 23 feet wide. The STGs would be operated by means of hydraulic cylinders, similar to those used at Winfield Dam, Corps' Huntington District, as opposed to a traditional gear driven chain or cable type hoist mechanism, as is currently used at Folsom and Oroville Dams. The hydraulic cylinders would be mounted above the gates and will pivot about their center point. The cylinders would have a bore of approximately 18 inches, a rod diameter of approximately 7 inches, a stroke of approximately 29.5 feet, and would take approximately 20 minutes to open.

Another concept that was investigated was the use of bottom mounted cylinders, similar to those used at Table Rock Dam, Corps Little Rock District. This approach was rejected when it was determined that it would necessitate an additional 3-4 feet in pier thickness (resulting in an unacceptable 15-20 additional feet of spillway width).

Each of the 12 cylinders would have its own dedicated hydraulic power unit (HPU). The HPUs would feature a 40 horsepower (hp) motor, a 25-gallon-per-minute (gpm) pump, and a 300-gallon reservoir. The cylinders will be oversized so that only one will be required to operate a gate. The gate design will feature a roller assembly which will prevent binding of the gate in the event of a hydraulic cylinder failure.

An additional benefit of the hydraulic cylinder hoist system will be its ability to provide sufficient damping to overcome any flow induced vibration, which is considered to be a potential problem on tainter gates which operate under such high heads. As an added precaution, a computer model study will be performed Dr. Noriaki Ishii of the Osaka Electro-Communication University to check the dynamic stability of the design.

Similar to the main dam tainter gates, consideration will be given to the use of self-lubricated composite trunnion bearings. Regardless of which type of trunnion materials are used, an auto lube system will be provided. It is anticipated that the size of the trunnions will be somewhat smaller diameter than that used on the existing tainter gates. The forensic report of the tainter gate failure on the main dam in 1995 determined that the large diameter of the existing trunnions was a contributing factor to the gate failure. The trunnion binding forces were transferred to the end frame. Most tainter gates at other facilities utilize much smaller trunnions than were used at Folsom. A notable example is Theodore Roosevelt Dam, which actually had a trunnion bearing seize and rotate in place rather than fail the end frame.

At the present time, it is intended, for security reasons, that each tainter gate would be protected by a dedicated bulkhead gate weighing approximately 40 tons. A traditional gear driven cable hoist mechanism, similar to the existing chain hoist mechanisms used on the existing tainter gates, will be used for raising the bulkhead gates. The hoist will consist of a 7 1/2 hp, 1150 revolutions per minute (rpm) motor which will connect to a 50:1 worm gear speed reducer (Falk Model 1700 Omnibox) by means of a 1 inch Wrapflex elastomer coupling. The twin 2.5-inch output shafts of the Omnibox speed reducer will each connect to a 105:1 parallel shaft triple reduction speed reducer (Falk Model 465) by means of a gear

coupling and a 6 to 8 foot long connecting shaft. The 7 ½-inch output shafts of the parallel shaft speed reducers will each connect to a cable drum by means of a 7 ½-inch gear coupling. Each cable drum will also be supported by a 4-inch diameter pillow block bearing. The cable drums will be 14-inch diameter (for a lifting speed of approximately 0.9 feet per minute) and will each have two 1-inch cables. The system is designed so that each of the two cable pairs can support 60 percent (approximately 80,000 pounds) of the gate weight. The lifting speed is predicated on the fact that the bulkheads would be operated on a seasonal basis rather than each time the tainter gates are operated. The hoist assembly will also feature an electric solenoid operated braking device, as well as an automated positive dogging mechanism, which will be used to hold the bulkheads in the open position.

All mechanical systems on the new spillway will incorporate redundant features. The hoist mechanism for the new spillway tainter gates will utilize two hydraulic cylinders per gate. Either of the cylinders will be capable of operating the gate by itself in the event that the other cylinder fails. A dedicated HPU will be provided for each cylinder. Adjacent HPUs would be interconnected for redundancy. In addition, a portable HPU unit will be provided as a backup. The hoist mechanisms for the bulkhead gates will include a total of seven motors for the six gates. The system will be designed so that each gate hoist can be coupled to one of two motors (similar to the system used for the tainter gate hoists at the existing spillway).

The proposed auxiliary spillway design will utilize permanent hoist mechanisms for operating the tainter gates and bulkhead gates, and a mobile crane could be used to perform routine maintenance. Therefore, no permanent crane would be necessary for this design. However, as previously noted, a less costly alternative may be investigated that would necessitate the addition of a permanent crane.

The O&M requirements will consist of an annual inspection of the STG hydraulic cylinders and operating system, trunnion assemblies, lubrication system, seals, and the bulkhead gate hoist system and seals. Major rehabilitation of the STGs and bulkhead gates will take place on a 25 year cycle.

7.7 ELECTRICAL DESIGN

This section addresses electrical changes at Folsom Dam associated with a dam raise of 3.5 feet and the associated upgrading of the three existing emergency tainter gates. Topics addressed include electrical power distribution, backup power, and redundant systems.

7.7.1 Electrical Power Distribution

Existing power distribution equipment and cables, from substation 5-kilovolt (kV) feeders to the existing utilization equipment are still functional and would be reused. This project cannot financially justify replacing existing electrical systems beyond what is necessary to support the raise effort. Anything beyond this would be considered O&M work and hence non-justifiable.

7.7.1.1 Existing Electrical Power Distribution

Folsom Dam was completed in 1956. Some of the existing power distribution system dates from the early 1950s, and some date from an electrical upgrade in 1972. The capacity of the existing 480-volt substation is adequate for supplying electrical loads to the current dam with three modified tainter gates.

New controls and a fiber-optic-connected distributed control system were installed in 1999 for remote control of the spillway and river outlet slide gates. The system is connected to the Central Valley Automated Control System (CVACS), which is operated by the Reclamation CCAO in Sacramento. Equipment installed for this project would be connected to CVACS for continued monitoring and control.

7.7.1.2 New Power Distribution System

The three upgraded emergency tainter gates will be served via motors that are the same size or one size higher than the existing 5 hp motors. The branch circuits and overcurrent protection serving these three motors will be upgraded as required, and will be re-fed from the existing motor control center (MCC) at level 6 of the dam. The additional load, if any, will be on the order of 2.7 kilovolt-ampere (kVA) for one gate being opened, which is a negligible increase for the overall dam's power distribution system

7.7.2 Backup Electrical Power

Backup electrical power would be provided from the existing emergency generator Building on the Folsom Facility site.

7.7.2.1 Emergency Electrical Power System

The 480-volt emergency power system is designed in accordance with National Fire Protection Association (NFPA) 110, for a Level 1 system. It has enough capacity to supply emergency power for the entire dam if ever connected to do so (and clearly not within the scope of this project). The system includes two 500-kilowatt (kW) (625 kVA), generators, either of which can start sequentially and run the minimum coincident demand load. These generators would provide reliable emergency power even when one unit is out of service for maintenance or repair, or because of failure. Combined, the two units could provide emergency power for the entire dam load at approximately 76 percent of their rated capacity. These generators could enable indefinite full operation during a catastrophic failure of the primary system, such as might be caused by an earthquake or sabotage.

7.7.2.2 Emergency Electrical Power Distribution

Emergency power from the generator building would be distributed through the existing emergency distribution system to "re-feed" the three emergency tainter gates. Another option would be to add in a transfer switch at level 6 of the dam, just ahead of the existing MCC, and then bring in an emergency feeder from the generator building via one of the existing conduits installed up to the dam at level 3 under the generator building contract.

This emergency feeder conduit would be then extended from level 3 to the level 6 transfer switch. This would enable all eight main dam tainter gates to have simultaneous back-up emergency power from the generator building.

7.7.2.3 Uninterruptible Power Supplies

All new systems that could not "live" through the 10-second delay before emergency power comes on would be fitted with battery-powered uninterruptible power supplies (UPS).

7.8 CONSTRUCTION CONSIDERATIONS

This section summarizes the anticipated approach to project construction of the 3.5-foot crest-wall raise and the replacement of the three emergency tainter gates, including means and methods and proposed scheduling.

7.8.1 Phased Construction and Work Packages

A phased construction approach has been identified for the 3.5-foot crest-wall raise based on completion of the dam safety static and seismic modifications to the dikes, both wing dams and MIAD, and on the location of the individual sites relative to each other. A phased construction approach allows for developing and implementing specific "work packages." For purposes of this report, a work package is considered to be a grouping of work elements defined either by an area or a specific program feature. Designated work packages should be compatible with future contracting/procurement efforts, and should represent major contracts as the program is currently envisioned. Work packages would be sized to take advantage of the strengths of both large and small disadvantaged businesses. Work packages would be coordinated with other ongoing projects at the Folsom Facility to reduce contractor conflicts and maximize available funding. The replacement of the three emergency tainter gates as part of the Folsom Dam Raise Project will be a separate work package from the crest-wall work packages. Other major non-integrated proposed construction features include the Folsom Dam Bridge and Road Project, City of Folsom Redundant Pipeline, downstream foundation treatment at MIAD, and various interim construction measures currently underway by the Corps and Reclamation.

Work package development would continue as the crest-wall raise and the emergency tainter gate replacement are brought forward through the design stage. For the purposes of this report, the following work packages have been identified, and are consistent with cost estimate development:

- **Work Package 1 – Crest-Wall Excavation and Construction at the Right Wing Dam and Dikes 4, 5, and 6.** This work package includes the excavation of the crest-wall foundation and the construction of the crest-walls at right wing dam and Dikes 4, 5, and 6. Construction would be phased to begin after any dam safety modifications are complete on the right wing dam and the dikes. Excavated materials will be disposed of off-site. It would not be practical to reconstitute these materials for reuse. Instead, suitably graded materials will be imported for backfill since several different

types of material are needed at the crest. Concrete will be supplied by commercial sources. Any embankment raises at new or existing access roads across the top of a dike would be included in the work package.

- **Work Package 2 – Crest-Wall Excavation and Construction at the Left Wing Dam and Dikes 7, 8 and MIAD.** This work package includes the excavation of the crest-wall foundation and the construction of the crest-walls at the left wing dam, Dikes 7 and 8, and MIAD. Construction would be phased to begin after any dam safety modifications are complete on the wing dam, the dikes and MIAD. Excavated materials will be disposed of off-site. It would not be practical to reconstitute these materials for reuse. Instead, suitably graded materials will be imported for backfill since several different types of material are needed at the crest. Concrete will be supplied by commercial sources. Any embankment raises at new or existing access roads across the top of a dike would be included in the work package.
- **Work Package 3 – Crest-Wall Excavation and Construction at Dikes 1, 2, and 3.** This work package includes the excavation of the crest-wall foundation and the construction of the crest-walls at the Dikes 1, 2 and 3. Construction would be phased to begin after any dam safety modifications are complete on the dikes. Excavated materials will be disposed of off-site. It would not be practical to reconstitute these materials for reuse. Instead, suitably graded materials will be imported for backfill since several different types of material are needed at the crest. Concrete will be supplied by commercial sources. Any embankment raises at new or existing access roads across the top of a dike would be included in the work package.
- **Work Package 4 – Emergency Tainter Gate Replacement.** This work package includes the removal and replacement of the three emergency tainter gates for the purpose of increasing the height of the tainter gates and relocating the trunnions above the free flow nappe for all possible reservoir water surface elevations. In order to do so, the existing spillway piers at the emergency spillway bays would be extended downstream. All gate operating equipment would be relocated at the bridge deck elevation. Pier extensions would be constructed prior to gate construction without interference with operations or delay to gate construction. Gate sections would be prefabricated either in a construction shop at the dam or at the gate manufacturer's plant. Construction in the gate bays would be limited to installation of stop logs, tainter gate demolition and assemblage of the prefabricated sections.

7.8.2 Bid-Ability

"Bid-ability" is the ease with which contract documents can be understood, bid, administered, and executed. To facilitate bid-ability for this project, the contractor will need to be able to accurately verify quantities for each construction line from the plans and specifications to propose a reliable bid. If plans and specifications are incomplete or vague, the overall project risk is transferred to the contractor. Often this translates into the contractor not being able to adequately estimate the project needs, which at minimum, results in bids being significantly elevated to cover the uncertainties. When complete and accurate information is included in plans and specifications, and the contractor is able to quantify or

place boundaries on this risk, bid-ability is greatly improved. Review of the construction documents during the design phases with emphasis on incorporating bid-ability is essential.

7.8.3 Constructibility and Construction Risk Overview

"Constructibility" can generally be described as the extent to which the project design provides for ease of construction and still meets the overall requirements of the completed facility. Establishing constructibility begins with the initial planning phase and extends into the detailed design, procurement, and field construction phases. A critical factor is determining if means and methods of construction can be employed to allow the project to be completed using industry standard practices, or innovative construction techniques that have been used successfully by the reviewer or company bidding the project.

In determining constructibility, a construction risk overview would be conducted. This is a review to determine if the major risks associated with the project can be identified and quantified. If the reviewer is able to accurately assess the risks primarily from a review of the available contract documentation, the project is determined to be both constructible and the risks reasonable. As with bid-ability, if this cannot be completed, realistic constructibility or construction risk assumptions would not be achieved. Proposed risk reduction considerations include discussions with contractors during the design phase, limiting the means and methods in plans and specification documentation, adequate construction funding, using local and regional cost indices to track as-bid or as-constructed prices, using an equitable price adjustment (EPA) clause in the contract, and accurate unit pricing.

On the basis of a preliminary risk overview by the design team, it is believed that one potential risk issue identified that may affect constructibility is the post-9/11 security requirements that would be required. If requirements are stringent to the point that construction workers' access to the site is greatly restricted, the ability to accurately assess constructibility is limited, resulting in a potentially large increase in cost and time for completing the work.

7.8.4 Construction Means and Methods

Construction means and methods primarily refer to construction equipment, operations, practices, procedures, and related activities. Below is a general description of means and methods that have been initially identified by the team. It should be noted, however, that the means and methods provided below are only one set of possibilities for achieving the desired results. Construction documents should not limit bidders from using their own means and methods, and taking advantage of resources within their respective companies, provided those means and methods reflect the requirements of the plans and specification documentation.

This discussion of means and methods below is organized by major work item, not by work package, because many of the work packages are assumed to employ similar means and methods.

7.8.4.1 Crest-Wall Excavation and Material Stockpiling

The crest-wall excavation would be accomplished by using standard excavation equipment, such as backhoes, front end loaders and dump trucks. Only equipment narrow enough to safely navigate on the confined crest of the dikes would be involved. The excavated material would be stockpiled near each site for later use as backfill.

7.8.4.2 Access and Haul Roads

Public access would be maintained to all park facilities, either via existing park roads and trails or temporary relocated roads. Public access would be restricted from the construction areas and haul roads.

Depending on site conditions, haul roads may need to be developed. More likely, haul roads constructed for the dam safety work packages that precede the crest-wall construction, would continue to be utilized. Upon completion of all construction, any haul roads could be re-graded and the area re-seeded. At this time, there is no consideration being given to using the main concrete dam as an access or haul road. The crest-wall construction has been structured such that no single work package includes work on both sides of the main dam.

7.8.4.3 Construction Field Office and Laydown Areas

Construction field offices and laydown areas would be located as near as possible to the specific project site.

7.8.4.4 Concrete

Commercial concrete sources would be used for all crest-wall concrete placements.

7.8.5 Construction Schedule

A preliminary schedule for the Folsom Dam Raise Project is presented in **Plate 7-4** and is presented by work package. Some non-raise alternative construction projects, such as the Folsom Dam Bridge and Road construction, are not shown. However, Reclamation construction projects for static and seismic safety that involves the dams and dikes are shown as they are predecessor activities to the crest-wall raise. The Folsom Dam Raise Project work packages are grouped similar to the dam safety work packages to allow for crest-wall construction to begin soon after the dam safety modifications have been implemented. The construction cost estimate is based on this preliminary schedule and was used to derive escalation allowances in determining the mid-point of construction for each work package.

7.8.6 Contracting and Procurement

As stated previously, the work packages described above are preliminary. As the crest-wall design and schedule progresses, refinement of these work packages likely would be required because of various issues, including availability of funding. Minor changes to

work packages should not have a significant impact to the overall program cost at this stage of estimate if the overall duration of the program schedule does not change. However, the impact to thc cost estimate should be reviewed for any significant changes to work packages development and major scheduling assumptions.

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CHAPTER 8.0
ADDITIONAL FOLSOM RAISE PROJECT FEATURES

The primary objectives of the Folsom Dam Raise Project are 1) flood damage reduction, 2) environmental restoration, and 3) construction of a permanent bridge downstream of the dam. Under the original authorized plan, the main concrete dam, the two wing dams, MIAD, and the eight dikes would all be raised. The L.L. Anderson Dam spillway at the upstream French Meadows Reservoir would be modified to allow safe passage of the PMF. Engineering details of the dam raise activities are included in **Chapter 7** of this report. This chapter addresses additional project features including a change in status of modifications to L.L. Anderson Dam, construction of Folsom Bridge, and ecosystem restoration and habitat improvement along the American River.

8.1 L.L. ANDERSON DAM SPILLWAY

L.L. Anderson Dam is on the Middle Fork of the American River at French Meadows Reservoir. It is primarily a water supply facility owned by the Placer County Water Agency (PCWA). In the event of the PMF in the American River watershed, the dam would be unable to contain the extreme flows and could fail, sending additional uncontrolled flood flows into Folsom Reservoir.

To address this issue, plans called for enlarging the spillway and making other modifications to L.L. Anderson Dam, so that it can contain the PMF and thereby reduce potential flood flows into Folsom Reservoir. Coordinating the flood control improvements to these two dams is a significant part of the watershed approach the Corps and its partners are taking to reduce Sacramento's flood risk.

Recently, an agreement was reached between the Federal Energy Regulatory Commission and PCWA, and the responsibility for repairs to the dam related to a PMF. With this agreement and concurrence from the Corps, L.L. Anderson Dam will be considered completed and not part of this project by the Corps and Reclamation. Documentation will be included in the PAC report to support this change.

8.2 FOLSOM BRIDGE

The project authorized in 2004 differs from the project recommended in the *2002 Long-Term Study* in that Congress approved construction of a permanent bridge rather than a temporary bridge. A permanent bridge would mitigate for the closure of Folsom Dam Road during construction, while also providing greater security for the dam. The September 2006 *Final Post Authorization Decision Document/EIS-EIR, American River Watershed Project, Folsom Dam Raise, Folsom Bridge* (Corps, 2006) documents the change from a temporary to a permanent bridge feature. Folsom Bridge construction is anticipated to be complete by December 2008.

8.3 ECOSYSTEM RESTORATION

Ecosystem restoration is one of the stated purposes of the Folsom Dam Raise Project. The lower American River flood plain has significant natural ecosystem assets that have become increasingly valued in California. Ecosystem restoration features of the Folsom Dam Raise Project are construction of automated temperature shutters; planting of native riparian, upland, wetland, and woodland vegetation; terracing riverbanks; and controlling non-native plants at two sites totaling approximately 620 acres. Details of these plans are discussed below.

8.3.1 Automated Temperature Shutters

Construction of Folsom Dam restricted salmon and steelhead to the 23-mile lower American River. Recent biological monitoring indicates that water temperatures in the lower American River tend to exceed the temperatures necessary to sustain the existing salmon and steelhead populations. Maintenance of optimal water temperatures for spawning and rearing depends on the ability of dam operators to releases cold water to the lower American River at critical times of the year.

Currently, dam operators must adjust the temperature shutters manually to deliver cold water. This manual operation does not allow for the flexibility and timeliness needed to optimize the cold water releases. Automating the temperature shutters will reduce this problem by allowing for the greatest flexibility and responsiveness to the fishery needs year-round.

8.3.2 Woodlake Restoration Site

The Woodlake site consists of 283 acres of open space located near Cal Expo, north of the City of Sacramento on the north bank of the American River. The restoration plan includes controlling non-native plants; restoring the interaction between the river and the floodplain; seeding to reestablish native grasslands; and planting reconstructed areas with riparian forest oak woodland and oak savanna species.

8.3.3 Bushy Lake Restoration Site

The 337-acre Bushy Lake site is immediately upstream from the Woodlake site. The restoration plan includes constructing wetlands to improve habitat values. In addition, it calls for the control of non-native plants combined with the construction of side channels planted with wetland species and the installation of a pump-and-delivery system to carry water to Bushy Lake. Further ecosystem restoration includes the creation of a channel from the lake to convey high flows to the river; terracing steep banks; and planting riparian forest, oak woodland, and oak savanna species on newly graded site areas.

CHAPTER 9.0
CONCLUSIONS

The following conclusions are based on the results of the analyses contained in this EDR for the Folsom Dam Raise Project.

- The primary objectives of the Folsom Dam Raise Project are flood damage reduction, ecosystem restoration, and construction of a permanent bridge downstream of the dam.
- The project alternative presented in this EDR includes a 3.5-foot cast-in-place concrete crest-wall on each of the eight dikes, both wing dams, and MIAD; and replacement of the three emergency tainter gates on the main dam. The currently authorized Folsom Dam Project includes a 7-foot dam raise and replacement of the eight existing main dam tainter gates. Flood routings of the 3.5-foot raise and the emergency tainter gate replacement, along with the six-STG auxiliary spillway, were performed to demonstrate that the alternative would provide flood damage reduction computed at 1 chance in 185 in any given year. This alternative would provide the capability for Folsom Dam to pass a 240-year design flood event.
- The purpose of this project is to reduce flood damages. The 3.5-foot raise increases the flood damage reduction capability of Folsom Dam and Reservoir by increasing the flood storage capacity. Replacement of the three emergency tainter gates enhances the utilization of the existing flood storage capacity. The proposed change to the Folsom Dam Raise Project flood damage reduction objective or element, integrated with the six-STG auxiliary spillway (as a without-project condition assuming the new Folsom Modification project is in place), provides much of the functionality that would have been achieved by the authorized Folsom Dam Raise Project, and it passes the PMF. The combined elements are identified in the PAC report as the selected plan.
- Hydrologic dam safety (safely passing the PMF) is addressed by the JFP, as described in Appendix C, as the proposed project of the Folsom Modification Project authorization. The Folsom Dam Raise Project does not address existing dam safety static or seismic deficiencies associated with the dikes, wing dams, or MIAD. Those deficiencies would be corrected under separate actions initiated by Reclamation.
- The design and construction of the raise components could be completed within 5 years, although the projects would be coordinated with other construction at Folsom Dam that could delay a part of the construction as much as 4 years.
- The Raise Project is strongly supported by the local Partners, including State Reclamation Board and SAFCA. Formulation of the Raise Project has been closely coordinated with the Partners and Reclamation.
- Construction of the 3.5-foot wall raise and the replacement of the main dam emergency tainter gates would cause some environmental resource impacts; but

mitigation measures are proposed to reduce these potential impacts to less than significant levels where possible.

- The 3.5-foot wall raise and the replacement of the main dam emergency tainter gates are economically feasible. The first cost for these features of the Folsom Dam Raise Project is $115.3 million. The annual cost and the average annual flood control benefits are estimated at $5.6 million and $17.2 million, respectively.

CHAPTER 10
REFERENCES

CHAPTER 1

United States Army Corps of Engineers, (Corps). 1996. American River Watershed Project, California, Supplemental Information Report and Final Supplemental Environmental Impact Statement/Environmental Impact Report. Sacramento District. Sacramento, California, March.

Corps, 2002a, American River Watershed, California: Long Term Study, Final Supplemental Plan Formulation Report/Environmental Impact Statement/Environmental Impact Report, February.

Corps, 2002b. Chief of Engineers (CECW-PM) Letter, Subject: American River Watershed, California, Long-Term Study.

Corps, State of California Reclamation Board, 1991, American River Watershed Investigation, California: Feasibility Report. December.

Water Resources Development Act (WRDA 1996), (Public Law 104-303), Section 101 (a)(1), American River Watershed, California.

Water Resources Development Act of 1999 (WRDA 1999) (Public Law 106-53), Section 101 (a)(6), American and Sacramento Rivers, California.

CHAPTER 2

Corps, 2002a, American River Watershed, California: Long Term Study, Final Supplemental Plan Formulation Report/Environmental Impact Statement/Environmental Impact Report, February.

Corps, 2002b. Chief of Engineers (CECW-PM) Letter, Subject: American River Watershed, California, Long-Term Study.

Corps, Reclamation, SAFCA, DWR and State of California Reclamation Board, Project Alternative Solutions Study (PASS), Final Report, Folsom Dam Flood Control and Hydrologic Risk Reduction Alternatives, October 31, 2005.

Corps, Reclamation, SAFCA, DWR and State of California Reclamation Board, PASS II, Final Report, Folsom Dam Raise and Auxiliary Spillway Alternative, June 2006.

CHAPTER 3

Corps, 2003, Folsom Dam Modification Project, Final Limited Reevaluation Report (LRR) and Environmental Assessment/Initial Study, American River Watershed, California, November.

CHAPTER 4

Corps, Sacramento District. 1987. Water Control Manual, Folsom Dam and Lake, American River, California. Appendix VIII to Master Water Control Manual, Sacramento River Basin, California. December 1987.

Corps, 2001, "American River Basin, California, Folsom Dam and Lake Revised PMF Study, Hydrology Office Report," Sacramento District, U.S. Army Corps of Engineers, October 2001.

Corps, 2004, "American River, California, Rain Flood Flow Frequency Analysis, Office Report" Sacramento District, U.S. Army Corps of Engineers, August 2004.

National Weather Service [NWS], 1999, Hydrometeorological Report (HMR) No.59 (includes HMR No. 58), "Probable Maximum Precipitation for California," Hydrometeorological Branch of the National Weather Service, February 1999.

SAFCA & Reclamation, 2004, "Folsom Dam Interim Operations Plan (2004), American River, California," September 2004.

USGS, 1981, "Guidelines for Determining Flood Flow Frequency, Bulletin #17B," Interagency Advisory Committee on Water Data, U.S. Geological Survey, revised September 1981.

Water Resources Development Act of 1996 (WRDA 1996), Section 101(a)(1).

CHAPTER 5

Corps, State of California Reclamation Board, 2001, Final Environmental Assessment/Initial Study, American River Watershed, California, Folsom Dam Modification Project, August.

Reclamation, 2006, Folsom Dam Safety and Flood Damage Reduction Draft Environmental Impact Study / Environmental Impact Report (EIS/EIR), (Document prepared by CDM), December.

CHAPTER 6

Corps, 2002, American River Watershed, California: Long Term Study, Final Supplemental Plan Formulation Report/Environmental Impact Statement/Environmental Impact Report, February.

Bro, 2004, Large Scale Direct Shear Testing of Monolith 15 Concrete/Foundation Contact, August 18, 2005.

Bro, 2005, Skewed Brazilian Splitting Tensile Strength Testing to Correlate Tests with Orientation of Healed Fractures.

Corps, 1950, Sacramento District, "Definite Project Report - Soils Data and Embankment Design," Folsom Project, American River California, Part IV Dam and Appurtenances, Appendix C, Section I, 20 February 1950.

Corps, 1952, Foundation Report, Left Wing Dam, Folsom Project, American River, CA, November 1952

Corps, 1954, Roddy, Russell, Foundation Report, Part "D", Main Concrete Dam, Monoliths 7-23, Folsom Project, American River, California.

Corps, 1988, Waterways Experiment Station, "Seismic Stability Evaluation of Folsom Dam and Reservoir Project, Report 5, Seismic Stability Evaluation of Dike 5," November 1988, Geotechnical Laboratory, Technical Report GL-87-1

Corps, 1989, Waterways Experiment Station, "Seismic Stability Evaluation of Folsom Dam and Reservoir Project, Report 6, Right and Left Wing Dams," April 1989, Geotechnical Laboratory, Technical Report GL-87-14.

Corps, 1990, Waterways Experiment Station, "Seismic Stability Evaluation of Folsom Dam and Reservoir Project, Report 4, Mormon Island Auxiliary Dam - Phase I," December 1990, Geotechnical Laboratory, Technical Report GL-87-14.

Corps, 1992, Waterways Experiment Station, "Seismic Stability Evaluation of Folsom Dam and Reservoir Project, Report 8, Mormon Island Auxiliary Dam - Phase II," August 1992, Geotechnical Laboratory, Technical Report GL-87-14.

Corps, 2004, SPK, Folsom Dam Resident Office, Staging Areas, and Access Roads, Specification No. 1410, Final Geotechnical Report, July 2004.

Corps, 2005, WES, In Situ Geophysical Surveys for Estimation of Foundation Rock Properties, Concrete Gravity Section, Folsom Dam; ERDC/GSL TR-05-18, August 2005.

Fuller, 2003, Rock Testing (Shear, sliding friction, unconfined compressive strength of holes TH-G through TH-P from drain gallery drilling) for URS, March 2003.

Goodman, 2005, Shear Strength of a Foundation with Two-dimensional Roughness; Paper submitted for the 2005 American Rock Mechanics Association Conference.

Greene, 2002, Memo – Rock Properties for Folsom Dam MODS, September 2002.

Jennings, 1994, Fault Activity Map of California and Adjacent Areas with Locations and Ages of Recent Volcanic Eruptions. California Division of Mines and Geology, Geologic Data Map Series, Map No. 6.

Kiersch, 1950, Folsom Dam Regional Geology Map – 1 inch = 1 mile. January 1950.

Kiersch, 1955, Kiersch and Treasher, Investigation, Corps Aerial and Engineering Geology – Folsom Dam Project, Central CA, May 1955.

Kleinfelder, 2002, Geotechnical Investigation Report – Folsom Dam Subsurface Exploration, November 27, 2002.

Kleinfelder, 2006, Geologic and Geotechnical Evaluation, Downstream Rock Scour Potential, Folsom Dam, Folsom, CA, January 18, 2006.

Loyd, 1984, General Geology of the Auburn 15-minute Quadrangle, Division of Mines and Geology, Open File Report, 1984.

Quest, 2005a, Summary Report on Shear Strength of Monolith 15. Discusses results of the direct shear testing of the 6-inch concrete and bedrock samples, January 2005.

Quest, 2005b, Report of Bond Strength of the Rock/Concrete Interface of Monoliths 15-19, Folsom Dam – Observations, findings, and recommendations, October 2005.

Reclamation, 1999, Hydraulic Model Study of Folsom Dam Spillway Performance and Stilling Basin Abrasion, September 1999.

Reclamation, 2001, Technical Report of Construction – Folsom Dam Spillway Rehabilitation, February 8, 2001.

Reclamation, 2002, Tech Service Center, Concrete Coring – Laboratory Testing program, Folsom Dam Modifications, April 2002.

Reclamation, 2004, Static and Dynamic Foundation Analysis – 3D Block Analysis, August 2004.

Reclamation, 2005, Results of Direct Shear Tests, October 2005.

Reclamation, 2006, Auxiliary Spillway. Drilled 5 rock core holes, geologic drill hole logs and field notes, January 11, 2006.

URS, 2001a, Final Report, Folsom Dam Modifications, Evaluation of Rock Mass Properties. June (draft) – December (final), December 12, 2001.

URS, 2001b, Deterministic and Probabilistic Seismic Hazard Analysis for Folsom Dam, California, July 5, 2001.

URS, 2002, Supplemental Report, Deterministic and Probabilistic Seismic Hazard Analysis, Folsom Dam, July 5, 2002.

URS, 2003a, Tech Memo, Folsom Dam Foundation Characterization. August 8, 2003 Addressed differences in rock mass properties in the May 2003 Rock Testing report with those from the 1989 DSAP report, August 8, 2003.

URS, 2003b, Tech Memo, Rock Testing Report. Testing done by FMS&M, May 9, 2003.

URS, 2003c, Final Report, Supplemental Report II, Deterministic and Probabilistic Seismic Hazard Analysis, Folsom Dam, June 2003.

URS, 2004a, Memo, Evaluation of Potential for Surface Faulting at Folsom Dam. Mapping and field investigation by URS to estimate age of last movement of Channel Fault, February 2004.

URS, 2004b, Direct Shear Testing of Scale Models for Folsom Dam Monolith 15, July 2004.

Wagner, 1981, Geologic Map of the Sacramento Quadrangle, California – 1:250,000.

Woodward-Clyde, 1983, Investigation of Concrete and Foundation Conditions (Fault Study) at Folsom Dam. Drilled holes TH-A through TH-F in drain gallery, conducted Goodman Jack testing, calculated rock mass modulus, August 1983.

CHAPTER 7

Annandale, 1995, Scour Technology, McGraw-Hill Professional, November,

Corps, Sacramento District, American River Watershed, CA, Folsom Dam Modification Project, Gate Size Decision Technical Memorandum.

Corps, 1980, Hydraulic Design of Reservoir Outlet Works, Engineering Manual 1110-2-1602, 15 October 1980.

Corps, 1987, Hydraulic Design Criteria, November 1987.

Corps, Hydraulic Design of Spillways, Engineering Manual 1110-2-1603, 16 Jan 1990.

Corps, 1999, American River Watershed, California, Information Paper, August 1999.

Corps, 2001, Sacramento District, American River Watershed, CA, Folsom Dam Modification Project, Final Limited Reevaluation Report, August 2001.

Corps, 2002a, American River Watershed, California: Long Term Study, Final Plan Formulation Report and Supplemental Environmental Impact Statement/Environmental Impact Report, February.

Corps, 2002b, American River Long Term Study. Special Analysis Report. Sacramento District, November.

Corps, 2004, Design Documentation Report, Folsom Dam Outlet Works Modification Project, Volumes I and II, August.

DWR, 1965, Oroville Dam Flood Control Structure.

Erbiste, P.C., 1984, Estimating Gate Weights, Water Power and Dam Construction, May, 1984.

ESA Consultants, Inc., Folsom Dam Improvements, Mini Raise, Preliminary, 24 August 1994.

Federal Legislation, 1996, Common Features Project

FEMA, Publication 64, Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners

Goodman and Ghanaat, 2005, Report on Bond Strength of the Rock/Concrete Interface of Monoliths 15-19.

Kleinfelder, 2006, Geologic and geotechnical Evaluation, Downstream Rock Scour Potential, Folsom Dam, Folsom, CA.

Murray, Burns, and Kienlen (MBK) Consulting Civil Engineers, Folsom Dam Modification Report New Outlets Plan, February 1998.

Paterka, 1974, Hydraulic Design of Stilling Basins and Energy Dissipaters, Engineering Monograph No. 25. Bureau of Reclamation, Denver, Colorado.

Pinto, N.L. de S., and Neidert, S.H., Model Prototype Conformity in Aerated Spillway Flow, International Conference on Hydraulic Modeling of Civil Engineering Structures, BHRA, Coventry, 1982.

Reclamation, 1971, Hydraulic Model Studies of the Folsom Spillway-Outlet Junction, REC-ERC-71-12, Reclamation, 1971. (Isbester, T.J.)

Reclamation, 1980, Air-Water Flow in Hydraulic Structures, Engineering Monograph No. 41, December 1980.

Reclamation, 1990, Cavitation in Chutes and Spillways, Engineering Monograph No. 42, April 1990.

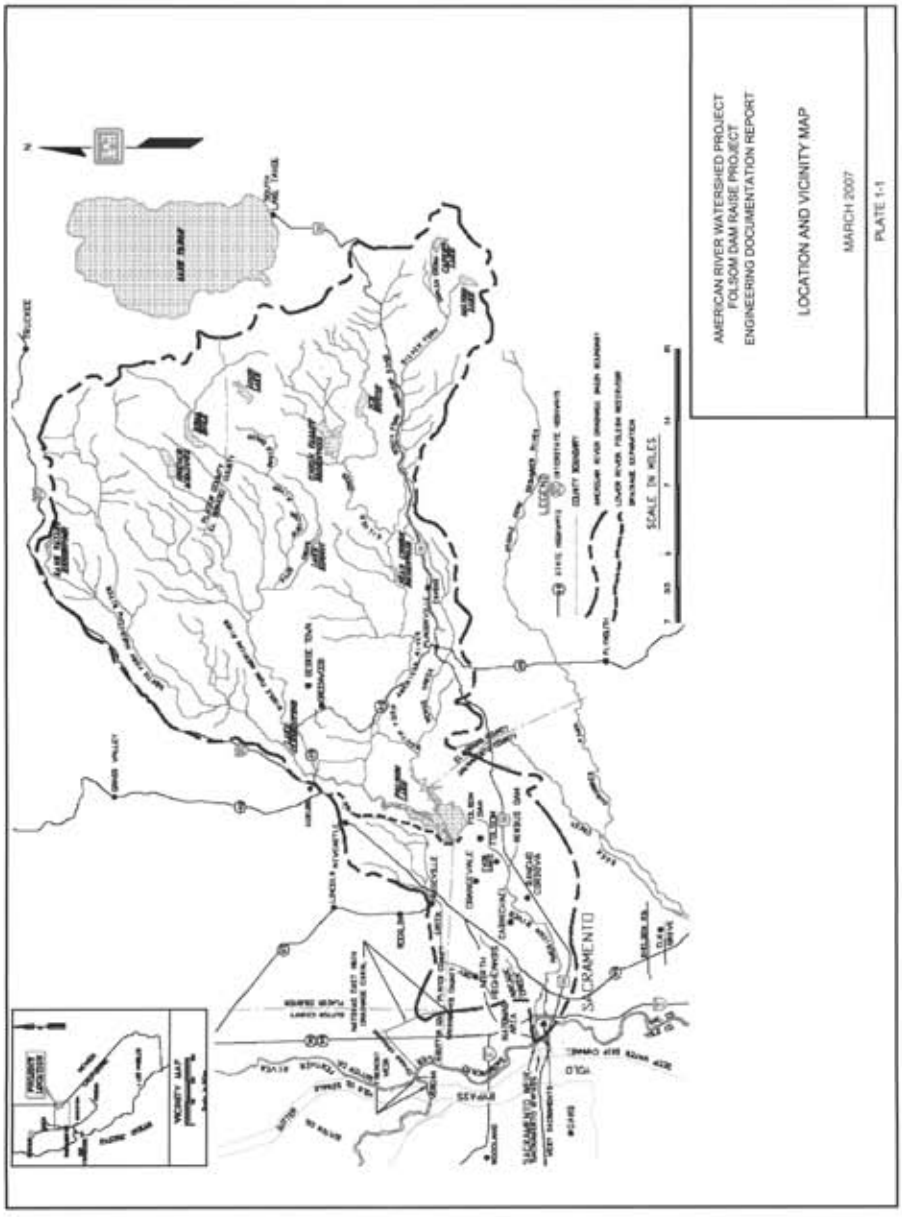
Reclamation, 1996, Folsom Dam Spillway Stilling Basin Rehabilitation, TM No. FOL-8130-REH-96-1, September 1996.

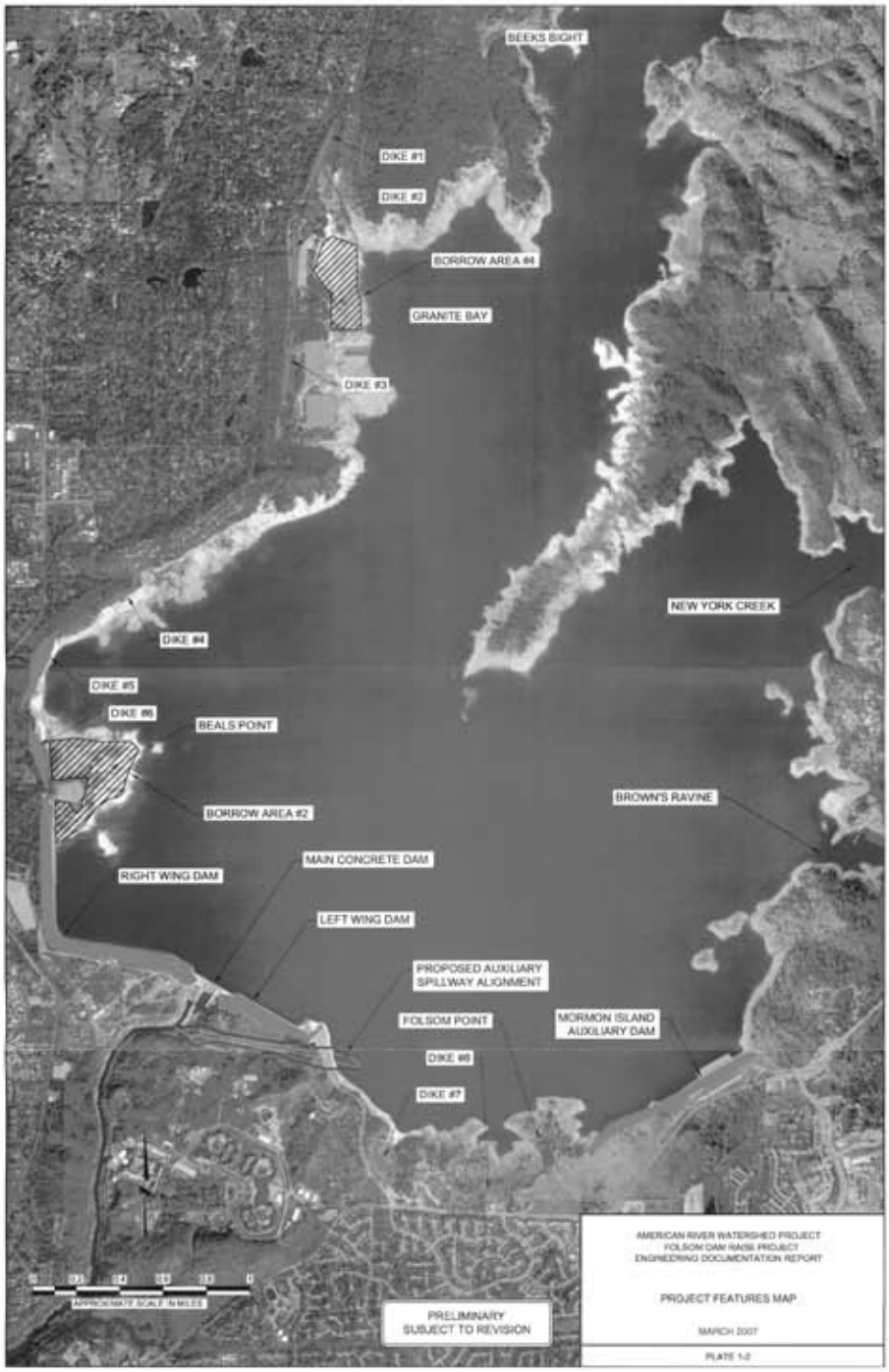
Reclamation, 1998, Aeration Enhancements at the Folsom Dam Outlet Works: Reducing Cavitation Damage Potential, April 1998.

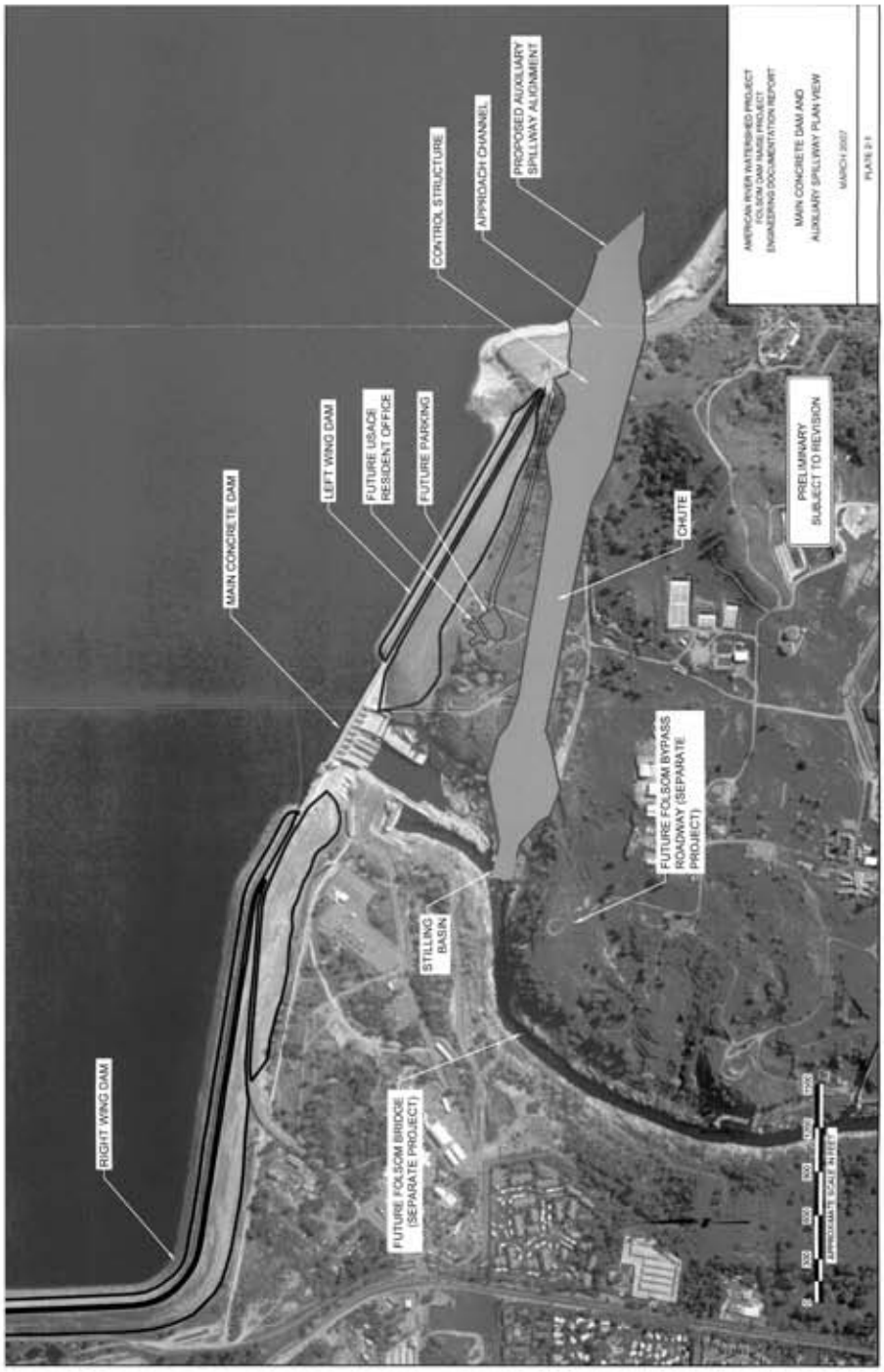
CHAPTER 8

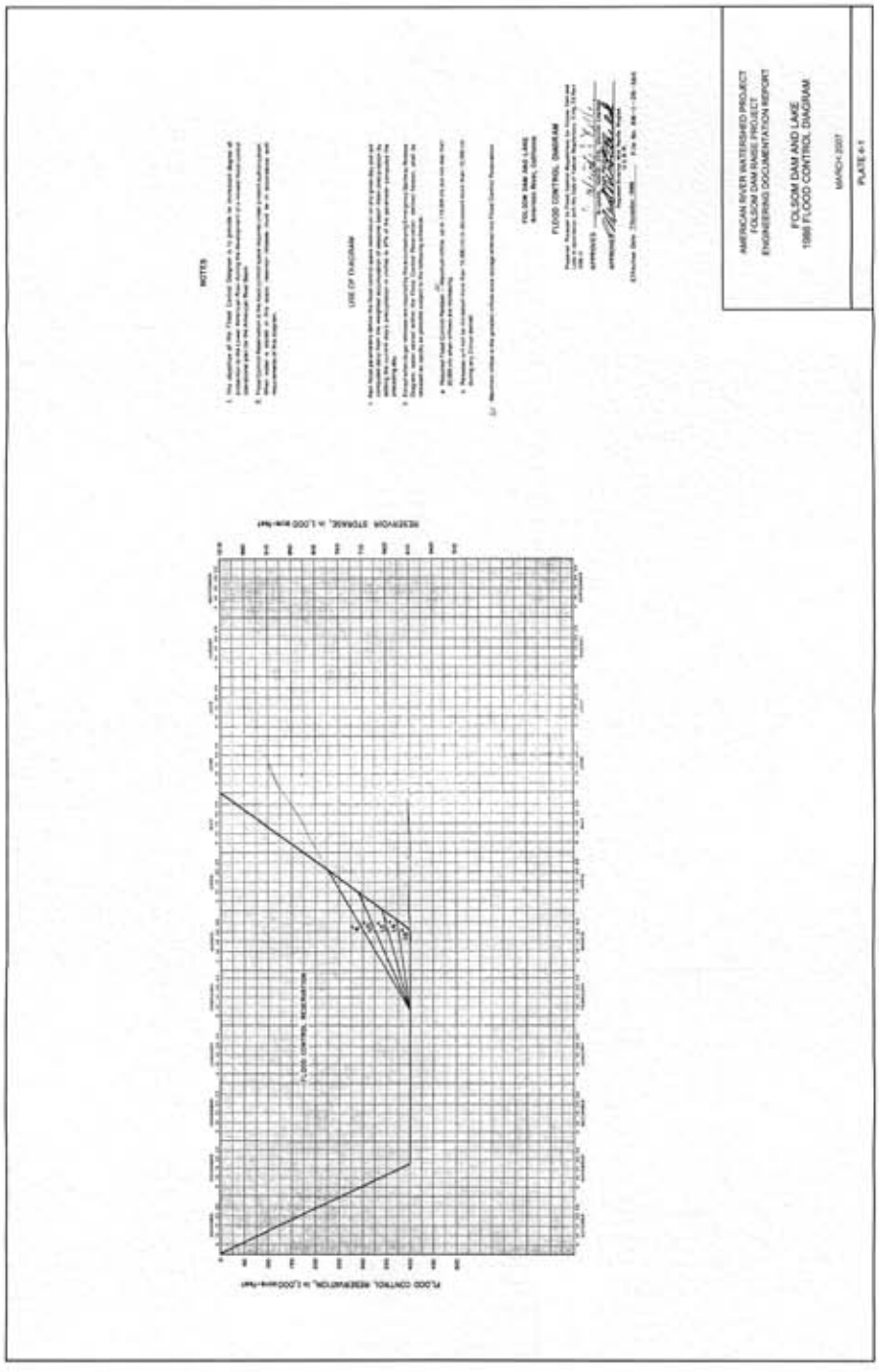
Corps, State of California Reclamation Board, 2001, Final Environmental Assessment/Initial Study, American River Watershed, California, Folsom Dam Modification Project, August.

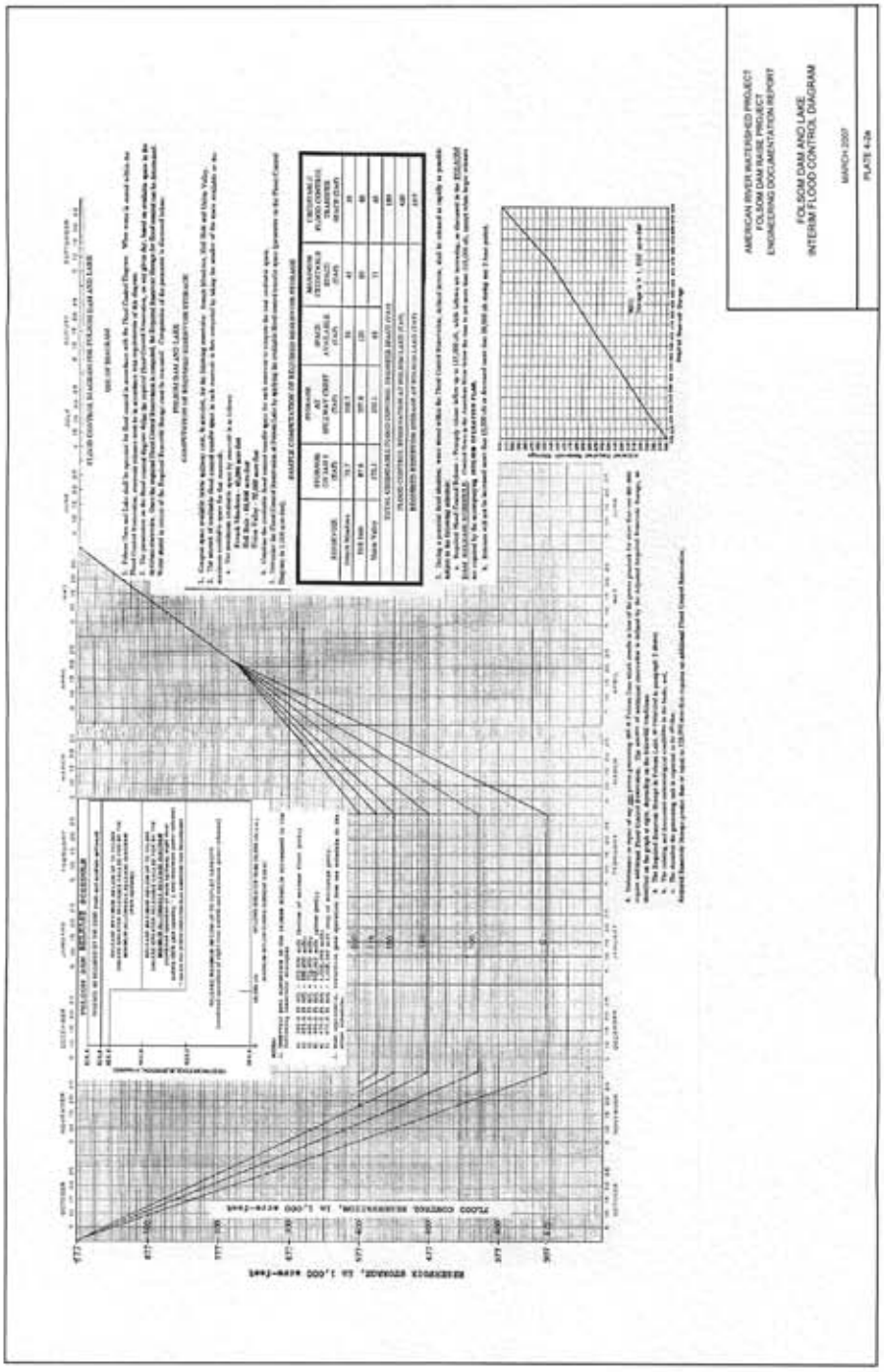
Corps, 2002, American River Watershed, California: Long Term Study, Final Supplemental Plan Formulation Report/Environmental Impact Statement/Environmental Impact Report, February.


AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
LOCATION AND VICINITY MAP
MARCH 2007
PLATE 1-1
SACRAMENTO
SCALE IN MILES
LEGEND


BEEKS BIGHT
DIKE #1
DIKE #2
BORROW AREA #4
GRANITE BAY
DIKE #3
NEW YORK CREEK
DIKE #4
DIKE #5
DIKE #6
BEALS POINT
BROWN'S RAVINE
BORROW AREA #2
MAIN CONCRETE DAM
RIGHT WING DAM
LEFT WING DAM
PROPOSED AUXILIARY SPILLWAY ALIGNMENT
FOLSOM POINT
MORMON ISLAND AUXILIARY DAM
DIKE #8
DIKE #7
APPROXIMATE SCALE IN MILES
PRELIMINARY SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
PROJECT FEATURES MAP
MARCH 2007
PLATE 1-2


RIGHT WING DAM
FUTURE FOLSOM BRIDGE (SEPARATE PROJECT)
STILLING BASIN
MAIN CONCRETE DAM
LEFT WING DAM
FUTURE USACE RESIDENT OFFICE
FUTURE PARKING
CONTROL STRUCTURE
APPROACH CHANNEL
PROPOSED AUXILIARY SPILLWAY ALIGNMENT
CHUTE
FUTURE FOLSOM BYPASS ROADWAY (SEPARATE PROJECT)
PRELIMINARY SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM MAINS PROJECT
ENGINEERING DOCUMENTATION REPORT
MAIN CONCRETE DAM AND
AUXILIARY SPILLWAY PLAN VIEW
MARCH 2007
PLATE D-1


AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
FOLSOM DAM AND LAKE
1986 FLOOD CONTROL DIAGRAM
MARCH 2007
PLATE E-1
NOTES
USE OF DIAGRAM
FOLSOM DAM AND LAKE
American River, California
FLOOD CONTROL DIAGRAM
APPROVED
FLOOD CONTROL RESERVATION
RESERVOIR STORAGE, in 1,000 acre-feet


AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
FOLSOM DAM AND LAKE
INTERIM FLOOD CONTROL DIAGRAM
MARCH 2007
PLATE 4-2a

Folsom Dam

Interim Operations Plan (2004)

What is the Plan

The plan is a modification to the Folsom Dam Flood Control Diagram that has been adopted by Sacramento Area Flood Control Agency (SAFCA) and the Bureau of Reclamation. The Corps has endorsed these flood operation rules. The modification consists of a set or rules that would accomplish the following:

A. Limit the outflow from Folsom Dam to a maximum of 145,000 cfs while the lake level is below elevation 470 feet. Outflows greater than 115,000 cfs would be limited to extreme flood events that occur very infrequently.

B. Utilize 100% gate openings for the eight 5-foot by 9-foot outlet gates in conjunction with the use of the service spillway, if required. This operation would be limited to extreme flood events that occur very infrequently.

Why is the Plan being implemented

The plan is necessary to provide an important increment of flood protection to areas downstream from Folsom Dam. These areas do not have protection from the FEMA Base Flood (1% Annual Exceedance Probability) without the implementation of the Interim Operating Plan.

How does the Plan work

The Interim Operation Plan is based on increasing the outlet capacity from the dam during the early stages of the flood and by limiting outflows above 115,000 cfs to the downstream channel capacity. Each feature of the plan is discussed below:

Limit Outflow to 145,000 cfs. The existing flood control rules call for a flood release from the dam of 160,000 cfs while the lake elevation is well below the normal full pool at elevation 466 feet. The current American River levee evaluations find that that 145,000 cfs can be safely carried by the levees for up to 36 hours. Therefore, the existing limit of 160,000 cfs is being modified to limit outflows to 145,000 cfs until the lake level increases to the maximum elevation that would not require the opening of the emergency spillway gates (elevation 470 feet). This modification reduces the frequency of flood discharges from the dam that exceed 145,000 cfs.

Allow Use of Maximum Outlet Capacity. The current operation plan limits the utilization of the outlet works gates to 60% open during periods when the spillway is also discharging water. This requirement has a detrimental effect on the ability of the dam to manage flood waters. The reason for the limit is that the potential for cavitation to damage the face of the dam is considered to be less if the gates are not fully opened. Cavitation has occurred in the past on the face of the spillway and is not considered a threat to the integrity of the dam if prompt maintenance actions to repair the damage are implemented. The Interim Plan allows the gates to be fully opened while the service spillway is in operation given a sufficiently large event. The gate operation allowed by the Interim Plan could potentially increase the cavitation damage to the spillway face. This is considered an acceptable risk and a plan has been developed whereby SAFCA will fund the work required to repair damage that might be sustained by the dam as a result of this operation. The increased outlet capacity that is achieved by this operation significantly improves the capability of the dam to discharge flood waters at controlled rates downstream from the dam. This capability is an important element in limiting the FEMA Base Flood to outflows of 145,000 cfs or less downstream from the dam.

Under What Conditions do the Provisions of the Plan Take Effect

The provisions of the plan are designed to be used very infrequently for short periods of time. For instance, none of the provisions would be activated for floods that have occurred in the last 100 years. It is estimated that in any given year there may be a 2% chance that the outlets will be operated at maximum gate opening while the spillway is operating. And a 1% chance that flows would exceed 115,000 cfs. The provisions that lead to implementation of the Interim Plan are the forecast of a very large flood in the next 24 hours (325,000 cfs peak inflow or 400,000 acre-feet inflow volume) or reservoir pool to exceed elevation 466 feet, either of which are extremely rare occurrence.

What operations are not affected by the Interim Plan

The Water Supply, Power, Recreation and Fishery operations are not changed by the Interim Plan.

What is changed by the Interim Plan?

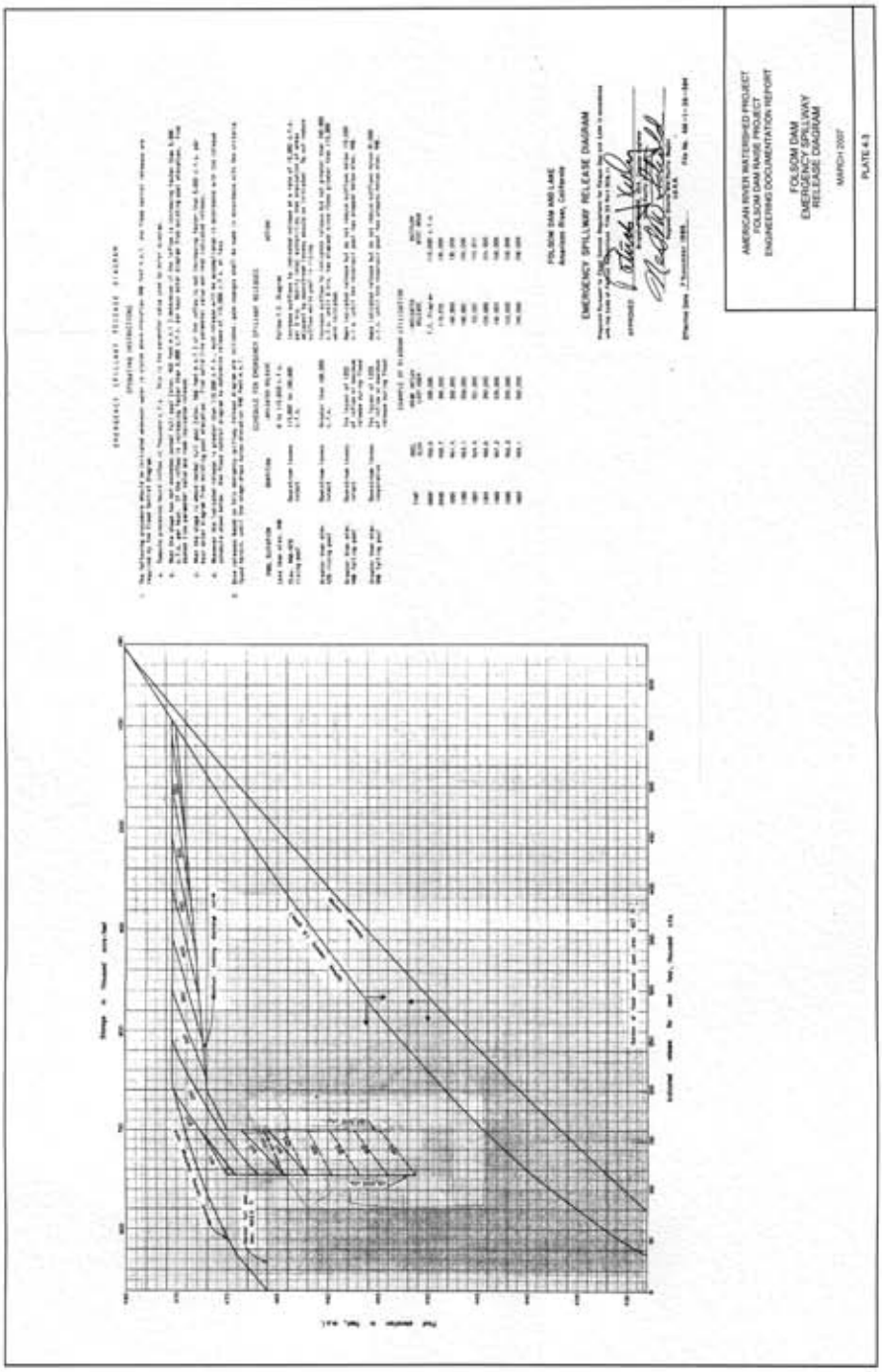
The maximum flood release from the dam is limited to 145,000 cfs instead of 160,000 cfs at the 1% flood level. The potential for cavitation damage to the face of the dam is slightly increased by maximum use of the existing outlets.

AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT

FOLSOM DAM
INTERIM OPERATIONS PLAN (2004)

MARCH 2007

PLATE 4-2b



AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT

FOLSOM DAM
EMERGENCY SPILLWAY
RELEASE DIAGRAM

MARCH 2007

PLATE 4-3

COMPARISON OF KEY OPERATIONAL DIFFERENCES BETWEEN PROJECTS

With-project comparisons made to existing SAFCA/Reclamation re-operation

Feature	Existing SAFCA/Reclamation Re-operation	Folsom Modification Project (six-STG)	Folsom Dam Raise Project (six-STG with raise)	Joint Federal Project
TOP OF DAM ELEVATION DAM RAISE INCREMENT	400.0 feet No Change	No Change	404.0 feet 407.5 feet 3.5 feet 7 feet	400.0 feet 404.0 feet 407.5 feet No Change 3.5 feet 7 feet
GROSS POOL ELEVATION	400.0 feet (977,000 acre-feet)	No Change	No Change	No Change
TOP SURCHARGE (PMF) POOL	479.4 feet (1,084,790 acre-feet)	477.5 feet	481.0 feet 484.5 feet	477.5 feet 481.0 feet
OBJECTIVE RELEASE				
Nominal	115,000 cfs	No Change	No Change	No Change
Emergency	160,000 cfs	No Change	No Change	No Change
SERVICE & EMERGENCY GATE CONFIGURATION	5-42 feet x 50 feet service gates 3-42 feet x 53 feet emergency gates[1]	No Change	5-42 feet x 66 feet service gates[2] 3-42 feet x 66 feet emergency gates[2]	TBD
OUTLET CONFIGURATION	4 Upper Tier 3-feet x 9-feet 4 Lower Tier 3-feet x 9-feet	No Change	No Change	No Change
OUTLET CAPACITY (with power) @ Elevation 418.5	24,800 cfs	No Change	No Change	No Change
AUXILIARY SPILLWAY CONFIGURATION	None	six-STG Sill elevation – 358 feet	six-STG Sill elevation – 358 feet[2]	four-STG to six-STG Sill elevation – 358 feet[2]
VARIABLE FLOOD CONTROL SPACE	400,000 – 670,000 acre-feet	400,000 – 600,000 acre-feet	400,000 – 600,000 acre-feet	400,000 – 600,000 acre-feet
RATE OF RELEASE CHANGE				
Increase Outflow ≤ 25 to/s Outflow ≥ 25 to/s Outflow ≥ 160 to/s Outflow ≥ 240 to/s	5,000 cfs/hour 7,500 cfs/hour Unlimited	No Change 15,000 cfs/hour 15,000 cfs/hour Unlimited	No Change 15,000 cfs/hour 15,000 cfs/hour Unlimited	No Change 15,000 cfs/hour Unlimited Unlimited
Decrease	5,000 cfs/hour	No Change	No Change	No Change
Aggressive Ramping 12-hour Forecast Window	145,000 cfs FEMA base flood 240 to/s < inflow < 360 to/s	Target 160,000 cfs 270 to/s < inflow < 370 to/s Target 145,000 cfs 250 to/s < inflow < 370 to/s Target 130,000 cfs 200 to/s < inflow < 360 to/s	Target 160,000 cfs 270 to/s < inflow < 370 to/s Target 145,000 cfs 250 to/s < inflow < 370 to/s Target 130,000 cfs 200 to/s < inflow < 360 to/s	Target 160,000 cfs 270 to/s < inflow < 370 to/s Target 145,000 cfs 250 to/s < inflow < 370 to/s Target 130,000 cfs 200 to/s < inflow < 360 to/s
CONDITIONS FOR LIMITATION				
Concurrent operation of Outlet Works and Spillway	66 percent Outlet Opening	60 percent Outlet Opening	60 percent Outlet Opening	66 percent Outlet Opening
Spillway Gate Operation	Controlled	Controlled	Controlled	Controlled
Mitigation to reduce impact to spawning gravels	None	60 percent of Inflow Rule Outflow = 60 percent of actual or forecasted Inflow (25 to/s < Inflow < 150 to/s) Dispense with rule if flood encroachment ≥ 20 percent	60 percent of Inflow Rule Outflow = 60 percent of actual or forecasted Inflow (25 to/s < Inflow < 150 to/s) Dispense with rule if flood encroachment ≥ 20 percent	60 percent of Inflow Rule Outflow = 60 percent of actual or forecasted Inflow (25 to/s < Inflow < 150 to/s) Dispense with rule if flood encroachment ≥ 20 percent
Vortices operation to prevent Formation	None	No Change	No Change	No Change
Spray operation to prevent impacts to powerhouse	None	No Change	No Change	No Change

Key:
@ - at
cfs - cubic feet per second
FEMA - Federal Emergency Management Agency
PMF - probable maximum flood
SAFCA - Sacramento Area Flood Control Agency
STG - submerged-tainter gate
TBD - to be determined
t/s - thousand cubic feet per second
w/o - without
< - less than
≥ - greater than or equal to

Notes:

[1] 7-foot dam raise is only associated with the four-STG configuration proposed as part of the Joint Federal Project with project condition.

[2] Utilization of emergency gates is limited to discharges greater than 240,000 cfs.

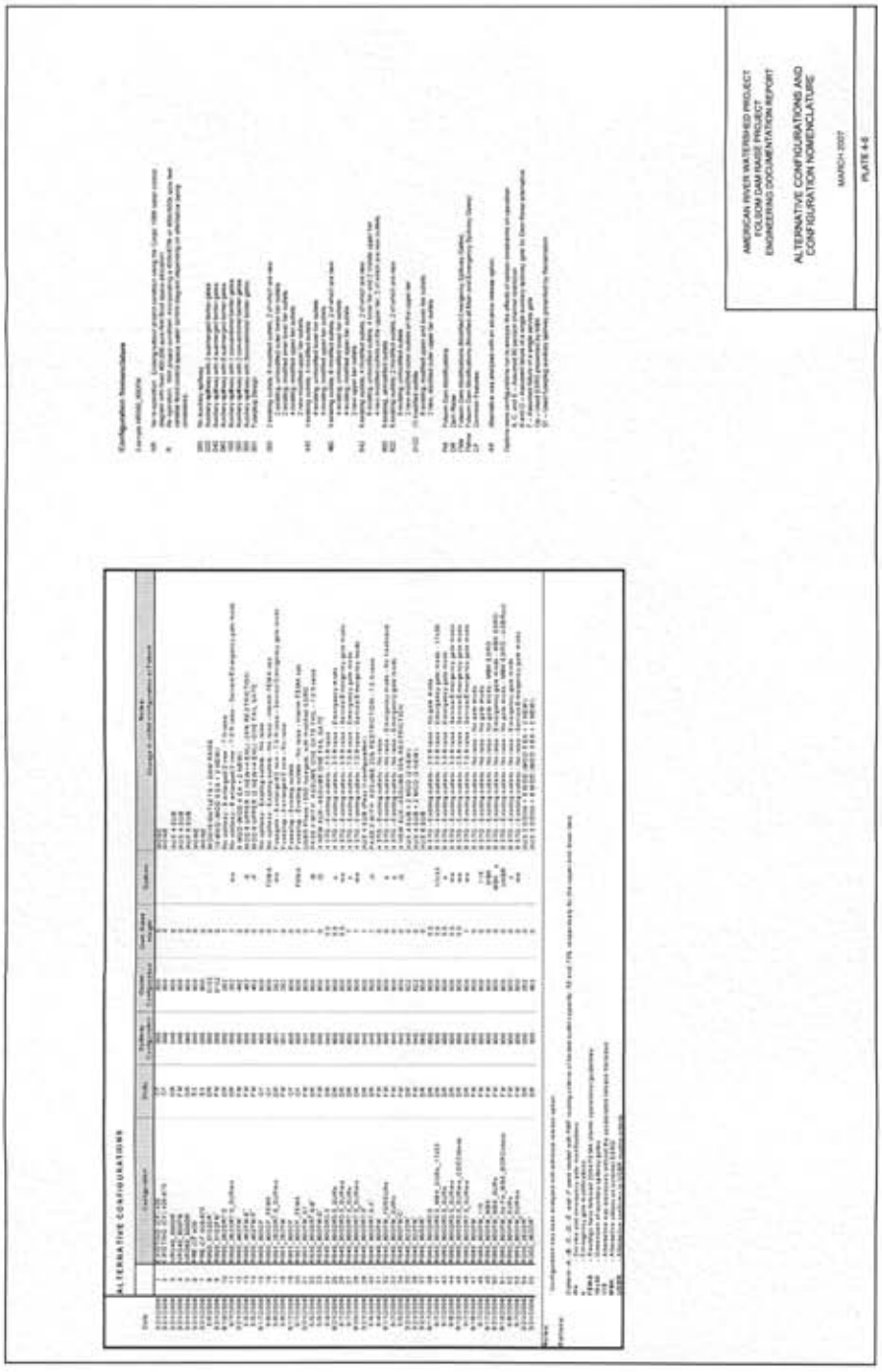
[3] Final configuration of the main spillway gates has not yet been determined, this analysis assumes a potential resizing of the gates to 42 feet x 66 feet exists only with a dam raise of 7 feet or higher.

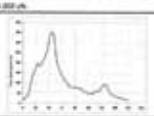
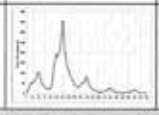
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT

COMPARISON OF KEY OPERATIONAL DIFFERENCES BETWEEN PROJECTS

MARCH 2007

PLATE 4-4


ALTERNATIVE CONFIGURATIONS
Configuration Nomenclature
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
ALTERNATIVE CONFIGURATIONS AND CONFIGURATION NOMENCLATURE
MARCH 2007
PLATE 4-5

Feature	1994 SIR	2001 LRR	2002 LRR	2006 FAC/EDR (proposed)
GROSS POOL ELEVATION	466.0 feet (977,000 acre-feet)	No Change	No Change	No Change
TOP SURCHARGE (PMF) POOL	474.0 feet (1,398,000 acre-feet)	477.4 feet (1,885,000 acre-feet)	No Change	To Be Determined
VARIABLE FLOOD CONTROL SPACE	400,000 – 600,000 acre-feet	No Change	No Change	No Change
OUTLET CONFIGURATION	Plan I 5 – 7 feet x 14 feet new Outlets Plan II 5 – 7 feet x 14 feet new Outlets 4 – 6 feet x 12 feet Enlarged Upper Tier Outlets 4 – 6 feet x 12 feet Enlarged Lower Tier Outlets	8 – 9.33 feet x 16.25 feet Enlarged Outlets	8 – 9.33 feet x 14 feet Enlarged Upper Tier 8 – 9.33 feet x 12 feet Enlarged Lower Tier	No Outlet Reconfiguration Proposed
OUTLET CAPACITY at Elevation 418	Plan I 67,300 cfs Plan II 73,938 cfs		115,938 cfs 99,700 cfs (Outlets 1 & 4 not enlarged)	24,900 cfs
HYDROLOGY				
Statistics 100-yr Peak 100-yr Max mean 3-Day Volume	1997 354,000 cfs 196,000 cfs	No Change	2004 360,700 cfs 188,970 cfs	No Change
Balanced Hydrograph Hypothetical PMF Shape			No Change	No Change
OBJECTIVE RELEASE				
Normal	115,000 cfs	No Change	No Change	No Change
Emergency	160,000 cfs	No Change	No Change	No Change
MAXIMUM RATE OF RELEASE CHANGE				
Increasing releases: Outflow ≤ 25,000 cfs Outflow ≤ 25,000 cfs Outflow ≥ 160,000 cfs Outflow ≥ 240,000 cfs	5,000 cfs/hour 15,000 cfs/hour Unlimited Unlimited	No Change	No Change	No Change
Decreasing releases: Outflow > 25,000 cfs Outflow ≤ 25,000 cfs	5,000 cfs/hour	No Change	No Change	No Change NMFS Decreasing Ramping Rates per 2002 Biological Opinion on CVP & SWP Operations
CONDITIONS FOR LIMITATION				
Concurrent operation of Outlet Works and Spillway	125 percent Outlet Opening	100 percent Outlet Opening	No Change (Except 60 percent gate opening restriction will imposed on any non-enlarged gates)	80 percent Outlet Opening
Spillway Gate Operation	Uncontrolled (free flow) Spill above 110,000 cfs	Uncontrolled (free flow) Spill above 15,800 cfs	Controlled Spill	No Change
Mitigation to reduce impact to spawning grounds	40 percent of Inflow Rule Outflow = 40 percent of actual or forecasted inflow (25 cfs < Inflow < 150 cfs) Objective with rule if flood encroachment ≥ 20percent	No Change	No Change	No Change
Vortices operation to prevent formation	None	None	Lower Tier Outlets Reduce gate openings by 20 percent if pool elevation ≤ 310 feet Upper Tier Outlets Reduce gate openings by 30 percent if the pool elevation ≤ 401 feet	None
AUXILIARY SPILLWAY	None	None	None	Options Six submerged roller gates discharge including at elevation 372 feet

KEY:

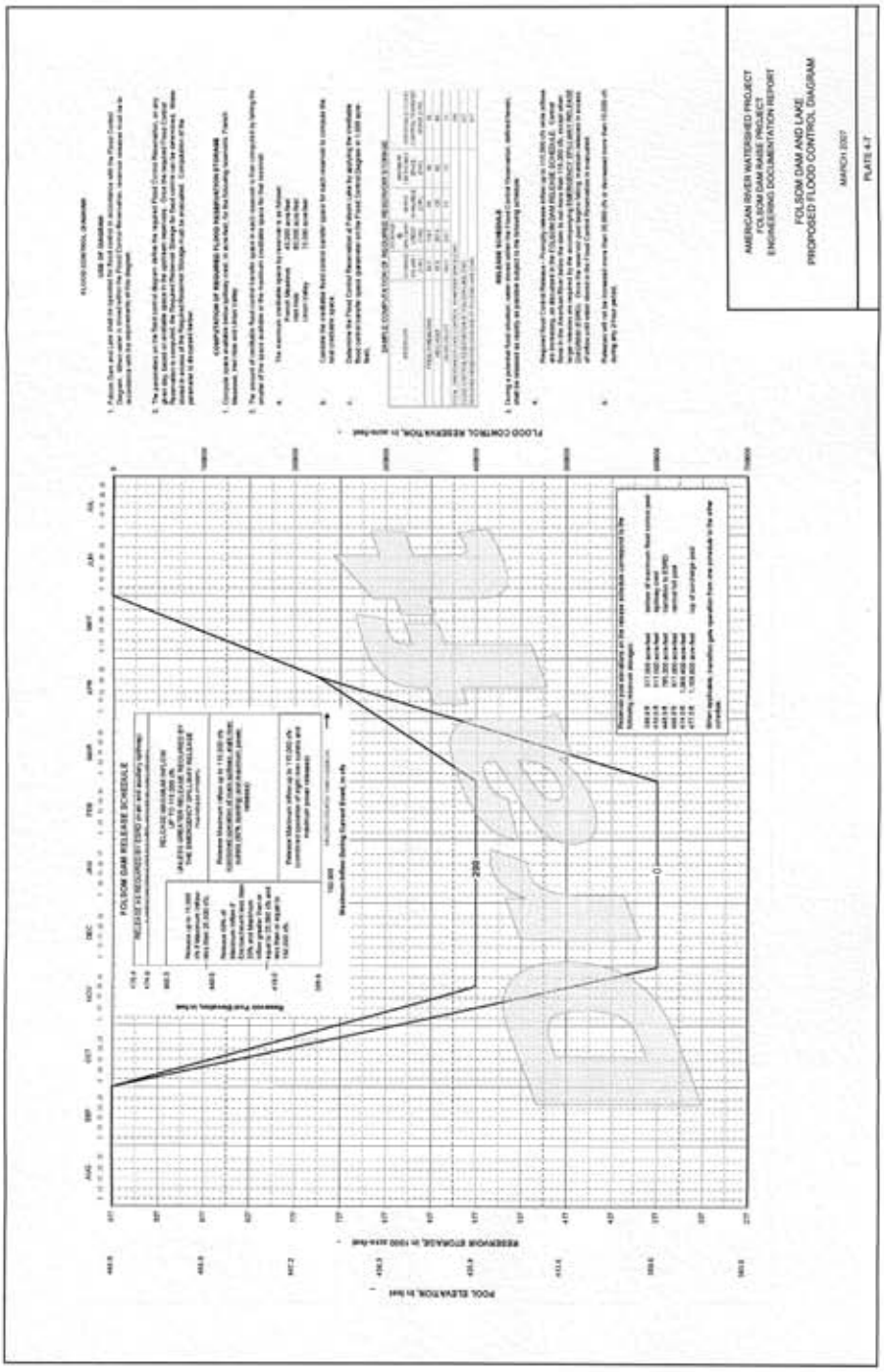
cfs – cubic feet per second
CVP – Central Valley Project
LRR – Limited Reevaluation Report
NMFS – National Marine Fisheries Service
PAC / EDR - Post Authorization Change/Engineering Documentation Report
PMF - probable maximum flood
SIR - Supplemental Information Report
STG-submerged-tainter-gate
SWP – State Water Project
tcfs – thousand cubic feet per second

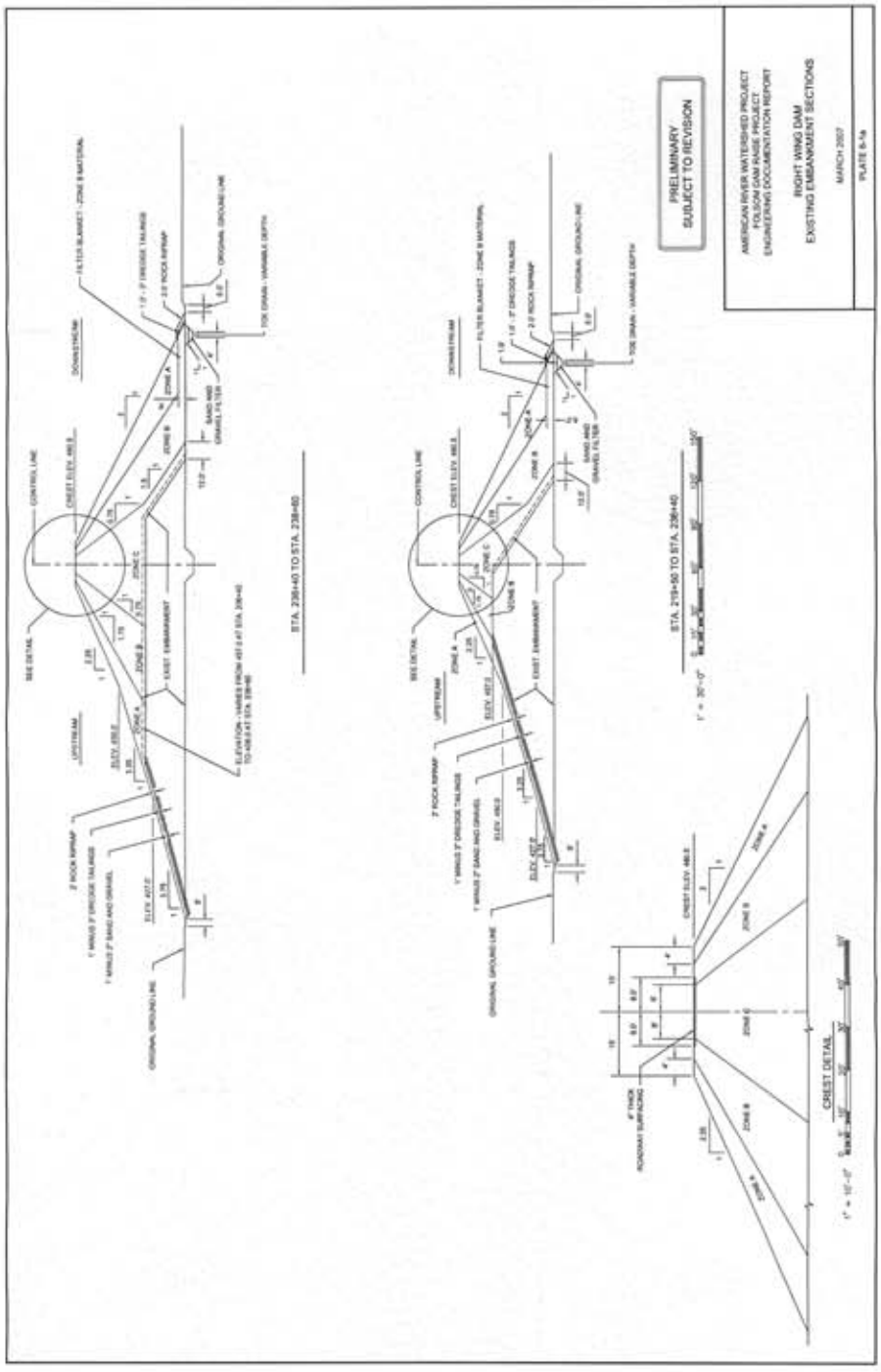
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT

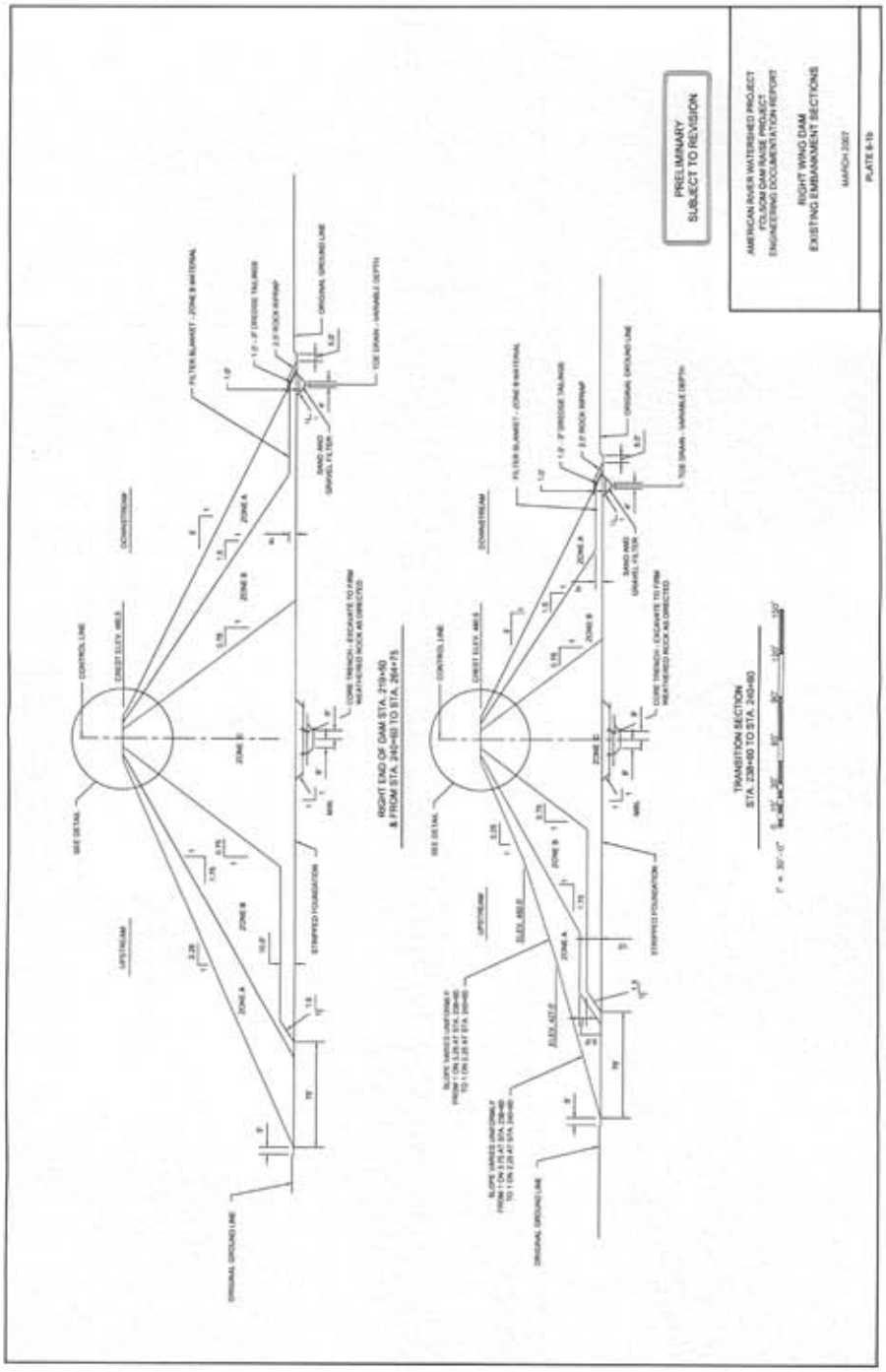
COMPARISON OF KEY OPERATIONAL DIFFERENCES (WITH - PROJECT COMPARISONS MADE TO IMMEDIATELY PRECEDING STUDY)

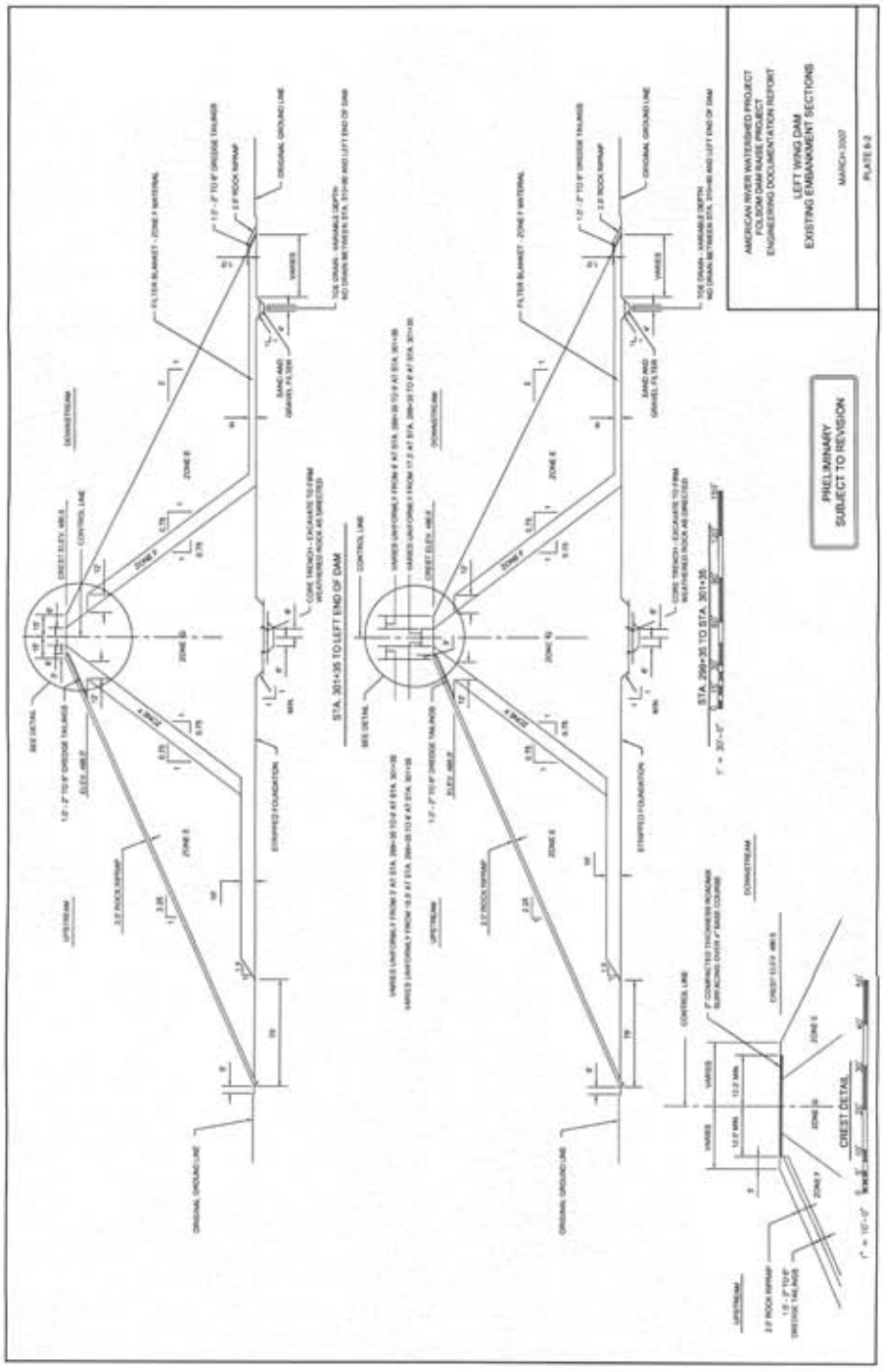
MARCH 2007

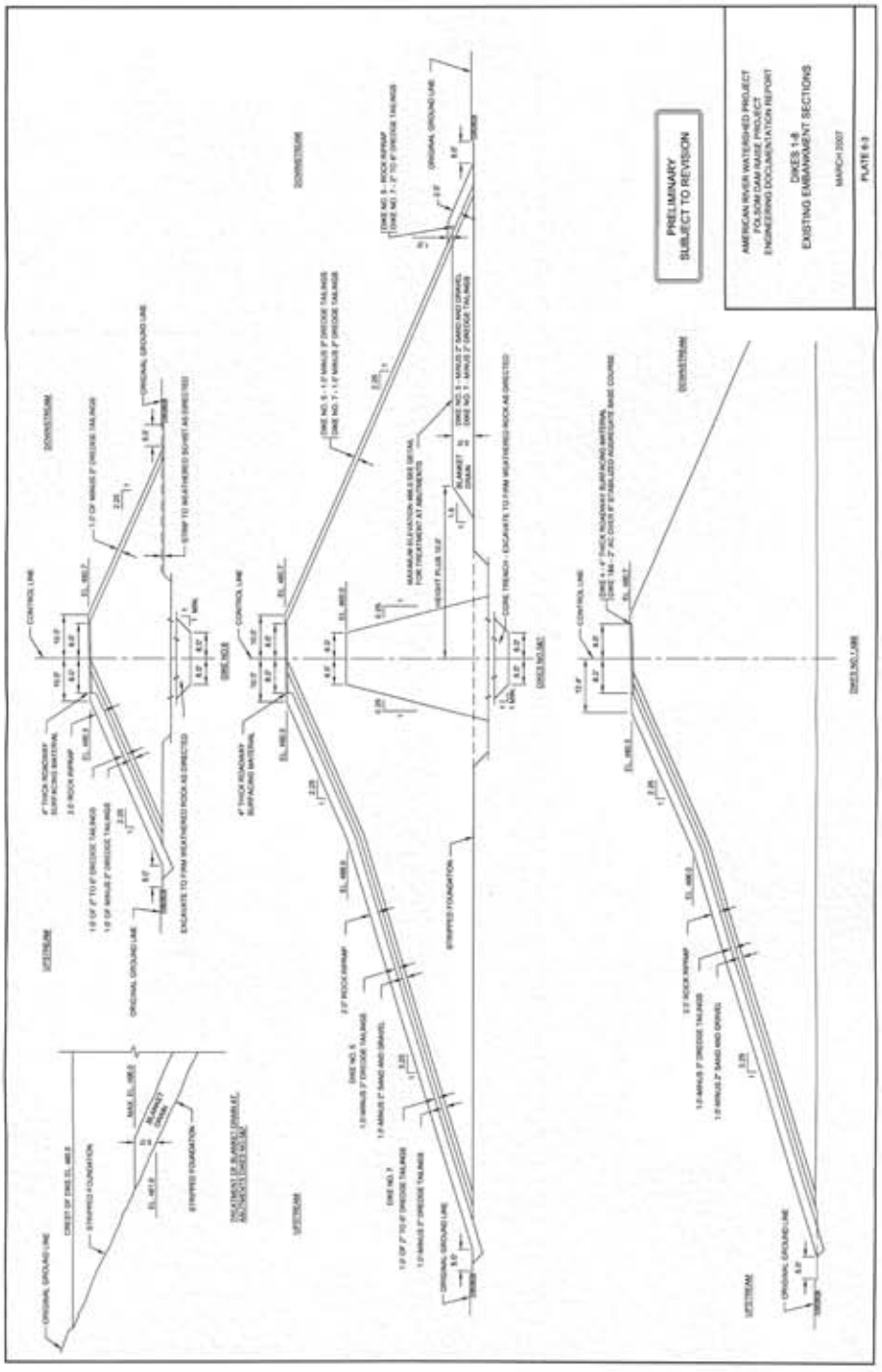
PLATE 4-6

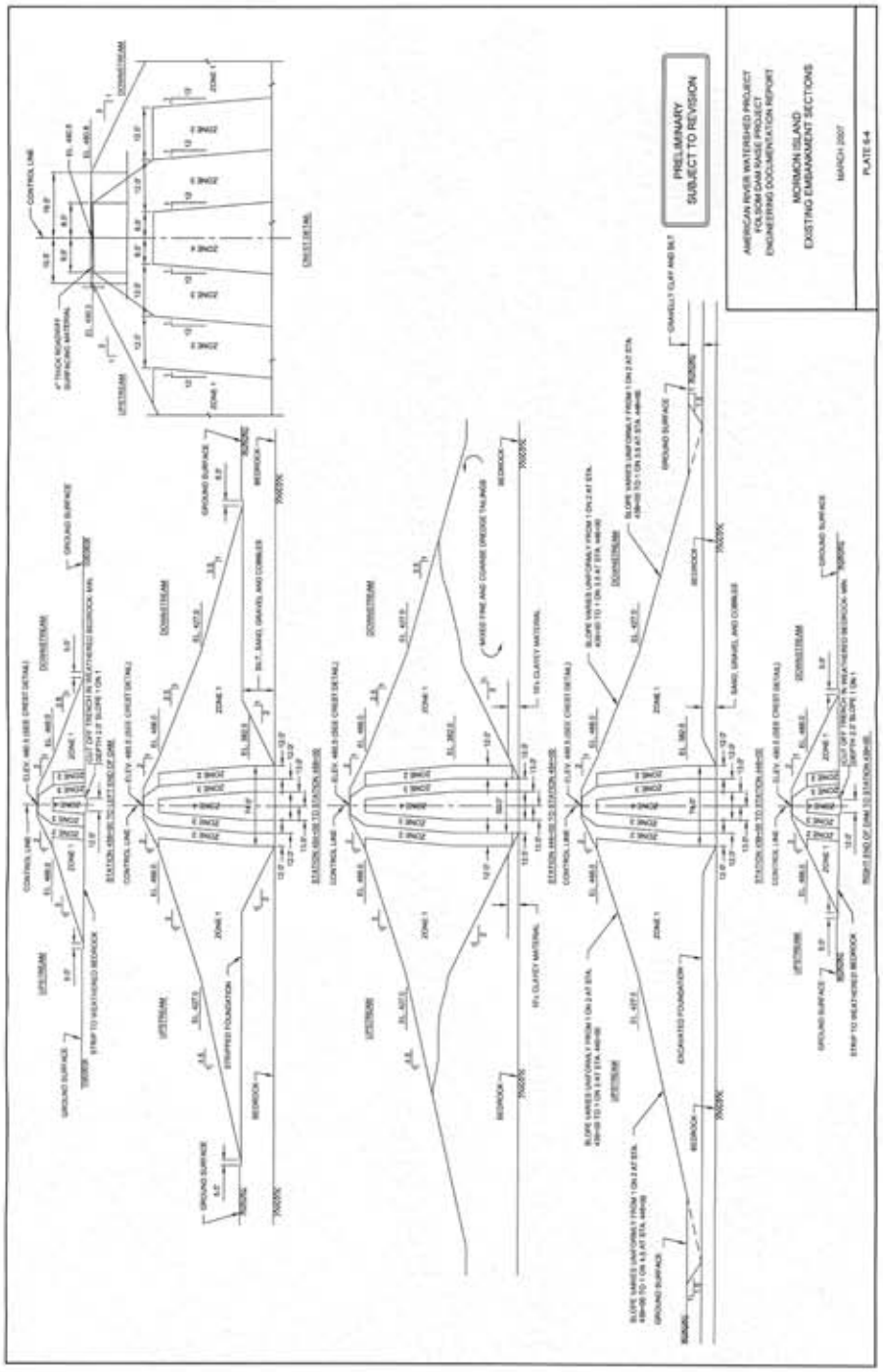

AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
FOLSOM DAM AND LAKE
PROPOSED FLOOD CONTROL DIAGRAM
MARCH 2007
PLATE 4-7
FLOOD CONTROL DIAGRAM
USE OF DIAGRAM
SAMPLE COMPUTATION OF RESERVED FLOOD RESERVOIR STORAGE
FLOOD CONTROL RESERVATION, in acre-feet
RELEASE SCHEDULE
POOL ELEVATION, in feet
RESERVOIR STORAGE, in 1000 acre-feet
FOLSOM DAM RELEASE SCHEDULE
RELEASE VS RESERVED STORAGE (Flood control function)
RELEASE WHEN AIR FLOW (IF ANY) EXCEEDS 115,000 CFS, THE EMERGENCY RELEASE REQUIRED BY (Emergency release schedule)
Release up to 115,000 cfs (Maximum inflow less than 25,000 cfs)
Release Maximum inflow up to 115,000 cfs, (Maximum inflow less than 115,000 cfs, but greater than 25,000 cfs)
Release 25% of Maximum Inflow (Maximum inflow greater than 115,000 cfs)
Release Maximum inflow up to 115,000 cfs, (Maximum inflow less than 115,000 cfs and maximum power releases)
Maximum pool elevations and the release schedule corresponding to the following reservoir storages
When applicable, transition gate operation from one schedule to the other schedule.

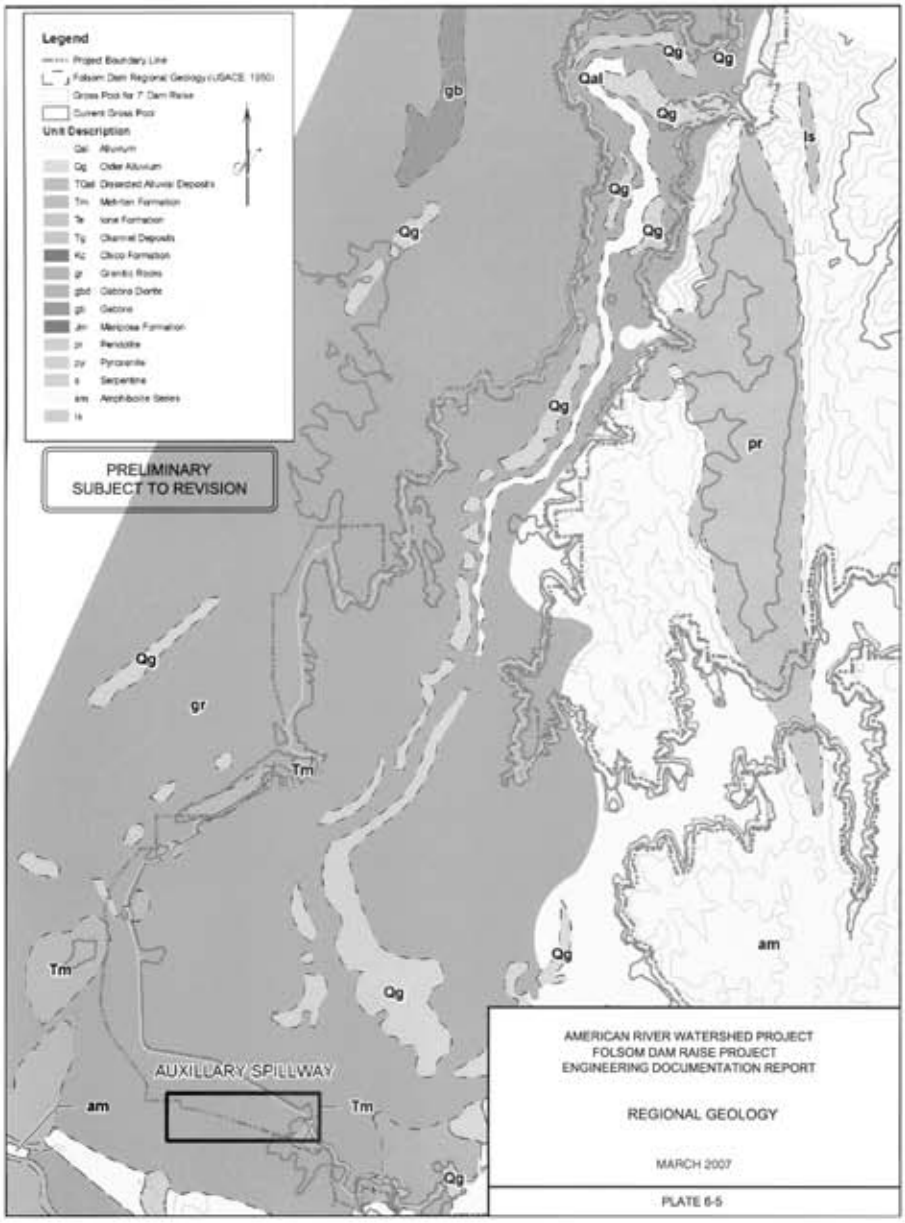

PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
RIGHT WING DAM
EXISTING EMBANKMENT SECTIONS
MARCH 2007
PLATE E-1a
STA. 238+40 TO STA. 238+60
STA. 239+60 TO STA. 238+40
CREST DETAIL


PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
RIGHT WING DAM
EXISTING EMBANKMENT SECTIONS
MARCH 2007
PLATE E-1b
RIGHT END OF DAM STA. 219+80
& FROM STA. 245+80 TO STA. 264+75
TRANSITION SECTION
STA. 238+80 TO STA. 240+80
CONTROL LINE
CREST ELEV. 480.5
UPSTREAM
DOWNSTREAM
ZONE A
ZONE B
STRIPPED FOUNDATION
ORIGINAL GROUND LINE
SAND AND GRAVEL FILTER
TOE DRAIN - VARIABLE DEPTH
FILTER BLANKET - ZONE B MATERIAL
3.0' ROCK RIPRAP
CORE TRENCH: EXCAVATE TO FIRM WEATHERED ROCK AS DIRECTED
ELEV. 455.0
SEE DETAIL

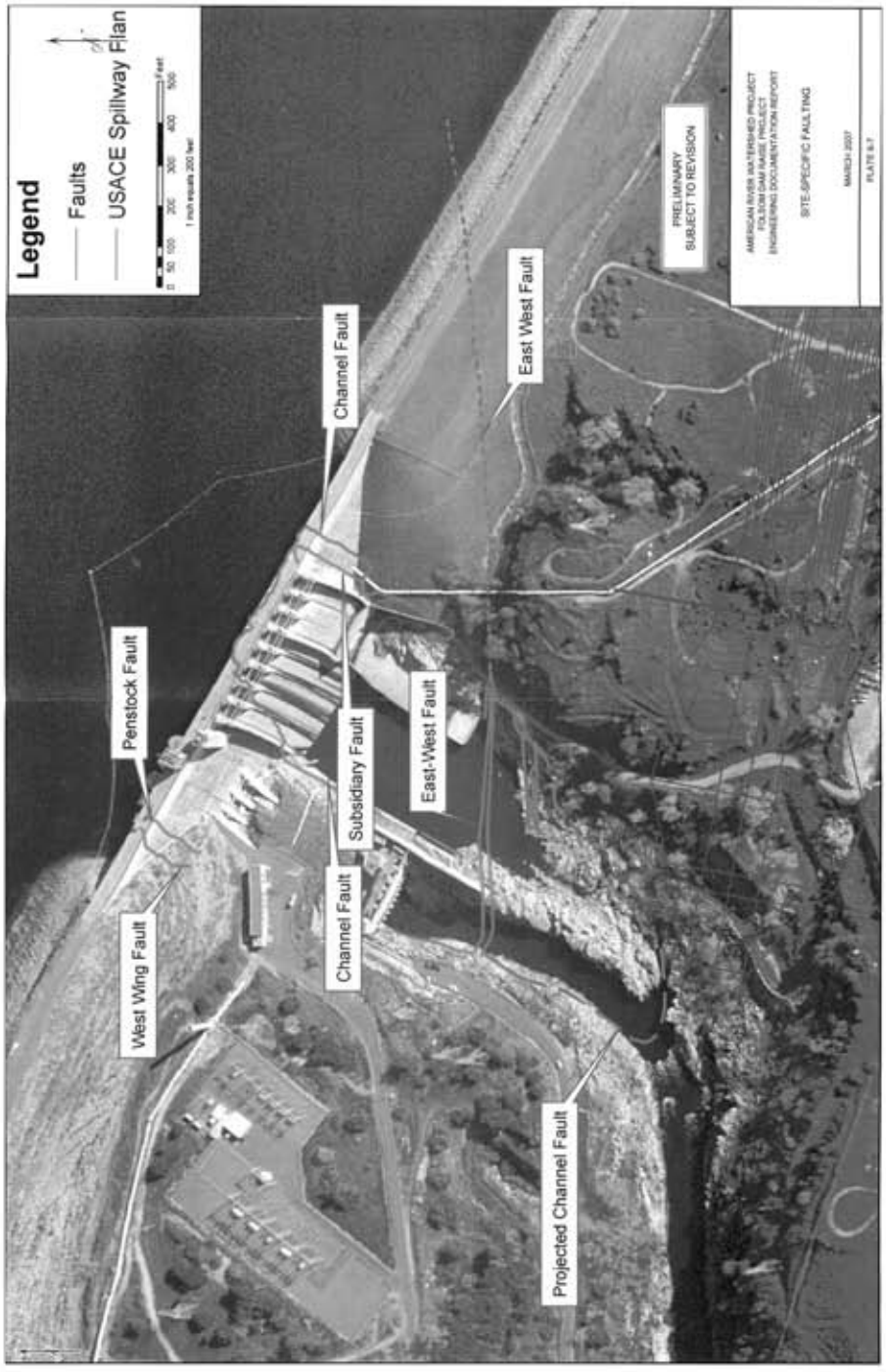

AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
LEFT WING DAM
EXISTING EMBANKMENT SECTIONS
MARCH 2007
PLATE E-2
PRELIMINARY
SUBJECT TO REVISION
STA. 301+35 TO LEFT END OF DAM
STA. 299+35 TO STA. 301+35
CREST DETAIL
CONTROL LINE
ZONE F
ZONE E
ZONE S
UPSTREAM
DOWNSTREAM
ORIGINAL GROUND LINE
SAND AND GRAVEL FILTER
STRIPPED FOUNDATION
3.0' ROCK RIPRAP
1.0' - 3' TOE DREDGE TAILINGS
CORE TRENCH - EXCAVATE TO FIRM WEATHERED ROCK AS DIRECTED

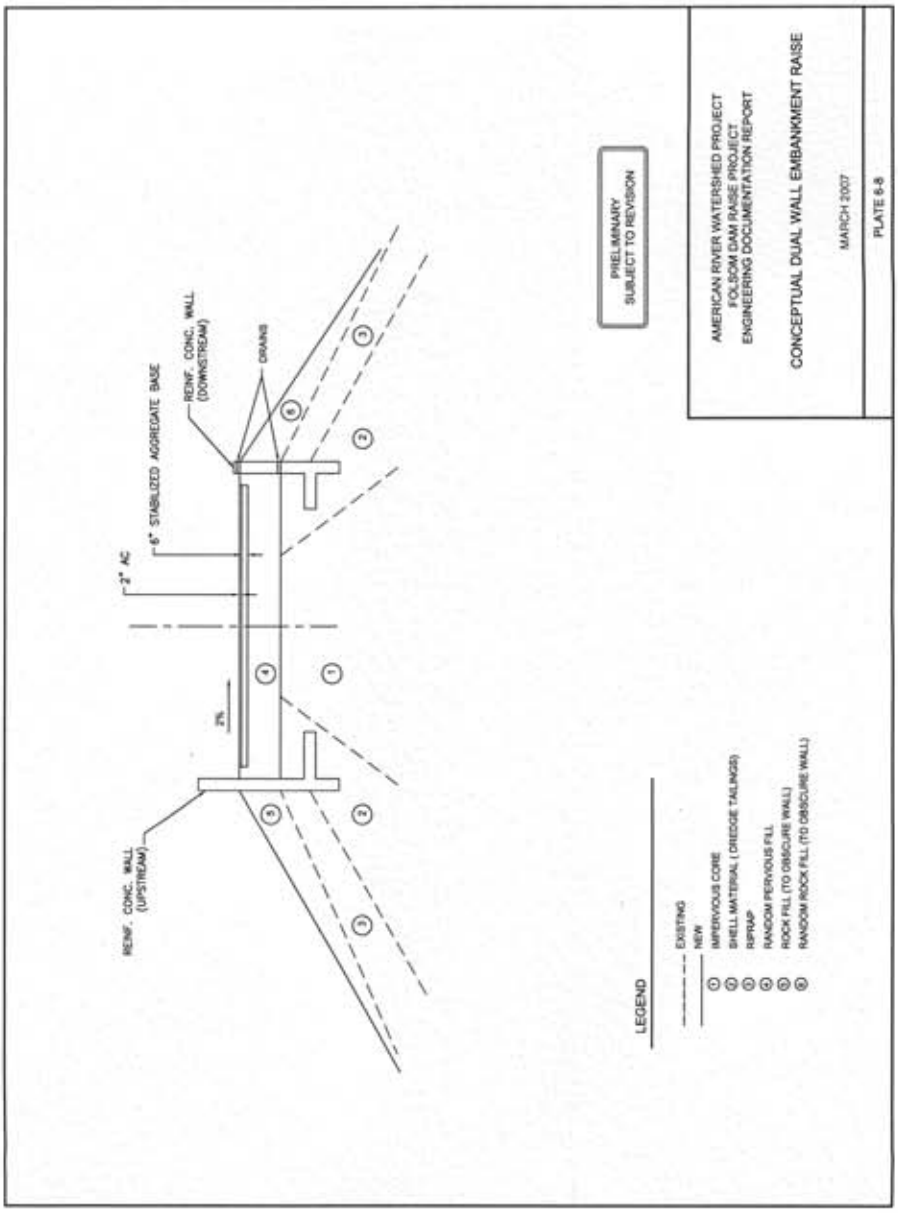

PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
DIKES 1-8
EXISTING EMBANKMENT SECTIONS
MARCH 2007
PLATE E-3

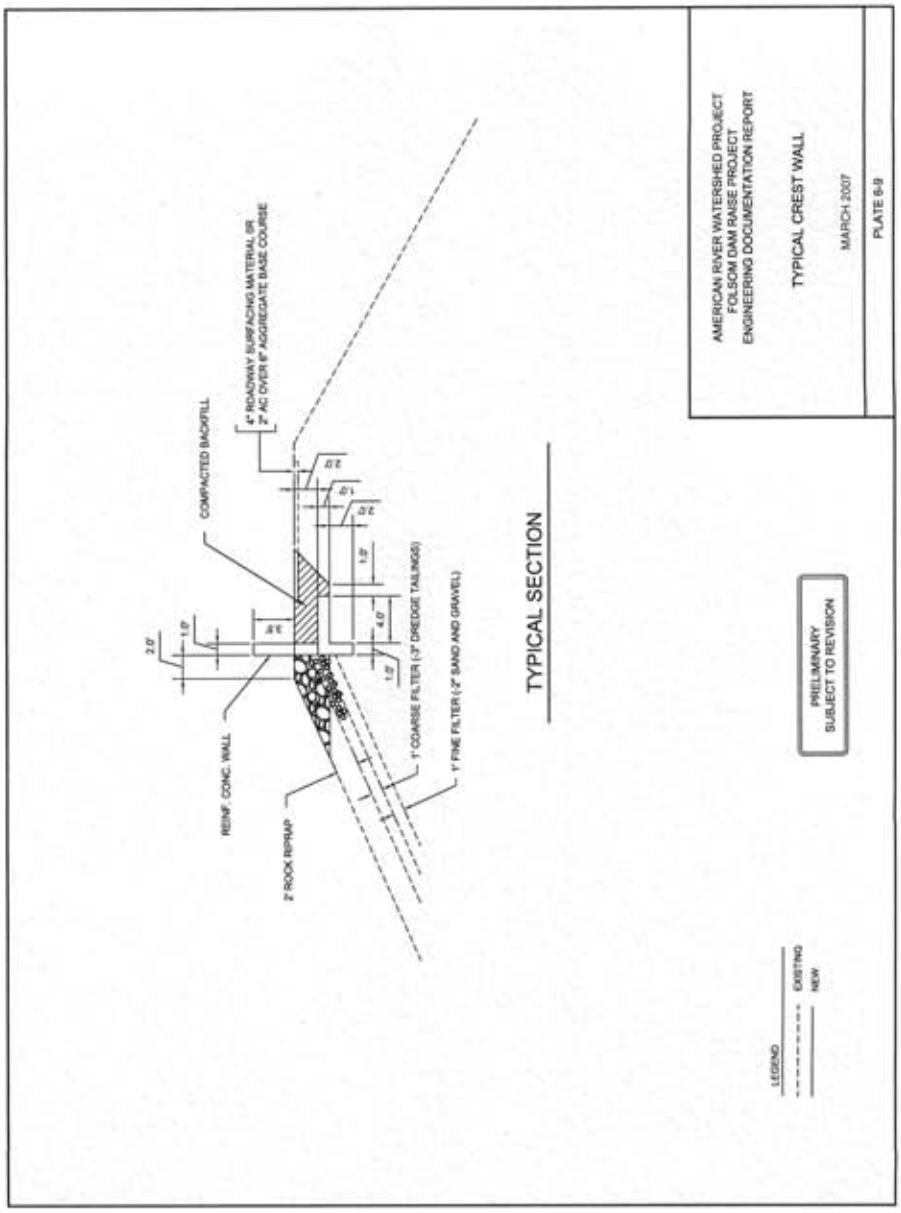

PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
MORMON ISLAND
EXISTING EMBANKMENT SECTIONS
MARCH 2007
PLATE E-4

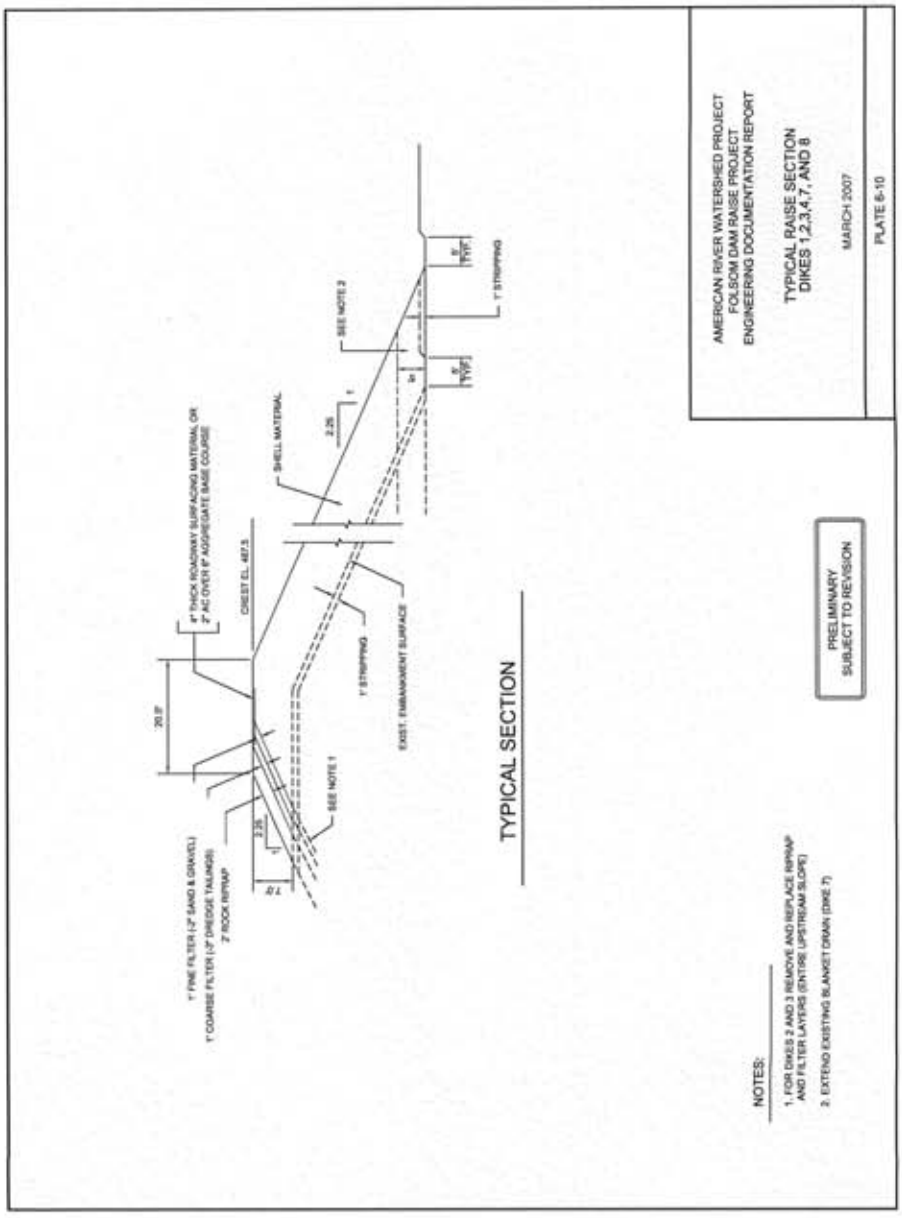

Legend
Project Boundary Line
Folsom Dam Regional Geology (USACE 1955)
Gross Pool for 7' Dam Raise
Current Gross Pool
Unit Description
Qal Alluvium
Qg Older Alluvium
TQal Dissected Alluvial Deposits
Tm Mehrten Formation
Te Ione Formation
Tc Channel Deposits
Kc Cloco Formation
gr Granitic Rocks
gbd Gabbro Diorite
gb Gabbro
Jm Mariposa Formation
pr Peridotite
py Pyroxenite
s Serpentine
am Amphibolite Series
ls
PRELIMINARY
SUBJECT TO REVISION
AUXILLARY SPILLWAY
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
REGIONAL GEOLOGY
MARCH 2007
PLATE 6-5

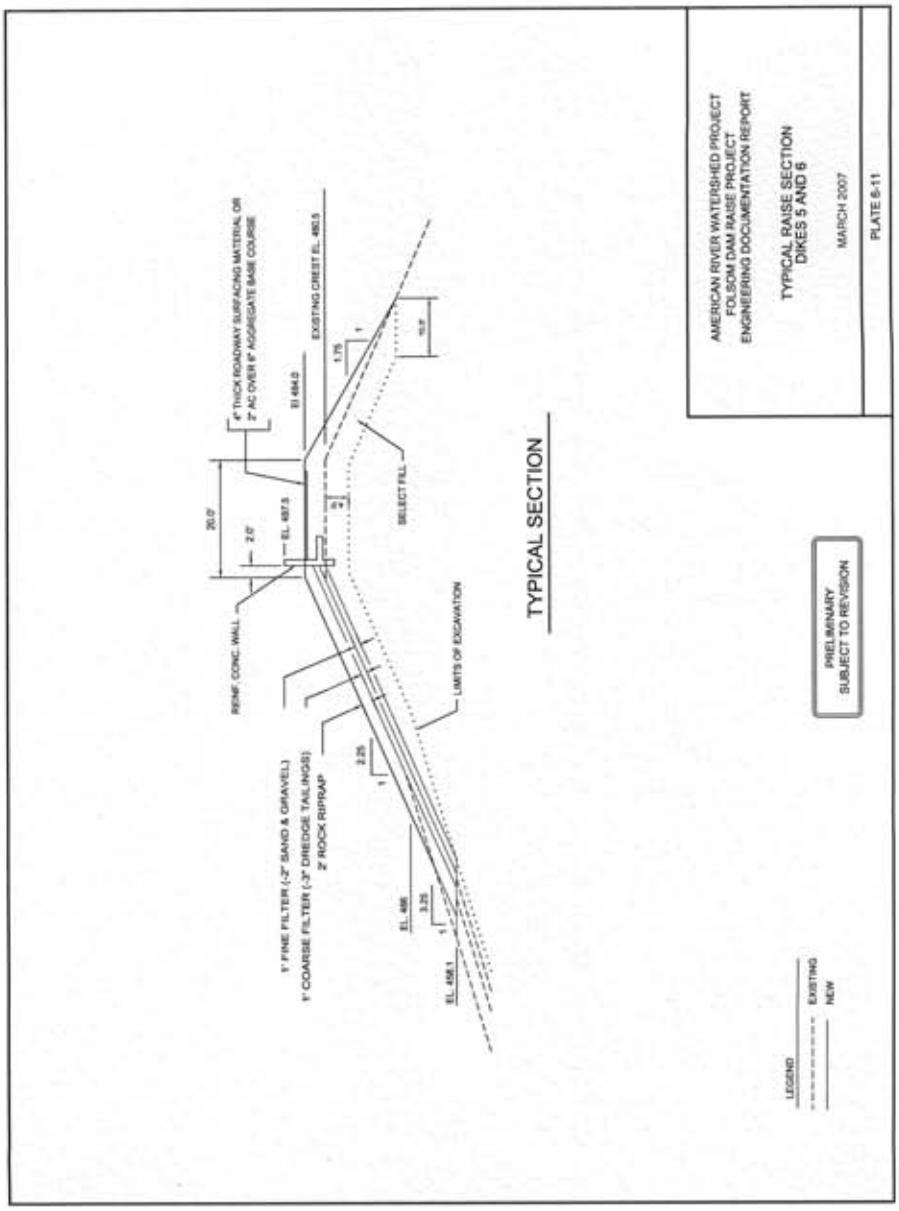

Legend
1 inch equals 500 feet
PRELIMINARY
SUBJECT TO REVISION
AUXILIARY SPILLWAY GEOLOGY
AND EXPLORATIONS
PLATE E-4

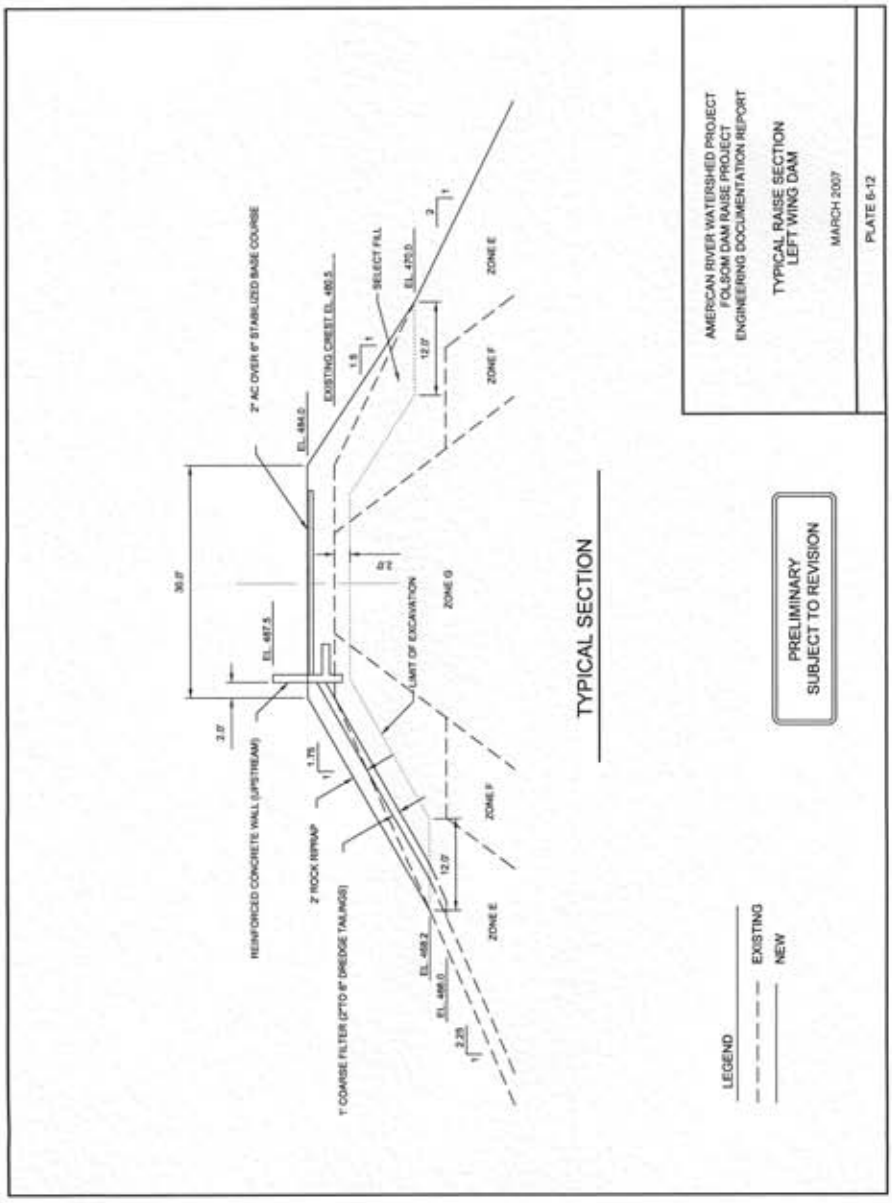

Legend
Faults
USACE Spillway Flan
Penstock Fault
West Wing Fault
Channel Fault
Subsidiary Fault
Channel Fault
East-West Fault
East West Fault
Projected Channel Fault
PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
SITE-SPECIFIC FAULTING
MARCH 2017
PLATE 6-7

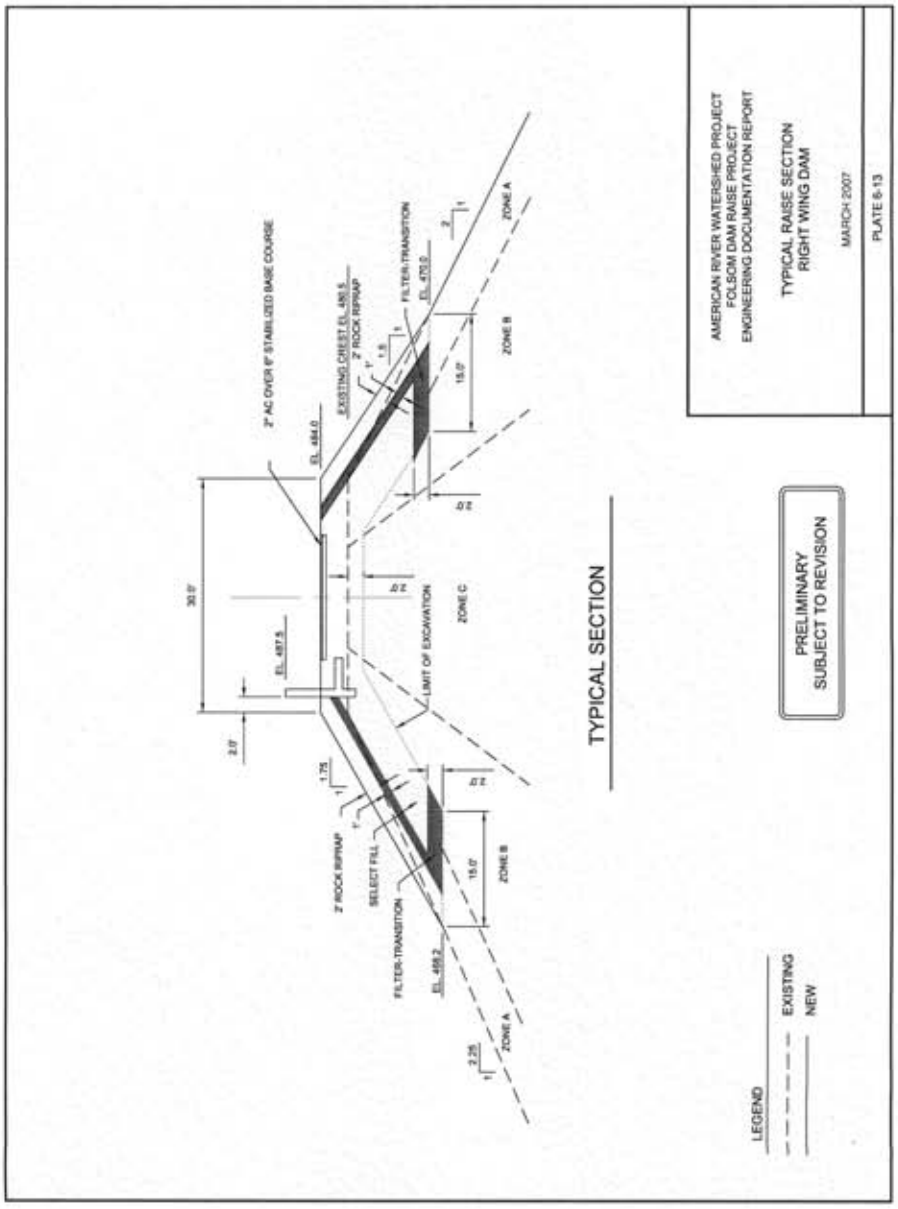

RENF. CONC. WALL (UPSTREAM)
2%
2" AC
6" STABILIZED AGGREGATE BASE
RENF. CONC. WALL (DOWNSTREAM)
DRAINS
LEGEND
EXISTING
NEW
1 IMPERVIOUS CORE
2 SHELL MATERIAL (DREDGE TAILINGS)
3 RIPRAP
4 RANDOM PERVIOUS FILL
5 ROCK FILL (TO OBSCURE WALL)
6 RANDOM ROCK FILL (TO OBSCURE WALL)
PRELIMINARY SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
CONCEPTUAL DUAL WALL EMBANKMENT RAISE
MARCH 2007
PLATE 6-8

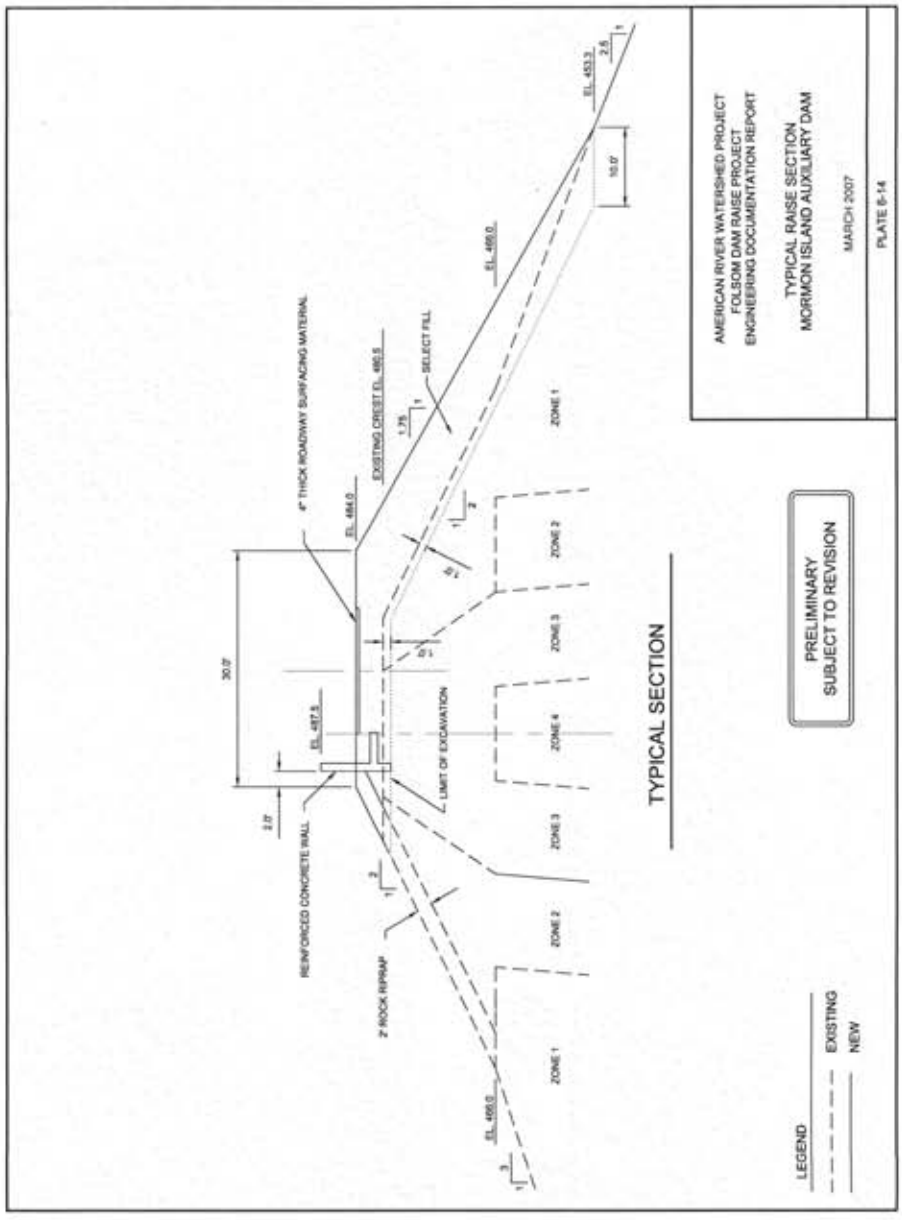

AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
TYPICAL CREST WALL
MARCH 2007
PLATE 6-9
TYPICAL SECTION
PRELIMINARY
SUBJECT TO REVISION
LEGEND
EXISTING
NEW
4" ROADWAY SURFACING MATERIAL OR
2" AC OVER 6" AGGREGATE BASE COURSE
COMPACTED BACKFILL
REINF. CONC. WALL
2' ROCK RIPRAP
1' COARSE FILTER (-3" DREDGE TAILINGS)
1' FINE FILTER (-2" SAND AND GRAVEL)

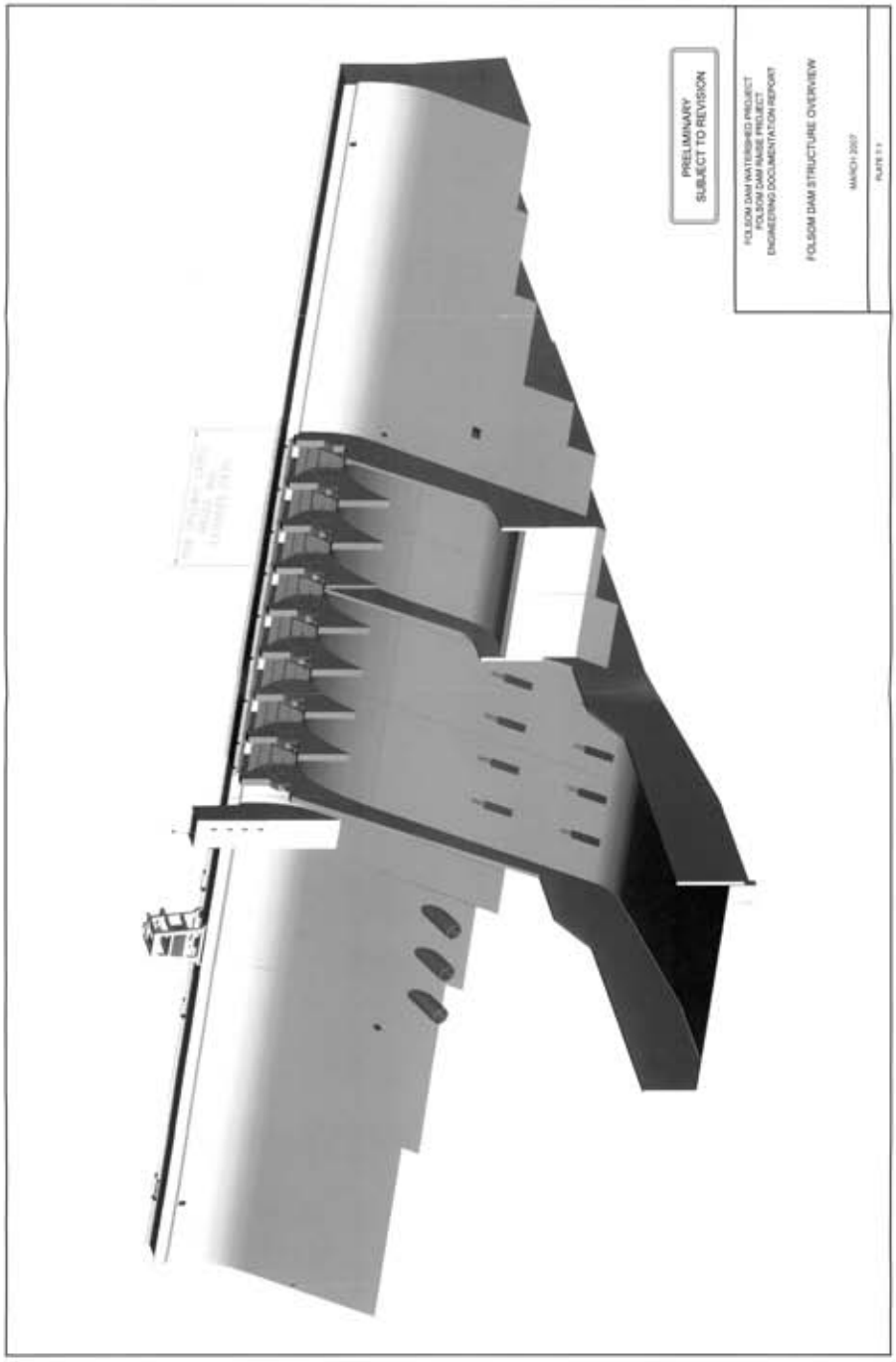

AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
TYPICAL RAISE SECTION
DIKES 1,2,3,4,7, AND 8
MARCH 2007
PLATE E-10
TYPICAL SECTION
PRELIMINARY
SUBJECT TO REVISION
NOTES:
1. FOR DIKES 2 AND 3 REMOVE AND REPLACE RIPRAP AND FILTER LAYERS (ENTIRE UPSTREAM SLOPE)
2. EXTEND EXISTING BLANKET DRAIN (DIKE 7)
SHELL MATERIAL
EXIST. EMBANKMENT SURFACE
SEE NOTE 1
SEE NOTE 2
1' STRIPPING
8" THICK ROADWAY SURFACING MATERIAL OR
3" AC OVER 6" AGGREGATE BASE COURSE
1' FINE FILTER (1/2" SAND & GRAVEL)
1' COARSE FILTER (3" DREDGE TAILINGS)
2' ROCK RIPRAP
CREST EL. 487.5
2.25
1
2H
1V
4H
4V TYP.

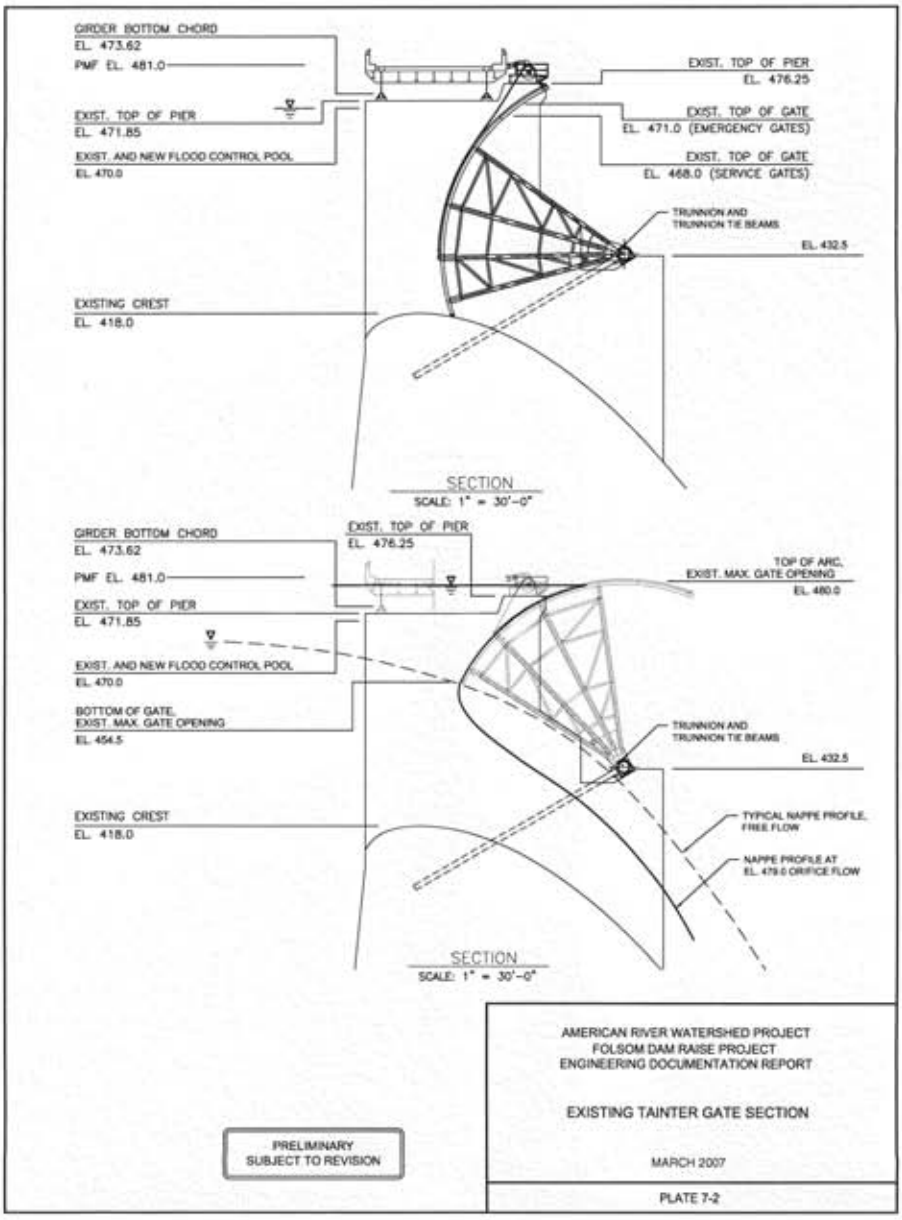

TYPICAL SECTION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
TYPICAL RAISE SECTION
DIKES 5 AND 6
MARCH 2007
PLATE 6-11
PRELIMINARY
SUBJECT TO REVISION
LEGEND
EXISTING
NEW
6" THICK ROADWAY SURFACING MATERIAL OR
2" AC OVER 6" AGGREGATE BASE COURSE
EXISTING CREST EL. 465.5
EL 464.0
20.0'
2.0'
EL. 457.5
1.75
1
SELECT FILL
REINF. CONC. WALL
LIMITS OF EXCAVATION
1' FINE FILTER (-2" SAND & GRAVEL)
1' COARSE FILTER (-3" DREDGE TAILINGS)
2' ROCK RIPRAP
2.25
1
EL. 448
3.25
1
EL. 438.1

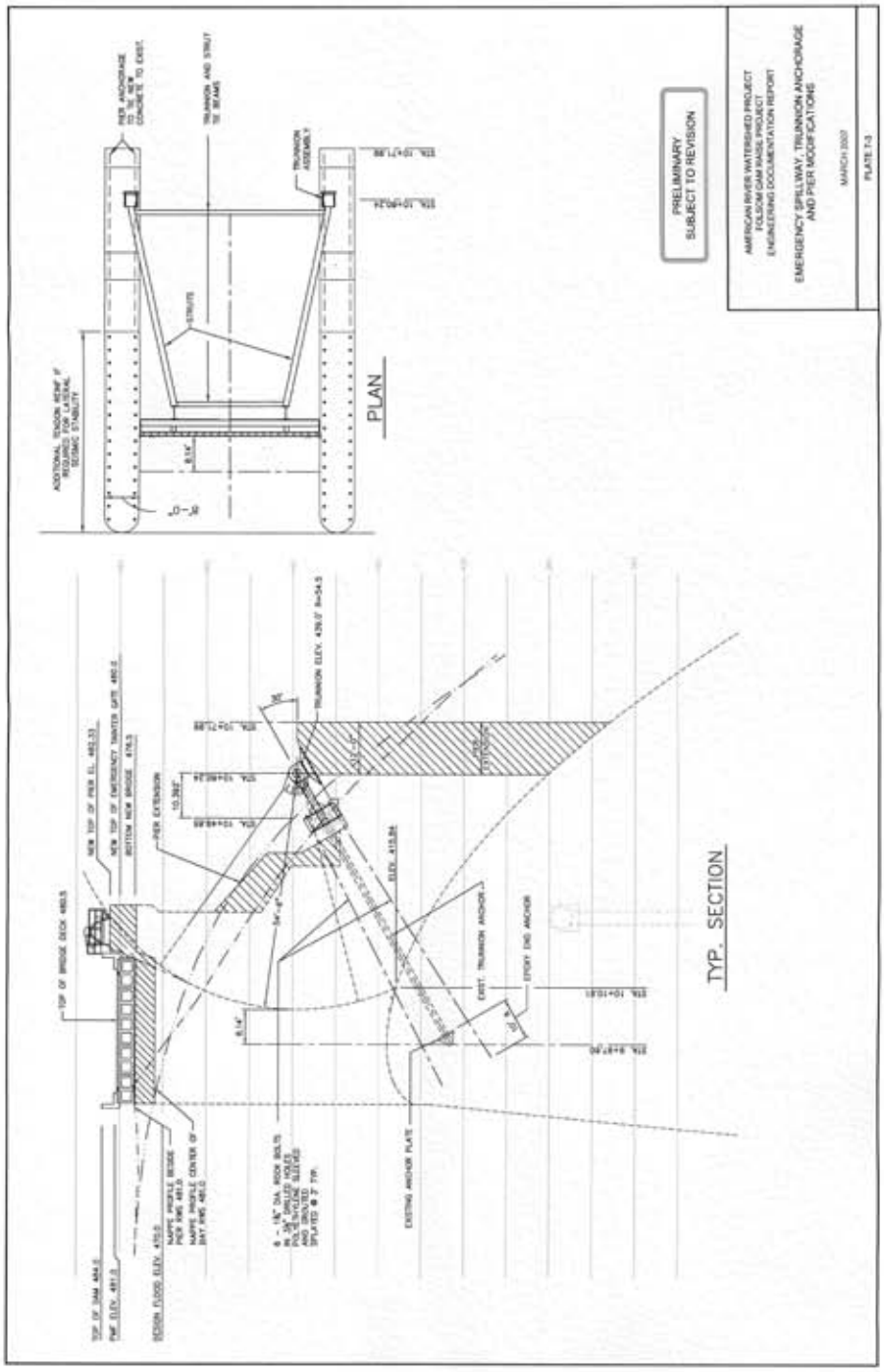

TYPICAL SECTION
PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
TYPICAL RAISE SECTION
LEFT WING DAM
MARCH 2007
PLATE E-12
LEGEND
EXISTING
NEW
2" AC OVER 6" STABILIZED BASE COURSE
EXISTING CREST EL. 480.5
SELECT FILL
EL. 475.0
EL. 484.0
EL. 487.5
EL. 488.2
EL. 488.0
REINFORCED CONCRETE WALL (UPSTREAM)
2' ROCK RIPRAP
1' COARSE FILTER (2"TO 6" DREDGE TAILINGS)
LIMIT OF EXCAVATION
ZONE E
ZONE F
ZONE G
30.0'
2.0'
12.0'
8.2'
1.8
1.75
2.25
2
1

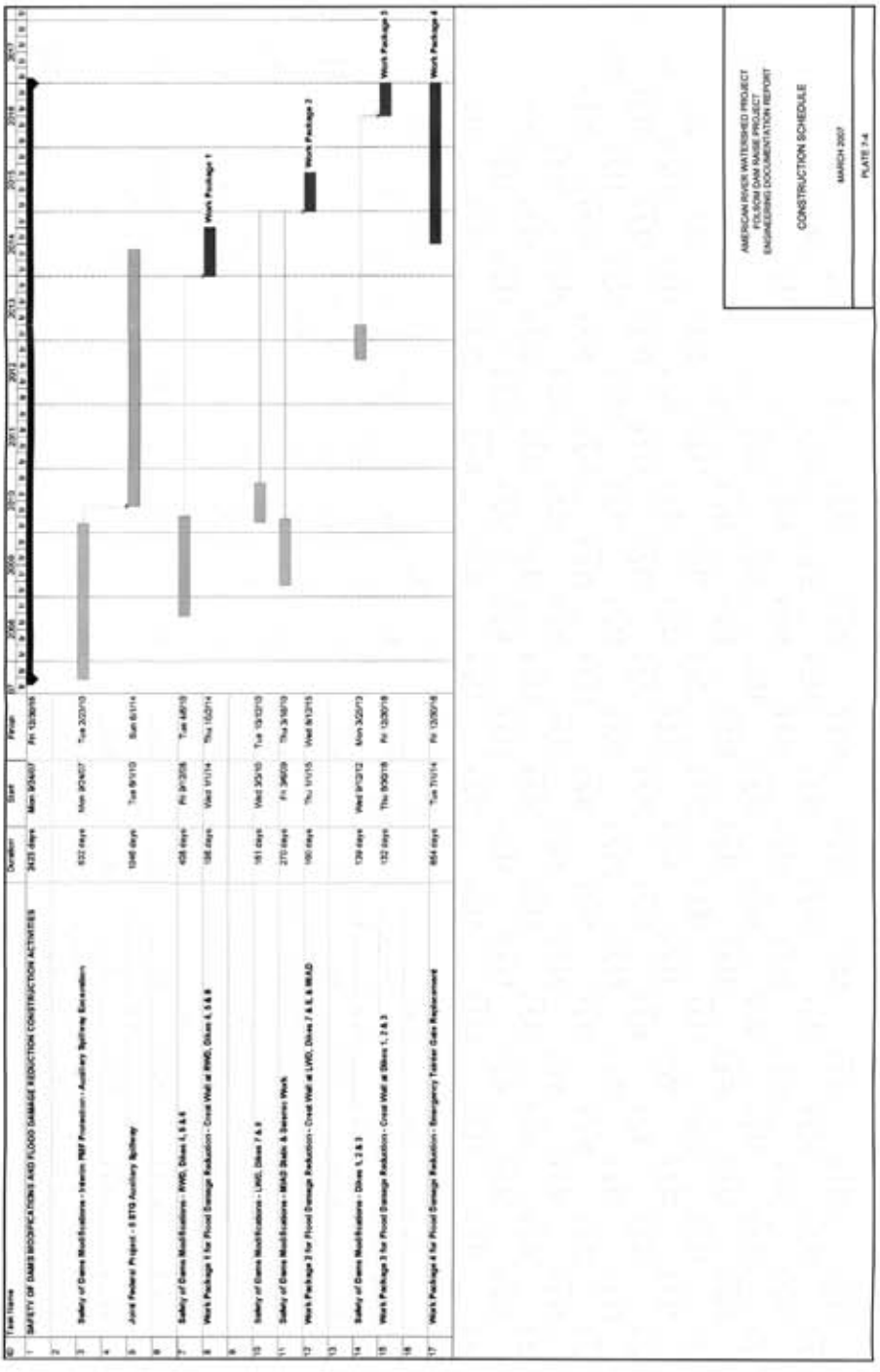

AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
TYPICAL RAISE SECTION
RIGHT WING DAM
MARCH 2007
PLATE E-13
PRELIMINARY
SUBJECT TO REVISION
TYPICAL SECTION
LEGEND
EXISTING
NEW
2" AC OVER 6" STABILIZED BASE COURSE
EL. 484.0
EXISTING CREST EL. 486.5
2' ROCK RIPRAP
FILTER-TRANSITION
EL. 470.0
ZONE A
ZONE B
ZONE C
LIMIT OF EXCAVATION
EL. 487.5
30.0'
2.0'
1.75
2.25
SELECT FILL
EL. 466.2
15.0'


AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
TYPICAL RAISE SECTION
MORMON ISLAND AUXILIARY DAM
MARCH 2007
PLATE E-14
PRELIMINARY
SUBJECT TO REVISION
TYPICAL SECTION
LEGEND
EXISTING
NEW
4" THICK ROADWAY SURFACING MATERIAL
EL. 484.0
EXISTING CREST EL. 480.5
SELECT FILL
EL. 489.0
EL. 453.3
10.0'
30.0'
EL. 487.5
1.0'
REINFORCED CONCRETE WALL
LIMIT OF EXCAVATION
2' ROCK RIPRAP
EL. 466.0
ZONE 1
ZONE 2
ZONE 3
ZONE 4


PRELIMINARY
SUBJECT TO REVISION
FOLSOM DAM WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
FOLSOM DAM STRUCTURE OVERVIEW
MARCH 2007
PLATE 5-1


GIRDER BOTTOM CHORD
EL. 473.62
PMF EL. 481.0
EXIST. TOP OF PIER
EL. 471.85
EXIST. AND NEW FLOOD CONTROL POOL
EL. 470.0
EXISTING CREST
EL. 418.0
EXIST. TOP OF PIER
EL. 476.25
EXIST. TOP OF GATE
EL. 471.0 (EMERGENCY GATES)
EXIST. TOP OF GATE
EL. 468.0 (SERVICE GATES)
TRUNNION AND
TRUNNION TIE BEAMS
EL. 432.5
SECTION
SCALE: 1" = 30'-0"
GIRDER BOTTOM CHORD
EL. 473.62
PMF EL. 481.0
EXIST. TOP OF PIER
EL. 471.85
EXIST. AND NEW FLOOD CONTROL POOL
EL. 470.0
BOTTOM OF GATE,
EXIST. MAX. GATE OPENING
EL. 454.5
EXISTING CREST
EL. 418.0
EXIST. TOP OF PIER
EL. 476.25
TOP OF ARC,
EXIST. MAX. GATE OPENING
EL. 460.0
TRUNNION AND
TRUNNION TIE BEAMS
EL. 432.5
TYPICAL NAPPE PROFILE,
FREE FLOW
NAPPE PROFILE AT
EL. 479.0 ORIFICE FLOW
SECTION
SCALE: 1" = 30'-0"
PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
EXISTING TAINTER GATE SECTION
MARCH 2007
PLATE 7-2


PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAILS PROJECT
ENGINEERING DOCUMENTATION REPORT
EMERGENCY SPILLWAY, TRUNNION ANCHORAGE
AND PIER MODIFICATIONS
MARCH 2007
PLATE T-3
PLAN
TYP. SECTION
TRUNNION ELEV. 439.0'
EXIST. TRUNNION ANCHOR
EPOXY END ANCHOR
EXISTING ANCHOR PLATE
TOP OF BRIDGE DECK 480.5
NEW TOP OF PIER EL. 482.33
NEW TOP OF EMERGENCY GATE 480.0
BOTTOM NEW BRIDGE 476.5
PIER EXTENSION
ELEV. 415.84
TOP OF DAM 484.0
PMF ELEV. 481.0
DESIGN FLOOD ELEV. 476.0
NAPE PROFILE RIDGE
NAPE PROFILE CENTER OF
BAY ANC 480.0
STRUTS
TRUNNION AND STRUT
TO BEAMS
TRUNNION
ASSEMBLY
PIER ANCHORAGE
TO BE NEW
CONCRETE TO EXIST.
ADDITIONAL TENSION STRIP IF
REQUIRED FOR LATERAL
SEISMIC STABILITY


AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM RAISE PROJECT
ENGINEERING DOCUMENTATION REPORT
CONSTRUCTION SCHEDULE
MARCH 2007
PLATE 7-4

Attachment B1 – PMF Routing Assumptions, Guidelines and Criteria
Folsom Dam Raise Project
Engineering Documentation Report

PMF ROUTING ASSUMPTIONS, GUIDELINES, AND CRITERIA

General Assumptions

- Flood control operation is prescribed by the U.S. Army Corps of Engineers (Corps). Although the current authorized Top of Flood Control Reservation is at reservoir elevation 466, a joint agreement between the U.S. Army Corps of Engineers (Corps) and the U.S. Bureau of Reclamation (Reclamation) had extended flood control operations into the surcharge storage space up to pool elevation 470.
- ***Any changes to the formally allocated flood control space should be documented and requested in writing.***
- Above pool elevation 466, the releases within the surcharge storage space are controlled by the Reclamation.
- The PMF event for Folsom Dam and Lake was developed in 2001 using Hydrometeorological Report (HMR) 59. The hydrograph was developed based on a North Fork storm centering with no upstream failures. LL Anderson Dam is presumed fixed so as to pass its PMF.
- The PMF event is preceded 8-days in advance by an antecedent flood (72-hours of rainfall) immediately followed by the main flood with a peak inflow of 905,770 ft^3/s and a 5-day volume of 3,206,000 acre-feet. The antecedent flood (50 percent PMF hydrograph) was derived using an HEC-1 model. This process required that each sub-area hydrograph ordinate be reduced by half and routed through the upstream reservoirs and reaches down to Folsom.
- Section 101(a)(6) of the Water Resources Development Act (WRDA) 1999 (Public Law 106-53) specifies that the Secretary of the Army and Secretary of the Interior shall coordinate. Upon completion and improvements to Folsom Dam, the variable space allocated to flood control within the reservoir shall be reduced from the current interim operating range of 400-670,000 acre-feet to 400,000-600,000 acre-feet.

Description of Alternatives

- Joint Federal Project
  - No Dam Raise
  - Existing spillway service/emergency gates <u>not</u> replaced.
  - Controlled spillway flows are maintained throughout operation (no free flow operation).
  - Discharges do not exceed 160,000 ft^3/s until the pool elevation rises above the Flood Pool elevation target set by routing the 0.05 probability flood event. Note that the antecedent event for the PMF is roughly equivalent in volume to the 0.05 probability flood event and should be taken into consideration when establishing the flood pool elevation requirement.
- Selected (Joint Federal) Project
  - 3.5 ft Dam Raise
  - Existing <u>emergency</u> spillway gates are replaced **and**/or increased in height.
  - Existing <u>service</u> spillway gates are not replaced.
  - Controlled spillway flows are maintained throughout (no **planned** free flow operation).
  - Discharges do not exceed 160,000 ft^3/s until the pool elevation rises above the Flood Pool elevation target ***at which enhanced flood protection can be provided.***
  - The service spillway gates**, while fully open,** could be overtopped for floods approaching the PMF. The following is as noted in Reclamation's 2004 Folsom Dam Hydrologic Corrective Action Study report: *Although the gates could fail under this condition, any failed gates would likely wash downstream. This is not viewed as a dam safety issue since they would not impede flows through the spillway. Any additional flow generated by failed gates would be relatively small compared to the total flow being discharged.* ***Recent model studies have shown the gates begin to overtop at a reservoir water surface of about 481.0. Given a 3.5 foot dam raise the maximum reservoir water surface should not be greater than 481.0. The BOR notes that if the gates are overtopped it will be by minimal depths.*** **Under different circumstances, a notable gate failure occurred at Folsom Dam on 17 July 1995. A spillway tainter gate broke as it was being raised. This is an example where a failed or malfunctioning gate partially impeded flows because it did not wash downstream.**

PMF ROUTING ASSUMPTIONS, GUIDELINES, AND CRITERIA

Summary of Physical Constraints

- All existing-sized (5' x 9') river outlets retain their 60% gate opening restriction during concurrent spillway gate operation. **Once flows exceed 115,000 cfs, the outlets should not be operated concurrently with the main dam spillway gates under normal flood operations.**
- Any power units that are assumed operating would become non-functional once the tailwater discharge exceeds 250,000 ft^3/s.
- Emergency tainter gate operations can begin once the tailwater discharge reaches 240,000 ft^3/s or water surface is within 1 ft of overtopping closed emergency gates
- **It is physically impossible to open the main dam service spillway gates beyond 457.0 feet. Therefore, it is physically impossible to operate the service spillway gates in "free flow" conditions. Gate tests were** ***performed on November 15, 2006 to determine the current and maximum spillway gate openings. The gate was reportedly opened to 40 feet (elevation 457) where it contacted the first limit switch. Operators at the dam believe the gates can be easily modified to be opened to the full opening height of 459.0. Reclamation prefers that orifice flow be maintained.*** **The final design of the new emergency tainter gates will determine how high they can be opened..**
- The safe long-term channel capacity of the downstream levees was assumed to be 160,000 ft^3/s.

Operation Criteria

- The freeboard requirement is set at 3 ft per Reclamation (Denver).
- No power units are available for use in the routings per Reclamation (Folsom). All power units are off-line.
- Releases from Folsom Dam must **not** be greater than the flows produced without the project in place.
- The dam was assumed to be releasing a minimum 2,000 ft^3/s at the start of the routing.
- Two methods are available for routing the PMF:
  - 1) use an antecedent flood starting routed at the bottom of the flood control pool. (The initial reservoir water surface was assumed to be at elevation 399.63). This established the initial starting conditions for the PMF (around pool elevation El 401) or
  - 2) route the PMF alone starting at normal full pool (466 ft). The second option is appropriate for projects with limited release capabilities.
- All routings reflect the first method which provides 600,000 acre-feet of Flood Control Reservation (also referred to as Flood Control Space) between the initial water surface and the top of joint use at elevation 466
- The PMF event was routed assuming a 4-hour delay in determining outflows until the releases reached 115,000 ft^3/s. This simulates initial delays in computing inflow, scheduling/performing gate changes, solving mechanical problems, or delays in staffing the facility. Once releases reached 115,000 ft^3/s outflows were adjusted based on 1-hour intervals until reaching the top of the surcharge storage space.
- Discharge must **not** exceed 160,000 ft^3/s while the water surface elevation is less than the storage space elevation, ***which provides the desired level of flood protection***.
- The downstream levees were assumed to remain intact throughout the antecedent event.

PMF ROUTING ASSUMPTIONS, GUIDELINES, AND CRITERIA

Operation Criteria (continued)

- Ramp up Rate Limitations.

Discharge is less than or equal to 20,000 ft^3/s	no more than 10,000 ft^3/s during any 2-hour period
Discharge is less than or equal to 160,000 ft^3/s	no more than 30,000 ft^3/s during any 2-hour period
Discharge is greater than or equal to 160,000 ft^3/s	***no more than 100,000 ft^3/s during any 1-hour period for discharges below 360,000 ft^3/s.***

Ramp down Rate Limitation:

Outflow is less than or equal to 115,000 ft^3/s	no more than 10,000 ft^3/s during any 2-hour period.
Outflow is greater than 115,000 ft^3/s	Lesser of maximum peak release or 125 percent of inflow while pool elevation greater than 448 feet.

- Above storage elevation (468 for the JFP routing) at which the desired level of flood protection is reached.–***Discharge should be increased by no more than 100,000 ft^3/s during any 1-hour period for discharges below 360,000 ft^3/s.*** (Note that the antecedent event for the PMF is roughly equivalent in volume to the 0.05 probability flood event and should be taken into consideration when establishing the flood pool elevation requirement. The maximum pool elevation for the antecedent event is slightly higher than the 0.05 probability flood event.)
- ***For discharges greater than 360,000 ft^3/s*** releases are limited to inflow.
- ***Discharge should be increased by no more than 100,000 ft^3/s during any 1-hour period for discharges below 360,000 ft^3/s. See above.***
- Releases cannot exceed discharge capacity.
- A ramp-down rate of 10,000 ft^3/s in one hour and no ramp down the next hour is considered acceptable
- The Accelerated Transition rule maximizes use of the downstream capacity. Releases were increased from 115,000 ft^3/s to 160,000 ft^3/s as soon as the requirements of the accelerated transition zone were met. The requirements of the accelerated transition zone are as follows. Releases may be increased from 115,000 ft^3/s to 130,000 ft^3/s when the current inflow is greater than 200,000 ft^3/s and the 12-hour forecasted inflow is greater than 360,000 ft^3/s. Releases may be increased from 130,000 ft^3/s to 145,000 ft^3/s when the current inflow is greater than 250,000 ft^3/s and the 12-hour forecasted inflow is greater than 370,000 ft^3/s. Releases may be increased from 145,000 ft^3/s to 160,000 ft^3/s when the current inflow is greater than 270,000 ft^3/s and the 12-hour forecasted inflow is greater than 370,000 ft^3/s. The requirement to limit the ramp-up rate to 15,000 ft^3/s per hour or no more than 30,000 ft^3/s during any 2-hour period still applies. Ramping rate requirements still apply.
- Fish and Wildlife Service Mitigation Rule. For inflows greater than or equal to 25,000 ft^3/s, less than or equal to 150,000 ft^3/s, limit the release to 60 percent of previous hour inflow. Discontinue this rule once the 12-hour forecast exceeds 150,000 ft^3/s or the reservoir rises above elevation 416.15 (20 percent encroachment).
- For a falling reservoir below elevation 448, releases were computed using an USACE drawdown algorithm which attempts to evacuate the Flood Control Reservation plus inflow in 1 day for each iteration while at the same time reduce the releases from 115,000 ft^3/s in 5,000 ft^3/s increments. The drawdown algorithm succeeds in evacuating most of the Flood Control Reservation below elevation 448 in a little more than 3 days.
- For a falling reservoir with releases at or below 15,000 ft^3/s, the ramp-down rate was limited to 1,000 ft^3/s per hour as defined in the USACE drawdown algorithm.

Attachment B2 – Project Cost
Folsom Dam Raise Project
Engineering Documentation Report

****** TOTAL PROJECT COST SUMMARY ****** 03/29/2007

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE FEASIBILITY REPORT, NED PLAN
PROJECT: FOLSOM DAM, 3.5' Raise and Replace 3 Emerg. Gates — U. S. ARMY CORPS OF ENGINEER, SACRAMENTO DISTRICT
LOCATION: CALIFORNIA — P.O.C. JOE W.YEE, CHIEF, COST ENGINEERING

Current MCACES Estimate Prepared: 1-Oct-2006
Effective Price Level (EPL): 1-Oct-2006

ACCOUNT NO.	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	FULLY FUNDED ESTIMATE..(3..... COST ($K)	CNTG ($K)	FULL ($K)
	FEDERAL COSTS							
4	Dams	49,054	24,650	50	73,704	58,761	29,528	88,289
6	FISH AND WILDLIFE, MI	34,296	18,779	55	53,075	42,955	23,931	66,886
8	ROADS/RAILROADS/BRIDGES	45,324	4,533	10	49,857	46,628	4,663	51,291
18	CULT. RESRC PRESERV. (1	1,450	437	30	1,887	1,755	527	2,282
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	130,124	48,399		178,523	150,099	58,649	208,748
1	LANDS AND DAMAGES (2	333	50	15	383	402	62	464
30	PLAN/ENGINEERING/DESIGN	50,230	2,482	19	52,712	52,156	2,863	55,021
31	CONSTRUCTION MANAGE'MT	11,748	4,593	39	16,341	14,773	6,210	20,983
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	192,435	55,524		247,959	217,432	67,784	285,216
	NON-FEDERAL CONTRIBUTION	61,387	18,962		80,349	69,842	23,174	93,016
	TOTAL FEDERAL COSTS	$131,048	$36,562		$167,610	$147,590	$44,610	$192,200
	NON-FEDERAL COSTS							
1	LANDS AND DAMAGES	8,600	955	11	9,555	8,860	1,003	9,863
2	RELOCATIONS	3,793	379	10	4,172	3,869	387	4,256
8	ROADS/RAILROADS/BRIDGES	28,000	0	0	28,000	28,000	0	28,000
30	PLAN/ENGINEERING/DESIGN	569	57	10	626	576	58	634
31	CONSTRUCTION MANAGE'MT	380	38	10	418	384	39	423
	SUBTOTAL NON-FEDERAL	41,342	1,429		42,771	41,687	1,487	43,174
	NON-FEDERAL CONTRIBUTION	61,387	18,962		80,349	69,842	23,174	93,016
	TOTAL NON-FEDERAL COSTS	$102,729	$20,391		$123,120	$111,530	$24,661	$136,200
	TOTAL FEDERAL & NON-FEDERAL COSTS	$233,777	$56,953		$290,730	$259,120	$69,271	$328,400

GENERAL NOTES

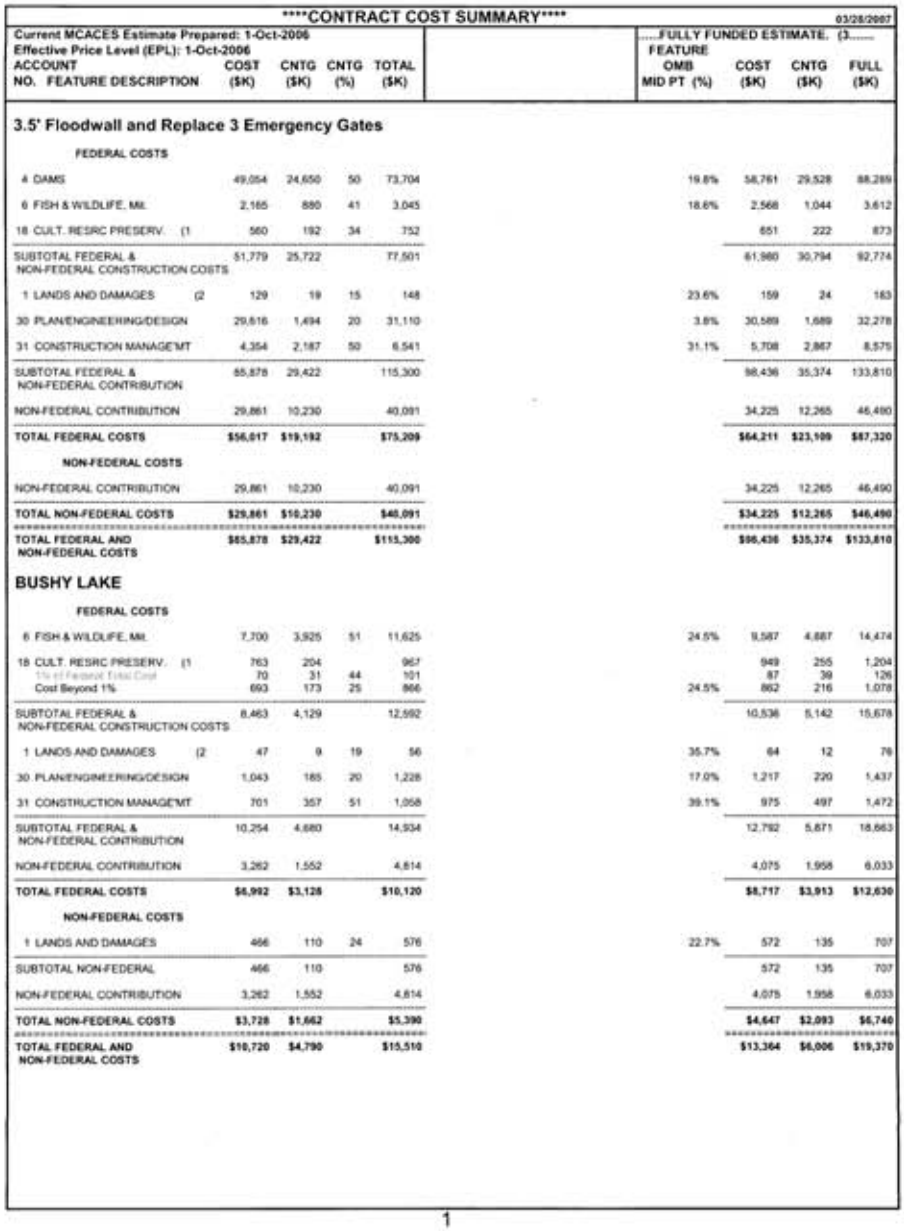
(1 Cultural Resources Preservation costs associated with mitigation and/or data recovery up to one percent of the total Federal cost are not subject to cost sharing.
(2 Federal administrative costs for non-Federal land acquisition.
(3 The Fully Funded cost estimate was prepared in compliance with EC 11-2-191 published in March 2006.
(4 01 Account for Land and Damages cost are from Real Estates.
(5 Feature 3.5' Raise and Replace 3 Emergency Gate - 04 Dams construction cost was based on MCACES dated Oct. 2006; 06 Fish & Wildlife Estimate was prepared by Environmental.
(6 Feature Bushy and Wood Lake - 06 Fish and Wildlife construction cost estimates was based on MCACES dated Jul. 2001 and Labor and Equipment adjusted on Nov. 2006.
(7 Feature Temperature Shutters - 06 Fish and Wildlife construction cost estimates was based on MCACES dated Nov. 2006.
(8 Feature Bridges - Estimate is based on the latest Project Cost Estimate (PCE price level Oct 2006) is presently in construction phase.
(9 30 Account Planning, Engineering and Design and 31 Account Construction Management cost was provided by its respective organizations.
(10 Total Sunk Cost as of Sept. 30, 2006 is $37,041K

CONTINGENCY RATIONALE

(A NORMAL DESIGN VARIANCES ARE EXPECTED - 20% NORMAL CONTINGENCY VALUES USED. (IN ACCOURDANCE WITH EI 01 D 010 -TABLE 13-1). DUE TO HIGHER REALIZED INFLATION THAN PROVIDED BY CWCCIS HISTORIC INFLATION RATE, A 3% COMPOUNDED PER YEAR INFLATION RATE WAS ADDED EQUALING A 50% TO 65% CONTINGENCY.
THE 3% WAS BASED ON THE ESTIMATED DIFFERENCES BETWEEN ENR NEWS RECORD, CALIFORNIA CONSTRUCTION COST INDEX AND CWCCIS HISTORIC RATE.

CHIEF, COST ENGINEERING — 3/28/07 — CHIEF, ENGINEERING DIVISION

The estimate was prepared in accordance with current guidance. The estimate has undergone an independent technical review.



****CONTRACT COST SUMMARY****

03/28/2007

Current MCACES Estimate Prepared: 1-Oct-2006
Effective Price Level (EPL): 1-Oct-2006

ACCOUNT NO.	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	FEATURE OMB MID PT (%)	FULLY FUNDED ESTIMATE: (3..... COST ($K)	CNTG ($K)	FULL ($K)
3.5' Floodwall and Replace 3 Emergency Gates									
	FEDERAL COSTS								
4	DAMS	49,054	24,650	50	73,704	19.8%	58,761	29,528	88,289
6	FISH & WILDLIFE, MI	2,165	880	41	3,045	18.6%	2,568	1,044	3,612
18	CULT. RESRC PRESERV. (1	560	192	34	752		651	222	873
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	51,779	25,722		77,501		61,980	30,794	92,774
1	LANDS AND DAMAGES (2	129	19	15	148	23.6%	159	24	183
30	PLAN/ENGINEERING/DESIGN	29,616	1,494	20	31,110	3.8%	30,589	1,689	32,278
31	CONSTRUCTION MANAGE'MT	4,354	2,187	50	6,541	31.1%	5,708	2,867	8,575
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	85,878	29,422		115,300		98,436	35,374	133,810
	NON-FEDERAL CONTRIBUTION	29,861	10,230		40,091		34,225	12,265	46,490
	TOTAL FEDERAL COSTS	**$56,017**	**$19,192**		**$75,209**		**$64,211**	**$23,109**	**$87,320**
	NON-FEDERAL COSTS								
	NON-FEDERAL CONTRIBUTION	29,861	10,230		40,091		34,225	12,265	46,490
	TOTAL NON-FEDERAL COSTS	**$29,861**	**$10,230**		**$40,091**		**$34,225**	**$12,265**	**$46,490**
	TOTAL FEDERAL AND NON-FEDERAL COSTS	**$85,878**	**$29,422**		**$115,300**		**$98,436**	**$35,374**	**$133,810**
BUSHY LAKE									
	FEDERAL COSTS								
6	FISH & WILDLIFE, MI	7,700	3,925	51	11,625	24.5%	9,587	4,887	14,474
18	CULT. RESRC PRESERV. (1	763	204		967		949	255	1,204
	1% of Federal Total Cost	70	31	44	101		87	39	126
	Cost Beyond 1%	693	173	25	866	24.5%	862	216	1,078
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	8,463	4,129		12,592		10,536	5,142	15,678
1	LANDS AND DAMAGES (2	47	9	19	56	35.7%	64	12	76
30	PLAN/ENGINEERING/DESIGN	1,043	185	20	1,228	17.0%	1,217	220	1,437
31	CONSTRUCTION MANAGE'MT	701	357	51	1,058	39.1%	975	497	1,472
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	10,254	4,680		14,934		12,792	5,871	18,663
	NON-FEDERAL CONTRIBUTION	3,262	1,552		4,814		4,075	1,958	6,033
	TOTAL FEDERAL COSTS	**$6,992**	**$3,128**		**$10,120**		**$8,717**	**$3,913**	**$12,630**
	NON-FEDERAL COSTS								
1	LANDS AND DAMAGES	466	110	24	576	22.7%	572	135	707
	SUBTOTAL NON-FEDERAL	466	110		576		572	135	707
	NON-FEDERAL CONTRIBUTION	3,262	1,552		4,814		4,075	1,958	6,033
	TOTAL NON-FEDERAL COSTS	**$3,728**	**$1,662**		**$5,390**		**$4,647**	**$2,093**	**$6,740**
	TOTAL FEDERAL AND NON-FEDERAL COSTS	**$10,720**	**$4,790**		**$15,510**		**$13,364**	**$6,006**	**$19,370**

1

******CONTRACT COST SUMMARY(CONT'D)******

Current MCACES Estimate Prepared: 1-Oct-2006
Effective Price Level (EPL): 1-Oct-2006

ACCOUNT NO.	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	FEATURE OMB MID PT (%)	FULLY FUNDED ESTIMATE. (3..... COST ($K)	CNTG ($K)	FULL ($K)
WOOD LAKE									
	FEDERAL COSTS								
6	FISH & WILDLIFE, Mit.	3,797	2,127	56	5,924	27.2%	4,829	2,705	7,534
18	CULT. RESRC PRESERV. (1	127	41		168		155	50	205
	1% of Federal Total Cost	36	17	47	53		46	22	68
	Cost Beyond 1%	91	24	26	115	19.1%	109	28	137
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	3,924	2,168		6,092		4,984	2,755	7,739
1	LANDS AND DAMAGES (2	52	11	21	63	41.3%	74	15	89
30	PLAN/ENGINEERING/DESIGN	598	108	20	706	19.0%	709	131	840
31	CONSTRUCTION MANAGE'MT	425	238	56	663	43.6%	610	342	952
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	4,999	2,525		7,524		6,377	3,243	9,620
	NON-FEDERAL CONTRIBUTION	1,398	826		2,224		1,790	1,060	2,850
	TOTAL FEDERAL COSTS	**$3,601**	**$1,699**		**$5,300**		**$4,587**	**$2,183**	**$6,770**
	NON-FEDERAL COSTS								
1	LANDS AND DAMAGES	522	84	16	606	25.4%	655	105	760
	SUBTOTAL NON-FEDERAL	522	84		606		655	105	760
	NON-FEDERAL CONTRIBUTION	1,398	826		2,224		1,790	1,060	2,850
	TOTAL NON-FEDERAL COSTS	**$1,920**	**$910**		**$2,830**		**$2,445**	**$1,165**	**$3,610**
	TOTAL FEDERAL AND NON-FEDERAL COSTS	**$5,521**	**$2,609**		**$8,130**		**$7,032**	**$3,348**	**$10,380**
TEMPERATURE CONTROL SHUTTERS									
	FEDERAL COSTS								
6	FISH & WILDLIFE, Mit.	17,790	11,563	65	29,353	29.8%	23,087	15,007	38,094
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	17,790	11,563		29,353		23,087	15,007	38,094
30	PLAN/ENGINEERING/DESIGN	2,704	541	20	3,245	22.6%	3,316	663	3,979
31	CONSTRUCTION MANAGE'MT	2,153	1,399	65	3,552	48.3%	3,192	2,075	5,267
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	22,647	13,503		36,150		29,595	17,745	47,340
	NON-FEDERAL CONTRIBUTION	7,926	4,724		12,650		10,358	6,212	16,570
	TOTAL FEDERAL COSTS	**$14,721**	**$8,779**		**$23,500**		**$19,237**	**$11,533**	**$30,770**
	NON-FEDERAL COSTS								
	NON-FEDERAL CONTRIBUTION	7,926	4,724		12,650		10,358	6,212	16,570
	TOTAL NON-FEDERAL COSTS	**$7,926**	**$4,724**		**$12,650**		**$10,358**	**$6,212**	**$16,570**
	TOTAL FEDERAL AND NON-FEDERAL COSTS	**$22,647**	**$13,503**		**$36,150**		**$29,595**	**$17,745**	**$47,340**

******CONTRACT COST SUMMARY(CONT'D)******

Current MCACES Estimate Prepared: 1-Oct-2006
Effective Price Level (EPL): 1-Oct-2006

ACCOUNT NO.	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	FEATURE OMB MID PT (%)	FULLY FUNDED ESTIMATE. (3. COST ($K)	CNTG ($K)	FULL ($K)
Folsom Temp. Bridge, Flood Damage Reduction and Dam Safety									
	FEDERAL COSTS								
6	FISH & WILDLIFE, MI.	1,621	162	10	1,783	1.4%	1,644	164	1,808
8	ROADS/RAILROADS/BRIDGES	40,587	4,059	10	44,646	2.8%	41,712	4,171	45,883
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	42,208	4,221		46,429		43,356	4,335	47,691
30	PLAN/ENGINEERING/DESIGN	8,276	77	10	8,353	0.4%	8,305	80	8,385
31	CONSTRUCTION MANAGE'MT	3,598	360	10	3,958	4.2%	3,749	375	4,124
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	54,082	4,658		58,740		55,410	4,790	60,200
	NON-FEDERAL CONTRIBUTION	18,940	1,630		20,570		19,394	1,679	21,073
	TOTAL FEDERAL COSTS	**$35,142**	**$3,028**		**$38,170**		**$36,016**	**$3,111**	**$39,127**
	NON-FEDERAL COSTS								
	NON-FEDERAL CONTRIBUTION	18,940	1,630		20,570		19,394	1,679	21,073
	TOTAL NON-FEDERAL COSTS	**$18,940**	**$1,630**		**$20,570**		**$19,394**	**$1,679**	**$21,073**
	TOTAL FEDERAL AND NON-FEDERAL COSTS	**$54,082**	**$4,658**		**$58,740**		**$55,410**	**$4,790**	**$60,200**
Bridge, Permanent Bridge Only									
	FEDERAL COSTS								
6	FISH & WILDLIFE, MI.	1,223	122	10	1,345	1.4%	1,240	124	1,364
8	ROADS/RAILROADS/BRIDGES	4,737	474	10	5,211	3.8%	4,916	492	5,408
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	5,960	596		6,556		6,156	616	6,772
1	LANDS AND DAMAGES (2	105	11	10	116	0.0%	105	11	116
30	PLAN/ENGINEERING/DESIGN	7,993	77	10	8,070	0.4%	8,022	80	8,102
31	CONSTRUCTION MANAGE'MT	517	52	10	569	4.2%	539	54	593
	TOTAL FEDERAL COSTS	**$14,575**	**$736**		**$15,311**		**$14,822**	**$761**	**$15,583**
	NON-FEDERAL COSTS								
1	LANDS AND DAMAGES	7,612	761	10	8,373	0.3%	7,633	763	8,396
2	RELOCATIONS	3,793	379	10	4,172	2.0%	3,869	387	4,256
30	PLAN/ENGINEERING/DESIGN	569	57	10	626	1.3%	576	58	634
31	CONSTRUCTION MANAGE'MT	380	38	10	418	3.1%	392	39	431
	TOTAL NON-FEDERAL COSTS	**$12,354**	**$1,235**		**$13,589**		**$12,470**	**$1,247**	**$13,717**
	TOTAL FEDERAL AND NON-FEDERAL COSTS	**$26,929**	**$1,971**		**$28,900**		**$27,292**	**$2,008**	**$29,300**
Funds Provided By User									
	NON-FEDERAL COSTS								
8	ROADS/RAILROADS/BRIDGES	28,000	0	0	28,000	0.0%	28,000	0	28,000
	TOTAL NON-FEDERAL COSTS	**$28,000**	**$0**		**$28,000**		**$28,000**	**$0**	**$28,000**
	TOTAL FEDERAL AND NON-FEDERAL COSTS	**$28,000**	**$0**		**$28,000**		**$28,000**	**$0**	**$28,000**

DETAILED ESTIMATE OF FIRST COST

03/28/2007

Effective Price Level (EPL) 1-Oct-2006

3.5' Floodwall and Replace 3 Emergency Gates

FEDERAL

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASON
01	**LANDS AND DAMAGES**							
0120	Project Design Memorandum (PDM)							
012003	Real Estate Analysis Documents							
01200301	Real Estate Supplement/Plan				17,600	2,600	14.8	-
01200302	Gross Appraisal/Report				6,200	900	14.5	-
01200303	Prelim Real Estate Acquistn Maps				5,200	800	15.4	-
01200305	Prelim Attys Opinion of Compnsbl				2,800	400	14.3	-
01200307	All Other Real Estate Analy/Docs				10,400	1,600	15.4	-
012303	CONSTRUCTION CONTRACT(S) DOCUMENTS							
01230302	Real Estate Acquisition Documents				4,500	700	15.6	-
01230312	Real Estate Rts Project Related Admin Doc.				82,200	12,100	14.7	-
	Subtotal, Construction Costs:				$128,900			
	Contingencies @ average of	14.8 % +/- *				$19,100		
01	**LANDS AND DAMAGES**			**TOTAL:**		**$148,000**		
04	**DAMS**							
0402	**Spillway, Machinery Deck**							
040201	Mob., Demob. and Preparatory Work:	1	JOB	LS	255,500	130,305	51.0	-
040208	Bridges, Redial Gate Machinery							
04020802	Site Work							
	INSTALL NEW RADIAL GATE MACHINRY							
	New Deck Anchor Bolts (4 Sets)	64	EA	260	16,640	8,486	51.0	-
	Purchase Radial Gate Mach,7.5HP	3	SET	1,531,300	4,593,900	2,342,889	51.0	-
	Assembl Mach Modules,Interm Pier	3	ASY	39,000	117,000	59,670	51.0	-
	Assembl Mach Modules,End Piers	1	ASY	36,400	36,400	18,564	51.0	-
	Install Mech/Deck Modules @Piers	4	ASY	25,050	100,200	51,102	51.0	-
	PUR RADIAL GATE MACHINERY, SPARE							
	Purch Spare Falk 465 Gear Set	1	EA	106,200	106,200	54,162	51.0	-
	Purch Spare Hoist Motor, 7.5 HP	1	EA	6,780	6,780	3,458	51.0	-
04020817	Electrical							
	Radial Gate Electrical System	3	EA	30,600	91,800	46,818	51.0	-
040299	Associated General Items							
04029902	Site Work							
	Remove & Store Jib Cranes	3	EA	3,430	10,290	5,248	51.0	-
	Set/Remove Safety Net(For Removl	4	EA	4,650	18,600	9,486	51.0	-
	Remove GateChain Hoist Machinery	7	ASY	8940	62,580	31,916	51.0	-
	Remove Hoist Deck & Handrail	3	SET	50,810	152,430	77,739	51.0	-
0403	**Spillway, Replace 3 Emergency Gates**							
040301	Mob., Demob. and Preparatory Work:	1	JOB	LS	1,105,300	563,703	51.0	-
040308	Bridges, Redial Gate Machinery							
04030802	Site Work							
	DEMO TAINTER GATES							
	Install Tntr Gate Upstr Stplgs	3	EA	6,130	18,390	9,379	51.0	-
	Set/Remove Safety Net	3	EA	4,650	13,950	7,115	51.0	-
	Prep Tntr Gates For Removal	3	EA	43,570	130,710	66,662	51.0	-
	Remove Tainter Gates, 3 EA	3	EA	228,380	685,140	349,421	51.0	-
	Slvge Metal Tntr Gates, 3EA	337.5	TN	730	246,375	125,651	51.0	-
	DEMO TAINTR GATE SEAL GUIDES							
	Conc Sawcut, 2"Deep, Gate Guides	850	LF	82	69,700	35,547	51.0	-
	Concrete Demo, Hand Tool, 12"Dp	850	CF	630	535,500	273,105	51.0	-
	DEMO TRUNNION CONC, 6 EA	365	CF	2,550	930,750	474,683	51.0	-
04034103	Concrete							
	Lower Pier Extension							
	Concrete	810	CY	2,830	2,292,300	1,169,073	51.0	-

DETAILED ESTIMATE OF FIRST COST(Cont'd)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASON
	Effective Price Level (EPL) 1-Oct-2006							
	Upper Pier Extension							
	Concrete	1,065	CY	1,500	1,597,500	814,725	51.0	-
04034105	Metal							
	Tainter Gates 3 EA							
	Tainter Gate Guides	425	LF	1,070	454,750	231,923	51.0	-
	Trunnion Block and Anchorage	3	SET	1,739,000	5,217,000	2,660,670	51.0	-
	Tainter Gates 3 EA	945,600	LB	9.20	8,699,520	4,436,544	51.0	-
	Trunnion Catwalk	3	EA	36,060	108,180	55,172	51.0	-
04034115	Mechanical							
	Tainter Gate Stoplogs	2	SET	1,465,000	2,930,000	1,494,300	51.0	-
0450	**3.5' FLOODWALLS**							
045001	Mob., Demob. and Preparatory Work:	1	JOB	LS	1,040,000	509,600	49.0	-
045A	DIKE 1							
045A02	Site Work:							
	Security Fencing	100	LF	223	22,300	10,927	49.0	-
	Traffic Control	1	JOB	LS	42,000	20,580	49.0	-
	Silt Fence	2,600	LF	8	20,800	10,192	49.0	-
	Floodwall Excavation							
	Stripping	1,060	CY	13.40	14,204	6,960	49.0	-
	Excavation	2,680	CY	13.40	35,912	17,597	49.0	-
	Trench Excavation	190	CY	13.40	2,546	1,248	49.0	-
	Floodwall Backfill							
	Random	1,350	CY	21.20	28,620	14,024	49.0	-
	Filter Material	320	CY	66	21,120	10,349	49.0	-
	Slope Protection	1,250	CY	80	100,000	49,000	49.0	-
	Top of Dike Access							
	Demo	1,930	CY	43	82,990	40,665	49.0	-
	Road Base (6" section)	1,450	CY	55	79,750	39,078	49.0	-
	Road Surfacing (2" section)	480	CY	283	135,840	66,562	49.0	-
045A03	Concrete							
	Flood Slab Concrete							
	Concrete	675	CY	403	272,025	133,292	49.0	-
	Reinforcing Steel	101,250	LB	1.90	192,375	94,264	49.0	-
	Flood Wall Concrete							
	Concrete	530	CY	914	484,420	237,366	49.0	-
	Reinforcing Steel	79,500	LB	1.90	151,050	74,015	49.0	-
	Anti-Graffiti	18,200	SF	8.80	160,160	78,478	49.0	-
045B	DIKE 2							
045B02	Site Work:							
	Security Fencing	100	LF	223	22,300	10,927	49.0	-
	Traffic Control	1	JOB	LS	27,600	13,524	49.0	-
	Silt Fence	2,000	LF	8	16,000	7,840	49.0	-
	Floodwall Excavation							
	Stripping	1,560	CY	13.40	20,904	10,243	49.0	-
	Excavation	4,220	CY	13.40	56,548	27,709	49.0	-
	Trench Excavation	150	CY	13.40	2,010	985	49.0	-
	Floodwall Backfill							
	Random	1,040	CY	21.20	22,048	10,804	49.0	-
	Filter Material C	960	CY	66	63,360	31,046	49.0	-
	Filter Material F	740	CY	66	48,840	23,932	49.0	-
	Slope Protection	960	CY	80	76,800	37,632	49.0	-
	Top of Dike Access							
	Demo	290	CY	44	12,760	6,252	49.0	-
	Random Fill	960	CY	21.20	20,352	9,972	49.0	-
	Road Base (6" section)	220	CY	55	12,100	5,929	49.0	-
	Road Surfacing (2" section)	70	CY	283	19,810	9,707	49.0	-
045B03	Concrete							
	Flood Slab Concrete							
	Concrete	520	CY	435	226,200	110,838	49.0	-
	Reinforcing Steel	78,000	LB	1.90	148,200	72,618	49.0	-
	Flood Wall Concrete							
	Concrete	410	CY	908	372,280	182,417	49.0	-
	Reinforcing Steel	61,500	LB	1.90	116,850	57,257	49.0	-
	Anti-Graffiti	14,000	SF	8.80	123,200	60,368	49.0	-

DETAILED ESTIMATE OF FIRST COST(Cont'd)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASON
	Effective Price Level (EPL) 1-Oct-2006							
045C	DIKE 3							
045C02	Site Work:							
	Security Fencing	100	LF	223	22,300	10,927	49.0	-
	Traffic Control	1	JOB	LS	26,500	12,985	49.0	-
	Silt Fence	1,900	LF	8	15,200	7,448	49.0	-
	Floodwall Excavation							
	Stripping	745	CY	13.40	9,983	4,892	49.0	-
	Excavation	1,960	CY	13.40	26,264	12,869	49.0	-
	Trench Excavation	140	CY	13.40	1,876	919	49.0	-
	Floodwall Backfill							
	Random	985	CY	21.20	20,882	10,232	49.0	-
	Filter Material	230	CY	66	15,180	7,438	49.0	-
	Slope Protection	915	CY	80	73,200	35,868	49.0	-
	Top of Dike Access							
	Demo	870	CY	44	38,280	18,757	49.0	-
	Random Fill	2,890	CY	21.20	61,268	30,021	49.0	-
	Road Base (6" section)	650	CY	55	35,750	17,518	49.0	-
	Road Surfacing (2" section)	220	CY	283	62,260	30,507	49.0	-
045C03	Concrete							
	Flood Slab Concrete							
	Concrete	495	CY	400	198,000	97,020	49.0	-
	Reinforcing Steel	74,250	LB	1.90	141,075	69,127	49.0	-
	Flood Wall Concrete							
	Concrete	390	CY	910	354,900	173,901	49.0	-
	Reinforcing Steel	58,500	LB	1.90	111,150	54,464	49.0	-
	Anti-Graffiti	13,300	SF	8.80	117,040	57,350	49.0	-
045D	DIKE 4							
045D02	Site Work:							
	Security Fencing	100	LF	223	22,300	10,927	49.0	-
	Traffic Control	1	JOB	LS	21,100	10,339	49.0	-
	Silt Fence	1,400	LF	8	11,200	5,488	49.0	-
	Floodwall Excavation							
	Stripping	570	CY	13.40	7,638	3,743	49.0	-
	Excavation	1,440	CY	13.40	19,296	9,455	49.0	-
	Trench Excavation	105	CY	13.40	1,407	689	49.0	-
	Floodwall Backfill							
	Random	730	CY	21.20	15,476	7,583	49.0	-
	Filter Material	170	CY	66	11,220	5,498	49.0	-
	Slope Protection	675	CY	80	54,000	26,460	49.0	-
045D03	Concrete							
	Flood Slab Concrete							
	Concrete	360	CY	404	145,440	71,266	49.0	-
	Reinforcing Steel	54,000	LB	1.90	102,600	50,274	49.0	-
	Flood Wall Concrete							
	Concrete	285	CY	915	260,775	127,780	49.0	-
	Reinforcing Steel	42,750	LB	1.90	81,225	39,800	49.0	-
	Anti-Graffiti	9,800	SF	8.80	86,240	42,258	49.0	-
045E	DIKE 5							
045E02	Site Work:							
	Security Fencing	100	LF	223	22,300	10,927	49.0	-
	Traffic Control	1	JOB	LS	28,700	14,063	49.0	-
	Silt Fence	2,100	LF	8	16,800	8,232	49.0	-
	Floodwall Excavation							
	Stripping	860	CY	13.40	11,524	5,647	49.0	-
	Excavation	2,160	CY	13.40	28,944	14,183	49.0	-
	Trench Excavation	160	CY	13.40	2,144	1,051	49.0	-
	Floodwall Backfill							
	Random	1,090	CY	21.20	23,108	11,323	49.0	-
	Filter Material	290	CY	66	19,140	9,379	49.0	-
	Slope Protection	1,010	CY	80	80,800	39,592	49.0	-
045E03	Concrete							
	Flood Slab Concrete							
	Concrete	545	CY	400	218,000	106,820	49.0	-
	Reinforcing Steel	81,750	LB	1.90	155,325	76,109	49.0	-
	Flood Wall Concrete							
	Concrete	430	CY	910	391,300	191,737	49.0	-
	Reinforcing Steel	64,500	LB	1.90	122,550	60,050	49.0	-
	Anti-Graffiti	14,700	SF	8.80	129,360	63,386	49.0	-

DETAILED ESTIMATE OF FIRST COST(Cont'd)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASON
	Effective Price Level (EPL) 1-Oct-2006							
045F	DIKE 6							
045F02	Site Work:							
	Security Fencing	100	LF	223	22,300	10,927	49.0	-
	Traffic Control	1	JOB	LS	23,400	11,466	49.0	-
	Silt Fence	1,610	LF	8	12,880	6,311	49.0	-
	Floodwall Excavation							
	Stripping	660	CY	13.40	8,844	4,334	49.0	-
	Excavation	1,660	CY	13.40	22,244	10,900	49.0	-
	Trench Excavation	120	CY	13.40	1,608	788	49.0	-
	Floodwall Backfill							
	Random	835	CY	21.20	17,702	8,674	49.0	-
	Filter Material	200	CY	66	13,200	6,468	49.0	-
	Slope Protection	775	CY	80	62,000	30,380	49.0	-
	Top of Dike Access							
	Demo	590	CY	44	25,960	12,720	49.0	-
	Road Base (6" section)	445	CY	55	24,475	11,993	49.0	-
	Road Surfacing (2" section)	150	CY	283	42,450	20,801	49.0	-
045F03	Concrete							
	Flood Slab Concrete							
	Concrete	420	CY	400	168,000	82,320	49.0	-
	Reinforcing Steel	241,500	LB	1.90	458,850	224,837	49.0	-
	Flood Wall Concrete							
	Concrete	330	CY	910	300,300	147,147	49.0	-
	Reinforcing Steel	49,500	LB	1.90	94,050	46,085	49.0	-
	Anti-Graffiti	11,270	SF	8.80	99,176	48,596	49.0	-
045G	DIKE 7							
045G02	Site Work:							
	Security Fencing	100	LF	223	22,300	10,927	49.0	-
	Traffic Control	1	JOB	LS	15,800	7,742	49.0	-
	Silt Fence	915	LF	8	7,320	3,587	49.0	-
	Floodwall Excavation							
	Stripping	370	CY	14.30	5,291	2,593	49.0	-
	Excavation	940	CY	14.30	13,442	6,587	49.0	-
	Trench Excavation	70	CY	14.30	1,001	490	49.0	-
	Floodwall Backfill							
	Random	475	CY	21.20	10,070	4,934	49.0	-
	Filter Material	110	CY	66	7,260	3,557	49.0	-
	Slope Protection	440	CY	80	35,200	17,248	49.0	-
045G03	Concrete							
	Flood Slab Concrete							
	Concrete	240	CY	400	96,000	47,040	49.0	-
	Reinforcing Steel	36,000	LB	1.90	68,400	33,516	49.0	-
	Flood Wall Concrete							
	Concrete	190	CY	900	171,000	83,790	49.0	-
	Reinforcing Steel	28,500	LB	1.90	54,150	26,534	49.0	-
	Anti-Graffiti	6,405	SF	8.80	56,364	27,618	49.0	-
045H	DIKE 8							
045H02	Site Work:							
	Security Fencing	100	LF	223	22,300	10,927	49.0	-
	Traffic Control	1	JOB	LS	15,800	7,742	49.0	-
	Silt Fence	910	LF	8	7,280	3,567	49.0	-
	Floodwall Excavation							
	Stripping	370	CY	13.40	4,958	2,429	49.0	-
	Excavation	940	CY	13.40	12,596	6,172	49.0	-
	Trench Excavation	70	CY	13.40	938	460	49.0	-
	Floodwall Backfill							
	Random	470	CY	21.20	9,964	4,882	49.0	-
	Filter Material	110	CY	66	7,260	3,557	49.0	-
	Slope Protection	440	CY	80	35,200	17,248	49.0	-
045H03	Concrete							
	Flood Slab Concrete							
	Concrete	240	CY	400	96,000	47,040	49.0	-
	Reinforcing Steel	36,000	LB	1.90	68,400	33,516	49.0	-
	Flood Wall Concrete							
	Concrete	185	CY	916	169,460	83,035	49.0	-
	Reinforcing Steel	27,750	LB	1.90	52,725	25,835	49.0	-
	Anti-Graffiti	6,370	SF	8.80	56,056	27,467	49.0	-

DETAILED ESTIMATE OF FIRST COST(Cont'd)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASON
	Effective Price Level (EPL) 1-Oct-2006							
045I	Right Wing Dam							
045I02	Site Work:							
	Security Fencing	100	LF	223	22,300	10,927	49.0 -	
	Traffic Control	1	JOB	LS	80,200	39,298	49.0 -	
	Silt Fence	6,850	LF	8	54,800	26,852	49.0 -	
	Floodwall Excavation							
	Stripping	2,790	CY	13.40	37,386	18,319	49.0 -	
	Excavation	7,050	CY	13.40	94,470	46,290	49.0 -	
	Trench Excavation	510	CY	13.40	6,834	3,349	49.0 -	
	Floodwall Backfill							
	Random	3,550	CY	21.20	75,260	36,877	49.0 -	
	Filter Material	840	CY	66	55,440	27,166	49.0 -	
	Slope Protection	3,300	CY	80	264,000	129,360	49.0 -	
045I03	Concrete							
	Flood Slab Concrete							
	Concrete	1,780	CY	400	712,000	348,880	49.0 -	
	Reinforcing Steel	267,000	LB	1.90	507,300	248,577	49.0 -	
	Flood Wall Concrete							
	Concrete	1,395	CY	915	1,276,425	625,448	49.0 -	
	Reinforcing Steel	209,250	LB	1.90	397,575	194,812	49.0 -	
	Anti-Graffiti	47,950	SF	8.80	421,960	206,760	49.0 -	
045J	Left Wing Dam							
045J02	Site Work:							
	Security Fencing	100	LF	223	22,300	10,927	49.0 -	
	Traffic Control	1	JOB	LS	27,200	13,328	49.0 -	
	Silt Fence	2,150	LF	8	17,200	8,428	49.0 -	
	Floodwall Excavation							
	Stripping	880	CY	13.40	11,792	5,778	49.0 -	
	Excavation	2,215	CY	13.40	29,681	14,544	49.0 -	
	Trench Excavation	160	CY	13.40	2,144	1,051	49.0 -	
	Floodwall Backfill							
	Random	1,115	CY	21.20	23,638	11,583	49.0 -	
	Filter Material	260	CY	66	17,160	8,408	49.0 -	
	Slope Protection	1,035	CY	80	82,800	40,572	49.0 -	
045J03	Concrete							
	Flood Slab Concrete							
	Concrete	560	CY	400	224,000	109,760	49.0 -	
	Reinforcing Steel	84,000	LB	1.90	159,600	78,204	49.0 -	
	Flood Wall Concrete							
	Concrete	440	CY	912	401,280	196,627	49.0 -	
	Reinforcing Steel	66,000	LB	1.90	125,400	61,446	49.0 -	
	Anti-Graffiti	15,050	SF	8.80	132,440	64,896	49.0 -	
045K	MIAD							
045K02	Site Work:							
	Security Fencing	100	LF	223	22,300	10,927	49.0 -	
	Traffic Control	1	JOB	LS	59,300	29,057	49.0 -	
	Silt Fence	4,925	LF	8	39,400	19,306	49.0 -	
	Floodwall Excavation							
	Stripping	2,010	CY	13.40	26,934	13,198	49.0 -	
	Excavation	5,070	CY	13.40	67,938	33,290	49.0 -	
	Trench Excavation	365	CY	13.40	4,891	2,397	49.0 -	
	Floodwall Backfill							
	Random	2,555	CY	22.40	57,232	28,044	49.0 -	
	Filter Material C	600	CY	67	40,200	19,698	49.0 -	
	Filter Material F	600	CY	67	40,200	19,698	49.0 -	
	Slope Protection	2,370	CY	81	191,970	94,065	49.0 -	
045K03	Concrete							
	Flood Slab Concrete							
	Concrete	1,280	CY	400	512,000	250,880	49.0 -	
	Reinforcing Steel	192,000	LB	1.90	364,800	178,752	49.0 -	
	Flood Wall Concrete							
	Concrete	1,000	CY	917	917,000	449,330	49.0 -	
	Reinforcing Steel	150,000	LB	1.90	285,000	139,650	49.0 -	
	Anti-Graffiti	34,475	SF	8.80	303,380	148,656	49.0 -	
	Subtotal, Construction Costs:				$49,053,783			
	Contingencies @ average of	50.3 % +/- *				$24,650,217		A

DETAILED ESTIMATE OF FIRST COST(Cont'd)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASON
	Effective Price Level (EPL) 1-Oct-2006							
04	**DAMS**			**TOTAL:**		**$73,704,000**		
06	**FISH AND WILDLIFE FACILITIES, Mitigation**							
0603	**WILDLIFE FACILITIES AND SANCTURARIES,**							
060373	Habitat and Feeding Facilities:							
06037302	Site Work:							
	Raise							
	Mitigation							
	Oak Woodland	1	JOB	LS	1,654,200	777,614	47.0	-
	Seasonal Wetland	1	JOB	LS	1,530	719	47.0	-
	VELB	1	JOB	LS	560	263	47.0	-
	Real Estate							
	Oak Woodland	1	JOB	LS	507,870	101,574	20.0	-
	Seasonal Wetland	1	JOB	LS	478	96	20.1	-
	VELB	1	JOB	LS	80	16	20.0	-
	Subtotal, Construction Costs:				$2,164,718			
	Contingencies @ average of	40.7 % +/- *				$880,282		
06	**FISH AND WILDLIFE FACILITIES, Mitigation**			**TOTAL:**		**$3,045,000**		
18	**CULTURAL RESOURCE PRESERVATION**							
	1% of Federal Obligations				560,000	192,000	34.3	
	Subtotal, Construction Costs:				$560,000			
	Contingencies @ average of	34.3 % +/- *				$192,000		
18	**CULTURAL RESOURCE PRESERVATION**			**TOTAL:**		**$752,000**		
30	**PLANNING, ENGINEERING & DESIGN**							
30	**PLANNING, ENGINEERING & DESIGN, Sunk Cost**				22,143,733			
302301	PLANS AND SPECIFICATION							
30230101	Surveys and Mapping, except RE				298,050	59,610	20.0	-
30230101	Survey Markers				192,840	38,568	20.0	-
30230101	Hydraulics Studies				350,640	70,128	20.0	-
30230101	Hydrology				175,300	35,060	20.0	-
30230101	Structural Design				52,600	10,520	20.0	-
30230102	Civil Design Analysis				192,840	38,568	20.0	-
30230102	Prepare Specs- Front End				87,650	17,530	20.0	-
30230102	Civil Design Prepare Tec Specs				131,490	26,298	20.0	-
30230102	Civil Design Prepare Plans				306,810	61,362	20.0	-
30230102	Review P&S(ITR)				131,490	26,298	20.0	-
30230104	BCOE Review and Certification				87,650	17,530	20.0	-
30230104	Revise P&S				87,650	17,530	20.0	-
30230105	Geotechnical Studies(Geol and Soils)				350,640	70,128	20.0	-
30230105	Revegetation Plan				407,620	81,524	20.0	-
302304	ENVIRONMENTAL STUDIES DOCUMENTS							
30230401	Coordination w/other agencies				113,960	22,792	20.0	-
30230403	Mitigation Analysis Report				105,190	21,038	20.0	-
30230404	Coordination w/other agencies				131,490	26,298	20.0	-
30230410	NPDES Permit/SPPCP				43,830	8,766	20.0	-
302305	HTRW STUDIES/REPORT							
30230502	HTRW Assessment Report				175,300	35,060	20.0	-
302306	CULTURAL RESOURCE							
30230601	Cultural Resource, Studies Doc.				219,150	43,830	20.0	-
302307	COST ESTIMATE							
30230701	Cost Estimates-Project				175,300	35,060	20.0	-
30230703	Cost Estimates-Contract				175,300	35,060	20.0	-
302308	OTHER STUDIES/INVESTIGATIONS							
30230801	O&M, Plan				87,650	17,530	20.0	-
30230801	Other Studies (ECIFP)				35,060	7,012	20.0	-
302309	CONTRACT AWARD DOCUMENTS							
30230903	Advertise				87,650	17,530	20.0	-
30230903	Repro				43,830	8,766	20.0	-
30230907	Award Contract				17,530	3,506	20.0	-
302310	ENGINEERING & DESIGN DURING				350,640	70,128	20.0	-

DETAILED ESTIMATE OF FIRST COST(Cont'd)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASON
	Effective Price Level (EPL) 1-Oct-2006							
30231402	Amendments to P&S				87,650	17,530	20.0	-
3024	VALUE ENGINEERING ANLYSIS				113,960	22,792	20.0	-
3025	CLOSE OUT							
302501	Physical Closeout Documents				105,190	21,038	20.0	-
302501	Local Sponsor Audit				87,650	17,530	20.0	-
302501	USACE Audit				87,650	17,530	20.0	-
302501	OMRR&R Manual				175,300	35,060	20.0	-
3026	PROGRAMS AND PROJECT MGMT				613,840	122,768	20.0	-
3026	FOLSOM SECURITY				1,095,000	218,953	20.0	-
3026	AIR QUALITY PERMIT 1% OF CONSTRUCTION				490,538	98,108	20.0	-
	Subtotal				$29,615,661			
	Contingencies @ average of	20.0 % +/- *				$1,494,339		
30	**PLANNING, ENGINEERING & DESIGN**			**TOTAL:**		**$31,110,000**		
31	**CONSTRUCTION MANAGEMENT (S & I)**							
312311	SUPERVISION AND ADMINISTRATION							
31231101	Project Office Supervn and Admin				1,451,180	728,771	50.2	-
31231102	Area Office S&A Documents				453,640	227,960	50.3	-
31231103	District Office S&A Documents				90,550	45,503	50.3	-
31231103	Contract Mods & Negotiations				54,420	27,347	50.3	-
3126	PROGRAMS AND PROJECT MGMT							
312601	Proj Mgmt Documents				1,001,320	503,177	50.3	-
312602	Funds Control Documents				181,540	91,226	50.3	-
312603	Trip Reports				90,550	45,503	50.3	-
312604	Upward reporting Documents				54,420	27,347	50.3	-
312605	Budgetary Documents				72,700	36,533	50.3	-
312606	Project Authorization Documents				90,550	45,503	50.3	-
312607	Annual Notification Ltr				45,280	22,754	50.3	-
312608	Fact Sheets				270,790	136,076	50.3	-
312609	Correspondance(Congress/State)				90,550	45,503	50.3	-
312610	Schedule and Cost Changes				108,840	54,694	50.3	-
312611	Project Work Directives				54,420	27,347	50.3	-
312612	Project Closeout Coord Documents				54,420	27,347	50.3	-
312613	Quarterly Cost Rpt to Local Sponsor				90,550	45,503	50.3	-
312614	All Other Programs/PM Documents				54,420	27,347	50.3	-
31261101	Mitigation Construction				43,540	21,879	50.3	-
	Subtotal				$4,353,680			
	Contingencies @ average of	50.2 % +/- *				$2,187,320		
31	**CONSTRUCTION MANAGEMENT (S & I)**			**TOTAL:**		**$6,541,000**		
	BUSHY LAKE							
	FEDERAL							
01	**LANDS AND DAMAGES**				46,646	9,354	20.1	-
	Subtotal, Construction Costs:				$46,646			
	Contingencies @ average of	20.1 % +/- *				$9,354		
01	**LANDS AND DAMAGES**			**TOTAL:**		**$56,000**		
06	**FISH AND WILDLIFE FACILITIES, Restoration**							
0603	WILDLIFE FACILITIES AND SANCTURARIES,							
060373	Habitat and Feeding Facilities:							
06037302	Site Work:							
	Seasonal Wetland	18	AC	60,400	1,087,200	554,472	51.0	-
	Riparian Forest	25	AC	58,800	1,470,000	749,700	51.0	-
	Oakwood Savannah	67	AC	28,900	1,936,300	985,815	50.9	-
	Side Channel	4	AC	107,600	430,400	219,504	51.0	-
	Terrace River Bank	7	AC	185,200	1,296,400	661,164	51.0	-
	Stream Channel	2	AC	60,400	120,800	61,608	51.0	-
	Wetland Treatment System	7.50	AC	125,000	937,500	478,125	51.0	-

DETAILED ESTIMATE OF FIRST COST(Cont'd)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASON
	Effective Price Level (EPL) 1-Oct-2006							
	Pump Delivery System	1	EA	421,200	421,200	214,812	51.0	-
	Subtotal, Construction Costs:				$7,699,800			
	Contingencies @ average of	51.0 % +/- *				$3,925,200		
06	**FISH AND WILDLIFE FACILITIES, Restoration**			**TOTAL:**		**$11,625,000**		
18	**CULTURAL RESOURCE PRESERVATION**							
	1% of Federal Obligations				70,000	31,000	44.3	
	Cost Above 1% of Federal Obligations				692,600	173,400	25.0	-
	Subtotal, Construction Costs:				$762,600			
	Contingencies @ average of	26.8 % +/- *				$204,400		
18	**CULTURAL RESOURCE PRESERVATION**			**TOTAL:**		**$967,000**		
30	**PLANNING, ENGINEERING & DESIGN**							
30	**PLANNING, ENGINEERING & DESIGN, Sunk Cost to Oct. 1 2001**				118,805			
302301	PLANS AND SPECFICATION							
30230101	Surveys and Mapping, except RE				46,780	9,356	20.0	-
30230101	Survey Markers				30,270	6,054	20.0	-
30230101	Hydraulics Studies				55,040	11,008	20.0	-
30230101	Hydrology				27,520	5,504	20.0	-
30230101	Structural Design				8,260	1,652	20.0	-
30230102	Civil Design Analysis				30,270	6,054	20.0	-
30230102	Prepare Specs- Front End				13,760	2,752	20.0	-
30230102	Civil Design Prepare Tec Specs				20,640	4,128	20.0	-
30230102	Civil Design Prepare Plans				48,160	9,632	20.0	-
30230102	Review P&S(ITR)				20,640	4,128	20.0	-
30230104	BCOE Review and Certification				13,760	2,752	20.0	-
30230104	Revise P&S				13,760	2,752	20.0	-
30230105	Geotechnical Studies(Geol and Soils)				55,040	11,008	20.0	-
30230105	Revegetation Plan				63,980	12,796	20.0	-
302304	ENVIRONMENTAL STUDIES DOCUMENTS							
30230401	Coordination w/other agencies				17,890	3,578	20.0	-
30230403	Mitigation Analysis Report				16,510	3,302	20.0	-
30230404	Coordination w/other agencies				20,640	4,128	20.0	-
30230410	NPDES Permit/SPPCP				6,880	1,376	20.0	-
302305	HTRW STUDIES/REPORT							
30230502	HTRW Assessment Report				27,520	5,504	20.0	-
302306	CULTURAL RESOURCE							
30230601	Cultural Resource, Studies Doc.				34,400	6,880	20.0	-
302307	COST ESTIMATE							
30230701	Cost Estimates-Project				27,520	5,504	20.0	-
30230703	Cost Estimates-Contract				27,520	5,504	20.0	-
302308	OTHER STUDIES/INVESTIGATIONS							
30230801	O&M, Plan				13,760	2,752	20.0	-
30230801	Other Studies (ECIFP)				5,500	1,100	20.0	-
302309	CONTRACT AWARD DOCUMENTS							
30230903	Advertise				13,760	2,752	20.0	-
30230903	Repro				6,880	1,376	20.0	-
30230907	Award Contract				2,750	550	20.0	-
302310	ENGINEERING & DESIGN DURING				55,040	11,008	20.0	-
30231402	Amendments to P&S				13,760	2,752	20.0	-
3024	VALUE ENGINEERING ANLYSIS				17,890	3,578	20.0	-
3025	CLOSE OUT							
302501	Physical Closeout Documents				16,510	3,302	20.0	-
302501	Local Sponsor Audit				13,760	2,752	20.0	-
302501	USACE Audit				13,760	2,752	20.0	-
302501	OMRR&R Manual				27,520	5,504	20.0	-
3026	PROGRAMS AND PROJECT MGMT				96,350	19,665	20.4	-
	Subtotal				$1,042,805			
	Contingencies @ average of	20.0 % +/- *				$185,195		
30	**PLANNING, ENGINEERING & DESIGN**			**TOTAL:**		**$1,228,000**		

DETAILED ESTIMATE OF FIRST COST(Cont'd)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASON
	Effective Price Level (EPL) 1-Oct-2006							
31	**CONSTRUCTION MANAGEMENT (S & I)**							
312311	SUPERVISION AND ADMINISTRATION							
31231101	Project Office Supervn and Admin				233,560	119,163	51.0	-
31231102	Area Office S&A Documents				73,010	37,219	51.0	-
31231103	District Office S&A Documents				14,570	7,427	51.0	-
31231103	Contract Mods & Negotiations				8,760	4,466	51.0	-
3126	PROGRAMS AND PROJECT MGMT							
312601	Proj Mgmt Documents				161,160	82,156	51.0	-
312602	Funds Control Documents				29,220	14,896	51.0	-
312603	Trip Reports				14,570	7,427	51.0	-
312604	Upward reporting Documents				8,760	4,466	51.0	-
312605	Budgetary Documents				11,700	5,964	51.0	-
312606	Project Authorization Documents				14,570	7,427	51.0	-
312607	Annual Notification Ltr				7,290	3,716	51.0	-
312608	Fact Sheets				43,580	22,216	51.0	-
312609	Correspondance(Congress/State)				14,570	7,427	51.0	-
312610	Schedule and Cost Changes				17,520	8,931	51.0	-
312611	Project Work Directives				8,760	4,466	51.0	-
312612	Project Closeout Coord Documents				8,760	4,466	51.0	-
312613	Quarterly Cost Rpt to Local Sponsor				14,570	7,427	51.0	-
312614	All Other Programs/PM Documents				8,760	4,466	51.0	-
31261101	Mitigation Construction				7,010	3,574	51.0	-
	Subtotal				$700,700			
	Contingencies @ average of	51.0 % +/- *				$357,300		
31	**CONSTRUCTION MANAGEMENT (S & I)**			**TOTAL:**		**$1,058,000**		
	NON-FEDERAL							
01	**LANDS AND DAMAGES**				466,457	109,543	23.5	-
	Subtotal, Construction Costs:				$466,457			
	Contingencies @ average of	23.5 % +/- *				$109,543		
01	**LANDS AND DAMAGES**			**TOTAL:**		**$576,000**		
	WOOD LAKE							
	FEDERAL							
06	**FISH AND WILDLIFE FACILITIES, Restoration**							
0603	WILDLIFE FACILITIES AND SANCTURARIES,							
060373	Habitat and Feeding Facilities:							
06037302	Site Work:							
	Excavation of Seed Bank	60	AC	22,740	1,364,400	764,879	56.1	-
	Riparian Forest Species	13	AC	56,369	732,797	410,366	56.0	-
	Riparian Oak Woodland Species	16	AC	27,306	436,896	244,242	55.9	-
	Oak Woodland Savannah Species	25	AC	28,572	714,300	400,008	56.0	-
	Seed Grassland	35	AC	11,214	392,490	219,794	56.0	-
	Excavation Artifical Berm	1.50	AC	104,200	156,300	87,528	56.0	-
	Subtotal, Construction Costs:				$3,797,183			
	Contingencies @ average of	56.0 % +/- *				$2,126,817		
06	**FISH AND WILDLIFE FACILITIES, Restoration**			**TOTAL:**		**$5,924,000**		
18	**CULTURAL RESOURCE PRESERVATION**							
	1% of Federal Obligations				36,000	17,000	47.2	
	Cost Above 1% of Federal Obligations				91,100	23,900	26.2	-
	Subtotal, Construction Costs:				$127,100			
	Contingencies @ average of	32.2 % +/- *				$40,900		

DETAILED ESTIMATE OF FIRST COST(Cont'd)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASON
	Effective Price Level (EPL) 1-Oct-2006							
18	**CULTURAL RESOURCE PRESERVATION**			**TOTAL:**		**$168,000**		
30	**PLANNING, ENGINEERING & DESIGN**							
30	**PLANNING, ENGINEERING & DESIGN,**	**Sunk Cost to Oct. 1 2001**			58,515			
302301	PLANS AND SPECFICATION							
30230101	Surveys and Mapping, except RE				27,300	5,460	20.0	-
30230101	Survey Markers				17,660	3,532	20.0	-
30230101	Hydraulics Studies				32,120	6,424	20.0	-
30230101	Hydrology				16,060	3,212	20.0	-
30230101	Structural Design				4,820	964	20.0	-
30230102	Civil Design Analysis				17,660	3,532	20.0	-
30230102	Prepare Specs- Front End				8,030	1,606	20.0	-
30230102	Civil Design Prepare Tec Specs				12,040	2,408	20.0	-
30230102	Civil Design Prepare Plans				28,100	5,620	20.0	-
30230102	Review P&S(ITR)				12,040	2,408	20.0	-
30230104	BCOE Review and Certification				8,030	1,606	20.0	-
30230104	Revise P&S				8,030	1,606	20.0	-
30230105	Geotechnical Studies(Geol and Soils)				32,120	6,424	20.0	-
30230105	Revegetation Plan				37,340	7,468	20.0	-
302304	ENVIRONMENTAL STUDIES DOCUMENTS							
30230401	Coordination w/other agencies				10,440	2,088	20.0	-
30230403	Mitigation Analysis Report				9,640	1,928	20.0	-
30230404	Coordination w/other agencies				12,040	2,408	20.0	-
30230410	NPDES Permit/SPPCP				4,010	802	20.0	-
302305	HTRW STUDIES/REPORT							
30230502	HTRW Assessment Report				16,060	3,212	20.0	-
302306	CULTURAL RESOURCE							
30230601	Cultural Resource, Studies Doc.				20,070	4,014	20.0	-
302307	COST ESTIMATE							
30230701	Cost Estimates-Project				16,060	3,212	20.0	-
30230703	Cost Estimates-Contract				16,060	3,212	20.0	-
302308	OTHER STUDIES/INVESTIGATIONS							
30230801	O&M, Plan				8,030	1,606	20.0	-
30230801	Other Studies (ECIFP)				3,210	642	20.0	-
302309	CONTRACT AWARD DOCUMENTS							
30230903	Advertise				8,030	1,606	20.0	-
30230903	Repro				4,010	802	20.0	-
30230907	Award Contract				1,610	322	20.0	-
302310	ENGINEERING & DESIGN DURING				32,120	6,424	20.0	-
30231402	Amendments to P&S				8,030	1,606	20.0	-
3024	VALUE ENGINEERING ANLYSIS				10,440	2,088	20.0	-
3025	CLOSE OUT							
302501	Physical Closeout Documents				9,640	1,928	20.0	-
302501	Local Sponsor Audit				8,030	1,606	20.0	-
302501	USACE Audit				8,030	1,606	20.0	-
302501	OMRR&R Manual				16,060	3,212	20.0	-
3026	PROGRAMS AND PROJECT MGMT				56,230	11,691	20.8	-
	Subtotal				$597,715			
	Contingencies @ average of	20.1 % +/- *				$108,285		
30	**PLANNING, ENGINEERING & DESIGN**			**TOTAL:**		**$706,000**		
31	**CONSTRUCTION MANAGEMENT (S & I)**							
312311	SUPERVISION AND ADMINISTRATION							
31231101	Project Office Supervn and Admin				141,760	78,984	55.7	-
31231102	Area Office S&A Documents				44,310	24,818	56.0	-
31231103	District Office S&A Documents				8,850	4,957	56.0	-
31231103	Contract Mods & Negotiations				5,320	2,980	56.0	-
3126	PROGRAMS AND PROJECT MGMT							
312601	Proj Mgmt Documents				97,810	54,784	56.0	-
312602	Funds Control Documents				17,730	9,931	56.0	-
312603	Trip Reports				8,850	4,957	56.0	-
312604	Upward reporting Documents				5,320	2,980	56.0	-
312605	Budgetary Documents				7,100	3,977	56.0	-
312606	Project Authorization Documents				8,850	4,957	56.0	-
312607	Annual Notification Ltr				4,420	2,476	56.0	-

DETAILED ESTIMATE OF FIRST COST(Cont'd)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASON
	Effective Price Level (EPL) 1-Oct-2006							
312608	Fact Sheets				26,450	14,815	56.0	-
312609	Correspondance(Congress/State)				8,850	4,957	56.0	-
312610	Schedule and Cost Changes				10,630	5,954	56.0	-
312611	Project Work Directives				5,320	2,980	56.0	-
312612	Project Closeout Coord Documents				5,320	2,980	56.0	-
312613	Quarterly Cost Rpt to Local Sponsor				8,850	4,957	56.0	-
312614	All Other Programs/PM Documents				5,320	2,980	56.0	-
31261101	Mitigation Construction				4,250	2,380	56.0	-
	Subtotal				$425,310			
	Contingencies @ average of	55.9 % +/- *				$237,804		
31	**CONSTRUCTION MANAGEMENT (S & I)**			**TOTAL:**		**$663,114**		
	NON-FEDERAL							
01	**LANDS AND DAMAGES**				522,381	83,619	16.0	-
	Subtotal, Construction Costs:				$522,381			
	Contingencies @ average of	16.0 % +/- *				$83,619		
01	**LANDS AND DAMAGES**			**TOTAL:**		**$606,000**		
	TEMPERATURE CONTROL SHUTTERS							
	FEDERAL							
06	**FISH AND WILDLIFE FACILITIES, Mitigation**							
0603	WILDLIFE FACILITIES AND SANCTURARIES,							
060373	Habitat and Feeding Facilities:							
06037302	Site Work:							
	Mob and Demob	1	JOB	LS	783,400	509,210	65.0	-
	Modify Guildes, Shutters & Track	15	SLT	1,045,000	15,675,000	10,188,010	65.0	-
	SandBlast & Paint Upper Metal Struct.	14400	SF	80	1,152,000	748,380	65.0	-
	Electrical	3000	LF	60	180,000	117,000	65.0	-
	Subtotal, Construction Costs:				$17,790,400			
	Contingencies @ average of	65.0 % +/- *				$11,562,600		
06	**FISH AND WILDLIFE FACILITIES, Mitigation**			**TOTAL:**		**$29,353,000**		
30	**PLANNING, ENGINEERING & DESIGN**							
302301	PLANS AND SPECFICATION							
30230101	Surveys and Mapping, except RE				136,920	27,384	20.0	-
30230101	Survey Markers				88,590	17,718	20.0	-
30230101	Hydraulics Studies				161,080	32,216	20.0	-
30230101	Hydrology				80,530	16,106	20.0	-
30230101	Structural Design				24,160	4,832	20.0	-
30230102	Civil Design Analysis				88,590	17,718	20.0	-
30230102	Prepare Specs- Front End				40,260	8,052	20.0	-
30230102	Civil Design Prepare Tec Specs				60,410	12,082	20.0	-
30230102	Civil Design Prepare Plans				140,950	28,190	20.0	-
30230102	Review P&S(ITR)				60,410	12,082	20.0	-
30230104	BCOE Review and Certification				40,260	8,052	20.0	-
30230104	Revise P&S				40,260	8,052	20.0	-
30230105	Geotechnical Studies(Geol and Soils)				161,080	32,216	20.0	-
30230105	Revegetation Plan				187,260	37,452	20.0	-
302304	ENVIRONMENTAL STUDIES DOCUMENTS							
30230401	Coordination w/other agencies				52,350	10,470	20.0	-
30230403	Mitigation Analysis Report				48,320	9,664	20.0	-
30230404	Coordination w/other agencies				60,410	12,082	20.0	-
30230410	NPDES Permit/SPPCP				20,140	4,028	20.0	-
302305	HTRW STUDIES/REPORT							
30230502	HTRW Assessment Report				80,530	16,106	20.0	-
302306	CULTURAL RESOURCE							
30230601	Cultural Resource, Studies Doc.				100,680	20,136	20.0	-

DETAILED ESTIMATE OF FIRST COST(Cont'd)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASON
	Effective Price Level (EPL) 1-Oct-2006							
302307	COST ESTIMATE							
30230701	Cost Estimates-Project				80,530	16,106	20.0	-
30230703	Cost Estimates-Contract				80,530	16,106	20.0	-
302308	OTHER STUDIES/INVESTIGATIONS							
30230801	O&M, Plan				40,260	8,052	20.0	-
30230801	Other Studies (EC/FP)				16,110	3,222	20.0	-
302309	CONTRACT AWARD DOCUMENTS							
30230903	Advertise				40,260	8,052	20.0	-
30230903	Repro				20,140	4,028	20.0	-
30230907	Award Contract				8,050	1,610	20.0	-
302310	ENGINEERING & DESIGN DURING				161,080	32,216	20.0	-
30231402	Amendments to P&S				40,260	8,052	20.0	-
3024	VALUE ENGINEERING ANLYSIS				52,350	10,470	20.0	-
3025	CLOSE OUT							
302501	Physical Closeout Documents				48,320	9,664	20.0	-
302501	Local Sponsor Audit				40,260	8,052	20.0	-
302501	USACE Audit				40,260	8,052	20.0	-
302501	OMRR&R Manual				80,530	16,106	20.0	-
3026	PROGRAMS AND PROJECT MGMT				281,990	56,454	20.0	-
	Subtotal				$2,704,120			
	Contingencies @ average of	20.0 % +/- *				$540,880		
30	**PLANNING, ENGINEERING & DESIGN**			**TOTAL:**		**$3,245,000**		
31	**CONSTRUCTION MANAGEMENT (S & I)**							
312311	SUPERVISION AND ADMINISTRATION							
31231101	Project Office Supervn and Admin				717,540	466,404	65.0	-
31231102	Area Office S&A Documents				224,310	145,787	65.0	-
31231103	District Office S&A Documents				44,770	29,098	65.0	-
31231103	Contract Mods & Negotiations				26,910	17,490	65.0	-
3126	PROGRAMS AND PROJECT MGMT							
312601	Proj Mgmt Documents				495,110	321,789	65.0	-
312602	Funds Control Documents				89,770	58,345	65.0	-
312603	Trip Reports				44,770	29,098	65.0	-
312604	Upward reporting Documents				26,910	17,490	65.0	-
312605	Budgetary Documents				35,950	23,365	65.0	-
312606	Project Authorization Documents				44,770	29,098	65.0	-
312607	Annual Notification Ltr				22,390	14,552	65.0	-
312608	Fact Sheets				133,890	87,020	65.0	-
312609	Correspondance(Congress/State)				44,770	29,098	65.0	-
312610	Schedule and Cost Changes				53,820	34,979	65.0	-
312611	Project Work Directives				26,910	17,490	65.0	-
312612	Project Closeout Coord Documents				26,910	17,490	65.0	-
312613	Quarterly Cost Rpt to Local Sponsor				44,770	29,098	65.0	-
312614	All Other Programs/PM Documents				26,910	17,490	65.0	-
31261101	Mitigation Construction				21,530	13,993	65.0	-
	Subtotal				$2,152,710			
	Contingencies @ average of	65.0 % +/- *				$1,399,174		
31	**CONSTRUCTION MANAGEMENT (S & I)**			**TOTAL:**		**$3,551,884**		

FOLSOM IFA, FLOOD WALLS 3.5'
IFA - Concept Plans
FOLSOM DAM
FOLSOM & CALIFORNIA
Price Level 1 Oct. 2006

Designed By: Sacramento - Concept Plans
Estimated By: S Fong, Karl Pankaskie

Prepared By: Sacramento, Cost Engineering Br
Joe Yee, Branch Chief

Preparation Date: 10/30/06
Effective Date of Pricing: 10/01/06
Est Construction Time: 250 Days

Sales Tax: 7.75%

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Release 1.2

Currency in DOLLARS

PROJECT LOCATION: Folsom IFA Existing Dikes

PROJECT NAME DIKE02

PROJECT DESCRIPTION
This estimate consists of costs to eleven concrete flood walls that will stick out 3.5' out of the existing eleven Folsom reservoir dikes. There is approximately 27,360 linear feet of walls to construct. For the dike length of each wall, see the estimate. The sketch shows that retaining wall is 8 feet tall therefore 4.5' wall is buried into the dikes. There is also 4 foot buried slab attached to the wall. The dike excavation materials are loaded and hauled to a stockpile yard approximately 2 miles away. Then the concrete retaining wall is built. After the concrete is cured, the earth materials are purchased or hauled back, placed, and/or compacted.

BASES OF DESIGN
This estimate is a budget estimate based on preliminary design concepts and sketches based on findings from "PASS Phase II Report Dam Raise and Auxiliary Spillway Alternatives" dated June 2006. Quantities were provided by Sacramento District.

ACQUISITION PLAN
The project will be acquired by bidding process.
This estimate acknowledges no Amendments at this time.
Prices are good for the period October 2006.

SUB-CONTRACTING PLAN
The following are subcontractor on this project:
Asphalt Subcontractor (BA)
Fencing Subcontractor (BF)
Rebar Subcontractor (BR)
Concrete Pump Subcontractor (BP)
Painting Subcontractor (BG)
It is assumed that the Prime Contractor will do the rest of the work.

PROJECT CONSTRUCTION
SITE ACCESS
The project site is located on the Folsom Dam Dikes in Folsom CA. There access road on top of each dike but because of wide of the dike and excavation required, it is only a one-way haul road and not much material can be store on the dike.
BORROW AREAS
The borrow sources for gravel, filter material, riprap slope protection, concrete, asphalt is a commercial source. Stockpile for earth waste and fill material is assumed 2 miles away.
CONSTRUCTION METHODOLOGY
The construction methodology is standard earthwork and concrete work.
UNUSUAL CONDITION (Soil, Water, Weather)
No unusual condition known at this time.
UNIQUE TECHNIQUES OF CONSTRUCTION
No unique construction is accomplished.

Currency DOLLARS

CONSTRUCTION WINDOWS
SCHEDULE
A schedule is not currently defined.

OVERTIME
This estimate contains no overtime to complete the project.

EQUIPMENT AND LABOR AVAILABILITY & DISTANCE TRAVELED
This estimate uses Davis Bacon labor rates for Sacramento County 10/19/2006, modification #36. Overall labor prices were increase 10% to match current labor costs found in the field.

Equipment rates used are from EP 1110-1-8, Volume 7 June 99.updated by 15% to current equipment prices. Also fuel prices were increase to current fuel prices.

ENVIRONMENTAL CONCERNS
No significant concerns noted.
>>>

Thu 22 Feb 2007 — Tri-Service Automated Cost Engineering System (TRACES) — TIME 15:05:08
Eff. Date 10/01/06 — PROJECT ITRIKE: FOLSOM IFA, FLOOD WALLS 3.5' - IFA - Concept Plans — SUMMARY PAGE 1
FLOOD WALL 3.5 ABOVE EXISTING DIKES
** PROJECT OWNER SUMMARY - CSI ITEM **

	QUANTITY	UOM	CONTRACT COST	CONTINGN	ESCALATN	E & D	S & A	TOTAL COST	UNIT COST
BB FLOOD WALLS 1 ->8, RW, LW & MIAD									
BB 04 FLOOD WALLS, 3.5' ABOVE DIKES									
BB 04 05 AUXILARY DAM(S) 11 SECTIONS									
BB 04 05 01 MOB, DEMOB & PREP WORK									
BB 04 05 01-001- MOB, DEMOB & PREPARATORY WORK									
BB 04 05 01-001--A01A Mob, Demob & Preparatory Work			961,397	0	0	0	0	961,397	
TOTAL MOB, DEMOB & PREPARATORY WORK			961,397	0	0	0	0	961,397	
BB 04 05 01-002- HAUL ROADS	5000.00	LF	-?	0	0	0	0	-?	-0.00
BB 04 05 01-003- DISPOSAL SITE AND Staging Area									
BB 04 05 01-003--A02A Clearing & Grub Disposal Site	14.00	ACR	17,364	0	0	0	0	17,364	1240.30
BB 04 05 01-003--C02A Seeding Disposal Site	14.00	ACR	62,768	0	0	0	0	62,768	4483.42
TOTAL DISPOSAL SITE AND Staging Area	14.00	ACR	80,132	0	0	0	0	80,132	5723.72
TOTAL MOB, DEMOB & PREP WORK			1,041,522	0	0	0	0	1,041,522	
BB 04 05 42 EARTH & ROCKFILL DAM, DIKE #1									
BB 04 05 42-001- D1 SITE WORK									
BB 04 05 42-001--A02A D1 Security Fencing	100.00	LF	22,311	0	0	0	0	22,311	223.11
BB 04 05 42-001--A02B D1 Traffic Control	1.30	MO	42,052	0	0	0	0	42,052	32347.57
BB 04 05 42-001--A02C D1 Silt Fence	2600.00	LF	20,607	0	0	0	0	20,607	7.93
TOTAL D1 SITE WORK	2600.00	LF	84,970	0	0	0	0	84,970	32.68
BB 04 05 42-002- D1 FLOOD WALL, EXCAVATION									
BB 04 05 42-002--K02A D1 Stripping/Exc, Haul 2mi Disp$	1060.00	BCY	14,191	0	0	0	0	14,191	13.39
BB 04 05 42-002--K02C D1 Excavtion, Haul 2mi Disp Site	2660.00	BCY	35,879	0	0	0	0	35,879	13.39
BB 04 05 42-002--K02E D1 Trench Exc,Haul 2mi Disp Site	190.00	BCY	2,544	0	0	0	0	2,544	13.39
TOTAL D1 FLOOD WALL, EXCAVATION			52,614	0	0	0	0	52,614	
BB 04 05 42-003A D1 FLOOD WALL, CONCRETE SLAB									
BB 04 05 42-003A-B03A D1 Flood Wall-Slab, Formwork	5200.00	SF	58,917	0	0	0	0	58,917	11.33

Currency: DOLLARS

Thu 22 Feb 200 — Tri-Service Automated Co: ...neering System (TRACES) — TME 15:05:08
Eff. Date 10/01/06 — PROJECT ITRDKE: FOLSOM IFA, FLOOD WALLS 3.5' - IFA - Concept Plans — SUMMARY PAGE 2
FLOOD WALL 3.5 ABOVE EXISTING DIKES
** PROJECT OWNER SUMMARY - CSI ITEM **

		QUANTITY	UOM	CONTRACT COST	CONTINGN	ESCALATN	E & D	S & A	TOTAL COST	UNIT COST
BB 04 05 42-003A-B03D	01 Flood Wall-Slab, Conc Placmnt	675.00	CY	213,082	0	0	0	0	213,082	315.68
TOTAL 01 FLOOD WALL, CONCRETE SLAB		675.00	CY	272,000	0	0	0	0	272,000	402.96
BB 04 05 42-003B	01 FLOOD WALL, CONCRETE SLAB RB									
BB 04 05 42-003B-B03C	01 Flood Wall-Slab, Reinforcement	101250.00	LB	189,013	0	0	0	0	189,013	1.87
TOTAL 01 FLOOD WALL, CONCRETE SLAB RB		101250.00	LB	189,013	0	0	0	0	189,013	1.87
BB 04 05 42-004A	01 FLOOD WALL, CONCRETE WALL									
BB 04 05 42-004A-D03A	01 Flood Wall-Wall, Formwork	28600.00	SF	344,899	0	0	0	0	344,899	12.06
BB 04 05 42-004A-D03D	01 Flood Wall-Wall, Conc Placmnt	530.00	CY	139,592	0	0	0	0	139,592	263.38
TOTAL 01 FLOOD WALL, CONCRETE WALL		530.00	CY	484,492	0	0	0	0	484,492	914.14
BB 04 05 42-004B	01 FLOOD WALL, CONCRETE WALL RB									
BB 04 05 42-004B-D03C	01 Flood Wall-Wall, Reinforcement	79500.00	LB	148,410	0	0	0	0	148,410	1.87
TOTAL 01 FLOOD WALL, CONCRETE WALL RB		79500.00	LB	148,410	0	0	0	0	148,410	1.87
BB 04 05 42-004C	01 FLOOD WALL, CONCRETE WALL AG									
BB 04 05 42-004C-D03F	01 Flood Wall, Anti-graffiti Ctg	18200.00	SF	140,226	0	0	0	0	140,226	8.80
TOTAL 01 FLOOD WALL, CONCRETE WALL AG		18200.00	SF	140,226	0	0	0	0	140,226	8.80
BB 04 05 42-005-	01 FLOOD WALL, BACKFILL									
BB 04 05 42-005--K02A	01 Backfill, Random	1350.00	BCY	28,468	0	0	0	0	28,468	21.24
BB 04 05 42-005--K02B	01 Backfill, Filter Material	320.00	BCY	20,991	0	0	0	0	20,991	65.60
BB 04 05 42-005--K02C	01 Backfill, Slope Protection RR	1250.00	BCY	99,577	0	0	0	0	99,577	79.66
TOTAL 01 FLOOD WALL, BACKFILL				149,236	0	0	0	0	149,236	
BB 04 05 42-006-	01 ASPHALT, TOP OF DIKE									
BB 04 05 42-006--A02A	01 Existing Demo	1930.00	SCY	83,906	0	0	0	0	83,906	43.47
BB 04 05 42-006--A02F	01 Base Course 6" Thk	1450.00	CCY	80,211	0	0	0	0	80,211	55.32
BB 04 05 42-006--A02G	01 Asphalt Concrete 2" Thk	480.00	ECY	135,826	0	0	0	0	135,826	282.97
TOTAL 01 ASPHALT, TOP OF DIKE		8670.00	SY	299,943	0	0	0	0	299,943	34.60

Currency in DOLLARS

Thu 22 Feb 2007 — Tri-Service Automated Cost Engineering System (TRACES) — TIME 15:05:06
Eff. Date 10/01/06 — PROJECT ITRDKE: FOLSOM IFA, FLOOD WALLS 3.5' - IFA - Concept Plans — SUMMARY PAGE 3
FLOOD WALL 3.5 ABOVE EXISTING DIKES
** PROJECT OWNER SUMMARY - CSI ITEM **

	QUANTITY SOM	CONTRACT COST	CONTINGN	ESCALATN	E & D	S & A	TOTAL COST	UNIT COST
TOTAL EARTH & ROCKFILL DAM, DIKE #1	2600.00 LF	1,840,904	0	0	0	0	1,840,904	708.04
BB 04 05 43 EARTH & ROCKFILL DAM, DIKE #2								
BB 04 05 43-001- D2 SITE WORK								
BB 04 05 43-001--A02A D2 Security Fencing	100.00 LF	22,311	0	0	0	0	22,311	223.11
BB 04 05 43-001--A02B D2 Traffic Control	1.00 MO	27,585	0	0	0	0	27,585	27585.48
BB 04 05 43-001--A02C D2 Silt Fence	2000.00 LF	15,852	0	0	0	0	15,852	7.93
TOTAL D2 SITE WORK	2000.00 LF	65,748	0	0	0	0	65,748	32.87
BB 04 05 43-002- D2 FLOOD WALL, EXCAVATION								
BB 04 05 43-002--K02A D2 Stripping/Exc, Haul 2mi Dispd	1560.00 BCY	20,885	0	0	0	0	20,885	13.39
BB 04 05 43-002--K02C D2 Excavtion, Haul 2mi Disp Site	4220.00 BCY	56,496	0	0	0	0	56,496	13.39
BB 04 05 43-002--K02E D2 Trench Exc,Haul 2mi Disp Site	150.00 BCY	2,008	0	0	0	0	2,008	13.39
TOTAL D2 FLOOD WALL, EXCAVATION	5926.00 BCY	79,389	0	0	0	0	79,389	13.40
BB 04 05 43-003A D2 FLOOD WALL, CONCRETE SLAB								
BB 04 05 43-003A-B03A D2 Flood Wall-Slab, Formwork	5200.00 SF	58,917	0	0	0	0	58,917	11.33
BB 04 05 43-003A-B03D D2 Flood Wall-Slab, Conc Placmnt	520.00 CY	167,348	0	0	0	0	167,348	321.82
TOTAL D2 FLOOD WALL, CONCRETE SLAB	520.00 CY	226,266	0	0	0	0	226,266	435.13
BB 04 05 43-003B D2 FLOOD WALL, CONCRETE SLAB RB								
BB 04 05 43-003B-B03C D2 Flood Wall-Slab, Reinforcement	78000.00 LB	145,610	0	0	0	0	145,610	1.87
TOTAL D2 FLOOD WALL, CONCRETE SLAB RB	78000.00 LB	145,610	0	0	0	0	145,610	1.87
BB 04 05 43-004A D2 FLOOD WALL, CONCRETE WALL								
BB 04 05 43-004A-D03A D2 Flood Wall-Wall, Formwork	22000.00 SF	265,307	0	0	0	0	265,307	12.06
BB 04 05 43-004A-D03D D2 Flood Wall-Wall, Conc Placmnt	410.00 CY	107,073	0	0	0	0	107,073	261.15
TOTAL D2 FLOOD WALL, CONCRETE WALL	410.00 CY	372,380	0	0	0	0	372,380	908.24
BB 04 05 43-004B D2 FLOOD WALL, CONCRETE WALL RB								
BB 04 05 43-004B-D03C D2 Flood Wall-Wall, Reinforcement	61500.00 LB	114,808	0	0	0	0	114,808	1.87
TOTAL D2 FLOOD WALL, CONCRETE WALL RB	61500.00 LB	114,808	0	0	0	0	114,808	1.87

Currency DOLLARS

	QUANTITY	UOM	CONTRACT COST	CONTINGN	ESCALATN	E & D	S & A	TOTAL COST	UNIT COST
BB 04 05 43-004C D2 FLOOD WALL, CONCRETE WALL AG									
BB 04 05 43-004C-D03F D2 Flood Wall, Anti-graffiti Ctg	14000.00	SF	123,251	0	0	0	0	123,251	8.80
TOTAL D2 FLOOD WALL, CONCRETE WALL AG	14000.00	SF	123,251	0	0	0	0	123,251	8.80
BB 04 05 43-005- D2 FLOOD WALL, BACKFILL									
BB 04 05 43-005--K02A D2 Backfill, Random	1040.00	BCY	22,085	0	0	0	0	22,085	21.24
BB 04 05 43-005--K02B D2 Backfill, Filter Material C	960.00	BCY	62,973	0	0	0	0	62,973	65.60
BB 04 05 43-005--K02C D2 Backfill, Filter Material F	740.00	BCY	48,541	0	0	0	0	48,541	65.60
BB 04 05 43-005--K02D D2 Backfill, Slope Protection RR	960.00	BCY	76,475	0	0	0	0	76,475	79.66
TOTAL D2 FLOOD WALL, BACKFILL			210,074	0	0	0	0	210,074	
BB 04 05 43-006- D1 ASPHALT, RAMP OVER DIKE 1EA									
BB 04 05 43-006--A02A D1 Existing Demo	290.00	BCY	12,741	0	0	0	0	12,741	43.93
BB 04 05 43-006--A02C D2 Backfill, Random	960.00	BCY	20,386	0	0	0	0	20,386	21.24
BB 04 05 43-006--A02F D1 Base Course 6" Thk	220.00	CCY	12,170	0	0	0	0	12,170	55.32
BB 04 05 43-006--A02G D1 Asphalt Concrete 2" Thk	70.00	SCY	19,808	0	0	0	0	19,808	282.97
TOTAL D1 ASPHALT, RAMP OVER DIKE 1EA	1300.00	SY	65,105	0	0	0	0	65,105	50.08
TOTAL EARTH & ROCKFILL DAM, DIKE #2	2000.00	LF	1,402,631	0	0	0	0	1,402,631	701.32
BB 04 05 44 EARTH & ROCKFILL DAM, DIKE #3									
BB 04 05 44-001- D3 SITE WORK									
BB 04 05 44-001--A02A D3 Security Fencing	100.00	LF	22,311	0	0	0	0	22,311	223.11
BB 04 05 44-001--A02B D3 Traffic Control	0.95	MO	26,500	0	0	0	0	26,500	27894.89
BB 04 05 44-001--A02C D3 Silt Fence	1900.00	LF	15,059	0	0	0	0	15,059	7.93
TOTAL D3 SITE WORK	1900.00	LF	63,870	0	0	0	0	63,870	33.62
BB 04 05 44-002- D3 FLOOD WALL, EXCAVATION									
BB 04 05 44-002--K02A D3 Stripping/Exc, Haul 2mi DispS	745.00	BCY	9,974	0	0	0	0	9,974	13.39
BB 04 05 44-002--K02C D3 Excavtion, Haul 2mi Disp Site	1960.00	BCY	26,240	0	0	0	0	26,240	13.39
BB 04 05 44-002--K02E D3 Trench Exc,Haul 2mi Disp Site	140.00	BCY	1,874	0	0	0	0	1,874	13.39
TOTAL D3 FLOOD WALL, EXCAVATION			38,088	0	0	0	0	38,088	
BB 04 05 44-003A D3 FLOOD WALL, CONCRETE SLAB									

	QUANTITY	UOM	CONTRACT COST	CONTINGN	ESCALATN	S & D	S & A	TOTAL COST	UNIT COST
RR 04 05 44-003A-B03A D3 Flood Wall-Slab, Formwork	3800.00	SF	43,055	0	0	0	0	43,055	11.33
RR 04 05 44-003A-B03D D3 Flood Wall-Slab, Conc Placmnt	495.00	CY	156,253	0	0	0	0	156,253	315.66
TOTAL D3 FLOOD WALL, CONCRETE SLAB	495.00	CY	199,308	0	0	0	0	199,308	402.64
RR 04 05 44-003B D3 FLOOD WALL, CONCRETE SLAB RR									
RR 04 05 44-003B-B03C D3 Flood Wall-Slab, Reinforcment	74250.00	LB	138,609	0	0	0	0	138,609	1.87
TOTAL D3 FLOOD WALL, CONCRETE SLAB RR	74250.00	LB	138,609	0	0	0	0	138,609	1.87
RR 04 05 44-004A D3 FLOOD WALL, CONCRETE WALL									
RR 04 05 44-004A-D03A D3 Flood Wall-Wall, Formwork	20900.00	SF	252,042	0	0	0	0	252,042	12.06
RR 04 05 44-004A-D03D D3 Flood Wall-Wall, Conc Placmnt	390.00	CY	102,716	0	0	0	0	102,716	263.38
TOTAL D3 FLOOD WALL, CONCRETE WALL	390.00	CY	354,758	0	0	0	0	354,758	909.64
RR 04 05 44-004B D3 FLOOD WALL, CONCRETE WALL RR									
RR 04 05 44-004B-D03C D3 Flood Wall-Wall, Reinforcment	58500.00	LB	109,207	0	0	0	0	109,207	1.87
TOTAL D3 FLOOD WALL, CONCRETE WALL RR	58500.00	LB	109,207	0	0	0	0	109,207	1.87
RR 04 05 44-004C D3 FLOOD WALL, CONCRETE WALL AG									
RR 04 05 44-004C-D03F D3 Flood Wall, Anti-graffiti Ctg	13300.00	SF	117,089	0	0	0	0	117,089	8.80
TOTAL D3 FLOOD WALL, CONCRETE WALL AG	13300.00	SF	117,089	0	0	0	0	117,089	8.80
RR 04 05 44-005- D3 FLOOD WALL, BACKFILL									
RR 04 05 44-005--K02A D3 Backfill, Random	985.00	BCY	20,917	0	0	0	0	20,917	21.24
RR 04 05 44-005--K02B D3 Backfill, Filter Material	230.00	BCY	15,087	0	0	0	0	15,087	65.60
RR 04 05 44-005--K02D D3 Backfill, Slope Protection RR	915.00	BCY	72,909	0	0	0	0	72,909	79.68
TOTAL D3 FLOOD WALL, BACKFILL			108,913	0	0	0	0	108,913	
RR 04 05 44-006- D1 ASPHALT, RAMP OVER DIKE 3EA									
RR 04 05 44-006--A02A D1 Existing Demo	870.00	BCY	38,222	0	0	0	0	38,222	43.93
RR 04 05 44-006--A02C D2 Backfill, Random	2890.00	BCY	61,371	0	0	0	0	61,371	21.24
RR 04 05 44-006--A02F D1 Base Course 6" Thk	650.00	CCY	35,957	0	0	0	0	35,957	55.32
RR 04 05 44-006--A02G D1 Asphalt Concrete 2" Thk	220.00	SCY	62,253	0	0	0	0	62,253	282.97

		QUANTITY	UOM	CONTRACT COST	CONTINGN	ESCALATN	S & D	S & A	TOTAL COST	UNIT COST
	TOTAL D1 ASPHALT, RAMP OVER DIKE 3EA	3900.00	SY	197,803	0	0	0	0	197,803	50.72
	TOTAL EARTH & ROCKFILL DAM, DIKE #3	1900.00	LF	1,327,647	0	0	0	0	1,327,647	698.76
BB D4 05 45	EARTH & ROCKFILL DAM, DIKE #4									
BB D4 05 45-001-	D4 SITE WORK									
BB D4 05 45-001--A02A	D4 Security Fencing	100.00	LF	22,311	0	0	0	0	22,311	223.11
BB D4 05 45-001--A02B	D4 Traffic Control	0.70	MO	21,073	0	0	0	0	21,073	30104.92
BB D4 05 45-001--A02C	D4 Silt Fence	1400.00	LF	11,096	0	0	0	0	11,096	7.93
	TOTAL D4 SITE WORK	1400.00	LF	54,481	0	0	0	0	54,481	38.91
BB D4 05 45-002-	D4 FLOOD WALL, EXCAVATION									
BB D4 05 45-002--K02A	D4 Stripping/Exc, Haul 2mi Disp0	570.00	BCY	7,631	0	0	0	0	7,631	13.39
BB D4 05 45-002--K02C	D4 Excavtion, Haul 2mi Disp Site	1440.00	BCY	19,278	0	0	0	0	19,278	13.39
BB D4 05 45-002--K02E	D4 Trench Exc,Haul 2mi Disp Site	105.00	BCY	1,406	0	0	0	0	1,406	13.39
	TOTAL D4 FLOOD WALL, EXCAVATION			28,315	0	0	0	0	28,315	
BB D4 05 45-003A	D4 FLOOD WALL, CONCRETE SLAB									
BB D4 05 45-003A-B03A	D4 Flood Wall-Slab, Formwork	2800.00	SF	31,725	0	0	0	0	31,725	11.33
BB D4 05 45-003A-B03D	D4 Flood Wall-Slab, Conc Placmnt	360.00	CY	113,637	0	0	0	0	113,637	315.66
	TOTAL D4 FLOOD WALL, CONCRETE SLAB	360.00	CY	145,362	0	0	0	0	145,362	403.78
BB D4 05 45-003B	D4 FLOOD WALL, CONCRETE SLAB RB									
BB D4 05 45-003B-B03C	D4 Flood Wall-Slab, Reinforcment	54000.00	LB	100,807	0	0	0	0	100,807	1.87
	TOTAL D4 FLOOD WALL, CONCRETE SLAB RB	54000.00	LB	100,807	0	0	0	0	100,807	1.87
BB D4 05 45-004A	D4 FLOOD WALL, CONCRETE WALL									
BB D4 05 45-004A-D03A	D4 Flood Wall-Wall, Formwork	15400.00	SF	185,715	0	0	0	0	185,715	12.06
BB D4 05 45-004A-D03D	D4 Flood Wall-Wall, Conc Placmnt	285.00	CY	75,064	0	0	0	0	75,064	263.38
	TOTAL D4 FLOOD WALL, CONCRETE WALL	285.00	CY	260,779	0	0	0	0	260,779	915.01
BB D4 05 45-004B	D4 FLOOD WALL, CONCRETE WALL RB									

		QUANTITY	UOM	CONTRACT COST	CONTINGN	ESCALATN	E & D	S & A	TOTAL COST	UNIT COST
BB 04 05 45-004B-D03C	D4 Flood Wall-Wall, Reinforcement	42750.00	LB	79,805	0	0	0	0	79,805	1.87
	TOTAL D4 FLOOD WALL, CONCRETE WALL RE	42750.00	LB	79,805	0	0	0	0	79,805	1.87
BB 04 05 45-004C	D4 FLOOD WALL, CONCRETE WALL AG									
BB 04 05 45-004C-D03F	D4 Flood Wall, Anti-graffiti Ctg	9800.00	SF	86,276	0	0	0	0	86,276	8.80
	TOTAL D4 FLOOD WALL, CONCRETE WALL AG	9800.00	SF	86,276	0	0	0	0	86,276	8.80
BB 04 05 45-005-	D4 FLOOD WALL, BACKFILL									
BB 04 05 45-005--K02A	D4 Backfill, Random	730.00	BCY	15,502	0	0	0	0	15,502	21.24
BB 04 05 45-005--K02B	D4 Backfill, Filter Material	170.00	BCY	11,151	0	0	0	0	11,151	65.60
BB 04 05 45-005--K02C	D4 Backfill, Slope Protection RR	675.00	BCY	53,790	0	0	0	0	53,790	79.69
	TOTAL D4 FLOOD WALL, BACKFILL			80,444	0	0	0	0	80,444	
	TOTAL EARTH & ROCKFILL DAM, DIKE #4	1400.00	LF	836,268	0	0	0	0	836,268	597.33
BB 04 05 46	EARTH & ROCKFILL DAM, DIKE #5									
BB 04 05 46-001-	D5 SITE WORK									
BB 04 05 46-001--A02A	D5 Security Fencing	100.00	LF	22,311	0	0	0	0	22,311	223.11
BB 04 05 46-001--A02B	D5 Traffic Control	1.00	MO	28,671	0	0	0	0	28,671	27305.54
BB 04 05 46-001--A02C	D5 Silt Fence	2100.00	LF	16,644	0	0	0	0	16,644	7.93
	TOTAL D5 SITE WORK	2100.00	LF	67,626	0	0	0	0	67,626	32.20
BB 04 05 46-002-	D5 FLOOD WALL, EXCAVATION									
BB 04 05 46-002--K02A	D5 Stripping/Exc, Haul 2mi Disp	860.00	BCY	11,513	0	0	0	0	11,513	13.39
BB 04 05 46-002--K02C	D5 Excavtion, Haul 2mi Disp Site	2160.00	BCY	28,917	0	0	0	0	28,917	13.39
BB 04 05 46-002--K02E	D5 Trench Exc,Haul 2mi Disp Site	160.00	BCY	2,142	0	0	0	0	2,142	13.39
	TOTAL D5 FLOOD WALL, EXCAVATION			42,573	0	0	0	0	42,573	
BB 04 05 46-003A	D5 FLOOD WALL, CONCRETE SLAB									
BB 04 05 46-003A-B03A	D5 Flood Wall-Slab, Formwork	4200.00	SF	47,587	0	0	0	0	47,587	11.33
BB 04 05 46-003A-B03D	D5 Flood Wall-Slab, Conc Placmnt	545.00	CY	172,043	0	0	0	0	172,043	315.67
	TOTAL D5 FLOOD WALL, CONCRETE SLAB	545.00	CY	219,630	0	0	0	0	219,630	402.99

Tri-Service Automated Cost ineering System (TRACES)
PROJECT ITEMS: FOLSOM IFA, FLOOD WALLS 3.5' - IFA - Concept Plans
FLOOD WALL 3.5 ABOVE EXISTING DIKES
** PROJECT OWNER SUMMARY - CSI ITEM **

		QUANTITY	UOM	CONTRACT COST	CONTINGN	ESCALATN	S & D	S & A	TOTAL COST	UNIT COST
BB 04 05 46-003B	D5 FLOOD WALL, CONCRETE SLAB RB									
BB 04 05 46-003B-B03C	D5 Flood Wall-Slab, Reinforcment	81750.00	LB	152,610	0	0	0	0	152,610	1.87
	TOTAL D5 FLOOD WALL, CONCRETE SLAB RB	81750.00	LB	152,610	0	0	0	0	152,610	1.87
BB 04 05 46-004A	D5 FLOOD WALL, CONCRETE WALL									
BB 04 05 46-004A-D03A	D5 Flood Wall-Wall, Formwork	23100.00	SF	278,573	0	0	0	0	278,573	12.06
BB 04 05 46-004A-D03D	D5 Flood Wall-Wall, Conc Placmnt	430.00	CY	113,252	0	0	0	0	113,252	263.38
	TOTAL D5 FLOOD WALL, CONCRETE WALL	430.00	CY	391,825	0	0	0	0	391,825	911.22
BB 04 05 46-004B	D5 FLOOD WALL, CONCRETE WALL RB									
BB 04 05 46-004B-D03C	D5 Flood Wall-Wall, Reinforcment	64500.00	LB	120,408	0	0	0	0	120,408	1.87
	TOTAL D5 FLOOD WALL, CONCRETE WALL RB	64500.00	LB	120,408	0	0	0	0	120,408	1.87
BB 04 05 46-004C	D5 FLOOD WALL, CONCRETE WALL AG									
BB 04 05 46-004C-D03F	D5 Flood Wall, Anti-graffiti Ctg	14700.00	SF	129,414	0	0	0	0	129,414	8.80
	TOTAL D5 FLOOD WALL, CONCRETE WALL AG	14700.00	SF	129,414	0	0	0	0	129,414	8.80
BB 04 05 46-005-	D5 FLOOD WALL, BACKFILL									
BB 04 05 46-005--K02A	D5 Backfill, Random	1090.00	BCY	23,147	0	0	0	0	23,147	21.24
BB 04 05 46-005--K02B	D5 Backfill, Filter Material	260.00	BCY	17,055	0	0	0	0	17,055	65.60
BB 04 05 46-005--K02C	D5 Backfill, Slope Protection RR	1010.00	BCY	80,458	0	0	0	0	80,458	79.66
	TOTAL D5 FLOOD WALL, BACKFILL			120,660	0	0	0	0	120,660	
	TOTAL EARTH & ROCKFILL DAM, DIKE #5	2100.00	LF	1,244,746	0	0	0	0	1,244,746	592.74
BB 04 05 47	EARTH & ROCKFILL DAM, DIKE #6									
BB 04 05 47-001-	D6 SITE WORK									
BB 04 05 47-001--A02A	D6 Security Fencing	100.00	LF	22,311	0	0	0	0	22,311	223.11
BB 04 05 47-001--A02B	D6 Traffic Control	0.81	MO	23,353	0	0	0	0	23,353	29009.51
BB 04 05 47-001--A02C	D6 Silt Fence	1610.00	LF	12,761	0	0	0	0	12,761	7.93
	TOTAL D6 SITE WORK	1610.00	LF	58,425	0	0	0	0	58,425	36.29

Currency in DOLLARS

	QUANTITY	UOM	CONTRACT COST	CONTINGN	ESCALATN	E & D	S & A	TOTAL COST	UNIT COST
BB 04 05 47-002- D6 FLOOD WALL, EXCAVATION									
BB 04 05 47-002--K02A D6 Stripping/Exc, Haul 2mi Disp0	660.00	BCY	8,836	0	0	0	0	8,836	13.39
BB 04 05 47-002--K02C D6 Excavtion, Haul 2mi Disp Site	1660.00	BCY	22,224	0	0	0	0	22,224	13.39
BB 04 05 47-002--K02E D6 Trench Exc,Haul 2mi Disp Site	120.00	BCY	1,607	0	0	0	0	1,607	13.39
TOTAL D6 FLOOD WALL, EXCAVATION			32,666	0	0	0	0	32,666	
BB 04 05 47-003A D7 FLOOD WALL, CONCRETE SLAB									
BB 04 05 47-003A-B03A D7 Flood Wall-Slab, Formwork	3220.00	SF	36,483	0	0	0	0	36,483	11.33
BB 04 05 47-003A-B03D D7 Flood Wall-Slab, Conc Placmnt	420.00	CY	132,582	0	0	0	0	132,582	315.67
TOTAL D7 FLOOD WALL, CONCRETE SLAB	420.00	CY	169,065	0	0	0	0	169,065	402.54
BB 04 05 47-003B D6 FLOOD WALL, CONCRETE SLAB RB									
BB 04 05 47-003B-B03C D6 Flood Wall-Slab, Reinforcment	241500.00	LB	450,830	0	0	0	0	450,830	1.87
TOTAL D6 FLOOD WALL, CONCRETE SLAB RB	241500.00	LB	450,830	0	0	0	0	450,830	1.87
BB 04 05 47-004A D6 FLOOD WALL, CONCRETE WALL									
BB 04 05 47-004A-D03A D6 Flood Wall-Wall, Formwork	17710.00	SF	213,572	0	0	0	0	213,572	12.06
BB 04 05 47-004A-D03D D6 Flood Wall-Wall, Conc Placmnt	330.00	CY	86,913	0	0	0	0	86,913	263.37
TOTAL D6 FLOOD WALL, CONCRETE WALL	330.00	CY	300,485	0	0	0	0	300,485	910.56
BB 04 05 47-004B D6 FLOOD WALL, CONCRETE WALL RB									
BB 04 05 47-004B-D03C D6 Flood Wall-Wall, Reinforcment	49500.00	LB	92,406	0	0	0	0	92,406	1.87
TOTAL D6 FLOOD WALL, CONCRETE WALL RB	49500.00	LB	92,406	0	0	0	0	92,406	1.87
BB 04 05 47-004C D6 FLOOD WALL, CONCRETE WALL AG									
BB 04 05 47-004C-D03F D6 Flood Wall, Anti-graffiti Ctg	11270.00	SF	99,217	0	0	0	0	99,217	8.80
TOTAL D6 FLOOD WALL, CONCRETE WALL AG	11270.00	SF	99,217	0	0	0	0	99,217	8.80
BB 04 05 47-005- D6 FLOOD WALL, BACKFILL									
BB 04 05 47-005--K02A D6 Backfill, Random	835.00	BCY	17,732	0	0	0	0	17,732	21.24
BB 04 05 47-005--K02B D6 Backfill, Filter Material	200.00	BCY	13,119	0	0	0	0	13,119	65.60

Currency DOLLARS

	QUANTITY	UOM	CONTRACT COST	CONTINGN	ESCALATN	E & D	S & A	TOTAL COST	UNIT COST
BB 04 05 47-005--K02D D6 Backfill, Slope Protection RR	775.00	BCY	61,756	0	0	0	0	61,756	79.69
TOTAL D6 FLOOD WALL, BACKFILL			92,607	0	0	0	0	92,607	
BB 04 05 47-006- D1 ASPHALT, BIKE PATH ON DIKE									
BB 04 05 47-006--A02A D1 Existing Demo	590.00	BCY	25,759	0	0	0	0	25,759	43.66
BB 04 05 47-006--A02F D1 Base Course 6" Thk	445.00	CCY	24,616	0	0	0	0	24,616	55.32
BB 04 05 47-006--A02G D1 Asphalt Concrete 2" Thk	150.00	ECY	42,446	0	0	0	0	42,446	282.97
TOTAL D1 ASPHALT, BIKE PATH ON DIKE	2664.00	SY	92,821	0	0	0	0	92,821	34.84
TOTAL EARTH & ROCKFILL DAM, DIKE #6	1610.00	LF	1,388,522	0	0	0	0	1,388,522	862.44
BB 04 05 48 EARTH & ROCKFILL DAM, DIKE #7									
BB 04 05 48-001- D7 SITE WORK									
BB 04 05 48-001--A02A D7 Security Fencing	100.00	LF	22,311	0	0	0	0	22,311	223.11
BB 04 05 48-001--A02B D7 Traffic Control	0.46	MO	15,810	0	0	0	0	15,810	34556.39
BB 04 05 48-001--A02C D7 Silt Fence	915.00	LF	7,252	0	0	0	0	7,252	7.93
TOTAL D7 SITE WORK	915.00	LF	45,373	0	0	0	0	45,373	49.59
BB 04 05 48-002- D7 FLOOD WALL, EXCAVATION									
BB 04 05 48-002--K02A D7 Stripping/Exc, Haul 2mi Disp$	370.00	BCY	4,953	0	0	0	0	4,953	13.39
BB 04 05 48-002--K02C D7 Excavtion, Haul 2mi Disp Site	940.00	BCY	12,584	0	0	0	0	12,584	13.39
BB 04 05 48-002--K02E D7 Trench Exc,Haul 2mi Disp Site	70.00	BCY	937	0	0	0	0	937	13.39
TOTAL D7 FLOOD WALL, EXCAVATION			18,475	0	0	0	0	18,475	
BB 04 05 48-003A D7 FLOOD WALL, CONCRETE SLAB									
BB 04 05 48-003A-S03A D7 Flood Wall-Slab, Formwork	1830.00	SF	20,735	0	0	0	0	20,735	11.33
BB 04 05 48-003A-S03D D7 Flood Wall-Slab, Conc Placmnt	240.00	CY	75,752	0	0	0	0	75,752	315.64
TOTAL D7 FLOOD WALL, CONCRETE SLAB	240.00	CY	96,487	0	0	0	0	96,487	402.03
BB 04 05 48-003B D7 FLOOD WALL, CONCRETE SLAB RR									
BB 04 05 48-003B-S03C D7 Flood Wall-Slab, Reinforcment	36000.00	LB	67,205	0	0	0	0	67,205	1.87
TOTAL D7 FLOOD WALL, CONCRETE SLAB RR	36000.00	LB	67,205	0	0	0	0	67,205	1.87

Thu 22 Feb 2007
Eff. Date 10/01/06

Tri-Service Automated Cost Engineering System (TRACES)
PROJECT ITRDKE: FOLSOM IFA, FLOOD WALLS 3.5' - IFA - Concept Plans
FLOOD WALL 3.5 ABOVE EXISTING DIKES
** PROJECT OWNER SUMMARY - CSI ITEM **

TIME 15:05:08
SUMMARY PAGE 11

	QUANTITY	UOM	CONTRACT COST	CONTINGN	ESCALATN	S & O	S & A	TOTAL COST	UNIT COST
RR 04 05 48-004A DT FLOOD WALL, CONCRETE WALL									
RR 04 05 48-004A-003A DT Flood Wall-Wall, Formwork	10065.00	SF	121,378	0	0	0	0	121,378	12.06
RR 04 05 48-004A-003D DT Flood Wall-Wall, Conc Placmnt	190.00	CY	50,037	0	0	0	0	50,037	263.35
TOTAL DT FLOOD WALL, CONCRETE WALL	190.00	CY	171,415	0	0	0	0	171,415	902.18
RR 04 05 48-004B DT FLOOD WALL, CONCRETE WALL RB									
RR 04 05 48-004B-003C DT Flood Wall-Wall, Reinforcement	28500.00	LB	53,204	0	0	0	0	53,204	1.87
TOTAL DT FLOOD WALL, CONCRETE WALL RB	28500.00	LB	53,204	0	0	0	0	53,204	1.87
RR 04 05 48-004C DT FLOOD WALL, CONCRETE WALL AG									
RR 04 05 48-004C-003F DT Flood Wall, Anti-graffiti Ctg	6405.00	SF	56,387	0	0	0	0	56,387	8.80
TOTAL DT FLOOD WALL, CONCRETE WALL AG	6405.00	SF	56,387	0	0	0	0	56,387	8.80
RR 04 05 48-005- DT FLOOD WALL, BACKFILL									
RR 04 05 48-005--K02A DT Backfill, Random	475.00	BCY	10,087	0	0	0	0	10,087	21.24
RR 04 05 48-005--K02B DT Backfill, Filter Material	110.00	BCY	7,216	0	0	0	0	7,216	65.60
RR 04 05 48-005--K02C DT Backfill, Slope Protection RR	440.00	BCY	35,051	0	0	0	0	35,051	79.64
TOTAL DT FLOOD WALL, BACKFILL			52,354	0	0	0	0	52,354	
TOTAL EARTH & ROCKFILL DAM, DIKE #T	915.00	LF	560,899	0	0	0	0	560,899	613.00
RR 04 05 49 EARTH & ROCKFILL DAM, DIKE #8									
RR 04 05 49-001- D8 SITE WORK									
RR 04 05 49-001--A02A D8 Security Fencing	100.00	LF	22,311	0	0	0	0	22,311	223.11
RR 04 05 49-001--A02B D8 Traffic Control	0.46	MO	15,755	0	0	0	0	15,755	34626.99
RR 04 05 49-001--A02C D8 Silt Fence	910.00	LF	7,213	0	0	0	0	7,213	7.93
TOTAL D8 SITE WORK	910.00	LF	45,279	0	0	0	0	45,279	49.76
RR 04 05 49-002- D8 FLOOD WALL, EXCAVATION									
RR 04 05 49-002--K02A D8 Stripping/Exc, Haul 2mi Disp$	370.00	BCY	4,953	0	0	0	0	4,953	13.39
RR 04 05 49-002--K02C D8 Excavtion, Haul 2mi Disp Site	940.00	BCY	12,584	0	0	0	0	12,584	13.39
RR 04 05 49-002--K02E D8 Trench Exc.Haul 2mi Disp Site	70.00	BCY	937	0	0	0	0	937	13.39
TOTAL D8 FLOOD WALL, EXCAVATION			18,475	0	0	0	0	18,475	

Currency DOLLARS

Thu 22 Feb 200[illegible]
Eff. Date 10/01/06

Tri-Service Automated Co[illegible]ineering System (TRACES)
PROJECT ITRDKE: FOLSOM IFA, FLOOD WALLS 3.5' - IFA - Concept Plans
FLOOD WALL 3.5 ABOVE EXISTING DIKES
** PROJECT OWNER SUMMARY - CSI ITEM **

TIME 15:05:08
SUMMARY PAGE 12

	QUANTITY	UOM	CONTRACT COST	CONTINGN	ESCALATN	E & D	S & A	TOTAL COST	UNIT COST
BB 04 05 49-003A D8 FLOOD WALL, CONCRETE SLAB									
BB 04 05 49-003A-B03A D8 Flood Wall-Slab, Formwork	1820.00	SF	20,621	0	0	0	0	20,621	11.33
BB 04 05 49-003A-B03D D8 Flood Wall-Slab, Conc Placmnt	240.00	CY	75,741	0	0	0	0	75,741	315.67
TOTAL D8 FLOOD WALL, CONCRETE SLAB	240.00	CY	96,362	0	0	0	0	96,362	401.59
BB 04 05 49-003B D8 FLOOD WALL, CONCRETE SLAB RB									
BB 04 05 49-003B-B03C D8 Flood Wall-Slab, Reinforcement	36000.00	LB	67,205	0	0	0	0	67,205	1.87
TOTAL D8 FLOOD WALL, CONCRETE SLAB RB	36000.00	LB	67,205	0	0	0	0	67,205	1.87
BB 04 05 49-004A D8 FLOOD WALL, CONCRETE WALL									
BB 04 05 49-004A-D03A D8 Flood Wall-Wall, Formwork	10010.00	SF	120,715	0	0	0	0	120,715	12.06
BB 04 05 49-004A-D03D D8 Flood Wall-Wall, Conc Placmnt	185.00	CY	48,726	0	0	0	0	48,726	263.38
TOTAL D8 FLOOD WALL, CONCRETE WALL	185.00	CY	169,441	0	0	0	0	169,441	915.90
BB 04 05 49-004B D8 FLOOD WALL, CONCRETE WALL RB									
BB 04 05 49-004B-003C D8 Flood Wall-Wall, Reinforcement	27750.00	LB	51,803	0	0	0	0	51,803	1.87
TOTAL D8 FLOOD WALL, CONCRETE WALL RB	27750.00	LB	51,803	0	0	0	0	51,803	1.87
BB 04 05 49-004C D8 FLOOD WALL, CONCRETE WALL AG									
BB 04 05 49-004C-003F D8 Flood Wall, Anti-graffiti Ctg	6370.00	SF	56,079	0	0	0	0	56,079	8.80
TOTAL D8 FLOOD WALL, CONCRETE WALL AG	6370.00	SF	56,079	0	0	0	0	56,079	8.80
BB 04 05 49-005- D8 FLOOD WALL, BACKFILL									
BB 04 05 49-005--K02A D8 Backfill, Random	470.00	BCY	9,981	0	0	0	0	9,981	21.24
BB 04 05 49-005--K02B D8 Backfill, Filter Material	110.00	BCY	7,214	0	0	0	0	7,214	65.60
BB 04 05 49-005--K02C D8 Backfill, Slope Protection RR	440.00	BCY	35,051	0	0	0	0	35,051	79.66
TOTAL D8 FLOOD WALL, BACKFILL			52,248	0	0	0	0	52,248	
TOTAL EARTH & ROCKFILL DAM, DIKE #8	910.00	LF	556,912	0	0	0	0	556,912	611.99
BB 04 05 50 EARTH & ROCKFILL DAM, RIGHT WING									
BB 04 05 50-001- RW SITE WORK									

Currency in DOLLARS

Thu 22 Feb 2007 — Tri-Service Automated Cost Engineering System (TRACES) — TIME 15:05:08
Eff. Date 10/01/06 — PROJECT ITEMS: FOLSOM IFA, FLOOD WALLS 3.5' - IFA - Concept Plans — SUMMARY PAGE 13
FLOOD WALL 3.5 ABOVE EXISTING DIKES
** PROJECT OWNER SUMMARY - CSI ITEM **

		QUANTITY	UOM	CONTRACT COST	CONTINGN	ESCALATN	E & D	S & A	TOTAL COST	UNIT COST
RB 04 05 50-001--A02A	RW Security Fencing	100.00	LF	22,311	0	0	0	0	22,311	223.11
RB 04 05 50-001--A02B	RW Traffic Control	3.43	MO	80,224	0	0	0	0	80,224	23423.20
RB 04 05 50-001--A02C	RW Silt Fence	6850.00	LF	54,292	0	0	0	0	54,292	7.93
TOTAL RW SITE WORK		6850.00	LF	156,828	0	0	0	0	156,828	22.89
RB 04 05 50-002- RW FLOOD WALL, EXCAVATION										
RB 04 05 50-002--K02A	RW Stripping/Exc, Haul 2mi Disp$	2790.00	BCY	37,352	0	0	0	0	37,352	13.39
RB 04 05 50-002--K02C	RW Excavtion, Haul 2mi Disp Site	7050.00	BCY	94,383	0	0	0	0	94,383	13.39
RB 04 05 50-002--K02E	RW Trench Exc,Haul 2mi Disp Site	510.00	BCY	6,828	0	0	0	0	6,828	13.39
TOTAL RW FLOOD WALL, EXCAVATION				138,563	0	0	0	0	138,563	
RB 04 05 50-003A RW FLOOD WALL, CONCRETE SLAB										
RB 04 05 50-003A-B03A	RW Flood Wall-Slab, Formwork	13700.00	SF	155,225	0	0	0	0	155,225	11.33
RB 04 05 50-003A-B03D	RW Flood Wall-Slab, Conc Placmnt	1780.00	CY	561,900	0	0	0	0	561,900	315.67
TOTAL RW FLOOD WALL, CONCRETE SLAB		1780.00	CY	717,124	0	0	0	0	717,124	402.88
RB 04 05 50-003B RW FLOOD WALL, CONCRETE SLAB RB										
RB 04 05 50-003B-B03C	RW Flood Wall-Slab, Reinforcment	267000.00	LB	498,434	0	0	0	0	498,434	1.87
TOTAL RW FLOOD WALL, CONCRETE SLAB RB		267000.00	LB	498,434	0	0	0	0	498,434	1.87
RB 04 05 50-004A RW FLOOD WALL, CONCRETE WALL										
RB 04 05 50-004A-D03A	RW Flood Wall-Wall, Formwork	75350.00	SF	908,678	0	0	0	0	908,678	12.06
RB 04 05 50-004A-D03D	RW Flood Wall-Wall, Conc Placmnt	1395.00	CY	367,397	0	0	0	0	367,397	263.37
TOTAL RW FLOOD WALL, CONCRETE WALL		1395.00	CY	1,276,074	0	0	0	0	1,276,074	914.75
RB 04 05 50-004B RW FLOOD WALL, CONCRETE WALL RB										
RB 04 05 50-004B-D03C	RW Flood Wall-Wall, Reinforcment	209250.00	LB	390,626	0	0	0	0	390,626	1.87
TOTAL RW FLOOD WALL, CONCRETE WALL RB		209250.00	LB	390,626	0	0	0	0	390,626	1.87
RB 04 05 50-004C RW FLOOD WALL, CONCRETE WALL AG										
RB 04 05 50-004C-D03F	RW Flood Wall, Anti-graffiti Ctg	47950.00	SF	422,135	0	0	0	0	422,135	8.80
TOTAL RW FLOOD WALL, CONCRETE WALL AG		47950.00	SF	422,135	0	0	0	0	422,135	8.80

Currency DOLLARS

		QUANTITY UOM	CONTRACT COST	CONTINGN	ESCALATN	E & D	S & A	TOTAL COST	UNIT COST
RR 04 05 50-005-	RW FLOOD WALL, BACKFILL								
RR 04 05 50-005--K02A	RW Backfill, Random	3550.00 BCY	75,387	0	0	0	0	75,387	21.24
RR 04 05 50-005--K02B	RW Backfill, Filter Material	840.00 BCY	55,101	0	0	0	0	55,101	65.60
RR 04 05 50-005--K02C	RW Backfill, Slope Protection RR	3300.00 BCY	262,883	0	0	0	0	262,883	79.66
TOTAL RW FLOOD WALL, BACKFILL			393,371	0	0	0	0	393,371	
TOTAL EARTH & ROCKFILL DAM, RIGHT WING		6450.00 LF	3,993,156	0	0	0	0	3,993,156	582.94
RR 04 05 51	EARTH & ROCKFILL DAM, LEFT WING								
RR 04 05 51-001-	LW SITE WORK								
RR 04 05 51-001--A02A	LW Security Fencing	100.00 LF	22,311	0	0	0	0	22,311	223.11
RR 04 05 51-001--A02B	LW Traffic Control	1.08 MO	29,213	0	0	0	0	29,213	27175.34
RR 04 05 51-001--A02C	LW Silt Fence	2150.00 LF	17,041	0	0	0	0	17,041	7.93
TOTAL LW SITE WORK		2150.00 LF	68,565	0	0	0	0	68,565	31.89
RR 04 05 51-002-	LW FLOOD WALL, EXCAVATION								
RR 04 05 51-002--K02A	LW Stripping/Exc, Haul 2mi DispS	880.00 BCY	11,781	0	0	0	0	11,781	13.39
RR 04 05 51-002--K02C	LW Excavtion, Haul 2mi Disp Site	2215.00 BCY	29,654	0	0	0	0	29,654	13.39
RR 04 05 51-002--K02E	LW Trench Exc,Haul 2mi Disp Site	160.00 BCY	2,142	0	0	0	0	2,142	13.39
TOTAL LW FLOOD WALL, EXCAVATION			43,577	0	0	0	0	43,577	
RR 04 05 51-003A	LW FLOOD WALL, CONCRETE SLAB								
RR 04 05 51-003A-B03A	LW Flood Wall-Slab, Formwork	4300.00 SF	48,720	0	0	0	0	48,720	11.33
RR 04 05 51-003A-B03D	LW Flood Wall-Slab, Conc Placmnt	560.00 CY	176,775	0	0	0	0	176,775	315.67
TOTAL LW FLOOD WALL, CONCRETE SLAB		560.00 CY	225,495	0	0	0	0	225,495	402.67
RR 04 05 51-003B	LW FLOOD WALL, CONCRETE SLAB RR								
RR 04 05 51-003B-B03C	LW Flood Wall-Slab, Reinforcement	84000.00 LB	156,811	0	0	0	0	156,811	1.87
TOTAL LW FLOOD WALL, CONCRETE SLAB RR		84000.00 LB	156,811	0	0	0	0	156,811	1.87
RR 04 05 51-004A	LW FLOOD WALL, CONCRETE WALL								
RR 04 05 51-004A-D03A	LW Flood Wall-Wall, Formwork	23650.00 SF	285,205	0	0	0	0	285,205	12.06
RR 04 05 51-004A-D03D	LW Flood Wall-Wall, Conc Placmnt	440.00 CY	115,896	0	0	0	0	115,896	263.40

Thu 22 Feb 2007 — Tri-Service Automated Cost Engineering System (TRACES) — TIME 15:05:08
Eff. Date 10/01/06 — PROJECT ITROKE: FOLSOM IFA, FLOOD WALLS 3.5' - IFA - Concept Plans — SUMMARY PAGE 15
FLOOD WALL 3.5 ABOVE EXISTING DIKES
** PROJECT OWNER SUMMARY - CSI ITEM **

	QUANTITY	UOM	CONTRACT COST	CONTINGN	ESCALATN	E & D	S & A	TOTAL COST	UNIT COST
TOTAL LW FLOOD WALL, CONCRETE WALL	440.00	CY	401,101	0	0	0	0	401,101	911.59
BB 04 05 51-004B LW FLOOD WALL, CONCRETE WALL RB									
BB 04 05 51-004B-003C LW Flood Wall-Wall, Reinforcment	66000.00	LB	123,208	0	0	0	0	123,208	1.87
TOTAL LW FLOOD WALL, CONCRETE WALL RB	66000.00	LB	123,208	0	0	0	0	123,208	1.87
BB 04 05 51-004C LW FLOOD WALL, CONCRETE WALL AG									
BB 04 05 51-004C-003F LW Flood Wall, Anti-graffiti Ctg	15050.00	SF	132,495	0	0	0	0	132,495	8.80
TOTAL LW FLOOD WALL, CONCRETE WALL AG	15050.00	SF	132,495	0	0	0	0	132,495	8.80
BB 04 05 51-005- LW FLOOD WALL, BACKFILL									
BB 04 05 51-005--K02A LW Backfill, Random	1115.00	BCY	23,678	0	0	0	0	23,678	21.24
BB 04 05 51-005--K02B LW Backfill, Filter Material	260.00	BCY	17,055	0	0	0	0	17,055	65.60
BB 04 05 51-005--K02C LW Backfill, Slope Protection RR	1035.00	BCY	82,468	0	0	0	0	82,468	79.68
TOTAL LW FLOOD WALL, BACKFILL			123,201	0	0	0	0	123,201	
TOTAL EARTH & ROCKFILL DAM, LEFT WING	2150.00	LF	1,274,453	0	0	0	0	1,274,453	592.77
BB 04 05 56 EARTH & ROCKFILL DAM, MIAD									
BB 04 05 56-001- MD SITE WORK									
BB 04 05 56-001--A02A MD Security Fencing	100.00	LF	22,311	0	0	0	0	22,311	223.11
BB 04 05 56-001--A02B MD Traffic Control	2.46	MO	59,332	0	0	0	0	59,332	24094.08
BB 04 05 56-001--A02C MD Silt Fence	4925.00	LF	39,035	0	0	0	0	39,035	7.93
TOTAL MD SITE WORK	4925.00	LF	120,678	0	0	0	0	120,678	24.50
BB 04 05 56-002- MD FLOOD WALL, EXCAVATION									
BB 04 05 56-002--K02A MD Stripping/Exc, Haul 2mi DispS	2010.00	BCY	26,909	0	0	0	0	26,909	13.39
BB 04 05 56-002--K02C MD Excavtion, Haul 2mi Disp Site	5070.00	BCY	67,876	0	0	0	0	67,876	13.39
BB 04 05 56-002--K02E MD Trench Exc,Haul 2mi Disp Site	365.00	BCY	4,887	0	0	0	0	4,887	13.39
TOTAL MD FLOOD WALL, EXCAVATION			99,671	0	0	0	0	99,671	
BB 04 05 56-003A MD FLOOD WALL, CONCRETE SLAB									
BB 04 05 56-003A-B03A MD Flood Wall-Slab, Formwork	9850.00	SF	111,604	0	0	0	0	111,604	11.33

Currency DOLLARS

Thu 22 Feb 2007
Eff. Date 10/01/08

Tri-Service Automated Cost Engineering System (TRACES)
PROJECT ITEMS: FOLSOM IFA, FLOOD WALLS 3.5' - IFA - Concept Plans
FLOOD WALL 3.5 ABOVE EXISTING DIKES
** PROJECT OWNER SUMMARY - CSI ITEM **

TIME 15:05:08
SUMMARY PAGE 16

	QUANTITY	UOM	CONTRACT COST	CONTINGN	ESCALATN	S & D	S & A	TOTAL COST	UNIT COST
BB 04 05 56-003A-B03D MD Flood Wall-Slab, Conc Placemt	1280.00	CY	404,048	0	0	0	0	404,048	315.66
TOTAL MD FLOOD WALL, CONCRETE SLAB	1280.00	CY	515,652	0	0	0	0	515,652	402.85
BB 04 05 56-003B MD FLOOD WALL, CONCRETE SLAB RB									
BB 04 05 56-003B-B03C MD Flood Wall-Slab, Reinforcemt	192000.00	LB	358,424	0	0	0	0	358,424	1.87
TOTAL MD FLOOD WALL, CONCRETE SLAB RB	192000.00	LB	358,424	0	0	0	0	358,424	1.87
BB 04 05 56-004A MD FLOOD WALL, CONCRETE WALL									
BB 04 05 56-004A-D03A MD Flood Wall-Wall, Formwork	54175.00	SF	653,319	0	0	0	0	653,319	12.06
BB 04 05 56-004A-D03D MD Flood Wall-Wall, Conc Placemt	1000.00	CY	263,380	0	0	0	0	263,380	263.38
TOTAL MD FLOOD WALL, CONCRETE WALL	1000.00	CY	916,699	0	0	0	0	916,699	916.70
BB 04 05 56-004B MD FLOOD WALL, CONCRETE WALL RB									
BB 04 05 56-004B-D03C MD Flood Wall-Wall, Reinforcemt	150000.00	LB	280,019	0	0	0	0	280,019	1.87
TOTAL MD FLOOD WALL, CONCRETE WALL RB	150000.00	LB	280,019	0	0	0	0	280,019	1.87
BB 04 05 56-004C MD FLOOD WALL, CONCRETE WALL AG									
BB 04 05 56-004C-D03F MD Flood Wall, Anti-graffiti Ctg	34475.00	SF	303,506	0	0	0	0	303,506	8.80
TOTAL MD FLOOD WALL, CONCRETE WALL AG	34475.00	SF	303,506	0	0	0	0	303,506	8.80
BB 04 05 56-005- MD FLOOD WALL, BACKFILL									
BB 04 05 56-005--K02A MD Backfill, Random	2555.00	BCY	54,257	0	0	0	0	54,257	21.24
BB 04 05 56-005--K02B MD Backfill, Filter Material C	600.00	BCY	39,358	0	0	0	0	39,358	65.60
BB 04 05 56-005--K02C D2 Backfill, Filter Material F	600.00	BCY	39,358	0	0	0	0	39,358	65.60
BB 04 05 56-005--K02D MD Backfill, Slope Protection RR	2370.00	BCY	188,804	0	0	0	0	188,804	79.66
TOTAL MD FLOOD WALL, BACKFILL			321,777	0	0	0	0	321,777	
TOTAL EARTH & ROCKFILL DAM, MIAD	4925.00	LF	2,916,427	0	0	0	0	2,916,427	592.17
TOTAL AUXILARY DAM(S) 11 SECTIONS	27360.00	LF	18,384,088	0	0	0	0	18,384,088	671.93
TOTAL FLOOD WALLS, 3.5' ABOVE DIKES	11.00	SEC	18,384,088	0	0	0	0	18,384,088	1671281
TOTAL FLOOD WALLS 1 ->8, RW, LW & MIAD	11.00	EA	18,384,088	0	0	0	0	18,384,088	1671281

Currency in DOLLARS

FOLSOM IFA,F-DAM,EMERGENCY GATE
IFA - Concept Plans
FOLSOM DAM
FOLSOM & CALIFORNIA
Price Level 1 Oct. 2006

Designed By: Sacramento - Concept Plans
Estimated By: S Fong, K Pankaskie, M Jacobs

Prepared By: Sacramento, Cost Engineering Br
Joe Yee, Branch Chief

Preparation Date: 09/24/06
Effective Date of Pricing: 10/01/06
Est Construction Time: 250 Days

Sales Tax: 7.75%

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38306

PROJECT LOCATION: Folsom IFA, Folsom Dam, 3R Gates

PROJECT NAME IFDM32

PROJECT DESCRIPTION
This estimate consists of costs to replace the three emergency spillway gates
on Folsom Dam with new higher radial gates in order to allow more water storage in the reservoir behind Folsom Dam. The new gates will have longer trunion arms and will require new seal plates and relocation of the trunion bearing Work involved includes: providing and placing new stoplogs and guide rails for dewatering, the demolition of the exiting gates, guides and mechanical equipment, relocation and replacement of the trunion bearings, installation of new gates, guide/seal plates and mechanical equipment. The piers between the gates will require modification(addition of concrete area) and the pier between gate 4 and 5 (emergency gate #1) will require additional undefined modification due to the two different trunion bearing positions between the original remaining spillway gate and the emergency spillway gate. It is assumed that the mechanical system for the remaining spillway gate will remain intact and that the emergency spillway gate will be located on a platform above. It is assumed that the electrical power/control running to the three emergency gates will be spliced and replaced from gate 5 onward.

BASES OF DESIGN
This estimate is a budget estimate based on preliminary design concepts and sketches based on findings from "PASS Phase II Report Dam Raise and Auxiliary Spillway Alternatives" dated June 2006

ACQUISITION PLAN
The project will be acquired by RFP, full and open.

SUB-CONTRACTING PLAN
The following are subcontractor on this project:
- Concrete Subcontractor
- Concrete Cutting/Drilling Subcontractor
- Rebar Subcontractor
- Electrical Subcontractor
- Crane Subcontractor

It is assumed that the Prime Contractor will do the rest of the work.

PROJECT CONSTRUCTION
SITE ACCESS
The project site is located at Folsom Dam, in Folsom, CA.

BORROW AREAS
No Borrow is required.

CONSTRUCTION METHODOLOGY
It is assumed that a ~90 ton crane will be placed on the existing bridge deck and will be used to remove the existing equipment and place the new equipment The gates will be replaced sequentially, working across the dam.

38306

UNUSUAL CONDITION
No unusual conditions.

UNIQUE TECHNIQUES OF CONSTRUCTION
No unique techiques used.

CONSTRUCTION WINDOWS
SCHEDULE
None is currently defined. This estimate does not consider the effects of mandated spills/releases and the resultant MOB/DEMOBS required.

OVERTIME
This estimate contains no overtime to complete the project.

EQUIPMENT AND LABOR AVAILABILITY & DISTANCE TRAVELED
This estimate uses Davis Bacon labor rates for Sacramento County 10/19/2006, modification #36. Overall labor prices were increase 10% to match current labor costs found in the field. Workman Comp used a high over water percent.

Equipment rates used are from EP 1110-1-8, Volume 7 June 99.updated by 15% to current equipment prices. Also fuel prices were increase to current fuel prices.

ENVIRONMENTAL CONCERNS
No significant concerns are noted.
>>>

Thu 22 Feb 2007 — Tri-Service Automated Cost .neering System (TRACES) — TIME 14:11:29
Eff. Date 10/01/06 — PROJECT ITRIGP: FOLSOM SPA,F-DAM,EMERGENCY GATE - IFR - Concept Plans — SUMMARY PAGE 1

** PROJECT INDIRECT SUMMARY - CSI ITEM **

	QUANTITY	UOM	TOTAL DIRECT	FOOH	BOOH	PROF	Misc Tax	BOND	TOTAL COST	UNIT COST
AA RAISE EXISTING DAM, 3 GATES MODS										
AA 04 DAMS - EXISTING FOLSOM DAM										
AA 04 02 SPILLWAY (MACHINERY DECK										
AA 04 02 01 MOB, DEMOB & PREPARATORY WORK										
AA 04 02 01-001- MOB, DEMOB & PREPARATORY WORK										
AA 04 02 01-001--A01A Mob, Demob & Preparatory Work			186,182	27,927	17,129	21,736	0	2,530	255,504	
TOTAL MOB, DEMOB & PREPARATORY WORK			186,182	27,927	17,129	21,736	0	2,530	255,504	
TOTAL MOB, DEMOB & PREPARATORY WORK			186,182	27,927	17,129	21,736	0	2,530	255,504	
AA 04 02 05 REMOVE R-GATE & MACHINERY DECKS										
AA 04 02 05-A01- REMOVE GATE MACHINERY & M-DECKS										
AA 04 02 05-A01--A02A Remove & Store Jib Cranes	3.00	EA	7,501	1,125	690	876	0	102	10,293	3431.10
AA 04 02 05-A01--C02C Set/Remove Safety Net(For Removl	4.00	EA	13,561	2,034	1,248	1,583	0	184	18,610	4652.50
AA 04 02 05-A01--E02A Remove GateChain Hoist Machinery	7.00	ASY	45,620	6,843	4,197	5,326	0	620	62,606	8943.75
AA 04 02 05-A01--G02B Remove Hoist Deck & Handrail	3.00	SET	111,077	16,661	10,219	12,968	0	1,509	152,434	50811.42
TOTAL REMOVE GATE MACHINERY & M-DECKS	3.00	EA	177,758	26,664	16,354	20,753	0	2,415	243,944	81314.59
TOTAL REMOVE R-GATE & MACHINERY DECKS	3.00	EA	177,758	26,664	16,354	20,753	0	2,415	243,944	81314.59
AA 04 02 08 BRIDGES, RADIAL GATE MACHINERY										
AA 04 02 08-A15- INSTALL NEW RADIAL GATE MACHINRY										
AA 04 02 08-A15--A05B New Deck Anchor Bolts (4 Sets)	64.00	EA	12,098	1,815	1,113	1,412	0	164	16,602	259.41
AA 04 02 08-A15--B15A Purchase Radial Gate Mach,7.5HP	3.00	SET	3,347,592	502,139	307,978	390,825	0	45,485	4,594,019	1531340
AA 04 02 08-A15--B15C Assembl Mach Modules,Interm Pier	3.00	ASY	85,167	12,775	7,835	9,943	0	1,157	116,878	38959.32
AA 04 02 08-A15--B15E Assembl Mach Modules,End Piers	1.00	ASY	26,500	3,975	2,438	3,094	0	360	36,367	36366.63
AA 04 02 08-A15--B15G Install Mach/Deck Modules @Piers	4.00	ASY	73,009	10,951	6,717	8,524	0	992	100,194	25048.38
TOTAL INSTALL NEW RADIAL GATE MACHINRY	3.00	EA	3,544,366	531,655	326,082	413,798	0	48,159	4,864,059	1621353
AA 04 02 08-A16- PUR RADIAL GATE MACHINERY, SPARE										
AA 04 02 08-A16--A15A Purch Spare Falk 665 Gear Set	1.00	EA	77,367	11,605	7,118	9,032	0	1,051	106,174	106173.85
AA 04 02 08-A16--A15C Purch Spare Hoist Motor, 7.5 HP	1.00	EA	4,942	741	455	577	0	67	6,782	6782.12
TOTAL PUR RADIAL GATE MACHINERY, SPARE	1.00	EA	82,309	12,346	7,572	9,609	0	1,118	112,956	112955.98

LABOR ID: CALM07 EQUIP ID: EQUP5U — Currency in DOLLARS — CREW ID: CALO7A

Thu 22 Feb 2007 — Tri-Service Automated Cost Engineering System (TRACES) — TIME 14:11:29
Eff. Date 10/01/06 — PROJECT ITR3GP: FOLSOM IFA,F-DAM,EMERGENCY GATE - IFA - Concept Plans — SUMMARY PAGE 2

** PROJECT INDIRECT SUMMARY - CSI ITEM **

		QUANTITY	UOM	TOTAL DIRECT	FOOH	WOOH	PROF	Misc Tax	BOND	TOTAL COST	UNIT COST
AA 04 02 08-A17-	INSTALL RADIAL GATE, ELEC SYSTEM										
AA 04 02 08-A17--A16A	Electrical Runs between Motors	600.00	LF	32,931	4,940	3,030	3,845	0	447	45,193	75.32
AA 04 02 08-A17--A16C	Electrical Runs & Conn to Motors	150.00	LF	23,896	3,584	2,198	2,790	0	325	32,793	218.62
AA 04 02 08-A17--A16G	Electrical Field Testing	24.00	CHR	9,986	1,498	919	1,166	0	136	13,704	570.99
	TOTAL INSTALL RADIAL GATE, ELEC SYSTEM	3.00	EA	66,813	10,022	6,147	7,800	0	908	91,689	30563.11
	TOTAL BRIDGES, RADIAL GATE MACHINERY	3.00	EA	3,493,488	554,023	339,801	431,207	0	50,185	5,068,704	1689568
	TOTAL SPILLWAY (MACHINERY DECK	3.00	SEC	4,057,427	608,614	373,283	473,697	0	55,130	5,568,152	1856051
AA 04 03	SPILLWAY(EMERGENCY TAINTER GATES										
AA 04 03 01	MOB, DEMOB & PREPARATORY WORK										
AA 04 03 01-001-	MOB, DEMOB & PREPARATORY WORK										
AA 04 03 01-001--A01A	Mob, Demob & Preparatory Work			805,417	120,812	74,098	94,031	0	10,944	1,105,302	
	TOTAL MOB, DEMOB & PREPARATORY WORK			805,417	120,812	74,098	94,031	0	10,944	1,105,302	
	TOTAL MOB, DEMOB & PREPARATORY WORK			805,417	120,812	74,098	94,031	0	10,944	1,105,302	
AA 04 03 39	REMOVE TAINTER GATES &GUIDES										
AA 04 03 39-A01-	DEMO TAINTER GATES										
AA 04 03 39-A01--A02A	Install Tntr Gate Upstr Stplgs	3.00	EA	13,405	2,011	1,233	1,563	0	182	18,397	6132.26
AA 04 03 39-A01--A02C	Set/Remove Safety Net	3.00	EA	10,171	1,526	936	1,187	0	138	13,958	4652.50
AA 04 03 39-A01--A02E	Prep Tntr Gates For Removal	3.00	EA	95,240	14,286	8,762	11,113	0	1,294	130,701	43567.01
AA 04 03 39-A01--A02K	Remove Tainter Gates, 3 EA	3.00	EA	499,251	74,888	45,931	58,267	0	6,784	685,140	228380.09
AA 04 03 39-A01--A02M	Slvge Metal Tntr Gates, 3EA	337.50	TON	180,379	27,057	16,595	21,059	0	2,451	247,541	733.65
	TOTAL DEMO TAINTER GATES	3.00	EA	798,447	119,767	73,457	93,217	0	10,849	1,095,737	365245.52
AA 04 03 39-C01-	DEMO TAINTR GATE SEAL GUIDES										
AA 04 03 39-C01-- A	Conc Sawcut, 2"Deep, Gate Guides	850.00	LF	50,894	7,634	4,682	5,942	0	692	69,844	82.17
AA 04 03 39-C01-- C	Concrete Demo, Hand Tool, 12"Dp	850.00	CF	388,514	58,277	35,743	45,358	0	5,279	533,171	627.26
	TOTAL DEMO TAINTR GATE SEAL GUIDES	360.00	LF	439,408	65,911	40,426	51,300	0	5,970	603,016	1675.04
AA 04 03 39-D01-	DEMO TRUNNION CONC, 6 EA										
AA 04 03 39-D01--A02-	Safety Net	4.00	EA	13,561	2,034	1,248	1,583	0	184	18,610	4652.50
AA 04 03 39-D01--A03A	Remove Airlines & Hoses	3.00	EA	34,169	5,125	3,144	3,989	0	464	46,892	15630.53

LABOR ID: CALM[illegible] EQUIP ID: EQUFSU Currency[illegible] CLARS CREW ID: CALDTA

** PROJECT INDIRECT SUMMARY - CSI ITEM **

		QUANTITY	UOM	TOTAL DIRECT	FOCH	HOCH	FHOF	Misc Tax	BOND	TOTAL COST	UNIT COST
AA 04 03 39-D01--A02B	Remove CatWalks	3.00	EA	13,665	2,050	1,257	1,595	0	186	18,752	6250.83
AA 04 03 39-D01--A02C	Remove Instrumentation	6.00	EA	7,826	1,174	720	914	0	106	10,740	1790.05
AA 04 03 39-D01--A02D	Disconnect Trunnion Anchors	6.00	EA	11,116	1,667	1,023	1,298	0	151	15,255	2542.45
AA 04 03 39-D01--A02E	Remove Trunnion Metal Blocks	6.00	EA	9,073	1,361	835	1,059	0	123	12,451	2075.17
AA 04 03 39-D01--A02F	Sawcut Trunnion Concrete	420.00	LF	42,982	6,447	3,954	5,018	0	584	58,986	140.44
AA 04 03 39-D01--A03-	Demo Trunnion and Concrete	13.50	CY	546,538	81,981	50,282	63,807	0	7,426	750,034	55558.08
	TOTAL DEMO TRUNNION CONC, 6 EA	345.00	CY	678,930	101,840	62,462	79,264	0	9,225	931,720	2552.66
	TOTAL REMOVE TAINTER GATES &GUIDES	3.00	EA	1,916,785	287,518	176,344	223,781	0	26,044	2,630,472	876823.98
AA 04 03 41	INSTALL, PIERS,TRUNNION,& GATES										
AA 04 03 41-A01-	CONCR LOWER PIER EXTENSION, 4EA										
AA 04 03 41-A01--B00N	Concrete Surface Treatment	3735.00	SF	29,796	4,469	2,741	3,479	0	405	40,890	10.95
AA 04 03 41-A01--B02M	Rockbolts,#11Drill&Install 30'L	6975.00	LF	344,996	51,749	31,740	40,278	0	4,688	473,450	67.88
AA 04 03 41-A01--B03-	Lower Pier, Reinforcing Dowel	1472.00	EA	445,745	66,865	41,010	52,042	0	6,057	611,739	415.58
AA 04 03 41-A01--B03A	Lower Pier, Ext Formwork	10820.00	SF	199,420	29,913	18,347	23,282	0	2,710	273,671	25.29
AA 04 03 41-A01--B03H	Lower Pier, Reinforcement	183600.00	LB	316,956	47,608	29,077	36,899	0	4,294	433,735	2.36
AA 04 03 41-A01--B03I	Lower Pier, Conc Placement	1240.00	CY	331,350	49,702	30,484	38,684	0	4,502	454,723	366.71
	TOTAL CONCR LOWER PIER EXTENSION, 4EA	810.00	CY	1,667,382	250,107	153,399	194,664	0	22,656	2,288,208	2824.95
AA 04 03 41-A03-	INSTALL TAINTER GATE GUIDES, 6EA										
AA 04 03 41-A03--A05A	Set New Gate Guide Embeds	425.00	LF	291,348	42,202	25,884	32,847	0	3,823	396,104	908.48
AA 04 03 41-A03--B03A	Place Concrete Around Embeds	30.00	CY	39,262	7,389	4,532	5,751	0	669	57,604	2253.47
	TOTAL INSTALL TAINTER GATE GUIDES, 6EA	425.00	LF	330,610	49,591	30,416	38,598	0	4,492	453,708	1067.55
AA 04 03 41-C05-	TRUNNION BLOCK & ANCHORAGE										
AA 04 03 41-C05-- -	Trunnion Anchor Conc Demo & Plat	50.00	CY	155,958	23,394	14,348	18,208	0	2,119	214,026	4280.52
AA 04 03 41-C05-- A	Trunnion Anchor Drill 6"	840.00	LF	323,334	48,500	29,747	37,749	0	4,393	443,722	528.24
AA 04 03 41-C05-- B	Trunnion Anchor Rods 5.5" dia	41500.00	LB	670,089	100,513	61,648	78,232	0	9,105	919,587	22.16
AA 04 03 41-C05-- C	Trunnion Anchor Grout & Conc Pl	156.00	CY	186,364	27,955	17,145	21,758	0	2,532	255,753	1639.45
AA 04 03 41-C05-- D	Trunnion Bases, 6 Ea	120000.00	LB	784,896	117,734	72,210	91,635	0	10,665	1,077,141	8.98
AA 04 03 41-C05-- E	Trunnion Blocks, 6 EA	180000.00	EA	1,178,845	176,227	108,086	137,161	0	15,963	1,612,282	8.96
AA 04 03 41-C05-- G	Trnion Pins & Bushing,6 Sets	40000.00	LB	492,219	73,833	45,284	57,466	0	6,688	675,489	11.26
AA 04 03 41-C05-- AA	Trunnion Anchor Layout	12.00	EA	13,560	2,034	1,248	1,583	0	184	18,609	1550.76
	TOTAL TRUNNION BLOCK & ANCHORAGE	3.00	SET	3,801,265	570,190	349,716	443,790	0	51,650	5,216,611	1738870
AA 04 03 41-E01-	TAINTER GATES, 3EA 56.83'HIGH										
AA 04 03 41-E01--A02A	Set/Remove Safety Net	8.00	EA	13,561	2,034	1,248	1,583	0	184	18,610	2326.25

LABOR ID: CALM07 EQUIP ID: EQUP3U Currency in DOLLARS CREW ID: CALOTA

** PROJECT INDIRECT SUMMARY - CSI ITEM **

		QUANTITY	UOM	TOTAL DIRECT	TOCH	HOOH	PROF	Misc Tax	BOND	TOTAL COST	UNIT COST
AA 04 03 41-E01--A05A	Furnish New Radial Gates	3.00	SET	4,964,293	744,644	456,715	579,571	0	67,452	6,812,675	2270892
AA 04 03 41-E01--A05C	Furnish & Install Gate Seals	3.00	EA	104,532	15,680	9,617	12,204	0	1,420	143,453	47817.83
AA 04 03 41-E01--A05G	Install New Radial Gates	3.00	EA	932,193	139,829	85,762	108,832	0	12,666	1,279,282	426427.29
AA 04 03 41-E01--A07G	Paint Gates 21-A-2, Epoxy-F Zinc	31752.00	SF	256,873	38,531	23,632	29,989	0	3,490	352,515	11.10
AA 04 03 41-E01--A50H	Reset Gate Instrumentation	16.00	EA	73,243	10,987	6,738	8,551	0	995	100,515	6282.14
	TOTAL TAINTER GATES, 3EA 56.83'HIGH	945600.00	LB	6,344,695	951,704	583,712	740,731	0	86,208	8,707,051	9.21
AA 04 03 41-F01-	INSTALL TRUNNION CATWALK										
AA 04 03 41-F01--A02A	Set/Remove Safety Net	3.00	EA	10,171	1,526	936	1,187	0	138	13,958	4652.50
AA 04 03 41-F01--B05A	Re-install Existg Catwalks Decks	3.00	EA	15,871	2,381	1,460	1,853	0	216	21,781	7260.18
AA 04 03 41-F01--B05C	Trunnion Handrailing	180.00	LF	19,060	2,859	1,754	2,225	0	259	26,157	145.31
AA 04 03 41-F01--C15A	Instl Perm Air Supply 3" Dia	3.00	EA	33,737	5,061	3,104	3,939	0	458	46,299	15432.96
	TOTAL INSTALL TRUNNION CATWALK	3.00	EA	78,839	11,826	7,253	9,204	0	1,071	108,194	36064.53
AA 04 03 41-G01-	CONCRETE UPPER PIER EXTENSN, 3EA										
AA 04 03 41-G01--B03-	Upper Pier, Reinforcing Dowel	750.00	EA	300,505	45,076	27,646	35,083	0	4,083	412,393	549.86
AA 04 03 41-G01--B03A	Upper Pier, Ext Formwork	13650.00	SF	336,088	50,413	30,920	39,238	0	4,567	461,225	33.79
AA 04 03 41-G01--B03H	Upper Pier, Reinforcement	50760.00	LB	129,284	19,393	11,896	15,094	0	1,757	177,421	3.50
AA 04 03 41-G01--B03I	Upper Pier, Conc Placement	1065.00	CY	398,427	59,764	36,655	46,516	0	5,414	546,775	513.40
	TOTAL CONCRETE UPPER PIER EXTENSN, 3EA	1065.00	CY	1,164,304	174,646	107,116	135,930	0	15,820	1,597,815	1500.30
	TOTAL INSTALL, PIERS,TRUNNION,& GATES	3.00	EA	13,387,095	2,008,064	1,231,613	1,562,917	0	181,897	18,371,585	6123862
AA 04 03 42	INSTALL GATE S-LOG GUIDE										
AA 04 03 42-C01-	TAINTER GATE US STOPLOGS										
AA 04 03 42-C01--A05A	Furnish & Set New Stoplogs	4.00	EA	1,922,123	288,318	176,835	224,404	0	26,117	2,637,797	659449.35
AA 04 03 42-C01--A05C	Frsh SLog sls & install air line	14.00	EA	212,969	31,945	19,593	24,864	0	2,894	292,266	20876.11
	TOTAL TAINTER GATE US STOPLOGS	2.00	SET	2,135,092	320,264	196,428	249,268	0	29,011	2,930,063	1465031
	TOTAL INSTALL GATE S-LOG GUIDE	4.00	EA	2,135,092	320,264	196,428	249,268	0	29,011	2,930,063	732515.73
	TOTAL SPILLWAY(EMERGENCY TAINTER GATES	3.00	EA	18,264,389	2,736,658	1,678,484	2,129,996	0	247,895	25,057,422	8345807
	TOTAL DAMS - EXISTING FOLSOM DAM	3.00	EA	22,301,816	3,345,272	2,051,767	2,603,692	0	303,025	30,605,574	10201858
	TOTAL RAISE EXISTING DAM, 3 GATES MODS	3.00	EA	22,301,816	3,345,272	2,051,767	2,603,692	0	303,025	30,605,574	10201858

Folsom Dam Temperature Shutters
Folsom Dam
Sacramento County, California
Baseline Cost Estimate
Modified Option 2B

Designed By: WW Cost Engineering
Estimated By: Karl Pankaskie, Michael Jacobs

Prepared By: Walla Walla Cost Engineering
Kim Callan Chief

Preparation Date: 11/06/06
Effective Date of Pricing: 10/01/06
Est Construction Time: 365 Days

Sales Tax: 7.75%

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Release 1.2

Currency in DOLLARS

PROJECT DESCRIPTION This Estimate consists of costs to remodel the temperature control shutters on the intake works Nimbus Fish Facility at Folsom Dam, Sacramento California. Scope of work includes the modification of the three existing trash rack superstructures to accommodate the installation of a cable hoists to operate the temperature control shutters. The three trash rack structures each have five slots approximately 8'4" wide and ~200' deep. The current trash racks are stacked one upon each other in the slot to an approximate total height of 130 feet. The trash racks and temperature control shutters must be repositioned one piece at a time. The current location of the temperature shutters causes interference with the trash racks. The intent is to relocate the temperature control shutters to a location that will not interfere with the trash racks and to reduce the quantity of labor required to reposition the temperature control shutters. The existing trash rack slot will be utilized to capture a new framework that will provide a slot for the trash racks and a slot for the temperature shutters. Both the shutters and trash racks will stack on top of each other in their respective slot. The shutter array is proposed to consist of five 26'high by approximately 8' wide shutters stacked one on top of each other for a total height of 130'. With 5 slots per intake structure (three structures total) this will require 25 shutters. The existing trash racks will be reutilized by narrowing them slightly to fit in the new framework. A pair of cable winches will be positioned at the top of the new framework that will operate the temperature control shutters. 10 winches will be required for each intake structure (30 total). The cable winches will attach to each side of the bottom shutter, allowing it to raise the entire stack of shutters. Each shutter will have a continuous stem to the deck on top of the superstructure that will allow it to be locked in position. The entire stack of shutters is lifted, then the shutter just above the desired opening height will be locked in position and the shutters underneath it can be lowered back down. Each inlet work superstructure and the trash racks will be repainted. Lead paint abatement is required. System 21 epoxy will be utilized.

BASIS OF ESTIMATE This is a budget estimate based on drawings and specifications, Catalogs, quotes, recent Similar Contracts, and Unit Price Book.

CONSTRUCTION SCHEDULE It is anticipated that construction will take one year.

CONSTRUCTION WINDOWS See Construction Schedule Above.

OVERTIME Overtime is not included.

ACQUISITION PLAN Full and open competition.

SUB-CONTRACTING PLAN The following are subcontractor for this project: Metal fabrication/machine subcontractor. Electrical subcontractor Paint subcontractor.

PROJECT CONSTRUCTION SITE ACCESS The project site is accessed via existing State and local roads. The access road on the top of the dam will be required and may require closing for portions of the project duration.

BORROW AREAS No borrow areas are required.

Currency DOLLARS

CONSTRUCTION METHODOLOGY The methodology is standard industry practice.

UNUSUAL CONDITIONS None noted.

UNIQUE TECHNIQUES OF CONSTRUCTION Construction techniques are standard.

EQUIPMENT AND LABOR AVAILABILITY & DISTANCE TRAVELED Labor and equipment is available within a 100 mile radius including Sacramento and the greater San Francisco Bay area.

ENVIRONMENTAL CONCERNS Environment protection requires consideration of air, water, and land, and involves noise, solid-waste management and management of radiant energy and radioactive materials, as well as other pollutants. In order to prevent environmental degradation, the Contractor and his subcontractors in the performance of this contract, shall Comply with all applicable Federal, State, and local laws, and regulations.

EQUIPMENT, LABOR RATES, MATERIAL AND OTHER COSTS This estimate uses Davis Bacon labor rates for Sacramento County, California, Decision # Equipment rates used are from EP 1110-1-8, Volume 3, June 2003.

Material prices were obtained from supply catalogs, quotes, recent similar contracts and the MCACES Unit Price Book.

Sales tax is applied.

Profit is included.

No contingency applied.
>>>

Thu 22 Feb 2007
Eff. Date 10/01/06

Tri-Service Automated Cost Engineering System (TRACES)
PROJECT ITRSHR: Folsom Dam Temperature Shutters - Folsom Dam
Folsom Dam Temperature Shutter Revi
** PROJECT OWNER SUMMARY - BID ITEM (Rounded to 100's) **

TIME 15:20:55
SUMMARY PAGE 1

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
AA FOLSOM DAM TEMPERATURE SHUTTERS							
AA.04 DAMS - MODIFY INTAKE STRUCTURES							
AA.04.04 POWER INTAKE WORKS, 5 SLOT/STR							
AA.04.04.57 MOD SHUTTER & TRASHRACKS							
AA.04.04.57.001- MOBILIZATION & DEMOBILIZATION	1.00	EA	783,400	0	0	783,400	783359.33
AA.04.04.57.002- MODIFY GUIDES,SHUTTERS &TRASHRCK	15.00	SLT	15,674,100	0	0	15,674,100	1044941
AA.04.04.57.003- SANDBLAST&PAINT UPPR METAL 3 STR	14400.00	SF	1,142,200	0	0	1,142,200	79.32
AA.04.04.57.004- ELECTRIAL LINE TO INTAKE STR	3000.00	LF	181,100	0	0	181,100	60.36
TOTAL MOD SHUTTER & TRASHRACKS	1.00	EA	17,780,700	0	0	17,780,700	17780749
TOTAL POWER INTAKE WORKS, 5 SLOT/STR	15.00	SLT	17,780,700	0	0	17,780,700	1185383
TOTAL DAMS - MODIFY INTAKE STRUCTURES	3.00	EA	17,780,700	0	0	17,780,700	5926914
TOTAL FOLSOM DAM TEMPERATURE SHUTTERS	75.00	EA	17,780,700	0	0	17,780,700	237076.66
TOTAL Folsom Dam Temperature Shutters	3.00	STR	17,780,700	0	0	17,780,700	5926914

Currency: DLLARS

		QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
AA	FOLSOM DAM TEMPERATURE SHUTTERS							
AA.04	DAMS - MODIFY INTAKE STRUCTURES							
AA.04.04	POWER INTAKE WORKS, 5 SLOT/STR							
AA.04.04.57	MOD SHUTTER & TRASHRACKS							
AA.04.04.57.001-	MOBILIZATION & DEMOBILIZATION							
AA.04.04.57.001-.01AA	Mobilization & Demobilization	1.00	EA	783,400	0	0	783,400	783359.33
	TOTAL MOBILIZATION & DEMOBILIZATION	1.00	EA	783,400	0	0	783,400	783359.33
AA.04.04.57.002-	MODIFY GUIDES,SHUTTERS &TRASHRCK							
AA.04.04.57.002-.A---	-- REMOVE EXISTING ITEMS --Slot-	15.00	EA	0	0	0	0	0.01
AA.04.04.57.002-.A02A	Remove Deck & Equipment per Slot	15.00	EA	72,700	0	0	72,700	4843.34
AA.04.04.57.002-.A02C	Remove Existing Shutter to Shop	75.00	EA	38,900	0	0	38,900	519.01
AA.04.04.57.002-.A02F	Remove Existing Trash-R to Shop	120.00	EA	62,300	0	0	62,300	519.01
AA.04.04.57.002-.A02H	Modify Deck & Retnstall, Ea Slot	15.00	EA	126,100	0	0	126,100	8407.73
AA.04.04.57.002-.C---	--- INSTALL NEW/MOD ITEMS -Slot-	15.00	EA	0	0	0	0	0.01
AA.04.04.57.002-.C15A	Install Hoists, 25 Ton/Ea	15.00	EA	6,092,500	0	0	6,092,500	406166.16
AA.04.04.57.002-.C16A	Connect Electrical to Hoist	15.00	EA	752,100	0	0	752,100	50137.18
AA.04.04.57.002-.C16K	Install Annunciator & Sensors	16.00	EA	19,800	0	0	19,800	1259.11
AA.04.04.57.002-.E05A	Fab &Install (Shut/Trash) Guides	60.00	EA	5,999,700	0	0	5,999,700	99995.33
AA.04.04.57.002-.E05C	Mod & Install Shutters	75.00	EA	2,437,700	0	0	2,437,700	32502.36
AA.04.04.57.002-.E05E	Mod & Install Trash-Racks	120.00	EA	72,400	0	0	72,400	603.11
	TOTAL MODIFY GUIDES,SHUTTERS &TRASHRCK	15.00	SLT	15,674,100	0	0	15,674,150	1044941
AA.04.04.57.003-	SANDBLAST&PAINT UPPR METAL 3 STR							
AA.04.04.57.003-.A09A	Setup Containment Enclosure, 3Ea	18900.00	SF	139,700	0	0	139,700	7.39
AA.04.04.57.003-.C09A	Sandblast Upper Metal Structure	14400.00	SF	283,300	0	0	283,300	19.68
AA.04.04.57.003-.E09B	Paint Sys 21-A-2, Epoxy-P Zinc	14400.00	SF	567,400	0	0	567,400	39.41
AA.04.04.57.003-.G09A	Remove Containment Enclosure,3Ea	18900.00	SF	151,700	0	0	151,700	8.02
	TOTAL SANDBLAST&PAINT UPPR METAL 3 STR	14400.00	SF	1,142,200	0	0	1,142,200	79.32
AA.04.04.57.004-	ELECTRIAL LINE TO INTAKE STR							
AA.04.04.57.004-.A16A	Transformer	3.00	EA	17,000	0	0	17,000	5656.26
AA.04.04.57.004-.B16A	Switches Controls & Devices	30.00	EA	90,600	0	0	90,600	3019.12
AA.04.04.57.004-.C16A	Power Line to Hoists	3000.00	LF	60,800	0	0	60,800	20.26
AA.04.04.57.004-.F16A	Fiber Optic Signal Cable	2000.00	LF	12,800	0	0	12,800	6.38

Currency in DOLLARS

	QUANTITY	UOM	CONTRACT	ESCALATN	CONTINGN	TOTAL COST	UNIT COST
TOTAL ELECTRIAL LINE TO INTAKE STR	3000.00	LF	181,100	0	0	181,100	60.36
TOTAL MOD SHUTTER & TRASHRACKS	1.00	EA	17,780,700	0	0	17,780,700	17780749
TOTAL POWER INTAKE WORKS, 5 SLOT/STR	15.00	SLT	17,780,700	0	0	17,780,700	1185583
TOTAL GAMS - MODIFY INTAKE STRUCTURES	3.00	EA	17,780,700	0	0	17,780,700	5926916
TOTAL FOLSOM DAM TEMPERATURE SHUTTERS	75.00	EA	17,780,700	0	0	17,780,700	237076.66
TOTAL Folsom Dam Temperature Shutters	3.00	STR	17,780,700	0	0	17,780,700	5926916

38306

Folsom Raise, Bushy Lake Updated
Base Line Cost Estimte

Designed By: Jones & Stokes
Estimated By: HDR Engineering

Prepared By: John D. Ruza

Preparation Date: 11/06/06
Effective Date of Pricing: 10/01/06
Est Construction Time: 180 Days

Sales Tax: 7.75%

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38306

Thu 09 Nov 2006 — Tri-Service Automated Cost Engineering System (TRACES) — TIME 08:45:44
Eff. Date 10/01/06 — PROJECT FSBL06: Folsom Raise, Bushy Lake Updated - Base Line Cost Estimate — SUMMARY PAGE 1
Architect/Engineer's Baseline Estimate
** PROJECT OWNER SUMMARY - SCOPE (Rounded to 100's) **

		QUANTITY	UOM	CONTRACT	OTHER	ESCALATN	OWN FURN	CONTINGN	SIOH	TOTAL COST	UNIT COST
05	Seasonal Wetland	18.00	AC	1,086,800	0	0	0	0	0	1,086,800	60375.29
07	Riparian Forest	25.00	AC	1,471,100	0	0	0	0	0	1,471,100	58845.01
09	Oak Woodland Savannah	67.00	AC	1,935,500	0	0	0	0	0	1,935,500	28887.66
13	Side Channel	4.00	AC	430,400	0	0	0	0	0	430,400	107603.32
15	Terrace Riverbank	7.00	AC	1,296,700	0	0	0	0	0	1,296,700	185248.64
18	Stream Channel	2.00	AC	120,800	0	0	0	0	0	120,800	60407.20
19	Wetland Treatment System	7.50	AC	937,300	0	0	0	0	0	937,300	124979.25
25	Pump and Delivery System	1.00	EA	421,200	0	0	0	0	0	421,200	421237.09
TOTAL	Folsom Raise, Bushy Lake Updated			7,699,900	0	0	0	0	0	7,699,900	

LABOR ID: SACVE — EQUIP ID: NAT99B — Currency ILLARS — CREW ID: NAT06A

Thu 09 Nov 2006 TIME 08:45:46
Eff. Date 10/01/06

Tri-Service Automated Cos Inseering System (TRACES)
PROJECT FOLS06: Folsom Raise, Bushy Lake Updated - Base Line Cost Estimte
Architect/Engineer's Baseline Estimate
SUMMARY PAGE 2

** PROJECT OWNER SUMMARY - FACILITY (Rounded to 100's) **

	QUANTITY	UOM	CONTRACT	OTHER	ESCALATN	OWN FURN	CONTINGN	SIOH	TOTAL COST	UNIT COST
05 Seasonal Wetland										
05.01 Clearing & Grubbing	18.00	AC	71,600	0	0	0	0	0	71,600	3976.19
05.02 Grading & Shaping	18.00	AC	755,700	0	0	0	0	0	755,700	41985.74
05.03 Plantings	6300.00	EA	182,400	0	0	0	0	0	182,400	28.95
05.04 Initial Watering	18.00	AC	13,600	0	0	0	0	0	13,600	758.08
05.05 Continuous Moisture Release	3150.00	EA	63,400	0	0	0	0	0	63,400	20.13
TOTAL Seasonal Wetland	18.00	AC	1,086,800	0	0	0	0	0	1,086,800	60375.29
07 Riparian Forest										
07.01 Clearing & Grubbing	25.00	AC	99,400	0	0	0	0	0	99,400	3976.09
07.02 Grading & Shaping	25.00	AC	1,049,500	0	0	0	0	0	1,049,500	41981.46
07.03 Plantings	5000.00	EA	202,600	0	0	0	0	0	202,600	40.52
07.04 Initial Watering	25.00	AC	19,000	0	0	0	0	0	19,000	758.08
07.05 Continuous Moisture Release	5000.00	EA	100,600	0	0	0	0	0	100,600	20.13
TOTAL Riparian Forest	25.00	AC	1,471,100	0	0	0	0	0	1,471,100	58845.01
09 Oak Woodland Savannah										
09.01 Clearing & Grubbing	67.00	AC	266,400	0	0	0	0	0	266,400	3976.24
09.02 Grading & Shaping	67.00	AC	1,544,100	0	0	0	0	0	1,544,100	23045.60
09.03 Plantings	1340.00	EA	47,200	0	0	0	0	0	47,200	35.24
09.04 Initial Watering	67.00	AC	50,800	0	0	0	0	0	50,800	758.09
09.05 Continuous Moisture Release	1340.00	EA	27,000	0	0	0	0	0	27,000	20.13
TOTAL Oak Woodland Savannah	67.00	AC	1,935,500	0	0	0	0	0	1,935,500	28887.46
13 Side Channel										
13.01 Clearing & Grubbing	4.00	AC	15,900	0	0	0	0	0	15,900	3976.95
13.02 Grading & Shaping	4.00	AC	347,900	0	0	0	0	0	347,900	86978.68
13.03 Plantings	1400.00	EA	35,400	0	0	0	0	0	35,400	25.27
13.04 Initial Watering	4.00	AC	3,000	0	0	0	0	0	3,000	758.04
13.05 Continuous Moisture Release	1400.00	EA	28,200	0	0	0	0	0	28,200	20.13
TOTAL Side Channel	4.00	AC	430,400	0	0	0	0	0	430,400	107603.32
15 Terrace Riverbank										
15.01 Clearing & Grubbing	7.00	AC	125,300	0	0	0	0	0	125,300	17892.87
15.02 Grading & Shaping	7.00	AC	1,081,300	0	0	0	0	0	1,081,300	154468.19
15.03 Plantings	1400.00	EA	56,700	0	0	0	0	0	56,700	40.52
15.04 Initial Watering	7.00	AC	5,300	0	0	0	0	0	5,300	758.09

LABOR ID: SACV06 EQUIP ID: HAT998 Currency in DOLLARS CREW ID: HATO6A

		QUANTITY	UOM	CONTRACT	OTHER	ESCALATN	OWN FURN	CONTINGN	SIOH	TOTAL COST	UNIT COST
15.05	Continuous Moisture Release	1400.00	EA	28,200	0	0	0	0	0	28,200	20.13
TOTAL	Terrace Riverbank	7.00	AC	1,296,700	0	0	0	0	0	1,296,700	185248.64
18	Stream Channel										
18.01	Clearing & Grubbing	2.00	AC	8,000	0	0	0	0	0	8,000	3977.47
18.02	Grading & Shaping	2.00	AC	84,000	0	0	0	0	0	84,000	41985.19
18.03	Plantings	700.00	EA	20,300	0	0	0	0	0	20,300	29.04
18.04	Initial Watering	2.00	AC	1,500	0	0	0	0	0	1,500	758.04
18.05	Continuous Moisture Release	350.00	EA	7,000	0	0	0	0	0	7,000	20.13
TOTAL	Stream Channel	2.00	AC	120,800	0	0	0	0	0	120,800	60407.25
19	Wetland Treatment System										
19.01	Clearing & Grubbing	7.50	AC	31,800	0	0	0	0	0	31,800	4242.36
19.02	Grading & Shaping	7.50	AC	463,800	0	0	0	0	0	463,800	61840.08
19.03	Plantings	5500.00	EA	69,100	0	0	0	0	0	69,100	12.56
19.06	Berm Construction	1100.00	LF	154,800	0	0	0	0	0	154,800	140.68
19.07	Sediment Basin Clay Liner	5000.00	CY	208,500	0	0	0	0	0	208,500	41.71
19.08	Overflow Wier	1.00	EA	9,300	0	0	0	0	0	9,300	9349.33
TOTAL	Wetland Treatment System	7.50	AC	937,300	0	0	0	0	0	937,300	124979.25
25	Pump and Delivery System										
25.01	Pump House	672.00	SF	244,600	0	0	0	0	0	244,600	363.91
25.02	Intake Structure	1.00	EA	10,000	0	0	0	0	0	10,000	9986.97
25.03	Outlet Structure	1.00	EA	12,600	0	0	0	0	0	12,600	12614.84
25.04	Delivery System	2530.00	LF	154,100	0	0	0	0	0	154,100	60.90
TOTAL	Pump and Delivery System	1.00	EA	421,200	0	0	0	0	0	421,200	421237.09
TOTAL	Folsom Raise, Bushy Lake Updated			7,699,900	0	0	0	0	0	7,699,900	

		QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
05	Seasonal Wetland	18.00	AC	812,300	121,800	58,000	83,700	12,900	1,086,800	60375.29
07	Riparian Forest	25.00	AC	1,099,600	164,900	75,900	113,300	17,400	1,471,100	58845.01
09	Oak Woodland Savannah	67.00	AC	1,446,700	217,000	99,800	149,000	23,000	1,935,500	28887.66
13	Side Channel	4.00	AC	321,700	48,300	22,200	33,100	5,100	430,400	107603.32
15	Terrace Riverbank	7.00	AC	949,300	145,400	66,900	99,800	15,400	1,296,700	185248.64
18	Stream Channel	2.00	AC	90,300	13,500	6,200	9,300	1,400	120,800	60407.20
19	Wetland Treatment System	7.50	AC	700,600	105,100	48,300	72,200	11,100	937,300	124979.25
25	Pump and Delivery System	1.00	EA	314,900	47,200	21,700	32,400	5,000	421,200	421237.09
TOTAL	Folsom Raise, Bushy Lake Updated			5,755,300	863,300	397,100	592,800	91,300	7,699,900	

Thu 09 Nov 2006 — Tri-Service Automated Cost Engineering System (TRACES) — TIME 08:45:46
Eff. Date 10/01/06 — PROJECT FDBL06: Folsom Raise, Bushy Lake Updated - Base Line Cost Estimte — SUMMARY PAGE 5
Architect/Engineer's Baseline Estimate
** PROJECT INDIRECT SUMMARY - FACILITY (Rounded to 100's) **

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
05 Seasonal Wetland								
05.01 Clearing & Grubbing	18.00 AC	53,500	8,000	3,700	5,500	800	71,600	3976.19
05.02 Grading & Shaping	18.00 AC	564,900	84,700	39,000	58,200	9,000	755,700	41985.74
05.03 Plantings	6300.00 EA	136,300	20,500	9,400	14,000	2,200	182,400	28.95
05.04 Initial Watering	18.00 AC	10,200	1,500	700	1,100	200	13,600	758.08
05.05 Continuous Moisture Release	3150.00 EA	47,600	7,100	3,300	4,900	800	63,400	20.13
TOTAL Seasonal Wetland	18.00 AC	812,300	121,800	56,000	83,700	12,900	1,086,800	60375.29
07 Riparian Forest								
07.01 Clearing & Grubbing	25.00 AC	74,300	11,100	5,100	7,700	1,200	99,400	3976.09
07.02 Grading & Shaping	25.00 AC	784,500	117,700	54,100	80,800	12,400	1,049,500	41981.46
07.03 Plantings	5000.00 EA	151,400	22,700	10,400	15,600	2,400	202,600	40.52
07.04 Initial Watering	25.00 AC	14,200	2,100	1,000	1,500	200	19,000	758.08
07.05 Continuous Moisture Release	5000.00 EA	75,200	11,300	5,200	7,700	1,200	100,600	20.13
TOTAL Riparian Forest	25.00 AC	1,099,600	164,900	75,900	113,300	17,400	1,471,100	58845.01
09 Oak Woodland Savannah								
09.01 Clearing & Grubbing	67.00 AC	199,100	29,900	13,700	20,500	3,200	266,400	3976.24
09.02 Grading & Shaping	67.00 AC	1,154,100	173,100	79,400	118,900	18,300	1,544,100	23045.60
09.03 Plantings	1340.00 EA	35,300	5,300	2,400	3,600	600	47,200	35.26
09.04 Initial Watering	67.00 AC	38,000	5,700	2,600	3,900	600	50,800	758.09
09.05 Continuous Moisture Release	1340.00 EA	20,200	3,000	1,400	2,100	300	27,000	20.13
TOTAL Oak Woodland Savannah	67.00 AC	1,446,700	217,000	99,900	149,000	23,000	1,935,500	28887.66
13 Side Channel								
13.01 Clearing & Grubbing	4.00 AC	11,900	1,800	800	1,200	200	15,900	3976.95
13.02 Grading & Shaping	4.00 AC	260,100	39,000	17,900	26,800	4,100	347,900	86978.48
13.03 Plantings	1400.00 EA	26,400	4,000	1,800	2,700	400	35,400	25.27
13.04 Initial Watering	4.00 AC	2,300	300	200	200	0	3,000	758.04
13.05 Continuous Moisture Release	1400.00 EA	21,100	3,200	1,500	2,200	300	28,200	20.13
TOTAL Side Channel	4.00 AC	321,700	48,300	22,200	33,100	5,100	430,400	107603.32
15 Terrace Riverbank								
15.01 Clearing & Grubbing	7.00 AC	93,400	14,000	6,500	9,600	1,500	125,900	17992.97
15.02 Grading & Shaping	7.00 AC	808,200	121,200	55,800	83,200	12,800	1,081,300	154468.19
15.03 Plantings	1400.00 EA	42,400	6,400	2,900	4,400	700	56,700	40.52
15.04 Initial Watering	7.00 AC	4,000	600	300	400	100	5,300	758.09

LABOR ID: SACV EQUIP ID: NAT99B Currency ILLAS CREW ID: NAT06A

Thu 09 Nov 200
Eff. Date 10/01/06

Tri-Service Automated Cost ineering System (TRACES)
PROJECT FSBL06: Folsom Raise, Bushy Lake Updated - Base Line Cost Estimate
Architect/Engineer's Baseline Estimate
** PROJECT INDIRECT SUMMARY - FACILITY (Rounded to 100's) **

TIME 08:45:46
SUMMARY PAGE 6

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
15.05 Continuous Moisture Release	1400.00 EA	21,100	3,200	1,500	2,200	300	28,200	20.13
TOTAL Terrace Riverbank	7.00 AC	969,300	145,400	66,900	99,800	15,400	1,296,700	185248.64
18 Stream Channel								
18.01 Clearing & Grubbing	2.00 AC	5,900	900	400	600	100	8,000	3977.47
18.02 Grading & Shaping	2.00 AC	62,800	9,400	4,300	6,500	1,000	84,000	41985.19
18.03 Plantings	700.00 EA	15,200	2,300	1,000	1,400	200	20,300	29.04
18.04 Initial Watering	2.00 AC	1,100	200	100	100	0	1,500	758.04
18.05 Continuous Moisture Release	350.00 EA	5,300	800	400	500	100	7,000	20.13
TOTAL Stream Channel	2.00 AC	90,300	13,500	6,200	9,300	1,400	120,800	60407.25
19 Wetland Treatment System								
19.01 Clearing & Grubbing	7.50 AC	23,800	3,600	1,600	2,400	400	31,800	4242.36
19.02 Grading & Shaping	7.50 AC	346,700	52,000	23,900	33,700	5,500	463,800	61840.08
19.03 Plantings	5500.00 EA	51,600	7,700	3,600	5,300	800	69,100	12.56
19.06 Berm Construction	1100.00 LF	115,700	17,400	8,000	11,900	1,800	154,800	140.68
19.07 Sediment Basin Clay Liner	5000.00 CY	155,900	23,400	10,800	16,100	2,500	208,500	41.71
19.08 Overflow Weir	1.00 EA	7,000	1,000	500	700	100	9,300	9349.33
TOTAL Wetland Treatment System	7.50 AC	700,600	105,100	48,300	72,200	11,100	937,300	124979.25
25 Pump and Delivery System								
25.01 Pump House	672.00 SF	182,800	27,400	12,600	18,800	2,900	244,600	363.91
25.02 Intake Structure	1.00 EA	7,500	1,100	500	800	100	10,000	9986.97
25.03 Outlet Structure	1.00 EA	9,400	1,400	700	1,000	100	12,600	12616.84
25.04 Delivery System	2530.00 LF	115,200	17,300	7,900	11,900	1,800	154,100	60.90
TOTAL Pump and Delivery System	1.00 EA	314,900	47,200	21,700	32,400	5,000	421,200	421237.09
TOTAL Folsom Raise, Bushy Lake Updated		5,755,300	863,300	397,100	592,800	91,300	7,699,900	

LABOR ID: SACV06 EQUIP ID: HAT99B Currency in DOLLARS CREW ID: NATO6A

Lower American, Woodlake
Base Line Cost Estimate

Designed By: Jones & Stokes
Estimated By: HDR Engineering

Prepared By: John D. Ruas

Preparation Date: 11/06/06
Effective Date of Pricing: 10/01/06
Est Construction Time: 180 Days

Sales Tax: 7.75%

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Thu 09 Nov 200- Tri-Service Automated Cos neering System (TRACES) TIME 08:47:16
Eff. Date 10/01/05 PROJECT PSNL06: Lower American, woodlake - Base Line Cost Estimate SUMMARY PAGE 1
Architect/Engineer's Baseline Estimate
** PROJECT INDIRECT SUMMARY - SCOPE (Rounded to 100's) **

		QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
03	Excavation of Seed Bank	60.00	AC	996,100	149,400	91,600	107,000	20,200	1,364,400	22739.74
07	Riparian Forest Species	13.00	AC	535,000	80,200	49,200	57,500	10,800	732,800	56365.98
08	Riparian Oak Woodland Species	16.00	AC	319,000	47,800	29,300	34,300	6,500	436,900	27304.10
09	Oak Woodland Savannah Species	25.00	AC	521,500	78,200	48,000	56,000	10,600	714,300	28570.50
10	Seed Grassland	35.00	AC	284,600	43,000	26,400	30,800	5,800	392,500	11214.61
16	Excavate Artifical Berm	1.50	AC	114,100	17,100	10,500	12,300	2,300	156,300	104189.34
TOTAL	Lower American, Woodlake			2,772,200	415,800	255,000	297,800	56,100	3,797,100	

LABOR ID: SACV06 EQUIP ID: NAT99B Currency in DOLLARS CREW ID: NATGEA

Thu 09 Nov 2006
Eff. Date 10/01/06

Tri-Service Automated Cost Engineering System (TRACES)
PROJECT FSWL06: Lower American, Woodlake - Base Line Cost Estimate
Architect/Engineer's Baseline Estimate
** PROJECT INDIRECT SUMMARY - FACILITY (Rounded to 100's) **

TIME 08:47:16
SUMMARY PAGE 2

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
03 Excavation of Seed Bank									
03.02 Grading & Shaping	60.00	AC	996,100	149,400	91,600	107,000	20,200	1,364,400	22739.74
TOTAL Excavation of Seed Bank	60.00	AC	996,100	149,400	91,600	107,000	20,200	1,364,400	22739.74
07 Riparian Forest Species									
07.01 Clearing & Grubbing	13.00	AC	38,800	5,800	3,600	4,200	800	53,100	4085.87
07.02 Grading & Shaping	13.00	AC	372,300	55,800	34,300	40,000	7,500	510,000	39227.94
07.03 Plantings	2600.00	EA	77,900	11,700	7,200	8,400	1,600	106,700	41.03
07.04 Initial Watering	13.00	AC	7,400	1,100	700	800	200	10,200	781.88
07.05 Continuous Moisture Release	2600.00	EA	38,600	5,800	3,500	4,100	800	52,800	20.32
TOTAL Riparian Forest Species	13.00	AC	535,000	80,200	49,200	57,500	10,600	732,800	56365.98
08 Riparian Oak Woodland Species									
08.01 Clearing & Grubbing	16.00	AC	47,500	7,100	4,400	5,100	1,000	65,000	4064.03
08.02 Grading & Shaping	16.00	AC	249,900	37,500	23,000	26,800	5,100	342,300	21392.53
08.03 Plantings	320.00	EA	6,800	1,000	600	700	100	9,400	29.31
08.04 Initial Watering	16.00	AC	9,100	1,400	800	1,000	200	12,400	777.84
08.05 Continuous Moisture Release	288.00	EA	5,600	800	500	600	100	7,700	26.84
TOTAL Riparian Oak Woodland Species	16.00	AC	319,000	47,800	29,300	34,300	6,500	436,900	27304.10
09 Oak Woodland Savannah Species									
09.01 Clearing & Grubbing	25.00	AC	74,200	11,100	6,800	8,000	1,500	101,700	4066.31
09.02 Grading & Shaping	25.00	AC	391,100	58,700	36,000	42,000	7,900	535,600	21425.98
09.03 Plantings	1250.00	EA	23,400	3,500	2,200	2,500	500	32,100	25.68
09.04 Initial Watering	25.00	AC	14,200	2,100	1,300	1,500	300	19,500	778.28
09.05 Continuous Moisture Release	1250.00	EA	18,500	2,800	1,700	2,000	400	25,400	20.32
TOTAL Oak Woodland Savannah Species	25.00	AC	521,500	78,200	48,000	56,000	10,600	714,300	28570.50
10 Seed Grassland									
10.01 Clearing & Grubbing	35.00	AC	104,300	15,600	9,600	11,200	2,100	142,800	4080.24
10.02 Grading & Shaping	35.00	AC	141,000	21,100	13,000	15,100	2,900	193,100	5515.99
10.03 Plantings	35.00	AC	21,400	3,200	2,000	2,300	400	29,300	837.22
10.04 Initial Watering	35.00	AC	20,000	3,000	1,800	2,100	400	27,300	781.17
TOTAL Seed Grassland	35.00	AC	286,600	43,000	26,400	30,800	5,800	392,500	11214.61

LABOR ID: SACV6 | EQUIP ID: NAT99R | Currency | LEARS | CREW ID: NAT06A

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
16 Excavate Artifical Berm									
16.01 Clearing & Grubbing	1.50	AC	20,100	3,000	1,800	2,200	400	27,500	18316.73
16.02 Grading & Shaping	1.50	AC	94,000	14,100	8,700	10,100	1,900	128,800	85872.63
TOTAL Excavate Artifical Berm	1.50	AC	114,100	17,100	10,500	12,300	2,300	156,300	104189.36
TOTAL Lower American, Woodlake			2,772,200	415,800	255,000	297,800	56,100	3,797,100	

38306

Attachment B3 – Annual Cost
Folsom Dam Raise Project
Engineering Documentation Report

SUMMARY OF TOTAL PROJECT ANNUAL COST

03/28/2007

PROJECT: FOLSOM DAM 3.5' RAISE AND REPLACE 3 EMERGENCY GATES
LOCACTION: California — **U. S. ARMY CORPS OF ENGINEER**
INTEREST RATE: 4.875% — **SACRAMENTO DISTRICT**

ITEM	COST ($)
Effective Price Level (EPL) 1-Oct-2006	
A. INVESTMENT COST	
1. FEDERAL TOTAL	148,924,000
2. NON-FEDERAL TOTAL	130,044,750
TOTAL PROJECT INVESTMENT	**$278,968,750**
B. ANNUAL COSTS	
1. FEDERAL TOTAL	8,000,000
2. NON-FEDERAL TOTAL	7,147,000
TOTAL PROJECT ANNUAL COST	**$15,147,000**

SUMMARY OF ANNUAL COSTS

ITEM	COST ($)
Effective Price Level (EPL) 1-Oct-2006	
3.5' Floodwall and Replace 3 Emergency Gates	
A. INVESTMENT COST	
1. FEDERAL TOTAL	58,476,000
2. NON-FEDERAL TOTAL	42,830,000
TOTAL PROJECT INVESTMENT	**$101,306,000**
B. ANNUAL COSTS	
1. FEDERAL TOTAL	3,142,000
2. NON-FEDERAL TOTAL	2,420,000
TOTAL ANNUAL COST	**$5,562,000**
Ecosystem	
A. INVESTMENT COST	
1. FEDERAL TOTAL	41,224,000
2. NON-FEDERAL TOTAL	21,412,000
TOTAL PROJECT INVESTMENT	**$62,636,000**
B. ANNUAL COSTS	
1. FEDERAL TOTAL	2,215,000
2. NON-FEDERAL TOTAL	1,150,000
TOTAL ANNUAL COST	**$3,365,000**
Folsom Temp. Bridge, Flood Damage Reduction and Dam Safety	
A. INVESTMENT COST	
1. FEDERAL TOTAL	32,234,000
2. NON-FEDERAL TOTAL	21,579,000

SUMMARY OF ANNUAL COSTS(CONT'ED)

ITEM	COST ($)
Effective Price Level (EPL) 1-Oct-2006	
TOTAL PROJECT INVESTMENT	$53,813,000
B. ANNUAL COSTS	
1. FEDERAL TOTAL	1,731,000
2. NON-FEDERAL TOTAL	1,159,000
TOTAL ANNUAL COST	$2,890,000
Bridge, Permanent Bridge Only	
A. INVESTMENT COST	
1. FEDERAL TOTAL	16,990,000
2. NON-FEDERAL TOTAL	14,850,750
TOTAL PROJECT INVESTMENT	$31,840,750
B. ANNUAL COSTS	
1. FEDERAL TOTAL	912,000
2. NON-FEDERAL TOTAL	840,000
TOTAL ANNUAL COST	$1,752,000
Funds Provided By User	
A. INVESTMENT COST	
2. NON-FEDERAL TOTAL	29,373,000
TOTAL PROJECT INVESTMENT	$29,373,000
B. ANNUAL COSTS	
2. NON-FEDERAL TOTAL	1,578,000
TOTAL ANNUAL COST	$1,578,000

DETAILED ESTIMATE OF ANNUAL COST

ITEM		COST ($)
Effective Price Level (EPL) 1-Oct-2006		
3.5' Floodwall and Replace 3 Emergency Gates		
A. INVESTMENT COST		
1. FEDERAL		
a. First Cost		75,209,000
Less 18. Cultural Resources Preservation		(752,000)
Less 30. PED Sunk Cost(Not Subject to IDC)		(22,144,000)
b. Interest During Construction		6,163,000
TOTAL		$58,476,000
2. NON-FEDERAL		
a. First Cost		40,091,000
b. Interest During Construction		2,739,000
TOTAL		$42,830,000
TOTAL PROJECT INVESTMENT		**$101,306,000**
B. ANNUAL COSTS		
1. FEDERAL		
a. Interest and Amortization:		
Interest @	4.875%	2,851,000
Amortization @	0.497%	291,000
Amortization Period	50	
TOTAL		$3,142,000
2. NON-FEDERAL		
a. Interest and Amortization:		
Interest @	4.875%	2,088,000
Amortization @	0.497%	213,000
Amortization Period	50	
c. Maintenance And Operation:		82,000
04--- Dams	82,000	
d. Replacement Costs:		37,000
04--- Dams	37,000	
TOTAL		$2,420,000
TOTAL ANNUAL COST		**$5,562,000**
Ecosystem		
A. INVESTMENT COST		
1. FEDERAL		
a. First Cost		38,921,000
Less 18. Cultural Resources Preservation		(154,000)
Less 30. PED Sunk Cost(Not Subject to IDC)		(178,000)
b. Interest During Construction		2,635,000
TOTAL		$41,224,000
2. NON-FEDERAL		
a. First Cost		20,870,000

DETAILED ESTIMATE OF ANNUAL COST(CONT'ED)

ITEM		COST ($)
Effective Price Level (EPL) 1-Oct-2006		
b. Interest During Construction		542,000
TOTAL		$21,412,000
TOTAL PROJECT INVESTMENT		**$62,636,000**
B. ANNUAL COSTS		
1. FEDERAL		
a. Interest and Amortization:		
Interest @	4.875%	2,010,000
Amortization @	0.497%	205,000
Amortization Period	50	
TOTAL		$2,215,000
2. NON-FEDERAL		
a. Interest and Amortization:		
Interest @	4.875%	1,044,000
Amortization @	0.497%	106,000
Amortization Period	50	
TOTAL		$1,150,000
TOTAL ANNUAL COST		**$3,365,000**
Folsom Temp. Bridge, Flood Damage Reduction and Dam Safety		
A. INVESTMENT COST		
1. FEDERAL		
a. First Cost		38,170,000
Less 30. PED Sunk Cost(Not Subject to IDC)		(7,502,000)
b. Interest During Construction		1,566,000
TOTAL		$32,234,000
2. NON-FEDERAL		
a. First Cost		20,570,000
b. Interest During Construction		1,009,000
TOTAL		$21,579,000
TOTAL PROJECT INVESTMENT		**$53,813,000**
B. ANNUAL COSTS		
1. FEDERAL		
a. Interest and Amortization:		
Interest @	4.875%	1,571,000
Amortization @	0.497%	160,000
Amortization Period	50	
TOTAL		$1,731,000
2. NON-FEDERAL		
a. Interest and Amortization:		

DETAILED ESTIMATE OF ANNUAL COST(CONT'ED)

ITEM		COST ($)
Effective Price Level (EPL) 1-Oct-2006		
Interest @	4.875%	1,052,000
Amortization @	0.497%	107,000
Amortization Period	50	
TOTAL		$1,159,000
TOTAL ANNUAL COST		**$2,890,000**
Bridge, Permanent Bridge Only		
A. INVESTMENT COST		
1. FEDERAL		
a. First Cost		15,311,000
b. Interest During Construction		1,679,000
TOTAL		$16,990,000
2. NON-FEDERAL		
a. First Cost		13,588,750
b. Interest During Construction		1,262,000
TOTAL		$14,850,750
TOTAL PROJECT INVESTMENT		**$31,840,750**
B. ANNUAL COSTS		
1. FEDERAL		
a. Interest and Amortization:		
Interest @	4.875%	828,000
Amortization @	0.497%	84,000
Amortization Period	50	
TOTAL		$912,000
2. NON-FEDERAL		
a. Interest and Amortization:		
Interest @	4.875%	724,000
Amortization @	0.497%	74,000
Amortization Period	50	
c. Maintenance And Operation:		42,000
08--- Roads	42,000	
TOTAL		$840,000
TOTAL ANNUAL COST		**$1,752,000**
Funds Provided By User		
2. NON-FEDERAL		
a. First Cost		28,000,000
b. Interest During Construction		1,373,000
TOTAL		$29,373,000
TOTAL PROJECT INVESTMENT		**$29,373,000**

DETAILED ESTIMATE OF ANNUAL COST(CONT'ED)

ITEM		COST ($)
Effective Price Level (EPL) 1-Oct-2006		
B. ANNUAL COSTS		
2. NON-FEDERAL		
a. Interest and Amortization:		
Interest @	4.875%	1,432,000
Amortization @	0.497%	146,000
Amortization Period	50	
TOTAL		$1,578,000
TOTAL ANNUAL COST		**$1,578,000**

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION	INTEREST RATE (%)
	Effective Price Level (EPL) 1-Oct-2006						
	3.5' Floodwall and Replace 3 Emergency Gates						
	FEDERAL COSTS						
01---	LANDS AND DAMAGES	148,000	Jan-2013	Jan-2014	Oct-2016	24,767	4.875
04---	DAMS	73,704,000	Jan-2014	Oct-2016	Oct-2016	5,035,239	4.875
06--- 3--	FISH & WILDLIFE FACILITIES WILDLIFE FACILITIES & SANCTUARIES	3,045,000	Jun-2014	Jun-2015	Oct-2016	278,238	4.875
18---	CULTURAL RESOURCE PRES. (NO IDC)	752,000					
30---	PLANNING, ENGR. & DESIGN (Sunk Cost Not Subject to IDC)						
		5,325,000	Oct-94	Oct-95		0	4.875
		877,000	Oct-95	Oct-96		0	4.875
		4,000	Oct-96	Oct-97		0	4.875
		272,000	Oct-97	Oct-98		0	4.875
		275,000	Oct-98	Oct-99		0	4.875
		1,424,000	Oct-99	Oct-2000		0	4.875
		2,928,000	Oct-2000	Oct-2001		0	4.875
		1,816,000	Oct-2001	Oct-2002		0	4.875
		802,000	Oct-2002	Oct-2003		0	4.875
		147,000	Oct-2003	Oct-2004		0	4.875
		1,864,000	Oct-2003	Oct-2004		0	4.875
		2,436,000	Oct-2004	Oct-2005		0	4.875
		3,974,000	Oct-2005	Oct-2006		0	4.875
30---	PLANNING, ENGR. & DESIGN						
		8,545,000	Oct-2006	Jan-2014	Oct-2016	3,088,332	4.875
		421,000	Jan-2014	Oct-2016	Oct-2016	28,761	4.875
31---	CONSTRUCTION MANAGEMENT	6,541,000	Jan-2014	Oct-2016	Oct-2016	446,862	4.875
CASH CONTRIBUTION		40,091,000	Jan-2014		Oct-2016	2,738,898	
TOTAL FEDERAL COST		**$75,209,000**				**$6,163,301**	
	NON-FEDERAL COSTS						
CASH CONTRIBUTION		40,091,000	Jan-2014		Oct-2016	2,738,898	4.875
TOTAL NON-FEDERAL		**$40,091,000**				**$2,738,898**	
	Ecosystem						
	FEDERAL COSTS						
01---	LANDS AND DAMAGES						
	Bushy Lake	56,000	Jun-2016	Oct-2016	Oct-2017	3,199	4.875
	Wood Lake	63,000	Jun-2017	Oct-2017	Oct-2018	3,599	4.875
06--- 3--	FISH & WILDLIFE FACILITIES WILDLIFE FACILITIES & SANCTUARIES						
	Bushy Lake	11,625,000	Oct-2016	Oct-2017	Oct-2017	279,988	4.875
	Wood Lake	5,924,000	Oct-2017	Oct-2018	Oct-2018	142,679	4.875
	Temperature Control Structure	29,354,000	Oct-2018	Oct-2019	Oct-2019	706,990	4.875
18---	CULTURAL RESOURCE PRES. (NO IDC)						
	Bushy Lake	101,000					4.875
	Wood Lake	53,000					4.875
18---	CULTURAL RESOURCE PRES. COST SUBJECT TO (IDC)						
	Bushy Lake	866,000	Oct-2016	Oct-2017	Oct-2017	20,858	4.875

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DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION(CONT'ED)

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION	INTEREST RATE (%)
	Effective Price Level (EPL) 1-Oct-2006						
	Wood Lake	115,000	Oct-2017	Oct-2018	Oct-2018	2,770	4.875
30---	PLANNING, ENGR. & DESIGN (Sunk Cost Not Subject to IDC)						
	Bushy Lake	77,000					
		42,000					
	Wood Lake	38,000					
		21,000					
30---	PLANNING, ENGR. & DESIGN						
	Bushy Lake	1,109,000	Oct-2006	Oct-2017	Oct-2017	348,566	4.875
	Wood Lake	647,000	Oct-2006	Oct-2018	Oct-2018	225,722	4.875
	Temperature Control Structure	3,245,000	Oct-2006	Oct-2019	Oct-2019	1,248,058	4.875
31---	CONSTRUCTION MANAGEMENT						
	Bushy Lake	1,058,000	Oct-2016	Oct-2017	Oct-2017	25,482	4.875
	Wood Lake	663,000	Oct-2017	Oct-2018	Oct-2018	15,968	4.875
	Temperature Control Structure	3,552,000	Oct-2018	Oct-2019	Oct-2019	85,550	4.875
CASH CONTRIBUTION		19,688,000				474,185	
TOTAL FEDERAL COST		**$38,921,000**				**$2,635,244**	
	NON-FEDERAL COSTS						
01---	LANDS AND DAMAGES						
	Bushy Lake	576,000	Jun-2016	Oct-2016	Oct-2017	32,905	4.875
	Wood Lake	606,000	Jun-2017	Oct-2017	Oct-2018	34,618	4.875
CASH CONTRIBUTION							
	Bushy Lake	4,814,000	Oct-2016		Oct-2017	115,945	4.875
	Wood Lake	2,224,000	Oct-2017		Oct-2018	53,565	4.875
	Temperature Control Structure	12,650,000	Oct-2018		Oct-2019	304,675	4.875
TOTAL NON-FEDERAL		**$20,870,000**				**$541,708**	
	Folsom Temp. Bridge, Flood Damage Reduction and Dam Safety						
	FEDERAL COSTS						
06---	FISH & WILDLIFE FACILITIES						
3--	WILDLIFE FACILITIES & SANCTUARIES	1,783,000	Jan-2007	Oct-2007	Dec-2008	143,480	4.875
2--	ROADS (Incl. Bridges)	44,646,000	Jan-2007	Dec-2008	Dec-2008	2,189,754	4.875
30---	PLANNING, ENGR. & DESIGN (Sunk Cost Not Subject to IDC)						
		866,000	Oct-92	Oct-95		0	4.875
		143,000	Oct-95	Oct-96		0	4.875
		1,000	Oct-96	Oct-97		0	4.875
		44,000	Oct-97	Oct-98		0	4.875
		45,000	Oct-98	Oct-99		0	4.875
		232,000	Oct-99	Oct-2000		0	4.875
		476,000	Oct-2000	Oct-2001		0	4.875
		295,000	Oct-2001	Oct-2002		0	4.875
		130,000	Oct-2002	Oct-2003		0	4.875
		24,000	Oct-2003	Oct-2004		0	4.875
		484,000	Oct-2003	Oct-2004		0	4.875
		1,851,000	Oct-2004	Oct-2005		0	4.875
		2,911,000	Oct-2005	Oct-2006		0	4.875
30---	PLANNING, ENGR. & DESIGN	851,000	Oct-2006	Dec-2008	Dec-2008	47,201	4.875
31---	CONSTRUCTION MANAGEMENT	3,958,000	Jan-2007	Dec-2008	Dec-2008	194,128	4.875
CASH CONTRIBUTION		20,570,000	Jan-2007		Dec-2008	1,008,897	
TOTAL FEDERAL COST		**$38,170,000**				**$1,565,666**	
	NON-FEDERAL COSTS						

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION(CONT'ED)

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION	INTEREST RATE (%)
	Effective Price Level (EPL) 1-Oct-2006						
CASH CONTRIBUTION		20,570,000	Jan-2007		Dec-2008	1,008,897	4.875
TOTAL NON-FEDERAL		**$20,570,000**				**$1,008,897**	
	Bridge, Permanent Bridge Only						
	FEDERAL COSTS						
01—	LANDS AND DAMAGES FY 95	116,000	Oct-2006	Jan-2007	Dec-2008	12,353	4.875
06— 3—	FISH & WILDLIFE FACILITIES WILDLIFE FACILITIES & SANCTUARIES	1,345,000	Jan-2007	Oct-2007	Dec-2008	108,234	4.875
08— 2—	ROADS, RAILROADS & BRIDGES ROADS (Incl. Bridges)	5,211,000	Jan-2007	Dec-2008	Dec-2008	255,584	4.875
30—	PLANNING, ENGR. & DESIGN	666,000	Oct-2003	Oct-2004	Dec-2008	169,097	4.875
		2,547,000	Oct-2004	Oct-2005	Dec-2008	498,028	4.875
		4,005,000	Oct-2005	Oct-2006	Dec-2008	560,547	4.875
		852,000	Oct-2006	Dec-2008	Dec-2008	47,257	4.875
31—	CONSTRUCTION MANAGEMENT	569,000	Jan-2007	Dec-2008	Dec-2008	27,908	4.875
TOTAL FEDERAL COST		**$15,311,000**				**$1,679,008**	
	NON-FEDERAL COSTS						
01—	LANDS AND DAMAGES FY 95	8,373,000	Oct-2006	Nov-2006	Dec-2008	919,509	4.875
02— C—	RELOCATIONS Constr. Activities CEMETERIES, UTILITIES, & STRUCTURES	4,172,000	Jun-2007	Nov-2007	Dec-2008	274,133	4.875
30—	PLANNING, ENGR. & DESIGN	626,250	Oct-2006	Nov-2007	Dec-2008	51,831	4.875
31—	CONSTRUCTION MANAGEMENT	417,500	Jun-2007	Dec-2008	Dec-2008	16,125	4.875
TOTAL NON-FEDERAL		**$13,588,750**				**$1,261,598**	
	Funds Provided By User						
	NON-FEDERAL COSTS						
08— 2—	ROADS, RAILROADS & BRIDGES ROADS (Incl. Bridges)	28,000,000	Jan-2007	Dec-2008	Dec-2008	1,373,317	4.875
TOTAL NON-FEDERAL		**$28,000,000**				**$1,373,317**	

DETAILED ESTIMATE OF M & O COSTS & REPLACEMENT COSTS

Effective Price Level (EPL) 1-Oct-2006

3.5' Floodwall and Replace 3 Emergency Gates

ACCOUNT NUMBER	ITEM	ANNUAL COST ($)	FACTOR (%)	M&O COST ($)	PROJECT LIFE YRS	ITEM LIFE YRS	FACTOR (%)	REPLACEMENT COST
04---	Dams							
	Floodwall							
	Misc. Cleaning of Floodwalls	35000	1.5	52719				
	Outlet Works							
	Air Box Rehab @ 25yrs	0	1.5	0	50	25	0.0213	30101
	Air Box Rehab @ 50yrs	0	1.5	0	50	50	0.0050	7021
	O&M and Inspection	19250	1.5	28995				
	Dams			81714				37122
	SUMMARY							
04---	Dams			81714				37122
	TOTAL			**$81,714**				**$37,122**

Bridge, Permanent Bridge Only

08---	Roads							
	Bridges	28204	1.5	42482				
	Roads			42482				0
	SUMMARY							
08---	Roads			42482				0
	TOTAL			**$42,482**				**$0**

Attachment B4 – Hydraulic Design
Folsom Dam Raise Project
Engineering Documentation Report

7-1.1 GENERAL INTRODUCTION

This attachment describes variables that determine the capability of the Folsom Dam Raise project alternatives to manage floods and to safely pass the accepted probable maximum flood (PMF). It addresses the existing dam's deficiency in flood damage reduction capability, the dam safety inadequacies, and discusses alternative solutions. The dam (as it currently exists) has two major problems. These are flood damage reduction and dam safety. The existing spillway gates and outlet works cannot pass the PMF without overtopping the Dam. Also, the existing outlets through the dam are not large enough to pass significant flood flows during the early part of large floods. The existing outlets can only release a maximum of 24,800 cubic feet per second (cfs) at the spillway crest elevation 418.0. The downstream channel has an objective or target flood release of 115,000 cfs and releases above 115,000 cfs must be made only during very large floods for dam safety purposes. Large flood flows can only be passed with the existing spillway tainter gates and therefore, a significant amount of flood damage reduction space must be filled with water before objective downstream release flows can be attained. The design alternatives investigated and described herein increase the flood control capability of Folsom Dam by increasing the available reservoir storage. Studies described below determine the project's capability to discharge flows (outflow capacity) and dissipate energy from high-velocity flows before they enter the American River channel. This study assumes an auxiliary spillway will be constructed on the left abutment. The auxiliary spillway will control flow discharges using six 23 feet wide by 33 feet high top-seal radial gates (also called submerged tainter gates or STGs) at invert elevation 368.0. Possible impacts to downstream water surface elevations, channel capacity stability and definition of the floodplain are briefly described. Ongoing studies and future analysis during the next phase of design are required to fully define these design requirements.

7-1.2 PROJECT DESCRIPTION

7-1.2.1 Previous Studies

The following studies previously performed are relative to the Folsom Dam Raise project:

- Original Design of Folsom Dam, by the Corps of Engineers
- ESA Consultants, Inc., Folsom Dam Improvements, Mini Raise, *Preliminary*, 24 August 1994.
- US Army Corps of Engineers, American River Watershed, California, Information Paper, August 1999.
- US Bureau of Reclamation, Folsom Dam Spillway Stilling Basin Rehabilitation, TM No. FOL-8130-REH-96-1, September 1996.

- Recommended Flood Operations for Folsom Dam, TM FD-8130-FD-TM-97-3, September 1997 by the USBR
- Long-Term Study, by the Corps of Engineers
- Folsom Dam Modifications Project - DDR, Design Plans and Specifications for the Upper Tier Conduits, by the Corps of Engineers
- PASS II Study, by the Corps of Engineers, USBR, and SAFCA (Sacramento Area Flood Control Agency)

7-1.2.2 Project Objectives – Relative to Hydraulic Design

The main objectives of the Folsom Dam Raise project are to ensure that:

- Hydraulic performance is acceptable.
- Adequate design provisions are made for the additional head and increased flow capacity of the spillway.
- The stilling basin(s) function satisfactorily at design flows and without excessive damage at higher flows.
- Combined releases from the service spillway, auxiliary spillway, and emergency spillway can be made without complex operational constraints.

7-1.2.3 Overview of Alternatives

With-Out Project Condition – The "without project condition" for the alternatives discussed below assumes completed construction of the Common Features project and an Auxiliary Spillway (except for the alternative that enlarges the existing sluices which does not include an auxiliary spillway). The auxiliary spillway provides for dam safety as well as flood control and as currently envisioned has a discharge capacity of 145,500 cfs at pool elevation 418.0. It will be near the left abutment (at the current overlook area) and consist of an approach channel, an Auxiliary Spillway Control Structure with six top-seal radial gates (also known as submerged tainter gates) that are 23 feet wide by 33 feet high with the sill at elevation 368, and a 169-foot wide rectangular, concrete-lined chute that leads into an energy dissipation area and exit channel. The discharge chute will run from the auxiliary spillway control structure towards the downstream end of the exit channel for the main dam (entering the American River in almost a direct line). A separate hydraulic jump stilling basin for the auxiliary spillway would be constructed.

Folsom Dam would then have four methods of discharging flows from the reservoir: three power penstocks, eight flood control outlets (four upper tier and four lower tier, all 5 ft x 9 ft), tainter/radial spillway gates set near the main spillway crest (five service and three emergency), and six submerged tainter gates in the auxiliary spillway.

To insure adequate tailwater for releases from the three emergency spillway gates, they should not be used unless the total outflow from the dam exceeds 300,000 cfs. To maintain controlled release by the gates, the emergency gates must be opened at a total outflow of about 240,000 cfs; the remainder of the 300,000 cfs must be provided by the auxiliary spillway. Because of the restriction on use of the emergency gates they are unusable for normal flood control purposes and use of the gates is limited to dam safety outflows. Under the "without project condition" assumed for this report, Folsom Dam and the American River can safely pass the PMF without overtopping the dam, however, operational restrictions on making releases through the existing service and emergency gates are very complex and don't leave much room for operator error or equipment malfunctions. Table 7-1.1 summarizes the capability of each outflow method.

TABLE 7-1.1
SUMMARY OF FOLSOM DAM OUTLET CAPACITY

Outlet Feature	Lake Elevation 400 feet Bottom of Maximum Flood Space	Lake Elevation 426 feet Bottom of Normal Flood Space	Lake Elevation 466 feet Normal Full Pool	Lake Elevation 484.5 feet Spillway Design Pool for 7 ft Dam Raise	Lake Elevation 481.0 feet Spillway Design Pool for 3.5 ft Dam Raise
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
3 Power Penstocks	7,000	7,000	7,000	0	0
4 Lower Outlets	13,000	13,800	14,900	10,400[2]	10,300[2]
4 Upper Outlets	10,500	11,500	12,900	9,200[2]	9,100[2]
5 Operating Spill Gates	0	12,500	209,500	467,000[3]	332,500[1]
3 Emergency Spill Gates	0	0	0	280,500[3]	256,500[1]
Auxiliary Spillway	70,600	174,000	279,000	319,400	312,400
Total Discharge Capability	**101,100**	**218,800**	**523,300**	**1,076,500[2]**	**910,900[2]**

Notes:
[1] Includes free flow capability.
[2] Includes 60% opening restriction.
[3] Includes free flow capability for all main dam tainter gates.

Key:
cfs – cubic feet per second

Described below is a series of progressive changes to the dam features to systematically increase project performance, flexibility, and dam safety. Specific alternatives are also described, but do not necessarily follow the progression.

Replacement of Gates on Emergency Spillway - The top of the three existing emergency spillway gates, when closed, is at elevation 471 feet above mean sea level. This effectively limits the flood control operation to 470 (one foot freeboard on gate). The existing gates also are restricted in their maximum opening. The maximum elevation the gate lip can be raised to is only 454.5. Replacing these gates with taller gates (set at about one foot below

the maximum pool) leads to increased project performance because releases of 115,000 to 160,000 cfs can continue to be made above pool elevation 470 (emergency gates no longer must be opened at that pool elevation). There would be more flexibility in dam operations because the gates would no longer have to be opened at the relatively low pool elevation of 470. Replacing the "spillway bridge" over the gates and designing the new gates to allow free flow under them effectively increases the maximum discharge capacity of the emergency spillway for large flood events, possibly allowing a slightly smaller auxiliary spillway than currently planned.

Replacement of Gates on Service Spillway - The top of the five existing service spillway gates, when closed, is at elevation 468 feet. Note that for any combination of projects constructed, if the pool elevation is allowed to exceed 480, these gates would be overtopped (maximum elevation of the gate arc is about 480). These gates are also restricted in their maximum opening, similar to the existing emergency gates. Replacing these gates with taller gates allows much more flexibility in dam operations because the gates would no longer have to be opened at the relatively low pool elevation of 467 (one foot freeboard on gate). The auxiliary spillway could then be the primary structure providing flood control for Folsom Dam. Replacing the "spillway bridge" over the gates and designing the new gates to allow free flow under them effectively increases the maximum discharge capacity of the service spillway for large flood events, allowing a smaller auxiliary spillway than currently planned.

Dam Raise – A minor dam raise coupled with replacement gates on the spillway (either the three emergency spillway gates or both the service and emergency spillway gates) may provide additional flood control and if paired with reducing the size of the auxiliary spillway, be cost effective as well. Any dam raise and corresponding increase in height of the replaced tainter gates on the main dam crest can be balanced with a narrower auxiliary spillway (narrower gates, or possibly fewer gates). The size of the auxiliary spillway and its gates can be refined in final design.

Following is a brief summary of the alternatives presented in Chapter 3. All but the first assume an auxiliary spillway as a without project condition.

7-1.2.3.1 Six Enlarged Main Dam Outlets plus two new Main Dam Outlets plus Eight Tainter Gates Replaced plus Seven-foot Dam Raise

This alternative is the baseline plan that represents both current authorizations (modification of Folsom Dam outlets and a Dam Raise). The existing outlet works of eight 5' x 9' outlets (4 upper tier, 4 lower tier) would become six new or enlarged 9'-4" x 14' upper tier, two enlarged 9'-4" x 12' lower tier, and two existing 5' x 9' lower tier. Current authorization also provides a dam raise of 7 feet for added flood protection benefits. This alternative includes replacing the eight radial gates on the spillway crest with taller gates and replacing/raising the bridge over the spillway. Raising the training walls would also be required. The top of dam would now be at elevation 487.5. With 3 ft of freeboard, the maximum pool would be up to elevation 484.5.

7-1.2.3.2 Six STG Auxiliary Spillway plus Replacement of Three Emergency Tainter Gates

This alternative replaces the three existing tainter gates atop the emergency spillway and the "bridge" above them for added flood protection benefits. Raising the training walls may also be required. The top of dam would remain at elevation 480.5. With 3 ft of freeboard, the maximum pool would be up to elevation 477.5.

7-1.2.3.3 Six STG Auxiliary Spillway plus 3.5-foot Dam Raise

This alternative is a dam raise of 3.5 feet to the earth embankment portion of the dam via a parapet wall. None of the existing tainter gates would be replaced. The flood control benefits of this are extremely limited due to flood release restrictions imposed by the height of the existing tainter gates on the service and emergency spillways. The prime benefit of raising the dam is to provide additional storage during extreme events. Raising the training walls may also be required. The top of dam would now be at elevation 484. With 3 ft of freeboard, the maximum pool would be up to elevation 481.

7-1.2.3.4 Six STG Auxiliary Spillway plus Replacement of Three Emergency Tainter Gates plus 3.5-foot Dam Raise

This alternative includes replacing the three radial gates on the emergency spillway crest with taller gates, replacing/raising the bridge above them, and adds a dam raise of 3.5 feet to the dam via a parapet wall for added flood protection benefits. Raising the training walls may also be required. The top of dam would now be at elevation 484. With 3 ft of freeboard, the maximum pool would be up to elevation 481. The existing service spillway gates would overtop during extreme events since the top of gates elevation is 480.0. Corps' criteria doesn't allow tainter gates to overtop but the USBR as owner and operator has jurisdiction at pool levels where the gates would be overtopped. This alternative is the "featured alternative" in the main body of this report.

7-1.2.3.5 Six STG Auxiliary Spillway plus Replacement of all Eight Tainter Gates plus 3.5-foot Dam Raise

This alternative includes replacing all eight radial gates on the spillway crest with taller gates, replacing/ raising the bridge over the spillway, and adds a dam raise of 3.5 feet to the dam via a parapet wall for added flood protection benefits. Of the alternatives presented herein, this provides the maximum flexibility in operations. The replaced tainter gates would be higher than the dam and would not overtop. Also, all eight of the tainter gates would be capable of opening enough to allow free-flow. This increases the capacity of the main dam spillway significantly so that a smaller auxiliary spillway could be constructed and the PMF could still be safely passed. Raising the training walls would be required. The top of dam would now be at elevation 484. With 3 ft of freeboard, the maximum pool would be up to elevation 481. .

7-1.2.3.6 Six STG Auxiliary Spillway plus Replacement of Three Emergency Tainter Gates plus Seven Feet Dam Raise

This alternative would include replacing the three radial gates on the emergency spillway crest with taller gates, replacing/raising the bridge above them and adds a dam raise of seven feet to the dam via a combination of earth fill and parapet wall. Raising the training walls would be required. The maximum pool would be up to elevation 484.5 with top of dam at elevation 487.5.

7-1.3 CRITERIA

The following list of documents provides applicable hydraulic design criteria for the project:

ER 1110-2-1150 Engineering and Design for Civil Works Projects

ER 1110-2-1156 Dam Safety – Organization, Responsibilities, and Activities

EM 1110-2-1601 Hydraulic Design of Flood Control Channels

EM 1110-2-1602 Hydraulic Design of Reservoir Outlet Works

EM 1110-2-1603 Hydraulic Design of Spillways

EC 1110-2-6061 Safety of Dams – Policy and Procedures

FEMA Publication 64, "Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners"

Peterka, A. J. 1974. "Hydraulic Design of Stilling Basins and Energy Dissipators," Engineering Monograph No. 25, US Bureau of Reclamation, Denver, CO.

7-1.4 HYDRAULIC DESIGN ELEMENTS & PARAMETERS

The dam discharge facilities include the powerhouse, outlet works, main dam service and emergency spillways, and the auxiliary spillway. Flows from any or all of these facilities merge together downstream of the dam and provide almost all of the flow in the lower American River.

7-1.4.1 Hydraulic Roughness

Hydraulic roughness values were selected for the rock/earth approach channels, the rock/earth exit channels from the stilling basin(s) to the American River, the American River from the Folsom Dam to the Folsom Dam Road Bridge currently being designed, and for the concrete surfaces within the spillway structure, the stilling basin(s), and the chute extending from the auxiliary spillway control structure to the auxiliary spillway stilling basin. A Manning's "n" value of 0.035 was assumed for the channel roughness in the approach

channel and in the exit channel. Manning's "n" values of 0.012 and 0.016 were used for establishing maximum velocities (maximum energy dissipation required) and depths of flow (maximum wall heights required), respectively. These "n" values were checked against recommended roughness heights (Ks) of 0.002 and 0.007 for concrete flood control channels in EM 1110-2-1601 (USACE 1994) and found to be reasonably consistent with that guidance.

7-1.4.2 Design Head/Discharge Coefficients

The existing ogee crest was under-designed some to increase discharge coefficients. This occurs due to the slightly negative pressures produced along the ogee at the higher pool elevations. The maximum H_e/H_d that Corps' criterion discusses is 1.33. The ogee crest for Folsom Dam was based on a design head of 50 ft. That corresponds to pool elevation 468. The maximum pool elevation for the dam raise alternatives may be as high as 484.5, corresponding to an actual head of 66.5 ft. High H_e/H_d ratios have the benefit of high discharge coefficients but also result in negative pressures that can cause significant cavitation damage. The table below shows H_e/H_d ratios for existing conditions and for each of the project alternative conditions. It assumes that the alternatives will utilize the existing ogee crest. The existing spillway crest elevation is 418.0

COMPARISON OF He/Hd RATIOS FOR EXISTING AND PROPOSED CONDITIONS

	Maximum Pool Elevation Feet - MSL	Energy Head (H_e) Feet	Design Head (H_d) Feet	H_e/H_d
Original Design	474.5	56.5	50.0	1.13
7-ft Raise	484.5	66.5	50.0	1.33
3.5-ft Raise	481.0	63.0	50.0	1.26

7-1.4.3 Discharge Rating Curves and Stage-Discharge Relationships

The discharge rating curves (pool stage versus discharge) have been extended to encompass the full range of reservoir pool elevations due to the dam raise.

There are operational constraints when operating the existing service and emergency tainter gates at Folsom Dam. The emergency gates are not to be opened until 300,000 cfs is being released into the American River. The top of the emergency gates in the closed position is at elevation 471 so that dam operators have to begin opening the emergency gates at pool elevation 470. Since the service gates are already open, the emergency gates need to be opened up at least 10 feet almost immediately so that a wave coming around the pier between the service gate and emergency gate will not impact the service gate trunnion. Operation of the service gates is also sensitive because the service gates must follow the pool up once the pool comes within about two feet of the top of gate. Another problem in

operation of the existing tainter gates is that they should not be operated in the transitional zone from orifice flow (part gate) to full open and should not be lowered to go from full open (gates out of the water) to part gate operation. The Corps computer program H3106 computes part gate open discharge rating curves for tainter gates, indicates when the transitional zone is entered, and states that "gate control uncertain – avoid operation at above pool and gate opening" for a particular calculated discharge based on gate opening and pool elevation/head. The USBR also has also noted this transitional zone. Model reports describe the transition zone as where model data was inconsistent with both the gated-discharge rating and the free-flow rating as a zone of instability where control can shift rapidly between two regimes. Measurements of discharge and pool elevation vary widely in this transition zone.

Discharge rating curves for the existing emergency gates are shown on Figure 7-1.1. The rating curve for the service spillway gates is similar but the gate top of gate is lower (elevation 468 vs. 471). Examination of Figure 7-1.1 shows that the controlled-discharge rating curves and the uncontrolled discharge (free-flow) rating curve are separated by the transition zone. In this zone surging can occur as the flow is unstable and can rapidly shift between controlled-discharge and free-flow. Operating in the transition zone is not recommended. Also, it is at present not physically possible to open the existing tainter gates enough to go to free-flow. Reservoir routings described elsewhere in this EDR use controlled-flow gate operations unless all tainter gates on the main dam crest are replaced.

Discharge rating curves for the new spillway radial gates that would replace the existing gates are shown on Figure 7-1.2. These rating curves also show a transition zone (blank area) between to controlled-discharge rating curves and the free flow rating curve. The new gates would be designed to allow free flow. Installation of the new gates would require modification of the piers to raise the trunnion axis to prevent spillway flows from impacting the trunnion tie beams. The piers would not need to be widened. The replaced gates would be taller, and the new trunnions would be out of the flow stream for large floods.

Discharge rating curves for the auxiliary spillway control structure, with gates fully open, are shown on Figure 7-1.3. Discharge rating curves for the existing outlet works upper tier gates are shown on Figure 7-1.4 and those for the existing lower tier gates are shown on Figure 7-1.5.

7-1.4.4 Water Surface Profiles

Water surface profiles were computed for the Auxiliary Spillway approach channel from the reservoir to the control structure, the Auxiliary Spillway chute from the control structure to the stilling basin, and the American River from the new bridge to the existing main dam stilling basin.

The WASP2 water surface profile program (Twiss and Sarvary, 1985) was used in computing water surface profiles for the Auxiliary Spillway chute. This program was specifically developed for high velocity prismatic channels, and allows the user to rapidly compute profiles and other pertinent hydraulic data, such as Froude numbers, sequent depths, and stream power.

A HEC-RAS model has been developed for the American River from downstream of Folsom Dam to Nimbus Dam for the Bridge project. New topography was obtained to construct this model. The primary reasons for developing this model was for the detailed bridge design, however, it was also needed for tailwater considerations in designing the auxiliary spillway energy dissipator and in analyzing the energy dissipation and the adequacy of the existing main dam spillway stilling basin. Results show that the tailwater rating curve for the main dam stilling basin that was used in the original design is in general agreement with the new computations. The old tailwater rating curve was used to analyze energy dissipation at the main dam.

7-1.4.5 Head Losses

Hydraulic head losses that will occur as flows pass through the spillway include frictional and form losses. As discussed in paragraph 1.4.1 above, frictional losses for concrete surfaces are calculated using Manning's "n" values of 0.012 for minimum losses and 0.016 for maximum losses. Manning's "n" values of 0.035-0.050 were used for rock cut areas. Consultations regarding the roughness heights of rock excavated areas with geotechnical and construction engineers as studies progress will allow the range of "n" values for rock cut to be decreased. Form losses for expansions, contractions, piers, roof and side curves, invert offsets, etc. will also occur as flows are passed.

7-1.4.6 Design Discharge Capacities & Velocities

The design discharge for the spillway(s) is the discharge that can be passed at the maximum pool. Discharges will be controlled by the gates for the full range of reservoir head unless all eight tainter gates on the main dam crest are replaced, in which case free-flow will be allowed for extreme discharges. See Figures 7-1.1, 7-1.2, 7-1.3, 7-1.4 and 7-1.5.

For the main dam spillway, average velocities through the gates will be over 40 fps for controlled releases at the maximum pool elevation 481 (assumes 3.5 ft dam raise). If free-flow occurs the velocities will be much higher and in any case, velocities on the spillway face will be even higher as discharges accelerate down the supercritical slope. For the auxiliary spillway, the average velocities through the gates and conduits with the gates fully open will be as high as 68 fps. Velocities in the supercritical chute and drop to the stilling basin will also be very high.

7-1.4.6.1 Maximum Discharge Capacity

Figure 7-1.6 shows the absolute maximum calculated discharge capacity from pool elevation 300' to pool elevation 484.5', assuming the outlet works are fully open for the full range of reservoir pool elevations. Maximum discharge capacities are shown for the outlet works (for all 8 conduits combined; to pool 418 only), the spillway (for controlled releases from all 8 radial gates combined), the auxiliary spillway (assumed to be six STGs, 23 ft x 33 ft), and combined operation of the three. The maximum release capacity exceeds the objective release of 115,000 cfs over a broad range of reservoir pools. Maximum discharge capacity for the outlets assumes no operational constraints due to vortex formation.

7-1.4.7 Conditions Effecting Design Capacity

7-1.4.7.1 Cavitation

Cavitation is the successive formation and collapse of vapor pockets in low-pressure areas associated with high-velocity flow. It results from the sudden reduction of the local pressure at any point to the vapor pressure of water. The collapse of the pockets sets up high-pressure shock waves that cause damage to the nearby boundary. Cavitation often causes severe damage to steel or concrete and it can occur at the conduit entrance, downstream from gate slots, in the conduit downstream from the gates, and anywhere that high velocity flows tend to separate from the flow boundary and the piezometric head approaches the vapor pressure of water.

The design head for the existing spillway crest curvature is 50 feet. As the maximum head increases above the design head the spillway becomes more susceptible to negative pressures leading to cavitation. Review of available spillway information indicates that cavitation can occur at part gate openings and tends to worsen as the gate opening increases. The cavitation potential at part gate openings would also increase if there are surface imperfections along the crest. It appears that negative pressures would be at least -10 ft and more negative for pool elevations at or above 482; a model study would be needed to determine the pressures corresponding to part gate openings. Negative pressures exceeding 15 to 20 ft of head are not recommended.

7-1.5 OTHER DESIGN CONSIDERATIONS RELATIVE TO DAM RAISE

Other design considerations relative to the raising the dam are outlined below. Certain hydraulic elements that may require modification include the existing spillway crest, the tainter gates, the existing bridge over the dam, the existing flood control outlets exit portals, and the stilling basin.

7-1.5.1 Modification of Existing Spillway Gates

At least three existing spillway gates would be replaced with taller gates for most alternatives. Installation of the larger gates would require modification of the piers to raise the trunnion axis to prevent spillway flows from impacting the trunnion tie beams. Structural design investigations indicate the piers would not need to be widened. The replaced gates would be taller, and the new trunnions would be out of the flow stream for large floods. The current tops of the existing five service spillway gates and the three emergency spillway gates, when closed, are elevation 468 and elevation 471 feet above mean sea level, respectively. This effectively limits the current flood control operation to elevation 471. Since the dam could be raised to as high as 484-487.5, it is necessary to replace the existing spillway gates to allow water to be stored against the closed gate up to lake elevation 480-483.5. This equates to one foot of freeboard on the gate at maximum pool.

7-1.5.2 New Spillway Bridge at the Main Concrete Dam

Where spillway gates are replaced, a new spillway bridge would be located at the top of the piers on the upstream side of the new spillway gates to replace the existing bridge. The bridge deck would be 4 feet thick and the low chord of the bridge would be lower than both the maximum Design Flood pool (elevation 482.5) and the PMF pool (elevation 484.5). The drawdown curve for flow over the spillway was computed using the procedures in Engineering Manual (EM) 1110-2-1603, Hydraulic Design of Spillways (USACE, 1992), to determine if the bridge deck would intersect spillway flows. Should pressure flow occur because flows impinge on the bridge, the spillway discharge would decrease and the reservoir pool elevation would increase. At maximum pool for the 7-foot dam raise, the center line nappe elevation would be about 480.4 feet. This is only one-tenth of a foot below the girder elevation of 480.5 feet. The girder would therefore be chamfered to provide a freeboard of at least 0.5 feet. At the piers, flow would slightly impinge on the bridge deck; however, it is not likely that pressure flow would occur. This will be further investigated during more detailed studies.

7-1.5.3 Cavitation Potential at Existing Dam Spillway Crest

The design head for the existing ogee crest is 50 feet. This would not change for any of the design alternatives discussed in this report unless model tests show that it is necessary to avoid cavitation problems. Using Hydraulic Design Chart (HDC) 111-16/2 (USACE, 1970), and assuming -20 feet is acceptable, increasing the maximum pool elevation from 474.5 to 481 for the 3.5 feet dam raise would increase the He/Hd ratio from 1.13 to 1.26 but would still be in the safe area relative to cavitation potential. However, increasing the maximum pool elevation to 484.5 for the 7.0 feet dam raise would indicate that the existing ogee could be subject cavitation and physical model tests would be necessary to determine if the existing crest has to be replaced. Modifications of the spillway crest shape would be made only if model studies and/or prototype data from other dams show that potential cavitation damage would be significant.

7-1.5.4 Modification of Sluice Exit Portals & Eyebrow Deflectors

Operating experience at Folsom Dam has shown that concurrent operation of the five service spillway gates and the outlet works creates a condition that results in cavitation damage to the dam in the vicinity of the sluice exit portals. This damage can be minimized if the full capacity of the outlets is not used. Previous model studies by Isbester indicated that the existing conduits should not be operated above 60 percent gate opening when spillway flows are occurring. This is the current operation procedure. This restriction could possibly be eliminated by modifying the spillway in the vicinity of the outlet exit portals. The existing eyebrow deflectors would also have to be replaced. This modification would allow 100 percent gate openings for the outlet gates. The operation studies contained in this EDR assumed that the 60 percent restriction remains. Since the increased discharge from lifting the 60 percent restriction on the operation of the existing sluice gates would be negligible for the alternatives that include an auxiliary spillway, modification to the existing sluice exit portals will not be made.

7-1.5.5 Advance Release

The term "advance release" refers to increasing releases from Folsom Dam to draw down the reservoir in advance of a predicted storm. For example, a peak inflow of 300,000+ cfs is anticipated to occur within the 3-day forecast window. Releases would then be ramped up to the maximum objective flow (115,000 cfs) as quickly as possible. Since the flow would be maximized as soon as possible, vortices may form at low lake level elevations. It is believed that any operations required to alleviate vortex formation will have minimal impact on advance release performance. Determining the details on the implementation of advanced release is not directly part of the Folsom Dam Outlet Works Modification project, but is a design consideration.

7-1.6 ENERGY DISSIPATION FEATURES

Water surface profiles computations to address energy dissipation were computed assuming minimum losses. Results of these runs were utilized in designing the stilling basins.

7-1.6.1 Service Spillway – and Required Modifications

The stilling basin is the energy-dissipating device for flows from the outlet works and the service spillway gates. The hydraulic jump is the basic feature used to dissipate excess hydromechanical energy in a stilling basin such as at Folsom Dam. Five of the eight spillway bays discharge into the main stilling basin and the remaining three emergency spillway bays discharge over a flip bucket. The stilling basin for Folsom Dam acts as a hydraulic jump basin when flows are from the service spillway. The tailwater curve near the end of the stilling basin and within the exit channel from the main dam spillway area is shown as Figure 7-1.7.

The existing stilling basin was designed so that fully developed and contained hydraulic jump action would exist in the stilling basin for flows up to 200,000 cfs, and to prevent failure (major damage) during passage of the spillway design flood, which at the time of design included a peak outflow from all eight spillway bays of 567,000 cfs at a lake elevation of 475.4. Above 200,000 cfs, hydraulic jump action is only partially effective, with the jump extending further downstream into the exit channel as flows increase. Increased pool elevations associated with the raised dam should not significantly change jump action in the existing stilling basin for flows up to 200,000 cfs. The addition and operation of the auxiliary spillway can be used as a positive influence on the characteristics of the hydraulic jump in the existing stilling basin. The increase in tailwater due to combined flows with the auxiliary spillway should cause the hydraulic jump to remain more within the stilling basin at higher discharges. Key design considerations are discussed below and will be evaluated in detail during future studies, which will include physical hydraulic modeling. A preliminary estimate was made of how much (if any) the existing stilling basin needs to be lengthened for satisfactory functioning during passage of the PMF. The stilling basin for the Auxiliary Spillway is currently expected to be a hydraulic-jump type. Also noteworthy are some conclusions from previous studies on scour potential in the stilling basin area (Bollaert, 2004) and exit channel (Kleinfelder, 2006).

7-1.6.1.1 Design Considerations

Many assumptions were required for this study, and must be verified and/or changed using a physical model before final design. In addition to the operational scenario described in Paragraph 7-1.7 below, some complicating factors and assumptions include the following:

- The energy dissipater for the existing spillway is a hybrid. The major portion of the existing spillway is known as the service spillway and includes five 42-foot-wide by 50-foot-high tainter gates on a concrete ogee crest exiting to a stilling basin. The stilling basin has a 1:8 sloping invert through most the basin's length, and has an end sill but does not have baffle blocks. The emergency portion of the spillway has three tainter gates on the ogee crest with the same width as the service gates, discharging to a flip bucket adjacent to the stilling basin. The flip bucket portion of the energy dissipator was designed to only function during extreme flood events. The highest flow physically modeled for the original design of the existing main dam stilling basin was 300,000 cfs. The model also reviewed a spillway Design Flood flow of 567,000 cfs, which included the full operation of the three emergency spillway gates.

- All spillway gates, including new/replaced gates for the Main Concrete Dam spillway and the Auxiliary Spillway, are fully functional.

7-1.6.1.2 Stilling Basin Length

In addition to reviewing the model tests performed for the existing stilling basin, the approach to evaluating the need to lengthen the existing stilling basin included the following considerations:

- The toe of the stilling basin was assumed to be at elevation 140, at which the basin invert slopes at a rate of 1:8 (slope of 0.125) to the floor of the basin, elevation 115.

- The velocity at the toe of the basin was estimated using an empirical equation taken from Open Channel Flow (Henderson, 1966),

- $v_1 = \sqrt{2g(Z - H/2)}$, where:

  v_1 = Velocity at toe of spillway
  g = Acceleration of gravity
  Z = Elevation difference from pool to the spillway toe
  H = Head on crest, feet

  The "Henderson" reference also includes a chart developed by Bradley and Peterka while with the USBR that is used to convert from the theoretical velocity in the above equation to the actual velocity. This amounts a coefficient that is applied to the above equation of about 0.92.

- Given the flow rate, and basin width of 242 feet, the depth of flow at the toe was computed. Water surface profiles were then computed down the 0.125 invert slope to basin floor elevation 115 using WASP2 (Twiss and Sarvary, 1985), a water surface

profile program developed to accurately and rapidly analyze high velocity, prismatic channels. WASP2 computes the Froude number and sequent depth at each station to allow the sequent depth to be compared to the tailwater for the downstream flow as the flow proceeds downstream.

- Results from this approach differ somewhat from the original modeling efforts by the Waterways Experiment Station (WES), now the Engineering Research Development Center (ERDC). WES provided water surface profiles for each of the tests performed within the stilling basins. In the cases shown in the modeling report, the jump in the water surface profile started at the toe of the spillway (at the upstream end of the sloping chute). Should this be the case for which the Auxiliary Spillway is being designed, the sequent depth for the design flow would be considerably higher than the tailwater elevation for the discharge assumed. This would result in less energy dissipation than desired. As part of future design studies, model tests would be done to better define the energy dissipation that would occur and to determine if lengthening the existing stilling basin would be worthwhile.

- After finding the location along the 0.125 slope where the sequent depth equals the tailwater elevation, the recommended length for the stilling basin was computed from equation 7-1 of EM 1110-2-1603, Hydraulic Design of Spillways (USACE, 1992),

$$L_b = K \times D_1 \times (F_1)^{1.5}$$

, where:

L_b = Recommended length of basin
D_1 = Flow depth along 0.125 slope - sequent depth = tailwater elevation
K = Coefficient, which equals 1.7 for Folsom Dam
F_1 = Froude number associated with D_1

This recommended length then was compared to the length available in the existing basin from the point along the 0.125 slope where the sequent depth matched the tailwater elevation to the downstream end of the existing basin. It was necessary to temper the above computations using generalized USACE criteria and empirical equations with results from model studies performed for the existing basin, and with actual past operational experiences. Future physical modeling will be required to finalize optimum stilling basin lengths.

7-1.6.2 Emergency Spillway – Flip Bucket

Flows from the emergency flip bucket spillway act in a very different manner than those from the service spillway. Flow follows a trajectory (like a ski jump) where the energy is mainly dissipated in the plunge pool that develops when discharges are high. Because the energy is not dissipated effectively except when a plunge pool exists, the emergency spillway is not utilized until the service spillway reaches its maximum release capacity at pool elevation 470, which is one foot below the top of the closed emergency gates (releases of 240,000 are being made through the main stilling basin). The pressures on the toe curve of

the flip bucket for the emergency spillway were investigated, using Plate 112-7 of HDC. See Figures 7-1.8 and 7-1.9.

7-1.6.3 Auxiliary Spillway – Stilling Basin

The stilling basin for the Auxiliary Spillway is expected to be a concrete lined hydraulic jump type similar to that of the stilling basin for the service spillway. The stilling basin design was generally patterned after the Type II basin (see Reclamation EM No. 25 titled Hydraulic Design of Stilling Basins and Energy Dissipators (Paterka, 1974)). See Figure 7-1.10 for a sketch of a Type II basin. Conservatively low Manning's "n" values of 0.012 for concrete and 0.035 for rock excavation were selected for energy dissipation considerations.

7-1.6.4 Merging Flows from the Stilling Basins

Physical model studies will be required to insure that flows blending together from the auxiliary spillway and service spillway merge well as they enter the American River, that forces on the auxiliary stilling basin walls are accounted for in wall design, and that the flow regime in the American River does not change dramatically over a broad range of conditions (this could lead to scour of the banks downstream of the confluence of these flows). The design scenarios analyzed are described below.

7-1.6.4.1 Service Spillway Gates Only

The first scenario investigated was based on the assumption that only the spillway service gates are releasing flow, and that flow is 160,000 cfs at pool elevation 470. Depth and velocity at the toe of the spillway were computed to be 5.1 feet and 129.5 feet per second (fps), respectively. The sequent depth for flows along the 0.125 slope matched tailwater elevation 192 at a point 50 feet upstream from the basin floor, elevation 115. The sequent depth was computed to be 70.4 feet. Using the approach above, the recommended basin length would exceed the existing basin length by more than 50 feet. However, previous modeling studies indicated that although hydraulic action was not optimal, the existing stilling basin should perform adequately with discharges of up to 200,000 cfs.

7-1.6.4.2 Service Spillway Gates and Auxiliary Spillway

Another scenario investigated was based on the assumption that the existing spillway service gates would be releasing 350,000 cfs and the Auxiliary Spillway would be releasing 159,000 cfs, with the pool at elevation 481. Depth and velocity at the toe of the spillway were computed to be 11.1 feet and 130 fps, respectively. Using the approach above, the recommended basin length would exceed the existing basin length by only 35 feet. The reduced basin length requirement demonstrates the advantages gained by using concurrent operation of the service spillway and Auxiliary Spillway. With the ability to pass some of the 500,000+ cfs through the Auxiliary Spillway, the tailwater would be higher at the downstream end of the basin, resulting in the jump beginning to form farther up the 0.125 slope, and probably allowing the existing stilling basin length to absorb the jump.

7-1.6.4.3 Service Spillway Reduced Flow

To further illustrate the advantage of using the Auxiliary Spillway to gain better stilling action in the Main Concrete Dam stilling basin, another scenario also was investigated. The service spillway gates releasing 130,000 cfs and the Auxiliary Spillway releasing 30,000 cfs, for a total discharge of 160,000 cfs at pool elevation 470.0, was studied. Depth and velocity at the toe of the spillway were computed to be 4.2 feet and 129.3 fps, respectively. Using the approach above, the recommended basin length would exceed the existing basin length by only 4 feet. This indicates that it could be advantageous to optimize releases from the Main Concrete Dam service gates and the Auxiliary Spillway to obtain better jump action in the Main Concrete Dam stilling basin.

7-1.6.4.4 Preliminary Findings

Considering the above discussions, it appears likely that the existing stilling basin length would be adequate if releases from the Main Concrete Dam service gates and the Auxiliary Spillway are coordinated and optimized for best hydraulic jump action in the existing basin. However, model tests may show that some lengthening of the stilling basin is desirable. During earlier studies for the Dam Raise Project, a conservative stilling basin extension of 60 feet was selected based on preliminary computations but primarily on judgment. For this report, a 60-foot lengthening will be assumed, but more detailed studies, a more up-to-date tailwater rating curve, geotechnical data, and model tests will actually be used to determine whether the existing stilling basin needs to be lengthened and by how much.

7-1.7 OPERATIONS

From a hydraulic viewpoint, the preferred order of making releases (not considering power releases) is the main dam sluices, the auxiliary spillway, the main dam service tainter gates, and finally the main dam emergency tainter gates. The sluices generally should be closed (or at least limited to 60% open) when the service tainter gates on the main dam are opened.

7-1.7.1 General

Model testing from previous studies has led to some observations that must be considered in operating procedures that govern releases through the outlet works spillways. Of major importance is that balanced gate operations that lead to uniform discharges across the width of the stilling basin minimize the formation of recirculating currents which can draw abrasive material into the stilling basin.

7-1.7.2 Gate Sequencing during Flood-Control Operations

Design considerations include the following:

- The peak (unregulated) PMF inflow would be about 902,000 cfs. Discharges would always be regulated so that peak inflows are never exceeded.

- The existing outlets in the dam would be the sole release capacity until pool elevation 368.0 (seal invert elevation of the auxiliary spillway) is reached. Power releases likely would be made during this time but (conservatively) were not included in the scenario described.

- As pool elevation 368.0 is exceeded, the auxiliary spillway gates would begin to discharge, and before the pool reaches elevation 418 (Main Concrete Dam spillway crest), total combined discharge from the outlets and the Auxiliary Spillway would reach the objective release of 115,000 cfs. When the reservoir is high enough, releases may be made through the Auxiliary Spillway only, thus conserving the cold-water pool. The transition can be made from combined releases to release through the auxiliary spillway only. The auxiliary spillway energy dissipator will be designed function well with and without combining flows from the main dam. Physical model tests will be used to confirm this.

- For the alternatives with the three emergency gates replaced, the auxiliary spillway by itself can hold the objective release of 115,000 cfs and above pool elevation 418, but flows must be transitioned to the service spillway before the gates are overtopped. The top of closed service spillway gates is at elevation 468.0. Because of this requirement, during the pool elevation's rise to elevation 467.0, the auxiliary spillway gates would transition to the closed position and the five service tainter gates would open as necessary to maintain the 115,000 cfs objective release. For pool elevations above 467.0, discharges would be from the service spillway gates, and would be limited to 160,000 cfs or less. The top of the emergency gates is dependent on the dam raise, if any. The gates would typically be opened when pool elevation is at one foot below the top of the gate. Opening the emergency gate requires a release of 300,000 cfs. Therefore, the dam releases must be ramped up to 300,000 cfs before the gates are opened. This can best be accomplished by opening the Auxiliary Spillway gates to supplement flows from the service gates. It is anticipated that the emergency gates would be utilized only for very extreme events when both the service spillway gates and auxiliary spillway gates are making releases much greater than 300,000. At a maximum PMF pool elevation of 481 (assumes a 3.5-foot raise), discharges from the dam would be about 355,000 cfs from the main concrete dam services gates, 215,000 cfs from the main concrete dam emergency gates, and 312,000 cfs from the auxiliary spillway gates. The existing top elevation along the service gates is elevation 480.0, so that the service tainter gates would be overtopped at the maximum PMF pool. This would not be allowed using Corps criteria but the USBR as owner and operator has jurisdiction above the flood control pool level.

- For alternatives with all eight crest gates replaced, the Auxiliary Spillway by itself can hold the objective release and can do so until very large storm events and high pools necessitate larger releases. Above a pool elevation of about 475, the service gates also would open. At very high pool elevations, the emergency spillway gates would open. At maximum PMF pool elevation 484.1 (for a 7-foot dam raise), discharges from the dam would be about 350,000 cfs from the main concrete dam services gates, 210,000 cfs from the main concrete dam emergency gates, and 320,000 cfs from the auxiliary spillway gates (combined discharge 882,000 cfs). It

would also be possible to open all main dam tainter gates to the free-flow condition. The later would allow the design to include a smaller auxiliary spillway.

7-1.8 EROSION CONTROL REQUIREMENTS

The erosion potential of flows exiting auxiliary spillway and sequencing of combined flows from service/auxiliary/emergency spillways has to be considered and minimized as practical. This is especially true of the "gates full open" discharges as the pool elevations approach maximum pool elevations. Physical model tests will serve as an aid to assess erosion potential, problems, and solutions.

7-1.8.1 Potential for Downstream Scour

Scour is the result of the erosive action of flowing water that attacks the bed and banks of streams and the piers and abutments of bridges. Different materials scour at different rates. Loose granular soil is rapidly eroded by flowing water, while cohesive/cemented soil and rock are more scour-resistant. Ultimately, over a long period of time, scour can be as deep for rock as for sand-bed streams.

Altered flow patterns may impact the river channel as flow exits the stilling basin(s), and for some distance downstream. Potential maximum discharge from the dam would increase with the dam raise and Auxiliary Spillway, although frequent flood discharges would remain essentially unchanged. An important design consideration is to determine if the altered flow patterns and increased potential discharges (and discharge duration) would attack the rock and result in excessive scour. The powerhouse road area and the new Folsom Dam Road Bridge are areas of concern.

If the model studies indicate that high velocity flows could attack and scour rock to an extent that is not acceptable, further assessment of rock scour potential would be done by expanding on the previous studies done by Kleinfelder (2005-2006 study on rock scour potential in the exit channel) to include other areas, such as below the Auxiliary Spillway exit and the chute area, if it is unlined. Annandale's Erodibility Index methodology would again be used for evaluation (2005).

The cost estimate includes costs for grouting (stabilizing) existing rock in the powerhouse road area under the assumption that additional scour could result from the project.

7-1.9 DOWNSTREAM CHANNEL CAPACITIES

The physical capacity of the American River to safely transport flows depends on the downstream levee system. Prior to 1956 (completion of construction of Folsom Dam), the north levee of the American River extended upstream from the Sacramento River to approximately the CalExpo area, a distance of about 5 miles. This levee and the south levee of the American River were designed to pass a flow of 180,000 cfs (USACE, 1957). The south levee of the American River extended upstream from CalExpo at that time but did not have a defined capacity because the north levee was not yet constructed. Presumably, flows

up to and greater than 180,000 cfs diverted to the north and the south levees would have been able to protect against very high flows. In conjunction with completion of the Folsom Dam project, USACE extended the north levee of the American River upstream approximately 8 miles to high ground. This levee was designed to equalize protection for areas north and south of the American River. The levees were designed to pass the most severe conditions of either a flow of 115,000 cfs with 5 feet of freeboard on the levee, or 152,000 cfs with 3 feet of freeboard on the levee. The former condition (115,000 cfs) controlled the levee heights downstream from the H Street bridge while the latter condition (152,000 cfs) controlled levee heights upstream from the H Street bridge (USACE, 1957). Regardless of levee design criteria, Folsom Dam has in the past been operated to control flood releases to 115,000 cfs. This is defined as the "objective" flood release for this design. Since completion of Folsom Dam, the "objective" flood release of 115,000 cfs was exceeded only in 1986. The maximum flow during that flood was 134,000 cfs.

The "objective" release remains 115,000 cfs, that is, normal flood operations would limit downstream flows to 115,000 cfs. With construction of the alternatives discussed herein, Folsom Dam outflows would not exceed 115,000 cfs for all historic floods of record, and also for a Design Flood that has a 1 percent chance of being exceeded in a given year (100-Year Design Flood). For floods larger than the 100-Year Design Flood, maximum outflows would increase. For the 200-Year Design Flood, Folsom Dam maximum outflows would increase to, but not exceed 160,000 cfs.

The Common Features Project (Federal Legislation, 1996) involves strengthening and raising American River levees to safely pass a flow of 160,000 cfs. Most of this work has been completed. Specifically, the levees are being improved to be structurally sound and competent to pass flows of 160,000 cfs. The maximum safe discharge capacity of the American River was assumed to be 160,000 cfs by the PASS Study team, for which downstream areas which could flood would commence evacuation procedures.

Some members of the project design team have expressed concern about possible lateral erosion of the river channel if flows of 160,000 cfs were made for an extended duration (up to 4 days). A study has been initiated to determine the measures required to safely pass the occurrence of a flow of 160,000 cfs for duration of up to 48 hours. This study will assess the stability of grass-lined levee slopes, critical bank erosion sites, and erosion-resistant geologic formations in the channel bed. It also will identify long-term monitoring and maintenance required to sustain the lower American River's ability to convey 160,000 cfs for an extended duration in any given year.

To understand the impact a reduced maximum safe flow would have on project performance, maximum capacities of 115,000 cfs and 145,000 cfs also were analyzed by the PASS Team. These flood routings are contained in the PASS report, Appendix B, Tables B4-1 through B4-5.

7-1.9.1 Potential for Levee Breaching

Investigation of potential levee breaching in currently underway but has not been completed. Potential levee breaching is most likely to occur at the locations where the rising

water surface attains an elevation equal to that of the predicted Probable Non-Failure Point (PNP) and then continues rising towards the Probable Failure Point (PFP), the elevation where the levee is very likely to have failed. These locations and determination of the PNP and PFP are based on site investigations, models, and engineering and geotechnical judgment, as are the levee breaching scenarios, the extents of the potential levee breaks and the judgment of existing levee reliability.

7-1.10 HYDRAULIC IMPACT ON DOWNSTREAM WATER SURFACE

This requires investigation by utilizing existing or new numerical models to investigate whether new operations implemented due to the increased discharge capacity of the project will cause any changes to the maximum water surfaces downstream for the design storm events.

7-1.11 MODEL STUDIES (REQUIREMENTS & RESULTS)

For a raise of Folsom Dam, a physical model study is needed to evaluate pressures on the spillway crest for gated and ungated operation, to determine the effect of the bridge on spillway flows from higher pools, and to determine the flow characteristics in the stilling basin for increased head and discharge. Hydraulic features related to a dam raise that would require physical model tests include the Folsom Main Concrete Dam spillway (overflow crest and downstream chute, stilling basin/flip bucket, exit channel, and exit of sluices) and the Auxiliary Spillway (approach channel, Control Structure, chute, and energy dissipation area.

7-1.11.1 Numerical Model

A physical model at a suitable scale that would include enough of the reservoir to establish whether satisfactory approach conditions to the auxiliary spillway structure exist would be impractical. Therefore, a 2D numerical model will be performed as well, providing boundary conditions to implement in the auxiliary spillway control structure model.

7-1.11.2 Full Model

A full model of the converging flows from the service spillway, auxiliary spillway and emergency spillway is also required for ensuring satisfactory hydraulic performance. This may require a numerical model of flows thru the chute and converging flows from two stilling basins and the powerhouse transitioning to riverine flow.

7-1.11.3 Sectional Model

The Dam Raise and replacement of the tainter gates requires a sectional model to establish gate rating curves and cavitation potential of existing spillway crest due to increased pools. The service and emergency tainter gates will be modeled in the sectional model.

7-1.12 INUNDATION MAPS FOR FLOOD EMERGENCY PLANS

The inundation maps for emergency action plans should be updated based upon the increased release capacity of Folsom Dam.

FEMA Publication 64, "Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners", indicates that three (3) inundation maps should be developed for the area below dams.

(1) Dam failure at the normal everyday pool elevation (Sunny Day Failure)

(2) Maximum spillway discharge at a full flood pool

(3) Maximum discharge at the PMF condition

Also, in some cases, the spillway or outlet works discharge where flooding starts should be indicated.

7-1.13 REFERENCES (CURRENT LIST FROM MODS DDR)

- ESA Consultants, Inc., Folsom Dam Improvements, Mini Raise, Preliminary, 24 August 1994.
- Murray, Burns, and Kienlen (MBK) Consulting Civil Engineers, Folsom Dam Modification Report New Outlets Plan, February 1998.
- Pinto, N.L. de S., and Neidert, S.H., Model Prototype Conformity in Aerated Spillway Flow, International Conference on Hydraulic Modeling of Civil Engineering Structures, BHRA, Coventry, 1982.
- U.S. Army Corps of Engineers, American River Watershed, California, Information Paper, August 1999.
- U.S. Army Corps of Engineers, Hydraulic Design Criteria, November 1987.
- U.S. Army Corps of Engineers, Hydraulic Design of Reservoir Outlet Works, Engineering Manual 1110-2-1602, 15 October 1980.
- US Army Corps of Engineers, Hydraulic Design of Spillways, Engineering Manual 1110-2-1603, 16 Jan 1990.
- U.S. Army Corps of Engineers, Sacramento District, American River Watershed, CA, Folsom Dam Modification Project, Final Limited Reevaluation Report, August 2001.
- U.S. Army Corps of Engineers, Sacramento District, American River Watershed, CA, Folsom Dam Modification Project, Gate Size Decision Technical Memorandum.

- U.S. Bureau of Reclamation, Air-Water Flow in Hydraulic Structures, Engineering Monograph No. 41, December 1980.
- U.S. Bureau of Reclamation, Aeration Enhancements at the Folsom Dam Outlet Works: Reducing Cavitation Damage Potential, April 1998.
- U.S. Bureau of Reclamation, Cavitation in Chutes and Spillways, Engineering Monograph No. 42, April 1990.
- U.S. Bureau of Reclamation, Folsom Dam Spillway Stilling Basin Rehabilitation, TM No. FOL-8130-REH-96-1, September 1996.
- U.S. Bureau of Reclamation, Hydraulic Model Studies of the Folsom Spillway-Outlet Junction, REC-ERC-71-12, USBR, 1971. (Isbester, T.J.)
- Twiss, Donald E., and Sarvary, David J. March 1985. "Water-Surface Profiles, Rectangular and Trapezoidal channels," USDA Soil Conservation Service, Davis, CA

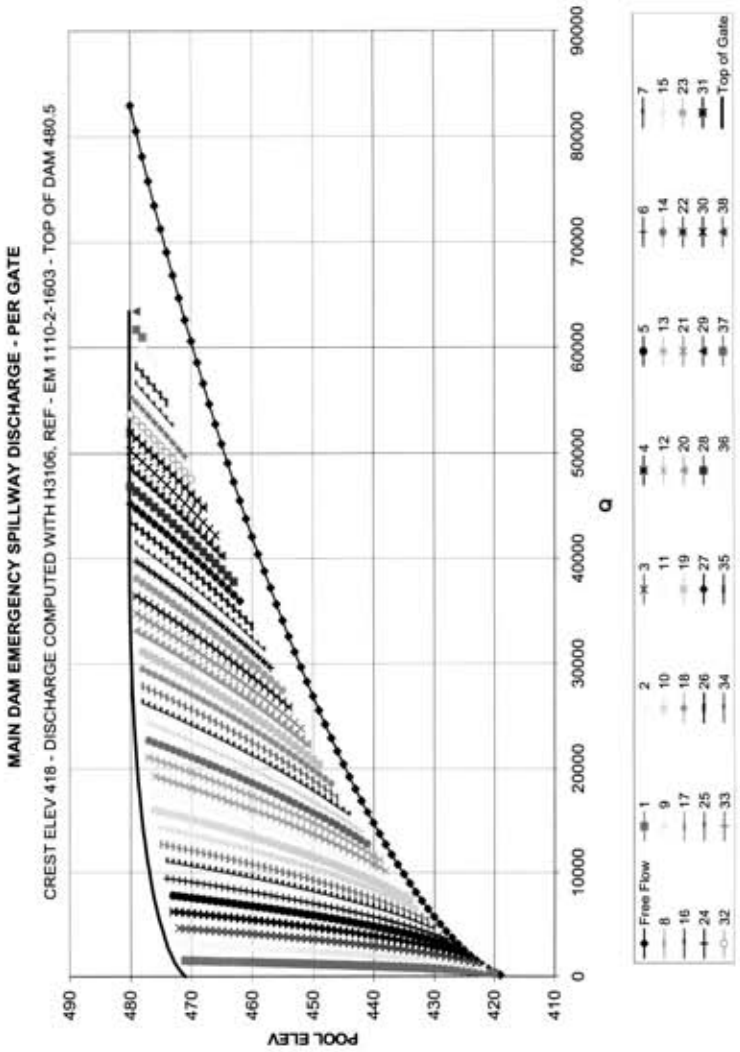


Figure 7-1.1 Folsom Dam – Discharge Capacity – Existing Emergency Spillway Gates

B4-23

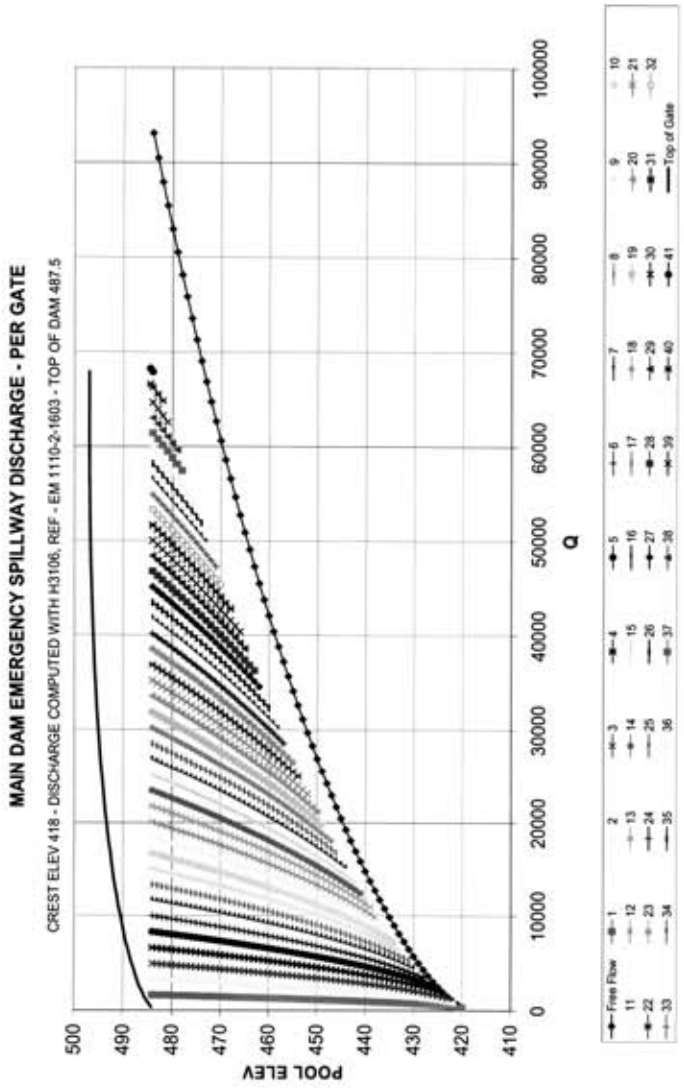


Figure 7-1.2 Folsom Dam – Discharge Capacity – New Spillway Gates

B4-24

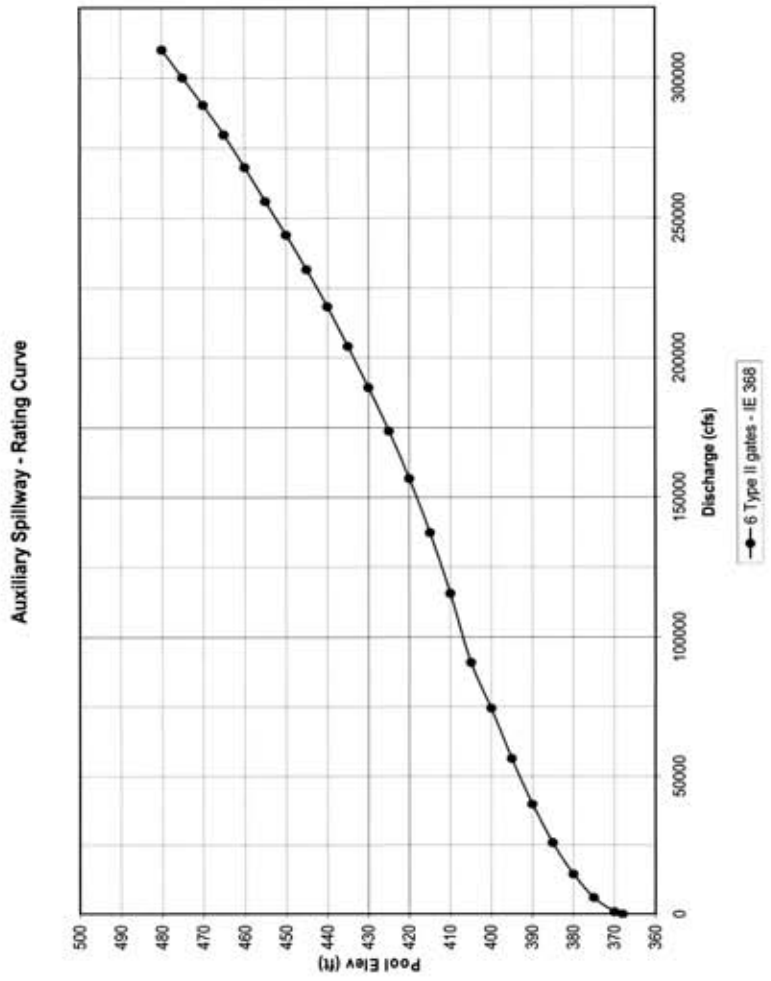


Figure 7-1.3 Folsom Dam – Discharge Capacity – Auxiliary Spillway

B4-25

Figure 7-1.4 Folsom Dam – Discharge Capacity – Upper Tier Outlet Works - 5' x 9' Gate Rating

B4-26

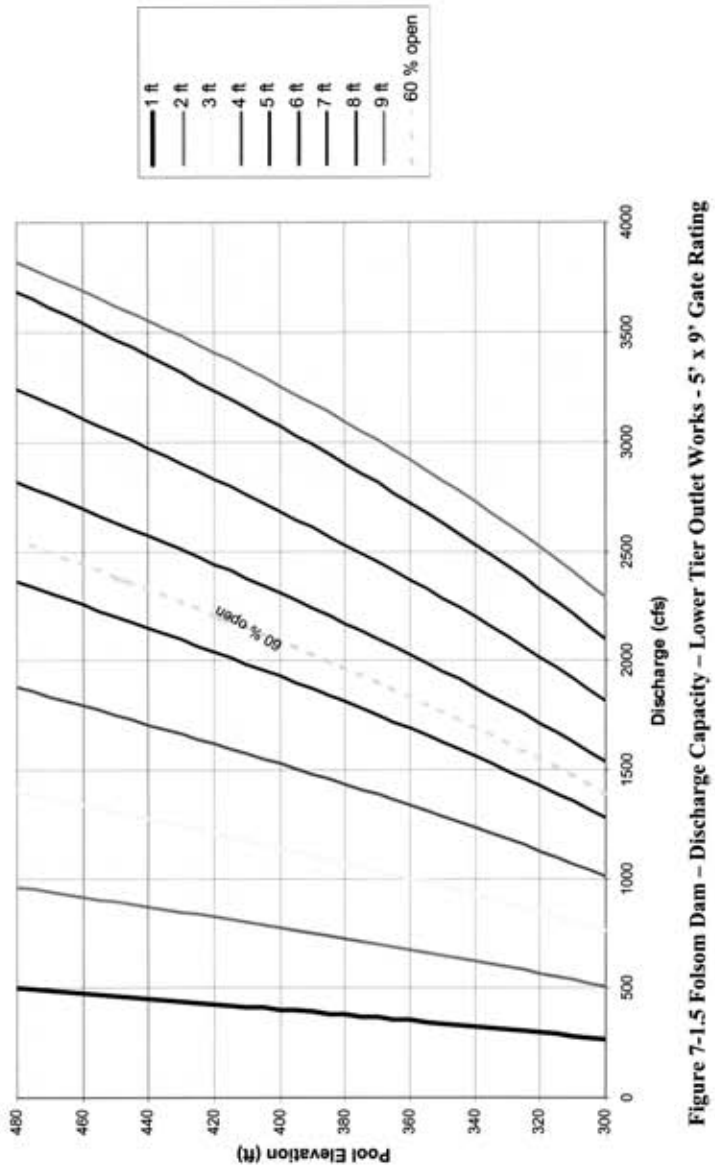


Figure 7-1.5 Folsom Dam – Discharge Capacity – Lower Tier Outlet Works - 5' x 9' Gate Rating

B4-27

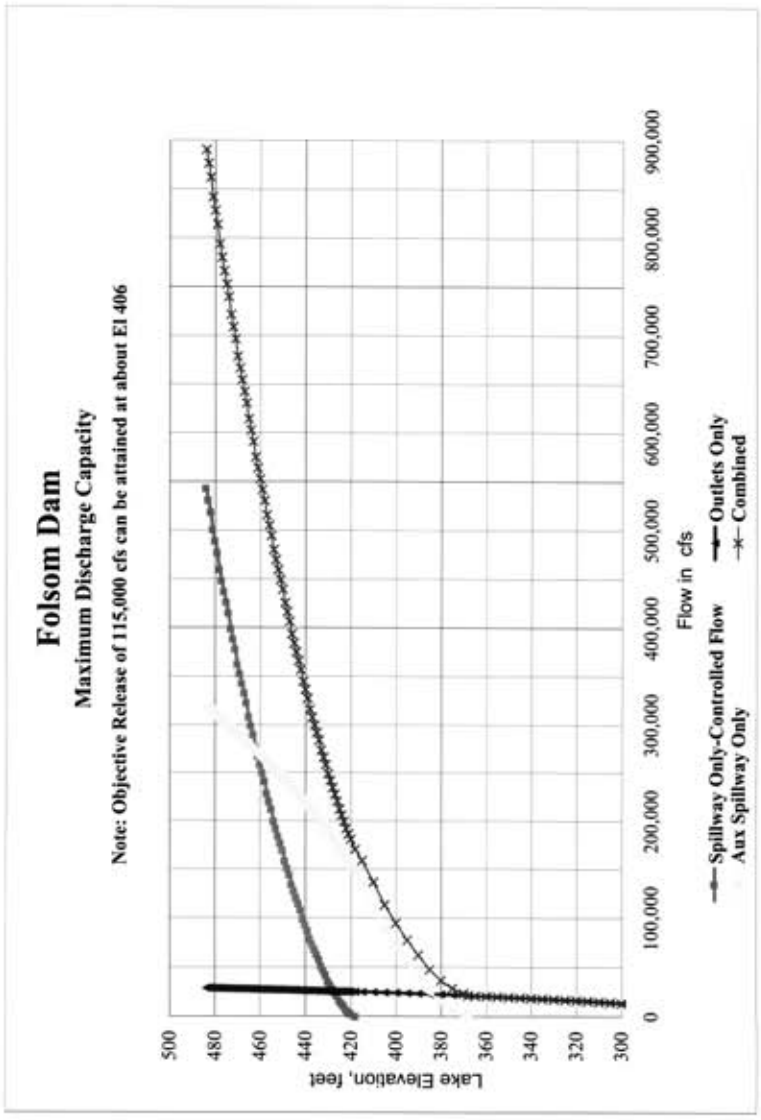


Figure 7-1.6 Folsom Dam - Maximum Discharge Capacity

B4-28

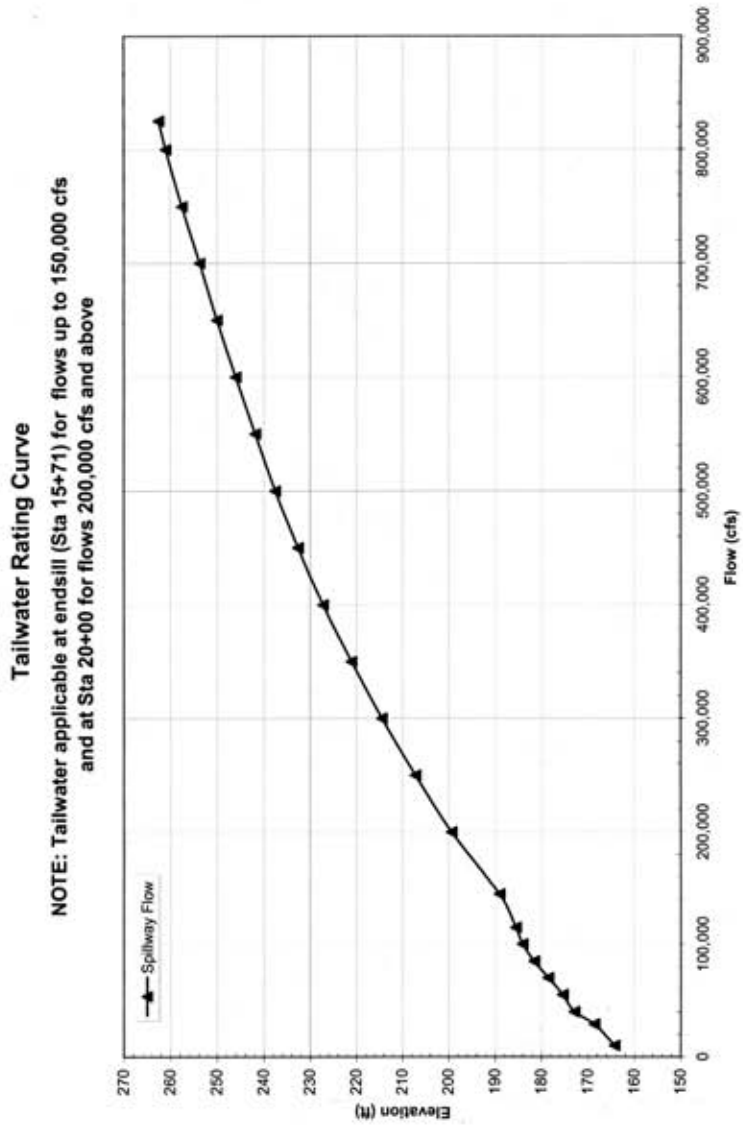


Figure 7-1.7 Tailwater curve, Combination of CORPS curve and data taken from 1:36 model.

B4-29

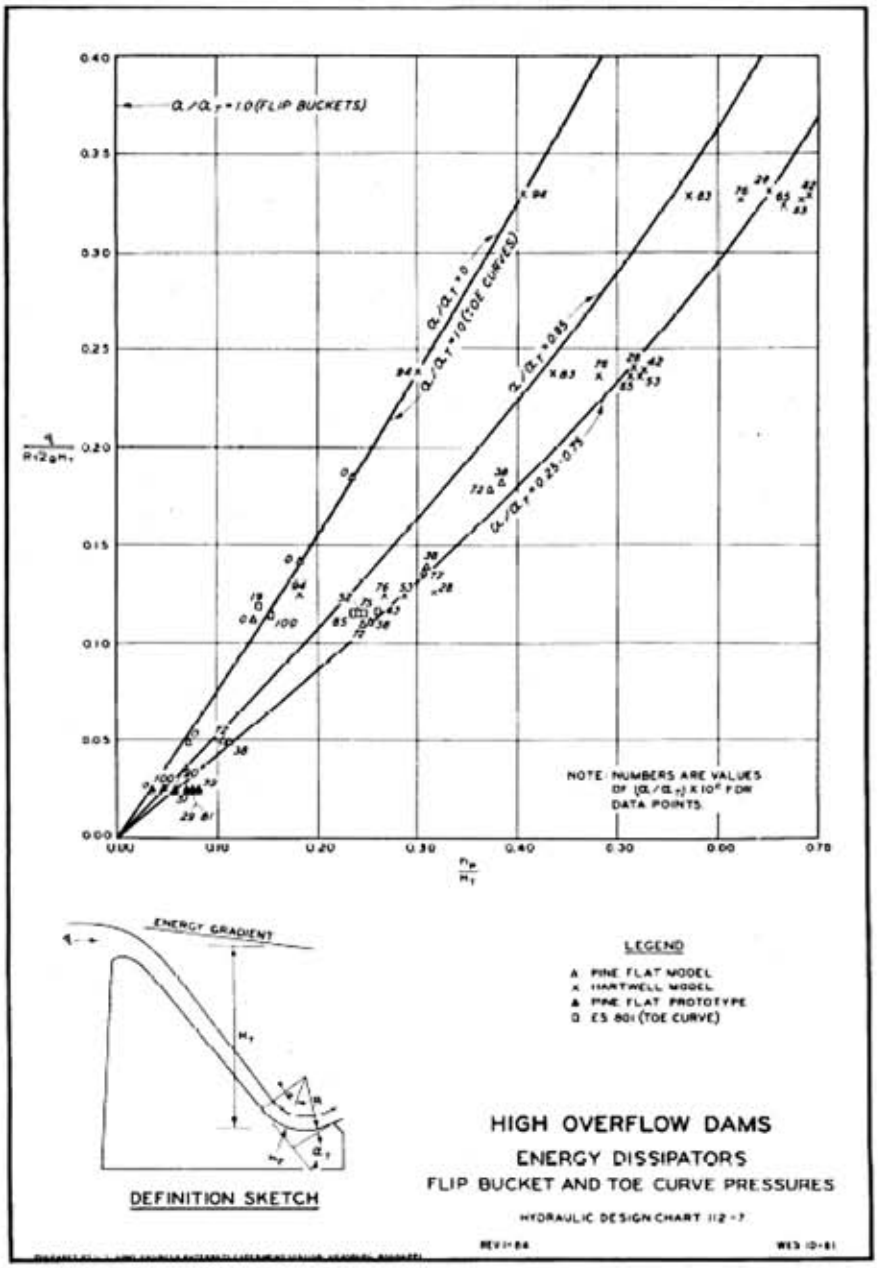


Figure 7-1.8 – HDC Plate 112-7 – Flip Bucket and Toe Curve Pressures

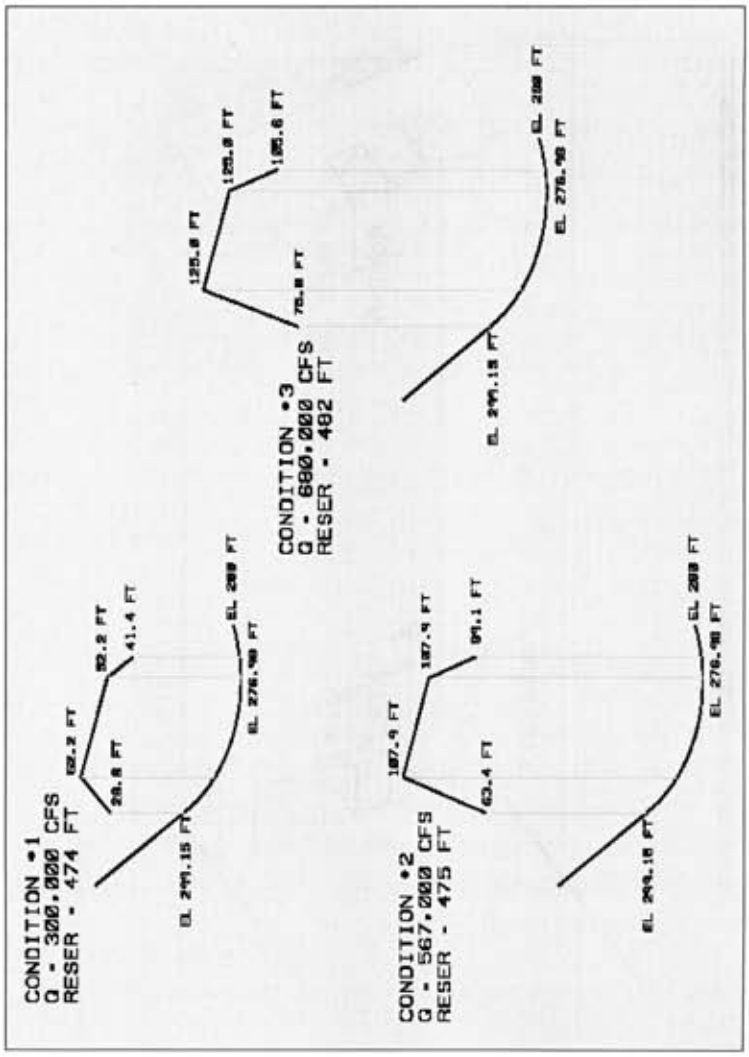


Figure 7-1.9 Flip bucket pressures for emergency spillway, based on Chart HDC 112-7.

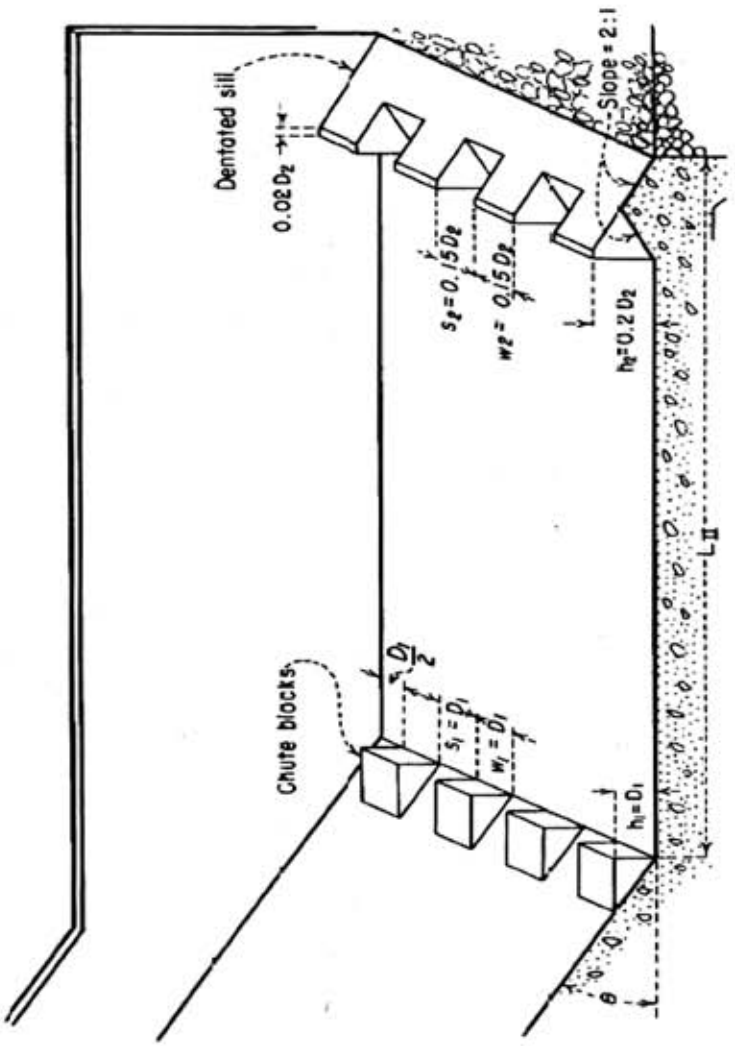


Figure 7-1.10 Type II Basin.

B4-32

American River Watershed Project

Post Authorization Change Report

American River Watershed Project

Folsom Dam Modification and
Folsom Dam Raise Projects

Appendix C
Folsom Dam Joint Federal Project
Engineering Documentation Report

US Army Corps of Engineers

Sacramento District
South Pacific Region

March 2007

EXECUTIVE SUMMARY

This Engineering Documentation Report (EDR) is an engineering refinement and technical implementation document to support the Post-Authorization Change (PAC) report of two currently authorized projects of the United States Army Corps of Engineers, Sacramento District's (Corps): the Folsom Modification Project and the Folsom Dam Raise Project. Both projects share an objective of improving flood damage reduction on the lower American River, primarily through structural modifications to the existing Folsom Dam and appurtenant facilities. Concurrently, the United States Bureau of Reclamation (Reclamation), the operator of Folsom Dam and Reservoir, is working to implement their Reclamation Safety of Dams program for safety improvements to the Folsom Facility. One of Reclamation's dam safety objectives is for the dam to safely pass the probable maximum flood (PMF). The timing of both of these Federal efforts creates an opportunity to develop a more efficient and cost effective joint plan that addresses both flood damage reduction and dam safety objectives into a single project, which is described as the Joint Federal Project.

The Joint Federal Project is one of the elements of a more comprehensive flood damage reduction and dam safety project which is the proposed selected plan (SP) that is discussed in the Post-Authorization Change (PAC) report. The Joint Federal Project element focuses only on the Folsom Modification flood damage reduction authority and Reclamation's dam safety objective in addressing the PMF. The Joint Federal Project element of the SP is being cost-split by the Corps and Reclamation based on a cost distribution between the flood damage reduction and dam safety objectives. This is discussed in detail in the PAC report.

The purpose of this EDR is to describe the Joint Federal Project and present preliminary design information, including cost and functional data. It is the Corps and Reclamation's goal, that by integrating and streamlining planning, design, and construction efforts in developing the Joint Federal Project, each agency will achieve its objective of flood damage reduction or dam safety at a significantly reduced cost over separate, individually implemented agency projects, and to provide the project benefits to the public in a more time-effective manner.

This EDR describes the features associated with the Joint Federal Project, and documents the engineering aspects of the project. It focuses on cost, performance, functionality, and compatibility of the project to the authorized Folsom Modification Project for flood damage reduction in conjunction with Reclamation's dam safety efforts and criteria. The Joint Federal Project would result in a collaborative effort that would cost effectively address: (1) protection of public safety related to the hydrologic integrity of the Folsom Facility and associated structures, and (2) improvement to overall flood damage reduction for the communities downstream along the lower American and Sacramento rivers.

Key design considerations include constructibility and environmental aspects. Constructibility considerations include: (1) provision for all service tainter gates to be available for releases at 24 hours notice; and (2) disturbance of existing utilities and dam

operations should be avoided to the extent practical. Environmental considerations include: (1) utilization of best management practices to limit disruption of aquatic habitat and turbidity resulting from construction operations; (2) minimization of construction impacts to existing habitat and fish; and (3) consideration of noise and air quality factors from construction activities.

PROJECT DESCRIPTION

The Folsom Modification Project was authorized in the *1999 Water Resources Development Act* (WRDA 1999). The authorized plan included elements of the Folsom Modification Plan as described in the *March 1996 American River Watershed Project, California, Supplemental Information Report* (1996 SIR), and subsequently modified in the Sacramento Area Flood Control Agency (SAFCA) Information Paper *Folsom Dam Modification Report, New Outlets Plan*, dated March 1998. The November 2003 *Folsom Modification Project Final Reevaluation Report and Environmental Assessment/Initial Study* is the latest authorization document and describes the two main functions of the Folsom Modification Project: to increase release capacity and to modify use of surcharge storage.

The features of the function to increase the release capacity of the dam were to include some variation of new outlets through the concrete portion of the existing dam, enlargement of the existing outlets, and modifications to the existing spillway and stilling basin as necessary. The new and enlarged outlets were to increase the release capacity to 115,000 cfs with the reservoir pool at spillway crest (elevation 418). The capability of maintaining the flood storage capacity gained by early releases of up to 115,000 cfs (prior to spillway flow) was calculated to reduce the probability of flooding in any one year from 1 chance in 81 to 1 chance in 154.

Implementing of the features of the function to modify use of surcharge storage would provide additional flood control storage of 46,200 acre-feet. Under existing conditions, the emergency spillway release diagram (ESRD) and physical features of the dam allow for surcharge storage to elevation 470 without overtopping the existing emergency tainter gates in their closed position. When the reservoir exceeds elevation 470, the emergency tainter gates must be open and the dam would release more than the objective release, potentially causing downstream flooding. The surcharge storage modifications would require both physical and operational changes to allow the flood pool to surcharge to elevation 474. The features associated with the surcharge storage project would include replacement of the three existing emergency tainter gates, raising the penstock hydraulic control pumps and controls, and increasing the height of the impervious core in Dikes 5 and 7 and the Mormon Island Auxiliary Dam (MIAD). The surcharge storage authority was deferred after the Folsom Dam Raise Project was authorized in 2004 and incorporated similar surcharge components as part of its authorized project.

As part of a joint effort strategy, an engineering Project Alternatives Solutions Study (PASS) effort was conducted jointly by the Corps and Reclamation in 2005, which included SAFCA, State of California Department of Water Resources (DWR), and the State of California Reclamation Board (State Reclamation Board). This effort resulted in rapid

development of engineering alternatives that addressed both flood damage reduction and dam safety objectives.

A follow up study known as the PASS II study further evaluated the least-cost alternative solution. The PASS II study was completed in early 2006 and is documented in the *Folsom Dam Raise and Auxiliary Spillway Alternative, Project Alternative Solutions Study (PASS) II*, dated June 2006. This study presented an engineered evaluation of an auxiliary spillway alternative consisting of four 17 feet 7 inches wide by 33 feet high submerged-tainter-gates (STG) along with a 7-foot dam raise. It also included replacement of all of the existing tainter gates. Optimization efforts of the PASS II alternative identified additional alternative variations of the four- and six-STG auxiliary spillway and a dam raise, with and without replacing the existing service and/or emergency tainter gates.

The result of this preliminary study was the identification of a Joint Federal Project, consisting of an auxiliary spillway with 23 feet wide by 33 feet high STGs at invert elevation 368.0. This resulting Joint Federal Project incorporates the flood damage reduction and dam safety objectives of both the Corps and Reclamation and achieves local partner goals in terms of levels of flood protection.

HYDROLOGY AND RESERVOIR OPERATIONS

This chapter presents the Corps' understanding of the hydrology of the American River Drainage Basin and Folsom Dam site. Also discussed are reservoir operations as they exist currently, and as they would be modified for various alternatives examined for the Folsom Modification Project. The Folsom Dam Operations and Planning Model, developed with Microsoft Excel, is used in all the routing and alternative analyses for the various American River Folsom Dam studies.

Table ES-1 outlines some of the basic assumptions adopted as water control diagram (WCD) or ESRD operational criteria.

TABLE ES-1
WATER CONTROL DIAGRAM AND EMERGENCY SPILLWAY RELEASE DIAGRAM

Condition	Outflow Restriction
Maximum objective release allowed by WCD (larger releases may be initiated by ESRD)	115,000 cfs
Maximum allowable rate of release change Increases: When discharge is greater than 20,000 cfs and less than or equal to 160,000 cfs When discharge is greater than 160,000 cfs Decreases: When discharge is greater than 20,000 cfs	 15,000 cfs/hour Unlimited 5,000 cfs/hour (decrease)
Maximum outflow allowed by WCD or ESRD	Do not exceed maximum inflow experienced during flood event
Release limitation if the actual or forecasted inflow is greater than 25,000 cfs and less than 150,000 cfs and reservoir is less than 20 percent encroached	Limit outflow to 60 percent of the maximum inflow experienced during the flood event
Maximum power available or relied upon for flood operations	Power penstocks would be assumed to have zero release capacity during all routings
Physical limitation of existing emergency tainter gates	Emergency tainter gates are not used until either the total outflow from the dam exceeds 240,000 cfs or the pool elevation is within 1 foot of overtopping the emergency gates while in the closed position
Release requirements (115,000 cfs to 160,000 cfs) based on Accelerated Transition Zone conditions as outlined on the proposed ESRD if current inflow is greater than 200,000 cfs and the 12-hour forecasted inflow is greater than 360,000 cfs if current inflow is greater than 250,000 cfs and the 12-hour forecasted inflow is greater than 370,000 cfs if the current inflow is greater than 270,000 cfs and the 12-hour forecasted inflow is greater than 370,000 cfs	 Increase release to 130,000 cfs Increase release to 145,000 cfs Increase release to 160,000 cfs
KEY: WCD – Water Control Diagram ESRD – Emergency Spillway Release Diagram cfs – cubic feet per second cfs/hour – cubic feet per second per hour	

Design of the existing ESRD restricts the maximum discharge to 160,000 cubic feet per second (cfs) until the reservoir's pool reaches elevation 470. Once the reservoir water surface exceeds elevation 470, the ESRD allows releases to be increased above the 160,000 cfs limitation. However, releases should not be made through the three emergency tainter gates until discharge in the stilling basin reaches 240,000 cfs to avoid incurring damages.

The contradiction in the ESRD is that it does not take into account the physical and operational limitations of the emergency spillway. When the emergency tainter gates are closed, the top of the gates is elevation 471. The routing model can force operation of the emergency tainter gates. The water surface must be within 1 foot of the top of the gates for this to occur. Sufficient tailwater is required to prevent erosion below the emergency spillway chute and adjacent areas. Although the existing ESRD does not require a discharge of 240,000 cfs until the pool rises above elevation 472, the dam operator can choose to make larger releases sooner. The effect of delaying operation of the emergency tainter gates is that above elevation 471, water would begin to flow over the top; possibly causing damages, failure, or making the tainter gates inoperable.

A large number of configurations were screened to determine which alternative best serves as the with-project condition. The configurations included various combinations of an auxiliary spillway with STGs, replacement or non-replacement of existing service and/or emergency conventional tainter gates, and the utilization of an emergency fuseplug spillway (proposed by Reclamation as a solution to address dam safety concerns only). The various gate combinations were analyzed at differing sill elevations. Combinations of modifications to the main dam outlets were also analyzed, and advance release criteria were incorporated into the release decisions. Of the numerous configurations considered, this document focuses on the with- and without-project conditions listed below:

- **Common Features - without-project condition**: Section 101(a) (1) of WRDA 1996 authorized construction of features that were common to three candidate plans identified by the Corps, SAFCA, and the State of California Reclamation Board (State Reclamation Board). Those commonalities included the following:
    - Levee modification along both banks of the lower American River
    - Levee modification along the east bank of the Sacramento River downstream from the Natomas Cross Canal
    - Installation of streamflow gages upstream from Folsom Reservoir and modification to a flood warning system along the lower American River
- **No main dam river outlet modification; auxiliary spillway with six 23 feet wide by 33 feet high STGs; no existing main dam tainter gate replacement; with-project condition**: This configuration is intended to satisfy the concerns of both dam safety and flood control. In this configuration, the auxiliary spillway sill is set at elevation 368. This alternative is intended to pass the unlikely occurrence of the PMF and allow Folsom Dam to release objective flow at lower pool elevations.

The resultant maximum elevations, obtained through routing the PMF through each of the proposed alternatives is provided in **Table ES-2**.

TABLE ES-2
MAXIMUM PROBABLE MAXIMUM FLOOD ELEVATIONS

Alternative	Maximum El, feet	
Without-project Condition	**PMF**	**Top of Dam**
Common Features	483.1[1]	480.5
With-project Condition		
Six-submerged-tainter-gate auxiliary spillway; no gate replacement; no dam raise	477.4	480.5
KEY PMF – Proable maximum flood El, feet – Elevation in feet		

Notes:
1. Alternatives do not meet the minimum freeboard space requirement of at least 3 feet.

ENVIRONMENTAL EFFECTS AND MITIGATION

Environmental effects from construction of the Joint Federal Project are discussed. Several previous environmental documents are relevant to the impact analysis for the main concrete dam outlet modification alternatives. These documents provided information about environmental, socioeconomic, and cultural conditions in the area; the effects of various actions on the resources in the area; and potential measures to avoid, minimize, reduce, or compensate for any significant effects using best management practices. Resources studied include hydrology, water quality, groundwater, water supply, air quality, aquatic resources, terrestrial vegetation and wildlife, soils, minerals, geological resources, visual resources, agricultural resources, and transportation and circulation element. Environmental effects were found to be less than significant with the following exceptions:

- **Air Quality:** Exhaust and fugitive dust emissions from construction and hauling equipment would cumulatively produce a significant air quality impact. Nitrogen oxide (NOx) emissions would trigger a general conformity evaluation, from which mitigation measures would be developed to reduce air quality impacts.
- **Terrestrial Vegetation and Wildlife:** Construction would have the potential to adversely affect special status plant or animal species, protected oak woodlands, native vegetation, and wetlands. These impacts would require compensatory mitigation as per the U.S. Fish and Wildlife Service biological opinion.
- **Soils, Minerals, and Geological Resources**: Construction activities would result in the loss of topsoil resources that would be mitigated to less than significant levels through the implementation of best management construction practices.
- **Transportation and Circulation:** The hauling of materials and supplies to the project sites would not have a significant impact on the level of service for most local roadways except for Scott Road north of White Rock, and East of Natoma Street. This impact would be mitigated as feasible.

- **Noise:** Nighttime noise increase at three residential receptor areas would exceed ambient noise criteria creating an unavoidable adverse impact, should mitigation measures not be effective in reducing noise levels.
- **Cultural Resources:** Cultural resources are known to exist at many locations proposed for staging and facility construction and could be disturbed or destroyed under any of the action alternatives. Cultural resources staff would prepare a determination of potential impacts and consult with the State Historic Preservation Office (SHPO). Cultural resource impacts would be evaluated and mitigated for under a programmatic agreement in consultation with the SHPO.
- **Recreation:** Contractor staging would emphasize use of areas with no current public access, away from residential areas. Excess materials would be used to create platforms above the normal operating reservoir water surface at elevation of 466.0 and would be be placed so as to maintain existing or equivalent public recreation access and use capacity during the peak recreation season.

  To minimize potential impacts to recreation, staging areas at Beal's Point and Folsom Point would be placed on constructed platforms or on adjacent unimproved areas a safe distance from primary recreational activities. Public safety would be maintained through the use of fencing or other similar measures. There would be nearly continuous public access to recreation areas and trails throughout the construction period through the use of traffic control measures, grade separated vehicular and/or pedestrian crossings, and/or temporary alternate public access detours. Closures could occur while the Partner Agencies are implementing these new measures that allow continued access or to address public safety and facility security objectives. In such cases, temporary closures would be accomplished during off-peak days or the off-season to minimize impacts on recreation activities. Reclamation's Central California Area Office would notify local agencies and the general public and accept input in advance of any possible extended closure(s) that may be necessary due to unforeseen project circumstances.

GEOTECHNICAL INVESTIGATIONS AND CONSIDERATIONS

A summary of engineering geology and geotechnical information that is available and is pertinent to the proposed Joint Federal Project is presented. The proposed auxiliary spillway and all of its design components are located within a semi-rectangular area beginning at the existing parking area and overlook approximately 3,000 feet east of the dam along the Dam Road, which has been restricted to traffic for the past two years. The western end of the facilities would terminate approximately 600 to 700 feet south of the existing dam stilling basin at the American River. Topographically, this project area begins at approximate upper elevation 525 descending along a gently west-southwest sloping natural ground surface to approximate elevation 115 to 120 at the American River. Although several areas of shallow access road cuts and fills exist throughout this project footprint, the majority of the site consists of annual grass cover and natural vegetation. One area of deeper fills is present at the west end of the project and a 50-foot high, steep road cut was constructed along

the former Dam Road. The parking area was created by placement of deep fill extending into the reservoir. No other significant structures are known to be present in this area.

The geologic, seismic, and geotechnical information available within the project area are presented. Geotechnical design considerations for design and construction of the Joint Federal Project auxiliary spillway include reuse of excavated materials, slope stability, rock cut slope stability, seepage potential, scour potential and foundation criteria. Excavated materials from the auxiliary spillway may be used to accomplish the proposed MIAD remediation and dike raises. Preliminary slope stability analyses for the auxiliary spillway suggest that the deeper portions of cuts could be constructed at steeper gradient and shallower cuts could also be steepened with adequate bench design intervals and vegetation. Rock cut slope stability design considerations include persistent faults, zones of intense fracturing, and/or alteration known to exist in portions of the auxiliary spillway. If adversely oriented, these would be detrimental to the auxiliary spillway and may require appropriate mitigation measures.

To date, no seepage analyses or evaluations have been performed; however, the presence of persistent structural features that represent seepage paths perpendicular to the auxiliary spillway and adjacent left wing dam axes would likely require further analysis. Seepage potential during construction has also not been evaluated based on the absence of data currently available. However, of particular concern is the potential for seepage beneath the left wing dam and into the auxiliary spillway or through the proposed cofferdam plug.

It is assumed likely that lateral loads on the proposed control structure will govern the geotechnical design of foundations. It is also anticipated that drilled shafts will be the most economical system to withstand this loading condition. Therefore, the lateral capacity of the shafts will control the design. Despite the current intent to line the entire auxiliary spillway approach channel, control structure, chute, and stilling basin, preliminary evaluations were performed to assess the potential for leaving portions of the auxiliary spillway exposed where low scour potential may be present.

Additional data, acquired during the Phase 2 auxiliary spillway geotechnical explorations will provide updated data characterization models. Analyses relative to each of these and other design considerations will result in better definition of the geotechnical design criteria for the auxiliary spillway, and thus improvement of the corresponding design components and estimated costs.

DESIGN AND CONSTRUCTION CONSIDERATIONS FOR JOINT FEDERAL PROJECT

The Joint Federal Project consists of a proposed auxiliary spillway constructed in the left abutment adjacent to the existing Folsom Dam. The new auxiliary spillway would regulate releases through a concrete gravity control structure with six STGs into a lined spillway chute and stilling basin, discharging directly into the American River. Design considerations and performance are discussed, including hydraulic, civil, structural, mechanical, and electrical design. Also discussed are construction considerations, cost and schedule to implement the project.

- **Hydraulic Design** - The Folsom Joint Federal Project should have the capability to manage floods and safely pass the PMF. The spillway design flood for Folsom Dam is the PMF. Design considerations include: acceptable hydraulic performance; satisfactory functionality of the auxiliary spillway and stilling basin at design flows; and combined releases from the service spillway, auxiliary spillway, and emergency spillway without complex operational constraints. The Joint Federal Project includes the addition of an auxiliary spillway near the left abutment of the main dam with six 23-foot wide by 33-foot high STGs at invert elevation 368.0. This alternative is effective because it increases the flood damage reduction capabilities at lower levels in the reservoir and allows Folsom Dam to safely pass the PMF without overtopping. The auxiliary spillway would include a converging approach channel, a concrete gravity control structure, a steep rectangular concrete-lined chute, and a stilling basin. The control structure has a vertical upstream face, an intake to each of the conduits that incorporates an elliptical roof curve, a vortex suppressor structure, the submerged tainter gates, and a rectangular concrete conduit to house each of the tainter gates. The control structure design is generally patterned after the existing auxiliary spillway at Oroville Dam. An abrupt rise of 4 feet in the approach channel invert at the upstream end of the approach channel concrete lining is included in the design to reduce approach velocities and allow for debris to drop out. Upstream of this abrupt rise, a slightly negative slope of -0.010 would be included in the approach channel to discourage debris material from migrating toward the structure. The control structure for the auxiliary spillway was designed for discharges up to 305,600 cfs. Average velocities through the gates and conduits with the gates fully open will be as high as 67 feet per second (fps) at maximum pool elevation 477.4. Velocities in the approach channel vary greatly from about 50 fps at the upstream end of the conduit roof curves to 8 fps or less at the upstream end of the approach channel. The maximum velocity at the upstream end of the proposed concrete lining in the approach channel is expected to be about 15 fps. Hydraulic model tests and further geotechnical data will be used to confirm velocities and assess whether or not the extent of the concrete (or other lining) can be reduced or needs to be increased. Because of relatively high Froude numbers ranging up to about 10, the stilling basin was patterned after the Type II basin, as described in Reclamation's *Hydraulic Design of Stilling Basins and Energy Dissipators*, Engineering Monograph No. 25. A design discharge of 90,000 cfs, concurrent with 25,000 cfs from the main dam sluices, was selected for the auxiliary spillway chute and stilling basin. The structures must function (without excessive damage) for the maximum discharges that can be released. A 3-D numerical model will be developed for the approach to the Joint Federal Project auxiliary spillway to determine hydraulic parameters and characteristics that can be used for design purposes and for modifying approach conditions to the auxiliary spillway physical model. A 2-D numerical model of the converging flows from the main dam service and emergency spillways and the auxiliary spillway may also be required as these flows transition to riverine flow. A 1:30 physical hydraulic model of the auxiliary spillway approach channel, the control structure, and about 800 feet of the chute downstream of the control structure will be performed. Ongoing studies and future analysis during the next phase of design are required to fully define design requirements.

- **Civil Design** – The auxiliary spillway project would include an access road across the top of the new spillway structure and would connect to the new bridge access road. Part of the existing access road from Folsom Dam Road to the Corps resident office and the toe of the main concrete dam would have to be realigned because of the presence of the auxiliary spillway control structure and chute alignment and the Folsom Bridge Road embankment. Folsom Point is a potential staging site and/or a potential material disposal site for material from the auxiliary spillway excavation. Continued public access to Folsom Point would require taking some measures for public health and safety reasons, to allow it to remain open for the duration of the auxiliary spillway and dam safety construction.

  Several utilities would be impacted by construction of the proposed Joint Federal Project alternative. A portion of the Natomas Pipeline, a raw water pipeline, would need to be relocated where it crosses the auxiliary spillway alignment. A number of power lines and telephone lines would require relocation as would some of the utilities servicing the Corps resident office building.

- **Structural and Mechanical Design** – The auxiliary spillway is the major new structural component of the proposed alternative and consists of a concrete gravity control structure housing six STGs, a rectangular chute downstream from the new control structure, and a concrete-lined stilling basin for energy dissipation. Due to time constraints, and to be consistent with the objectives of the Joint Federal Project, the structural engineering effort focuses on "worst-case" loading for the most critical structures. Accordingly, the concrete auxiliary spillway was analyzed for the maximum credible earthquake (MCE)[1], and other structures were sized conservatively, based on the experience of the design team. The auxiliary spillway control structure was site-adapted from DWR's *Oroville Dam Flood Control Structure* (DWR, 1965) primarily to provide enhanced flood control and hydrologic risk reduction. Site adaptations from the existing control structure at Oroville Dam include using 59-foot-wide independent concrete monoliths, each containing two-STGs similar in size to those at Oroville. A variety of tainter gate sizes and invert elevations were investigated with the three-monolith, six-gate configuration at invert elevation 368.0, approximately 10 feet lower than the equivalent Oroville spillway, providing the best project function at least cost.

  Preliminary two-dimensional (2-D) and three-dimensional (3-D) stability and stress analyses were performed by Reclamation and the Corps for the auxiliary spillway control structure. For evaluating gross pool and PMF pool conditions, hydrostatic models were used, while a pseudostatic and, subsequently, nonlinear time history methodologies were used for preliminary seismic analyses. For Corps static analyses, the requirements for sliding and overturning were taken from Engineering Circular (EC) 1110-2-6058 (Corps, 2003). For the Corps dynamic analyses, SAP2000 version 10 was used, and guidance from Engineering Manual (EM) 1110-2-6050 (Corps, 1999) and EM 1110-2-6051 (Corps, 2003) was followed for both stability and stress analyses. Reclamation used LS-DYNA to perform a dynamic analysis, and their

[1] During the feasibility study, technical criteria, standards, and/or guidelines from involved agencies would be considered and designed for (e.g., the Corps MCE and Reclamation probabilistic upper-bound earthquake would be analyzed and considered in the feasibility design).

results were applied to a Risk Analysis, following Reclamation guidance. Both agencies' analyses demonstrate structural stability based on the conservative assumptions made. In addition, the State of California Division of Safety of Dams (DSOD) provided an independent check on sliding stability and magnitude and distribution of stresses for the control structure. The analyses concluded the structure was stable for both the sliding and linear stress check.

- **Electrical Design** – The proposed new power distribution system is specifically designed for reliability with emergency on-site generation. These features would provide a reliable, fault-tolerant, and easily maintained system. A new single-ended substation would be located at the new spillway. Emergency electrical power would be provided from the existing emergency generator building on the Folsom project site. An additional provision for portable generator plug-in will be provided at the auxiliary spillway.
- **Construction Considerations** – A phased construction approach has been identified for the Folsom Dam auxiliary spillway. A phased construction approach allows for developing and implementing specific "work packages." Designated work packages should be compatible with future contracting/procurement efforts, and should represent major contracts as the program is currently envisioned. Work packages would be coordinated with other ongoing projects at the Folsom Facility to reduce contractor conflicts and maximize available funding. Other major proposed construction features include the Folsom Dam Bridge and Road project, City of Folsom Redundant Pipeline, downstream foundation treatment at MIAD, and various interim constructions measures currently underway by the Corps and Reclamation.
- **Schedule** – A preliminary schedule for the Joint Federal Project (six-STG auxiliary spillway) is presented that shows an approximate construction start date of July 2007 for Work Package 1 (flood damage reduction interim measures). Work Package 2 (safety of dams modifications for interim PMF protection, including auxiliary spillway excavation) would begin September 2007, and Work Package 3 (6-STG auxiliary spillway construction) would begin in June 2010. Work Package 4 (miscellaneous projects) would begin in January 2011. All Joint Federal Project work is anticipated to be complete by 2014.
- **Cost** – A feasibility-level cost estimate for the Joint Federal Project was developed using MCACES. The estimated total first cost assigned only to flood damage reduction is $683.0 million. The six-STG auxiliary spillway project is economically feasible. The annual cost assigned only to flood damage reduction is $37.9 million and the average annual flood control benefits are $89.9 million, respectively.

CONCLUSIONS

The following conclusions are based on the results of the analyses contained in this EDR for the Folsom Dam Joint Federal Project.

- The Joint Federal Project is one of the elements of a more comprehensive flood damage reduction and dam safety project which is the proposed selected plan (SP). The Joint Federal Project element of the SP is being cost-split by the Corps and Reclamation based on a cost distribution between the flood damage reduction and dam safety objectives.
- The Joint Federal Project combines the Corps' flood damage reduction objective of the authorized Folsom Modification Project and Reclamation's dam safety hydrologic risk reduction objective. The six-STG auxiliary spillway increases the flood control capability of Folsom Dam and Reservoir by increasing the outflow capacity at lower lake levels, resulting in better utilization of the existing storage capacity. This project also addresses the existing hydrologic dam safety deficiency of inadequate spillway capacity. The additional release capacity provided by the auxiliary spillway allows the dam the capability to safely pass the PMF.
- An auxiliary spillway, consisting of six 23 feet wide by 33 feet high STG with invert elevation 368, is equivalent to the flood damage reduction of the authorized Folsom Modification Project (while also satisfying the dam safety objective of passing the PMF). This comparison to the currently authorized project is based on the construction of ten new or enlarged river outlets in the main concrete dam.
- Flood routings of the six-STG auxiliary spillway have been performed to demonstrate that the Joint Federal Project would provide a flood control level of protection computed at one chance in 156 in any given year. This alternative would provide the capability for Folsom Dam to pass a 200-year design flood event.
- The design and construction of the six-STG would take about eight years.
- The energy dissipater at the end of the six-STG auxiliary spillway chute would be designed to dissipate energy from high velocity flows before they enter the American River channel. Ongoing studies and future analysis would determine what necessary measures would be required to address possible impacts to downstream water surface elevations and channel erosion potential.
- During project development, further study of reservoir reoperations would be made to focus on reducing the variable space allocated to flood control within the reservoir from the current operating range of 400,000 to 670,000 acre-feet to an operating range of 400,000 to 600,000 acre-feet.
- Construction of the six-STG auxiliary spillway would cause some resource impacts. Mitigation measures would be proposed to reduce these potential impacts to less than significant levels where possible.
- Preliminary geologic, geotechnical, seismic, and hydrogeologic investigations support the geotechnical viability of locating the auxiliary spillway at the site. Further data and analysis obtained during the ongoing Phase 2 explorations will enhance these data and allow further evaluation of key design considerations, including:
    - Cofferdam seepage

- Sliding block stability
- Gate structure foundation design
- Long-term seepage

- Structural analyses of the proposed Joint Federal Project auxiliary spillway for stability and stress indicate that the structure can achieve adequate margins of safety using cost-effective design and construction techniques.
- The Joint Federal Project is strongly supported by the local Partners, including the State of California Reclamation Board and SAFCA. Formulation of the Joint Federal Project has been closely coordinated with the Partners and Reclamation.
- A feasibility-level cost estimate for the Joint Federal Project was developed using MCACES. The estimated total first cost assigned only to flood damage reduction is $683.0 million. The six-STG auxiliary spillway project is economically feasible. The annual cost assigned only to flood damage reduction is $37.9 million and the average annual flood control benefits are $89.9 million, respectively.

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Attachment C2	Project Cost - Folsom Dam Joint Federal Project Engineering Documentation Report
Attachment C3	Project Annual Cost - Folsom Dam Joint Federal Project Engineering Documentation Report

ACRONYM AND ABBREVIATION LIST

2002 Long-Term Study	American River Watershed Long-Term Study Final Supplemental Plan Formulation Report
2-D	Two dimensional
3-D	Three dimensional
ASP	Available stream power
ATS	Automatic transfer switch
AWWA	American Water Works Association
°C	Degrees centigrade
CFR	Code of Federal Regulation
cfs	Cubic feet per second
Corps	United States Army Corps of Engineers
CVP	Central Valley Project
CWCCIS	Civil Works Construction Cost Index System
D	Distance
DDR	Design Documentation Report
DPR	State of California Department of Parks and Recreation
DSOD	State of California Division of Safety of Dams
DWR	State of California, Department of Water Resources
E	East
EC	Engineering Circular
EDR	Engineering Documentation Report
EIS/EIR	Environmental Impact Statement / Environmental Impact Report
elevation XXX	elevation, feet above mean sea level
EM	Engineering manual
EPA	Equitable price adjustment
ESRD	Emergency spillway release diagram
ERDC	Engineer Research and Development Center
FERC	Federal Energy Regulation Commission
fps	Feet per second
ft/min	Feet per minute
g	Acceleration due to gravity
gpm	Gallons per minute
GSI	Geologic strength indices
HEC-RAS	Hydrologic Engineering Centers – River Analysis System

hp	Horsepower
HPU	Hydraulic power unit
JFP	Folsom Dam Joint Federal Project
Js	Relative ground structure number
K	Erodibility Index (mean value; mean minus 1 standard deviation)
Kb	Particle/block size number
Kd	Discontinuity shear strength number
km	Kilometers
Ks	Roughness heights
kV	Kilovolt
kVA	Kilovolt-ampere
kW	Kilowatt
LRR	Limited Reevaluation Report
LDW	Left wing dam
M	Modal magnitude
M-CACES	Microcomputer-Aided Cost Estimating System
MCC	Motor Control Center
MCE	Maximum credible earthquake
MDE	Maximum design earthquake
MIAD	Mormon Island Auxiliary Dam
Ms	Mass strength number
NA	Not applicable
NC	Not classified
NE	Northeast
NFPA	National Fire Protection Association
NMFS	National Marine Fisheries Service
NO_x	Nitrogen oxides
NW	Northwest
NWS	National Weather Service
OBE	Operating basis earthquake
PAC	Post-Authorization Change
PASS	Project Alternatives Solutions Study
PGA	Peak horizontal ground acceleration
PG&E	Pacific Gas and Electric Company
PL	Public Law
PMF	Probable maximum flood
P&S	Plans and specifications

psi	Pounds per square inch
Reclamation	United States Department of the Interior, Bureau of Reclamation
R&U	Risk and uncertainty
RMR	Rock mass rating
RQD	Rock quality designation
RRFM	Reservoir Release Forecast Model
RSP	Required stream power
SAFCA	Sacramento Area Flood Control Agency
SIR	Supplemental Information Report
SMUD	Sacramento Municipal Utility District
SP	Selected plan
SRA	State Recreation Area
State Reclamation Board	State of California Reclamation Board
STG	Submerged tainter gates
SW	Southwest
SWP	State Water Project
TAF	Thousand acre-feet
UCS	Unconfined compressive strength
UPS	Uninterruptible power supply
USGS	United States Geological Survey
v:h	Vertical to horizontal ratio
W	West
WCD	Water control diagram
WES	Waterways Experiment Station
WRDA	Water Resources Development Act

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CHAPTER 1.0
INTRODUCTION

This Engineering Documentation Report (EDR) is an engineering refinement and technical implementation document to support the Post-Authorization Change (PAC) report of the Folsom Modification Project and the Folsom Dam Raise Project. Both currently authorized projects share an objective of implementing flood damage reduction on the lower American River, primarily through structural modifications to the existing Folsom Dam and appurtenant facilities. Concurrently, the United States Bureau of Reclamation (Reclamation), the operator of Folsom Dam and Reservoir, is working to implement their Reclamation Safety of Dams Program for safety improvements to the Folsom facility. One of Reclamation's dam safety objectives is for the dam to safely pass the probable maximum flood (PMF). The timing of both these federal efforts creates an opportunity to develop a more efficient and cost-effective joint plan that consolidates both flood damage reduction and dam safety objectives into a single project, which is described as the Joint Federal Project.

The Joint Federal Project is one of the elements of a more comprehensive flood damage reduction and dam safety project which is the proposed selected plan (SP) that is discussed in the PAC report. The Joint Federal Project element focuses only on the Folsom Modification flood damage reduction authority and Reclamation's dam safety objective in addressing the PMF. The Joint Federal Project element of the SP is being cost-split by the United States Army Corp or Engineers, Sacramento District (Corps) and Reclamation based on a cost distribution between the flood damage reduction and dam safety objectives. This is discussed in detail in the PAC report.

The purpose of this EDR is to describe the Joint Federal Project and present preliminary design information, including cost and functional data. This report does not preclude investigation of additional alternatives (using the Joint Federal Project as a baseline alternative) to obtain additional flood damage reduction benefits.

1.1 SCOPE OF REPORT

This EDR describes the features associated with the Joint Federal Project and documents the engineering aspects of the project. It focuses on cost, performance, functionality, and compatibility of the project to the authorized Folsom Modification Project for flood damage reduction in conjunction with Reclamation's dam safety efforts and criteria.

1.2 PROJECT AUTHORIZATION AND APPROVAL

Authorization to construct a dam on the American River was included in the Flood Control Act of 1944. Construction of Folsom Dam was initiated in 1948 and completed in 1956. The storms of 1986 raised concerns over the adequacy of the existing flood control system resulting in the December 1991 *American River Watershed Investigation Feasibility Report* (Corps, 1991). Congressional guidance was forthcoming in the 1993 Defense Appropriations Act, authorizing additional studies to develop solutions to the flood problems. This study effort was documented in the March 1996 *American River Watershed Project,*

California, Supplemental Information Report (1996 SIR) (Corps, 1996). The 1996 SIR described multiple alternative plans, of which certain levee and other flood system improvements were common to all alternatives. In the 1996 Water Resources Development Act (WRDA), Congress authorized only a portion of the 1996 SIR recommended plan. The authorized elements became known as "Common Features." While efforts moved forward to further develop and implement the Common Features, discussions continued on ways to achieve higher levels of flood protection for Sacramento.

1.2.1 Folsom Modification Authorization

The Folsom Modification Project was authorized as follows. Under Section 101(a)(6) of the WRDA of 1999 (Public Law [PL] 106-53), Congress authorized physical modifications at Folsom Dam, consistent with the descriptions provided in the *Corps Supplemental Information Report for the American River Watershed Project, California*, (Corps, 1996), as modified by the *Folsom Dam Modification Report, New Outlets Plan*, dated March 1998, prepared by the Sacramento Area Flood Control Agency (SAFCA) (SAFCA, 1998).

Corps Headquarters provided guidance on the intent of this authorization directing that a decision document be prepared to support the authorized project. A *Limited Reevaluation Report* (LRR) was prepared in August 2001 (Corps, 2001). The primary purpose of the LRR was to demonstrate that the authorized operational and structural modifications to Folsom Dam were economically justified, technically sound, and environmentally acceptable, and clearly defined the project features.

As part of the reevaluation effort, the design of the authorized plan was examined to determine if enlarging the eight existing river outlets would result in a cost savings compared to constructing new outlets beneath the emergency spillway and constructing a new stilling basin downstream of the emergency spillway. As a result of this evaluation, a plan to enlarge the eight existing river outlets was developed with the outlets designed to allow for concurrent spillway releases.

Following publication of the LRR in 2001, constructibility and operability reviews of the LRR-proposed enlarged gates prompted additional design refinements. These refinements were documented in a final LRR report dated November 2003 (Corps, 2003), which was submitted to the assistant secretary of the Army and approved in January 2004.

1.2.2 Folsom Dam Raise Authorization

The Folsom Dam Raise Project was authorized as follows. On 5 November 2002, based on the findings of the 2002 *Long-Term Study Feasibility Report, a Chief of Engineers' Report* was signed that recommended a 7-foot raise in the height of Folsom Dam. Under Section 128 of the Energy and Water Development Appropriations Act for 2004 (PL 108-137), Congress then authorized the Folsom Dam Raise Project based on the recommendations contained in the November 2002 *Chief of Engineers Report*.

1.2.3 Reclamation Dam Safety Program

Reclamation's Dam Safety Program was officially implemented by PL 95-578 (1978), as amended by PL 98-404 (1984). The secretary of the Department of the Interior was thereby authorized to construct, restore, operate, and maintain new or modified features at existing dams for dam safety purposes and, in order to preserve the structural safety of the dams and related facilities, to perform such modifications as he determined to be reasonably required.

1.2.4 Joint Federal Project

The Energy and Water Development Appropriations Act for 2006 (PL 109-103) provided further direction regarding actions at Folsom Dam. The secretary of the Army and the secretary of the Department of the Interior were directed to collaborate on authorized activities to maximize flood damage reduction improvements and address dam safety at Folsom Dam and Reservoir. In developing the improvements, the secretaries were directed to consider reasonable modifications to existing authorized projects, including a potential auxiliary spillway.

1.3 PROJECT OBJECTIVES

The objective of the Joint Federal Project is to significantly reduce the risk of flooding along the main stem of the American River in the Sacramento area while meeting dam and public safety objectives. The Joint Federal Project seeks to combine the Corps' flood damage reduction objective of the authorized Folsom Modification Project with Reclamation's dam safety objective. The Joint Federal Project would result in a collaborative effort that would cost effectively address: (1) protection of public safety related to the hydrologic integrity of the Folsom Facilities and associated structures, and (2) improvement to overall flood damage reduction for the communities downstream along the lower American and Sacramento rivers.

The Joint Federal Project seeks to achieve the following performance objectives: (1) reduce flood risk to areas along the American River to a level sufficient to meet the local objective of a computed 200-year design flood event, and (2) meet Reclamation's objective of safely passing the PMF at Folsom Dam. It is the Corps' and Reclamation's goal, that by integrating and streamlining planning, design, and construction efforts in developing the Joint Federal Project, each agency will achieve its objective of flood damage reduction or dam safety at a significantly reduced cost relative to separate, individually implemented agency projects, and to provide the project benefits to the public in a more time-effective manner.

At minimum, the Joint Federal Project also retains opportunities for further flood protection as provided by the Folsom Dam Raise Project.

1.4 PROJECT SITE AND CONDITIONS

The American River Watershed covers about 2,100 square miles northeast of Sacramento, including portions of Placer, El Dorado, and Sacramento counties. Runoff from the basin flows through Folsom Reservoir into the lower American River and through the Sacramento metropolitan area. The river has a system of levees along both banks and leveed floodways.

Folsom Dam is located at the confluence of the North and South forks of the American River, near the City of Folsom, approximately 29 miles upstream from the City of Sacramento. **Plate 1-1** shows the American River Watershed.

The present Folsom facility consists of a gravity-type main concrete dam, left and right earth embankment wing dams, an auxiliary earthfill dam (Mormon Island Auxiliary Dam [MIAD]), and eight earth embankment dikes located around the rim of the reservoir. **Plate 1-2** depicts the Folsom Dam and Reservoir area and shows the project features.

The reservoir has a capacity of 977,000 acre-feet at its gross pool elevation of 466 feet above mean sea level (elevation 466). The top of the main concrete dam is at elevation 480.5 and spillway crest is at elevation 418. Under extreme conditions, the current maximum allowable pool elevation is 475.4 feet. The objective release for flood control from the dam to the lower American River is 115,000 cubic feet per second (cfs).

The river outlet works consist of eight 5-foot by 9 foot-rectangular outlets located in the center four monoliths of the main concrete dam. The four upper tier outlets are at springline elevation 280; the four lower tier outlets are at springline elevation 210. The outlet works are capable of passing 24,816 cfs (at 100 percent gate opening) through the dam with the reservoir pool at spillway crest elevation 418. The outlets are operated primarily to evacuate the flood control space during flood season and, to a lesser extent, to provide colder lower-pool water for fisheries in the fall.

The gated overflow spillway is located in the central gravity section of the main concrete dam with spillway crest elevation 418. The spillway is divided by piers into eight equal sections. The first five sections (westernmost) comprise the service spillway. They are controlled by five 42-foot by 50-foot (tainter) radial gates; discharging into the stilling basin. The three remaining spillway sections are for emergency use when release requirements exceed 300,000 cfs. They are controlled by three 42-foot by 53-foot tainter gates. Water discharges over a flip bucket onto the emergency stilling basin slab. The rated capacity of the entire spillway is 567,000 cfs.

Three 15.5-foot-diameter penstocks pass through the west non-overflow section of the main concrete dam. Normal releases through the penstocks provide power generation and downstream water supply deliveries, however these penstock flows were not considered during the analysis of flood routings. The combined capacity of the three penstocks is 8,000 cfs. In addition, there is one 7-foot-diameter intake conduit, located west of the penstocks, which supplies water to several local water districts.

1.5 KEY DESIGN CONSIDERATIONS

A major concern exists regarding the potential for erosion below the emergency spillway chute and adjacent areas. It has been determined that even small flows could cause severe erosion below the emergency spillway; continuous flows without sufficient tailwater could allow this erosion to migrate towards the stilling basin serving the main service spillway. It is estimated that sufficient tailwater would not be present to operate the emergency spillway until discharges exceed 300,000 cfs. Modifications to the three emergency tainter gates should be consistent with the assumptions used in the original design of the emergency stilling basin.

Normal flood operations at Folsom Dam would limit downstream flows to a maximum of 115,000 cfs. Upon completion of the Common Features project, outflows from the dam could be increased from 115,000 cfs to the new non-damaging channel capacity of the lower American River of 160,000 cfs.

Key design considerations also include constructibility and environmental considerations.

Constructibility considerations include the following:

- All of the service spillway gates need to be available for releases at 24 hours notice.
- Disturbance of existing utilities and dam operations should be avoided to the extent practical.

Environmental considerations include the following:

- Best management practices are to be implemented to limit disruption of aquatic habitat and turbidity resulting from construction operations.
- Construction impacts to existing habitat and fish are to be minimized.
- Noise and air quality factors from construction activities are to be considered.

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CHAPTER 2.0
BACKGROUND OF THE JOINT FEDERAL PROJECT

This chapter describes the current authorizations for flood damage reduction associated with Folsom Dam and Reservoir as background for a flood damage reduction and dam safety alternative described as the Joint Federal Project.

2.1 DESCRIPTION OF CURRENTLY AUTHORIZED PROJECTS

There are currently two authorizations associated with flood damage reduction involving Folsom Dam and Reservoir: the Folsom Modification Project authorization and the Folsom Dam Raise Project authorization.

The Folsom Modification Project was authorized in the WRDA 1999. The authorized plan included elements of the Folsom Modification Plan as described in the 1996 SIR (Corps, 1996), and subsequently modified in the SAFCA Information Paper *Folsom Dam Modification Report, New Outlets Plan*, dated March 1998. The November 2003 Folsom Modification Project Final LRR and Environmental Assessment/Initial Study is the latest authorization document, and describes the two main functions of the Folsom Modification Project: to increase release capacity and to modify use of surcharge storage (Corps, 2003).

The features of the function to increase the release capacity of the dam were to include some variation of new river outlets through the concrete portion of the existing dam, enlargement of the eight existing river outlets, and modifications to the existing spillway and stilling basin as necessary. The new and enlarged river outlets were to increase the release capacity to 115,000 cfs with the reservoir pool at spillway crest (elevation 418). The capability of maintaining the flood storage capacity gained by early release (prior to spillway flow) was calculated to reduce the probability of flooding in any one year from 1 chance in 81 to 1 chance in 154.

Implementing of the features of the function to modify use of surcharge storage would provide additional flood control storage of 46,200 acre-feet. Under existing conditions, the emergency spillway release diagram (ESRD) and physical features of the dam allow for surcharge storage to elevation 470 without overtopping the existing emergency spillway gates in their closed position. When the reservoir exceeds elevation 470, the emergency spillway gates must be open and the dam would release more than the objective release, potentially causing downstream flooding. The surcharge storage modifications would require both physical and operational changes to allow the flood pool to surcharge to elevation 474. The features associated with the surcharge storage project would include replacement of the three existing emergency spillway tainter gates, raising the penstock hydraulic control pumps and controls, and increasing the height of the impervious core in Dikes 5 and 7 and MIAD.

The Folsom Dam Raise Project was authorized in the Energy and Water Development Appropriation Act of 2004. The project, as authorized, consisted of the following major elements:

- Raise Folsom Dam including the main concrete dam, the left and right embankment wing dams, MIAD, and the eight dikes by 7 feet
- Construct a permanent bridge downstream of the dam
- Modify the spillway of L.L. Anderson Dam at French Meadows Reservoir
- Implement ecosystem restoration features to benefit the lower American River

Some of these elements are depicted on **Plates 1-2** and **2-1**. L.L. Anderson Dam is located at French Meadows Reservoir, on the Middle Fork of the American River, about 50 miles upstream of Folsom Dam.

Raising the dam 7 feet would require that all eight of the existing spillway gates be replaced by larger gates. In addition, the spillway bridge piers would be modified, the spillway bridge would be replaced, and the existing stilling basin would be extended about 60 feet to provide adequate energy dissipation. The modifications would add approximately 93,000 acre-feet of flood storage capacity to the reservoir.

A permanent bridge located downstream of the dam, as shown on **Plate 2-1**, would carry rerouted traffic from Folsom Dam Road during and after construction of the dam raise. The authorized project differs from the project recommended in the 2002 Long-Term Study (Corps, 2002a) in that Congress approved construction of a permanent bridge in lieu of a temporary one. A permanent bridge would both mitigate closure of Folsom Dam Road during construction, and provide greater long-term security for the dam.

Modifications to L.L. Anderson Dam would involve enlarging the spillway to allow safe passage of the PMF. Under present conditions the spillway is unable to pass the PMF without overtopping the embankment dam. A failure of L.L. Anderson Dam would significantly increase the PMF at Folsom Dam.

The ecosystem restoration features of the authorized project include the construction of automatic temperature control shutters at Folsom Dam to benefit American River fisheries (the existing shutters are operated manually) and active habitat restoration at Woodlake Restoration Site and Bushy Lake Restoration Site, both located on the lower American River.

2.2 BACKGROUND OF AUTHORIZED PROJECTS

Because the Folsom Modification Project, authorized in WRDA 1999, differed from what was presented in the 1996 SIR, an LRR was prepared in August 2001 (Corps, 2001). At the same time, additional studies for yet additional flood protection and for dam safety were being conducted, which were documented in the February 2002 *American River Watershed Long-Term Study Final Supplemental Plan Formulation Report* (2002 Long-Term Study) (Corps, 2002a). To assimilate common features between the 2001 LRR and the 2002 Long-Term Study, and to reflect changes in the Folsom Modification Project design since

publication of the 2001 LRR, the *Folsom Dam Modification Project LLR* was revised in 2003 (2003 LRR).

Recommendations from the 2002 Long-Term Study that were authorized in 2004 WDRA included raising the dam by 7 feet (mini-raise), modifying the spillway at L.L. Anderson Dam, constructing a permanent bridge downstream of Folsom Dam, and modifying emergency release operations to permit surcharge. These authorized features, some of which make up the Folsom Dam Raise Project described in a separate EDR, carry design implications for the previously authorized Folsom Modification Project, as described below.

Under the Folsom Dam Raise Project, all eight existing spillway gates would be modified, spillway bridge piers would be modified, and the spillway bridge would be replaced. If the Folsom Modification Project were implemented first, as authorized, then gate modifications would need to be made twice. Consequently, the 2003 LRR refined the elements related to increasing release capacity to be consistent with the modifications in the 2002 Long-Term Study, and to reflect changes in the design from what was described in the 2001 LRR. These changes include the following:

- Constructing two new upper tier river outlets 9.33 feet wide by 14 feet high
- Enlarging the four existing upper tier river outlets to 9.33 feet by 14 feet, and the four existing lower tier river outlets to 9.33 feet by 12 feet
- Providing additional anchorage for the stilling basin slab and training walls
- Deferring replacement of the three emergency spillway gates authorized as part of WRDA 1999, since the Folsom Dam Raise Project would address the gates

Since preparation of the 2001 LRR and the authorization of the Folsom Dam Raise Project, design efforts have identified further changes to the Folsom Modification Project as reflected in the 2003 LRR. **Table 2-1** summarizes the 1996 SIR project features, the originally authorized elements, and the features modified in the 2003 LRR.

TABLE 2-1
COMPARISON OF AUTHORIZED AND REFINED PROJECT FEATURES, FOLSOM MODIFICATION PROJECT

Function	Project Features in 1996 SIR	Authorized project Features (WRDA 1999)	Project Features in 2003 LRR
Increase Release Capacity (115,000 cfs objective release)	Lower spillway crest by 15 feet	In lieu of lowering the spillway, construct five new river outlets under the auxiliary spillway (two 7-foot by 14-foot slide gates per outlet)	Add two new upper tier river outlets (9 feet 4 inches by 14 feet)
	Enlarge eight existing river outlets to 6 feet by 12 feet	Enlarge 8 existing river outlets to 6 feet by 12 feet	Enlarge eight existing river outlets to 9 feet 4 inches by 14 feet (four upper tier outlets), and 9 feet 4 inches by 12 feet (four lower tier outlets)
		Construct new stilling basin downstream from auxiliary spillway	Use existing stilling basin, but with additional anchorage of apron slab and walls
Modify Use of Surcharge Storage	Raise impervious core in Mormon Island Auxiliary Dam, Dike 5, and Dike 7	No change	No change
	Modify surcharge operation to provide additional flood space	No change	No change
	Construct parapet wall at Newcastle Powerhouse	No change	No parapet wall required
	Raise penstock gate hoists and relocate hydraulic pumps	No change	No change
	Replace three emergency spillway tainter gates with 42-foot by 59-foot tainter gates (new top of gate elevation of 476 feet)	No change	Design tainter gate foundations to permit expansion in future, if Folsom Dam Raise Project is implemented
	Top-seal existing spillway tainter gates	No change	Top-seal not used (not technically feasible)
Revise Reoperation (permanent reoperation)	Reduce variable space allocated to flood control from 400-670 TAF to 400-600 TAF	No change	No change
Update Folsom Dam Flood Management Plan	Revise plan to reflect operational capabilities provided by outlet modifications, surcharge storage space, and improved forecasting	No change	No change

KEY:
LRR – Limited Reevaluation Report
TAF – thousand acre-feet
SIR – Supplemental Information Report
WRDA – Water Resources Development Act

Engineering documents were prepared for construction implementation of the project proposed in the 2003 LRR. The *Folsom Dam Outlet Works Modification Project Design Documentation Report* (DDR) (Corps, 2004) discussed the Folsom Modification Project in two parts: The Outlet Works Modification Project (with the increase release capacity function) and the Surcharge Storage Project (with the modify use of surcharge storage function).

With regards to the surcharge storage modification features, the DDR stated that because the project had many features similar in nature to the modifications proposed by the 2002 Long-Term Study, which included raising the dam, the detailed design of the surcharge storage features was deferred following congressional decision granting authorization to raise the dam.

The 2004 DDR presented the following description of the designed Outlet Works Modification Project features.

The primary feature of the increase release capacity function would be the modification of the main dam river outlets. The six upper tier river outlets (four modified and two new) would be 9.33 feet wide by 14 feet high; the two new river outlets would be skewed 3.5 degrees so that they would exit just inside the sidewalls of the existing spillway (see **Plate 2-2**). The four lower tier outlets would be 9.33 feet wide by 12 feet high. The river outlets would be over-excavated to allow for a formed concrete surface. The existing slide gates, gate bodies, and gate hoists would be replaced by larger units.

Subsequent to the 2004 DDR, it was decided to divide the modification of the river outlets into an upper tier contract (six outlets) and a lower tier contract (a maximum of four outlets). Construction documents were prepared for the six upper tier outlets. Proposals were received in March 2005 but exceeded the fully funded, updated authorized cost (Section 902 limit). The solicitation was cancelled in January 2006.

Without implementation of the Outlet Works Modification Project, significant flood risks remain. In the Energy and Water Development Appropriations Act of 2006, Congress directed that expedited action be taken to maximize flood damage reduction improvements and address dam safety needs at Folsom Dam. In addition, the existing authorized projects were expanded to include consideration of an auxiliary spillway.

The Folsom Dam Raise Project was authorized in the Energy and Water Development Appropriation Act of 2004 based on recommendations contained in the November 2002 Chief of Engineers' Report (Corps, 2002b), which were based on findings in the 2002 Long-Term Study.

Since authorization, the Folsom Dam Raise Project has been subject to cost increases due to increases in construction material costs, a decrease in the availability of contractors, and safety and security considerations at the dam. Modifications of the spillway at L.L. Anderson Dam are no longer being considered part of the Folsom Dam Raise Project since the owner, Placer County Water Agency, is responsible to resolve all dam safety issues

separately. Efforts are moving forward on design and advance implementation of the Folsom Bridge; the bridge is scheduled for completion in December, 2008. Efforts to raise Folsom Dam have continued, but at a slower pace. Any dam raise needs to be considered concurrently with further features to modify the dam. Recent studies related to the Folsom Dam Raise Project have sought compatibility and greater efficiency for the flood control projects and Reclamation's dam safety objectives.

2.3 BACKGROUND OF JOINT FEDERAL PROJECT

As part of a joint strategy, an engineering Project Alternatives Solutions Study (PASS) was conducted by the Corps and Reclamation in 2005, as well as other stakeholders including SAFCA, State of California Department of Water Resources (DWR), and the State of California Reclamation Board (State Reclamation Board). Engineering alternatives were quickly developed that addressed both flood damage reduction and dam safety objectives. A follow-up study known as PASS II further evaluated the least costly alternative solution. The Study was completed early in 2006 and is documented in the Folsom Dam Raise and Auxiliary Spillway Alternative, PASS II, dated June 2006 (Corps, 2006). This study presented an engineered evaluation of an auxiliary spillway alternative consisting of four submerged-tainter-gates (STGs) along with a 7-foot dam raise. Optimization efforts of the PASS II alternative identified additional alternative variations of the four- and six-STG auxiliary spillway and a dam raise, with and without emergency spillway gate replacement. The result of this preliminary study was the identification of an alternative known as the Joint Federal Project, consisting of an auxiliary spillway with six STGs. This resulting Joint Federal Project incorporates the flood damage reduction and dam safety objectives of both the Corps and Reclamation and achieves local partner goals of levels of flood protection along with public safety protection.

A description of the preliminary investigation, design, and construction considerations associated with the Joint Federal Project are presented in the following chapters.

CHAPTER 3.0
HYDROLOGY AND RESERVOIR OPERATIONS

This chapter presents the Corps' understanding of the hydrology of the American River Drainage Basin and Folsom Dam site. Also discussed are reservoir operations as they exist currently, and as they would be modified for various alternatives examined for the Folsom Modification Project. The Folsom Dam Operations and Planning Model, developed with Microsoft Excel, is used in all the routing and alternative analyses for the various American River Folsom Dam studies.

3.1 HYDROLOGY

This section presents hydrology of the Folsom Dam area including information on design floods and the PMF.

3.1.1 Design Floods

Hydrology for the American River projects has been extensively studied by the Corps. In that process, unregulated flow frequency statistics for the American River at Fair Oaks were developed and have subsequently been updated to include flood data for the years 1905 through 2004. The statistical analysis used for this report followed procedures found in *Bulletin 17B, Guidelines for Determining Flood Flow Frequency* (United States Geologic Survey [USGS], 1982). The resultant statistics adopted for the American River at Fair Oaks are shown in **Table 3-1**. A complete discussion of the development of the adopted statistics is provided in the *Rain Flood Flow Frequency Analysis, American River, California* (Corps, 2004).

TABLE 3-1
AMERICAN RIVER AT FAIR OAKS –
UNREGULATED FLOW STATISTICS

Duration	Log Mean (cfs)	Log Standard Deviation (cfs)	Skew
1 Day	4.453	0.425	-0.05
3 Days	4.326	0.414	-0.05
7 Days	4.162	0.398	-0.13
15 Days	4.015	0.373	-0.26
30 Days	3.897	0.360	-0.42
KEY: cfs – cubic feet per second			

The unregulated flow statistics shown above were used to develop a series of inflow design (synthetic hydrograph) events for Folsom Dam used in the modeling/analysis of the various conditions and alternatives studied. The shape of each inflow design hydrograph was

patterned using the shape adopted for the American River PMF. **Figure 3-1** shows both an inflow design event and the PMF inflow hydrograph. Once the unimpaired (natural) flow hydrographs were developed, they were routed throughout the system, including the upstream reservoirs. This process transformed them into regulated inflow hydrographs, to serve as inflow to Folsom Dam. Baseline or the most likely routings (i.e., with no risk and uncertainty considerations) assumed that upstream reservoirs would be full at the start of the flood routing. This assumption provides the most critical condition for Folsom Dam routings.

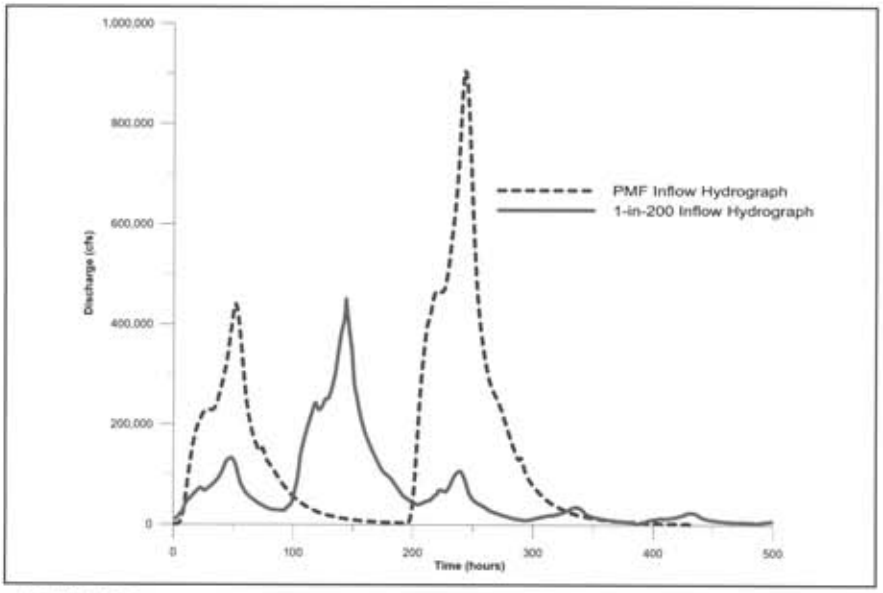


FIGURE 3-1
SHAPES OF PROBABLE MAXIMUM FLOOD AND INFLOW HYDROGRAPH SERIES

Corps guidance (ER 1105-2-101) requires the use of risk analysis in flood damage reduction studies. For risk and uncertainty purposes, the analyses herein cover Folsom Reservoir's response to a range of design. The flood events, routed using the Folsom Dam Operations and Planning Model, range from a 1-in-2-year-chance of being exceeded to those with a 1 in 550 chance of being exceeded. Refer to **Section 3.4.2** to see its application to the operations.

3.1.2 Probable Maximum Flood

By definition, a PMF results from a combination of the most severe meteorological and hydrologic conditions considered reasonably possible in a particular region. The PMF is

a flood derived in accordance with procedures developed by the Federal Government (National Weather Service [NWS], 1999) and accepted by the State of California in its dam safety program as a viable method for developing spillway design floods in the United States. The PMF applied in this analysis was jointly developed by the Corps and Reclamation and is documented in the report *American River Basin, Folsom Dam, Revised PMF* (Corps, 2001). The PMF is used to design a reservoir to keep a dam from overtopping; it is not used as a measure for developing alternatives to provide downstream flood protection. The following scenarios shown in **Table 3-2** were considered during development of the PMF:

TABLE 3-2
AMERICAN RIVER AT FAIR OAKS –
PROBABLE MAXIMUM FLOOD VOLUMES

	Peak (thousand cubic feet)	72-Hour (thousand acre-feet)
No upstream dam failure		
North Fork PMF	906	2810
South Fork PMF #1	896	2805
South Fork PMF #2	889	2805
Upstream dam failures		
North Fork PMF	1183	2935
South Fork PMF #1	1127	3206
South Fork PMF #2	1322	3205

Notes:
1. North Fork PMF - Storm centering over French Meadows Reservoir (with or without failure of LL Anderson Dam).
2. South Fork PMF #1 - Storm centering near Placerville basin (with or without failure of both LL Anderson Dam and Union Valley Dam).
3. South Fork PMF #2 - Storm centering over Union Valley and Ice House Reservoirs (with or without failure of both LL Anderson Dam and Union Valley Dam).

When upstream dam failures are considered, the South Fork PMF #2 scenario (storm centering over Union Valley and Ice House Reservoirs) produces the largest peak and 72-hour volume. The South Fork scenarios include failures of both Union Valley Dam on the South Fork of the American River and L.L Anderson Dam on the Middle Fork of the American River. The dam failure scenarios are considered unlikely to occur. Due to the Federal Energy Regulatory Commission relicensing program, all upstream projects are responsible for safely passing their PMF events and must make the necessary modifications to comply with those requirements. Without any upstream dam failures, the peak and 72-hour volumes are nearly identical for both the North Fork and South Fork storm centerings. The following summarizes the assumptions adopted for this report with regards to the PMF:

- The PMF implemented within this analysis is designed and centered over the North Fork of the American River.
- L.L. Anderson Dam (French Meadows Reservoir, located upstream of Folsom Dam on the Middle Fork of the American River) passes its PMF event, without failure, with the assumption that the existing physical and operational inadequacies would be corrected according to previous studies investigating those issues.

3.2 OPERATIONAL RULES FOR FLOOD CONTROL

Flood control operation of Folsom Dam is governed by two sets of operating criteria: the water control diagram (WCD) and the emergency spillway release diagram (ESRD).

3.2.1 Water Control Diagram

The WCD represents a compilation of regulating criteria, guidelines, guide curves, and specifications that govern the storage and release functions of water resource projects. The diagram indicates pool levels and limiting rates of project releases required during various seasons of the year to meet all functional objectives of a particular project, acting separately or in combination with other projects in a system. The operational rules are expressed in the form of graphs and tables, supplemented by concise specifications, and are used to help determine regulation (release) schedules. The 1986 WCD as presented in the December 1987 Folsom Dam and Lake Water Control Manual and interim WCD for Folsom Dam currently in use are provided as **Plates 3-1 and 3-2a**. Both diagrams maintain a minimum allowable flood control reservation of 400,000 acre-feet; the interim WCD, however, allows for a variable allocation of an additional 270,000 acre-feet of reserved flood control space based on creditable storage available in upstream reservoirs. **Plate 3-2b**, presents further details in the agreement and interim operation of Folsom Dam and Lake as per **Plate 3-2a**.

3.2.2 Emergency Spillway Release Diagram

The ESRD is applied when circumstances require that a gated spillway be used to meet the release requirements. The ESRD transitions normal low outflows to significantly higher outflows gradually so as not to constitute a major hazard to downstream interests. For Folsom Dam, the transition from normal low outflows to significantly higher flows begins at discharges greater than 115,000 cfs. Because Folsom Dam would rely on the induced surcharge capabilities of its gated spillway(s) to control less frequently occurring events, each alternative proposed herein would require that an ESRD be designed and tailored to that alternative's release capabilities. The ESRD approved for current operations is provided as **Plate 3-3**.

Table 3-3 outlines some of the basic assumptions adopted as WCD or ESRD operational criteria. **Plate 3-4** provides a detailed outline of various operational differences between the American River Watershed Projects; Folsom Modifications, Folsom Dam Raise, and the Folsom Dam Joint Federal Project.

TABLE 3-3
WATER CONTROL DIAGRAM AND EMERGENCY SPILLWAY RELEASE DIAGRAM

Condition	Outflow Restriction
Maximum objective release allowed by WCD (larger releases may be initiated by ESRD)	115,000 cfs
Maximum allowable rate of release change Increases: When discharge is greater than 20,000 cfs and less than or equal to 160,000 cfs When discharge is greater than 160,000 cfs Decreases: When discharge is greater than 20,000 cfs	 15,000 cfs/hour Unlimited 5,000 cfs/hour (decrease)
Maximum outflow allowed by WCD or ESRD	Do not exceed maximum inflow experienced during flood event
Release limitation if the actual or forecasted inflow is greater than 25,000 cfs and less than 150,000 cfs and reservoir is less than 20 percent encroached	Limit outflow to 60 percent of the maximum inflow experienced during the flood event
Maximum power available or relied upon for flood operations	Power penstocks would be assumed to have zero release capacity during all routings
Physical limitation of existing emergency tainter gates	Emergency tainter gates are not used until either the total outflow from the dam exceeds 240,000 cfs or the pool elevation is within 1 foot of overtopping the emergency tainter gates while in the closed position
Release requirements (115,000 cfs to 160,000 cfs) based on Accelerated Transition Zone conditions as outlined on the proposed ESRD if current inflow is greater than 200,000 cfs and the 12-hour forecasted inflow is greater than 360,000 cfs if current inflow is greater than 250,000 cfs and the 12-hour forecasted inflow is greater than 370,000 cfs if the current inflow is greater than 270,000 cfs and the 12-hour forecasted inflow is greater than 370,000 cfs	 Increase release to 130,000 cfs Increase release to 145,000 cfs Increase release to 160,000 cfs
KEY: WCD – Water Control Diagram ESRD – Emergency Spillway Release Diagram cfs – cubic feet per second cfs/hour – cubic feet per second per hour (flow rate of change)	

3.2.3 Emergency Spillway Release Diagram Operational Contradictions

Spillway tainter gates are not designed for overtopping. According to EM 1110-2-3600, the maximum normal operating pool is limited to allow 2 feet of freeboard when the gates are closed. Due to downstream considerations, the Corps and Reclamation elevated the

maximum normal operating pool level from elevation 466 to 470 by allowing some use of the surcharge storage space. This minimized downstream impacts for the longest time period possible while lengthening the downstream notification and evacuation period. The vehicle for the operational agreement is the 1986 ESRD. Operation using the 1986 ESRD essentially reduces the design freeboard for the emergency spillway gates from 5 feet to 1 foot when the gates are in the closed position.

Design of the existing ESRD restricts the maximum discharge to 160,000 cfs until the reservoir's pool reaches elevation 470. Once the reservoir water surface exceeds elevation 470, the ESRD allows releases to be increased above the 160,000 cfs limitation. However, releases should not be made through the three emergency tainter gates until discharge in the stilling basin reaches 240,000 cfs to avoid incurring damages. The contradiction in the ESRD is that it does not take into account the physical and operational limitations of the emergency spillway. When the emergency tainter gates are closed, the top of the gates is elevation 471. The routing model can force operation of the emergency tainter gates. The water surface must be within 1 foot of the top of the gates for this to occur. Sufficient tailwater is required to prevent erosion below the emergency spillway chute and adjacent areas. Refer to **Section 3.2.4.4** for additional background on this operational constraint. Although the existing ESRD does not require a discharge of 240,000 cfs until the pool rises above elevation 472, the dam operator can choose to make larger releases sooner. The effect of delaying operation of the emergency tainter gates is that above elevation 471, water would begin to flow over the top; possibly causing damages, failure, or making the tainter gates inoperable.

3.2.4 Reclamation and Corps Variances in Routing Assumptions

During the development of project alternatives and configurations, various differences between Reclamation and Corps routing assumptions were encountered. These differences cause the output generated by Reclamation and the Corps, for the same alternative configuration, to be widely different. The resulting differences impact parameters such as the maximum water surface elevation produced through routing the PMF by as much as several feet. The Corps and Reclamation reached an agreement that Reclamation operating standards and criteria should take precedence due to their jurisdiction over dam safety operations. Per Code of Federal Regulations (CFR) 33 208.11, the project owner (Reclamation) has full responsibility for the safety of the dam/appurtenant facilities and for regulation of the project during surcharge storage utilization. **Attachment C1** includes a summary of the latest routing assumptions above the flood pool and related design criteria developed through on-going discussions between the Corps and Reclamation. The analysis and results provided herein implements the routing assumptions described above in **Table 3-3** and on **Plate 3-4**. At the time of the routings, some of Reclamation's requirements had not have been fully identified. For differences between the assumptions used in the routings and those adopted after subsequent discussions, compare **Table 3-3** and **Plate 3-4** with **Attachment C1**. Future design studies, such as the hydraulic modeling, should facilitate efforts to refine the selected project. The following discussion highlights some of the assumptions that influence the routing results.

3.2.4.1 Maximum Operating Flood Pool

Generally, dam safety operation commences once the reservoir water surface exceeds the authorized flood control space. Storage space extending above and beyond the authorized flood control space is designated as surcharge storage space. The demarcation at Folsom Dam between the authorized flood control space and surcharge storage space is normal full pool (elevation 466 feet). Surcharge capacity is needed to pass the PMF. Levee breaching flows should occur only when the reservoir is within the surcharge storage space. The maximum surcharge water surface coincides with the maximum PMF pool elevation.

For the Joint Federal Project, achieving the flood damage reduction goal requires the use of some of the surcharge storage space. The target elevation within the surcharge storage space is determined by the design flood. Once the reservoir water surface exceeds the specified target elevation, the operation is focused strictly on dam safety. This concept is applied to the routing herein.

3.2.4.2 Rating Curves

The existing main dam spillway rating curves (1997), utilized within the Corps' routing model, were produced by Reclamation based on physical model study results. The Corps' computer program (H3106) was used to generate rating curves for the various alternatives which include modifications to the main and/or emergency tainter gates. A spillway rating curve for the current design was also created. A quick check of the differences indicates that the computer program produces a broader zone of instability than defined in Reclamation's spillway rating table. Refer to **Section 6.4.2.6** for further discussion. The result of this restriction is higher, more conservative pool elevations and reduced flood damage reduction benefits for any particular configuration. All model results reflect orifice (controlled) spillway flow operation. The routing results herein reflect use of Reclamation's rating curves for alternatives with unmodified spillway gates and computer generated ratings for alternatives with modified spillway gates.

3.2.4.3 Computational Time Interval

The computational time interval utilized in the Corps routings is one hour. Release decisions made within the routings are only allowed to look back at information provided one hour prior (i.e., the previous time-step). Reclamation generally agrees with this same standard. There is one exception. In the routing of the fuseplug auxiliary spillway, Reclamation relies on current hour information. This provides similar results as if the operations were handled with a shorter time step (i.e., 15-minute interval). The Corps and Reclamation have discussed the modeling assumptions and the possibility of coincident operation of the main dam tainter gates with operation of the fuseplug. Reclamation's premise is that the operators have the data/tools/ability to enact this operation. In this instance, applying the hour look-back standard would only result in higher, more conservative maximum PMF pool elevations. A shorter time step is appropriate for the fuseplug. Since Reclamation has jurisdictional authority regarding dam safety operations, this exception prevails. All routings provided herein, without a fuseplug feature, use a one-hour look-back window.

3.2.4.4 Required In-channel Flows for Emergency Gate Releases

The Corps and Reclamation have had many discussions regarding the prercquisite tailwater discharge required to initiate operation of the emergency tainter gates. The Corps has documcntation from the 1950s on the structural design analysis of Folsom Dam and its appurtenant works. The flip bucket is to be used only for spillway discharges above 300,000 cfs. It is undetermined if the 300,000+ cfs criterion includes contributions from the emergency spillway. Since the sole purpose for the emergency tainter gates is dam safety, Reclamation has jurisdiction over its prescribed operation. Reclamation maintains that 240,000 cfs is the appropriate threshold for operation of the emergency tainter gates. Therefore, the Corps routings herein incorporate 240,000 cfs as the in-channel flow requirement. This in-channel flow requirement is needed to provide a pool of water at a ccrtain dcpth within the stilling basin, deep enough to dissipate the force exhibited by flows coming down the emergency spillway. Without sufficient "padding" the force of flow discharging through the emergency spillway may damage structures within the stilling basin, potentially causing greater damage to the sidewalls and foundation of the dam.

3.2.4.5 Physical Constraints in Operations

Restrictions in operation are required to avoid jeopardizing the integrity of the dam and its appurtenances during high pool conditions. A constraint incorporated within the Corps' routings avoids pool elevations overtopping main dam tainter gates. Various alternative configurations proposed herein, recommend modifications or cnlargements to either the emcrgency gates or emergency and service gates. Maximum operating pool elevations will change according to the alternative configuration proposed. **Table 3-4** presents the critical clevations corresponding to the gate modification proposed by any particular alternative configuration.

TABLE 3-4
PARAMETERS APPLIED IN MODELING

Configuration	Emergency Tainter Gates (El, feet)		Main Dam Tainter Gates (El, feet)
	Operating Constraint	Top of Closed Gates	Top of Open Gates
No raise No gate modification	470.0	471.0	480.0
No raise With three-gate modification	475.5	476.5	480.0
No raise With eight-gate modification	475.5	476.5	491.5
3.5-foot raise With three -gate modification	479.0	480.0	480.0
3.5 foot raise With eight -gate modification	479.0	480.0	491.5
7.0-foot raise With eight -gate modification	482.5 (bridge replaced)	483.5	497.0
KEY El, feet – Elevation in feet			

Notes:

1. *The parameter assumptions are dependent solely on the dam height configuration and whether or not a given alternative includes modifications to either the three emergency spillway gates or both the emergency and main dam service spillway gates.*
2. *Minimum operating pool requirement based on 1 foot of remaining freeboard when the emergency tainter gates are in the closed position.*

The Corps recognizes that Reclamation's jurisdictional authority takes precedence in the decision to operate the emergency spillway gates once the pool level exceeds the top of flood control pool.

3.2.4.6 Discharge Rate of Increase

A rapid rate of flow increase downstream is of great concern, especially when the discharge is expected to exceed 160,000 cfs (emergency objective release). Emergency evacuations will generally take place while the discharge is held to 160,000 cfs or less. Corps guidance EM 1110-2-1420 clearly indicates that project operation plans should ensure that release rates-of-change should be gradual and not exceed the historical maximum rates of increase. Also, the operations should ensure that the resultant peak discharge is no greater

than peak inflow. The Corps recognizes that Reclamation's jurisdictional authority takes precedence in this decision. At the time of the routings, Reclamation's requirements were unknown. The routings provided herein use an unlimited rate-of-increase once the discharge exceeds 160,000 cfs. The discharge is limited so as not to exceed previous hour inflow. When releases greater than 160,000 cfs are required, any delays will only increase the magnitude of the dam safety release requirement.

3.3 OPERATIONS AND ALTERNATIVE DESCRIPTIONS

Past routings and alternative analyses were performed using the Utah State University's Reservoir Release Forecast Model (RRFM). The current analyses were conducted with a different model. This should be considered when comparing previous results to current output. Also, note that advance release or forecast based operations (FBO) results are not covered in the PAC/EDR reports. FBO is connected to directives to update the Flood Management Plan under the Folsom Modifications authorization. Current efforts do not preclude consideration of FBO.

There are two versions of RRFM. The latest version of RRFM is more robust than the one used during the American River Long-Term Study. RRFM provides the user with a choice between two modes of operation – planning/study mode and real-time operations mode. RRFM is able to generate probabilistic distributions of outflow based on statistically defined inflow parameters for study or planning purposes. It is also able to forecast releases based on hydrometeorological input parameters for day-to-day real-time operations. The primary interface of RRFM is through input windows or screens much like most software packages. Adaptation of the earlier version of RRFM was extensive. However, the challenges and complexities presented in the American River Watershed Projects (i.e., Folsom Modifications and Folsom Dam Raise projects) require a deeper technical interface with software code and scripting and an ability to automate complex and iterative processes. No efforts were made to further adapt the earlier version or to use the latest version for study purposes. Uncertainties with what exactly would be required of the Folsom Dam model, today and in the future, dictated the use of another piece of software. RRFM did not provide the necessary adaptability. It was decided that the flexibility offered by Microsoft Excel - with its Visual Basic for Applications, macros, and spreadsheet functions - provided the flexibility and adaptability that is required to fully explore any potential alternatives and configurations. Thus, the Folsom Dam Operations and Planning Model, developed with Excel, is currently used in all the routing and alternative analyses for the various American River studies.

A comprehensive listing of alternatives for various tainter gate, river outlet, and auxiliary spillway configurations analyzed for this project are provided in **Plate 3-5**. The initial screening of what configurations would move forward was determined from this initial list. The configurations included various combinations of an auxiliary spillway with STGs, conventional tainter gates, and fuseplug. The various gate combinations were analyzed at differing sill elevations. Combinations of modifications to the main dam outlets were also analyzed, and advance release criteria were incorporated into the release decisions. Of the configurations in **Plate 3-5**, this document focuses on the with- and without-project conditions listed below:

- Common Fcatures (modcl run R000_800CF), without-project condition
- No main dam rivcr outlet modification, six-STG auxiliary spillway, no tainter gate replaccment (model run R060_800FM), with-project condition

3.3.1 Existing Operations – Without-Project Conditions

The Folsom Modification Project was first authorized in 1996. As the project has evolved, design changes and refinements have been investigated and incorporatcd into the analysis. For comparative purposes, a summary comparison of key operational differences is provided as **Plate 3-6**.

3.3.1.1 Outlet Efficiency

Prior to the Reclamation and SAFCA *Interim Operations Plan* (2004) shown in **Plates 3-2a** and **3-2b**, releases from Folsom Dam's eight main dam river outlets were limited to 60 percent of their capacity when used in conjunction with the service spillway to prevent cavitation from damaging the face of the dam. The current interim operations agreement, however, allows all gates to be fully opened while the service spillway is in operation. The increased discharge improves the capability of the dam to discharge flood waters at controlled rates downstream from the dam. Mitigation of damages due to cavitation is outlined in the *2004 Interim Operations Plan*. The alternatives proposed herein do not addrcss approaches to remedy this issue; consequently, any with-project condition assumes the eight main dam river outlets are functioning at 60 percent of their capacity.

3.3.1.2 Interim Operation Measures

The water control diagram (WCD) for Folsom Dam was originally designed in 1986 with a seasonally allocated flood control storage space of 400,000 acre-feet (**Plate 3-1**). However, the interim operation agreement between Reclamation and SAFCA was executed in 1994. In that interim operation plan, flood control storage in the reservoir was changed to a variable space allocation ranging from 400,000 acre-feet to 670,000 acre-feet (**Plate 3-2a**), dcpending on the amount of creditable vacant space in three existing upstream reservoirs. In the *Water Resources Development Act of 1996* (WRDA, 1996), Congress directed Reclamation to continue that reoperation indefinitely.

3.3.1.3 Common Features

Section 101(a) (1) of WRDA 1996 authorized construction of features that were common to three candidate plans identified by the Corps, SAFCA, and the State of California Reclamation Board (State Reclamation Board). Those commonalities included the following:

- Levee modification along both banks of the lower American River
- Levee modification along the east bank of the Sacramento River downstream from the Natomas Cross Canal

- Installation of streamflow gages upstream from Folsom Reservoir and modification to a flood warning system along the lower American River

All analyses and routings performed assume complete implementation of Common Features.

3.3.2 Future Operations – With-Project Conditions

This section presents future operations for with-project conditions.

3.3.2.1 Outlet Efficiency

One of the intended benefits of any river outlet modification would be to eliminate damages that occur as discharge is made concurrently through the river outlets and over the service spillway. Main dam river outlets being redesigned would be capable of releasing 100 percent of their capacity. Main dam river outlets that are not modified would still be operated at 60 percent their capacity.

3.3.2.2 Reoperation Measures

Following improvements and project completion, the variable space allocated to flood control within the reservoir would be reduced from the current operating range of 400,000 to 670,000 acre-feet (**Plate 3-2a**) to 400,000 to 600,000 acre-feet, as shown in the proposed flood control diagram (**Plate 3-7**).

3.3.2.3 No Outlet Modifications - Six-Submerged-Tainter-Gate Auxiliary Spillway

This configuration is intended to satisfy the concerns of both dam safety and flood control. In this configuration, the auxiliary spillway sill invert is set at elevation 368. This alternative is intended to pass the unlikely occurrence of the PMF and allow Folsom Dam to release objective flow at lower pool elevations.

The routing model does not require the user to pre-define a gate operation sequence. The routing model only specifies the total discharge requirement throughout each event. By examining this information, one can deduce the best method of splitting or distributing the flow amongst the outlet works and spillway features. The following provides an idea of how the auxiliary spillway might be integrated into the gate operation sequence. Generally, the outlet works would be brought on-line first followed by the auxiliary spillway. Together, the outlets and auxiliary spillway can maintain the normal objective release (115,000 cfs) once the pool reaches elevation 411. While releases of 115,000 cfs are being made, the use of the outlet works and/or auxiliary spillway could be reduced as the main spillway is given control of the discharge. The main spillway could take over fully while a release of 160,000 cfs is maintained. As soon as sufficient tailwater of 240,000 cfs is achieved in the main stilling basin, the emergency spillway gates would be primed for operation.

3.3.2.4 Addition of Surcharge Storage Space

With the increased release capacity at the project, the original maximum surcharge storage space at elevation 475.5 increases to elevation 477.0. Although the updated PMF event presented in the 2002 Long Term Study Final Supplemental Plan Formulation Report (2002 Long Term Study) is substantially larger than the event used for the original sizing of the project, the additional surcharge storage space allows for the updated PMF event to be contained. Given the additional goal of controlling discharge of a specific design event to non-damaging flows, flood control operations might need to extend into the surcharge storage space. The maximum pool elevation attained by routing the desired design event is labeled flood damage reduction (FDR) flood pool in **Figure 3-2**. Thus to attain a desired project performance, an alternative might include appropriation of some of the surcharge storage space for FDR purposes. This would occur if the authorized flood storage reservation was not sufficient in containing the specified design event.

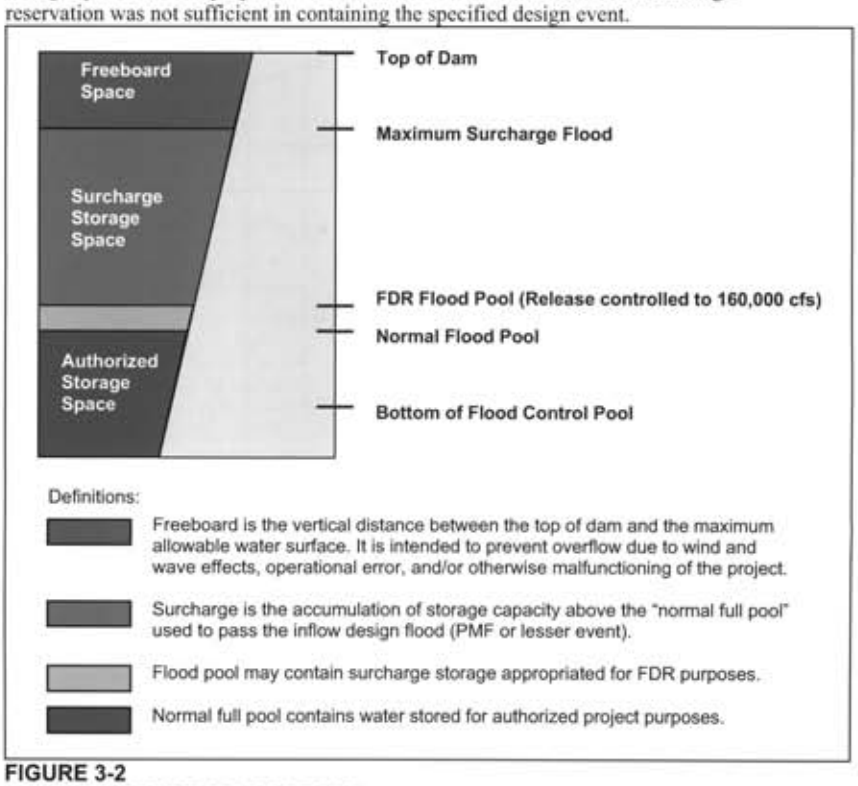


FIGURE 3-2
STORAGE SPACE ALLOCATIONS

Figure 3-2 describes how space is allocated within the reservoir. The authorized storage space remains constant and independent of any modifications to the project. The surcharge storage space is used to contain extreme events within the reservoir. The surcharge space requirement is greatly affected by the inflow design flood volume, the total discharge capacity of the project, and the plan of operation. Freeboard space above the maximum allowable surcharge storage is needed to prevent overtopping mainly by wind or wave action. Refer to **Table 3-5** below for key water surface elevations associated with the various alternatives.

TABLE 3-5
PERTINENT INFORMATION

Alternative	Top of Dam	Maximum Surcharge Flood Pool[1]	Freeboard[3]	FDR Flood Pool[4]	Normal Full Pool	Normal Flood Control Reservation Range[5]
	El, feet	El, feet	El, feet	El, feet	El, feet	El, feet (acre-feet)
Pre-Common Features	480.5	475.5[2]	5	470.0	466.0	425.8 (400,000)
Common Features	480.5	475.5[2]	5	470.0	466.0	425.8 388.3 (400,000 – 670,000)
Folsom Modifications (Joint Federal Project)	480.5	477.5	3	468.0	466.0	425.8 to 399.7 (400,000 – 600,000)
Folsom Raise 3.5 feet	484.0	481.0	3	474.0	466.0	425.8 to 399.7 (400,000 – 600,000)
Folsom Raise 7.0 feet	487.0	484.5	3	477.0	466.0	425.8 to 399.7 (400,000 – 600,000)
KEY El, feet – Elevation in feet						

Notes:

1. *These values reflect the highest allowable pool elevation given both freeboard and top of dam height requirements. The maximum surcharge flood pool is established by routing a PMF through the reservoir. The PMF has been updated or revised periodically (e.g. 1946, 1980, 1991, and 2001).*
2. *The existing project requires more surcharge storage than is available under the original project design. Under the without-project conditions, the 2001 PMF event would overtop Folsom Dam.*
3. *Reclamation has determined that 3 feet provides sufficient freeboard for the with-project alternatives.*
4. *The FDR flood pool is established by routing the single design 1-in-200 chance event through Folsom Dam. The release from Folsom Dam will not exceed 160,000 cfs as long as the water surface remains at or below the FDR flood pool. The antecedent event for the PMF is roughly equivalent in volume to the 1-in-200 chance event and should also be taken into consideration when establishing the FDR flood pool elevation requirement. Optimization using Reclamation standards/criteria is necessary to firmly establish the FDR flood pool.*
5. *The authorized storage space allocation for flood control differs with the alternatives. The flood space requirement itself varies seasonally. The maximum space would be needed only during the most critical flood period (December through February).*

3.4 FLOOD ROUTING RESULTS

This section presents a discussion of PMF routings for various with- and without-project conditions alternatives.

3.4.1 Probable Maximum Flood Routings

Any adopted alternative for Folsom Dam must be capable of controlling a PMF event to a maximum reservoir elevation without encroaching into the prescribed freeboard. For this analysis, some assumptions made in routing the PMF through the Folsom Dam operations and planning model were different from those routings performed in the development of flood damage reduction alternatives. These differences, which are unique to the PMF routings, are described below.

- A reduced efficiency is assumed on discharge through the main dam river outlets. Lower tier outlets are functioning at 50 percent operability and the upper tier outlets at 75 percent. An alternate practice would be to assume non-functioning main dam river outlets.
- The PMF is routed with an antecedent event, which sets the initial starting condition for the PMF. The initial starting storage for the antecedent event is 377,000 acre-feet (bottom of the flood control space). An alternate practice would be to route the PMF alone starting at 977,000 acre-feet (normal full [gross] pool).

The resultant maximum elevations, obtained through routing the PMF through each of the proposed alternatives is provided in **Table 3-6**.

TABLE 3-6
MAXIMUM PROBABLE MAXIMUM FLOOD ELEVATIONS

Alternative[2]	Maximum El, feet	
Without-project Condition	**PMF**	**Top of Dam**
Common Features (model run R000_800CF)	483.1[1]	480.5
With-project Condition		
Six-submerged-tainter-gate auxiliary spillway; no gate replacement; no dam raise (model run R060_800DR)	477.4	480.5
KEY PMF – Proable maximum flood El, feet – Elevation in feet		

Notes:
1. *Alternative does not meet the minimum freeboard space requirement of at least 3 feet.*
2. *An explanation of nomenclature is provided in* ***Plate 3-5****.*

3.4.2 Uncertainty in Operations

Uncertainty considered in this analysis includes attempts to account for estimating relationships such as discharge-frequency, reservoir inflows versus outflow (i.e., unregulated versus regulated flow values), and rating curves. Previous analyses determined this uncertainty using the MONTE™ software package to perform Monte Carlo simulations,

integrating the uncertainty associated with any of these relationships. The current analysis uses the Flood Damage Analysis software developed by the Corps, Hydrologic Engineering Center. The resulting output is a measure of flood risk associated with a particular project configuration.

Uncertainty in hydrology and reservoir operations is described via a band of uncertainty around paired data relationships or ranges of possible values. In hydrology, this uncertainty band is described by the confidence limits around unregulated flow-frequency curves. In reservoir operations, this band resembles a range of maximum and minimum outflow estimates around a reservoir inflow/outflow relationship. This analysis incorporates a reasonable in reservoir operations, determined through various scenarios, to describe the range of uncertainty of the maximum and minimum reservoir releases associated with any given flood event. These risk analysis scenarios reflect the operating conditions ranging from the most likely to occur (base) to the most extreme operating conditions likely to produce the largest (maximum) or smallest (minimum) expected release. The criterion for operation is based on actual flood operations and analysis of historical data, resulting from coordinated effort by representatives of the Corps, SAFCA, and Reclamation. The operating criteria and assumptions associated with each scenario are summarized below in **Table 3-7**.

TABLE 3-7
OPERATING CRITERIA AND ASSUMPTIONS

Factor	Scenario		
	Base (cfs)	Maximum Outflow (cfs)	Minimum Outflow (cfs)
Initial Encroachment (acre-feet)	0	50,000	0
Extra Space in Folsom Lake (acre-feet)	0	0	100,000
Upstream Reservoir Space (acre-feet)	0	0	150,000
Starting Storage (acre-feet)	377,000	427,000	440,000
Initial Delay in Releases (hours)	4	8	0
Main Dam River Outlets Operation During Concurrent Spillway Operation (percent open)	60	0	60
KEY cfs – cubic feet per second			

The following figures (**Figures 3-3** through **3-4**) represent output from the Folsom Dam operations and planning model, as outlined in the operations and alternative descriptions presented in **Section 3.3**. Represented are the inflow/outflow relationships for each alternative configuration. Given a fixed inflow, the uncertainty in operation is shown through the shaded band residing above and below the base outflow. The inflow/outflow relationships for key events are noted by vertical dashed lines.

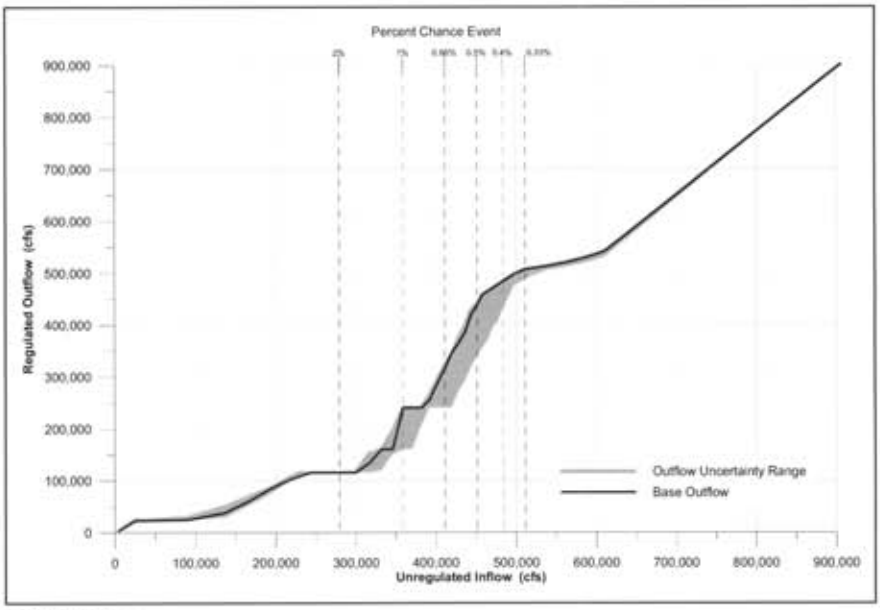


FIGURE 3-3
INFLOW VS. OUTFLOW RELATIONSHIP FOR EXISTING OPERATIONS WITHOUT-PROJECT CONDITION – COMMON FEATURES

Model Run R000_282CF

Water Control Diagram	400/670 SAFCA/Reclamation Interim Operation
Outlet Configuration	2 existing, unmodified outer lower tier outlets 2 existing, modified inner lower tier outlets 4 existing, modified upper tier outlets 2 new modified upper tier outlets
Main Spillway Gates	Unmodified
Emergency Gates	Unmodified
Auxiliary Spillway	None
Dam Raise	None
PMF Peak Elevation	483.1

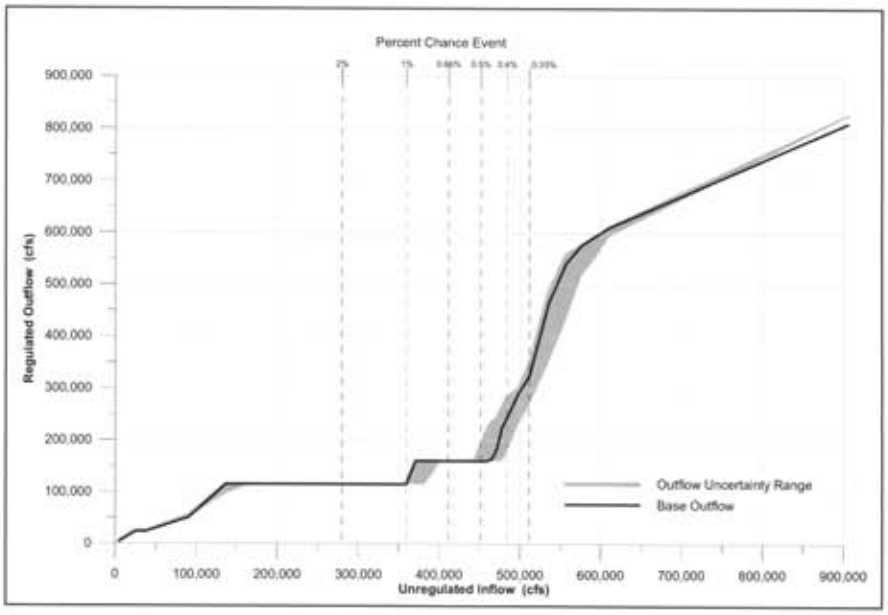


FIGURE 3-4
INFLOW VS. OUTFLOW RELATIONSHIP FOR FUTURE OPERATIONS WITH PROJECT CONDITIONS – JOINT FEDERAL PROJECT

Folsom Dam Joint Federal Project (Model Run R060_800FM)

Water Control Diagram	400/600 Reoperation
Outlet Configuration	Eight existing main dam outlets, unmodified
Main Spillway Gates	Unmodified
Emergency Gates	Unmodified
Auxiliary Spillway	Six-submerged (23- by 33-foot) tainter-gates
Dam Raise	None
PMF Peak Elevation	477.4

CHAPTER 4.0
ENVIRONMENTAL EFFECTS AND MITIGATION FOR JOINT FEDERAL PROJECT

The Joint Federal Project is defined as a six-STG auxiliary spillway. The environmental impacts of this feature are fully analyzed in the *Folsom Dam Safety and Flood Damage Reduction Environmental Impact Statement / Environmental Impact Report (EIS/EIR* (Reclamation, 2006)*)*. This chapter provides a summary of the impacts for the Joint Federal Project by resource category along with proposed mitigation measures to minimize potential impacts to less than significant levels when possible.

4.1 HYDROLOGY, WATER QUALITY, AND GROUNDWATER

Construction of the Joint Federal Project, in itself, would not change the hydrology of the American River nor alter current operations of the reservoir. The proposed modifications to the Folsom Facility could ultimately lead to revisions of Folsom Dam operations that would provide for earlier releases of reservoir water in advance of a major storm (hydrologic event). Construction of this alternative would allow for the release of 115,000 cfs (the existing objective release) sooner than is now possible, with the potential for a maximum release of 160,000 cfs (existing emergency release) reflecting the emergency channel capacity of the American River downstream of Folsom Dam. These larger, earlier releases from Folsom Reservoir would create and conserve flood storage space based on projected reservoir inflows resulting from a major storm impacting the upper American River watershed. However, the proposed modifications would be operated using existing criteria until the completion of the revised water control manual and supporting supplemental environmental compliance documentation. This would be completed one year prior to completion of proposed modifications, at which time the full potential benefits of the proposed modifications would be realized.

Construction of this alternative would not affect local or Central Valley Project water supplies developed at Folsom Reservoir.

4.2 AIR QUALITY

Exhaust emissions from construction equipment and materials hauling trucks, fugitive dust produced by excavators and haul trucks on dirt roads, fugitive dust emissions from materials processing facilities and concrete batch plants would cumulatively produce a significant air quality impact. Nitrogen oxide (NOx) emissions would trigger a general conformity evaluation, from which mitigation measures would be developed to reduce air quality impacts.

4.3 AQUATIC RESOURCES

Construction of this alternative would have less than a significant impact on in-reservoir aquatic resources. The majority of the fish species inhabiting the reservoir are introduced game or prey species, and special status species are not known to inhabit the

immediate vicinity of the project sites. Construction near Dike 6 would have the potential to remove a seasonal wetland. Loss of the wetland would be considered to be significant requiring compensation.

4.4 TERRESTRIAL VEGETATION AND WILDLIFE

Construction of this alternative would have the potential to adversely affect special status plant or animal species and protected oak woodlands, would result in losses of native vegetation, and would result in a permanent loss of project area wetlands. All vegetation impacts would be mitigated to less than significant levels. Construction activities could result in the alteration or loss of habitat for wildlife special status species. Construction activities would result in direct and indirect impacts to a number of elderberry shrubs, which are habitat for the Valley Elderberry Longhorn Beetle (*Desmocerus californicus),* a Federally-listed threatened species that is protected by the Endangered Species Act. These impacts would require compensatory mitigation as per the U.S. Fish and Wildlife Service biological opinion.

4.5 SOILS, MINERALS, AND GEOLOGICAL RESOURCES

Construction activities would result in the loss of topsoil resources. This impact would be mitigated to less than significant levels through the implementation of best management construction practices.

4.6 VISUAL RESOURCES

Construction work on the auxiliary spillway would result in a temporary visual impact to visitors of the Folsom Lake State Recreation Area (SRA). The visual resource impairment is expected to be temporary during construction, and less than significant.

4.7 AGRICULTURAL RESOURCES

This alternative would not impact local or regional agricultural resources.

4.8 TRANSPORTATION AND CIRCULATION

The hauling of materials and supplies to the project sites would not have a significant impact on the level of service for most local roadways except for Scott Road north of White Rock, and East of Natoma Street. This impact would be mitigated as feasible.

4.9 NOISE

Construction equipment, materials processing facilities, and haul trucks will increase noise levels within the project area. During the day time, there would be a perceptible increase in noise for the project area, but due to the distance between sensitive noise receptors and noise sources, the increase would not be considered as significant. However, nighttime noise increase at three residential receptor areas would exceed ambient noise criteria creating an unavoidable adverse impact, should mitigation measures not be effective in reducing noise levels.

4.10 CULTURAL RESOURCES

Since preparation of the previous environmental documentation for outlet modification work, Folsom Dam has become eligible for listing as a historic resource. Prior to construction activities, cultural resources staff would prepare a determination of potential impacts and consult with the State Historic Preservation Office. Cultural resources are known to exist at many locations proposed for staging and facility construction. Cultural resources could be disturbed or destroyed under any of the action alternatives. Cultural resource impacts would be evaluated and mitigated for under a programmatic agreement in consultation with the State Historic Preservation Office.

4.11 LAND USE, PLANNING, AND ZONING

Construction of this alternative would be conducted in compliance with local planning and zone rules.

4.12 RECREATION

Contractor staging would emphasize use of areas with no current public access, away from residential areas. Excess materials would be used to create platforms above the normal operating reservoir water surface at elevation of 466.0 and would be be placed so as to maintain existing or equivalent public recreation access and use capacity during the peak recreation season.

To minimize potential impacts to recreation, staging areas at Beal's Point and Folsom Point would be placed on constructed platforms or on adjacent unimproved areas a safe distance from primary recreational activities. Public safety would be maintained through the use of fencing or other similar measures. There would be nearly continuous public access to recreation areas and trails throughout the construction period through the use of traffic control measures, grade separated vehicular and/or pedestrian crossings, and/or temporary alternate public access detours. Closures could occur while the Partner Agencies are implementing these new measures that allow continued access or to address public safety and facility security objectives. In such cases, temporary closures would be accomplished during off-peak days or the off-season to minimize impacts on recreation activities. Reclamation's Central California Area Office would notify local agencies and the general public and accept input in advance of any possible extended closure(s) that may be necessary due to unforeseen project circumstances.

4.13 UTILITIES

Construction planning and sequencing will be performed so that existing utilities would not be impacted by construction activities. The 42-inch water main would be rerouted to accommodate any auxiliary spillway alternative.

4.14 HYDROPOWER

Construction of this alternative would not impact hydropower operations at Folsom or Nimbus dams.

4.15 POPULATION AND HOUSING

Construction of this alternative would not impact local or regional population or housing.

4.16 PUBLIC HEALTH AND SAFETY

This alternative would include construction planning and implementation elements providing safety considerations for local public and visitors to the SRA.

4.17 INDIAN TRUST ASSETS

There are no Indian Trust Assets within the project area that would be affected by construction activities.

4.18 ENVIRONMENTAL JUSTICE

There are no ethnic or low income groups defined by environmental justice guidance within the project area that would be disproportionately impacted by construction activities.

CHAPTER 5.0
GEOTECHNICAL INVESTIGATIONS AND CONSIDERATIONS

This chapter provides a summary of available engineering geology, and geotechnical information that is pertinent to the proposed Folsom Dam Joint Federal Project. An aerial photographic view of the entire Folsom Reservoir and Dam project area is provided as **Plate 1-2**. A list of references and a corresponding map showing the general location of explorations with regard to this project are provided in **Chapter 8**. Neither the reports nor the data contained within these referenced reports are reproduced herein. Rather, this chapter describes available data, relevant interpretations, and a summary of these findings as they apply to the proposed project elements.

The Joint Federal Project will consist of a six-STG auxiliary spillway as shown on **Plate 2-1**. This plate also shows the proposed Folsom Dam Road realignment project that occurs immediately adjacent and to the south.

The proposed auxiliary spillway and all of its design components are located within a semi-rectangular area beginning at the existing parking area and overlook approximately 3,000 feet east of the dam along the Dam Road, which has been restricted to traffic for the past two years. The western end of the facilities will terminate approximately 600 to 700 feet south of the existing dam stilling basin at the American River. Topographically, this project area begins at approximate upper elevation 525 descending along a gently west-southwest sloping natural ground surface to approximate elevation 115 to 120 at the American River. Although several areas of shallow access road cuts and fills exist throughout this project footprint, the majority of the site consists of annual grass cover and natural ground. One area of deeper fills is present at the west end of the project and a 50-foot high, steep road cut was constructed along the former Dam Road. The parking area was created by placement of deep fill extending into the reservoir. No other significant structures are known to be present in this area.

The following sections describe geologic, seismic, and geotechnical information within the project area along with a summary of those findings. These discussions are followed by a summary of these conditions as they relate to potential design considerations for the auxiliary spillway project.

5.1 SUMMARY OF GEOTECHNICAL INVESTIGATIONS

Geologic and geotechnical data within the project area generally consists of geologic mapping, site-specific geotechnical explorations, and detailed laboratory testing and analyses. This summary describes this information and is followed by a summary of the collective findings. A complete list of geologic and geotechnical references is provided in **Chapter 8**, References.

5.1.1 Geologic Mapping

Regional geologic mapping has been performed by a number of geologists in the region and within the Folsom Reservoir and Dam area that provide crucial geologic unit descriptions and contact locations. Geologic mapping was performed by George Kiersch (Kiersch, 1950) during initial foundation investigations for Folsom Dam and Reservoir. In 1984, Ralph Loyd (Loyd, 1984) performed bedrock mapping of the Folsom Quadrangle at a scale of 1:24,000. A regional geologic compilation of multiple geologic maps was prepared by David Wagner (Wagner, 1981) for the Sacramento 2-degree sheet. As-built foundation excavation mapping was performed (Corps, 1952 and 1954) at the main dam, wing dams, and MIAD. More recently, geologic mapping and rock discontinuity mapping has been performed by Reclamation (Reclamation, 1999 and 2001) and also by Kleinfelder (2006) for the main dam stilling basin scour analysis and auxiliary spillway, respectively. Collectively, these data provide a strong basis for surface interpretation of the nature and extent of surficial and geologic earth units.

The major geologic earth units in the Folsom Reservoir region are shown on **Plate 5-1**. The primary earth unit in the area is the Mesozoic diorite of Rocklin-Penryn Pluton, a late stage igneous intrusion associated with the emplacement of the Sierra Nevada Batholith. The eastern boundary of this pluton occurs between the main dam and MIAD, a little over ½ mile east of the auxiliary spillway project area. East of this contact, northwest striking and steeply dipping foliated Jurassic metamorphic rocks prevail. Tertiary volcanics of the Mehrten Formation cap these two primary bedrock formations forming isolated ridgelines and peaks throughout this area. One such peak occurs within the eastern portion of the auxiliary spillway forming the highest hilltop along the southeast of the proposed inlet and gate structure cuts. Shallow alluvium and fill also form thin veneers over this sequence of units throughout the project area. These geologic mapping efforts are shown collectively on **Plate 5-2**.

Faulting has also been mapped largely on the basis of field geologic mapping and interpretation of aerial photographs. Faults have been mapped in the project area by Kiersch (1950), Wagner (1981), Woodward-Clyde (1983), Loyd (1984), Jennings (1994), URS (2004a), and Reclamation (2004). No active faults are mapped or otherwise known to exist within the immediate vicinity of Folsom Reservoir and Dam. Several faults have been mapped that occur within the auxiliary spillway and main and left wing dam areas but none are suspected to be young enough to be capable of generating design earthquakes. These faults are significant in that they represent potential zones of intense fracturing and persistent discontinuities along which low shear strength exists and thus may influence design considerations. These faults include the channel and subsidiary faults dipping gently to the northwest and outcropping in the main dam and spillway area, the east-west fault mapped beneath the left wing dam, and the penstock faults represented by steeply dipping structures outcropping near the penstocks. These fault locations are shown on **Plate 5-3**.

Surface discontinuity mapping and statistical analyses were also performed (Corps, 2005; Kleinfelder, 2005). These data identified two structural blocks of differing discontinuity orientations and characteristics referred to as the north and south blocks. These blocks are separated by the mapped east-west fault, as shown on **Plate 5-4**. The south

structural block coincides with the entire auxiliary spillway project footprint. A stereonet showing the orientations of these south block discontinuities is provided as **Figure 5-1a**. **Figures 5-1b** shows the results of a preliminary assessment of the Norcal (2005a) televiewer data for the Corps, Phase I explorations, (Corps 2006; Kleinfelder, 2006). These stereonets suggest that discontinuities represented by joints, fractures, faults, and foliation within the auxiliary spillway project area may be generally consistent and represented by the following structural sets in **Table 5-1**.

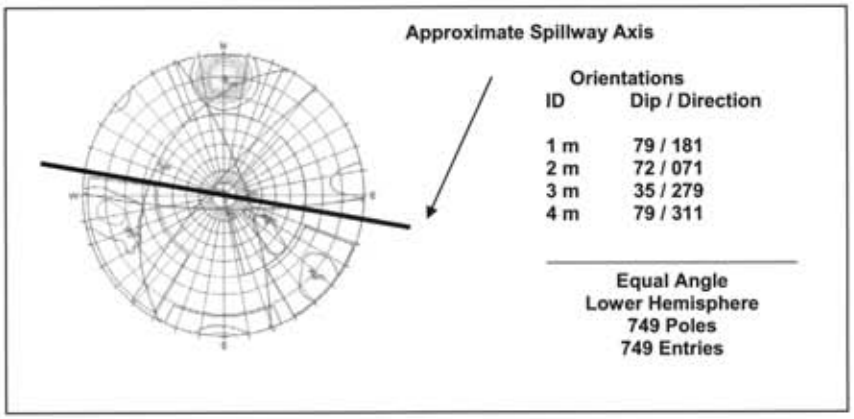


FIGURE 5-1a
CONTOURED POLE PLOT STEREONET SHOWING DISCONTINUITY SETS FOR STRUCTURAL BLOCK II

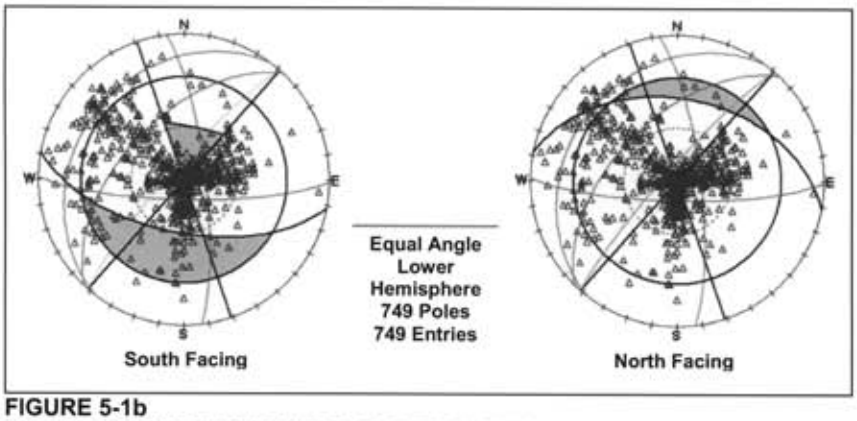


FIGURE 5-1b
MARKLAND EVALUATION FOR SOUTH FACING AND NORTH FACING SLOPES

TABLE 5-1
SOIL AND ROCK PROFILE AND CHARACTERISTICS

Set	Strike	Dip	Relation to Auxiliary Spillway	Comments
1	N89°W	79°SW	Parallel± to spillway, steeply dipping	
2	N7°W	78°NE	Perpendicular± to spillway, steeply dipping	Parallel to Penstock Faults, if present
3	N41°E	82°NW	Subparallel± to spillway, steeply dipping	Parallel to East-West Fault
4	N37°E	25-55°NW	Subparallel±, low angle dip out of southern cut slope	Parallel to channel fault

KEY:
W – West
SW – Southwest
NE – Northeast
E – East
NW – Northwest

5.1.2 Geotechnical Explorations

Geotechnical explorations have been performed in the auxiliary spillway area during the initial foundation investigations (Corps, 1950), overwater explorations at the heel of the main dam (Kleinfelder, 2002), below the main dam (Reclamation, 1999 and 2001), for the alternate Dam Road and bridge alignment (URS, 2005), and jointly for the auxiliary spillway Phase I exploration program (Corps, 2006b,; Reclamation, 2006). Seismic refraction studies were also performed in the auxiliary spillway footprint for the auxiliary spillway and alternative road alignment (Norcal, 2005b; URS, 2005).

These data have been compiled in plan and profile view relative to the proposed auxiliary spillway. Locations of all available borings and refraction lines are shown on **Plate**

5-2. Borings and refraction data have also been captured in GIS (shapefile) format. In general, the auxiliary spillway is underlain by dioritic (i.e. granitic) rock with weathering, hardness, and discontinuity spacing that varies with depth. Zones of discontinuity and rock mass characteristics have been classified into five zones with increasing depth, as described in **Table 5-2**.

TABLE 5-2
SOIL AND ROCK PROFILE AND CHARACTERISTICS

Zone	Name	Description	Weathering Grade	Strength
A	Soil and Fill	Soil and loose rock; Resdiual soil profiles and fills	VI	R0
B	Weak Rock	Highly weathered to decomposed; Highly to intensely fractured	IV – V	R1 – R2
C	Moderate Rock	Slightly to moderately weathered; Slightly to moderately fractured	II – III	R3 – R4
D	Hard Rock	Fresh or unweathered; Slightly to unfractured	I	R5 – R6
E	Mehrten Formation	NC	NC	NC

KEY:
NC – Not classified
Note: All values rock mass rating (RMR) system

Rock mass ratings (RMRs) and geologic strength indices (GSIs) were developed for the zones based upon the available data described above. These values are generally described in **Table 5-3**.

TABLE 5-3
ROCK MASS RATING AND GEOLOGIC STRENGTH INDEX

Zone	Name	RQD Rating	Ground-water Rating	Discontinuity Condition Rating	UCS Rating	RMR	GSI
A	Soil and Fill	NA	NA	NA	NA	NA	NA
B	Weak Rock	7	15	10	1	39	34
C	Moderate Rock	14	15	10	4	50	45
D	Hard Rock	18	15	0	9	59	54
E	Mehrten Formation	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

KEY:
RQD – Rock quality designation
UCS – Unconfined compressive strength
RMR – Rock mass rating
GSI – Geologic strength index
NA – Not applicable

Seismic refraction velocities were developed by Norcal for the auxiliary spillway and for excavations associated with the nearby proposed alternate Dam Road alignment and bridge construction, and are outlined in **Table 5-4**.

TABLE 5-4
SEISMIC REFRACTION VELOCITIES

Zone	Norcal, 2005a	Norcal, 2005b	Weathering Grade
A	V1: 1,100-1,400 fps	V1: 1,200-2,100 fps	VI
B	V2: 2,900-3,700 fps	V2: 2,000-5,000 fps	IV – V
C	V3: 4,800-10,400 fps	V3: 12,600-14,900 fps	II – III
D	Not differentiated	Not differentiated	I
E	Not differentiated	Not differentiated	NC
KEY: fps – feet per second			

Although Norcal was the geophysical consultant for both of these adjacent projects, the three identified velocity layers are not consistent. The velocities for the bridge project to the south of the auxiliary spillway were somewhat lower. Norcal is in the process of reviewing these data utilizing the existing boring information as ground truthing and will revise these velocity profiles accordingly.

Plates 5-5 through **5-7** are geologic profiles and cross-sections of the proposed auxiliary spillway design components relative to these subsurface zones. These subsurface interpretations are prepared on the basis of the available data only and are subject to variation depending upon future subsurface exploration findings.

5.1.3 Geotechnical Testing and Analysis

Extensive geotechnical field and laboratory testing and analysis have been performed on rock samples obtained from explorations outlined above within the auxiliary spillway project area. These studies largely focused on the sliding block stability evaluations for the main dam in the present configuration as well as the revised pool elevation for a proposed reservoir raise project.

Large scale direct shear testing was performed by Anders Bro (Bro, 2004 and 2005), Fuller, Mossbarger (2003), URS (2003a and 2004b), Reclamation (2005). Shear strength estimates using these values and considering the roughness coefficients of rock discontinuities were performed by Greene (2002), Goodman (2005), Quest Structures (2005a and 2005b), and URS (2001a and 2003b). Engineer Research and Development Center (ERDC), formerly known as Waterways Experiment Station (WES) also estimated in-situ geophysical properties in 2005. Concrete strength testing was also performed (Reclamation, 2002, 2005 and 2006). Goodman Jack testing and rock mass modulus estimates were performed by Woodward-Clyde (1983). Stability evaluations utilizing these data were performed by the Corps (1989) and Kleinfelder (2006), and three-dimensional (3-D) block analyses by the Reclamation (2004). Geotechnical foundation design criteria were developed for the alternative Dam Road Bridge by URS (2006) and for the auxiliary spillway project by Kleinfelder (2006).

These laboratory tests and development of parameters were primarily focused on the main dam and foundation materials. In general, these studies developed shear strengths and

rock mass moduli for the concrete, concrete-foundation rock interface, and for the foundation rock.

5.1.4 Ground Motions

Ground motion studies for this project were performed by URS Corporation. Results of the ground motion studies were presented in three reports (URS, 2001b, 2002 and 2003c). The 2001 report developed horizontal ground motions for operating basis earthquake (OBE), maximum design earthquake (MDE), and maximum credible earthquake (MCE). The OBE and the MDE have been defined probabilistically as ground motions having 10 percent and 0.5 percent probability of exceedance in a design life of 50 years, respectively (return periods of 500 and 10,000 years, respectively). The MCE is defined as the 84th percentile motion estimated deterministically from a M6.5 event on the nearby branch of Bear Mountain fault zone (source to site distance of 14 km). The 2002 report presented the seismic design criteria for a seismic event appropriate during the construction period (approximately 7 years) defined as 6.76 percent probability of exceedance in 7 years (return period of approximately 100 years). The 2001 and the 2002 reports provided the recommendations to take vertical ground motions as two-thirds of the horizontal motions at all periods. However, based on some recent research, period-dependent vertical ground motions were provided in the 2003 report.

A summary of the peak horizontal and vertical accelerations in terms of 'g' for different seismic events is provided in **Table 5-5**. **Table 5-6** presents the results of deaggregation in terms of mean and modal magnitude (M) and distances (D) for probabilistic events. These are the controlling magnitudes and distances for each probabilistic seismic event. The mean values are the average of the parameters contributing and the modal values are the most commonly occurring value contributing to the hazard. The MCE is a deterministic event and represents M6.5 at a distance of 14 km. Horizontal and vertical spectral acceleration values at other periods for each seismic event as well as a suite of spectra-matched time histories were also presented in these reports.

TABLE 5-5
SEISMIC DESIGN GROUND MOTIONS

Seismic Event	Probability of Exceedance	Peak Ground Acceleration, PGA (g)	
		Horizontal	Vertical
OBE	10% in 50 years	0.10	0.0704
MDE	0.5% in 50 years	0.28	0.2374
MCE	84th percentile deterministic	0.38	0.3220
Construction Loads	6.76% in 7 years	0.057	0.0401

KEY:
OBE – Operating Basis Earthquake
MDE – Maximum Design Earthquake
MCE – Maximum Credible Earthquake
g – Acceleration due to gravity

TABLE 5-6
DEAGGREGATION RESULTS

Seismic Event	Mean		Modal	
	M	D (km)	M	D (km)
OBE	5.7	41	5.1	14
MDE	5.7	13	5.3	8
Construction Loads	5.7	65	5.3	37.5

KEY:
OBE – Operating Basis Earthquake
MDE – Maximum Design Earthquake
M – Modal magnitude
D – Distance
km – kilometers

5.2 GEOTECHNICAL DESIGN CONSIDERATIONS

The geotechnical design considerations revolve around the proposed design components to construct the auxiliary spillway. These generally include the excavation, suitability of exporting materials to other sites, temporary and long-term stability of excavated slopes, temporary and long-term seepage potential, seismic design, geotechnical foundation design criteria, and scour potential at exposed sections of the auxiliary spillway. The following sections provide a summary of the referenced data relative to these potential design considerations.

5.2.1 Excavation Characteristics

Excavation characteristics at the proposed auxiliary spillway will vary with depth and are generally defined by the fracture spacing and seismic velocity data summarized in **Section 5.2**. These data are summarized in **Table 5-7**.

TABLE 5-7
EXCAVATION CHARACTERISTICS

Zone	Material	Average Velocity	Average Fracture Spacing	Caterpillar Handbook Designation (2001)
A	Soil and Fill	<2,000 fps	NA	Rippable
B	Soft Rock	2,000-5,000 fps	<2 feet	Rippable
C	Moderate Rock	5,000-8,000 fps	2-6.5 feet	Marginally rippable
D	Hard Rock	8,000-12,000 fps	>6.5 feet	Marginally to non-rippable
E	Mehrten Formation	<12,000 fps	Unknown	Marginally rippable

KEY:
fps – feet per second
< – less than
> – greater than

5.2.2 Reuse of Excavated Materials

Potential reuse opportunities for the excavated soil and rock generated from the auxiliary spillway project include the proposed remediation of MIAD and dike raises. MIAD remediation is proposed to involve stripping of the downstream slope and placing an estimated one million cubic yards of shell material. General specifications have not been established but material having an internal angle of friction of 33 degrees was used in the initial analyses with a maximum of 10 percent fines. Although material properties have not been evaluated through extensive laboratory testing of physical properties, it is likely that the rock zones C and D would generate material for reuse in this application but would require processing. The volume of these zones has not been estimated at this time.

Should an embankment raise alternative for the dike raises proceed, they may also represent a source of reuse for the auxiliary spillway excavated materials. Detailed specifications of the material properties for the raised dikes is not available but is generally proposed to consist of a filter and bedding layer beneath the riprap on the waterside slope and the placement of shell material on the downstream slope. This would require the import of shell materials and filter materials. Both materials could likely be produced by processing the zone C and D rock materials from the auxiliary spillway excavation but may not be feasible given the need for transportation across the reservoir.

These material applications are summarized in **Table 5-8**.

TABLE 5-8
EXCAVATED MATERIAL REUSE POTENTIAL

Zone	Material	Shell Material Potential	Filter Material Potential	General Embankment Material Potential
A	Soil and Fill	Poor	Poor	High
B	Soft Rock	Low	Low	High
C	Moderate Rock	Moderate	Moderate	Moderate
D	Hard Rock	High	High	Low
E	Mehrten Formation	Moderate	Moderate	Moderate

5.2.3 Excavated Slope Stability (Temporary and Permanent)

All of the proposed excavations for the approach channel, control structure, chute, and stilling basin are proposed as permanent slopes with the exception of the 1:1 false cut that is proposed for the control structure, leaving the approach channel cut for later excavation to leave a cofferdam plug until the remaining auxiliary spillway construction is complete. **Plates 5-5** through **5-7** show the approach channel, control structure, and chute in profile and cross-sectional view with the interpreted soil and rock zones described above. Markland analyses have been performed based on preliminary rock mass and discontinuity data from Reclamation and Corps auxiliary spillway explorations to date, and initial interpretations of downhole televiewer orientation information. These analyses provided

preliminary conclusions that the cut slopes could be constructed at allowable gradients as outlined in **Table 5-9**.

TABLE 5-9
ALLOWABLE SLOPE GRADIENTS

Zone	Material	Allowable Gradient South-Facing	Allowable Gradient North-Facing	Comments
A	Soil and Fill	28°; 1:2 (v:h)	28°; 1:2 (v:h)	Presently designed at 1:3 (v:h)
B	Soft Rock	28°; 1:2 (v:h)	28°; 1:2 (v:h)	Presently designed at 1:1.5 (v:h)
C	Moderate Rock	53°; 1:0.75 (v:h)	43°; 1:1 (v:h)	Presently designed at 1:0.5 (v:h)
D	Hard Rock	53°; 1:0.75 (v:h)	43°; 1:1 (v:h)	Presently designed at 1:0.5 (v:h)
E	Mehrten Formation	45°; 1:1 (v:h)	45°; 1:1 (v:h)	Presently designed at 1:3 (v:h)

KEY:
v:h – vertical to horizontal
° - degrees

Table 5-9 also shows the present slope geometries proposed for the auxiliary spillway cut slopes. Preliminary slope stability analyses suggest that the deeper portions of cuts could be constructed at a steeper gradient (i.e., 1:0.5 versus 1:1 as proposed) and shallower cuts could also be steepened from 1:3 as proposed to 1:2 with adequate bench design intervals and vegetation. Ongoing studies for the Phase 2 exploration of the auxiliary spillway will provide substantial new data that will allow re-evaluation of rock kinematics and thus allowable slope gradients.

Persistent faults, zones of intense fracturing and/or alteration are known to exist in portions of the auxiliary spillway and, if adversely oriented, may represent a sliding block potential that would be detrimental to the rock cut slope stability and potentially the stability of the adjacent left wing dam embankment. Evaluation of this potential has not been possible given the lack of oriented core data until very recently. If unstable, this would require stabilization methods beyond any rock bolting or stabilization of adversely oriented localized discontinuities described above. Mitigation of sliding block potential would likely require offloading and/or layback that would significantly influence the project design especially on the south side where it is adjacent to the proposed Folsom Dam Road realignment project. The ongoing Phase 2 explorations will also provide valuable data for reconsideration of this potential as well. An allowance has been included in the cost estimate for mitigation of this potential.

5.2.4 Seepage (Temporary and Permanent)

To date, no seepage analyses or evaluation has been performed. Permeability values need to be developed for the soil and rock profile (i.e., zones A-E) described above. As discontinuities will control rock permeability beneath the soil and fill zones, characterization of the aperture, infilling material, orientation, persistence, and spacing of discontinuities will become essential to seepage analysis. The presence of persistent structural features that represent seepage paths perpendicular to the auxiliary spillway and adjacent left wing dam

axes would likely require seepage controls such as grouting and/or placement of filter blankets and/or relief wells to alleviate excessive hydrostatic forces on the proposed rock cut slopes and approach channel, control structure, and chute concrete liner. This potential can be further evaluated as permeability data is developed from pressure/packer testing proposed as part of the Phase 2 auxiliary spillway explorations.

Seepage potential during construction has also not been evaluated based on the absence of data. Seepage beneath the left wing dam and into the auxiliary spillway during construction is a consideration. Of particular concern is the potential for seepage through the proposed cofferdam plug. As shown on **Plate 5-5**, this temporary excavation is proposed at a gradient of 1:1 and would expose rock zones B and C. Again, the permeability of these zones has not been evaluated based on the lack of available data but will be addressed as data becomes available during the Phase 2 auxiliary spillway explorations.

5.2.5 Seismic Design

The design of structures and consideration of seismic stability of permanent slopes will require the application of dynamic loading described previously in **Section 5.2.3** and summarized in **Tables 5-5** and **5-6**.

5.2.6 Geotechnical Foundation Design Criteria

It is assumed likely that lateral loads on the proposed control structure will govern the geotechnical design of foundations. It is also anticipated that drilled shafts will be the most economical system to withstand this loading condition. Therefore, the lateral capacity of the shafts will control the design. Preliminary correlations were performed during evaluation of the Phase 1 exploration data (Kleinfelder, 2006). These correlations suggest that the side shaft resistance available to provide axial or downward capacity is on the order of 2.2 Mega Pascals (MPa). Therefore, using a safety factor of 2.5 to account for unknown construction techniques, the allowable capacity of the shafts in sidewall shear is approximately 1.5 MPa, or approximately 200 pounds per square inch (psi). The lateral loading on the shafts will dictate the shaft tip elevation and can provide either values for input into the computer program LPILE™, or spring constants for structural design. The diameter of the shafts will be required for this additional information. These data and further geotechnical foundation design criteria can be developed based on data provided from the ongoing Phase 2 auxiliary spillway explorations.

5.2.7 Scour Potential

Despite the intent to line the entire auxiliary spillway approach channel, control structure, chute, and stilling basin, preliminary evaluations were performed to assess the potential for leaving portions of the auxiliary spillway exposed where low scour potential may be present. Preliminary analyses were performed using the Annandale (1995) rock scour method based on initial results from the Phase 1 auxiliary spillway exploration data. Rock mass and discontinuity data were converted to the Annandale model parameters to develop Erodibility Indices, as summarized in **Table 5-10**.

TABLE 5-10
ROCK SCOUR POTENTIAL

Zone	Material	Ms	Kb	Kd	Js	K
A	Soil and Fill	2.04	7.05	2.02 (1.92)	0.67	19.5 (18.5)
B	Soft Rock	30	17.3	1.72 (1.55)	0.67	598 (539)
C	Moderate Rock	100	21.6	1.81 (1.51)	0.67	2619 (2185)

KEY:
Ms – Mass strength number
Kb – Particle/block size number
Kd – Discontinuity shear strength number
Js – Relative ground structure number
K – Erodibility Index (mean value; mean minus 1 standard deviation)

These values can be converted to required stream power (RSP) values using the Annandale (1995) empirical relationships and then compared to available stream power (ASP) derived from hydraulic modeling for the auxiliary spillway. If RSP values are found to be significantly higher than ASP values for portions of the auxiliary spillway, further consideration could be given to the frequency and consequence of these flows and whether it would be feasible to leave these portions of the auxiliary spillway unlined. Ongoing Phase 1 explorations for the auxiliary spillway will provide more definitive data and subsequent analyses in this regard.

5.3 CONCLUSIONS

Preliminary geologic, geotechnical, seismic, and hydrogeologic data have been developed that are directly applicable to the auxiliary spillway design. Further data and analysis obtained during the ongoing Phase 2 auxiliary spillway explorations will enhance these data and allow further evaluation of key design considerations. Several critical design considerations have been identified during these previous geotechnical studies, including:

- Cofferdam seepage
- Sliding block stability
- Control structure foundation design
- Long-term seepage

Additional data, updated data characterization models, and analyses relative to each of these and other design considerations will result in better definition of the geotechnical design criteria for the auxiliary spillway and thus improvement of the corresponding design components and estimated costs. As these data and findings are developed, close coordination between the geotechnical engineers and the design team will be essential.

CHAPTER 6.0
FOLSOM DAM JOINT FEDERAL PROJECT ALTERNATIVE

6.1 DESCRIPTION

The Joint Federal Project consists of a proposed auxiliary spillway constructed in the left abutment adjacent to the existing Folsom Dam. The new auxiliary spillway would regulate releases through a concrete gravity control structure with six STGs into a lined spillway chute and stilling basin, discharging directly into the American River. Plan and profile views of the proposed auxiliary spillway are shown in **Plates 6-1** to **6-3**. The design aspects and construction considerations associated with this plan are described in the following sections.

6.2 PERFORMANCE

The Joint Federal Project would provide a flood control level of protection computed at 1 chance in 156. The six-STG auxiliary spillway would provide the capability for Folsom Dam to pass a 200-year design flood event.

The Joint Federal Project, in conjunction with maximum releases from the existing dam, is capable of passing the PMF event.

6.3 COST

The cost estimate prepared for this report is considered a feasibility-level cost estimate. The estimate was developed using Microcomputer-Aided Cost Estimating System (MCACES), backed up with detailed labor, equipment and material cost for each construction item. The estimated first cost for the Joint Federal Project for costs assigned only to flood damage reduction is $683.0 million. See **Attachment C2** for a project cost summary, detailed estimate of first cost and a summary of the MCACES estimate. The effective price level for the estimate is October 2006.

Annual cost was developed based on 50-year life of the project and 4.875 percent interest rate. The estimated annual cost for the Joint Federal Project for costs assigned only to flood damage reduction is $37.9 million. See **Attachment C3** for detail of the annual costs.

Some of the assumptions made in the preparation of the cost estimate are:

- The design of the gates would be similar to the existing tainter gates at Oroville Dam.
- Concrete required for the auxiliary spillway would be batched on site and would be temperature controlled to control the heat of hydration.
- Stripping and excavated material would be hauled 2.25 miles for stockpiling or disposal at Folsom Point and/or site D-2 near the right abutment of MIAD.

- Temporary haul roads 60 feet wide would be developed for the hauling of excavated material.
- All concrete (other than used for construction of the auxiliary spillway), riprap and filter material required would be from commercial sources.
- The weight of reinforcing steel would be based on 150 pounds/cubic yard of concrete.
- All construction would be on Federal land; therefore no real estate cost has been included in the cost of this project.
- The mitigation cost provided by the Corps' Environmental Section will be used for banking buyout.
- A contingency varying between 20 and 38 percent was applied to the various construction features depending on the level of information provided.
- A 3 percent compounded projected inflation factor was added to the contingencies to capture a higher unrealized inflation rate above what is provided in the Civil Works Construction Cost Index System.

6.4 HYDRAULIC DESIGN

This section provides the rationale behind the selection of the types, dimensions, and other pertinent features of the Joint Federal Project. The spillway design flood for Folsom Dam is the PMF. The existing spillway gates cannot pass the PMF without overtopping the Dam. Also, the amount of flood damage reduction storage in the lake is insufficient, partially because the existing sluices through the dam are not large enough to pass significant flood flows during the early part of large floods. The existing sluices can only release a maximum of about 24,800 cfs at the bottom of the flood damage reduction storage space. The downstream channel has an objective or target flood release of 115,000 cfs. Under existing conditions, large flood flows can only be passed with the existing spillway tainter gates (crest elevation 418.0). Therefore, a significant amount of flood damage reduction storage space must be filled with water before the dam can release the downstream target release amount. The Joint Federal Project includes the addition of an auxiliary spillway near the left abutment of the main dam with six 23 feet wide by 33 feet high STGs at invert elevation 368.0. This alternative is effective because it increases the flood damage reduction capabilities at lower levels in the reservoir and allows Folsom Dam to safely pass the PMF without overtopping.

6.4.1 Hydraulic Design Elements and Parameters

The auxiliary spillway would include a converging approach channel, a concrete gravity control structure, a steep rectangular concrete-lined chute, and a stilling basin. The control structure has a vertical upstream face, an intake to each of the tainter gates that incorporate a double elliptical roof curve, a vortex suppressor structure, the submerged tainter gates, and a rectangular concrete conduit to house each of the tainter gates. The control structure design is generally patterned after the existing auxiliary spillway at Oroville Dam. An abrupt rise of 4 feet in the approach channel invert near the upstream end of the

approach channel concrete lining is included in the design to reduce approach velocities and allow for debris to drop out. Upstream of this abrupt rise, a slightly negative slope of -0.010 would be included in the approach channel to discourage debris material from migrating toward the structure.

6.4.1.1 Design Head/Discharge Coefficients

The existing ogee crest and the five existing service spillway tainter gates and three existing emergency spillway tainter gates at the main dam would not be replaced. Therefore, the design head of 50 feet for the ogee crest section would not change. The existing ogee crest was under-designed so as to increase discharge coefficients at the higher pool elevations. The maximum He/Hd that Corps' criterion discusses as being satisfactory is 1.33. High He/Hd ratios have the benefit of high discharge coefficients but also result in negative pressures that can cause significant cavitation damage. The existing spillway crest is at elevation 418.0. The maximum pool elevation during passage of the PMF would be elevation 477.4. This would result in a maximum energy head of 59.4 feet and an He/Hd of 1.19. This is within the maximum crest under-designing criteria for the Corps. Therefore, excessive negative pressures and possible cavitation problems at the higher reservoir pool stages would not be anticipated. If design refinements result in the dam being raised with a corresponding higher maximum pool, the possibility of excessive negative pressures may need to be investigated with a physical model study.

6.4.1.2 Water Surface Profiles

Water surface profiles were computed for the auxiliary spillway approach channel from the reservoir to the control structure, the auxiliary spillway chute from the control structure to the stilling basin, and the American River from the proposed bridge to the existing main dam stilling basin. The WASP2 water surface profile program (Twiss and Sarvary, 1985) was used in computing water surface profiles for the auxiliary spillway. This program was specifically developed for high velocity prismatic channels, and allows the user to rapidly compute profiles and other pertinent hydraulic data, such as Froude numbers, sequent depths, and stream power.

A total width of 169 feet is required at the control structure exit for the auxiliary spillway, including the five piers separating the six 23-foot wide gates. This width was also adopted for the rectangular, concrete chute downstream from the gated control structure. The invert slope from the gate sill station 10+00 (elevation 368), through 23-foot wide by 33-foot high conduits, to station 11+12.37 (elevation 366.87) is 0.010. This relatively mild slope was used through the conduits to decrease the probability of rapid pulsating flow and/or standing waves. Downstream from station 11+12.37, the slope increases to 0.020 down to station 32+00 (elevation 325.12). At station 32+00, the invert profile would begin to transition to a conventional stilling basin. Manning's "n" values of 0.012 and 0.016 were also used for establishing maximum velocities and establishing depths of flow, respectively. The initial flow depth leaving the short conduit housing the gates varied with discharge and was computed by applying Bernoulli's Equation and assuming a minimal head loss from the approach channel to the downstream end of the control structure conduits. The pool elevation required to discharge 90,000 cfs with auxiliary spillway gates full open would be

about elevation 405.1. The flow depth for 90,000 cfs near the downstream end of the conduits would be about 23.5 feet, dropping to about 13.0 feet a short distance downstream of the conduits. For maximum loss conditions, flow depths would vary from 13.0 feet near the upstream end of the chute to about to 9.9 feet at station 32+00. For a discharge of 135,000, the flow depth near the downstream end of the conduits would be about 29 feet, dropping to about 20.0 feet a short distance downstream of the conduits. For maximum loss conditions, flow depths would vary from 20.0 feet near the upstream end of the chute to about 13.7 feet at station 32+00. Beginning at station 32+00, depths would decrease rapidly as the invert slope increases to enter the energy dissipator.

To determine appropriate wall heights, freeboard plus an additional vertical depth to account for possible flow bulking and waves, would need to be added. A conservative nominal chute wall height of 30 feet was selected for cost estimating purposes for this report. Walls would need to be a few feet higher for a short distance downstream of the conduit exits since the conduit height for each of the alternatives is 33 feet and the conduits would be flowing full for the higher discharges. Wall heights would be refined during physical model testing and future studies by considering the waves produced in the model, flow bulking, and geotechnical resistance to any overtopping of the chute walls from waves or other hydraulic instabilities. The goal will be to not only pass the design flow of 90,000 cfs (with freeboard) but also contain enough of the maximum release at PMF pool to prevent catastrophic failure of the chute during passage of the PMF. The "gates full open" discharge through the auxiliary spillway structure at maximum pool elevation 477.4 is 305,600 cfs. For this scenario, the flow depth exiting the conduits would be very near the top of the conduits (33 feet) and decrease to about 26 feet a short distance downstream of the exit of the conduits as the total flow width increases from 138 feet to 169 feet. Flow depths would decrease as flows proceed downstream of the control structure. Water surface profiles were also computed assuming minimum losses. Results of these runs were utilized in designing the stilling basin but are not critical for determining wall heights.

A physical hydraulic model will be used to determine the final design water surface profiles in the approach channel to the auxiliary spillway control structure. A simple Hydrologic Engineering Center – River Analysis System (HEC-RAS) model was developed primarily to assess velocities that might be experienced in the approach channel. Velocities approaching the gates are expected to be about 9 to 11 feet per second (fps) at about 100 feet from the intake based on a simple HEC-RAS model assuming a Manning's "n" value of 0.035 and a contraction loss coefficient of 0.10. These velocities are based on the gates being full open. The approach velocity would accelerate to 30 fps or higher near the intake. A 2-D numerical model of the approach channel will also be performed and results from this model will be used as inputs to in the physical model as well as in the final design.

6.4.1.3 American River Water Surface Profiles

A preliminary HEC-RAS model has been developed for the American River from downstream of the proposed bridge to the main dam stilling basin. New topography was obtained to construct this numerical model. This model was useful in the proposed bridge design, for tailwater considerations in designing the auxiliary spillway stilling basin, and in analyzing the energy dissipation and the adequacy of the existing main dam spillway stilling

basin. Preliminary results show that the tailwater rating curve for the main dam stilling basin that was used in the original design is in general agreement with the new computations. A physical hydraulic model will be used during final design for assisting in the determination of water surface profiles and tailwater rating curves.

6.4.1.4 Stage-Discharge Relationships

The discharge rating curve (pool stage versus discharge) for the Joint Federal Project auxiliary spillway was patterned after the Oroville Dam service spillway and adjusted for the number and widths of the gates. The Oroville Dam structure has eight 17-feet 7-inch wide by 33-feet high tainter gates with a maximum head on the gates of about 90 feet. Reclamation performed model tests to determine the discharge ratings for the Oroville Dam structure. The STGs for the Joint Federal Project are of similar type and size, and would pass discharges in the same head range. The maximum pool elevation of 477.4 would be 93 feet above the centerline of the gates. Since the Folsom Dam design is almost identical to the Oroville Dam service spillway (except for the number and width of gates), the Oroville Dam discharge ratings were used for the Folsom Dam auxiliary spillway discharge ratings after adjustments were made for invert elevation, number of gates, and area of gates. Model studies will be used to confirm and/or develop more accurate discharge ratings. The rectangular openings that house the STGs would continue a short distance before flows would exit to a supercritical concrete channel for open channel flow. The minimum distance is governed by structural considerations. Stage versus discharge relationships for the proposed auxiliary spillway with the gates fully opened are shown in **Table 6-1**.

TABLE 6-1
POOL ELEVATION VERSUS DISCHARGE FOR AUXILIARY SPILLWAY

Pool Elevation (feet)	Q cfs	Pool Elevation (feet)	Q cfs	Pool Elevation (feet)	Q cfs
368	0	410	111,800	455	255,000
370	1,545	415	133,900	460	266,600
375	6,410	420	153,300	465	277,700
380	14,130	425	170,700	470	287,900
385	24,850	430	187,300	475	298,000
390	39,240	435	202,400	477.4	305,600
395	53,950	440	216,500	480	310,600
400	70,630	445	230,100	480.5	311,500
405	88,850	450	242,800	484.5	319,400

KEY:
Q - Pool Elevation versus Discharge
cfs – cubic feet per section

Notes:
1. *Invert Elevation of all gates is 368.0*
2. *Six 23-foot by 33-foot submerged-tainter-gates*

6.4.1.5 Head Losses

Manning's "n" values of 0.012 and 0.016 were used for establishing maximum velocities (maximum energy dissipation required) and depths of flow (maximum chute wall heights required), respectively. These "n" values were checked against recommended roughness heights (Ks) of 0.002 and 0.007 for concrete flood control channels in Engineering Manual (EM) 1110-2-1601 (Corps, 1994) and were found to be reasonably consistent with that guidance. Manning's "n" values of 0.035 and 0.050 were used for rock cut areas for minimum losses and maximum losses, respectively. Geotechnical and construction engineers will be consulted as studies progress to obtain more accurate estimates of the hydraulic roughness heights to be expected from the rock excavation so that the range of "n" values can be reduced. Form losses for expansions, contractions, piers, roof and side curves, invert offsets, etc. will also occur as flows are passed. A contraction loss coefficient of 0.1 was used for the approach channel contraction. An expansion head loss coefficient of 0.3 was used to account for expansions in the concrete chute downstream of the control structure.

6.4.1.6 Design Discharge Capacities and Velocities

The control structure for the auxiliary spillway was designed for discharges up to 305,600 cfs (see **Table 6-1**). Average velocities through the gates and conduits with the gates fully open will be as high as 67 fps at maximum pool elevation 477.4. Velocities in the approach channel vary greatly from about 50 fps at the upstream end of the conduit roof curves to 2 fps or less at the upstream end of the approach channel. The maximum velocity at the upstream end of the proposed concrete lining in the approach channel is expected to be about 15 fps. Hydraulic model tests and further geotechnical data will be used to confirm the velocities that will be experienced and assess whether or not the extent of the concrete (or other lining) can be reduced or needs to be increased.

The downstream channel has an objective or target flood release of 115,000 cfs. Therefore, a design discharge of 90,000 cfs (combined with 25,000 cfs from the main dam outlets) was selected for the concrete lined chute and stilling basin. However, there are a myriad of discharges and combinations of greater discharges that the chute and stilling basin could be exposed to during the project life. Upon completion of the Joint Federal Project project and the Common Features Project, the auxiliary spillway would probably become the first choice (after the existing sluices) for flood releases. An auxiliary spillway release of 135,000 cfs concurrent with a release of 25,000 cfs from the main dam sluices could be made without failure of the upgraded levees on the American River. The chute wall heights would be designed to provide full Corps and Reclamation freeboard requirements for the 90,000 cfs water surface profile plus an allowance for waves. In addition to the 135,000 cfs mentioned above, another scenario to be considered in the final design process is the maximum discharge of 305,600 cfs that could occur under PMF conditions. One solution would be to design the top of chute walls to contain 305,600 cfs without considering waves and freeboard. This will be investigated in more detail as the design proceeds. The stilling basin should function satisfactorily with increasing damage as flows exceed design discharge.

6.4.2 Design Considerations/Conditions Effecting Design Capacity/Operations

6.4.2.1 Vortices

Vortices can affect intake efficiency and possibly create a debris and safety hazard. The intensity of the vortex is a function of the submergence of the intake, the discharge, and the intake and approach channel geometry. **Plate 6-4** indicates that planned operation of the auxiliary spillway design presented in this report could result in vortices problems. For this reason, a vortex suppressor similar to the structure at Theodore Roosevelt Dam has been incorporated into the design. This structure comprises a set of beams placed above the intake opening that disrupt vortices. Model tests of the Oroville Dam auxiliary spillway structure (after which the Folsom Dam auxiliary spillway is patterned) showed that when a near vertical wall above the inlet for the gates was used, a vortex suppressor was not needed. Physical hydraulic model tests of the selected alternative will be used to determine whether a vortex suppressor is needed and if so, the type of modifications needed for the proposed suppressor.

6.4.2.2 Cavitation

Cavitation is the successive formation and collapse of vapor pockets in low-pressure areas associated with high-velocity flow. It results from the sudden reduction of the local pressure at any point to the vapor pressure of water. The collapse of the pockets sets up high-pressure shock waves that cause damage to the nearby boundary. Cavitation often causes severe damage to steel or concrete and it can occur at the conduit entrance, downstream from gate slots, in the conduit downstream from the gates, and anywhere that high velocity flows tend to separate from the flow boundary and the piezometric head approaches the vapor pressure of water. Reclamation performed an applicable study on reducing cavitation potential for the main dam sluices and spillway.

The auxiliary spillway control structure described in this report is very similar to that constructed for Oroville Dam. However, the Folsom Dam auxiliary spillway intake "roof" curves are designed to be double elliptical curves instead of the simple ellipse used for the "roof" curve for Oroville Dam. The double elliptical curves will be designed in accordance with the Corps' EM 1110-2-1602. The model study for the Oroville Dam spillway describes approach velocities slightly less than would occur at the higher pool elevations being proposed at Folsom Dam. For a discharge of 277,000 cfs through the Oroville Dam spillway (1,969 cfs per foot of gate), pressures as low as -31.7 feet were recorded at the upper corner of the outside conduit intakes. Pressures below -20 feet typically indicate a strong possibility of cavitation. The unit discharge for the Folsom Dam Joint Federal Project for the design discharge of 90,000 cfs would be 652 cfs per foot of gate but the unit discharge for the (gates full open) maximum pool condition would be about 2,210 cfs per foot of gate. Therefore, the potential exists for cavitation, especially at the higher pool elevations. Although some cavitation would be acceptable at the higher pool elevations, the design goal will be to decrease the potential for cavitation to the extent practical. Potential for cavitation will be investigated in more detail as the design process proceeds. Physical hydraulic model tests will be used to investigate cavitation potential, and modifications made as needed to

eliminate and/or minimize cavitation. An extension of the piers separating the gates and eliminating the curvature on the outside walls may also be helpful in minimizing the potential for cavitation and tested in the model.

Other areas of the Joint Federal Project auxiliary spillway where cavitation problems could potentially occur include the area where the gate structure becomes an exit chute, offsets at joints (either as constructed or developing after construction), imperfections in the concrete finish, abrasion damage from mineral or other debris, damage to the concrete due to vandalism, transitions both laterally in the chute side walls and the invert, and the approach to and within the energy dissipater at the downstream end of the chute. To the extent practical, these potential cavitation areas will also be investigated with model tests. Elimination of and/or minimization of cavitation potential for most of these areas can best be addressed by a conservative and clear design and specifications of transitions, offsets, and construction tolerances, etc., succeeded by detailed, thorough, and firm inspections with rigid enforcement to minimize departures from specifications. Specifications, instructions to field personnel, and the operations manual also would need to be clear regarding construction developments that would present potential cavitation problems, and the maintenance procedures to be performed to minimize potential cavitation. At locations where the invert slope changes significantly, a large radius circular curve or a parabolic invert transition, assuming velocities at least 25 percent higher than maximum design velocities, would be incorporated into the design to provide positive pressures on the invert.

6.4.2.3 Gate Vibration

The auxiliary spillway control structure is very similar to the gated structure at Oroville Dam. Although no significant vibration problems have been reported at Oroville Dam, the gates at Oroville Dam haven't experienced hydraulic heads near the maximum design heads. Due to the higher heads that the Folsom Gates will be subject to, consideration will be given to flow induced vibrations. Therefore, the design will incorporate features such as the use of hydraulic lifting cylinders to dampen vibrations and insure dynamic stability.

6.4.2.4 Eyebrow Deflectors

Eyebrow deflectors were installed for each of the existing Folsom Dam river outlet sluices to help prevent cavitation damage at the exit portals during concurrent sluice and spillway discharges. However, previous model studies by Isbester indicated that the existing conduits should not be operated above 60 percent gate opening when spillway flows are occurring. The Folsom Modification Project plan included model tests to determine improved eyebrows that would allow lifting the restriction of 60 percent. However, the Joint Federal Project would make the benefit of lifting the 60 percent restriction negligible, so the plan for the Joint Federal Project does not include modifying eyebrows for the existing sluices.

6.4.2.5 Sequencing of Discharge Facilities During Flood-Control Operations

Balanced gate operations that result in uniform discharges across the width of the stilling basin are of major importance. This will minimize the formation of re-circulating

currents, which can draw abrasive material into the stilling basin. Also, when the reservoir is high enough, releases may be made over the spillway through the tainter gates for the main dam, thus conserving the cold-water pool. Optimum sequencing of discharges from the main dam's sluices, service tainter gates, and emergency gates with the proposed auxiliary spillway discharges can impact the tailwater versus hydraulic jump depths and have a positive impact on energy dissipation and downstream erosion for the main dam and auxiliary stilling basins.

6.4.2.6 Limitations of Gate Operation for the Existing Tainter Gates

There are existing problems and complexities in operating the service and emergency tainter gates at Folsom Dam. The emergency gates should not be opened until a total flow of 300,000 cfs is being released into the American River. The top of the existing emergency gates in the closed position is at elevation 471; therefore, dam operators need to begin opening the emergency gates at pool elevation 470. Because the service gates would already be open, the emergency gates would need to be raised at least 10 feet as rapidly as possible so that a wave coming around the pier between the service gate and emergency gate would not impact the service gate trunion. Operation of the service gates is also complex and sensitive because the service gates must be raised to follow the pool elevation once the pool comes to within about two feet of the top of gate.

Another problem in operation of the existing tainter gates is that they should not be operated in the transitional zone from orifice flow (partial gate opening) to full open and should not be lowered to go from full open (gates out of the water) to orifice flow operation. The Corps computer program H3106 computes partial gate open discharge rating curves for tainter gates, indicates when the transitional zone is entered, and states that "gate control uncertain – avoid operation at above pool and gate opening" for a particular calculated discharge based on gate opening and pool elevation/head. Reclamation also has noted this transitional zone. Model reports (including Report R-99-08 for Folsom modeling performed in 1997) describe the transition zone to be where model data is inconsistent with both the gated-discharge rating and the free-flow rating, revealing a zone of instability where control can shift rapidly between two regimes. Measurements of discharge and pool elevation vary widely in this transition zone.

Results from Reclamation's physical model study showed general agreement with the Corps program. Model study Report R-94-04 (model of Vallecito Dam) describes the condition also, with a better relationship to the H3106 output. The report describes discharge uncertainty under conditions of small head to gate opening ratios. The report mentions that the region where h/d is less than about 2.2 is very difficult to evaluate. The coefficient of discharge varies widely between h/d values of 1 (crest/weir control) and 2.2 (orifice control). The report also indicates that one study (Boss, 1989) recommended orifice type flow should not be used for "water measurement" below h/d ratios less than two. The report recognizes that h/d ratios less that two are unavoidable with radial gates. The Corps program establishes the limit where gate control is uncertain as about h/d of 1.6-1.7. Any h/d value below this will indicate the message mentioned above.

The addition of the Joint Federal Project auxiliary spillway simplifies the above problems, however, significant operational challenges and limitations would still exist since the existing service spillway and emergency gates are not being replaced under the Joint Federal Project alternative.

6.4.3 Energy Dissipation Features – Auxiliary Spillway – Stilling Basin

A stilling basin dissipates energy of flows from the main dam outlet works and the service spillway. Five of the eight spillway bays discharge into the main stilling basin and the remaining three emergency spillway bays discharge over a flip bucket. The stilling basin for Folsom Dam acts as a hydraulic jump basin when flows are discharged from the main spillway service gates. Flows from the emergency flip bucket spillway act very differently. The emergency gates should be the last discharge gates to open because considerable damage downstream of the flip bucket will be experienced which will probably draw rocks back into the main dam stilling basin and possibly result in geotechnical failures, resulting in considerable damage. Existing operational rules that require total releases of 300,000 cfs before the emergency gates are opened will remain in place but the addition of the proposed auxiliary spillway ensures that the rule can be met even if there are physical or operational problems with the existing tainter gates.

Because of relatively high Froude numbers ranging up to about 10, the stilling basin was patterned after the Type II basin, as described in Reclamation's *Hydraulic Design of Stilling Basins and Energy Dissipators*, Engineering Monograph No. 25 (**Figure 6-1**). A design discharge of 90,000 cfs, concurrent with 25,000 cfs from the main dam sluices, was selected for the auxiliary spillway chute and stilling basin. The structures must function (without excessive damage) for the maximum discharges that can be released. The tailwater elevation for 115,000 cfs in the American River at the auxiliary stilling basin exit would be about elevation 181. The design included transitioning the invert of the chute from station 32+00 (elevation 325.12) to the stilling basin floor with a long parabolic drop to ensure positive pressures. The chute width includes a 1:30 expansion (169 feet to 222.33 feet) from station 32+00 to the stilling basin (station 40+00). An expansion loss coefficient of 0.3 was used to account for transition losses. Manning's "n" values of 0.012 for concrete and 0.035 for rock excavation were selected for energy dissipation considerations. The flow depth (for Q = 90,000 cfs) entering the stilling basin would be about 3.65 feet with a velocity of about 111 fps. The Froude number entering the basin would be approximately 10.2. The sequent depth would be 51 feet, which would require wall heights of about 53 feet and a stilling basin length of about 204 feet. However, consideration was given to the likelihood of discharges up to 135,000 cfs concurrent with 25,000 cfs from the main dam sluices being part of the flood reduction package and the length and wall heights in this report are reflective of that scenario. This would require wall heights of 66 feet and a basin length of 280 feet (about four times the sequent depth). The basin floor was set at elevation 130.2. Energy dissipation is optimal for the design discharge with the D2 for 90,000 cfs and the tailwater elevation for 115,000 cfs in the American River matching. However, the basin dimensions set for this report use the more conservative auxiliary spillway discharge of 135,000 cfs concurrent with 25,000 cfs from the main dam sluices. The "height of the tailwater over the end sill" versus the sequent depth for higher discharges (up to the gates full open discharge at maximum

pool) indicates that adequate energy dissipation should occur at the maximum discharges. However, the stilling basin walls would be overtopped and damage to the stilling basin would be expected at auxiliary spillway discharges exceeding 135,000 cfs. Further analyses and physical model studies will be utilized to optimize the stilling basin length and other dimensions.

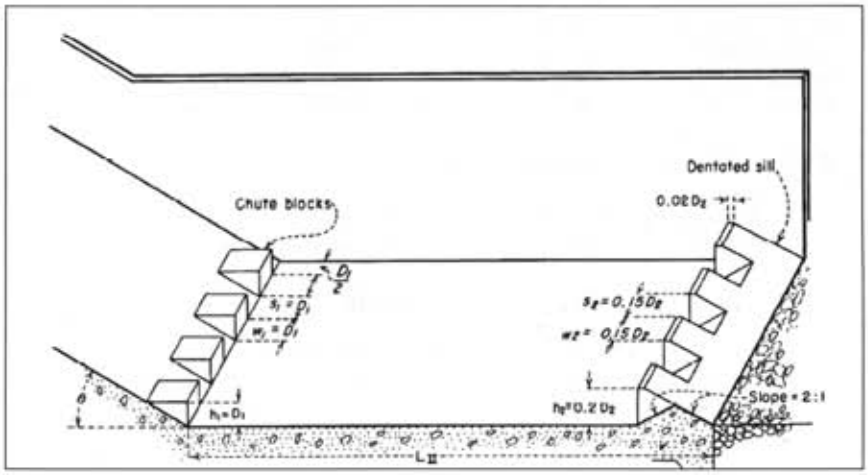


FIGURE 6-1
TYPE II STILLING BASIN

6.4.4 Erosion Control Requirements

The erosion potential of flows exiting the auxiliary spillway and sequencing of combined flows from service/auxiliary/emergency spillways need to be considered and minimized as practical. Physical model tests will serve as an aid to assess erosion potential, problems, and solutions.

6.4.5 Model Studies

A 2-D numerical model will be developed for the approach to the Joint Federal Project auxiliary spillway to determine hydraulic parameters and characteristics that can be used for design purposes and for modifying approach conditions to the auxiliary spillway physical model. A 1:30 physical hydraulic model of the auxiliary spillway approach channel, the control structure, and about 800 feet of the chute downstream of the control structure will be performed. This is required to develop discharge rating curves and to assess and identify and/or find solutions for vorticies, cavitation, debris, erosive velocities and turbulence, excessive waves, gate vibrations, etc. A 1:17 +/- model of the main dam spillway may be deemed necessary to better define the transition zone from part gate operation to full gate openings to minimize some of the complexities and restrictions in operation of the tainter

gates. A 1:40 +/- physical hydraulic model of the American River from the proposed bridge vicinity to the main dam stilling basin (including the lower end of the auxiliary spillway chute and stilling basin) will also be part of the detail design studies. This is required to evaluate and modify the design of the auxiliary spillway stilling basin, confirm and/or develop tailwater rating curves for both the auxiliary and main dam stilling basins and develop recommended sequencing of discharge from the main dam sluices, service tainter gates, and emergency tainter gates, and the auxiliary spillway. This would allow optimization of the auxiliary spillway stilling basin dimensions and energy dissipation at both stilling basins, minimize the abrasion and cavitation damage to the stilling basins, and minimize erosion of the bed and banks downstream in the American River floodway.

6.4.6 Prototype Testing and Monitoring

Although prototype testing and instrumentation requirements will be part of the detailed design package, these will be developed in later design stages.

6.5 CIVIL DESIGN AND INFRASTRUCTURE

The Joint Federal Project includes a six-STG auxiliary spillway. The tops of all existing dams and dikes would remain elevation 480.5 under the Joint Federal Project.

6.5.1 Roads

The JFP does not include a dam raise component so most of the access roads and recreational facilities around the reservoir are not affected by the project. The Folsom Point Recreation Area, however, and its access road would require some public health and safety measures such as fencing and traffic separation for this site to be used as a staging area and as a potential disposal site for excavation material from the auxiliary spillway construction.

6.5.1.1 Auxiliary Spillway Access Road

The Folsom Bridge project (separate project performed under the Folsom Dam Raise authorization) would include an access road extending from the new road alignment to the existing Folsom Dam Road in the vicinity of the existing Folsom Dam Overlook area to provide access to the left wing dam and the area at the toe of the left wing dam. The auxiliary spillway project would include an access road across the top of the new spillway structure and would connect to the new bridge access road. Because of the proximity of the auxiliary spillway control structure to the bridge road alignment, the access road is likely to be bench-cut into the slope of the spillway inlet channel, merging into the cut of the bridge access road. This road must accommodate semi-trucks with oversized loads.

6.5.1.2 Access Turnout to Relocated Natomas Pipeline

A portion of the Natomas pipeline would be situated between the auxiliary spillway channel and the new Folsom Bridge Road between stations 52+00 and 55+00 of the road. The Folsom Bridge Road in this area is on an embankment. Need for access to the pipeline

would be infrequent and normally limited to City of Folsom employees but could be accommodated by providing a turnout and shoulder turn lane on the north side of Folsom Bridge Road near station 55+00. This turnout or shoulder turn lane should be accessible to westbound traffic only.

6.5.1.3 Access Road to Left Wing Dam Toe and Stilling Basin

Part of the existing access road from Folsom Dam Road to the Corps resident office and the toe of the main concrete dam would have to be realigned because of the presence of the auxiliary spillway control structure and chute alignment and the Folsom Bridge Road embankment. For the eastern portion of the access road, the new alignment would be located nearer the toe of the left wing dam, connecting to the resident office access road. For access to the toe of the main concrete dam and the stilling basin, the new alignment would extend from the resident office vicinity to the beginning of the existing concrete pavement, about 700 feet downstream from the dam. New portions of the road would be paved with asphalt-concrete.

6.5.1.4 Powerhouse Access Road

Armoring the existing powerhouse access road may be necessary to prevent erosion of the embankment caused by discharges from the auxiliary spillway. Hydraulic model studies and geotechnical site investigations may be needed to determine the extent of any armoring. The road that may be in jeopardy is approximately 400 feet long.

6.5.1.5 Folsom Point Recreation Area Access Road

Access to Folsom Point recreation facilities is provided by a paved two-lane road crossing over the reservoir divide east of the Dike 8 left abutment. An area adjacent to Folsom Point is a potential staging site and/or a potential material disposal site for material from the auxiliary spillway excavation. Access to Folsom Point would be maintained for the duration of the auxiliary spillway and dam safety projects but some modifications involving fencing and traffic separation would be required for public health and safety.

6.5.1.6 Folsom Bridge Road

The Folsom Bridge Road would serve to replace access across Folsom Dam via the existing Folsom Dam Road with a new bridge that crosses the American River approximately 1,500 feet downstream from Folsom Dam. The road would be constructed on a new alignment from Folsom-Auburn Road to the Folsom Dam Overlook and reconstructed/widened along the existing road alignment from the overlook to East Natomas Street, a total distance of approximately 2 miles. The road is being designed as a four-lane road with an asphalt-concrete surface.

The proposed alignment for the new Folsom Bridge Road interferes with a portion of the existing access road to the stilling basin. The Bridge project would maintain access to the stilling basin by constructing a temporary graveled alignment alongside the toe of the fill for the new Folsom Bridge Road. A permanent alignment would be provided as part of the

auxiliary spillway contract. This alignment would be located between the new auxiliary spillway chute and the left wing dam.

The proposed Folsom Bridge Road alignment does not directly interfere with the auxiliary spillway control structure (invert at elevation of 368) or the spillway chute or terminal structure, although the hillside excavation for the road in the vicinity of the control structure partially coincides with the excavation required for the auxiliary spillway.

6.5.2 Utility Relocations

Several utilities would be impacted by construction of the proposed Joint Federal Project alternative. Specifically, the Natomas Pipeline, a raw water pipeline, would need to be relocated. The realigned pipeline section would need to be installed prior to any outage and a very short-term water supply interruption coordinated with all downstream water users while the new pipeline section is put into service. Additionally, a number of power lines and telephone lines would require relocation as would some of the utilities servicing the Corps resident office building. Each of these potential relocations is discussed below.

6.5.2.1 Existing Natomas Pipeline

Reclamation operates and maintains the existing aboveground raw water pipeline (Natomas Pipeline) that provides water from Folsom Reservoir to the City of Folsom and California Department of Corrections water treatment plants, and water for the Corps resident office fire protection system. The pipeline is 42 inches in diameter, and is approximately 2,800 feet long from where the pipeline exits the dam at Adit 4 to the Folsom standpipe. The aboveground raw water pipeline is made of American Water Works Association C200 welded steel with a coal tar enamel interior lining. The chute alignment for the auxiliary spillway would cross a portion of the aboveground raw water pipeline. Approximately 600 feet of the existing Natomas pipeline would be relocated in kind as an aboveground pipeline. It would extend from an existing anchor block on the dam side of the chute to an anchor block on the far side of the chute. A new steel pipeline bridge, 180 feet long, would be constructed to span the auxiliary spillway chute to support the 42-inch pipeline. The pipe relocation would be constructed, and then cut into the pipeline at each of the anchor blocks, limiting the disruption of water supply to the amount of time needed to make the change over at the anchor blocks. The chute would be excavated beneath the relocated pipeline after its completion. In addition, the 8-inch-diameter fire protection pipeline and the metering station that services the Corps resident office would need to be relocated. The City of Folsom has stated that it can only accept outage for a few hours; therefore, all new pipeline features must be in place and ready prior to disrupting service. The changeover would be conducted at each end of the pipeline simultaneously. Alternative measures will be considered during the design phase to minimize downtime.

6.5.2.2 Future Redundant Pipeline

The cities of Roseville and Folsom and the San Juan Water District need a reliable, redundant system supplying raw water from Folsom Dam. Currently, water purveyors, the

Corps, and Reclamation are evaluating a range of conceptual alternatives for meeting the purveyors' water needs.

Only one of the conceptual alternatives under study for the pipeline would have an impact on the proposed auxiliary spillway design: a required pipeline intake structure and provision in the auxiliary spillway approach channel for a pipeline intake. While the impact would be minor, the alternative would require connecting an 84-inch-diameter inlet pipe to the proposed auxiliary spillway side approach channel. All engineering design and construction costs associated with this alternative would be the responsibility of the water purveyors.

6.5.2.3 Power Lines

The dam's left abutment area is crisscrossed by several aerial power lines, all of which would require either partial or complete realignment.

The Corps resident office receives power from the Sacramento Municipal Utility District (SMUD) for a 12-kilovolt (kV) service that was formerly an abandoned 115 kV Pacific Gas and Electric Company (PG&E) power line. Five wood poles and approximately 1,500 feet of conductor would require relocation if the office building remains in use during the spillway construction. If the building is relocated, the power line would be decommissioned.

The 4,160-volt power line that serves Reclamation's yard on the right abutment would require relocation of seven poles and approximately 2,000 feet of conductor.

SMUD's 230 kV high voltage power line would require partial relocation. The existing trussed towers would be replaced by three steel poles. The extent of the relocation would be a distance of approximately 2,000 feet.

6.5.2.4 Telephone Lines

Telephone and Internet needs for the Corps resident office are served by AT&T. The actual alignment has yet to be determined. An alignment is being studied that would avoid relocation if the office building remains in use following the completion of the new Folsom Bridge Road.

A telephone line services a Reclamation station located near the City of Folsom's standpipe, and is routed on the 4,160-volt power poles. Two telephone poles would need to be relocated in addition to the power poles and about 500 feet of wire.

6.5.2.5 Corps Resident Office Utilities

The proposed auxiliary spillway chute alignment would necessitate relocation of some of the utilities servicing the Corps resident office building if the office building remains in use following the completion of the new Folsom Bridge Road. These utilities include the 8-inch-diameter fire protection pipeline connected to the 42-inch-diameter Natomas Pipeline, a mounded leach field, and the power and communication lines noted in the preceding

paragraphs. The fire protection pipeline relocation work would include a valved connection to the 42-inch-diameter pipeline, a metering station, shut-off valve, and approximately 200 feet of below-grade 8-inch-diameter pipe. The mounded leach field is about 7,500 square feet in area and would be relocated to another site adjacent to the existing septic tank.

6.6 STRUCTURAL AND MECHANICAL DESIGN

This section addresses structural features and components of the Folsom Dam Joint Federal Project, namely a new six-STG auxiliary spillway. Details of the steel gate structures, including the STGs, bulkhead gates, and related operating machinery are also described. The project design team recognizes that differences exist in routing criteria and analysis methods among the project stakeholders. Therefore, it has been agreed upon that routings will be conducted based on the criteria of the agency, which has jurisdiction; however, the design of new structural components should accommodate the most stringent criteria.

The auxiliary spillway is the major new structural component of the proposed alternative and consists of a concrete gravity control structure housing six STGs, a rectangular chute downstream from the new control structure, and a concrete-lined stilling basin for energy dissipation. Due to time constraints, and to be consistent with the objectives of the Joint Federal Project, the structural engineering effort focuses on "worst-case" loading for the most critical structures. Accordingly, the concrete auxiliary spillway was analyzed for the MCE, and other structures were sized conservatively, based on the experience of the design team. The MCE is a deterministically defined (Corps) event that can be described as a moment magnitude (M) 6.5 on the East Branch of the Bear Mountain fault zone, at a distance of 14 kilometers from the site, with a peak horizontal ground acceleration of 0.38 g (84^{th} percentile MCE).

The following paragraphs provide details of the structural components of the featured alternative. **Plate 2-1** contains an overview of Folsom Dam.

6.6.1 Auxiliary Spillway

Plan and profile views of the proposed auxiliary spillway are shown in **Plates 6-1** to **6-3**. The following sections discuss the structural components of the auxiliary spillway.

6.6.1.1 Auxiliary Spillway Control Structure

The auxiliary spillway control structure was site-adapted from DWR's Oroville Dam flood control structure (DWR, 1965) primarily to provide enhanced flood control and hydrologic risk reduction, and to safely pass the PMF event. The Oroville Dam flood control structure is a reinforced concrete gravity structure socketed into the sound rock of its site. It provides eight STGs, 17 feet, 7 inches wide, by 33.08 feet high, to control flood releases in two 94.33-foot-wide concrete monoliths.

Site adaptations from the existing control structure at Oroville Dam include using 59 foot wide independent concrete monoliths, each containing two submerged tainter gates

similar in height to those at Oroville (**Plates 6-5** to **6-7**) but widened to 23 feet. A variety of gate sizes and invert elevations were investigated with the three-monolith, six-gate configuration at invert elevation 368.0, approximately 10 feet lower than the equivalent Oroville spillway, providing the best project function at least cost. The concrete section for the control structure was deepened to add a grout drain gallery near the upstream face of the monoliths, and the bottom was sloped 8 degrees up in the downstream direction. These changes were made to allow for less competent rock at Folsom, as compared to Oroville. The grout/drain gallery (**Plate 6-7**) would provide capability for split spaced grouting in the grout curtain with increased grout pressures after the concrete structure is in place to provide confinement. The gallery also would provide access for post-construction monitoring and maintaining drains to reduce uplift (reduce risk of structure instability) and for access to address any problems encountered after completion of construction.

The invert slab would be reinforced in its top surface to control cracking and to improve its performance as a high-velocity water passage. The piers and breast wall would be adequately reinforced to carry water and seismic loads. The piers were extended upstream and vortex beaming was added similar to that developed in model testing for Theodore Roosevelt Dam modifications. Continuous reinforced concrete trunnion beams would be used to address problems experienced with the partial trunnion beaming used at Oroville. Continuous beaming also reduces pier flexure, a concern with the thin piers normally desired for hydraulic efficiency. In addition, continuous concrete beaming would be used with hydraulic cylinders to control gate opening. These cylinders provide positive closure force, dampen any flow-induced vibrations, and improve control relative to the cable lifts used at Oroville.

Steel bulkhead gates and concrete shear walls will be provided for each gate as a means of preventing damage to the STGs. The bulkhead gates, each with its own hoist, are anticipated to remain in place while the submerged tainter gates are closed allowing the water between the gates to be pumped out. Removing the contained water eliminates the medium for transferring loads from the bulkheads to the submerged tainter gates. The concrete shear walls would be cast in place panels spanning each spillway bay directly over the operating equipment and trunnion beams to prevent damage that could leave the gates inoperable.

Flanking non-overflow concrete monoliths would be trapezoidal in shape. This shape was investigated for use with the Auburn and Marysville projects and found to provide stability and strength for seismic loads while avoiding stress concentrations at the heel and curvature points found with conventional concrete sections.

6.6.1.2 Auxiliary Spillway Control Structure Stability and Stress Analysis

Preliminary two-dimensional (2-D) and three-dimensional (3-D) stability and stress analyses were performed for the through-flow monoliths of the auxiliary spillway control structure. Analyses were completed progressively, beginning with 2-D conventional static calculations and building up to nonlinear 2-D and 3-D computer models using SAP2000. For this range of analyses, static and seismic load cases were considered (in the upstream-downstream and vertical directions). Both pseudostatic and time history analyses were performed on the seismic computer models.

Two basic loading conditions were evaluated:

- Usual load condition, which represents the normal operating pool
- Extreme load conditions, which represent the PMF pool or an earthquake during normal operating conditions

The details of the structure were simplified for the analyses. The vortex breaker, trunnion beams, trunnion anchorage, and attached structural features were omitted for simplicity. Potential shear keys at the base of the structural and between adjacent monoliths, which have been assumed for cost purposes, were not included in these preliminary analyses.

The overall stability of the monoliths was considered, for both sliding and rotation, and compared to Corps guidance. Maximum stress was computed in the piers to determine if the preliminary widths were adequate. In addition, Reclamation performed a separate 3-D analysis of the entire dam (considering cross-canyon loadings as well) to evaluate stress. The results from both agencies' analyses showed that the geometry of the structure is adequate.

Conventional Stability Analyses

The required factor of safety for sliding, and the limit on resultant location, were taken from Engineering Circular (EC) 1110-2-6058 (Corps, 2003); the selected factors of safety are applicable to both critical and normal structures. Per EC 1110-2-6058, the required sliding factor of safety used in the analysis was 2.0 for the usual load condition and 1.1 for both extreme loading conditions. The limits on the location of the resultant were 100 percent of the base in compression for the normal operating condition, and the resultant within the base for extreme loading conditions.

Material properties and strength parameters used for the analyses were conservatively estimated until further explorations of the foundation materials are completed. For the sliding analysis, the internal shear angle used for the rock was 45 degrees, and the cohesion value was assumed to be zero. The weight of the concrete was assumed to be 155 pounds per cubic foot, considering the weight of the concrete in the existing dam and the fact that a similar mix design would be specified.

The weight of the control structure was calculated for a 59-foot concrete monolith, which included a prestressed concrete bridge with 6-inch slab, vortex breaker, tainter gate, shear wall covering the gate and lifting equipment, and the applicable mass of water on the invert. The total weight of the structure also accounted for voids attributable to the 8-foot by 8-foot grout gallery through the invert and the 2-foot-diameter air vent through the breastwall. The base of the invert also was sloped at 8 degrees from horizontal to increase the structure's resistance to sliding.

For normal operating conditions, a headwater elevation of 466.0 was used. Tailwater was not considered for uplift or resisting hydrostatic force calculations because the gates will be closed during normal operating conditions and a drainage system exists under the chute slab that begins at the toe of the concrete control structure. The uplift pressures along the base were reduced by placing a drainage gallery and foundation drains approximately 12 feet from the upstream face of the control structure, and the effectiveness of the drainage system

was taken as 50 percent. In addition, flow to the drains would be controlled by a grout curtain. It also was taken into consideration that while sustaining a pool elevation 466.0, the bulkheads would be in place and the tainter gates would be in the lowered position with water between the bulkhead and tainter gate removed. This preliminary operation plan was intended to safeguard the STGs against any potential damage. Subsequently, only the mass of the water on the invert upstream of the bulkhead could be used for stability. To accommodate these details, and for the structure to remain stable, it was necessary to increase the amount of mass concrete in the breastwall. The PMF condition was evaluated using a headwater elevation of 484.0, and tailwater to the top sill of the outlets. For this condition, all gates would be open and the mass of water flowing over the invert could be used for stability calculations. As with normal operating conditions, uplift pressures along the base were reduced by using a drainage gallery and foundation drains with 50 percent effectiveness, and a grout curtain to control flow to the drains.

The pseudostatic analysis, or the seismic coefficient method, was used for preliminary seismic evaluation. This analysis considered the MCE and the normal operating pool. In addition to hydrostatic forces from the reservoir's normal pool, an inertia force due to the horizontal acceleration of the dam, and hydrodynamic forces resulting from the reaction of the reservoir water against the dam, was considered. Inertia forces were calculated using the determined weight of the structure multiplied by a seismic coefficient. The seismic coefficient was determined by taking two thirds of the peak horizontal ground acceleration (PGA) for Folsom Dam, given in a 2001 report by URS titled *Probabilistic and Deterministic Seismic Hazard Analyses, Folsom Dam*. The PGA selected from this analysis was 0.38 g. Hydrodynamic forces were calculated using Westergaard's parabolic approximation, given in EM 1110-2-2200 (Corps, 1995). The seismic coefficient method was used only to determine the resultant location and sliding stability. In strong seismic areas, a stress analysis should be performed to determine the magnitude and distribution of stresses throughout the structure under static and dynamic load conditions.

The State of California Division of Safety of Dams (DSOD) provided an independent check on sliding stability and magnitude and distribution of stresses for the control structure used in the PASS II project. The control structure in PASS II had 49 foot independent monoliths and the same invert elevation. The analyses concluded the structure was stable for both the sliding and linear stress check. These independent checks verified the validity of using the 2-D stability analyses, mentioned above, for preliminary sizing of alternatives incorporating similar designs.

Corps Computer Models

Static Analyses

In SAP2000, a 3-D fixed-base model of the monolith and a 2-D dam-foundation model were built and used for a pseudostatic analysis of the MCE case only. Upstream-downstream motion was considered. The 3-D model was run linearly, but the 2-D model was nonlinear because nonlinear friction isolator links were used to connect the dam to the foundation. These links have no tensile capacity; that is, they "break" if they experience tension and the model redistributes the base pressure until results converge. Using these links, the final step of the model more accurately depicts the percent base in compression and, in turn, affects the stress distribution near the heel.

These models differ from the conventional analyses in that vertical acceleration was included and the coincident pool (446 ft), as determined by EM 1110-2-2100 (Corps, 2005), was used. In addition, the full PGA was applied to the model. Stability and stress results were obtained from these models, following the guidance of EM 1110-2-2200 (Corps, 1995). See tables below for results.

Dynamic Analyses

The 2-D dam-foundation model was used to perform nonlinear time history analyses for the MCE case - using the Imperial Valley, San Fernando, and Chalfant seismic events for the site-specific PGA of 0.38g (horizontal) and 0.25g (vertical). Upstream-downstream and vertical motion were considered. For comparison purposes, another version of the 2-D dam-foundation model was analyzed without the links.

Following EM 1110-2-6050 (Corps, 1999) and EM 1110-2-6051 (Corps, 2003), stability and stress results are evaluated differently for dynamic analyses. For stability, the total duration of instability (rotational or sliding) and permanent displacement are quantified, rather than factors of safety. Strict guidelines for acceptable values are not presented; rather, engineering judgment is used to determine adequacy. For stress, the severity and duration of stress excursions (instances of principal stress greater than allowable tensile strength of concrete) are considered in determining structural adequacy.

The stability and stress results, which are summarized in the tables below, were adequate. No stress excursions were determined, and stability results were reasonable. The maximum principal stresses occurred in the heel of the piers. Since the addition of tainter gate anchorage to the model would increase the stresses in the vicinity of the anchorage point, this will be considered in subsequent analyses and design.

Reclamation Computer Models

As part of a risk analysis (Reclamation, 2006a and 2006b), Reclamation created a 3-D model of the entire auxiliary spillway and control structure, using the software LS-DYNA. A nonlinear time history analysis was performed for the San Salvador event with pool elevation of 466. Upstream-downstream, vertical, and cross-canyon motion were considered. The

PGA values for this 140,000 to 625,000 year event are approximately -0.9g to 0.6g (upstream-downstream), - ±0.5g (vertical), and ±0.3g (cross-canyon).

The results of this modeling effort are worth noting for comparison purposes. Maximum stress occurred in the heel of the piers, at values up to 0.4ksi for upstream-downstream motion, similar to but higher than the time history analysis results generated by Corps models for the MCE at coincident pool. Sliding stability generally appears adequate.

Results

The results of the Corps analyses, both conventional and SAP2000 computer models, are displayed in **Tables 6-1** through **6-3** below. Results are tabulated differently for pseudostatic analyses versus dynamic analyses, following Corps guidance, and this is reflected in the results tables. Since the conventional 2-D analysis did not explore stress, this model is omitted from the stress results table. Similarly, the 2-D dam-foundation model with no links was not considered for sliding stability and is thus omitted from the table.

While updates and refinements to the structure and, subsequently, the model, remain, these preliminary analyses indicate that the structure will meet both Corps and Reclamation design criteria for stability and stress.

TABLE 6-1
SLIDING STABILITY RESULTS

model description	seismic method	Total Duration of Sliding Instability (s)			Sliding FS	Permanent Displacement
		Chalfant	Imperial	San Fernando		
Conv., 2D	pseudostatic				1.29	
3D	pseudostatic				1.74	
2D	pseudostatic				1.67	
2D	time history	0	0	0		0.02"

TABLE 6-2
ROTATIONAL STABILITY RESULTS

model description	seismic method	Total Duration of Rotational Instability (s)			% Base in Compression
		Chalfant	Imperial	San Fernando	
Conv., 2D	pseudostatic				92%
3D	pseudostatic				89%
2D	pseudostatic				75%
2D	time history	0.15	0.15	0.05	
no links, 2D	time history	0.25	0.35	0.10	

TABLE 6-3
STRESS RESULTS

model description	seismic method	Principal Stresses (ksi)		controlling event
		SMAX	SMIN	
3D	pseudostatic	0.438	-0.389	
2D	pseudostatic	0.023	-0.134	
2D	time history	0.200	-0.377	San Fernando
no links, 2D	time history	0.115	-0.199	Imperial Valley

6.6.1.3 Proposed Auxiliary Spillway Chute and Energy Dissipater

A reinforced concrete, rectangular chute would be used, similar to that at Oroville Dam (**Plate 6-8**). It would have a 5-foot thick reinforced concrete slab anchored to the rock with 20- to 30-foot long No. 11 reinforcing dowels at 10-foot centers. Under-drain pipes sloping down to the sides similar to those used at Oroville would be provided to reduce uplift forces on the slab. Drain pipes would be provided in pervious backfill on the outside of the walls to carry away water from the drains beneath the dam and additional water from the ladder drains. These pipes would be sized to facilitate inspection and maintenance with appropriate access provided. An average wall height of 30 feet was used for the cost estimate; actual wall height would be determined from physical and numerical hydraulic modeling results, and would vary along the length of the chute. Wall thickness and reinforcing were based on the Oroville flood control outlet and experience with walls of similar height for other projects.

6.6.1.4 Concrete-Lined Stilling Basin

A section through the concrete-lined stilling basin is shown in **Plate 6-9**. The wall and slab thickness, anchorage pattern, and reinforcing were based on the Folsom Dam stilling basin walls and experience with walls of similar height for other projects. The 222.33-foot width of the stilling basin was determined from Reclamation's Type II stilling basin and an average wall height of 66 feet over a length of 280 feet was determined from preliminary hydraulic modeling. The stilling basin design is considered to be adequate for energy dissipation; however, it will be overtopped during high release events. The stilling basin dimensions used in this estimate will be optimized once physical modeling has been completed.

6.6.2 Auxiliary Spillway Tainter Gates and Operating System

The auxiliary spillway would feature six STGs similar in design to the gates used at Oroville Dam, which features eight STGs 33 feet tall and 17 feet 7 inches wide. The proposed auxiliary spillway tainter gates would be 33 feet tall and 23 feet wide. The STGs would be operated by means of hydraulic cylinders, similar to those used at Winfield Dam, Corps' Huntington District, as opposed to a traditional gear driven chain or cable type hoist mechanism, as is currently used at Folsom and Oroville Dams. The hydraulic cylinders

would be mounted above the gates and would pivot about their centerpoint. The cylinders would have a bore of approximately 18 inches, a rod diameter of approximately 7 inches, a stroke of approximately 29.5 feet, and would take approximately 20 minutes to open.

Another concept that was investigated was the use of bottom-mounted cylinders, similar to those used at Table Rock Dam, Corps' Little Rock District. This approach was rejected when it was determined that it would necessitate an additional 3 to 4 feet in pier thickness (resulting in an unacceptable 15 to 20 additional feet of spillway width).

Each of the 12 cylinders would have its own dedicated hydraulic power unit (HPU). The HPUs would feature a 40 horsepower (hp) motor, a 25-gallon-per-minute (gpm) pump, and a 300-gallon reservoir. The cylinders will be oversized so that only one will be required to operate a gate. The gate design will feature a roller assembly, which will prevent binding of the gate in the event of a hydraulic cylinder failure.

An additional benefit of the hydraulic cylinder hoist system will be its ability to provide sufficient damping to overcome any flow induced vibration, which is considered to be a potential problem on tainter gates which operate under such high heads. As an added precaution, a computer model study will be performed Dr. Noriaki Ishii of the Osaka Electro-Communication University to check the dynamic stability of the design.

Similar to the main dam spillway gates, consideration will be given to the use of self-lubricated composite trunnion bearings. Regardless of which type of trunnion materials are used, an auto lube system will be provided. It is anticipated that the size of the trunnions will be somewhat smaller than that used on the existing tainter gates. The forensic report of the tainter gate failure of 1995 determined that the large diameter of the existing trunnions was a contributing factor to the gate failure because the trunnion binding forces were transferred to the endframe. Most tainter gates at other facilities utilize much smaller trunnions than were used at Folsom. A notable example is Theodore Roosevelt Dam, which actually had a trunion bearing seize and rotate in place rather than fail the endframe.

At the present time, it is intended, for security reasons, that each tainter gate would be protected by a dedicated bulkhead gate weighing approximately 40 tons. A traditional gear driven cable hoist mechanism, similar to the existing chain hoist mechanisms used on the existing tainter gates, would be used for raising the bulkhead gates. The hoist would consist of a 7 1/2 hp, 1150 revolutions per minute (rpm) motor which would connect to a 50:1 worm gear speed reducer (Falk Model 1700 Omnibox) by means of a 1 inch Wrapflex elastomer coupling. The twin 2.5 inch output shafts of the Omnibox speed reducer would each connect to a 105:1 parallel shaft triple reduction speed reducer (Falk Model 465) by means of a gear coupling and a 6 to 8 foot long connecting shaft. The 7 ½ inch output shafts of the parallel shaft speed reducers would each connect to a cable drum by means of a 7 ½ inch gear coupling. Each cable drum would also be supported by a 4-inch diameter pillow block bearing. The cable drums would be 14 inch diameter (for a lifting speed of approx 0.9 feet per minute [ft/min]) and would each have two 1-inch cables. The system would be designed so that each of the two cable pairs can support 60 percent (approximately 80,000 pounds) of the gate weight. The lifting speed would be predicated on the fact that the bulkheads would be operated on a seasonal basis rather than each time the tainter gates are operated. The hoist

assembly would also feature an electric solenoid operated braking device, as well as an automated positive dogging mechanism, which would be used to hold the bulkheads in the open position.

All mechanical systems on the new spillway would incorporate redundant features. The hoist mechanism for the new spillway tainter gates would utilize two hydraulic cylinders per gate. Either of the cylinders would be capable of operating the gate by itself in the event that the other cylinder fails. A dedicated HPU will be provided for each cylinder. Adjacent HPUs would be interconnected for redundancy. In addition, a portable HPU unit would be provided as a backup. The hoist mechanisms for the bulkhead gates would include a total of seven motors for the six gates. The system would be designed so that each gate hoist can be coupled to one of two motors (similar to the system used for the tainter gate hoists at the existing spillway).

The proposed auxiliary spillway design would utilize permanent hoist mechanisms for operating the tainter gates and bulkhead gates, and a mobile crane could be used to perform routine maintenance. Therefore, no permanent crane would be necessary for this design. However, as previously noted, a less costly alternative may be investigated that would necessitate the addition of a permanent crane.

The O&M requirements will consist of an annual inspection of the STG hydraulic cylinders and operating system, trunnions, lubrication system, seals, and the bulkhead gate hoist system. Major rehabilitation of the tainter gates and bulkhead gates will take place on a 25 year cycle.

6.7 ELECTRICAL DESIGN

This chapter addresses electrical changes at Folsom Dam associated with the addition of a six-STG auxiliary spillway. Topics addressed include electrical power distribution, backup power, and redundant systems.

6.7.1 Electrical Power Distribution

Existing power distribution overhead conductors, feeding from 4160-volt switchboard "UHA" in the Western Area Power Administration (WAPA) switchyard, would have to be upgraded to carry its current electrical load and the added load of the new auxiliary spillway (per Bob Beingessner of Reclamation). This 4160-volt feeder is called "Dam East Abutment" and crosses over the river several hundred yards down stream of the dam.

6.7.2 New Power Distribution System

The proposed new power distribution system is specifically designed for reliability with emergency on-site generation. These features would provide a reliable, fault-tolerant, and easily maintained system.[1]

6.7.2.1 Power Supply

A new single-ended substation would be located at the new spillway. This substation would be fed from the existing switchyard breaker "Dam East Abutment" via the upgraded 4160-volt overhead pole line crossing the river. The switchyard is connected to the Folsom Powerplant, Nimbus Dam generators, and transmission grid. Consequently, several primary power sources exist for the 5 kV switchgear, and therefore for the new substation. The reused breaker in the 5 kV switchgear would be fully reconditioned (and upgraded if necessary); no other work is anticipated on the 5 kV switchgear. However, these improvements are contingent on results of a load study and evaluation being performed by Reclamation.

6.7.2.2 Substation

The single-ended substation will be fitted with a 4160-volt (delta connected) to 480-volt (resistance-grounded wye-connected) 300 kilovolt-ampere (kVA) transformer. The transformer would be of epoxy cast coil construction for maximum reliability. They would be designed for an 80-degrees-centigrade (°C) rise above a 30°C average ambient (40°C maximum ambient) temperature.[2] The single-ended substation would be fully sized at 600 amps. All systems within the auxiliary spillway would be able to start and run at the same time without overloading the system.

6.7.2.3 480-Volt Distribution

The 480-volt power would be distributed from the substation to a 600-amp automatic transfer switch (ATS). The ATS would supply a local 600-amp motor control center (MCC) switchboard providing power to the local systems.

6.7.3 Emergency Electrical Power

Emergency electrical power would be provided from the existing emergency generator building on the Folsom project site. An additional provision for portable generator plug-in will be provided at the auxiliary spillway.

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[1] Distributed redundancy is discussed in Redundancy Provides the Key to Data Center Reliability, CEE News, September 2000.

[2] The Connected Load is ~1,425-kVA (April 2002), including the assumed future upsizing of the spillway gate motors from 5-horsepower to 10-horsepower. The estimated Minimum Coincident Demand Load is ~450-kVA with two HPUs, two spillway gates, the sump pumps, one penstock hoist, the elevator running and all non-motor loads on line at 0.8 Load Factor.

6.7.4 Existing Emergency Electrical Power System

The existing 480-volt emergency power system (generator building project) is designed in accordance with National Fire Protection Association (NFPA) 110, for a Level 1 system. It would supply emergency power for the entire spillway. The system includes two existing 500-kilowatt (kW) (625 kVA), generators, either of which can start sequentially and run the minimum coincident demand load. These generators would provide reliable emergency power even when one unit is out of service for maintenance or repair, or because of failure. Combined, the two units would provide emergency power for the entire combined spillway and dam load at approximately 50 percent of their rated capacity. These generators would enable indefinite full operation during a catastrophic failure of the primary system, such as might be caused by an earthquake or sabotage. The emergency power system also would provide sufficient emergency power for the enlarged spillway gates that would be installed when the top of the dam is raised.

6.7.5 New Emergency Electrical Power Distribution

Emergency power would be distributed to the automatic transfer switch via a route through the existing dam. Several empty conduits were provided from the generator building to the dam under the generator building contract. These conduits will be extended through the dam, using the utility shaft in part, and then routed out of the control tower and along the top of the dam feeding towards the auxiliary spillway. The feeder to the auxiliary spillway would be stepped up/down to 4,160 volts with 300 kVA dry-type transformers at the tower and at the auxiliary spillway to limit voltage drop over the lengthy 3625-foot run.

6.7.6 Uninterruptible Power Supplies

All existing systems that could not "live" through the 10-second delay before emergency power comes on would be fitted with battery-powered uninterruptible power supplies (UPS). This measure would be applied to all new systems.

6.8 CONSTRUCTION CONSIDERATIONS

This section summarizes the anticipated approach to project construction of the six-STG auxiliary spillway, including means and methods and proposed scheduling.

6.8.1 Phased Construction and Work Packages

A phased construction approach has been identified for the Folsom Dam auxiliary spillway. In addition, other Federal projects to be constructed in conjunction with the auxiliary spillway would have a similar sequenced or phased nature. A phased construction approach allows for developing and implementing specific "work packages." For purposes of this report, a work package is considered to be a grouping of work elements defined either by an area or a specific program feature. Designated work packages should be compatible with future contracting/procurement efforts, and should represent major contracts as the program is currently envisioned. Work packages would be sized to take advantage of the strengths of

both large and small disadvantaged businesses. Work packages would be coordinated with other ongoing projects at the Folsom Facility to reduce contractor conflicts and maximize available funding. Other major proposed construction features include the Folsom Dam Bridge and Road project, City of Folsom Redundant Pipeline, downstream foundation treatment at MIAD, and various interim constructions measures currently underway by the Corps and Reclamation.

Work package development would continue as the auxiliary spillway is brought forward through the design stage. For the purposes of this report, the following work packages have been identified, and are consistent with cost estimate development for the auxiliary spillway:

- **Work Package 1 – Interim Measures.** This work package includes any interim measures associated with modifications to the existing main concrete dam tainter gates, including tainter gate-opening modifications and similar measures for incremental flood protection benefits in the near term.
- **Work Package 2 – Auxiliary Spillway Excavation.** This work package covers costs to partially excavate the auxiliary spillway chute and approach channel to serve to pass the PMF-level flows as an interim dam safety objective. Any rock excavation materials to be processed for other projects would be trucked for shell material processing via a processing plant near MIAD. Excess excavation materials would be hauled on a road to be developed adjacent to the reservoir and placed at a stockpile site. Some of the material would be incorporated into the MIAD overlay work. Reclamation would be performing the above-mentioned work. Hydrologic risk reduction can be achieved when the spillway excavation is completed including the approach chute and a portion of the spillway chute.
- **Work Package 3 – Auxiliary Spillway Excavation-to-Grade and Construction.** This work package consists of final excavation-to-grade for the auxiliary spillway approach channel, control structure, chute, and stilling basin, plus construction of the auxiliary spillway, including construction of the approach channel, control structure, chute slab and walls, and stilling basin. Excavation materials would be transported to one or more disposal sites, including the Folsom Point area, the water-side of Dike 7 and a disposal site near the MIAD right abutment.
- **Work Package 4 – Miscellaneous Projects.** This work package includes implementing various miscellaneous project elements: (1) relocations, (2) erosion protection, (3) recreation impacts, (4) new fencing and access roads, and (5) security improvements.

Additional benefits can be realized through optimization of the design process, materials excavation and distribution, and construction scheduling. These issues will be thoroughly evaluated in follow-on design efforts.

6.8.2 Bid-Ability

"Bid-ability" is the ease with which contract documents can be understood, bid, administered, and executed. To facilitate bid-ability for this project, the contractor will need to be able to accurately verify quantities for each construction line from the plans and specifications in order to propose a reliable bid. If plans and specifications are incomplete or vague, the overall project risk is transferred to the contractor. Often this translates into the contractor not being able to adequately estimate the project needs, which at minimum, results in bids being significantly elevated to cover the uncertainties. When complete and accurate information is included in plans and specifications, and the contractor is able to quantify or place boundaries on this risk, bid-ability is greatly improved. Review of the construction documents during the design phases with emphasis on incorporating bid-ability is essential.

6.8.3 Constructibility and Construction Risk Overview

"Constructibility" can generally be described as the extent to which the project design provides for ease of construction and still meets the overall requirements of the completed facility. Establishing constructibility begins with the initial planning phase and extends into the detailed design, procurement, and field construction phases. A critical factor is determining if means and methods of construction can be employed to allow the project to be completed using industry standard practices, or innovative construction techniques that have been used successfully by the reviewer or company bidding the project.

In determining constructibility, a construction risk overview would be conducted. This is a review to determine if the major risks associated with the project can be identified and quantified. If the reviewer is able to accurately assess the risks primarily from a review of the available contract documentation, the project is determined to be both constructible and the risks reasonable. As with bid-ability, if this cannot be completed, realistic constructibility or construction risk assumptions would not be achieved. Proposed risk reduction thoughts for consideration include discussions with contractors during the design phase, limiting the means and methods of specification in the plans and specifications, adequate construction funding, using local and regional cost indices to track as-bid or as-constructed prices, using an equitable price adjustment (EPA) clause in the contract, and accurate unit pricing.

On the basis of a preliminary risk overview by the design team, it is believed that one potential risk issue identified that may affect constructibility is the post 9/11 security requirements that would be required. If requirements are stringent to the point that construction workers' access to the construction site is greatly restricted, the ability to accurately assess constructibility is limited, resulting in a potentially large increase in cost and time for completing the work.

6.8.4 Construction Means and Methods

Construction means and methods primarily refer to construction equipment, operations, practices, procedures, and related activities. Below is a general description of means and methods that have been initially identified by the team. It should be noted,

however, that the means and methods provided below are only one set of possibilities for achieving the desired results; construction documents should not limit bidders from using their own means and methods, and taking advantage of resources within their respective companies, provided those means and methods reflect the specification in the plans and specifications.

This discussion of means and methods below is organized by major work item, not by work package, because many of the work packages are assumed to employ similar means and methods.

6.8.4.1 Spillway Excavation and Material Processing

The decomposed granite and superficial soils in the spillway excavation area can be loosened using a 400 hp dozer (Cat D-9) with either a single shank or multiple shanks. Using standard excavation equipment, push dozers, and off-highway haulers, the material would be taken for processing or spread at a stockpile site. The underlying competent bedrock would be broken, employing industry standard drill and blast techniques. Loosened materials would be loaded into off-highway haulers using a 190,000-pound excavator (Cat 375).

Excavation materials would be transported to one or more disposal sites, including, but not limited to, the Folsom Point area, the water-side of Dike 7 and a disposal site near the MIAD right abutment.

6.8.4.2 Access and Haul Roads

Public access to all park facilities would be maintained, including Folsom Point, either via existing park roads or temporary relocated roads. Public access would be restricted from the construction areas, the processing areas, and haul roads.

To reduce construction traffic on city streets and to allow the use of oversized construction equipment, internal haul roads would be developed adjacent to the reservoir. The internal haul roads would be graded into the weathered granite and have an earthen road base installed. The internal roadways would be sized to allow passage of oversized equipment. The crests of the wing dams and MIAD would be included as part of the internal road network. Given the space limitations of the crests, only conventional equipment would use the wing dams or MIAD. At this time, there is no consideration being given to using the main concrete dam as a haul road. A construction haul road would be constructed from the auxiliary spillway site to the Dike 7 stockpile area and then on to Folsom Point and MIAD (R1 and D2 borrow/stockpile sites). This would allow transport of material between these project facilities.

6.8.4.3 Construction Field Office, Heavy Equipment Maintenance Yard and Laydown Areas

Following is a preliminary estimate of the locations for the construction field office heavy equipment maintenance yard (if applicable) and laydown (construction staging) areas for each of the work packages:

- **Work Package 1 – Interim Measures.** Field office and laydown areas could be located near the main concrete dam adjacent to the Corps field office facilities and the overlook area just east of the left wing dam.
- **Work Package 2 – Auxiliary Spillway Excavation.** One field office and laydown area could be sited on the left side of the dam near the auxiliary spillway and a second field office and laydown area could be sited at MIAD at the downstream toe, or at Folsom Point. Material processing and load out operations would be located in the overlook area just east of the left wing dam. The heavy equipment maintenance yard could be located at Folsom Point, in the vicinity of the haul road.
- **Work Package 3 – Auxiliary Spillway Excavation-to-Grade and Construction.** Some field office and laydown area is available near the auxiliary spillway; and a substantial area is available near Folsom Point. The area required to erect and operate a concrete batch plant, including adequate aggregate storage areas, is available at Folsom Point and possibly near the LWD. The LWD site has the advantage of being in very close proximity to the work site and removed from housing and recreation sites. Folsom Point, on the other hand, has an advantage of minimizing security concerns compared to staging areas near the main dam. The heavy equipment maintenance yard could be located at Folsom Point or at Dike 7, in the vicinity of the haul road.
- **Work Package 4 – Miscellaneous Projects.** Multiple field office and laydown areas of various sizes would be required. Potential locations remain to be determined.

6.8.4.4 Concrete Batch Plant

The construction of the new control structure, spillway, and stilling basin will require large quantities of temperature controlled concrete. This will necessitate the use of a contractor-provided, on-site concrete batch plant and deliveries of large quantities of concrete aggregates, concrete sand, and cement. It is estimated that the concrete batch plant and material stockpiles will require about ten acres of land. An area near Folsom Point can accommodate this requirement. The in-reservoir haul road would be used for concrete transport from Folsom Point to keep truck traffic off local roads. Another potential batch plant site is the area at the toe of the LWD, perhaps in combination with part of the paved overlook area at the east end of the LWD for use as aggregate storage. With the relocation of the 42-inch Natomas pipeline and the Corps' office building, the LWD site could increase by several acres.

6.8.4.5 Concrete Materials and Placement

Delivery of concrete aggregate, sand, and cement will involve a large volume of truck traffic. Due to the quantities involved and operating hours of aggregate and cement suppliers, the delivery scheduling would not be restricted solely to traffic off-peak hours. Deliveries are not expected to cause a significant impact on traffic.

The construction of the new control structure, spillway, and stilling basin will require large quantities of temperature controlled concrete. It is likely unavoidable that some batching and placements will have to occur in the night-time hours. This is especially true for large volume placements and placements that occur in the hot summer season. Night-time placements will be included in the design considerations and allowed in the construction contract documents.

6.8.5 Construction Schedule

A preliminary schedule for the Joint Federal Project (six-STG auxiliary spillway) is presented in **Plate 6-10** and is presented by work package. The construction cost estimate is based on this preliminary schedule and was used to derive escalation allowances in determining the mid-point of construction for each work package.

6.8.6 Contracting and Procurement

As stated previously, the work packages described above are preliminary. As the auxiliary spillway design and schedule progresses, refinement of these work packages likely would be required because of various issues, including availability of funding. Minor changes to work packages should not have a significant impact to the overall program cost at this stage of estimate if the overall duration of the program schedule does not change. However, the impact to the cost estimate should be reviewed for any significant changes to work packages development and major scheduling assumptions.

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CHAPTER 7.0
CONCLUSIONS

The following conclusions are based on the results of the analyses contained in this EDR for the Folsom Dam Joint Federal Project.

- The Joint Federal Project is one of the elements of a more comprehensive flood damage reduction and dam safety project which is the proposed SP. The Joint Federal Project element of the SP is being cost-split by the Corps and Reclamation based on a cost distribution between the flood damage reduction and dam safety objectives.
- The Joint Federal Project combines the Corps' flood damage reduction objective of the authorized Folsom Modification Project and Reclamation's dam safety hydrologic risk reduction objective. The six-STG auxiliary spillway increases the flood control capability of Folsom Dam and Reservoir by increasing the outflow capacity at lower lake levels, resulting in better utilization of the existing storage capacity. This project also addresses the existing hydrologic dam safety deficiency of inadequate spillway capacity. The additional release capacity provided by the auxiliary spillway allows the dam the capability to safely pass the PMF.
- An auxiliary spillway, consisting of six-STGs with invert elevation 368, is equivalent to the flood damage reduction of the authorized Folsom Modification Project (while also satisfying the dam safety objective of passing the PMF). This comparison to the authorized project is based on the construction of ten new or enlarged river outlets in the main concrete dam.
- Flood routings of the six-STG auxiliary spillway have been performed to demonstrate that the Joint Federal Project would provide a flood control level of protection computed at 1 chance in 156 in any given year. This alternative would provide the capacity for Folsom Dam to pass a 200-year design flood event.
- The design and construction of the six-STG auxiliary spillway would take about eight years.
- The Joint Federal Project is strongly supported by the local Partners, including the State Reclamation Board and SAFCA. Formulation of the Joint Federal Project has been closely coordinated with the Partners and Reclamation.
- The energy dissipator at the end of the six-STG auxiliary spillway chute is designed to dissipate energy from high velocity flows before they enter the American River channel. Ongoing studies and future analysis will determine what necessary measures are required to address possible impacts to downstream water surface elevations and channel erosion potential.
- During project development, further study of reservoir reoperations will be done to focus on reducing the variable space allocated to flood control within the reservoir

from the current operating range of 400,000 to 670,000 acre-feet to an operating range of 400,000 to 600,000 acre-feet.

- Construction of the six-STG auxiliary spillway would cause some resource impacts; but mitigation measures would be proposed to reduce these potential impacts to less than significant levels where possible.
- Preliminary geologic, geotechnical, seismic, and hydrogeologic investigations of the auxiliary spillway site support the geotechnical viability of locating the auxiliary spillway at this site. Further data and analysis obtained during the ongoing Phase 2 explorations will enhance these data and allow further evaluation of key design considerations, including:
    - Cofferdam seepage
    - Sliding block stability
    - Gate structure foundation design
    - Long-term seepage
- Structural analyses of the auxiliary spillway for stability and stress indicate that the structure can achieve adequate margins of safety using cost-effective design and construction techniques.
- A feasibility-level cost estimate for the Joint Federal Project was developed using MCACES. The estimated total first cost assigned only to flood damage reduction is $683.0 million. The six-STG auxiliary spillway project is economically feasible. The annual cost assigned only to flood damage reduction is $37.9 million and the average annual flood control benefits are $89.9 million, respectively.

CHAPTER 8.0
REFERENCES

CHAPTER 1

Sacramento Area Flood Control Agency (SAFCA). 1998. Folsom Dam Modification Report, New Outlets Plan,. Prepared by Murray, Burns and Kienlen, Sacramento, California.

U.S. Army Corps of Engineers, (Corps). 1996. American River Watershed Project, California, Supplemental Information Report and Final Supplemental Environmental Impact Statement/Environmental Impact Report. Sacramento District. Sacramento, California, March.

Corps. 2001. Folsom Dam Modification Project, Limited Reevaluation Report and Environmental Assessment/Initial Study, American River Watershed, California. August.

Corps. 2003. Folsom Dam Modification Project, Final Limited Reevaluation Report and Environmental Assessment/Initial Study, American River Watershed, California, November.

Corps, State of California Reclamation Board, 1991, American River Watershed Investigation, California: Feasibility Report. December.

Water Resources Development Act (WRDA 1996), (Public Law 104-303), Section 101 (a)(1), American River Watershed, California.

Water Resources Development Act of 1999 (WRDA 1999) (Public Law 106-53), Section 101 (a)(6), American and Sacramento Rivers, California.

CHAPTER 2

Corps. 1996. American River Watershed Project, California, Supplemental Information Report and Final Supplemental Environmental Impact Statement/Environmental Impact Report. Sacramento District. Sacramento, California. March.

Corps, 2001, Folsom Dam Modification Project, Limited Reevaluation Report and Environmental Assessment/Initial Study, American River Watershed, California, August.

Corps. 2002a. American River Watershed, California: Long Term Study, Final Supplemental Plan Formulation Report/Environmental Impact Statement/Environmental Impact Report. February.

Corps. 2002b. Chief of Engineers (CECW-PM) Letter, Subject: American River Watershed, California, Long-Term Study.

Corps. 2003. Folsom Dam Modification Project, Final Limited Reevaluation Report and Environmental Assessment/Initial Study, American River Watershed, California. November.

Corps. 2004. Design Documentation Report (DDR), Folsom Dam Outlet Works Modification Project, Volumes I and II. August.

Corps. Reclamation, SAFCA, DWR and State of California Reclamation Board. 2006. Project Alternative Solutions Study II (PASS II), Final Report, Folsom Dam Flood Control and Hydrologic Risk Reduction Alternatives. October.

SAFCA. 1998. Folsom Dam Modification Report New Outlets Plan. February.

CHAPTER 3

Corps. Sacramento District. 1987. Water Control Manual, Folsom Dam and Lake, American River, California. Appendix VIII to Master Water Control Manual, Sacramento River Basin, California. December.

Corps. 2001. "American River Basin, California, Folsom Dam and Lake Revised PMF Study, Hydrology Office Report," Sacramento District, U.S. Army Corps of Engineers. October.

Corps. 2004. "American River, California, Rain Flood Flow Frequency Analysis, Office Report" Sacramento District, U.S. Army Corps of Engineers. August.

National Weather Service [NWS]. 1999. Hydrometeorological Report (HMR) No.59 (includes HMR No. 58), "Probable Maximum Precipitation for California," Hydrometeorological Branch of the National Weather Service. February.

SAFCA & Reclamation. 2004. "Folsom Dam Interim Operations Plan (2004), American River, California." September.

USGS. 1981. "Guidelines for Determining Flood Flow Frequency, Bulletin #17B," Interagency Advisory Committee on Water Data, U.S. Geological Survey, revised September.

CHAPTER 4

Reclamation. 2006. Folsom Dam Safety and Flood Damage Reduction Draft Environmental Impact Study / Environmental Impact Report (DEIS/EIR), (Document prepared by CDM), December.

CHAPTER 5

Annandale. 1995. Scour Technology, McGraw-Hill Professional. November.

Bro. 2004. Large Scale Direct Shear Testing of Monolith 15 Concrete/Foundation Contact.

Bro. 2005. Skewed Brazilian Splitting Tensile Strength Testing to Correlate Tests with Orientation of Healed Fractures.

Corps. 1950. Definite Project Report, Folsom Project, American River, CA. Part IV – Dam and Appurtenances.

Corps. 1952. Foundation Report, Left Wing Dam, Folsom Project, American River, CA.

Corps. 1954. Roddy, Russell, Foundation Report, Part "D", Main Concrete Dam, Monoliths 7-23, Folsom Project, American River, California.

Corps. 1989. Seismic Stability Evaluation of Folsom Dam – Dam Safety Assurance Program.

Corps. 2004. SPK, Folsom Dam Resident Office, Staging Areas, and Access Roads, Specification No. 1410; Final Geotechnical Report. July.

Corps. 2005. WES, In Situ Geophysical Surveys for Estimation of Foundation Rock Properties, Concrete Gravity Section, Folsom Dam; ERDC/GSL TR-05-18. August.

Corps. 2006a. SPK – J. Bolton – Top of Dam Explorations and Permeability Testing, Dikes 5 &7 and Mormon Island, Draft Permeability Report. 2006 (in progress).

Corps. 2006b. Auxiliary Spillway. Drilled 15 rock core holes and conducted optical televiewer surveys. April.

Corps. 2006c. DRAFT – American River Watershed Project, California, Folsom Modifications and Folsom Dam Raise Projects. October.

Fuller. 2003. Rock Testing (Shear, sliding friction, unconfined compressive strength of holes TH-G through TH-P from drain gallery drilling) for URS. March 2003.

Goodman. 2005. Shear Strength of a Foundation with Two-dimensional Roughness; Paper submitted for the 2005 American Rock Mechanics Association Conference.

Greene. 2002. Memo – Rock Properties for Folsom Dam MODS. September.

Jennings. 1994. Fault Activity Map of California and Adjacent Areas with Location and Ages of Recent Volcanic Eruptions. California Division of Mines and Geology, Geologic Data Map Series, Map No. 6.

Kiersch. 1950. Folsom Dam Regional Geology Map – 1 inch = 1 mile. January.

Kiersch. 1955. Kiersch and Treasher, Investigation, Corps Aerial and Engineering Geology – Folsom Dam Project, Central CA, May.

Kleinfelder. 2002. Geotechnical Investigation Report – Folsom Dam Subsurface Exploration, November.

Kleinfelder. 2005. Spillway Scour Analysis, January.

Kleinfelder. 2006. Geologic and Geotechnical Evaluation, Downstream Rock Scour Potential, Folsom Dam, Folsom, CA.

Loyd. 1984. General Geology of the Auburn 15-minute Quadrangle, Division of Mines and Geology, Open File Report.

Norcal. 2005a. Seismic Refraction Survey of Auxiliary Spillway – Draft Letter Report. The refraction was never verified and correlated with Phase 1 drilling. October.

Norcal. 2005b. Geophysical – Seismic Refraction Survey of Dam Road Realignment for URS.

Norcal. 2005c. Geophysical for URS – DRAFT Preliminary Roadway Materials Report for Folsom Dam Bridge, Folsom, CA. October.

Quest. 2005a. Summary Report on Shear Strength of Monolith 15. Discusses results of the direct shear testing of the 6-inch concrete and bedrock samples. January.

Quest. 2005b. Report of Bond Strength of the Rock/Concrete Interface of Monoliths 15-19, Folsom Dam – Observations, findings, and recommendations, October.

Reclamation. 1999. Hydraulic Model Study of Folsom Dam Spillway Performance and Stilling Basin Abrasion. September.

Reclamation. 2001. Technical Report of Construction – Folsom Dam Spillway Rehabilitation. February.

Reclamation. 2002. Tech Service Center, Concrete Coring – Laboratory Testing program, Folsom Dam Modifications. April.

Reclamation. 2004. Static and Dynamic Foundation Analysis – 3D Block Analysis. August 2004.

Reclamation. 2005. Results of Direct Shear Tests. October.

Reclamation. 2006. Auxiliary Spillway. Drilled 5 rock core holes, geologic drill hole logs and field notes. January.

URS. 2001a. Final Report, Folsom Dam Modifications, Evaluation of Rock Mass Properties. June (draft) – December (final). December.

URS. 2001b. Deterministic and Probabilistic Seismic Hazard Analysis for Folsom Dam, California. 2001.

URS. 2002. Supplemental Report, Deterministic and Probabilistic Seismic Hazard Analysis, Folsom Dam. July.

URS. 2003b. Final Report, Supplemental Report II, Deterministic and Probabilistic Seismic Hazard Analysis, Folsom Dam. June.

URS. 2003a. Tech Memo, Folsom Dam Foundation Characterization. August 8, 2003 Addressed differences in rock mass properties in the May 2003 Rock Testing report with those from the 1989 DSAP report. August.

URS. 2003b. Tech Memo, Rock Testing Report. Testing done by FMS&M. May.

URS. 2003c. Final Report, Supplemental Report II, Deterministic and Probabilistic Seismic Hazard Analysis, Folsom Dam. June.

URS. 2004a. Memo, Evaluation of Potential for Surface Faulting at Folsom Dam. Mapping and field investigation by URS to estimate age of last movement of Channel Fault. February.

URS. 2004b. Direct Shear Testing of Scale Models for Folsom Dam Monolith 15. July.

URS. 2005. DRAFT Preliminary Roadway Materials Report for Folsom Dam Bridge; Folsom CA. October.

URS. 2006. DRAFT Foundation Report for Folsom Bridge, Folsom, CA. May.

Wagner. 1981. Geologic Map of the Sacramento Quadrangle, California – 1:250,000.

Woodward-Clyde. 1983. Investigation of Concrete and Foundation Conditions (Fault Study) at Folsom Dam. Drilled holes TH-A through TH-F in drain gallery, conducted Goodman Jack testing, calculated rock mass modulus. August.

CHAPTER 6

Boes and Hager. 2003. Two Phase Flow Characteristics of Stepped Spillways, ASCE, HY Journal, September.

Corps, Reclamation, SAFCA, DWR and State of California Reclamation Board. 2006. Project Alternative Solutions Study (PASS) II, Final Report, Folsom Dam Raise and Auxiliary Spillway Alternative. June.

Corps. 1999. Engineering and Design for Civil Works, Engineer Regulation 1110-2-1150, 31 August.

Corps. 1980. Hydraulic Design of Reservoir Outlet Works, Engineering Manual 1110-2-1602. October.

Corps. 1987. Hydraulic Design Criteria, November.

Corps. 1990. Hydraulic Design of Spillways, Engineering Manual 1110-2-1603, 16 Jan 1990.

Corps. 1992. Dam Safety – Organization, Responsibilities, and Activities, Engineering Regulation ER 1110-2-1156, 31 July.

Corps. 1994. Hydraulic Design of Flood Control Channel, Change 1, ENG 4794-R, June.

Corps. 1995. Gravity Dam Design, Engineering Manual EM 1110-2-2200, 30 June.

Corps. 1999. American River Watershed, California, Information Paper. August.

Corps. 1999. Engineering Regulation ER 1110-2-1150, Engineering and Design for Civil Works Projects. August.

Corps. 1999. Response Spectra and Seismic Analysis for Concrete Hydraulic Structures. EM 111-2-6050. June.

Corps. 2001. Sacramento District, American River Watershed, CA, Folsom Dam Modification Project, Final Limited Reevaluation Report, August.

Corps. 2002. American River Watershed, California: Long Term Study, Final Supplemental Plan Formulation Report/Environmental Impact Statement/Environmental Impact Report, February.

Corps. 2003. Time-History Dynamic Analysis of Concrete Hydraulic Structures. EM 1110-2-6051. December.

Corps. 2003. Engineering and Design: Stability Analysis of Concrete Structures, Engineering Circular EC 1110-2-6058. November.

Corps. 2004. Design Documentation Report, Folsom Dam Outlet Works Modifications Project, Volumes I and II. August.

Corps. 2004. Engineering and Design, Safety of Dams – Policy and Procedures, Engineering Circular EC 1110-2-6061. April.

DWR. Original Design of Oroville Dam.

DWR.1965. Oroville Dam Flood Control Structure.

ESA Consultants, Inc.. 1994. Folsom Dam Improvements, Mini Raise, Preliminary. August.

FEMA. Publication 64, Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners.

Murray, Burns, and Kienlen (MBK) Consulting Civil Engineers. 1998. Folsom Dam Modification Report New Outlets Plan. February.

Peterka, A. J. 1974. Hydraulic Design of Stilling Basins and Energy Dissipators, Engineering Monograph No. 25, US Bureau of Reclamation, Denver, Colorado.

Pinto, N.L. de S., and Neidert, S.H., Model Prototype Conformity in Aerated Spillway Flow, International Conference on Hydraulic Modeling of Civil Engineering Structures, BHRA, Coventry.

Reclamation. 1971. Hydraulic Model Studies of the Folsom Spillway-Outlet Junction, REC-ERC-71-12, Reclamation,. (Isbester, T.J.)

Reclamation. 1980. Air-Water Flow in Hydraulic Structures, Engineering Monograph No. 41, December.

Reclamation. 1990. Cavitation in Chutes and Spillways, Engineering Monograph No. 42, April.

Reclamation. 1996. Folsom Dam Spillway Stilling Basin Rehabilitation, TM No. FOL-8130-REH-96-1. September.

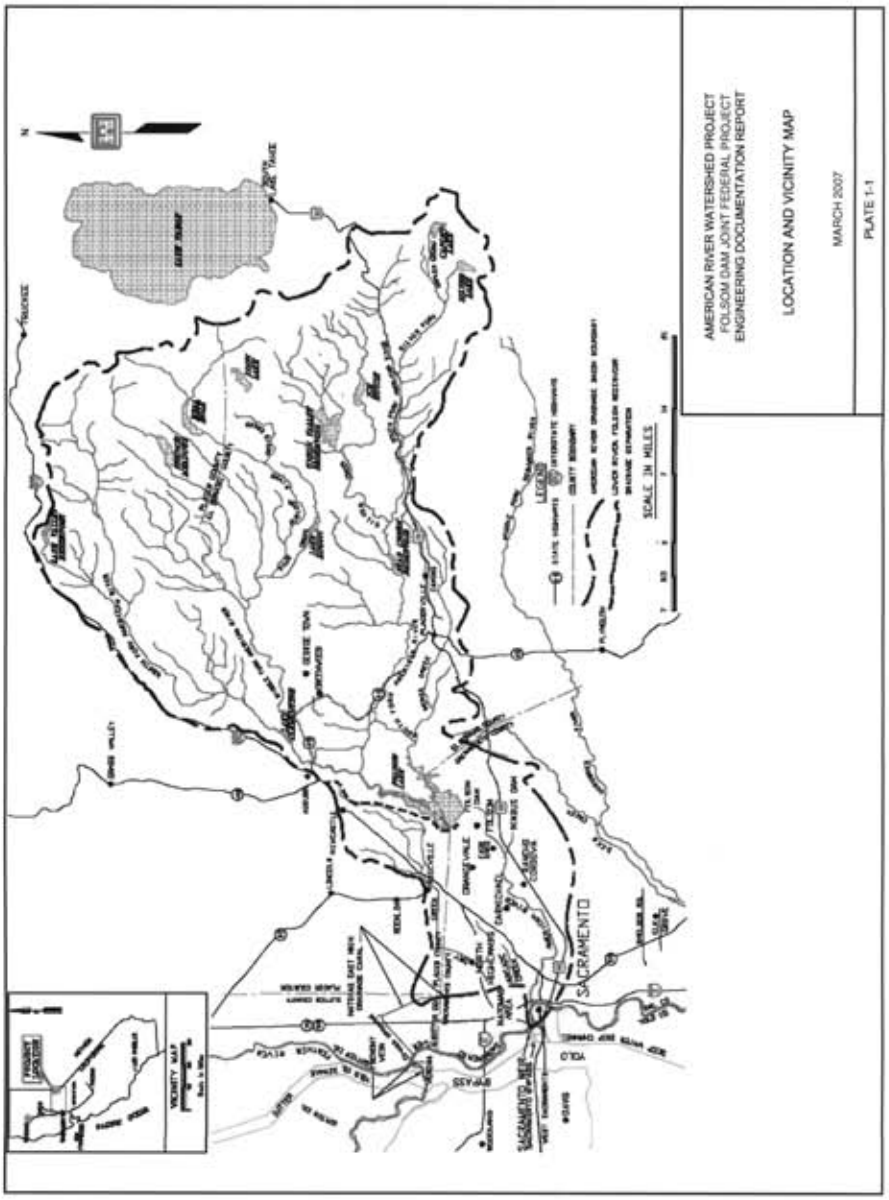
Reclamation. 1997. Recommended Flood Operations for Folsom Dam, TM FD-8130-FD-TM-97-3. September 1997.

Reclamation. 1998. Aeration Enhancements at the Folsom Dam Outlet Works: Reducing Cavitation Damage Potential. April.

Reclamation. 2006a. Folsom Dam Joint Federal Project Short Term Evaluation 3-D LS-DYNA Analysis. TM FOL-8130-JFP-2006-2. December.

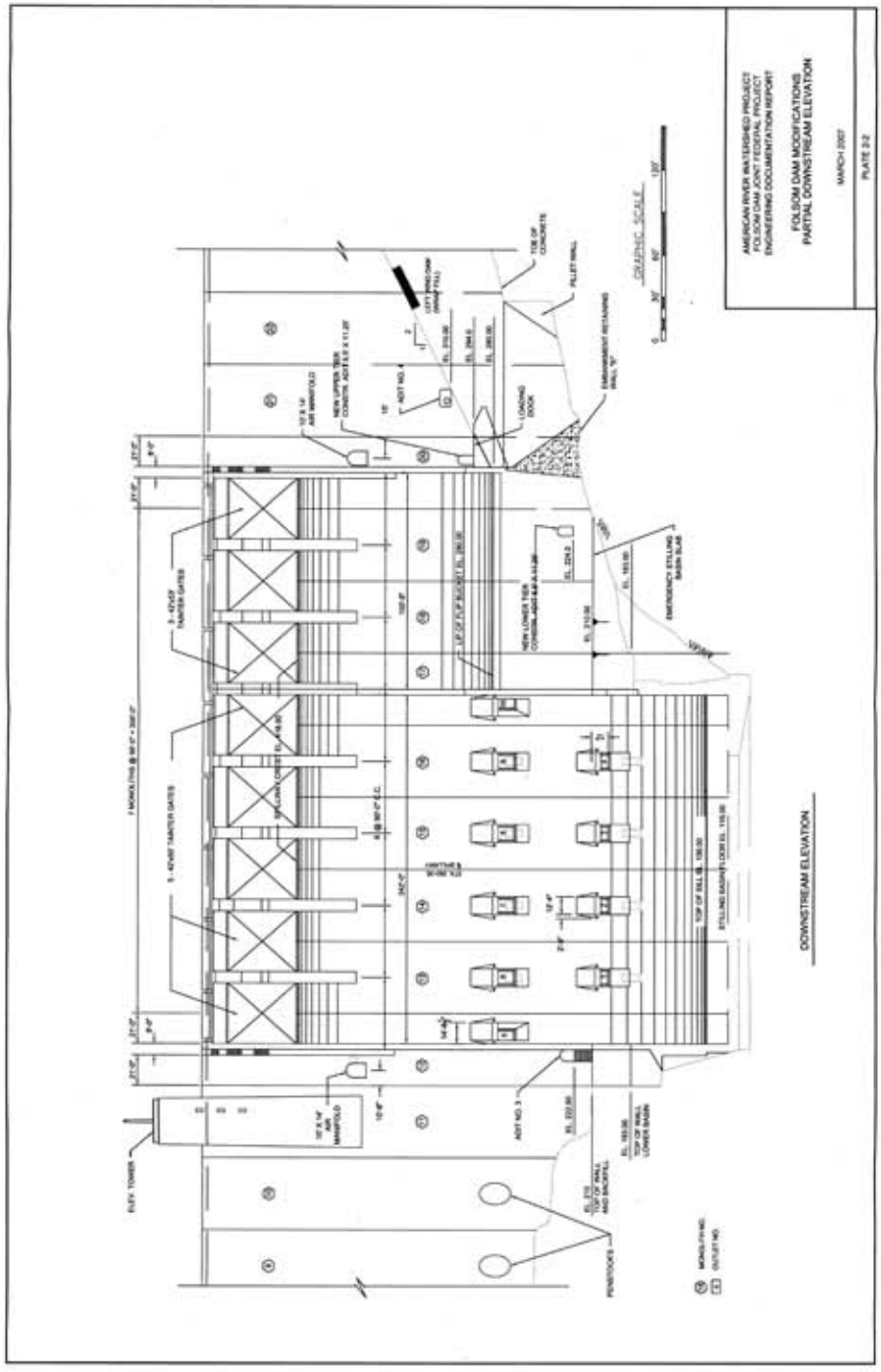
Reclamation. 2006b. Folsom Dam Joint Federal Project Short Term Evaluation Risk Analysis Report. TM FOL-8130-JFP-2006-3. December.

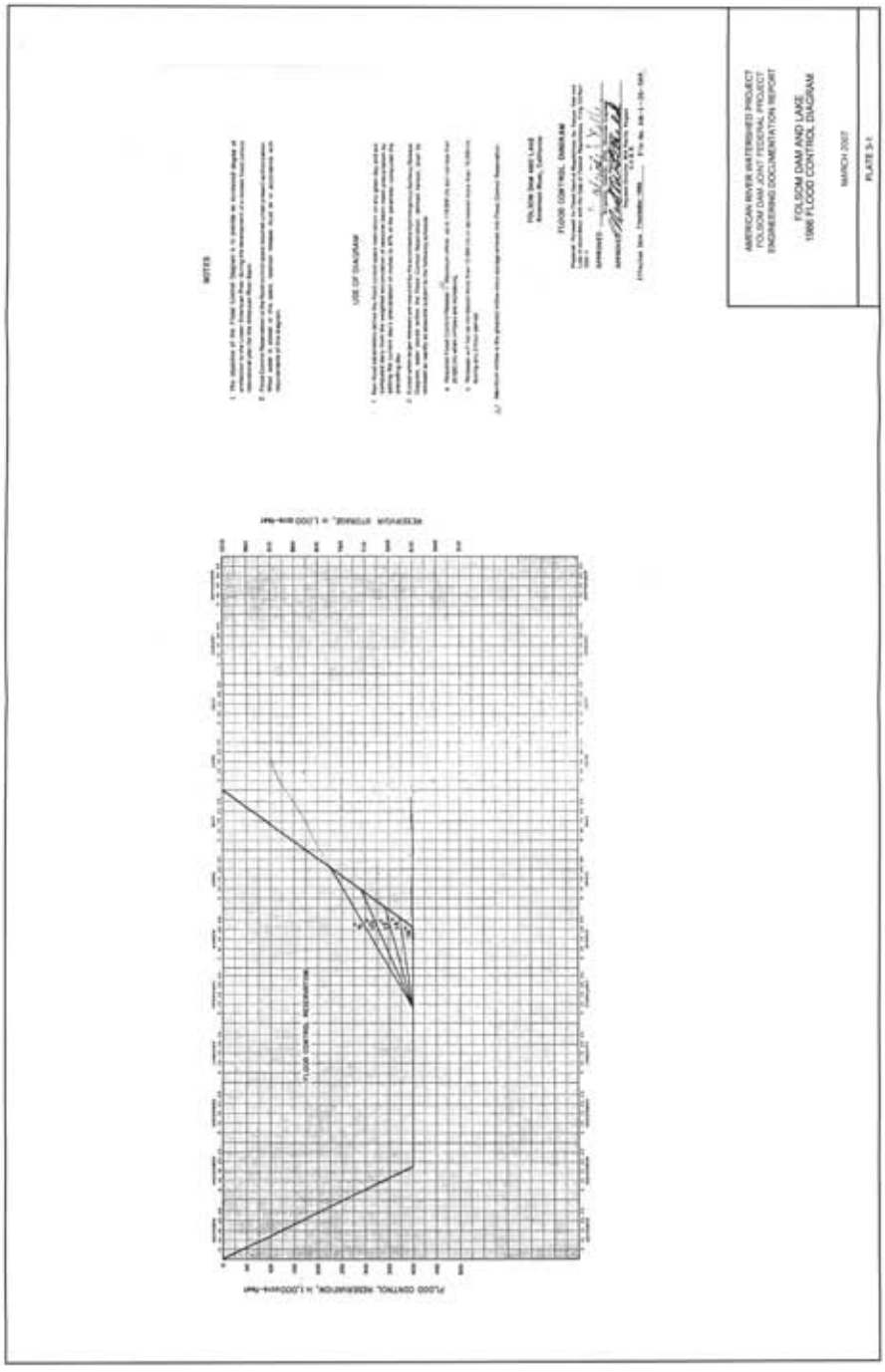
URS. 2001. Probabilistic and Deterministic Seismic Hazard Analyses, Folsom Dam, Central California, Final Report. July.

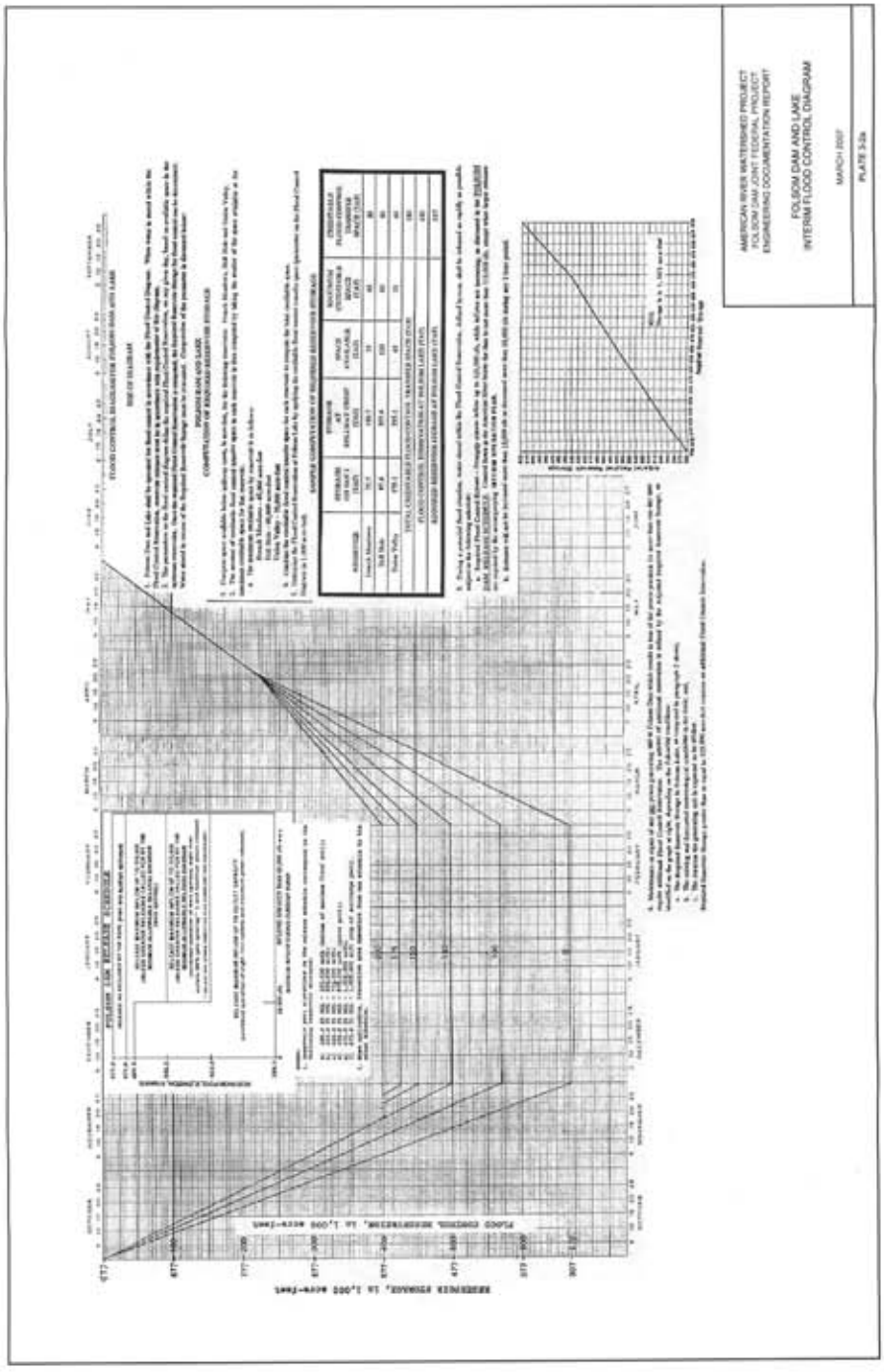

AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT
LOCATION AND VICINITY MAP
MARCH 2007
PLATE 1-1
SACRAMENTO
FOLSOM DAM
FOLSOM LAKE
LEGEND
SCALE IN MILES
VICINITY MAP


BEEKS BIGHT
DIKE #1
DIKE #2
BORROW AREA #4
GRANITE BAY
DIKE #3
NEW YORK CREEK
DIKE #4
DIKE #5
DIKE #6
BEALS POINT
BROWN'S RAVINE
BORROW AREA #2
MAIN CONCRETE DAM
RIGHT WING DAM
LEFT WING DAM
PROPOSED AUXILIARY SPILLWAY ALIGNMENT
FOLSOM POINT
MORMON ISLAND AUXILIARY DAM
DIKE #8
DIKE #7
APPROXIMATE SCALE IN MILES
PRELIMINARY SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT
PROJECT FEATURES MAP
MARCH 2007
PLATE 1-2


RIGHT WING DAM
FUTURE FOLSOM BRIDGE (SEPARATE PROJECT)
STILLING BASIN
MAIN CONCRETE DAM
LEFT WING DAM
FUTURE USACE RESIDENT OFFICE
FUTURE PARKING
CONTROL STRUCTURE
APPROACH CHANNEL
PROPOSED AUXILIARY SPILLWAY ALIGNMENT
CHUTE
FUTURE FOLSOM BYPASS ROADWAY (SEPARATE PROJECT)
PRELIMINARY SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT
MAIN CONCRETE DAM AND
AUXILIARY SPILLWAY PLAN VIEW
MARCH 2007
PLATE 2-1


AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT
FOLSOM DAM MODIFICATIONS
PARTIAL DOWNSTREAM ELEVATION
MARCH 2007
PLATE 2-2
GRAPHIC SCALE
DOWNSTREAM ELEVATION


AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT
FOLSOM DAM AND LAKE
1986 FLOOD CONTROL DIAGRAM
MARCH 2007
PLATE 3-1
NOTES
USE OF DIAGRAM
FLOOD CONTROL DIAGRAM
FOLSOM DAM AND LAKE
RESERVOIR STORAGE, in 1,000 Acre-feet
FLOOD CONTROL RESERVATION, in 1,000 cfs-days


AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT
FOLSOM DAM AND LAKE
INTERIM FLOOD CONTROL DIAGRAM
MARCH 2007
PLATE 3-3a

Folsom Dam

Interim Operations Plan (2004)

What is the Plan

The plan is a modification to the Folsom Dam Flood Control Diagram that has been adopted by Sacramento Area Flood Control Agency (SAFCA) and the Bureau of Reclamation. The Corps has endorsed these flood operation rules. The modification consists of a set or rules that would accomplish the following:

A. Limit the outflow from Folsom Dam to a maximum of 145,000 cfs while the lake level is below elevation 470 feet. Outflows greater than 115,000 cfs would be limited to extreme flood events that occur very infrequently.

B. Utilize 100% gate openings for the eight 5-foot by 9-foot outlet gates in conjunction with the use of the service spillway, if required. This operation would be limited to extreme flood events that occur very infrequently.

Why is the Plan being implemented

The plan is necessary to provide an important increment of flood protection to areas downstream from Folsom Dam. These areas do not have protection from the FEMA Base Flood (1% Annual Exceedance Probability) without the implementation of the Interim Operating Plan.

How does the Plan work

The Interim Operation Plan is based on increasing the outlet capacity from the dam during the early stages of the flood and by limiting outflows above 115,000 cfs to the downstream channel capacity. Each feature of the plan is discussed below:

Limit Outflow to 145,000 cfs. The existing flood control rules call for a flood release from the dam of 160,000 cfs while the lake elevation is well below the normal full pool at elevation 466 feet. The current American River levee evaluations find that that 145,000 cfs can be safely carried by the levees for up to 36 hours. Therefore, the existing limit of 160,000 cfs is being modified to limit outflows to 145,000 cfs until the lake level increases to the maximum elevation that would not require the opening of the emergency spillway gates (elevation 470 feet). This modification reduces the frequency of flood discharges from the dam that exceed 145,000 cfs.

Allow Use of Maximum Outlet Capacity. The current operation plan limits the utilization of the outlet works gates to 60% open during periods when the spillway is also discharging water. This requirement has a detrimental affect on the ability of the dam to manage flood waters. The reason for the limit is that the potential for cavitation to damage the face of the dam is considered to be less if the gates are not fully opened. Cavitation has occurred in the past on the face of the spillway and is not considered a threat to the integrity of the dam if prompt maintenance actions to repair the damage are implemented. The Interim Plan allows the gates to be fully opened while the service spillway is in operation given a sufficiently large event. The gate operation allowed by the Interim Plan could potentially increase the cavitation damage to the spillway face. This is considered an acceptable risk and a plan has been developed whereby SAFCA will fund the work required to repair damage that might be sustained by the dam as a result of this operation. The increased outlet capacity that is achieved by this operation significantly improves the capability of the dam to discharge flood waters at controlled rates downstream from the dam. This capability is an important element in limiting the FEMA Base Flood to outflows of 145,000 cfs or less downstream from the dam.

Under What Conditions do the Provisions of the Plan Take Effect

The provisions of the plan are designed to be used very infrequently for short periods of time. For instance, none of the provisions would be activated for floods that have occurred in the last 100 years. It is estimated that in any given year there may be a 2% chance that the outlets will be operated at maximum gate opening while the spillway is operating. And a 1% chance that flows would exceed 115,000 cfs. The provisions that lead to implementation of the Interim Plan are the forecast of a very large flood in the next 24 hours (325,000 cfs peak inflow or 400,000 acre-feet inflow volume) or reservoir pool to exceed elevation 466 feet, either of which are extremely rare occurrence.

What operations are not affected by the Interim Plan

The Water Supply, Power, Recreation and Fishery operations are not changed by the Interim Plan.

What is changed by the Interim Plan?

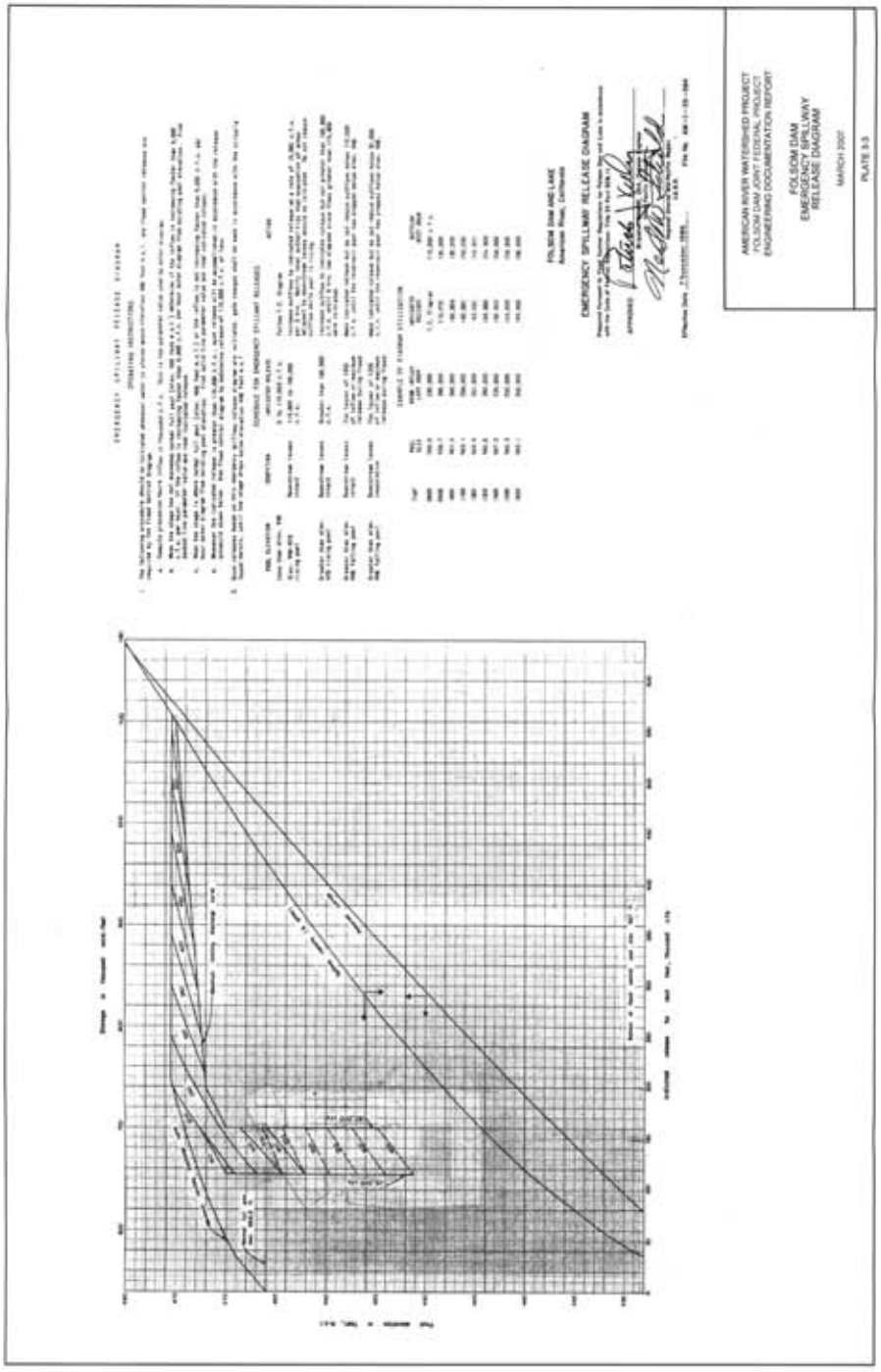
The maximum flood release from the dam is limited to 145,000 cfs instead of 160,000 cfs at the 1% flood level. The potential for cavitation damage to the face of the dam is slightly increased by maximum use of the existing outlets.

AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT

FOLSOM DAM
INTERIM OPERATIONS PLAN (2004)

MARCH 2007

PLATE 3-2b



AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT

FOLSOM DAM
EMERGENCY SPILLWAY
RELEASE DIAGRAM

MARCH 2007

PLATE 3-3

COMPARISON OF KEY OPERATIONAL DIFFERENCES BETWEEN PROJECTS

With-project comparisons made to existing SAFCA/Reclamation re-operation

Feature	Existing SAFCA/Reclamation Re-operation	Folsom Modification Project (six-STG)	Folsom Dam Raise Project (six-STG with raise)	Joint Federal Project
TOP OF DAM ELEVATION DAM RAISE INCREMENT	480.5 feet No Change	No Change	484.0 feet 487.5 feet 3.5 feet 7 feet	480.5 feet 484.0 feet 487.5 feet No Change 3.5 feet 7 feet
GROSS POOL ELEVATION	466.0 feet (977,000 acre-feet)	No Change	No Change	No Change
TOP SURCHARGE (PMF) POOL	475.4 feet (1,084,780 acre-feet)	477.5 feet	481.0 feet 484.5 feet	477.5 feet 481.0 feet
OBJECTIVE RELEASE				
Normal	115,000 cfs	No Change	No Change	No Change
Emergency	160,000 cfs	No Change	No Change	No Change
SERVICE & EMERGENCY GATE CONFIGURATION	3-42 feet x 32 feet service gates 3-42 feet x 33 feet emergency gates[1]	No Change	3-42 feet x 68 feet service gates[3] 3-42 feet x 68 feet emergency gates[3]	TBD
OUTLET CONFIGURATION	4-Upper Tier 9-feet x 9-feet 4-Lower Tier 5-feet x 9-feet	No Change	No Change	No Change
OUTLET CAPACITY (w/o power) @ Elevation 410.5	24,800 cfs	No Change	No Change	No Change
AUXILIARY SPILLWAY CONFIGURATION	Nasa	six-STG Sill elevation = 398 feet	six-STG Sill elevation = 398 feet[2]	four-STG to six-STG Sill elevation = 398 feet[2]
VARIABLE FLOOD CONTROL SPACE	400,000 – 670,000 acre-feet	400,000 – 600,000 acre-feet	400,000 – 600,000 acre-feet	400,000 – 600,000 acre-feet
RATE OF RELEASE CHANGE				
Increase Outflow ≤ 25 kcfs Outflow ≥ 25 kcfs Outflow ≥ 145 kcfs Outflow ≥ 245 kcfs	5,000 cfs/hour 7,000 cfs/hour Unlimited	No Change 15,000 cfs/hour 15,000 cfs/hour Unlimited	No Change 15,000 cfs/hour 15,000 cfs/hour Unlimited	No Change 15,000 cfs/hour Unlimited Unlimited
Decrease	5,000 cfs/hour	No Change	No Change	No Change
Aggressive Ramping 12-hour Forecast Window	145,000 cfs-FEMA base flood 245 kcfs < Inflow < 365 kcfs	Target 160,000 cfs 270 kcfs < Inflow < 370 kcfs Target 145,000 cfs 250 kcfs < Inflow < 370 kcfs Target 130,000 cfs 200 kcfs < Inflow < 360 kcfs	Target 160,000 cfs 270 kcfs < Inflow < 370 kcfs Target 145,000 cfs 250 kcfs < Inflow < 370 kcfs Target 130,000 cfs 200 kcfs < Inflow < 360 kcfs	Target 160,000 cfs 270 kcfs < Inflow < 370 kcfs Target 145,000 cfs 250 kcfs < Inflow < 370 kcfs Target 130,000 cfs 200 kcfs < Inflow < 360 kcfs
CONDITIONS FOR LIMITATION				
Concurrent operation of Outlet Works and Spillway	60 percent Outlet Opening	60 percent Outlet Opening	60 percent Outlet Opening	60 percent Outlet Opening
Spillway Gate Operations	Controlled	Controlled	Controlled	Controlled
Mitigations to reduce impact to spawning gravels	None	60 percent of Inflow Rule Outflow = 60 percent of actual or forecasted inflow (25 kcfs < Inflow < 150 kcfs) Dispense with rule if flood encroachment ≥ 20 percent	60 percent of Inflow Rule Outflow = 60 percent of actual or forecasted inflow (25 kcfs < Inflow < 150 kcfs) Dispense with rule if flood encroachment ≥ 20 percent	60 percent of Inflow Rule Outflow = 60 percent of actual or forecasted inflow (25 kcfs < Inflow < 150 kcfs) Dispense with rule if flood encroachment ≥ 20 percent
Vortices operation to prevent Formation	None	No Change	No Change	No Change
Spray operation to prevent impacts to powerhouse	None	No Change	No Change	No Change

Key
@ - at
cfs - cubic feet per second
FEMA - Federal Emergency Management Agency
PMF - probable maximum flood
SAFCA - Sacramento Area Flood Control Agency
STG - submerged-tainter-gate
TBD - to be determined
kcfs - thousand cubic feet per second
w/o - without
< - less than
≥ - greater than or equal to

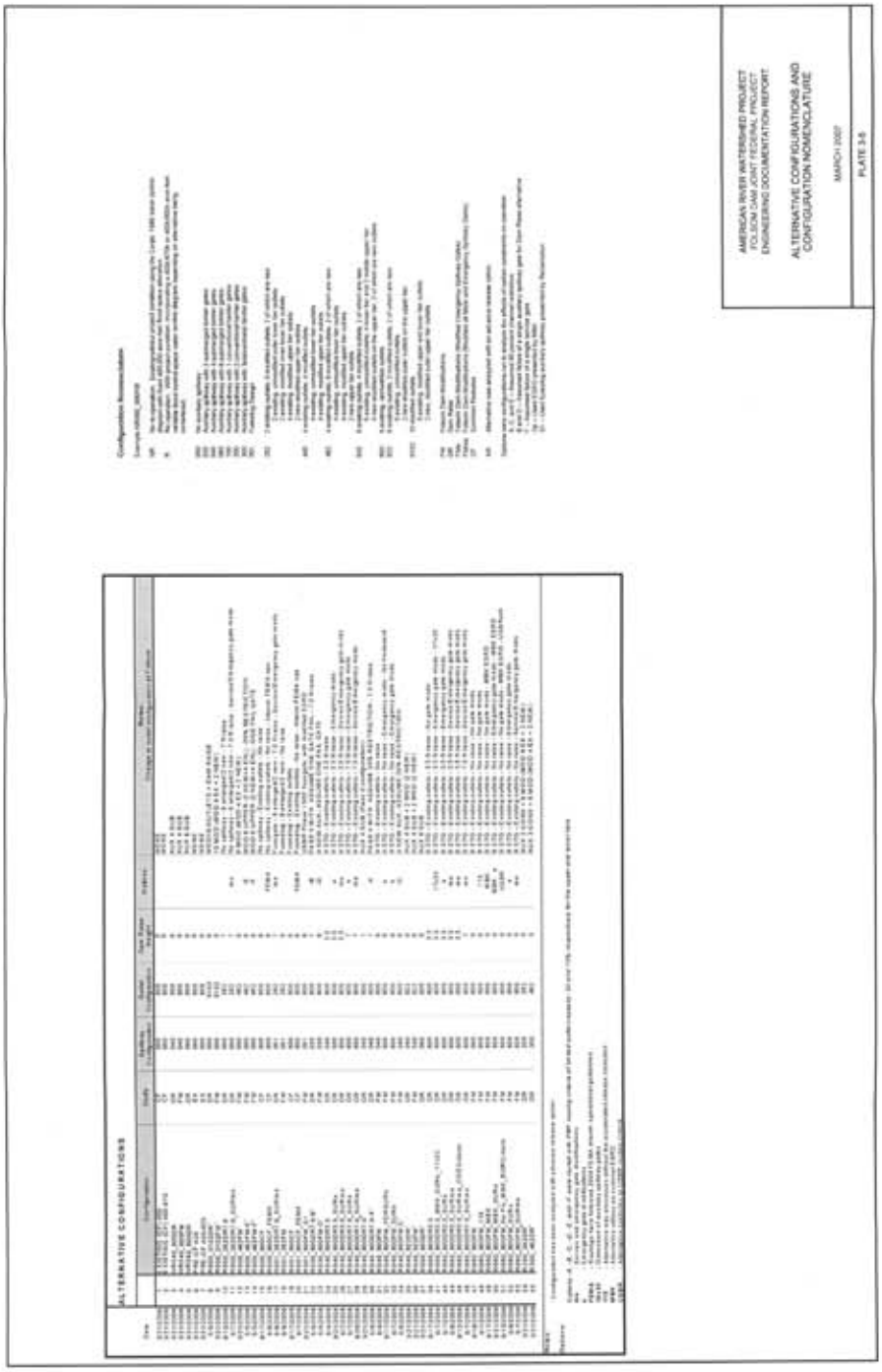
Notes:
1 7-foot dam raise is only associated with the four-STG configuration proposed as part of the Joint Federal Project with-project condition.
2 Utilization of emergency gates is limited to discharges greater than 240,000 cfs.
3 Final configuration of the main spillway gates has not yet been determined; this analysis assumes a potential resizing of the gates to 42 feet x 68 feet exists only with a dam raise of 7 feet or higher.

AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT

COMPARISON OF KEY OPERATIONAL DIFFERENCES BETWEEN PROJECTS

MARCH 2007

PLATE 3-4

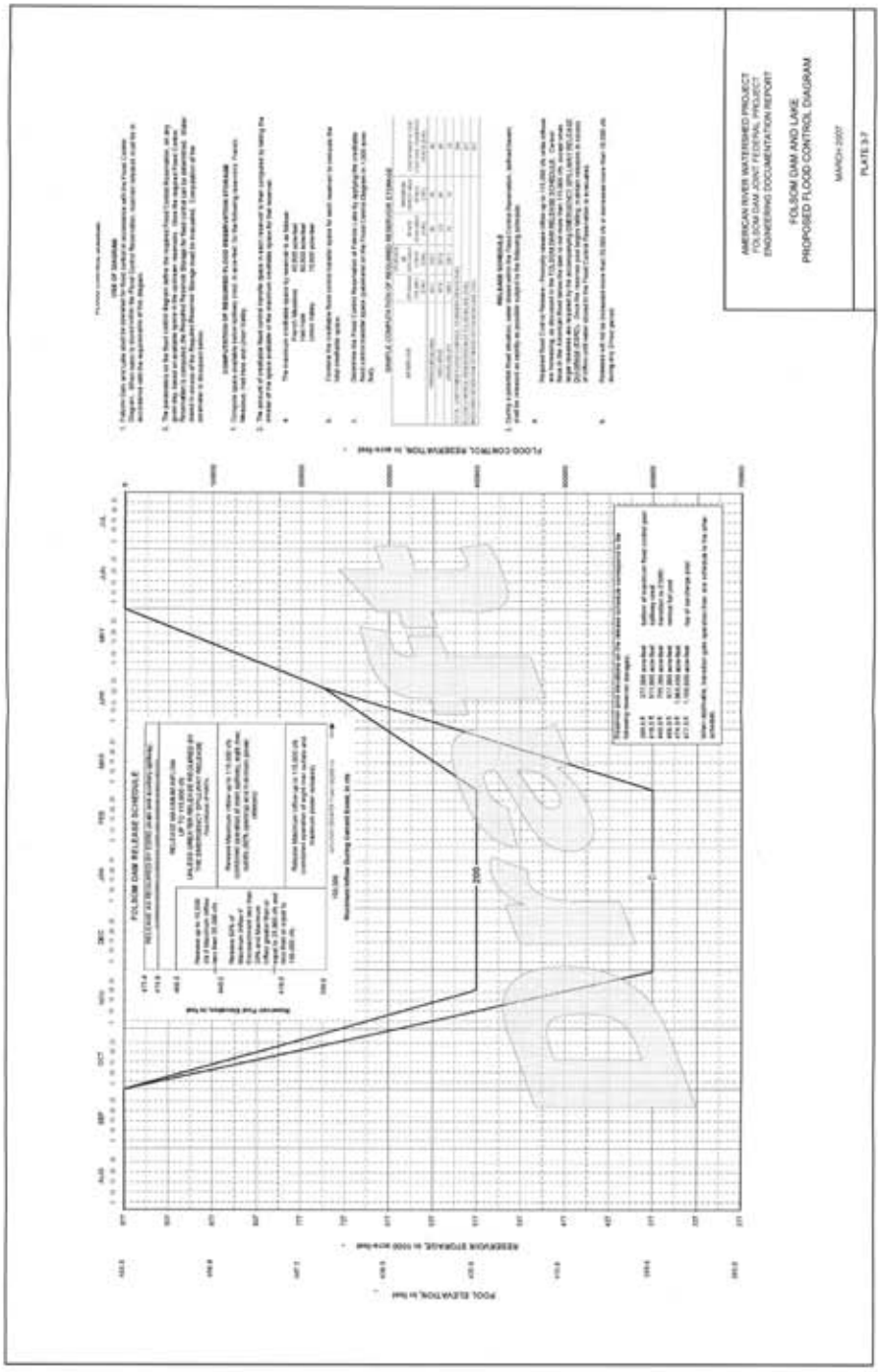

ALTERNATIVE CONFIGURATIONS
Configuration
Notes
Configuration Nomenclature
AMERICAN RIVER WATERSHED PROJECT
FOLSOM AREA FLOOD CONTROL PROJECT
ENGINEERING DOCUMENTATION REPORT
ALTERNATIVE CONFIGURATIONS AND CONFIGURATION NOMENCLATURE
MARCH 2007
PLATE 3-8

AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM WATER CONTROL PROJECT
ENGINEERING DOCUMENTATION REPORT

COMPARISON OF KEY OPERATIONAL DIFFERENCES
(WITH – PROJECT COMPARISONS MADE TO
IMMEDIATELY PRECEDING STUDY)

MARCH 2007

PLATE 9.6

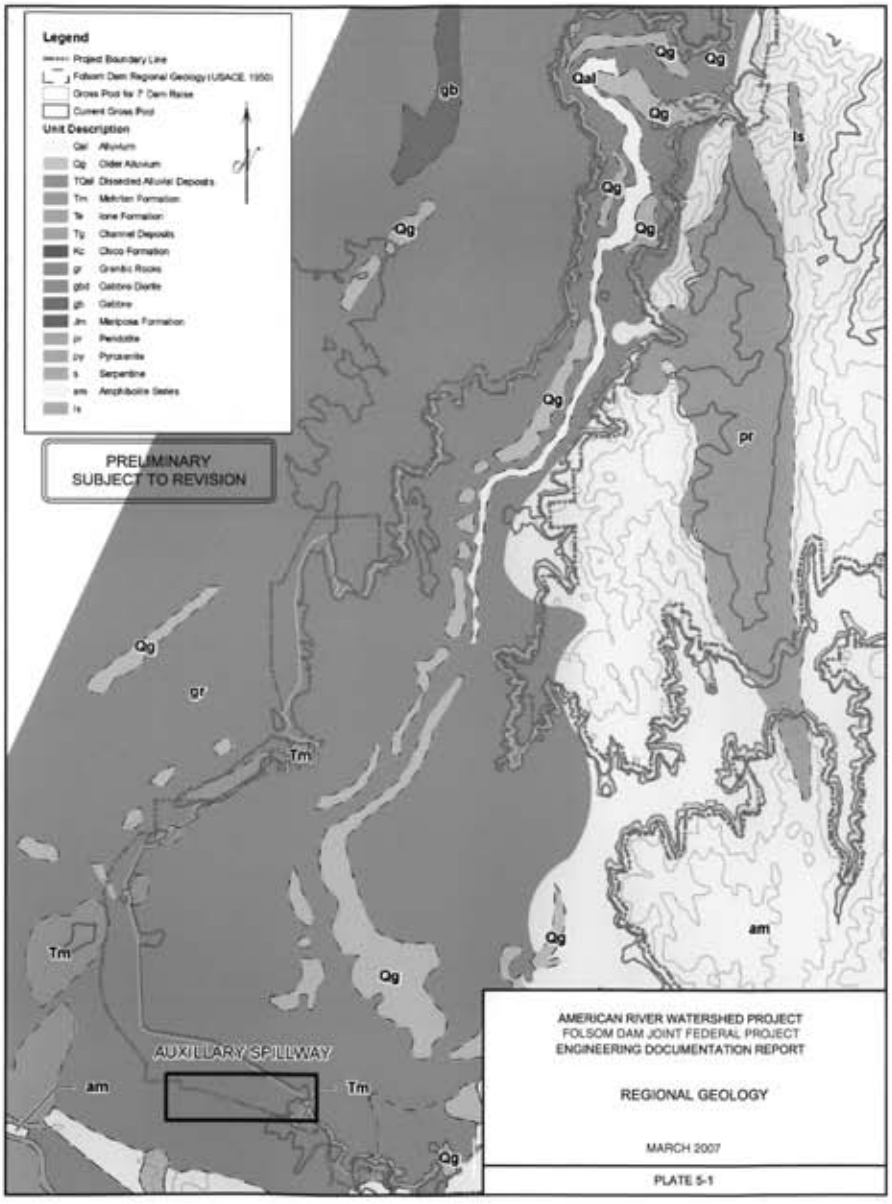


AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT

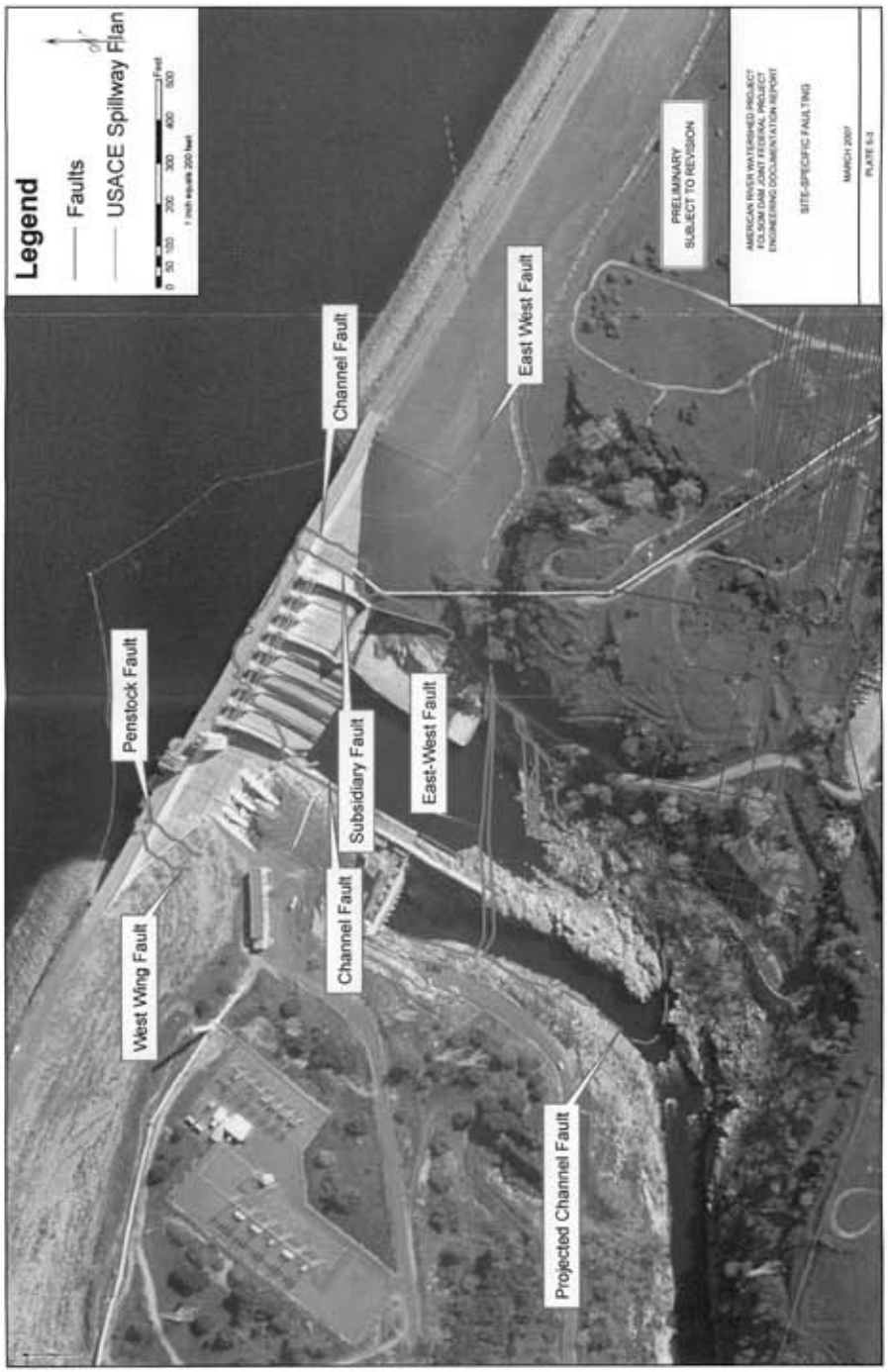
FOLSOM DAM AND LAKE
PROPOSED FLOOD CONTROL DIAGRAM

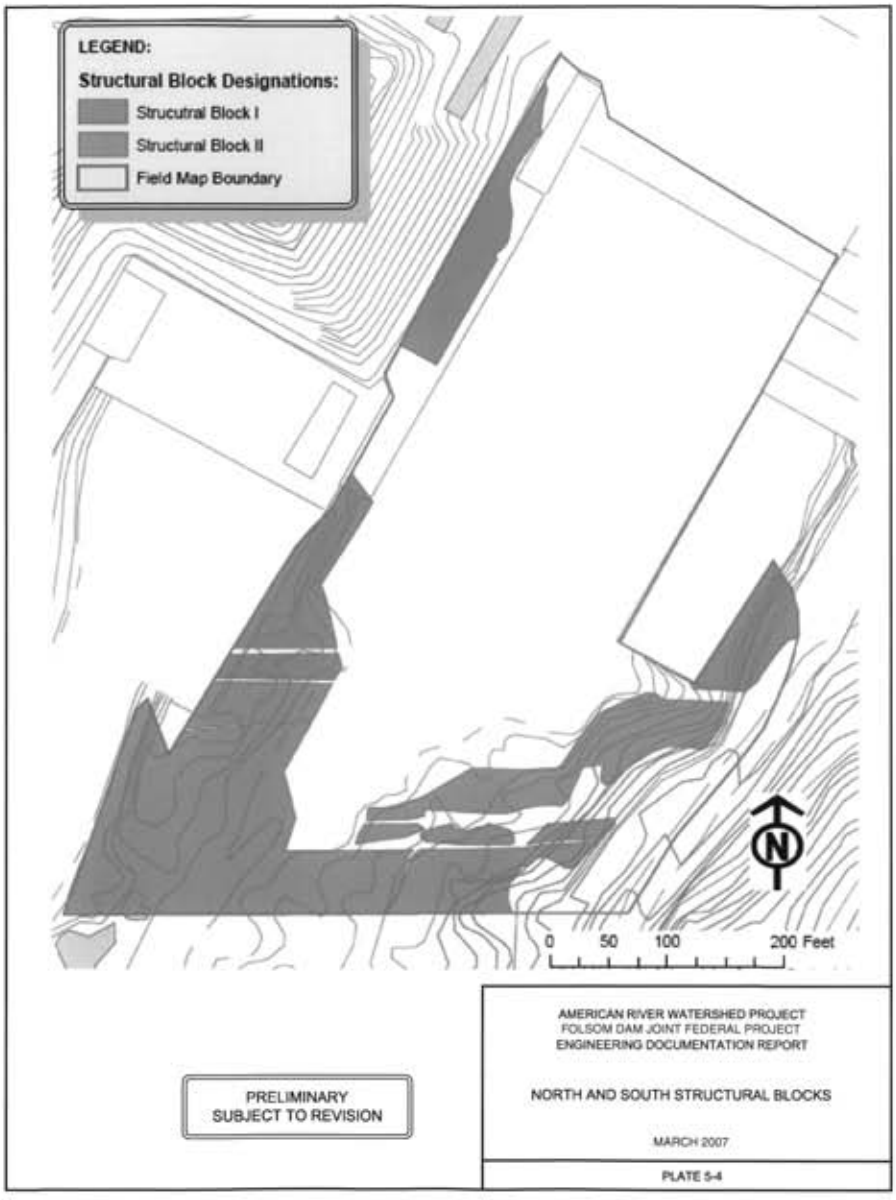
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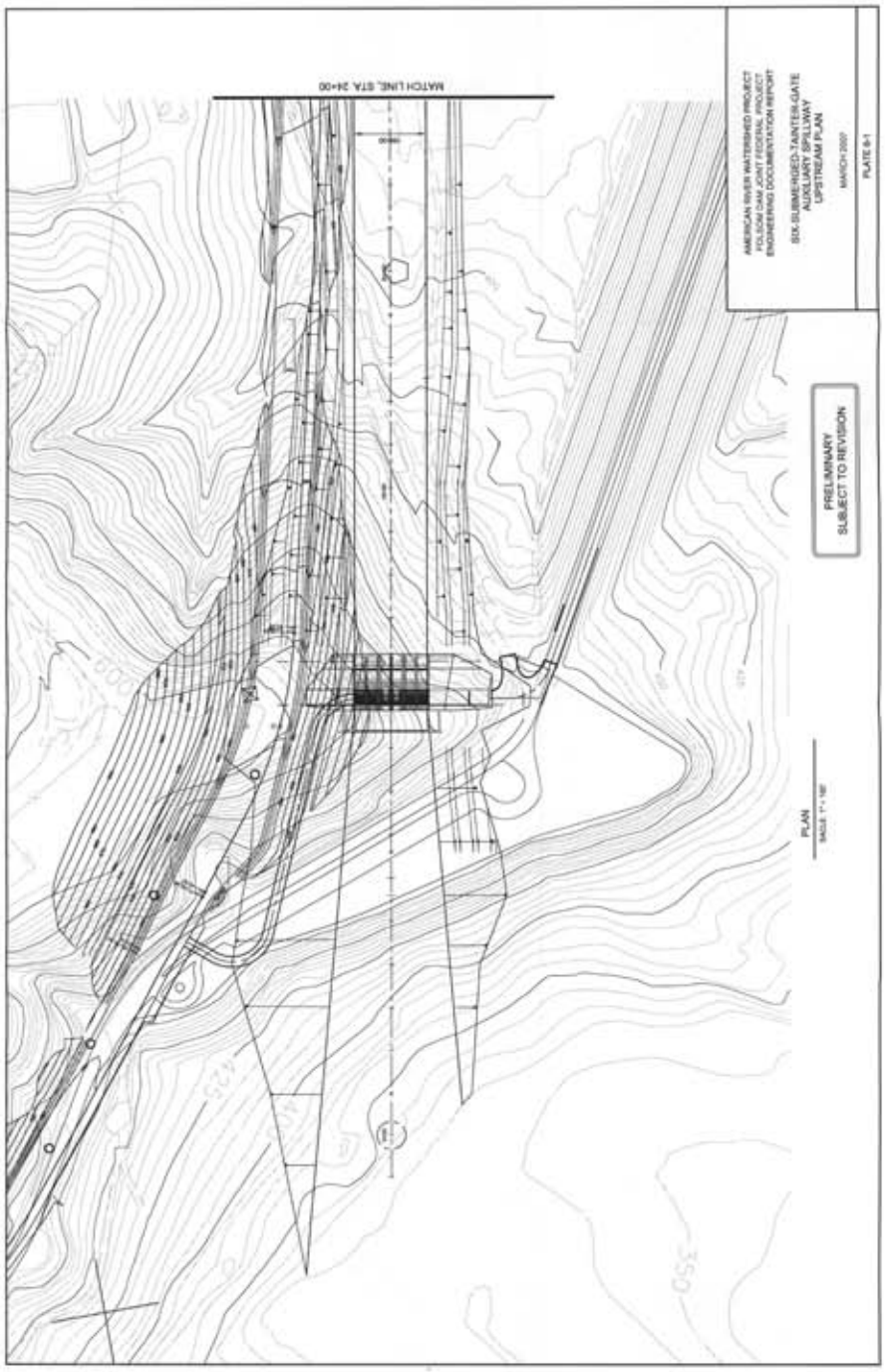
PLATE 3-7


Legend
Project Boundary Line
Folsom Dam Regional Geology (USACE 1955)
Gross Pool for 7' Dam Raise
Current Gross Pool
Unit Description
Qal Alluvium
Qg Older Alluvium
TQal Dissected Alluvial Deposits
Tm Mehrten Formation
Te Ione Formation
Tg Channel Deposits
Kc Chico Formation
gr Granitic Rocks
gbd Gabbro Diorite
gb Gabbro
Jm Mariposa Formation
pr Peridotite
py Pyroxenite
s Serpentine
am Amphibolite Series
ls
PRELIMINARY
SUBJECT TO REVISION
AUXILLARY SPILLWAY
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT
REGIONAL GEOLOGY
MARCH 2007
PLATE 5-1

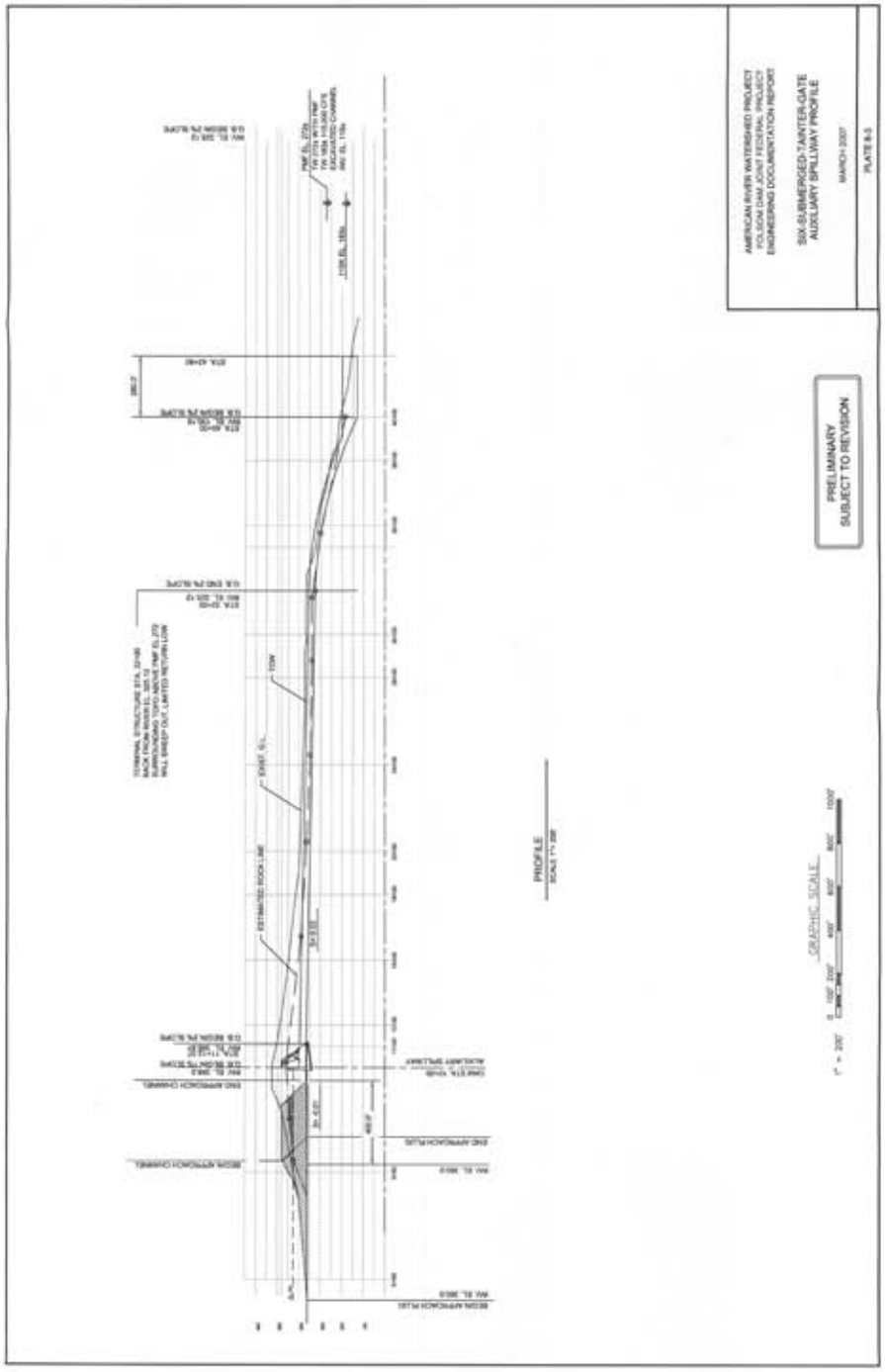

Legend
DH-8 USBR Borings (2005-2006)
D2 USACE Borings (2005-2006)
Phase II Proposed Borings
CB-14 URS Coreholes (2005)
MB-19 URS Hollow/Solid Stem Auger/Borings (2006)
1F-84 Horizontal Drill Hole (USACE, 1950)
1F-56 Vertical Drill Hole (USACE, 1950)
SF-2 Auger Hole (USACE, 1950)
3F-6 Churn Drill Hole (USACE, 1950)
204 Coreholes (USACE, 1950)
GSTS Plan
Artificial Fill (Kleinfelder 2005)
Mehrten Conglomerate (Kleinfelder 2005)
Granodiorite Outcrops (Kleinfelder 2005)
Folsom Dam Regional Geology (USACE, 1950)
0
500
Feet
1,000
1 inch equals 500 feet
PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT
AUXILIARY SPILLWAY GEOLOGY
AND EXPLORATIONS
MARCH 2007
PLATE E-2

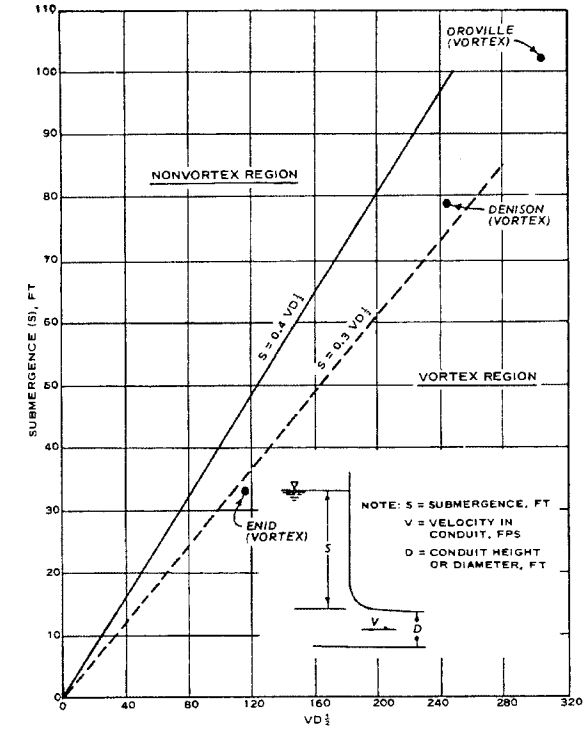

Legend
Faults
USACE Spillway Flan
Penstock Fault
West Wing Fault
Channel Fault
Subsidiary Fault
Channel Fault
East-West Fault
East West Fault
Projected Channel Fault
PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT
SITE-SPECIFIC FAULTING
MARCH 2007
PLATE E-3


LEGEND:
Structural Block Designations:
Strucutral Block I
Structural Block II
Field Map Boundary
N
0 50 100 200 Feet
PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT
NORTH AND SOUTH STRUCTURAL BLOCKS
MARCH 2007
PLATE 5-4


AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM MODIFICATIONS PROJECT
ENGINEERING DOCUMENTATION REPORT
SIX-SUBMERGED-TAINTER-GATE
AUXILIARY SPILLWAY
UPSTREAM PLAN
MARCH 2007
PLATE 6-1
PRELIMINARY
SUBJECT TO REVISION
MATCH LINE, STA. 24+00
PLAN


AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT
SIX-SUBMERGED-TAINTER-GATE
AUXILIARY SPILLWAY
DOWNSTREAM PLAN
MARCH 2007
PLATE E-2
PRELIMINARY
SUBJECT TO REVISION
PLAN
MATCH LINE STA. 24+00


AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT
SIX-SUBMERGED-TAINTER-GATE
AUXILIARY SPILLWAY PROFILE
MARCH 2007
PLATE 8-3
PRELIMINARY
SUBJECT TO REVISION
PROFILE
GRAPHIC SCALE



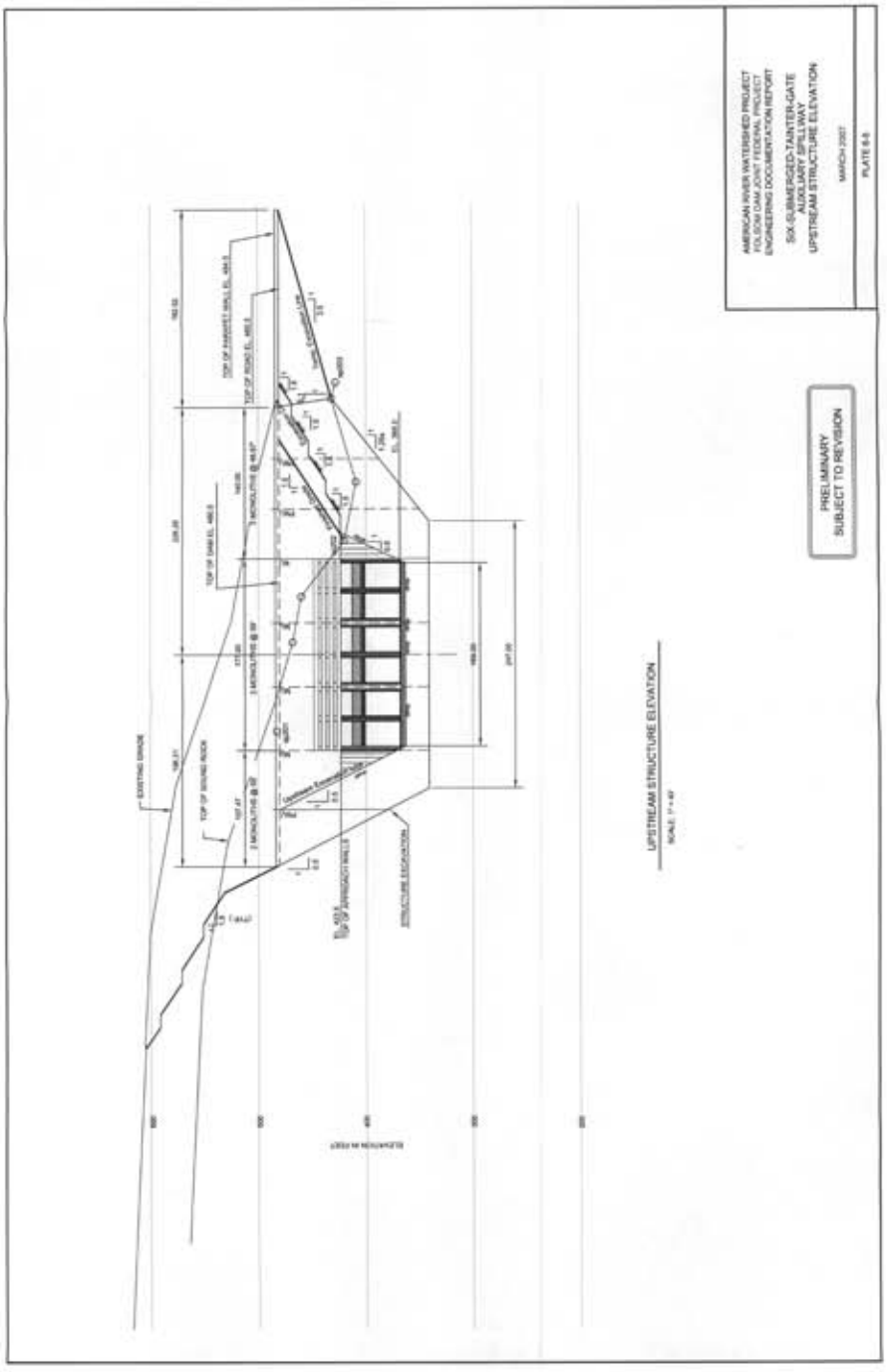
PRELIMINARY
SUBJECT TO REVISION

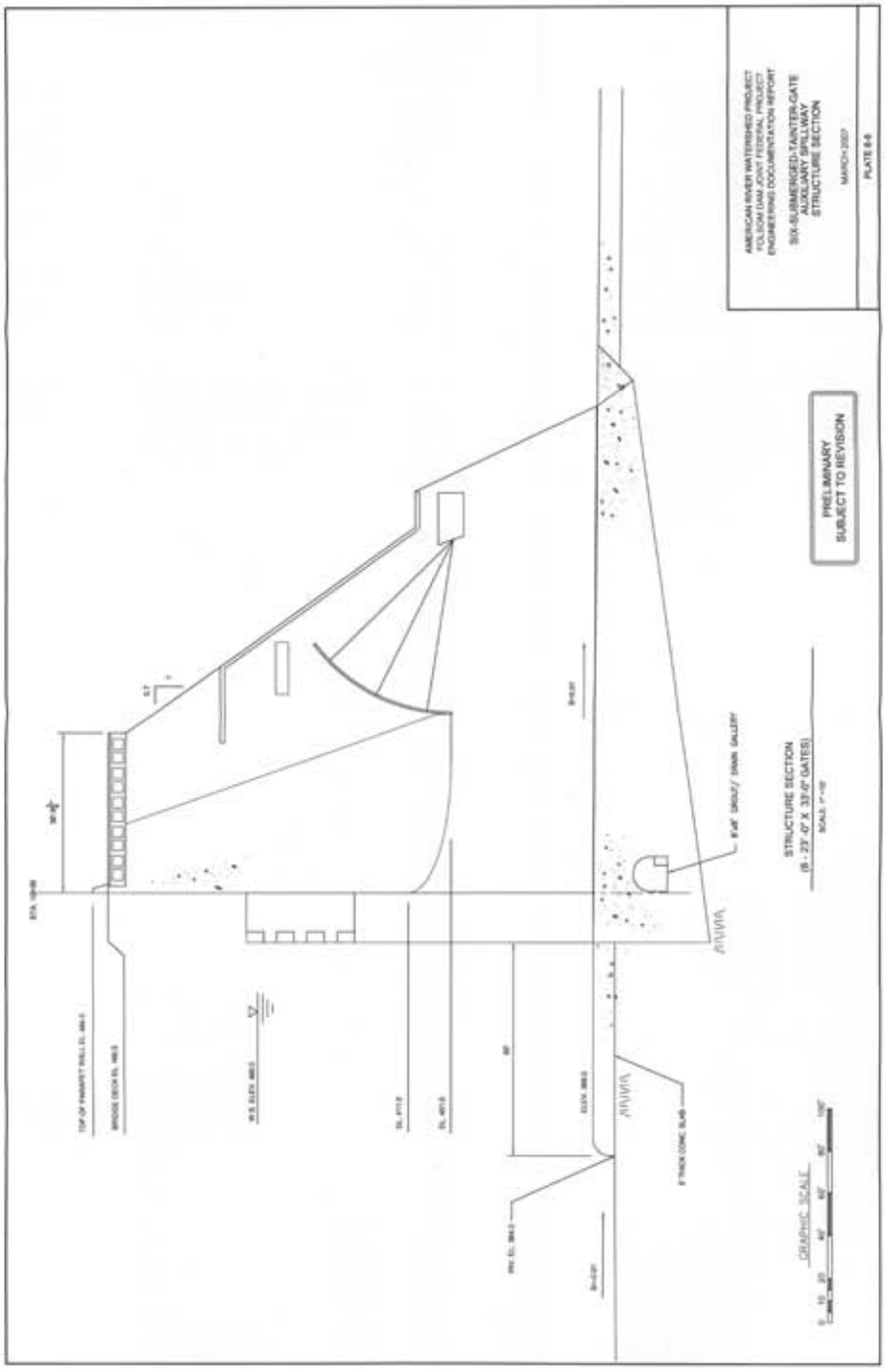
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT

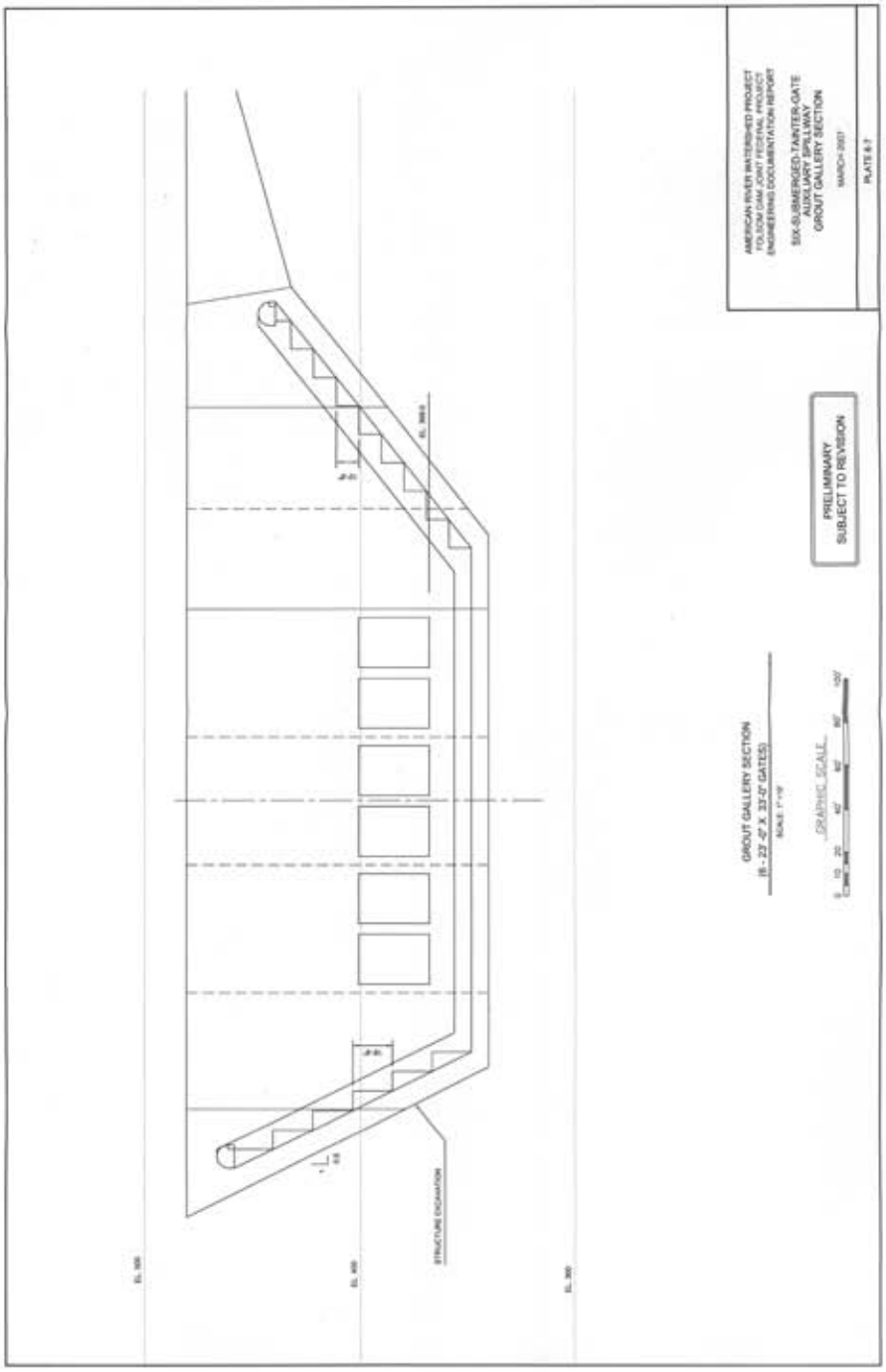
VORTEX INTENSITY

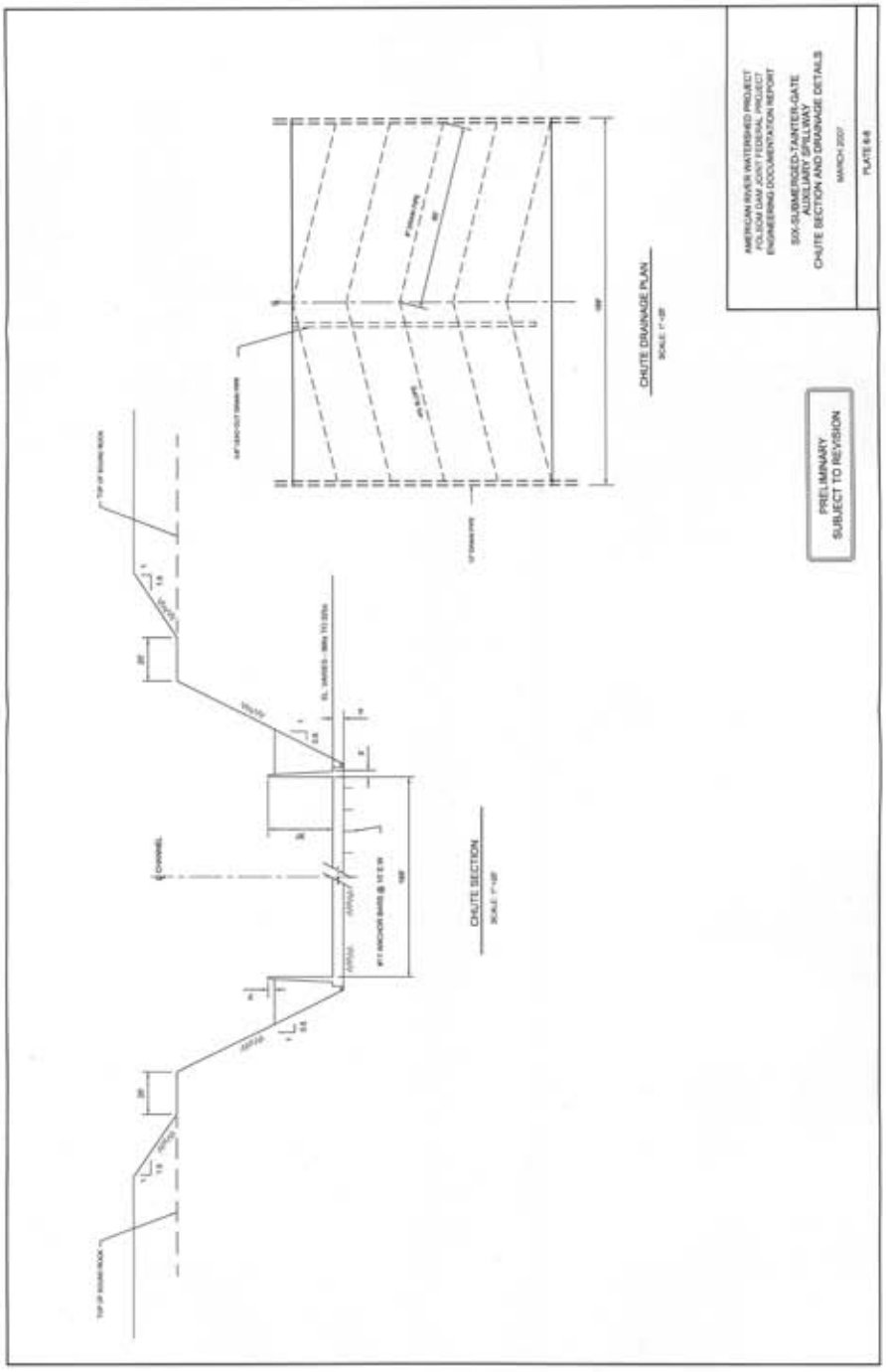
MARCH 2007

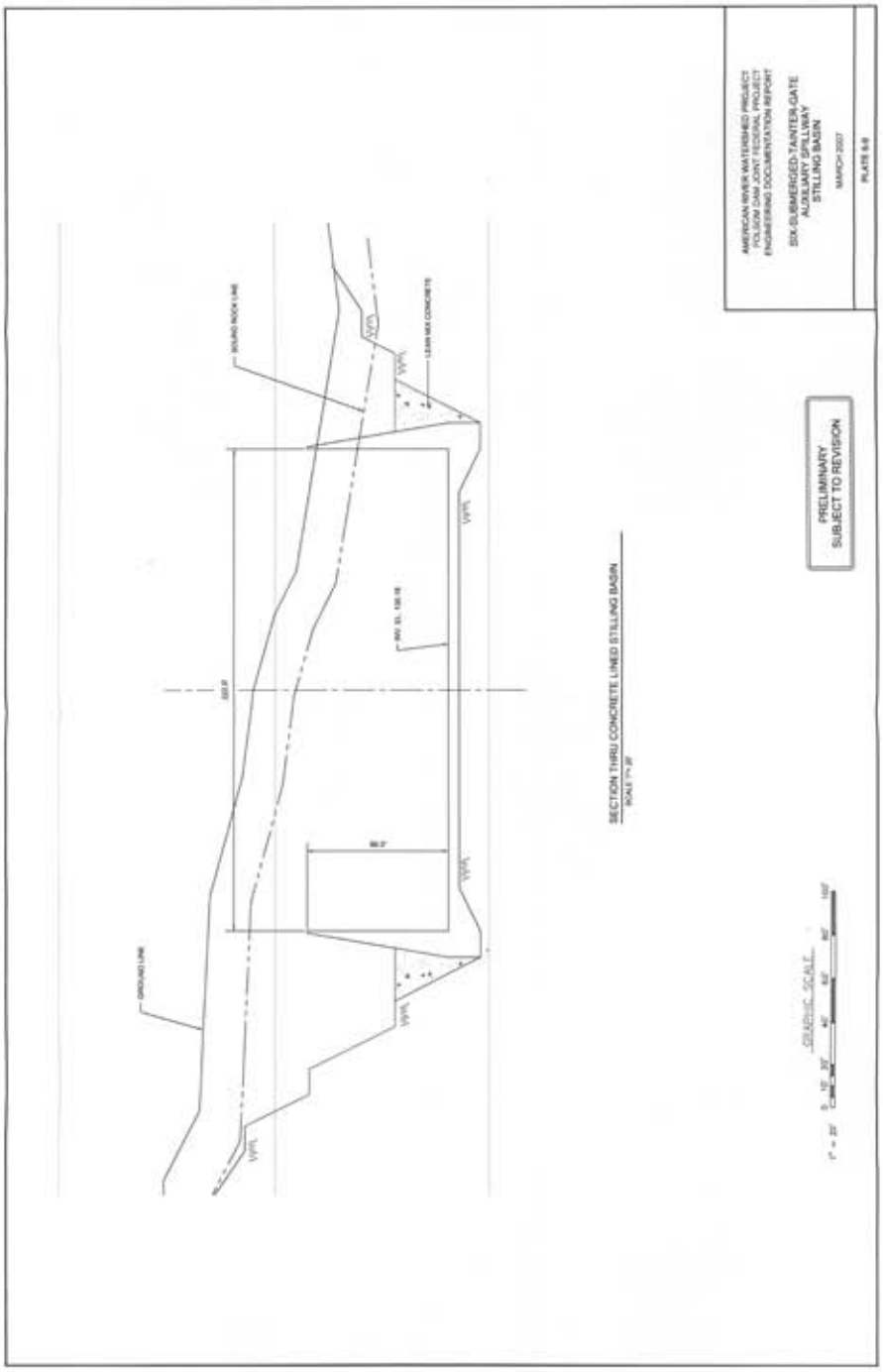
PLATE 6-4

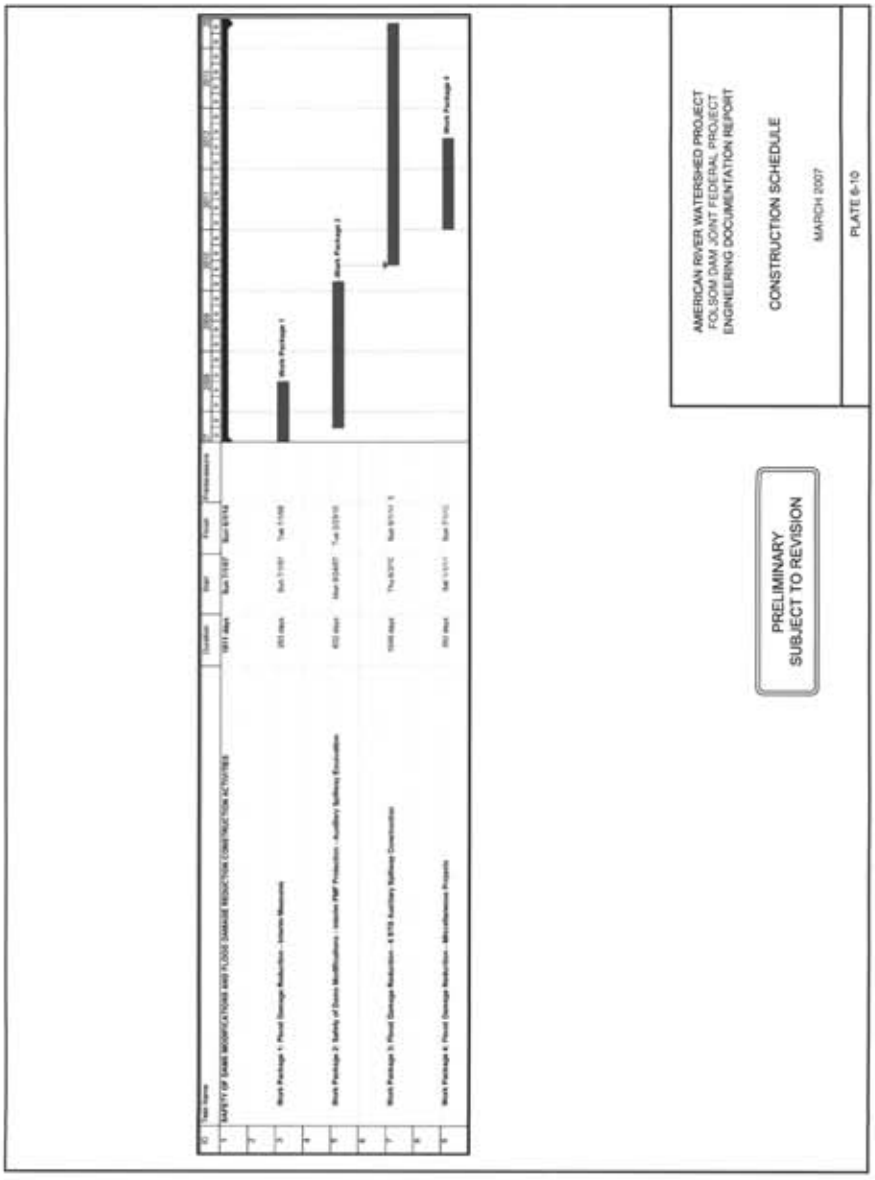

AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT
SIX SUBMERGED TAINTER GATE
AUXILIARY SPILLWAY
UPSTREAM STRUCTURE ELEVATION
MARCH 2007
PLATE E-8
PRELIMINARY
SUBJECT TO REVISION
UPSTREAM STRUCTURE ELEVATION


AMERICAN RIVER WATERSHED PROJECT
FOLSOM, CALIFORNIA
ENGINEERING DOCUMENTATION REPORT
SIX-SUBMERGED-TAINTER-GATE
AUXILIARY SPILLWAY
STRUCTURE SECTION
MARCH 2007
PLATE E-8
PRELIMINARY
SUBJECT TO REVISION
STRUCTURE SECTION
(6 - 29'-0" X 33'-0" GATES)
GRAPHIC SCALE


AMERICAN RIVER WATERSHED PROJECT
FOLSOM, CALIFORNIA
ENGINEERING DOCUMENTATION REPORT
SIX-SUBMERGED-TAINTER-GATE
AUXILIARY SPILLWAY
GROUT GALLERY SECTION
MARCH 2007
PLATE 6-7
PRELIMINARY
SUBJECT TO REVISION
GROUT GALLERY SECTION
(6 - 23'-0" X 33'-0" GATES)
GRAPHIC SCALE
EL. 500
EL. 400
EL. 300
STRUCTURE EXCAVATION


AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT
SIX-SUBMERGED-TAINTER-GATE
AUXILIARY SPILLWAY
CHUTE SECTION AND DRAINAGE DETAILS
MARCH 2007
PLATE E-8
PRELIMINARY
SUBJECT TO REVISION
CHUTE DRAINAGE PLAN
CHUTE SECTION
CHANNEL


AMERICAN RIVER WATERSHED PROJECT
FOLSOM, CALIFORNIA PROJECT
ENGINEERING DOCUMENTATION REPORT
SIX-SUBMERGED-TAINTER-GATE
AUXILIARY SPILLWAY
STILLING BASIN
MARCH 2007
PLATE 6-8
PRELIMINARY
SUBJECT TO REVISION
SECTION THRU CONCRETE LINED STILLING BASIN
GRAPHIC SCALE
GROUND LINE
SOUND ROCK LINE
LEAN MIX CONCRETE
EV. EL. 138.16


PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM DAM JOINT FEDERAL PROJECT
ENGINEERING DOCUMENTATION REPORT
CONSTRUCTION SCHEDULE
MARCH 2007
PLATE E-10

Attachment C1 – PMF Routing Assumptions, Guidelines and Criteria
Folsom Dam Joint Federal Project
Engineering Documentation Report

PMF ROUTING ASSUMPTIONS, GUIDELINES, AND CRITERIA

General Assumptions

- Flood control operation is prescribed by the U.S. Army Corps of Engineers (Corps). Although the current authorized Top of Flood Control Reservation is at reservoir elevation 466, a joint agreement between the U.S. Army Corps of Engineers (Corps) and the U.S. Bureau of Reclamation (Reclamation) had extended flood control operations into the surcharge storage space up to pool elevation 470.
- ***Any changes to the formally allocated flood control space should be documented and requested in writing.***
- Above pool elevation 466, the releases within the surcharge storage space are controlled by the Reclamation.
- The PMF event for Folsom Dam and Lake was developed in 2001 using Hydrometeorological Report (HMR) 59. The hydrograph was developed based on a North Fork storm centering with no upstream failures. LL Anderson Dam is presumed fixed so as to pass its PMF.
- The PMF event is preceded 8-days in advance by an antecedent flood (72-hours of rainfall) immediately followed by the main flood with a peak inflow of 905,770 ft^3/s and a 5-day volume of 3,206,000 acre-feet. The antecedent flood (50 percent PMF hydrograph) was derived using an HEC-1 model. This process required that each sub-area hydrograph ordinate be reduced by half and routed through the upstream reservoirs and reaches down to Folsom.
- Section 101(a)(6) of the Water Resources Development Act (WRDA) 1999 (Public Law 106-53) specifies that the Secretary of the Army and Secretary of the Interior shall coordinate. Upon completion and improvements to Folsom Dam, the variable space allocated to flood control within the reservoir shall be reduced from the current interim operating range of 400-670,000 acre-feet to 400,000-600,000 acre-feet.

Description of Alternatives

- Joint Federal Project
  - No Dam Raise
  - Existing spillway service/emergency gates not replaced.
  - Controlled spillway flows are maintained throughout operation (no free flow operation).
  - Discharges do not exceed 160,000 ft^3/s until the pool elevation rises above the Flood Pool elevation target set by routing the 0.05 probability flood event. Note that the antecedent event for the PMF is roughly equivalent in volume to the 0.05 probability flood event and should be taken into consideration when establishing the flood pool elevation requirement.
- Selected (Joint Federal) Project
  - 3.5 ft Dam Raise
  - Existing emergency spillway gates are replaced **and**/or increased in height.
  - Existing service spillway gates are not replaced.
  - Controlled spillway flows are maintained throughout (no **planned** free flow operation).
  - Discharges do not exceed 160,000 ft^3/s until the pool elevation rises above the Flood Pool elevation target ***at which enhanced flood protection can be provided.***
  - The service spillway gates**, while fully open,** could be overtopped for floods approaching the PMF. The following is as noted in Reclamation's 2004 Folsom Dam Hydrologic Corrective Action Study report: *Although the gates could fail under this condition, any failed gates would likely wash downstream. This is not viewed as a dam safety issue since they would not impede flows through the spillway. Any additional flow generated by failed gates would be relatively small compared to the total flow being discharged.* ***Recent model studies have shown the gates begin to overtop at a reservoir water surface of about 481.0. Given a 3.5 foot dam raise the maximum reservoir water surface should not be greater than 481.0. The BOR notes that if the gates are overtopped it will be by minimal depths.*** **Under different circumstances, a notable gate failure occurred at Folsom Dam on 17 July 1995. A spillway tainter gate broke as it was being raised. This is an example where a failed or malfunctioning gate partially impeded flows because it did not wash downstream.**

PMF ROUTING ASSUMPTIONS, GUIDELINES, AND CRITERIA

Summary of Physical Constraints

- All existing-sized (5' x 9') river outlets retain their 60% gate opening restriction during concurrent spillway gate operation. **Once flows exceed 115,000 cfs, the outlets should not be operated concurrently with the main dam spillway gates under normal flood operations.**
- Any power units that are assumed operating would become non-functional once the tailwater discharge exceeds 250,000 ft^3/s.
- Emergency tainter gate operations can begin once the tailwater discharge reaches 240,000 ft^3/s or water surface is within 1 ft of overtopping closed emergency gates
- **It is physically impossible to open the main dam service spillway gates beyond 457.0 feet. Therefore, it is physically impossible to operate the service spillway gates in "free flow" conditions. Gate tests were per*formed on November 15, 2006 to determine the current and maximum spillway gate openings. The gate was reportedly opened to 40 feet (elevation 457) where it contacted the first limit switch. Operators at the dam believe the gates can be easily modified to be opened to the full opening height of 459.0. Reclamation prefers that orifice flow be maintained.* The final design of the new emergency tainter gates will determine how high they can be opened..**
- The safe long-term channel capacity of the downstream levees was assumed to be 160,000 ft^3/s.

Operation Criteria

- The freeboard requirement is set at 3 ft per Reclamation (Denver).
- No power units are available for use in the routings per Reclamation (Folsom). All power units are off-line.
- Releases from Folsom Dam must **not** be greater than the flows produced without the project in place.
- The dam was assumed to be releasing a minimum 2,000 ft^3/s at the start of the routing.
- Two methods are available for routing the PMF:
    - 1) use an antecedent flood starting routed at the bottom of the flood control pool. (The initial reservoir water surface was assumed to be at elevation 399.63). This established the initial starting conditions for the PMF (around pool elevation El 401) or
    - 2) route the PMF alone starting at normal full pool (466 ft). The second option is appropriate for projects with limited release capabilities.
- All routings reflect the first method which provides 600,000 acre-feet of Flood Control Reservation (also referred to as Flood Control Space) between the initial water surface and the top of joint use at elevation 466
- The PMF event was routed assuming a 4-hour delay in determining outflows until the releases reached 115,000 ft^3/s. This simulates initial delays in computing inflow, scheduling/performing gate changes, solving mechanical problems, or delays in staffing the facility. Once releases reached 115,000 ft^3/s outflows were adjusted based on 1-hour intervals until reaching the top of the surcharge storage space.
- Discharge must **not** exceed 160,000 ft^3/s while the water surface elevation is less than the storage space elevation, ***which provides the desired level of flood protection***.
- The downstream levees were assumed to remain intact throughout the antecedent event.

PMF ROUTING ASSUMPTIONS, GUIDELINES, AND CRITERIA

Operation Criteria (continued)

- Ramp up Rate Limitations

Discharge is less than or equal to 20,000 ft^3/s	no more than 10,000 ft^3/s during any 2-hour period
Discharge is less than or equal to 160,000 ft^3/s	no more than 30,000 ft^3/s during any 2-hour period
Discharge is greater than or equal to 160,000 ft^3/s	***no more than 100,000 ft^3/s during any 1-hour period for discharges below 360,000 ft^3/s.***

Ramp down Rate Limitation:

Outflow is less than or equal to 115,000 ft^3/s	no more than 10,000 ft^3/s during any 2-hour period.
Outflow is greater than 115,000 ft^3/s	Lesser of maximum peak release or 125 percent of inflow while pool elevation greater than 448 feet.

- Above storage elevation (468 for the JFP routing) at which the desired level of flood protection is reached.–***Discharge should be increased by no more than 100,000 ft^3/s during any 1-hour period for discharges below 360,000 ft^3/s.*** (Note that the antecedent event for the PMF is roughly equivalent in volume to the 0.05 probability flood event and should be taken into consideration when establishing the flood pool elevation requirement. The maximum pool elevation for the antecedent event is slightly higher than the 0.05 probability flood event.)
- ***For discharges greater than 360,000 ft^3/s*** releases are limited to inflow.
- ***Discharge should be increased by no more than 100,000 ft^3/s during any 1-hour period for discharges below 360,000 ft^3/s. See above.***
- Releases cannot exceed discharge capacity.
- A ramp-down rate of 10,000 ft^3/s in one hour and no ramp down the next hour is considered acceptable
- The Accelerated Transition rule maximizes use of the downstream capacity. Releases were increased from 115,000 ft^3/s to 160,000 ft^3/s as soon as the requirements of the accelerated transition zone were met. The requirements of the accelerated transition zone are as follows. Releases may be increased from 115,000 ft^3/s to 130,000 ft^3/s when the current inflow is greater than 200,000 ft^3/s and the 12-hour forecasted inflow is greater than 360,000 ft^3/s. Releases may be increased from 130,000 ft^3/s to 145,000 ft^3/s when the current inflow is greater than 250,000 ft^3/s and the 12-hour forecasted inflow is greater than 370,000 ft^3/s. Releases may be increased from 145,000 ft^3/s to 160,000 ft^3/s when the current inflow is greater than 270,000 ft^3/s and the 12-hour forecasted inflow is greater than 370,000 ft^3/s. The requirement to limit the ramp-up rate to 15,000 ft^3/s per hour or no more than 30,000 ft^3/s during any 2-hour period still applies. Ramping rate requirements still apply.
- Fish and Wildlife Service Mitigation Rule. For inflows greater than or equal to 25,000 ft^3/s, less than or equal to 150,000 ft^3/s, limit the release to 60 percent of previous hour inflow. Discontinue this rule once the 12-hour forecast exceeds 150,000 ft^3/s or the reservoir rises above elevation 416.15 (20 percent encroachment).
- For a falling reservoir below elevation 448, releases were computed using an USACE drawdown algorithm which attempts to evacuate the Flood Control Reservation plus inflow in 1 day for each iteration while at the same time reduce the releases from 115,000 ft^3/s in 5,000 ft^3/s increments. The drawdown algorithm succeeds in evacuating most of the Flood Control Reservation below elevation 448 in a little more than 3 days.
- For a falling reservoir with releases at or below 15,000 ft^3/s, the ramp-down rate was limited to 1,000 ft^3/s per hour as defined in the USACE drawdown algorithm.

Attachment C2 – Project Cost
Folsom Dam Joint Federal Project
Engineering Documentation Report

****TOTAL PROJECT COST SUMMARY****

03/21/2007

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE FEASIBILITY REPORT, NED PLAN
PROJECT: FOLSOM DAM 6 - 23'X33' STG's USACE COST PORTION — U. S. ARMY CORPS OF ENGINEER, SACRAMENTO DISTRICT
LOCATION: CALIFORNIA — P.O.C. JOE W.YEE, CHIEF, COST ENGINEERING

Current MCACES Estimate Prepared: 1-Oct-2006
Effective Price Level (EPL): 1-Oct-2006

ACCOUNT NO.	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	FEATURE OMB MID PT (%)	.....FULLY FUNDED ESTIMATE. (2..... COST ($K)	CNTG ($K)	FULL ($K)
	FEDERAL COSTS								
4	DAMS	394,982	143,638	37	538,620	12.4%	441,418	164,083	605,501
6	FISH & WILDLIFE, Mit.	407	0	0	407	0.0%	407	0	407
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	395,389	143,638		539,027		441,825	164,083	605,908
30	PLAN/ENGINEERING/DESIGN	90,642	9,249	20	99,891	3.8%	93,835	9,887	103,722
31	CONSTRUCTION MANAGE'MT	32,366	11,716	36	44,082	18.8%	38,372	13,998	52,370
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	518,397	164,603		683,000		574,032	187,968	762,000
	NON-FEDERAL CONTRIBUTION	181,439	57,561		239,000		200,911	65,789	266,700
	TOTAL FEDERAL COSTS	**$336,958**	**$107,042**		**$444,000**		**$373,121**	**$122,179**	**$495,300**
	NON-FEDERAL COSTS								
	NON-FEDERAL CONTRIBUTION	181,439	57,561		239,000		200,911	65,789	266,700
	TOTAL NON-FEDERAL COSTS	**$181,439**	**$57,561**		**$239,000**		**$200,911**	**$65,789**	**$266,700**
	TOTAL FEDERAL AND NON-FEDERAL COSTS	**$518,397**	**$164,603**		**$683,000**		**$574,032**	**$187,968**	**$762,000**

GENERAL NOTES

(1 Federal administrative costs for non-Federal land acquisition.
(2 The Fully Funded cost estimate was prepared in compliance with EC 11-2-191 published in March 2006.
(3 04 Account Dams $9,610K sunk cost are cost carried over from Folsom Mods Project. Remaining cost are based on the MCACES cost estimate dated Jan. 2007.
(4 06 Account Fish and Wildlife Cost $407K sunk cost are cost carried over from Folsom Mods Project.
(5 30 Account Planning, Engineering and Design and 31 Account Construction Management cost was provided by its respective organizations.
(6 30 Account Planning, Engineering and Design $44,398K sunk cost are cost carried over from Folsom Mods Project.
(7 31 Account Construction Management $1,535K sunk cost are cost carried over from Folsom Mods Project.
(8 Total Sunk Cost as of Sept. 30, 2006 is $55,950K

CONTINGENCY RATIONALE

(A NORMAL DESIGN VARIANCES ARE EXPECTED - 20% NORMAL CONTINGENCY VALUES USED. (IN ACCOURDANCE WITH EI 01 D 010 -TABLE 13-1). DUE TO HIGHER REALIZED INFLATION THAN PROVIDED BY CWCCIS HISTORIC INFLATION RATE, A 3% COMPOUNDED PER YEAR INFLATION RATE WAS ADDED EQUALING A 37% CONTINGENCY.
THE 3% WAS BASED ON THE ESTIMATED DIFFERENCES BETWEEN ENR NEWS RECORD, CALIFORNIA CONSTRUCTION COST INDEX AND CWCCIS HISTORIC RATE.

Sherman C. Fong for CHIEF, COST ENGINEERING — CHIEF, ENGINEERING DIVISION

The estimate was prepared in accordance with current guidance. The estimate has undergone an independent technical review, and that all issues that may have been identified in the independent technical review have been resolved.

DETAILED ESTIMATE OF FIRST COST

03/14/2007

Effective Price Level (EPL) 1-Oct-2006

Auxilliary Spillway, 6-23'x33' STG

FEDERAL

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASO
04	DAMS							
04	DAMS	Sunk Cost			9,609,585			
0401	Main Dam							
040199	Associated General Items, Cost Carryover from Folsom Mods Project.							
04019902	Site Work							
	Stilling Basin							
	Sunk Cost to Oct 2005	1	JOB	LS	438,695	0	0.0	-
	Sunk Cost to Oct 2004	1	JOB	LS	2,545	0	0.0	-
04019914	Conveying Systems							
	EGB							
	Sunk Cost to Oct 2006	1	JOB	LS	683,508	0	0.0	-
	Sunk Cost to Oct 2005	1	JOB	LS	3,252,990	0	0.0	-
	Sunk Cost to Oct 2004	1	JOB	LS	65,000	0	0.0	-
04019919	Buildings, Grounds, and Utilities							
	Resident Office/Staging Area							
	Sunk Cost to Oct 2006	1	JOB	LS	2,850,717	0	0.0	-
	Sunk Cost to Oct 2005	1	JOB	LS	2,316,130	0	0.0	-
0402	AUXILLIARY SPILLWAY 6-23'x33' STG							
040201	Mob., Demob. and Preparatory Work:	1	JOB	LS	43,688,000	13,797,537	31.6	-
040203	CARE & DIVERSION OF WATER	1	JOB	LS	2,270,100	862,638	38.0	-
040204	PERMANENT ACCESS ROADS & PARKING	1	JOB					
04020402	Site Work:							
	ACCESS ROAD							
	Access Road Embankment							
	Common	94,970	CY	10.30	978,191	371,713	38.0	-
	Rock	284,915	CY	32	9,117,280	3,464,566	38.0	-
	Backfill	55,390	CY	20	1,107,800	420,964	38.0	-
	Access Roadway - 5751 LF							
	Road Base (6" section)	2,560	CY	71	181,760	69,069	38.0	-
	Road Surfacing (2" section)	855	CY	264	225,720	85,774	38.0	-
	Traffic Controls	1	JOB	LS	1,374,000	522,120	38.0	-
040210	EARTHWORK FOR STRUCTURES							
04021002	Site Work							
	Clear and Grub	49.80	AC	8,434	420,013	159,605	38.0	-
	Rock Excavation	166,390	CY	32	5,324,480	2,023,302	38.0	-
	Hual Road and Stockpile Remediation	1	JOB	LS	2,774,000	1,054,120	38.0	-
040211	FOUNDATION WORK							
04021102	Site Work							
	Stabilization of Large Rock Blocks							
	Rock Bolts 30 ft/Bolt 1-3/4"Dia.	7,650	LF	69	527,850	200,583	38.0	-
	Foundation Surface Preparation	9210	SY	67	617,070	234,487	38.0	-
	Foundation Shear Key Excavation 169 LF							
	Rock Excavation & Haul	2,940	CY	84	246,960	93,845	38.0	-
	Foundation Column Exc, 2 Ea, 140'VLF*	1,630	CY	807	1,315,410	499,856	38.0	-
04021103	Concrete							
04021103	Foundation Shear Key							
	Concrete	2,940	CY	231	679,140	258,073	38.0	-
	Reinforcement	147,000	LB	2.20	323,400	122,892	38.0	-
	Foundation Column Concr, 8' D., 140'VLF*							
	Concrete	1,630	CY	192	312,960	118,925	38.0	-
	Reinforcement	46,520	LB	2.90	134,908	51,265	38.0	-
04021113	Instrumentation							
	Structural Instrumentation							
	Accelerometers	2	EA	37,620	75,240	28,591	38.0	-
	Piezometers	6	EA	10,080	60,480	22,982	38.0	-
	Instrumentation	2	EA	54,500	109,000	41,420	38.0	-
040212	SEEPAGE CONTROL:							

DETAILED ESTIMATE OF FIRST COST(Cont'd)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASON
	Effective Price Level (EPL) 1-Oct-2006							
04021202	Site Work							
	Approach Plug Grout Grout Curtain*	55,200	LF	128	7,065,600	2,684,928	38.0	-
	Foundation Conc 2 Colum Seal (1 Stage)*	1,120	LF	147	164,640	62,563	38.0	-
	Grout Curtain Control Structure (2 Stage)	13,100	LF	243	3,183,300	1,209,654	38.0	-
	Grout Curtain L&R Wing (2 Stage)	6,400	LF	277	1,772,800	673,664	38.0	-
	Grout Curtain Consolidation (2 Stage)	2,880	LF	296	852,480	323,942	38.0	-
	Gallery Grout Curtain - inside Dam							
	Drilling and Grouting (In Grout Gallery within Structures) (3 Stage)							
	Gallery	10,310	LF	557	5,742,670	2,182,215	38.0	-
	Gallery Wing	7,700	LF	413	3,180,100	1,208,438	38.0	-
	Gallery Drain Holes (In Grout Gallery within Structures)							
	Drilling (3.5" drain holes)	5,365	LF	197	1,056,905	401,624	38.0	-
040225	APPROACH CHANNEL							
04022502	Site Work							
	Approach Channel Earthwork							
	Excavation (Sta. -95 to Sta. 5+60) (Plug for Approach Channel Excavation)							
	Common Excavation	447,980	CY	8.90	3,987,022	1,515,068	38.0	-
	Rock Excavation	120,804	CY	60	7,248,240	2,754,331	38.0	-
	Excavation Above El. 426 (Sta. 5+60 to Sta. 9+40) Channel							
	Common Excavation	254,490	CY	8.70	2,214,063	841,344	38.0	-
	Rock Excavation	101,900	CY	60	6,114,000	2,323,320	38.0	-
	Excavation Below El. 426 (Sta. 5+60 to Sta. 9+40) Channel							
	Rock Inwater Excavation	166,150	CY	82	13,624,300	5,177,234	38.0	-
	Approach Channel Stabilization	4,000	SY	509	2,036,000	773,680	38.0	-
	Approach Channel Rock Anchor	2,210	LF	40	88,400	33,592	38.0	-
	Approach Channel Surface Preparation	1,210	SY	67	81,070	30,807	38.0	-
	Approach Backfill							
	Elliptical Wall Backfill	58,000	CY	53	3,074,000	1,168,120	38.0	-
	Elliptical Wall Bedding	2,900	CY	53	153,700	58,406	38.0	-
	Elliptical Wall Riprap	5,800	CY	130	754,000	286,520	38.0	-
	Approach Channel Silt Dredging	2,000	CY	350	700,000	266,000	38.0	-
04022503	Concrete							
	Approach Channel Slab							
	Concrete	1,880	CY	292	548,960	208,605	38.0	-
	Reinforcement	188,000	LBS	2.10	394,800	150,024	38.0	-
	Approach Channel Elliptical Approach Walls							
	Concrete	2,250	CY	447	1,005,750	382,185	38.0	-
	Reinforcement	187,780	LBS	2.50	469,450	178,391	38.0	-
040227	SPILLWAY CHUTE							
04022702	Site Work							
	Chute Slab Anchor Bolts, 1							
	Anchors	93,886	LF	40	3,755,440	1,427,067	38.0	-
	Chute Slab Anchor Bolts, 2							
	Anchors	39,208	LF	40	1,568,320	595,962	38.0	-
	Chute Slab Anchor Bolts, 3							
	Anchors	4,810	LF	40	192,400	73,112	38.0	-
	Chute Surface Preparation	48,800	SY	56	2,732,800	1,038,464	38.0	-
	Chute 6" Drain							
	6" Perf PVC Herringbone Drain Under Slat	19,500	LF	72	1,404,000	533,520	38.0	-
	Chute 12" Drain							
	12 " Perf PVC Pipe on Edges	4,200	LF	68	285,600	108,528	38.0	-
	Chute Backfill							
	Pervious Fill	120,000	CY	35	4,200,000	1,596,000	38.0	-
04022703	Concrete							
	Chute Slab, 1							
	Concrete	68,060	CY	295	20,077,700	7,629,526	38.0	-
	Reinforcement	6,688,831	LBS	2.10	14,046,545	5,337,687	38.0	-
	Chute Slab, 2							
	Concrete	32,490	CY	306	9,941,940	3,777,937	38.0	-
	Reinforcement	3,248,750	LBS	2.10	6,822,375	2,592,503	38.0	-
	Chute Slab, 3							
	Concrete	4,672	CY	306	1,429,632	543,260	38.0	-
	Reinforcement	467,260	LBS	2.10	981,246	372,873	38.0	-
	Chute Wall, 1							
	Concrete	9,335	CY	838	7,822,730	2,972,637	38.0	-
	Reinforcement	1,446,670	LB	2.20	3,182,674	1,209,416	38.0	-
	Chute Wall, 2							
	Concrete	5,570	CY	923	5,141,110	1,953,622	38.0	-
	Reinforcement	974,795	LB	2.20	2,144,549	814,929	38.0	-

2

DETAILED ESTIMATE OF FIRST COST(Cont'd)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASON
	Effective Price Level (EPL) 1-Oct-2006							
	Chute Wall, 3							
	Concrete	2,338	CY	474	1,108,212	421,121	38.0	-
	Reinforcement	409,307	LB	2.30	941,406	357,734	38.0	-
	Remove temporary Wall							
	Concrete	1,489	CY	585	871,065	331,005	38.0	-
	Stilling Basin Earthwork							
	Backfill Lean Mix Concrete on side of walls	16,860	CY	290	4,889,400	1,857,972	38.0	-
	Stilling Basin Backfill							
	Pervious Fill	41,000	CY	23	943,000	358,340	38.0	-
	Stilling Basin Slab Anchors							
	Anchors	17,992	LF	40	719,680	273,478	38.0	-
	Stilling Basin Surface Preparation	27,420	SY	67	1,837,140	698,113	38.0	-
04023503	Concrete							
	Stilling Basin Slab							
	Concrete	18,532	CY	299	5,541,068	2,105,606	38.0	-
	Reinforcement	1,853,185	LBS	2.10	3,891,689	1,478,842	38.0	-
	Stilling Basin Chute Blocks							
	Concrete	695	CY	663	460,785	175,098	38.0	-
	Reinforcement	69,362	LBS	2.10	145,660	55,351	38.0	-
	Stilling Basin Chute Dentaled Sill							
	Concrete	1,132	CY	431	487,892	185,399	38.0	-
	Reinforcement	113,176	LBS	2.10	237,670	90,315	38.0	-
	Stilling Basin Chute Dentaled Blocks							
	Concrete	165	CY	830	136,950	52,041	38.0	-
	Reinforcement	16,435	LBS	2.10	34,514	13,115	38.0	-
	Stilling Basin Side and End Walls							
	Concrete	16,205	CY	392	6,352,360	2,413,897	38.0	-
	Reinforcement	1,863,575	LBS	1.70	3,168,078	1,203,870	38.0	-
040236	STILLING BASIN, Across River Bank*							
04023602	Site Work							
	Access Road							
	Road Cut	1,000	BCY	10.30	10,300	3,914	38.0	-
	Road Plat Form Gravel Fill	2,000	BCY	23	46,000	17,480	38.0	-
	Rock Slope Anchors	14,795	LF	236	3,491,620	1,326,816	38.0	-
	Foundation Wall Rock Excavation	5,100	BCY	16	81,600	31,008	38.0	-
	Foundation Rock Anchor	2,550	LF	43	109,650	41,667	38.0	-
	Foundation Rock Wall Anchor	8,250	LF	198	1,633,500	620,730	38.0	-
	Foundation Surface Prep	1,840	SY	100	184,000	69,920	38.0	-
	Concrete Retaining Wall							
	Concrete	9,700	CY	404	3,918,800	1,489,144	38.0	-
	Reinforcement	831,365	LBS	2.30	1,912,140	726,613	38.0	-
	Foundation Drainage 8" Dia. Pipe	750	LF	43	32,250	12,255	38.0	-
	Foundation Backfill	19,000	ECY	23	437,000	166,060	38.0	-
040242	Conrete Dam - Earth and Rock Fill							
	Embankment connection to Left Wing Dam							
04024202	Site Work							
	Embankment	24,000	CY	83	1,992,000	756,960	38.0	-
	Roadway - Length 183 lf							
	Road Base (6" section)	120	CY	71	8,520	3,238	38.0	-
	Road Surfacing (2" section)	40	CY	264	10,560	4,013	38.0	-
	Road Stripping	183	LF	3.90	714	271	38.0	-
04024303	Flood In Dam							
	D1 Flood Wall Slab							
	Concrete	73	CY	566	41,318	15,701	38.0	-
	Reinforcement	10,950	LBS	2.10	22,995	8,738	38.0	-
	D1 Flood Wall							
	Concrete wall	58	CY	1060	61,480	23,362	38.0	-
	Reinforcement	8,700	LBS	2.10	18,270	6,943	38.0	-
	D1 Flood Wall Anti-Graffiti	1,981	SF	11	21,791	8,281	38.0	-
	D1 Flood Wall Backfill							
	Random	35	BCY	28	980	372	38.0	-
	Filter Material	1,127	BCY	77	86,779	32,976	38.0	-
	Slope Protection RS	136	BCY	93	12,648	4,806	38.0	-
04024403	Floodwall Outside of Dam							
	Security Fence	100	LF	250	25,000	9,500	38.0	-
	Traffic Control	1	JOB	LS	61,000	23,180	38.0	-
	Silt Fence	500	LF	9.20	4,600	1,748	38.0	-

DETAILED ESTIMATE OF FIRST COST(Cont'd)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASON
	Effective Price Level (EPL) 1-Oct-2006							
	Excavation	515	CY	26	13,390	5,088	38.0	-
	OD Concrete, Slap	130	CY	522	67,860	25,787	38.0	-
	Reinforcement	16,852	LBS	2.10	35,389	13,448	38.0	-
	OD Flood Wall							
	Concrete	102	CY	1,040	106,080	40,310	38.0	-
	Reinforcement	13,241	LBS	2.10	27,806	10,566	38.0	-
	OD Flood Wall Anti-Graffiti	3,500	SF	11	38,500	14,630	38.0	-
	OD Flood Wall Backfill							
	Random	61	BCY	28	1,708	649	38.0	-
	Filter Material	1,991	BCY	77	153,307	58,257	38.0	-
	Slope Protection RS	241	BCY	93	22,413	8,517	38.0	-
04024405	Asphalt, Top of Dike							
	Demo Existing Road	1,930	BCY	52	100,360	38,137	38.0	-
	Base Course 6"	1,450	CCY	67	97,150	36,917	38.0	-
	Asphalt Concrete 2"	480	ECY	346	166,080	63,110	38.0	-
040251	CONCRETE, NON OVERFLOW SECTION:							
04025103	Concrete							
	Mass Concrete							
	Concrete	92,830	CY	172	15,966,760	6,067,369	38.0	-
	Reinforcement	227,500	LBS	3.40	773,500	293,930	38.0	-
	Dam Roadway Slab							
	6" Conc. Slab	168	CY	763	128,184	48,710	38.0	-
	Reinforcement	21,875	LBS	2.10	45,938	17,456	38.0	-
	Dam Sidewalk Slab							
	Concrete, 2' wide x 9" thick	30	CY	1927	57,810	21,968	38.0	-
	Reinforcement	2,971	LBS	2.14	6,358	2,416	38.0	-
	Dam Parapet Wall At Top of Spillway							
	Concrete Parapet Walls	55	CY	1336	73,480	27,922	38.0	-
	Reinforced Parapet Walls	7,440	LBS	2.10	15,624	5,937	38.0	-
04025199	Associated General Items							
	Gallery Dewatering Pump	4	EA	65,570	262,280	99,666	38.0	-
	Deck Road Drains	2,250	LF	15	33,750	12,825	38.0	-
	Deck Stripping	500	LF	3.20	1,600	608	38.0	-
	Deck Expansion Jts	175	LF	12	2,100	798	38.0	-
	Upstream Guard Rail 1.5 ft height	250	LF	122	30,500	11,590	38.0	-
	Downstream Open Guard Rail 3.5 ft height	250	LF	140	35,000	13,300	38.0	-
040252	CONCRETE, OVERFLOW SECTION:							
04025203	Gate Piers							
	Concrete	11,287	CY	496	5,598,352	2,127,374	38.0	-
	Reinforcement	1,871,625	LBS	3.80	7,112,175	2,702,627	38.0	-
	Breast Wall							
	Concrete	11,830	CY	528	6,246,240	2,373,571	38.0	-
	Reinforcement	591,500	LBS	3.80	2,247,700	854,126	38.0	-
	Vortex breaker							
	Concrete	1,545	CY	1167	1,803,015	685,146	38.0	-
	Reinforcement	251,409	LBS	3.80	955,354	363,035	38.0	-
04025205	Gate Piers Noise							
	Steel Plates	295,960	LBS	9.30	2,752,428	1,045,923	38.0	-
04025299	Associated General Items							
	Hand Rails	552	LF	228	125,856	47,825	38.0	-
040253	GATES, STOPLOGS AND EQUIPMENT							
	Tainter Gates Systems							
	6ea - 23'w x 33.5'h Submerged							
04025303	Concrete							
	Trunnion Beam (34' High)							
	Trunnion Beam	370	CY	2,621	969,770	368,513	38.0	-
	Reinforcement	373,930	LBS	3.80	1,420,934	539,955	38.0	-
	Radial Equipment Operating Deck	185	CY	1,266	234,210	89,000	38.0	-
	Reinforcement	92,500	LBS	3.80	351,500	133,570	38.0	-
	Radial Equipment Protection Concrete	560	CY	2,437	1,364,720	518,594	38.0	-
04025305	Metals							
	Tainter Access	6	EA	173,200	1,039,200	394,896	38.0	-
	Radial Gates	6	EA	2,623,700	15,742,200	5,982,036	38.0	-
	Trunion Guides	12	SET	119,500	1,434,000	544,920	38.0	-
	Trunion	12	SET	478,400	5,740,800	2,181,504	38.0	-
	Operating Equipment	6	SET	1,455,200	8,731,200	3,317,856	38.0	-
04024116	Electrical							

DETAILED ESTIMATE OF FIRST COST(Cont'd)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	(%)*	REASON
	Effective Price Level (EPL) 1-Oct-2006							
	Tainter Bring in Power	2,850	LF	276	786,600	298,908	38.0 -	
	Tainter Electrical System	2,850	LF	917	2,613,450	993,111	38.0 -	
040254	Spillway Bulkhead, Slots & Hoists							
04025414	Metals							
	Spillway Bulkhead Gates, 7 Ea Guides & Storage Area							
	Bulkhead Hoists and Railing Platform							
	Bulkheads Gates 6 ea	1,770	SF	403	713,310	271,058	38.0 -	
	Bulkheads Gates 6 ea	6	EA	2,005,000	12,030,000	4,571,400	38.0 -	
	Bulkheads Guides	7	EA	322,000	2,254,000	856,520	38.0 -	
	Bulkhead Lifting System	6	SET	1,900,000	11,400,000	4,332,000	38.0 -	
040255	BRIDGES, SUPERSTRUCTURE & DECK:	180	LF					
04025503	Concrete							
	Precast, Prestress Concrete Box Girder Bridge 30 EA							
	Precast Prestressed Box Girders 14	430	CY	3,330	1,431,900	544,122	38.0 -	
	Roadway Concrete Slab							
	6" Reinf. Conc. Slab	121	CY	597	72,237	27,450	38.0 -	
	Reinforcement	15,630	LBS	2.10	32,823	12,473	38.0 -	
	Bridge Parapet Sidewalk Slab							
	Concrete 2' wide x 9" thick	20	CY	674	13,480	5,122	38.0 -	
	Reinforcement	2,123	LBS	2.10	4,458	1,694	38.0 -	
	Bridge Parapet Wall @ Top of Dam							
	Concrete	40	CY	1049	41,960	15,945	38.0 -	
	Reinforcement	5,317	LBS	2.10	11,166	4,243	38.0 -	
04025599	Bridge Associated General Items							
	Upstream Guard Rail 1.5 ft height	177	LF	122	21,594	8,206	38.0 -	
	Downstream Open Guard Rail 3.5 ft height	177	LF	140	24,780	9,416	38.0 -	
	Expansion Jts	280	LF	8.00	2,240	851	38.0 -	
	Stripping	177	LF	2.00	354	135	38.1 -	
	Drains	32	LF	11.00	352	134	38.1 -	
04029916	Electrical							
	Fiber Optic Line	2,850	LF	185	527,250	200,355	38.0 -	
	Security Construction Monitoring							
	Security Monitoring	1	JOB	LS	2,161,000	821,180	38.0 -	
	Subtotal, Construction Costs:				$394,982,277			
	Contingencies @ average of 37.3 % +/- *					$143,637,723		A
04	**DAMS**			**TOTAL:**		**$538,620,000**		
06	**FISH AND WILDLIFE FACILITIES, Mitigation- Cost Carried Over From Folsom Mods Project.**							
06	**FISH AND WILDLIFE FACILITIES Sunk Cost**				406,531			
0603	**WILDLIFE FACILITIES AND SANCTURARIES,**							
060373	Habitat and Feeding Facilities:							
06037302	Site Work:							
	Mitigation							
	Sunk Cost to Oct 2006	1	JOB	LS	320,309	0	0.0 -	
	Sunk Cost to Oct 2005	1	JOB	LS	86,222	0	0.0 -	
	Subtotal, Construction Costs:				$406,531			
06	**FISH AND WILDLIFE FACILITIES, Mitigation- Cost Carried Over Fr TOTAL:**					**$406,531**		
30	**PLANNING, ENGINEERING & DESIGN**							
30	**PLANNING, ENGINEERING & DESIGN, Sunk Cost**				44,398,102			
302301	PLANS AND SPECIFICATION							
30230101	Surveys and Mapping, except RE				2,341,500	468,300	20.0 -	
30230101	Survey Markers				1,514,980	302,996	20.0 -	
30230101	Hydraulics Studies				2,754,710	550,942	20.0 -	
30230101	Hydrology				1,377,170	275,434	20.0 -	
30230101	Structural Design				413,200	82,640	20.0 -	
30230102	Civil Design Analysis				1,514,980	302,996	20.0 -	
30230102	Prepare Specs- Front End				688,580	137,716	20.0 -	
30230102	Civil Design Prepare Tec Specs				1,033,010	206,602	20.0 -	
30230102	Civil Design Prepare Plans				2,410,370	482,074	20.0 -	

DETAILED ESTIMATE OF FIRST COST(Cont'd)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE ($)	AMOUNT ($)	CONTINGENCY ($)*	CONTINGENCY (%)*	REASON
	Effective Price Level (EPL) 1-Oct-2006							
30230102	Review P&S(ITR)				1,033,010	206,602	20.0	-
30230104	BCOE Review and Certification				688,580	137,716	20.0	-
30230104	Revise P&S				688,580	137,716	20.0	-
30230105	Geotechnical Studies(Geol and Soils)				2,754,710	550,942	20.0	-
30230105	Revegetation Plan				3,202,350	640,470	20.0	-
302304	ENVIRONMENTAL STUDIES DOCUMENTS							
30230401	Coordination w/other agencies				895,280	179,056	20.0	-
30230403	Mitigation Analysis Report				826,410	165,282	20.0	-
30230404	Coordination w/other agencies				1,033,010	206,602	20.0	-
30230410	NPDES Permit/SPPCP				344,340	68,868	20.0	-
302305	HTRW STUDIES/REPORT							
30230502	HTRW Assessment Report				1,377,170	275,434	20.0	-
302306	CULTURAL RESOURCE							
30230601	Cultural Resource, Studies Doc.				1,721,690	344,338	20.0	-
302307	COST ESTIMATE							
30230701	Cost Estimates-Project				1,377,170	275,434	20.0	-
30230703	Cost Estimates-Contract				1,377,170	275,434	20.0	-
302308	OTHER STUDIES/INVESTIGATIONS							
30230801	O&M, Plan				688,580	137,716	20.0	-
30230801	Other Studies (ECIFP)				275,470	55,094	20.0	-
302309	CONTRACT AWARD DOCUMENTS							
30230903	Advertise				688,580	137,716	20.0	-
30230903	Repro				344,340	68,868	20.0	-
30230907	Award Contract				137,740	27,548	20.0	-
302310	ENGINEERING & DESIGN DURING				2,754,710	550,942	20.0	-
30231402	Amendments to P&S				688,580	137,716	20.0	-
3024	VALUE ENGINEERING ANLYSIS				895,280	179,056	20.0	-
3025	CLOSE OUT							
302501	Physical Closeout Documents				826,410	165,282	20.0	-
302501	Local Sponsor Audit				688,580	137,716	20.0	-
302501	USACE Audit				688,580	137,716	20.0	-
302501	OMRR&R Manual				1,377,170	275,434	20.0	-
3026	PROGRAMS AND PROJECT MGMT				4,822,400	964,110	20.0	-
	Subtotal				$90,642,492			
	Contingencies @ average of	20.0 % +/- *				$9,248,508		
30	**PLANNING, ENGINEERING & DESIGN**			**TOTAL:**		**$99,891,000**		
31	**CONSTRUCTION MANAGEMENT (S & I)**							
31	**CONSTRUCTION MANAGEMENT (S & I)**	**Sunk Cost From Past Contr Contracts**			1,535,428			
312311	SUPERVISION AND ADMINISTRATION							
31231101	Project Office Supervn and Admin				10,276,500	3,905,231	38.0	-
31231102	Area Office S&A Documents				3,212,470	1,220,739	38.0	-
31231103	District Office S&A Documents				641,260	243,679	38.0	-
31231103	Contract Mods & Negotiations				385,370	146,441	38.0	-
3126	PROGRAMS AND PROJECT MGMT							
312601	Proj Mgmt Documents				7,090,860	2,694,527	38.0	-
312602	Funds Control Documents				1,285,600	488,528	38.0	-
312603	Trip Reports				641,260	243,679	38.0	-
312604	Upward reporting Documents				385,370	146,441	38.0	-
312605	Budgetary Documents				514,860	195,647	38.0	-
312606	Project Authorization Documents				641,260	243,679	38.0	-
312607	Annual Notification Ltr				320,630	121,839	38.0	-
312608	Fact Sheets				1,917,610	728,692	38.0	-
312609	Correspondance(Congress/State)				641,260	243,679	38.0	-
312610	Schedule and Cost Changes				770,750	292,885	38.0	-
312611	Project Work Directives				385,370	146,441	38.0	-
312612	Project Closeout Coord Documents				385,370	146,441	38.0	-
312613	Quarterly Cost Rpt to Local Sponsor				641,260	243,679	38.0	-
312614	All Other Programs/PM Documents				385,370	146,441	38.0	-
31261101	Mitigation Construction				308,300	117,154	38.0	-
	Subtotal				$32,366,158			
	Contingencies @ average of	38.0 % +/- *				$11,715,842		
31	**CONSTRUCTION MANAGEMENT (S & I)**			**TOTAL:**		**$44,082,000**		

FOLSOM IFA, AUX SPILLWAY, 6GATES
IFA - Concept Plans
FOLSOM DAM
FOLSOM & CALIFORNIA
Price Level 1 Oct. 2006

Designed By: Sacramento - Concept Plans
Estimated By: Sherman Fong, KWP, MPJ

Prepared By: Sacramento, Cost Engineering Br
Joe Yee, Branch Chief

Preparation Date: 01/26/07
Effective Date of Pricing: 01/26/07
Est Construction Time: 730 Days

Sales Tax: 7.75%

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PROJECT LOCATION: Folsom IFA, Aux Spillway, 6 new gates

PROJECT NAME IFAU66

PROJECT DESCRIPTION
This estimate consists of costs to construct a new 6 gate auxiliary spillway structure, concrete lined channel and stilling basin approximately mile off of the end of the right wing of Folsom Dam. The new structures channel will join the exiting dams stilling basin approximately 1/3 mile downstream of the main dam. The gates are approximately 23'wide and 33' tall. The gate design for Oroville dam was utilized as a basis for quantities for this structure. A significant amount of blasting and excavation will be required to construct the structure and accompanying channel. It is assumed that the existing earthen area off of the face of the proposed structure will serve as a cofferdam to allow the construction of the new structure without additional reinforcement. The dewatering structure at the stilling basin will be created by a temporary concrete wall. It also creates a stilling basin for runoff to settle out be for returning water to the river. It is assumed that the majority of the material removed will be placed at areas R1 and D2 (vicinity of Mormon Island). A two lane haul road will be constructed between the right wing of Folsom Dam and the new structure extending to the East to Mormon Island. The road will be constructed within the boundaries of the reservoir to the greatest extent possible and terminate to the east of Mormon Island. Remediation is assumed to be minimal as the road will be developed into a bicycle/ nature path at the end of the project (funded by others). Encroachment to the south of the structure/spillway is assumed to be limited by the proposed construction of a new highway/bridge as well as the presence of Folsom Prison. Construction interference will be kept at a minimum.

BASES OF DESIGN
This estimate is a budget estimate based on preliminary design concepts and sketches based on findings from "PASS Phase II Report Dam Raise and Auxiliary Spillway Alternatives" dated June 2006. Because of the minimal drawing, the quantities & scope of work was supplied by the designers.

ACQUISITION PLAN
The project will be acquired by RFP, full and open.

SUB-CONTRACTING PLAN
The following are subcontractor on this project:

Drilling/Grouting Subcontractor	FG
Electrical Subcontractor	FE
Rebar Subcontractor	FR
Soil Nail/Gunite Subcontractor	FS
Concrete Pump Subcontractor	FP
Security Install Subcontractor	FI
Fencing Subcontractor	FC
Mechanical Subcontractor	FM
Scaffolding Subcontractor	FL
Saw-cutting Subcontractor	FD
Crane Subcontractor	FN
Asphalt Subcontractor	FA

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Blasting Subcontractor	FO
Painting Subcontractor	FQ
Seeding Subcontractor	SE

It is assumed that the Prime Contractor will do the rest of the work.

PROJECT CONSTRUCTION
SITE ACCESS
The project site is located East of Folsom Dam, in Folsom, CA. Existing dirt roads exits on site. 40' wide haul roads are developed and removed in the estimate. Two tower cranes will be used as crane access when building the concrete auxiliary dam.

BORROW AREAS
Primary Borrow/Fill area is near Mormon Island (Areas R1 and DD). All other material will be purchase from at commercial source. A concrete batch plant should be setup on site. This batch plant is included in the concrete unit price. Construction water is obtained free in the stilling basin from a BOR water right.

CONSTRUCTION METHODOLOGY
The construction methodology is standard earth and concrete dam construction. Field office overhead percent of 15% used is based on the field overhead for the Outlet Modification contract. Also at 5% mobilization and demobilization for the first year was used and additional 3% for each additional years.

UNUSUAL CONDITION
The construction of the dam, chute and stilling must not interfere with traffic on the new highway next to the new structure. Also extra security is required by dam security personnel. No other unusual conditions are known at the time estimate was developed.

UNIQUE TECHNIQUES OF CONSTRUCTION
None

CONSTRUCTION WINDOWS
SCHEDULE
None is currently defined. The construction should be complete in three to four years. There is a flood season and reservoir levels must be kept below the plug design.

OVERTIME
This estimate contains 3 shifts overtime to complete the excavation and blasting of the project.

EQUIPMENT AND LABOR AVAILABILITY & DISTANCE TRAVELED
This estimate uses Davis Bacon labor rates for Sacramento County 10/19/2006, modification #36. Overall labor prices were increase 10% to match current labor costs found in the field.

Equipment rates used are from EP 1110-1-8, Volume 7 June 99,updated by 15% to

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current equipment prices. Also fuel prices were increase to current fuel prices.

ENVIRONMENTAL CONCERNS
At least one endangered species, the Elderberry Beetle, is encountered in this area. Relocation and replanting of appropriate habitat will be required. Blasting and soil erosion pollution is a concern. Blasting inside the lake reservoir uses plastic explosive to prevent contamination of the reservoir water. Turbidity curtains are installed and removed at the RI disposal site and the approach channel.

>>>

		QUANTITY	UOM	TOTAL DIRECT	POOH	HOOH	PROF	AIHQ FEE	BOND	TOTAL COST	UNIT COST
FF	NEW AUXILIARY SPILLWAY,6EA GATES										
FF 04	DAMS										
FF 04 02	AUXILARY SPILLWAY, 23'W X 33.5'H										
FF 04 02 01	MOB, DEMOB & PREPARATORY WORK										
FF 04 02 01-001-	MOB, DEMOB & PREP WORK, MULTI YR										
FF 04 02 01-001--A01A	Mob, Demob & Prep Work, First Yr	5.00	%	12,919,934	2,842,385	1,576,232	1,629,824	398,336	387,334	19,754,045	3950809
FF 04 02 01-001--A01B	Mob, Demob & Prep Work, SecondYr	3.00	%	7,826,874	1,721,912	954,879	987,345	241,311	234,646	11,966,968	3988989
FF 04 02 01-001--A01C	Mob, Demob & Prep Work, Third Yr	3.00	%	7,826,874	1,721,912	954,879	987,345	241,311	234,646	11,966,968	3988989
FF 04 02 01-001--A01D	Mob, Demob & Prep Work, Forth Yr	3.00	%	0	0	0	0	0	0	0	0.02
	TOTAL MOB, DEMOB & PREP WORK, MULTI YR	4.00	YR	28,573,682	6,286,210	3,485,989	3,604,513	880,958	856,627	43,687,980	10921995
	TOTAL MOB, DEMOB & PREPARATORY WORK			28,573,682	6,286,210	3,485,989	3,604,513	880,958	856,627	43,687,980	
FF 04 02 03	CARE & DIVERSION OF WATER										
FF 04 02 03-002-	PUMPING @ THE APPROACH CHANNEL										
FF 04 02 03-002--A02G	Pump Intake Excavation	170.00	CY	1,376	393	188	174	42	41	2,104	12.38
FF 04 02 03-002--A02H	Pump Intake Utiltiy Vault Slab	5.00	CY	2,052	452	250	259	63	62	3,138	627.58
FF 04 02 03-002--A02I	Pump Intakes U-Vault Oil/Wate	4.00	EA	224,403	49,413	27,402	28,333	6,925	6,734	343,409	85852.26
FF 04 02 03-002--A02K	Pump Intake Backfill	150.00	CY	1,696	373	207	214	52	51	2,593	17.28
FF 04 02 03-002--C02F	Pumping Above Dam to Reservoir	12.00	MO	234,121	51,507	28,563	29,534	7,218	7,019	357,961	29830.11
FF 04 02 03-002--C02G	Pumping, Stilling B to River	12.00	MO	468,242	103,013	57,126	59,068	14,436	14,038	715,923	59660.22
	TOTAL PUMPING @ THE APPROACH CHANNEL	18.00	MO	932,090	205,060	113,715	117,581	28,737	27,944	1,425,128	79173.75
FF 04 02 03-003-	ENVIRONMENTAL CONTROLS										
FF 04 02 03-003--D02A	Silt Fence - Approach Channel	1800.00	LF	10,763	2,368	1,313	1,358	332	323	16,456	9.14
FF 04 02 03-003--D02B	Silt Fence - Spillway Str	1000.00	LF	5,979	1,315	729	754	184	179	9,142	9.14
FF 04 02 03-003--D02C	Silt Fence - Chute	200.00	LF	1,196	263	146	151	37	36	1,828	9.14
FF 04 02 03-003--D02E	Silt Fence - Stilling Basin	800.00	LF	4,841	1,065	591	611	149	145	7,402	9.25
FF 04 02 03-003--D02F	Silt Fence - Haul Roads	9325.00	LF	55,758	12,267	6,803	7,034	1,719	1,672	85,252	9.14
FF 04 02 03-003--D02G	Turbidity Curtain Approach Chan	2100.00	LF	101,806	22,397	12,420	12,843	3,139	3,052	155,657	74.12
FF 04 02 03-003--D02H	Turbidity Curtain Stockpile R1	3000.00	LF	145,180	31,940	17,712	18,314	4,476	4,352	221,974	73.99
FF 04 02 03-003--D02I	Silt Fence, D2 Stockpile Site	2000.00	LF	11,959	2,631	1,459	1,509	369	359	18,285	9.14
FF 04 02 03-003--D02J	Silt Fence, R1 Stockpile Area	400.00	LF	2,392	526	292	302	74	72	3,657	9.14
FF 04 02 03-003--E02A	Straw Bales over the 2 Years	4000.00	EA	18,074	3,976	2,205	2,280	557	542	27,635	6.91
FF 04 02 03-003--F01G	Oil Spill Cleanup Kits	109.00	EA	6,851	1,507	836	864	211	205	10,476	104.76
FF 04 02 03-003--G01G	Approach Channel, Fish Control	12.00	MO	187,847	41,326	22,917	23,696	5,792	5,632	287,210	23934.16

		QUANTITY	UOM	TOTAL DIRECT	FOOH	HOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
	TOTAL ENVIRONMENTAL CONTROLS	18.00	MO	552,647	121,582	67,423	69,715	17,039	16,568	844,975	46943.05
	TOTAL CARE & DIVERSION OF WATER	18.00	MO	1,484,738	326,642	181,138	187,297	45,776	44,512	2,270,102	126116.80
FF 04 02 04	PERMANENT ACCESS ROADS & PARKING										
FF 04 02 04-002-	ACCESS ROAD, COMMON EXCAVATION										
FF 04 02 04-002--J02A	AccesR,Common Excv&Haul to EmbankX	94970.00	BCY	637,388	140,225	77,761	80,405	19,651	19,109	974,540	10.26
	TOTAL ACCESS ROAD, COMMON EXCAVATION	94970.00	BCY	637,388	140,225	77,761	80,405	19,651	19,109	974,540	10.26
FF 04 02 04-003-	ACCESS ROAD, ROCK EXCAVATION										
FF 04 02 04-003--K02A	Presplit Drilling, 20'Bench 4d	29954.00	LF	326,154	71,754	39,791	41,144	10,056	9,778	498,676	16.65
FF 04 02 04-003--K02B	Constr Drilling, 20'Bench 5.25"d	29954.00	LF	700,357	154,079	85,444	88,349	21,593	20,996	1,070,817	35.75
FF 04 02 04-003--K02C	Rock Blasting, 10'X10', 5.25"Dia	284915.00	BCY	1,436,352	315,997	175,235	181,193	44,284	43,061	2,196,123	7.71
FF 04 02 04-003--K02F	AccesR,Rock Excv Haul to S2orN2	284915.00	BCY	3,553,041	781,669	433,471	448,209	109,544	106,519	5,432,452	19.07
	TOTAL ACCESS ROAD, ROCK EXCAVATION	284915.00	BCY	6,015,904	1,323,499	733,940	758,896	185,477	180,354	9,198,068	32.28
FF 04 02 04-004-	ACCESS ROAD, EMBANKMENT COMMON										
FF 04 02 04-004--K05G	AccesR,Embankment - Common	55390.00	BCY	730,671	160,748	89,142	92,173	22,527	21,905	1,117,166	20.17
	TOTAL ACCESS ROAD, EMBANKMENT COMMON	55390.00	BCY	730,671	160,748	89,142	92,173	22,527	21,905	1,117,166	20.17
FF 04 02 04-011-	ACCESS ROAD, PAVING 26' WIDE										
FF 04 02 04-011--A02A	Access Roadway,Top & Base Course	2540.00	CY	110,888	26,155	14,504	14,998	3,665	3,564	181,775	71.01
FF 04 02 04-011--C02A	Access Roadway,2" AC Pavement	655.00	CY	147,674	32,488	18,016	18,629	4,553	4,427	225,788	264.08
	TOTAL ACCESS ROAD, PAVING 26' WIDE	5751.00	LF	266,562	58,644	32,521	33,626	8,218	7,991	407,563	70.87
FF 04 02 04-012-	ACCESS ROAD,TRAFFIC CONTROL,LNUT										
FF 04 02 04-012--A02A	Traffic Light,Permanent Controls	1.00	EA	500,000	110,000	61,000	63,074	15,416	14,990	764,479	764479.35
FF 04 02 04-012--B02B	Jersey Barricade Traffic Control	6000.00	LF	195,000	42,900	23,790	24,599	6,012	5,846	298,147	74.54
FF 04 02 04-012--B02E	Barricade, 9' Long Pop up	2.00	EA	140,000	30,800	17,080	17,661	4,316	4,197	214,054	107027.11
FF 04 02 04-012--B16A	Barricade Fiber OpticLine/Trenc	500.00	LF	60,599	13,332	7,393	7,644	1,868	1,817	92,654	185.31
FF 04 02 04-012--S02P	Barricade CCTCT Cable Runs	500.00	LF	3,006	661	367	379	93	90	4,596	9.19
	TOTAL ACCESS ROAD,TRAFFIC CONTROL,LNUT	1.00	MO	898,605	197,693	109,630	113,357	27,705	26,940	1,373,930	1373930
	TOTAL PERMANENT ACCESS ROADS & PARKING	5750.00	LF	8,549,130	1,880,809	1,042,994	1,078,456	263,579	256,299	13,071,267	2273.26

38306

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Tri-Service Automated Cost Engineering System (TRACES)
PROJECT TITLE: FOLSOM IFR, AUX SPILLWAY, HUNTER - IFR - Concept Plans
AUX SPILLWAY, 6 GATES2
** PROJECT INDIRECT SUMMARY - CSI ITEM **

	QUANTITY	UOM	TOTAL DIRECT	FOOH	MOOH	PMOF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 10 EARTHWORK FOR STRUCTURES,DAM EXC										
FF 04 02 10-001- HAUL ROAD & DISPOSAL SITE PREP										
FF 04 03 10-001--A30C Clear & Grub, Approach Channel	11.80	AC	46,170	10,157	5,633	3,824	1,423	1,384	70,592	5982.40
FF 04 02 10-001--A31A Clear & Grub, Dam Structure	6.20	AC	10,344	2,276	1,260	1,010	376	367	15,662	2526.07
FF 04 02 10-001--A31B Clear & Grub, Spillway Chute	4.60	AC	8,649	1,903	1,052	844	314	307	13,069	2841.53
FF 04 02 10-001--A32A Clear & Grub, Training Wall	17.70	AC	86,339	18,995	10,533	2,462	2,988	1,321	132,009	7458.14
FF 04 02 10-001--A24C Clear & Grub, Stilling Basin	9.50	AC	123,903	27,259	15,116	13,430	3,820	3,715	189,443	19941.33
TOTAL HAUL ROAD & DISPOSAL SITE PREP	49.80	AC	274,700	60,435	33,514	34,533	8,669	8,236	420,012	8433.98
FF 04 02 10-003- DAM FOUNDAT, ROCK BLASTING & EXC										
FF 04 02 10-003--K02A Freight Drilling, 20'Bench Alla	23031.00	LF	278,427	59,254	27,868	28,436	7,843	6,848	349,256	15.16
FF 04 02 10-003--K02B Constr Drilling, 20'Bench 0.25"d	54239.00	LF	332,752	121,405	67,436	69,729	17,842	16,571	445,135	15.34
FF 04 02 10-003--K02C Rock Blasting, 10'x10', 3.25"dia	146390.00	BCY	846,727	229,080	71,581	74,014	18,888	17,580	897,381	5.39
FF 04 02 10-003--K02F Rock Exc & Haul to D2 or H1	146390.00	BCY	2,144,173	474,118	264,029	273,006	69,724	64,881	3,388,931	19.89
TOTAL DAM FOUNDAT, ROCK BLASTING & EXC	146390.00	CY	3,532,079	777,057	430,914	445,185	104,898	101,880	5,480,403	32.46
FF 04 02 10-004- HAUL ROAD & STOCKPILE RECREATION										
FF 04 02 10-004--C02A Stock Pile Area D2, Remediation	27.00	ACR	234,987	56,097	31,108	32,166	7,862	7,444	369,664	14439.43
FF 04 02 10-004--C02B Stock Pile Area H1, Remediation	27.00	ACR	234,987	56,097	31,108	32,166	7,862	7,444	369,664	14439.43
FF 04 02 10-004--C03C Haul Road, Remediation	20000.00	CY	114,135	23,110	13,825	14,398	3,519	3,422	174,408	8.62
FF 04 02 10-004--S02- Boat Ramp Named,Remove Old Surfa	10740.00	CY	65,507	14,612	7,992	8,264	2,020	1,964	100,358	9.31
FF 04 02 10-004--S02A Boat Ramp Named,Top 4Base Course	8070.00	CY	374,776	82,451	45,723	47,277	11,555	11,236	573,018	71.01
FF 04 02 10-004--S02C Boat Ramp Named, 2" AC Pavement	2690.00	CY	466,612	102,215	56,683	58,610	14,320	13,909	710,373	264.08
FF 04 02 10-004--K01A Seeding, Haul Road	17.20	ACR	53,591	11,790	6,538	6,760	1,651	1,607	81,938	4763.85
FF 04 02 10-004--K01C Seeding, Stockpile H1	27.00	ACR	84,125	18,508	10,263	10,613	2,594	2,522	128,624	4763.85
FF 04 03 10-004--K01E Seeding, Stockpile D2	27.00	ACR	84,125	18,508	10,263	10,612	2,594	2,522	128,624	4763.85
FF 04 02 10-004--K02F Seeding,Chute,Stilling Basn &Road	20.30	ACR	63,250	13,915	7,716	7,979	1,950	1,896	96,706	4763.85
TOTAL HAUL ROAD & STOCKPILE RECREATION	101.30	AC	1,414,096	399,101	221,320	228,845	55,931	54,386	2,773,679	27326.88
TOTAL EARTHWORK FOR STRUCTURES,DAM EXC	452320.00	CY	5,620,880	2,236,594	685,747	709,043	173,298	168,512	8,594,093	19.00
FF 04 02 11 FOUNDATION WORK										
FF 04 02 11-A--- FOUNDATION SURFACE PREPARATION										
FF 04 02 11-401- ROCK BOLTS, 30' LONG, #11 REBAR										
FF 04 02 11-401--S02M RockBolts,#11Drill&Install 30'L	6975.00	LF	291,258	64,089	35,546	36,754	8,983	8,735	445,475	63.87
FF 04 02 11-401--S02N RockBolts,#11 Grouting Ful-30'L	85.00	CF	8,053	1,992	1,104	1,142	279	271	13,841	162.84

LABOR ID: CADRC EQUIP ID: WAC890 Currency DLLARS CREW ID: FITPAC

/ri 09 Mar 2007 Tri-Service Automated Cos. ;ineering System (TRACSE) TIME 07:19:50
Eff. Date 01/26/07 PROJECT ITRJF1: FOLSOM IFA, AUX SPILLWAY, 6GATES - IFA - Concept Plans SUMMARY PAGE 6
AUX SPILLWAY, 6 GATES2
** PROJECT INDIRECT SUMMARY - CSI ITEM **

		QUANTITY	UOM	TOTAL DIRECT	FOOH	MOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 11-A01--B02G	Rockbolts,#11 Testing 30'L	250.00	EA	44,873	9,872	5,475	5,661	1,383	1,345	68,610	274.44
TOTAL	ROCK BOLTS, 30' LONG,#11 REBAR	7650.00	LF	345,284	75,963	42,125	43,557	10,645	10,351	527,925	69.01
FF 04 02 11-A02-	FOUNDATION SURFACE PREPARATION										
FF 04 02 11-A02--A02A	FD, Pick & Clean Rock Surface	9210.00	SY	52,904	11,639	6,454	6,674	1,631	1,586	80,888	8.78
FF 04 02 11-A02--A02C	FD, Water Blast Surface	9210.00	SY	32,816	7,220	4,004	4,140	1,012	984	50,174	5.45
FF 04 02 11-A02--A03D	FD, Slush Grout / Gunite	9210.00	SY	319,913	70,381	39,029	40,356	9,863	9,591	489,133	53.11
TOTAL	FOUNDATION SURFACE PREPARATION	9210.00	SY	405,632	89,239	49,487	51,170	12,506	12,161	620,195	67.34
FF 04 02 11-A03-	FOUNDATION SHEAR KEY ROCK EXC										
FF 04 02 11-A03--K02A	Presplit Drilling, 20'Bench 4"d	4600.00	LF	70,435	15,496	8,593	8,885	2,172	2,112	107,692	23.41
FF 04 02 11-A03--K02B	Constr Drilling, 20'Bench 5.25"d	905.00	LF	9,181	2,020	1,120	1,158	283	275	14,037	15.51
FF 04 02 11-A03--K02C	Rock Blasting, 10'X10', 5.25"Dia	2940.00	BCY	32,838	7,224	4,006	4,142	1,012	984	50,208	17.08
FF 04 02 11-A03--K02F	Rock Exc & Haul to S2 or R2	2940.00	BCY	48,376	10,643	5,902	6,103	1,491	1,450	73,965	25.16
TOTAL	FOUNDATION SHEAR KEY ROCK EXC	2940.00	CY	160,830	35,383	19,621	20,288	4,959	4,822	245,903	83.64
FF 04 02 11-A05-	FOUNDATION CONC KEY -176'L,20'D										
FF 04 02 11-A05--B03A	Key Concrete Formwork off-Rock	900.00	SF	43,047	9,475	5,254	5,433	1,328	1,291	65,848	73.16
FF 04 02 11-A05--B03C	Key Concrete Reinforcement	147000.00	LB	213,643	47,001	26,064	26,951	6,587	6,405	324,651	2.22
FF 04 02 11-A05--B03D	Key Concrete Placement	2940.00	CY	400,803	88,177	48,898	50,560	12,357	12,016	612,811	208.44
TOTAL	FOUNDATION CONC KEY -176'L,20'D	2940.00	CY	657,513	144,653	80,217	82,944	20,272	19,712	1,005,310	341.94
FF 04 02 11-A10-	FOUNDTN COLUMN EXC, 2EA,140'VLF										
FF 04 02 11-A10--K02A	Presplit Drilling, 20'Bench 4"d	3500.35	LF	61,431	13,515	7,495	7,749	1,894	1,842	93,926	26.83
FF 04 02 11-A10--K02B	Constr Drilling, 20'Bench 5.25"d	1812.57	LF	19,203	3,345	1,855	1,918	469	456	23,244	12.82
FF 04 02 11-A10--K02C	Rock Blasting, 2'X 2', 5.25"Dia	2510.00	BCY	9,143	2,012	1,115	1,153	282	274	13,980	5.57
FF 04 02 11-A10--K02E	Rock Exc in Column to Stockpile	1630.00	BCY	753,040	165,669	91,871	94,994	23,217	22,576	1,151,367	706.36
FF 04 02 11-A10--K02F	Rock Exc & Haul to S2 or R2	1630.00	BCY	21,205	4,665	2,587	2,675	654	636	32,421	19.89
TOTAL	FOUNDTN COLUMN EXC, 2EA,140'VLF	1630.00	CY	860,021	189,205	104,923	108,490	26,515	25,783	1,314,937	806.71
FF 04 02 11-A12-	FOUNDTN COLUMN CONC 8'D 140'VLF										
FF 04 02 11-A12--B03A	Column Concrete NO Formwork	1.00	SF	0	0	0	0	0	0	0	0.03
FF 04 02 11-A12--B03C	Column Concrete Reinforcement	46520.00	LB	86,424	19,013	10,544	10,902	2,665	2,591	132,139	3.84
FF 04 02 11-A12--B03D	Column Concrete Placement	1630.00	CY	205,136	45,130	25,027	25,877	6,325	6,150	313,644	192.42
TOTAL	FOUNDTN COLUMN CONC 8'D 140'VLF	1630.00	CY	291,560	64,143	35,570	36,780	8,989	8,741	445,784	273.49

LABOR ID: CAIM07 EQUIP ID: NAT998 Currency in DOLLARS CREW ID: FITRAC

		QUANTITY	UOM	TOTAL DIRECT	FOOH	HOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 11-M---	STRUCTURAL INSTRUMENTATION	8.00	EA	0	0	0	0	0	0	0	0.00
FF 04 02 11-M01-	ACCELEROMETERS (2 EA)										
FF 04 02 11-M01--A02A	Drill 4"Dia Core Bore Holes,2EA	300.00	LF	8,275	1,820	1,010	1,044	255	248	12,652	42.17
FF 04 02 11-M01--A02C	Install Instrumentation 2 EA	300.00	LF	37,574	8,266	4,584	4,740	1,158	1,126	57,450	191.50
FF 04 02 11-M01--A02G	Grout Bore Holes 2 EA	50.00	CF	3,361	739	410	424	104	101	5,139	102.79
TOTAL	ACCELEROMETERS (2 EA)	300.00	LF	49,210	10,826	6,004	6,208	1,517	1,475	75,241	250.80
FF 04 02 11-M02-	PIEZOMETERS (6 EA)										
FF 04 02 11-M02--J02A	Drill 4"Dia Core Bore Holes,6EA	900.00	LF	27,178	5,979	3,316	3,428	838	815	41,554	46.17
FF 04 02 11-M02--J02C	Install Transducer 6 EACH	900.00	LF	9,838	2,164	1,200	1,241	303	295	15,042	16.71
FF 04 02 11-M02--J02F	Place Sand, Bentonite & Grout	75.00	CF	2,544	560	310	321	78	76	3,890	51.86
TOTAL	PIEZOMETERS (6 EA)	900.00	LF	39,560	8,703	4,826	4,990	1,220	1,186	60,485	67.21
FF 04 02 11-M03-	INSTRUMENTATION-NOT ABOVE ITEMS										
FF 04 02 11-M03---A--	Automation to Instrumentation			71,276	15,681	8,696	8,991	2,198	2,137	108,978	
TOTAL	INSTRUMENTATION-NOT ABOVE ITEMS			71,276	15,681	8,696	8,991	2,198	2,137	108,978	
TOTAL	FOUNDATION WORK	6765.00	SY	2,880,888	633,795	351,468	363,418	88,821	86,368	4,404,758	651.11
FF 04 02 12	SEEPAGE CONTROL - 1,297 HOLES										
FF 04 02 12-----	APPROACH PLUG GROUT CURTAIN(1STG	55200.00	LF	-83	-18	-10	-10	-3	-2	-127	-0.00
TOTAL	APPROACH PLUG GROUT CURTAIN(1STG	55200.00	LF	-83	-18	-10	-10	-3	-2	-127	-0.00
FF 04 02 12--01-	ROCK DRILLING FOR GROUT HOLES										
FF 04 02 12--01--A02E	Drilling, Grout Holes	55200.00	LF	422,434	92,935	51,537	53,289	13,024	12,664	645,883	11.70
TOTAL	ROCK DRILLING FOR GROUT HOLES	55200.00	LF	422,434	92,935	51,537	53,289	13,024	12,664	645,883	11.70
FF 04 02 12--02-	REDRILLING GROUT CURTAIN HOLES										
FF 04 02 12--02--K02F	ReDrilling, Grouting Hole	43200.00	LF	342,453	75,340	41,779	43,200	10,558	10,267	523,597	12.12
TOTAL	REDRILLING GROUT CURTAIN HOLES	43200.00	LF	342,453	75,340	41,779	43,200	10,558	10,267	523,597	12.12
FF 04 02 12--03-	HOOKUPS TO GROUT HOLES GR CURTN										

		QUANTITY UOM	TOTAL DIRECT	FOOH	WOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 12--03--A02G	Pressure Washing & Testing	960.00 EA	126,871	27,912	15,478	16,000	3,912	3,804	193,981	202.06
FF 04 02 12--03--A03E	Hookups to Grout Holes	960.00 EA	3,146,451	692,219	383,867	396,918	97,009	94,329	4,810,793	5011.24
FF 04 02 12--03--A03G	Pressure Grout (Installatn Time	38.00 CHR	2,206	485	269	278	68	66	3,373	88.76
FF 04 02 12--03--A03O	Bentonite/Cement Cleanup	48.00 CHR	4,656	1,024	568	587	144	140	7,119	148.32
TOTAL	HOOKUPS TO GROUT HOLES GR CURTN	960.00 EA	3,280,184	721,641	400,182	413,789	101,132	98,339	5,015,266	5224.24
FF 04 02 12--04-	PORTLAND CEMENT USED IN G CURTN									
FF 04 02 12--04--A03I	Bag Cement Used (Mat Costs)	55100.00 BAG	576,298	126,786	70,308	72,699	17,768	17,277	881,136	15.99
TOTAL	PORTLAND CEMENT USED IN G CURTN	55100.00 BAG	576,298	126,786	70,308	72,699	17,768	17,277	881,136	15.99
FF 04 02 12--05-	BENTONITE USED IN GR CURTAIN									
FF 04 02 12--05--A03K	Bag Bentonite Used (Mat Costs)	551.00 BAG	5,743	1,268	703	727	178	173	8,811	15.99
TOTAL	BENTONITE USED IN GR CURTAIN	551.00 BAG	5,743	1,268	703	727	178	173	8,811	15.99
FF 04 02 12--06-	HRWR WATER REDUCING AMIXTURE									
FF 04 02 12--06--A03M	Water Reducing Admixture (Mats)	551.00 GAL	9,651	2,123	1,177	1,217	298	289	14,756	26.78
TOTAL	HRWR WATER REDUCING AMIXTURE	551.00 GAL	9,651	2,123	1,177	1,217	298	289	14,756	26.78
FF 04 02 12-A---	POUND CONC 3 COLUMNS SEAL (1STG	1120.00 LF	-2	0	0	0	0	0	-3	-0.00
FF 04 02 12-A01-	ROCK DRILLING FOR GROUT HOLES									
FF 04 02 12-A01--A02E	Drilling, Grout Holes	1120.00 LF	9,199	2,024	1,122	1,160	284	276	14,065	12.56
TOTAL	ROCK DRILLING FOR GROUT HOLES	1120.00 LF	9,199	2,024	1,122	1,160	284	276	14,065	12.56
FF 04 02 12-A03-	HOOKUPS TO GROUT HOLES GR CURTN									
FF 04 02 12-A03--A02G	Pressure Washing & Testing	16.00 EA	3,172	698	387	400	98	95	4,850	303.09
FF 04 02 12-A03--A03E	Hookups to Grout Holes	16.00 EA	63,423	13,953	7,738	8,001	1,955	1,901	96,971	4060.68
FF 04 02 12-A03--A03G	Pressure Grout (Installatn Time	38.00 CHR	2,206	485	269	278	68	66	3,373	88.76
FF 04 02 12-A03--A03O	Bentonite/Cement Cleanup	16.00 CHR	1,552	341	189	196	48	47	2,373	148.32
TOTAL	HOOKUPS TO GROUT HOLES GR CURTN	16.00 EA	70,353	15,478	8,583	8,875	2,169	2,109	107,567	6722.91
FF 04 02 12-A04-	PORTLAND CEMENT USED IN G CURTN									
FF 04 02 12-A04--A03I	Bag Cement Used (Mat Costs)	2576.00 BAG	26,943	5,927	3,287	3,399	831	809	41,194	15.99

Fri 09 Mar 2007 — Tri-Service Automated Cost Engineering System (TRACES) — TIME 07:19:50
Eff. Date 01/26/07 — PROJECT ITN(P): FOLSOM IFA, ACK SPILLWAY, 6GATES - IFA - Concept Plans — SUMMARY PAGE 7
AUX SPILLWAY, 6 GATES2
** PROJECT INDIRECT SUMMARY - CSI ITEM **

		QUANTITY	UOM	TOTAL DIRECT	FOOH	HOOH	PROF	AIHQ FEE	BOND	TOTAL COST	UNIT COST
TOTAL	PORTLAND CEMENT USED IN G CURTN	2576.00	BAG	24,943	3,927	3,267	3,399	831	808	41,194	15.99
FF 04 02 12-A05-	BENTONITE USED IN GR CURTAIN										
FF 04 02 12-A05--A03K	Bag Bentonite Used (Not Costed)	25.00	BAG	261	38	32	33	8	8	400	15.99
TOTAL	BENTONITE USED IN GR CURTAIN	25.00	BAG	261	38	32	33	8	8	400	15.99
FF 04 02 12-A06-	HYMR WATER REDUCING ADMIXTURE										
FF 04 02 12-A06--A03M	Water Reducing Admixture (Mat'l)	25.00	GAL	560	123	68	71	17	17	857	34.27
TOTAL	HYMR WATER REDUCING ADMIXTURE	25.00	GAL	560	123	68	71	17	17	857	34.27
FF 04 02 12-B---	GROUT CURTAIN, CONTROL STR (2STU										
FF 04 02 12-B02-	ROCK DRILLING-GROUT HOLES 16KA										
FF 04 02 12-B02--A02E	Drilling, Grout Holes	13100.00	LF	119,235	24,232	14,547	15,041	3,676	3,575	182,305	13.92
TOTAL	ROCK DRILLING-GROUT HOLES 16KA	13100.00	LF	119,235	24,232	14,547	15,041	3,676	3,575	182,305	13.92
FF 04 02 12-B03-	REDRILLING GROUT CURTAIN HOLES										
FF 04 02 12-B03--K02F	Redrilling, Grouting Hole	6550.00	LF	44,791	14,234	7,905	8,173	1,998	1,942	99,043	15.12
TOTAL	REDRILLING GROUT CURTAIN HOLES	6550.00	LF	44,791	14,234	7,905	8,173	1,998	1,942	99,043	15.12
FF 04 02 12-B04-	HOOKUPS TO GROUT HOLES GR CURTN										
FF 04 02 12-B04--A02G	Pressure Washing & Testing	524.00	EA	103,876	22,833	12,679	13,104	3,203	3,114	158,822	303.09
FF 04 02 12-B04--A02E	Hookups to Grout Holes	524.00	EA	1,711,697	376,573	208,827	215,927	52,774	51,316	2,617,115	4994.49
FF 04 02 12-B04--A03Q	Pressure Grout (Installath Time	76.00	CHR	4,412	971	538	557	136	132	6,746	88.76
FF 04 02 12-B04--A03Q	Bentonite/Cement Cleanup	32.00	CHR	3,104	683	379	392	96	93	4,746	148.32
TOTAL	HOOKUPS TO GROUT HOLES GR CURTN	524.00	EA	1,823,090	401,060	222,417	229,979	56,209	54,655	2,787,429	5319.32
FF 04 02 12-B05-	PORTLAND CEMENT USED IN G CURTN										
FF 04 02 12-B05--A02I	Bag Cement Used (Not Costed)	6878.00	BAG	71,938	15,826	8,776	9,075	2,218	2,157	109,990	15.99
TOTAL	PORTLAND CEMENT USED IN G CURTN	6878.00	BAG	71,938	15,826	8,776	9,075	2,218	2,157	109,990	15.99
FF 04 02 12-B06-	BENTONITE USED IN GR CURTAIN										

LABOR ID: CA1AM EQUIP ID: NAFP9A Currency DOLLARS CREW ID: TTRAC

		QUANTITY	UOM	TOTAL DIRECT	FOOH	SOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 12-B06--A03K	Bag Bentonite Used (Mat Costs)	70.00	BAG	732	141	89	92	23	22	1,119	15.99
TOTAL	BENTONITE USED IN GR CURTAIN	70.00	BAG	732	141	89	92	23	22	1,119	15.99
FF 04 02 12-B07-	HRWR WATER REDUCING AMIXTURE										
FF 04 02 12-B07--A03M	Water Reducing Admixture (Mats)	70.00	GAL	1,165	256	142	147	36	35	1,782	25.46
TOTAL	HRWR WATER REDUCING AMIXTURE	70.00	GAL	1,165	256	142	147	36	35	1,782	25.46
FF 04 02 12-C---	GROUT CURTAIN, L&R WING STR(2STG										
FF 04 02 12-C03-	ROCK DRILLING-GROUT HOLES 16EA										
FF 04 02 12-C03--A02E	Drilling, Grout Holes	6400.00	LF	70,939	15,607	8,655	8,949	2,187	2,127	108,463	16.95
TOTAL	ROCK DRILLING-GROUT HOLES 16EA	6400.00	LF	70,939	15,607	8,655	8,949	2,187	2,127	108,463	16.95
FF 04 02 12-C03-	REDRILLING GROUT CURTAIN HOLES										
FF 04 02 12-C03--K02F	ReDrilling, Grouting Hole	3200.00	LF	44,341	9,755	5,410	5,594	1,367	1,329	67,795	21.19
TOTAL	REDRILLING GROUT CURTAIN HOLES	3200.00	LF	44,341	9,755	5,410	5,594	1,367	1,329	67,795	21.19
FF 04 02 12-C04-	HOOKUPS TO GROUT HOLES GR CURTN										
FF 04 02 12-C04--A02G	Pressure Washing & Testing	256.00	EA	90,748	11,165	6,191	6,402	1,565	1,521	77,592	303.09
FF 04 02 12-C04--A03E	Hookups to Grout Holes	256.00	EA	837,047	184,150	102,120	105,592	25,807	25,094	1,279,811	4999.26
FF 04 02 12-C04--A03G	Pressure Grout (Installatn Time	76.00	CHR	4,412	971	538	557	136	132	6,746	88.76
FF 04 02 12-C04--A03O	Bentonite/Cement Cleanup	32.00	CHR	3,104	683	379	392	96	93	4,746	148.32
TOTAL	HOOKUPS TO GROUT HOLES GR CURTN	256.00	EA	895,312	196,969	109,228	112,942	27,603	26,841	1,368,896	5347.25
FF 04 02 12-C05-	PORTLAND CEMENT USED IN G CURTN										
FF 04 02 12-C05--A03I	Bag Cement Used (Mat Costs)	13760.00	BAG	143,918	31,662	17,558	18,155	4,437	4,315	220,044	15.99
TOTAL	PORTLAND CEMENT USED IN G CURTN	13760.00	BAG	143,918	31,662	17,558	18,155	4,437	4,315	220,044	15.99
FF 04 02 12-C06-	BENTONITE USED IN GR CURTAIN										
FF 04 02 12-C06--A03K	Bag Bentonite Used (Mat Costs)	138.00	BAG	1,443	318	176	182	45	43	2,207	15.99
TOTAL	BENTONITE USED IN GR CURTAIN	138.00	BAG	1,443	318	176	182	45	43	2,207	15.99

		QUANTITY UOM	TOTAL DIRECT	FOOH	WOOH	PROF	AIPQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 12-C07-	HRWR WATER REDUCING AMIXTURE									
FF 04 02 12-C07--A03M	Water Reducing Admixture (Mats)	138.00 GAL	2,528	556	306	319	78	76	3,865	28.01
TOTAL	HRWR WATER REDUCING AMIXTURE	138.00 GAL	2,528	556	306	319	78	76	3,865	28.01
FF 04 02 12-D---	GROUT CURTAIN, CONSOLIDATN (2STG									
FF 04 02 12-D02-	ROCK DRILLING-GROUT HOLES 14EA									
FF 04 02 12-D02--A02E	Drilling, Grout Holes	2880.00 LF	34,777	7,651	4,243	4,387	1,072	1,043	53,173	18.46
TOTAL	ROCK DRILLING-GROUT HOLES 14EA	2880.00 LF	34,777	7,651	4,243	4,387	1,072	1,043	53,173	18.46
FF 04 02 12-D04-	HOOKUPS TO GROUT HOLES GR CURTN									
FF 04 02 12-D04--A02G	Pressure Washing & Testing	144.00 EA	28,546	6,280	3,483	3,601	880	856	43,646	303.09
FF 04 02 12-D04--A03E	Hookups to Grout Holes	144.00 EA	470,503	103,511	57,401	59,353	14,506	14,105	719,380	4995.70
FF 04 02 12-D04--A03G	Pressure Grout (Installath Time	76.00 CHR	4,412	971	538	557	136	132	6,746	88.76
FF 04 02 12-D04--A03O	Bentonite/Cement Cleanup	32.00 CHR	3,104	683	379	392	96	93	4,746	148.32
TOTAL	HOOKUPS TO GROUT HOLES GR CURTN	144.00 EA	506,566	111,444	61,801	63,902	15,618	15,187	774,518	5378.60
FF 04 02 12-D05-	PORTLAND CEMENT USED IN G CURTN									
FF 04 02 12-D05--A03I	Bag Cement Used (Mat Costs)	1572.00 BAG	16,442	3,617	2,006	2,074	507	493	25,139	15.99
TOTAL	PORTLAND CEMENT USED IN G CURTN	1572.00 BAG	16,442	3,617	2,006	2,074	507	493	25,139	15.99
FF 04 02 12-D06-	BENTONITE USED IN GR CURTAIN									
FF 04 02 12-D06--A03K	Bag Bentonite Used (Mat Costs)	16.00 BAG	167	37	20	21	5	5	256	15.99
TOTAL	BENTONITE USED IN GR CURTAIN	16.00 BAG	167	37	20	21	5	5	256	15.99
FF 04 02 12-D07-	HRWR WATER REDUCING AMIXTURE									
FF 04 02 12-D07--A03M	Water Reducing Admixture (Mats)	16.00 GAL	439	97	54	55	14	13	672	41.98
TOTAL	HRWR WATER REDUCING AMIXTURE	16.00 GAL	439	97	54	55	14	13	672	41.98
FF 04 02 12-E---	GALLEY GROUT CURTAIN (3STG)	10310.00 LF	-15	-3	-2	-2	0	0	-24	-0.00
FF 04 02 12-E01-	ROCK DRILLING FOR GROUT HOLES									

		QUANTITY	UOM	TOTAL DIRECT	FOOH	HOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 12-E01--A02E	Drilling, Grout Holes	10310.00	LF	1,261,441	277,517	153,896	159,128	38,892	37,817	1,928,691	187.07
TOTAL	ROCK DRILLING FOR GROUT HOLES	10310.00	LF	1,261,441	277,517	153,896	159,128	38,892	37,817	1,928,691	187.07
FF 04 02 12-E02-	REDRILLING GROUT CURTAIN HOLES										
FF 04 02 12-E02--H02F	ReDrilling, Grouting Hole	8670.00	LF	1,175,203	258,545	143,375	148,250	36,233	35,232	1,796,837	207.25
TOTAL	REDRILLING GROUT CURTAIN HOLES	8670.00	LF	1,175,203	258,545	143,375	148,250	36,233	35,232	1,796,837	207.25
FF 04 02 12-E03-	HOOKUPS TO GROUT HOLES GR CURTN										
FF 04 02 12-E03--A02G	Pressure Washing & Testing	360.00	EA	71,365	15,700	8,707	9,003	2,200	2,139	109,114	303.09
FF 04 02 12-E03--A03E	Hookups to Grout Holes	360.00	EA	1,180,126	259,628	143,975	148,871	36,385	35,380	1,804,364	5012.12
FF 04 02 12-E03--A03G	Pressure Grout (Installatn Time	38.00	CHR	2,206	485	269	278	68	66	3,373	88.76
FF 04 02 12-E03--A03O	Bentonite/Cement Cleanup	48.00	CHR	4,656	1,024	568	587	144	140	7,119	148.32
TOTAL	HOOKUPS TO GROUT HOLES GR CURTN	360.00	EA	1,258,354	276,838	153,519	158,739	38,796	37,725	1,923,971	5344.36
FF 04 02 12-E04-	PORTLAND CEMENT USED IN G CURTN										
FF 04 02 12-E04--A03I	Bag Cement Used (Mat Costs)	5900.00	BAG	61,709	13,576	7,528	7,784	1,903	1,850	94,350	15.99
TOTAL	PORTLAND CEMENT USED IN G CURTN	5900.00	BAG	61,709	13,576	7,528	7,784	1,903	1,850	94,350	15.99
FF 04 02 12-E05-	BENTONITE USED IN GR CURTAIN										
FF 04 02 12-E05--A03K	Bag Bentonite Used (Mat Costs)	59.00	BAG	617	136	75	78	19	19	944	15.99
TOTAL	BENTONITE USED IN GR CURTAIN	59.00	BAG	617	136	75	78	19	19	944	15.99
FF 04 02 12-E06-	HPWR WATER REDUCING AMIXTURE										
FF 04 02 12-E06--A03M	Water Reducing Admixture (Mats)	59.00	GAL	1,018	224	124	128	31	31	1,556	26.37
TOTAL	HPWR WATER REDUCING AMIXTURE	59.00	GAL	1,018	224	124	128	31	31	1,556	26.37
FF 04 02 12-F---	GALLEY WING WGROUT CURTAIN(ISTG)	7700.00	LF	-12	-3	-1	-1	0	0	-18	-0.00
FF 04 02 12-F01-	ROCK DRILLING FOR GROUT HOLES										
FF 04 02 12-F01--A02E	Drilling, Grout Holes	7700.00	LF	641,289	141,083	78,237	80,897	19,772	19,226	980,504	127.34
TOTAL	ROCK DRILLING FOR GROUT HOLES	7700.00	LF	641,289	141,083	78,237	80,897	19,772	19,226	980,504	127.34

		QUANTITY	UOM	TOTAL DIRECT	FOCH	HOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 12-F02-	REDRILLING GROUT CURTAIN HOLES										
FF 04 02 12-F02--R02F	ReDrilling, Grouting Hole	4970.00	LF	686,034	150,928	83,696	86,542	21,151	20,567	1,048,918	211.05
TOTAL	REDRILLING GROUT CURTAIN HOLES	4970.00	LF	686,034	150,928	83,696	86,542	21,151	20,567	1,048,918	211.05
FF 04 02 12-F03-	HOOKUPS TO GROUT HOLES GR CURTN										
FF 04 02 12-F03--A02G	Pressure Washing & Testing	192.00	EA	38,061	8,373	4,643	4,801	1,173	1,141	58,194	303.09
FF 04 02 12-F03--A03E	Hookups to Grout Holes	192.00	EA	632,105	139,063	77,117	79,739	19,488	18,950	966,462	5033.66
FF 04 02 12-F03--A03G	Pressure Grout (Installatn Time	38.00	CHR	2,206	485	269	278	68	66	3,373	88.76
FF 04 02 12-F03--A03O	Bentonite/Cement Cleanup	72.00	CHR	6,985	1,537	852	881	215	209	10,679	148.32
TOTAL	HOOKUPS TO GROUT HOLES GR CURTN	192.00	EA	679,357	149,458	82,882	85,700	20,945	20,367	1,038,709	5409.94
FF 04 02 12-F04-	PORTLAND CEMENT USED IN G CURTN										
FF 04 02 12-F04--A03I	Bag Cement Used (Mat Costs)	7050.00	BAG	73,737	16,222	8,996	9,302	2,273	2,211	112,741	15.99
TOTAL	PORTLAND CEMENT USED IN G CURTN	7050.00	BAG	73,737	16,222	8,996	9,302	2,273	2,211	112,741	15.99
FF 04 02 12-F05-	BENTONITE USED IN GR CURTAIN										
FF 04 02 12-F05--A03K	Bag Bentonite Used (Mat Costs)	71.00	BAG	743	163	91	94	23	22	1,135	15.99
TOTAL	BENTONITE USED IN GR CURTAIN	71.00	BAG	743	163	91	94	23	22	1,135	15.99
FF 04 02 12-F06-	HRWR WATER REDUCING AMIXTURE										
FF 04 02 12-F06--A03M	Water Reducing Admixture (Mats)	71.00	GAL	1,179	259	144	149	36	35	1,802	25.39
TOTAL	HRWR WATER REDUCING AMIXTURE	71.00	GAL	1,179	259	144	149	36	35	1,802	25.39
FF 04 02 12-G---	GALLEY DRAIN HOLES	72.00	EA	0	0	0	0	0	0	0	0.00
FF 04 02 12-G01-	ROCK DRILLING FOR DRAIN HOLES										
FF 04 02 12-G01--A02E	Drilling, Drain Holes, 72 Ea	5365.00	LF	687,977	151,355	83,933	86,787	21,211	20,625	1,051,888	196.04
FF 04 02 12-G01--A02F	PVC Piping 3.5" Dia. 72	745.00	LF	2,003	441	244	253	62	60	3,062	4.11
TOTAL	ROCK DRILLING FOR DRAIN HOLES	5365.00	LF	689,979	151,795	84,177	87,040	21,273	20,685	1,054,950	196.64
TOTAL	SEEPAGE CONTROL - 1,297 HOLES	102075.00	LF	15,972,471	3,315,944	1,838,841	1,901,362	464,701	451,866	23,045,185	225.77
FF 04 02 25	APPROACH CHANNEL, STA 0+95- 9+40										

		QUANTITY	UOM	TOTAL DIRECT	FOOH	SOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 25-A02-	APP CHANNL,C-EXC STA0-95>STA5+60										
FF 04 02 25-A02--A02A	ApChan, Common Exc&HaultoD2orR2	447980.00	BCY	2,610,792	574,374	318,517	329,344	80,494	78,270	3,991,793	8.91
TOTAL	APP CHANNL,C-EXC STA0-95>STA5+60	447980.00	CY	2,610,792	574,374	318,517	329,344	80,494	78,270	3,991,793	8.91
FF 04 02 25-A02A	APP CHANNL,R-EXC STA0-95>STA5+60										
FF 04 02 25-A02A-K02A	Presplit Drilling, 20'Bench 4"d	12700.00	LF	138,297	30,425	16,872	17,446	4,264	4,148	211,450	16.65
FF 04 02 25-A02A-K02B	Constr Drilling, 20'Bench 5.25"d	54355.00	LF	586,306	128,987	71,529	73,961	18,076	17,577	896,438	16.49
FF 04 02 25-A02A-K02C	Rock Blasting, 10'K10', 5.25"Dia	120804.00	BCY	2,438,670	536,507	297,518	307,633	75,167	73,110	3,728,625	30.87
FF 04 02 25-A02A-K02F	ApChan, Rock Exca Haulto D2orR2	120804.00	BCY	1,485,887	326,895	181,278	187,442	45,812	44,546	2,271,860	18.81
TOTAL	APP CHANNL,R-EXC STA0-95>STA5+60	120804.00	CY	4,649,159	1,022,815	567,197	586,482	143,339	139,380	7,108,373	58.84
FF 04 02 25-A03-	APP CHANNL,C-EXC"a"ST5+60>ST9+40										
FF 04 02 25-A03--A02A	ApChanA, Common Exc&Haul D1orR2	254690.00	BCY	1,444,378	317,763	176,214	182,205	44,532	43,302	2,208,395	8.68
TOTAL	APP CHANNL,C-EXC"a"ST5+60>ST9+40	254690.00	CY	1,444,378	317,763	176,214	182,205	44,532	43,302	2,208,395	8.68
FF 04 02 25-A03A	APP CHANNL,R-EXC"a"ST5+60>ST9+40										
FF 04 02 25-A03A-K02A	Presplit Drilling, 20'Bench 4"d	10713.00	LF	116,678	25,669	14,235	14,719	3,597	3,498	178,396	16.65
FF 04 02 25-A03A-K02B	Constr Drilling, 20'Bench 5.25"d	45850.00	LF	494,631	108,819	60,345	62,397	15,250	14,829	756,270	16.49
FF 04 02 25-A03A-K02C	Rock Blasting, 10'K10', 5.25"Dia	101900.00	BCY	2,057,193	452,583	250,978	259,511	63,426	61,674	3,145,364	30.87
FF 04 02 25-A03A-K02F	ApChanA, Rock Exca Haul-D2orR2	101900.00	BCY	1,359,089	299,000	165,809	171,446	41,902	40,745	2,077,991	20.39
TOTAL	APP CHANNL,R-EXC"a"ST5+60>ST9+40	101900.00	CY	4,027,591	886,070	491,366	508,073	124,175	120,746	6,158,021	60.43
FF 04 02 25-A04-	APP CHANNL,R-EXC"b"ST5-60>ST9+40										
FF 04 02 25-A04--K02A	Presplit Drilling, 20'Bench 4"d	17467.00	LF	190,179	41,839	23,202	23,991	5,863	5,701	290,775	16.65
FF 04 02 25-A04--K02B	Constr Drilling, 20'Bench 5.25"d	74754.00	LF	806,414	177,411	98,382	101,727	24,863	24,176	1,232,973	16.49
FF 04 02 25-A04--K02C	Rock Blasting, 10'K10', 5.25"Dia	166150.00	BCY	3,354,434	737,976	409,241	423,155	103,421	100,565	5,128,791	30.87
FF 04 02 25-A04--K02G	ApChanB, Dredge & Pile on Shore	166150.00	BCY	2,311,189	508,462	281,965	291,552	71,257	69,288	3,533,713	21.27
FF 04 02 25-A04--K02H	ApChanB, Rock Exca Haul-D2orR2	166150.00	BCY	2,208,633	485,899	269,453	278,615	68,095	66,214	3,376,908	20.32
TOTAL	APP CHANNL,R-EXC"b"ST5-60>ST9+40	166150.00	CY	8,870,849	1,951,587	1,082,244	1,119,040	273,498	265,944	13,563,161	81.63
FF 04 02 25-A05-	APP CHANNL,STABILISATION SOIlNAIL										
FF 04 02 25-A05--A02A	App Chan, Soil Nails, Set Up	170.00	EA	69,676	15,329	8,500	8,790	2,148	2,089	106,532	626.66
FF 04 02 25-A05--B02A	App Chan, Soil Nails, 170 Each	10000.00	LF	924,234	203,332	112,757	116,590	28,495	27,708	1,413,116	141.31
FF 04 02 25-A05--C02A	App Chan, Soil Nails, Grout	70.00	CY	7,596	1,671	927	958	234	228	11,614	165.91
FF 04 02 25-A05--D02A	App Chan, Soil Nails,Wire Fabric	4000.00	SY	69,598	15,311	8,491	8,780	2,146	2,087	106,412	26.60

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		QUANTITY	UOM	TOTAL DIRECT	FOH	HOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 25-A05--E02A	App Chan, Soil Shotcrete,2"Thk	670.00	CY	135,643	29,841	16,568	17,111	4,182	4,067	207,392	309.54
FF 04 02 25-A05--F02A	App Chan,SoilN Horiz Drain Setup	70.00	EA	14,345	3,156	1,750	1,810	442	430	21,933	313.33
FF 04 02 25-A05--H02A	App Chan,SoilN Horiz Drains,70Ea	4000.00	LF	109,296	24,045	13,334	13,787	3,370	3,277	167,109	41.78
TOTAL APP CHANNL,STABILIZATION SOILWAL		4000.00	SY	1,330,388	292,685	162,307	167,826	41,017	39,884	2,034,108	508.53
FF 04 02 25-A05A APP CHANNL, ROCK ANCHOR,33'L,#11											
FF 04 02 25-A05A-B02G RockAnchr, #11 Drill 25'L/Ea		2210.00	LF	25,612	5,635	3,125	3,231	790	768	39,159	17.72
FF 04 02 25-A05A-B02M RockAnchr, #11 Install Bar		11338.00	LB	31,566	6,945	3,851	3,982	973	946	48,263	4.26
FF 04 02 25-A05A-B02Q RockAnchr,#11 Grouting Ful-25'L		10.00	CF	1,207	266	147	152	37	36	1,845	184.55
TOTAL APP CHANNL, ROCK ANCHOR,33'L,#11		85.00	EA	58,385	12,845	7,123	7,365	1,800	1,750	89,268	1050.21
FF 04 02 25-A06- APP CHANNL, SURFACE PREPARATION											
FF 04 02 25-A06--A02A APP Chan,Pick &Clean Rock Surfac		1210.00	SY	6,950	1,529	848	877	214	208	10,627	8.78
FF 04 02 25-A06--A02C APP Chan, Water Blast Surface		1210.00	SY	4,311	948	526	544	133	129	6,592	5.45
FF 04 02 25-A06--A03D APP Chan, Slush Grout / Gunite		1210.00	SY	42,019	9,244	5,126	5,301	1,295	1,260	64,246	53.10
TOTAL APP CHANNL, SURFACE PREPARATION		1210.00	SY	53,281	11,722	6,500	6,721	1,643	1,597	81,464	67.33
FF 04 02 25-A06A APP CHANNL, FD SLAB CONCRETE 5'T											
FF 04 02 25-A06A-B03A Channel Slab, Formwork off-Rock		4130.00	SF	73,283	16,122	8,941	9,245	2,259	2,197	112,047	27.13
FF 04 02 25-A06A-B03C Channel Slab, Reinforcement		188000.00	LB	243,711	58,016	32,173	33,267	8,130	7,906	403,203	2.14
FF 04 02 25-A06A-B03E Channel Slab, Mass Conc Placemt		1880.00	CY	285,980	62,916	34,890	36,076	8,817	8,574	437,252	232.58
TOTAL APP CHANNL, FD SLAB CONCRETE 5'T		1880.00	CY	622,975	137,054	76,003	78,587	19,207	18,677	952,502	506.65
FF 04 02 25-A07A APP CHANNL,ELLIPTIACAL WALLS10'T											
FF 04 02 25-A07A-A03A Channel Walls, Formwork Curved		17596.00	SF	334,865	73,670	40,854	42,243	10,324	10,039	511,995	29.10
FF 04 02 25-A07A-A03C Channel Walls, Reinforcement		187780.00	LB	304,001	66,880	37,088	38,349	9,373	9,114	464,805	2.48
FF 04 02 25-A07A-A03E Channel Walls, Conc Placement		2250.00	CY	322,485	70,947	39,343	40,681	9,943	9,668	493,067	219.14
TOTAL APP CHANNL,ELLIPTIACAL WALLS10'T		2250.00	CY	961,352	211,497	117,285	121,273	29,640	28,821	1,469,867	653.27
FF 04 02 25-A08- APP CHANNL, ELLIPT WALL BACKFILL											
FF 04 02 25-A08--A02E App Channel, Impervious Backfill		58000.00	ECY	2,003,393	440,746	244,414	252,724	61,767	60,061	3,063,104	52.81
FF 04 02 25-A08--A02F App Channel, Rip Rap Bedding		2900.00	ECY	100,170	22,037	12,221	12,636	3,088	3,003	153,155	52.81
FF 04 02 25-A08--A02H App Channel, Rip Rap		5800.00	ECY	493,927	108,664	60,259	62,308	15,228	14,808	755,195	130.21
TOTAL APP CHANNL, ELLIPT WALL BACKFILL		66700.00	CY	2,597,490	571,448	316,894	327,668	80,083	77,872	3,971,454	59.54

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/ri 09 Mar 2007 Tri-Service Automated Cost ,ineering System (TRACES) TIME 07:19:50
Eff. Date 01/26/07 PROJECT ITRJF1: FOLSOM IFA, AUX SPILLWAY, 6GATES - IFA - Concept Plans SUMMARY PAGE 14
AUX SPILLWAY, 6 GATES2
** PROJECT INDIRECT SUMMARY - CSI ITEM **

	QUANTITY	UOM	TOTAL DIRECT	FOOH	HOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 25-A09- APP CHANNL, SIPHON SILT,4'K UPST										
FF 04 02 25-A09--A02A Org, Set up Boats & Siphon Pipes	1.00	EA	101,692	22,372	12,406	12,828	3,135	3,049	155,483	155482.59
FF 04 02 25-A09--B02A Org, Siphon Silt, 4,000' U/S	2000.00	BCY	261,800	57,596	31,940	33,026	8,072	7,849	400,282	200.14
FF 04 02 25-A09--C02A Org, Remove Boats & Siphon Pipes	1.00	EA	92,980	20,456	11,346	11,729	2,867	2,787	142,162	142162.30
TOTAL APP CHANNL, SIPHON SILT,4'K UPST	2000.00	CY	456,472	100,424	55,690	57,583	14,074	13,685	697,927	348.96
TOTAL APPROACH CHANNEL, STA 0+95- 9+40	845.00	LF	27,683,111	6,090,284	3,377,339	3,492,169	853,501	829,928	42,326,332	50090.33
FF 04 02 27 SPILLWAY CHUTE, STA 11+00- 40+00										
FF 04 02 27-B03- CHUTE1,ROCK ANCHR,33'L,#11 REBAR										
FF 04 02 27-B03--B02G RockAnchr, #11 Drill 25'L/Ea	93886.00	LF	1,088,037	239,368	132,741	137,254	33,545	32,619	1,663,564	17.72
FF 04 02 27-B03--B02M RockAnchr, #11 Install Bar	481663.00	LB	1,340,988	295,017	163,601	169,163	41,344	40,202	2,050,316	4.26
FF 04 02 27-B03--B02Q RockAnchr,#11 Grouting Fol-25'L	404.00	CF	48,763	10,728	5,949	6,151	1,503	1,462	74,557	184.55
TOTAL CHUTE1,ROCK ANCHR,33'L,#11 REBAR	3611.00	EA	2,477,789	545,114	302,290	312,568	76,393	74,283	3,788,437	1049.14
FF 04 02 27-B04- CHUTE, FOUNDATION SURFACE PREP										
FF 04 02 27-B04--A02A CHUTE, Pick & Clean Rock Surface	40850.00	SY	234,649	51,623	28,627	29,600	7,234	7,035	358,768	8.78
FF 04 02 27-B04--A02C CHUTE, Water Blast FD Surface	40850.00	SY	145,552	32,022	17,757	18,361	4,488	4,364	222,544	5.45
FF 04 02 27-B04--A03D CHUTE, Slush Grout / Gunite FD	40850.00	SY	1,418,379	312,043	173,042	178,926	43,730	42,522	2,168,643	53.09
TOTAL CHUTE, FOUNDATION SURFACE PREP	48800.00	SY	1,798,580	395,688	219,427	226,887	55,452	53,921	2,749,955	56.35
FF 04 02 27-B04A CHUTE1,CONCRETE M-SLABS, 5' Thk										
FF 04 02 27-B04A-B03A Chutel Slab, Formwork off-Rock	153565.00	SF	2,655,852	584,287	324,014	335,030	81,883	79,621	4,060,688	26.44
FF 04 02 27-B04A-B03C Chutel Slab, Reinforcement	6488831	LB	9,382,541	2,064,159	1,144,670	1,183,589	289,274	281,285	14,345,518	2.14
FF 04 02 27-B04A-B03D Chutel Slab, Mass Conc Placemt	68060.00	CY	10,480,788	2,305,773	1,278,456	1,322,130	323,134	314,210	16,024,692	235.45
TOTAL CHUTE1,CONCRETE M-SLABS, 5' Thk	68060.00	CY	22,519,181	4,954,220	2,747,340	2,840,750	694,291	675,116	34,430,898	505.89
FF 04 02 27-B05A CHUTE1,CONCRETE RETAINING WALLS										
FF 04 02 27-B05A-B03A Chutel Walls, Formwork 2S Batter	260278.00	SF	3,617,113	795,765	441,288	456,292	111,520	108,440	5,530,417	21.25
FF 04 02 27-B05A-B03C Chutel Walls, Reinforcement	1446670	LB	2,102,524	462,555	256,508	265,229	64,823	63,033	3,214,673	2.22
FF 04 02 27-B05A-B03D Chutel Walls, Concrete Placement	9335.00	CY	1,501,032	330,227	183,126	189,352	46,278	45,000	2,295,016	245.85
TOTAL CHUTE1,CONCRETE RETAINING WALLS	9335.00	CY	7,220,670	1,588,547	880,922	910,873	222,621	216,473	11,040,106	1182.66
FF 04 02 27-B05K CHUTE2,ROCK ANCHR,33'L,#11 REBAR										

LABOR ID: CAL907 EQUIP ID: NAT998 Currency in DOLLARS CREW ID: FITRAC

Fri 09 Mar 2007 Tri-Service Automated Cost Engineering System (TRACES) TIME 07:19:30
Eff. Date 01/26/97 PROJECT ITAJF1: FOLLOW IFA, AUX SPILWAY, 60ATSS - IFA - Concept Plans SUMMARY PAGE 15
AUX SPILWAY, 4 GATES2
** PROJECT INDIRECT SUMMARY - CSI ITEM **

		QUANTITY	UOM	TOTAL DIRECT	FOOH	HOOH	EHOF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FY 04 02 27-B05K-B02G	RockAnchr, #11 Drill 25'L/Ea	39208.00	LF	494,378	99,963	55,434	57,219	14,059	13,622	694,726	17.72
FY 04 02 27-B05K-B02M	RockAnchr, #11 Install Bar	28149.00	LB	560,016	123,204	68,322	70,645	17,344	16,789	856,241	4.26
FY 04 02 27-B05K-B02Q	RockAnchr,#11 Grouting Pul-25'L	169.00	CF	20,399	4,488	2,489	2,573	629	612	31,189	184.55
TOTAL CHUTE2,ROCK ANCHR,33'L,#11 REBAR		1509.00	EA	1,034,793	227,654	126,245	130,437	31,904	31,023	1,582,156	1049.17
FY 04 02 27-B05M CHUTE2,CONCRETE M-SLABS, 5'-Thk											
FY 04 02 27-B05M-B03A Chute2 Slab, Formwork off-Rock		85983.00	SF	1,600,535	308,118	170,865	176,675	43,180	41,987	2,141,360	24.44
FY 04 02 27-B05M-B03C Chute2 Slab, Reinforcement		3248750	LB	4,557,079	1,002,557	555,964	574,666	140,500	136,619	6,967,585	2.14
FY 04 02 27-B05M-B03D Chute2 Slab, Mass Conc Placement		32490.00	CY	5,100,888	1,122,195	622,308	643,467	157,266	152,922	7,799,047	240.04
TOTAL CHUTE2,CONCRETE M-SLABS, 5'-Thk		32490.00	CY	11,058,502	2,432,870	1,349,137	1,395,008	340,946	331,529	16,907,992	520.41
FY 04 02 27-B05O CHUTE2,CONCRETE RETAINING WALLS											
FY 04 02 27-B05O-B03A Chute2 Walls, Formwork 28 Natter		92694.00	SF	2,457,736	540,702	299,844	310,039	75,775	73,682	3,757,777	40.54
FY 04 02 27-B05O-B03C Chute2 Walls, Reinforcement		974793.00	LB	1,416,723	311,679	172,840	178,717	43,679	42,473	2,166,111	2.22
FY 04 02 27-B05O-B03D Chute2 Walls, Concrete Placement		5570.00	CY	902,959	198,651	110,161	113,907	27,839	27,070	1,380,588	247.86
TOTAL CHUTE2,CONCRETE RETAINING WALLS		5570.00	CY	4,777,418	1,051,032	582,845	602,662	147,293	143,225	7,304,475	1311.40
FY 04 02 27-B05S CHUTE3,ROCK ANCHR,33'L,#11 REBAR											
FY 04 02 27-B05S-B02G RockAnchr, #11 Drill 25'L/Ea		4810.00	LF	55,743	12,263	6,801	7,032	1,719	1,671	85,228	17.72
FY 04 02 27-B05S-B02M RockAnchr, #11 Install Bar		24677.00	LB	68,703	15,115	8,382	8,667	2,118	2,060	105,044	4.26
FY 04 02 27-B05S-B02Q RockAnchr,#11 Grouting Pul-25'L		21.00	CF	2,535	558	309	320	78	76	3,875	184.55
TOTAL CHUTE3,ROCK ANCHR,33'L,#11 REBAR		185.00	EA	126,980	27,936	15,492	16,018	3,915	3,807	194,148	1049.45
FY 04 02 27-B05U CHUTE3,CONCRETE M-SLABS, 5'-Thk											
FY 04 02 27-B05U-B03A Chute3 Slab, Formwork off-Rock		12360.00	SF	227,912	50,141	27,805	28,731	7,027	6,833	348,447	28.28
FY 04 02 27-B05U-B03C Chute3 Slab, Reinforcement		467260.00	LB	655,434	144,195	79,963	82,682	20,208	19,650	1,002,131	2.14
FY 04 02 27-B05U-B03D Chute3 Slab, Mass Conc Placement		4672.00	CY	708,094	155,781	86,387	89,325	21,831	21,228	1,082,646	231.73
TOTAL CHUTE3,CONCRETE M-SLABS, 5'-Thk		4672.00	CY	1,591,439	350,117	194,156	200,737	49,066	47,711	2,433,245	520.81
FY 04 02 27-B05W CHUTE3,CONCRETE RETAINING WALLS											
FY 04 02 27-B05W-B03A Chute3 Walls, Formwork 28 Nat CR		17915.00	SF	371,159	81,655	45,281	46,821	11,443	11,127	567,487	31.68
FY 04 02 27-B05W-B03C Chute3 Walls, Reinforcement		409307.00	LB	623,960	137,183	76,074	78,661	19,225	18,694	953,397	2.33
FY 04 02 27-B05W-B03D Chute3 Walls, Concrete Placement		2338.00	CY	353,248	77,715	43,096	44,562	10,891	10,590	540,102	231.01
TOTAL CHUTE3,CONCRETE RETAINING WALLS		2338.00	CY	1,347,367	296,553	164,452	170,043	41,559	40,411	2,060,986	881.52

LABOR ID: CALWI EQUIP ID: NAT99B Currency DOLLARS CREW ID: FITTRAC

	QUANTITY	UOM	TOTAL DIRECT	FOOH	WOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 27-B06- CHUTE, DRAINAGE 6"Dia PERF PIPE										
FF 04 02 27-B06--A02A Chute, Herringbone Drain Rock Tr	780.00	BCY	3,890	856	475	491	120	117	5,947	7.62
FF 04 02 27-B06--A02F Chute, Rock Excs Haul to D2orR1	780.00	BCY	10,501	2,310	1,281	1,325	324	315	16,055	20.58
FF 04 02 27-B06--C02A Chute, 6"Dia Herringbone Drain	19500.00	LF	386,912	85,121	47,203	48,808	11,929	11,599	591,573	30.34
FF 04 02 27-B06--E02C Chute,Select Gravel Around6"Pipe	9750.00	ECY	515,036	113,308	62,834	64,971	15,879	15,441	787,469	80.77
TOTAL CHUTE, DRAINAGE 6"Dia PERF PIPE	19500.00	LF	916,339	201,595	111,793	115,594	28,252	27,471	1,401,044	71.85
FF 04 02 27-B07- CHUTE, DRAINAGE 12"Dia PERF PIPE										
FF 04 02 27-B07--A02A Chute, Herringbone Drain Rock Tr	630.00	BCY	3,142	691	383	396	97	94	4,803	7.62
FF 04 02 27-B07--A02F Chute, Rock Excs Haul to D2orR1	630.00	BCY	8,485	1,867	1,035	1,070	262	254	12,973	20.59
FF 04 02 27-B07--C02C Chute, 12"Dia Herringbone Drain	4200.00	LF	140,514	30,913	17,143	17,726	4,332	4,213	214,841	51.15
FF 04 02 27-B07--E02C ChuteSelect GravelAround 12"Pipe	630.00	ECY	33,279	7,321	4,060	4,198	1,026	998	50,883	80.77
TOTAL CHUTE, DRAINAGE 12"Dia PERF PIPE	4200.00	LF	185,420	40,792	22,621	23,390	5,717	5,559	283,500	67.50
FF 04 02 27-B08- CHUTE, STRUCTURAL BACKFILL										
FF 04 02 27-B08--E02A Chute, Str Fill Behind Conc Wall	120000.00	ECY	2,705,743	595,263	330,101	341,324	83,421	81,117	4,136,969	34.47
TOTAL CHUTE, STRUCTURAL BACKFILL	120000.00	CY	2,705,743	595,263	330,101	341,324	83,421	81,117	4,136,969	34.47
TOTAL SPILLWAY CHUTE, STA 11+00- 40+00	2900.00	LF	57,760,821	12707381	7,046,820	7,286,412	1,780,830	1,731,445	88,313,910	30453.07
FF 04 02 35 STILLING BASIN, STA 40+00- 42+80										
FF 04 02 35-A07- STILLING B,TEMP CONC WALL REMOVE										
FF 04 02 35-A07--02AA Stilling B,Temp Conc Wall Remove	1489.00	CY	569,240	125,233	69,467	71,809	17,550	17,046	870,345	584.52
TOTAL STILLING B,TEMP CONC WALL REMOVE	1489.00	CY	569,240	125,233	69,467	71,809	17,550	17,046	870,345	584.52
FF 04 02 35-F01- STILLING B, SURFACE PREPARATION										
FF 04 02 35-F01--A02A ST, Pick & Clean Rock Surface	27240.00	SY	156,471	34,424	19,089	19,738	4,824	4,691	239,237	8.78
FF 04 02 35-F01--A02C ST, Water Blast Surface	27240.00	SY	97,059	21,353	11,841	12,244	2,992	2,910	148,399	5.45
FF 04 02 35-F01--A03D ST, Slush Grout / Gunite	27240.00	SY	945,952	208,109	115,406	119,330	29,165	28,359	1,446,322	53.10
TOTAL STILLING B, SURFACE PREPARATION	27240.00	SY	1,199,482	263,886	146,337	151,312	36,981	35,960	1,833,958	67.33
FF 04 02 35-F03- STILLING B, ROCK ANCHR,#11 REBAR										
FF 04 02 35-F03--B02G RockAnchr, #11 Drill 25'L/Ea	17992.00	LF	208,508	45,872	25,438	26,303	6,429	6,251	318,800	17.72
FF 04 02 35-F03--B02M RockAnchr, #11 Install Bar	92304.00	LB	256,983	56,536	31,352	32,418	7,923	7,704	392,916	4.26

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		QUANTITY	UOM	TOTAL DIRECT	FOOH	BOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 35-F03--B02Q	RockAnchr,#11 Grouting Ful-25'L	78.00	CF	9,415	2,071	1,149	1,188	290	282	14,395	184.55
TOTAL STILLING B, ROCK ANCHR,#11 REBAR		692.00	EA	474,905	104,479	57,938	59,906	14,642	14,237	726,111	1049.29
FF 04 02 35-G01- STILLING B, MASS SLAB 5'+THK											
FF 04 02 35-G01--B03A	StillB Slab, Formwork off-Rock	48538.00	SF	839,453	184,680	102,413	105,895	25,881	25,166	1,283,490	26.44
FF 04 02 35-G01--B03C	StillB Slab, Reinforcement	1853185	LB	2,599,495	571,889	317,138	327,921	80,145	77,932	3,974,521	2.14
FF 04 02 35-G01--B03D	StillB Slab, Mass Conc Placemt	18532.00	CY	2,788,239	613,413	340,165	351,731	85,964	83,590	4,263,102	230.04
TOTAL STILLING B, MASS SLAB 5'+THK		18532.00	CY	6,227,187	1,369,981	759,717	785,547	191,991	186,688	9,521,112	513.77
FF 04 02 35-G03- STILLING B, CHUTE BLOCKS 11 EA											
FF 04 02 35-G03--B03A	StillB C-Blk, Formwork	5014.00	SF	172,393	37,926	21,032	21,747	5,315	5,168	263,582	52.57
FF 04 02 35-G03--B03C	StillB C-Blk, Reinforcement	69362.00	LB	97,295	21,405	11,870	12,274	3,000	2,917	148,760	2.14
FF 04 02 35-G03--B03D	StillB C-Blk, Concrete Placement	730.00	CY	129,091	28,400	15,749	16,285	3,980	3,870	197,374	270.38
TOTAL STILLING B, CHUTE BLOCKS 11 EA		695.00	CY	398,779	87,731	48,651	50,305	12,295	11,955	609,716	877.29
FF 04 02 35-G03A STILLING B, DENTATED SILL											
FF 04 02 35-G03A-B03A	StillB D-Sill, Formwork	2664.00	SF	120,577	26,527	14,710	15,211	3,718	3,615	184,358	69.20
FF 04 02 35-G03A-B03C	StillB D-Sill, Reinforcement	113176.00	LB	158,754	34,926	19,368	20,026	4,895	4,759	242,728	2.14
FF 04 02 35-G03A-B03D	StillB D-Sill, Concrete Placement	1132.00	CY	198,545	43,680	24,222	25,046	6,121	5,952	303,567	268.17
TOTAL STILLING B, DENTATED SILL		1132.00	CY	477,876	105,133	58,301	60,283	14,733	14,327	730,653	645.45
FF 04 02 35-G03B STILLING B, DENTATED BLOCKS 11EA											
FF 04 02 35-G03B-B03A	StillB D-Blk, Formwork	840.00	SF	59,809	13,158	7,297	7,545	1,844	1,793	91,446	108.86
FF 04 02 35-G03B-B03C	StillB D-Blk, Reinforcement	16435.00	LB	23,054	5,072	2,813	2,908	711	691	35,248	2.14
FF 04 02 35-G03B-B03D	StillB D-Blk, Concrete Placement	165.00	CY	29,754	6,546	3,630	3,753	917	892	45,492	275.71
TOTAL STILLING B, DENTATED BLOCKS 11EA		165.00	CY	112,616	24,776	13,739	14,206	3,472	3,376	172,186	1043.55
FF 04 02 35-G05- STILLING B,SIDES WALLS 2S BATTER											
FF 04 02 35-G05--B03A	StillB Walls, Formwork 2S Batter	48157.00	SF	1,215,005	267,301	148,231	153,271	37,460	36,425	1,857,693	38.58
FF 04 02 35-G05--B03C	StillB Walls, Reinforcement	1863575	LB	2,100,524	462,555	256,508	265,229	64,823	63,033	3,214,673	1.73
FF 04 02 35-G05--B03D	StillB Walls, Concrete Placement	17015.00	CY	2,939,848	646,767	358,661	370,856	90,639	88,135	4,494,907	264.17
TOTAL STILLING B,SIDES WALLS 2S BATTER		16205.00	CY	6,257,378	1,376,623	763,400	789,356	192,922	187,594	9,567,273	590.39
FF 04 02 35-G09- STILLING B,CONCR& COMMON BACKFIL											

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		QUANTITY	UOM	TOTAL DIRECT	FOOH	HOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 35-G09--K02G	Stilln, Lean Mix Concrete Backfi	16865.00	CY	3,149,664	692,926	384,259	397,326	97,108	94,426	4,815,706	285.63
FF 04 02 35-G09--K02H	Stilling B, Backfill Bhnd Wall	41000.00	ECY	621,408	136,710	75,812	78,389	19,159	18,630	950,106	23.17
TOTAL STILLING B,CONCR& COMMON BACKFIL		57860.00	CY	3,771,071	829,636	460,071	475,713	116,266	113,055	5,765,812	99.65
TOTAL STILLING BASIN, STA 40+00- 42+80		255.00	LF	19,468,535	4,283,478	2,377,601	2,458,440	600,853	584,258	29,797,165	116851.63
FF 04 02 36 STILLING BASIN,OFSITE RIVER BANK											
FF 04 02 36-C05- FAR BANK, ROAD ACCESS											
FF 04 02 36-C05--A02A	Access Road Cut - Rocky Material	1000.00	BCY	6,759	1,487	825	853	208	203	10,334	10.33
FF 04 02 36-C05--A02C	Access Road Platform Gravel Fill	2000.00	ECY	30,313	6,669	3,698	3,824	935	909	46,347	23.17
TOTAL FAR BANK, ROAD ACCESS				37,071	8,156	4,523	4,676	1,143	1,111	56,680	
FF 04 02 36-C07- FAR BANK, ROCK SLOPE ANCHRS,55'L											
FF 04 02 36-C07--B02M	Rockbolts,1.75"Drill&Install55'L	14795.00	LF	1,418,026	311,966	172,999	178,881	43,719	42,512	2,168,103	146.54
FF 04 02 36-C07--B02N	Rockbolts,1.75"Grouting Part30'L	1416.00	CF	332,372	73,122	40,549	41,928	10,247	9,964	508,183	358.89
FF 04 02 36-C07--B02O	Rockbolts,1.75"Testing/Stres55'L	269.00	EA	249,032	54,787	30,382	31,415	7,678	7,466	380,759	1415.46
FF 04 02 36-C07--B02P	Rockbolts,1.75"Grouting Part25'L	1181.00	CF	287,454	63,240	35,069	36,262	8,863	8,618	439,506	372.15
TOTAL FAR BANK, ROCK SLOPE ANCHRS,55'L		269.00	EA	2,286,884	503,114	279,000	288,486	70,507	68,560	3,496,551	12998.33
FF 04 02 36-D01- FAR BANK, WALL FOUNDATN ROCK EXC											
FF 04 02 36-D01--A02A	Far Bank Wall Exc Rocky Material	5100.00	BCY	53,506	11,771	6,528	6,750	1,650	1,604	81,809	16.04
TOTAL FAR BANK, WALL FOUNDATN ROCK EXC		5100.00	BCY	53,506	11,771	6,528	6,750	1,650	1,604	81,809	16.04
FF 04 02 36-D02- FAR BANK, ROCK ANCHR,#11 REBAR											
FF 04 02 36-D02--B02O	RockAnchr, #11 Drill 25'L/Ea	2550.00	LF	29,549	6,501	3,605	3,728	911	886	45,179	17.72
FF 04 02 36-D02--B02M	RockAnchr, #11 Install Bar	14625.00	LB	40,716	8,958	4,967	5,136	1,255	1,221	62,253	4.26
FF 04 02 36-D02--B02Q	RockAnchr,#11 Grouting Ful-25'L	11.00	CF	1,328	292	162	167	41	40	2,030	184.55
TOTAL FAR BANK, ROCK ANCHR,#11 REBAR		75.00	EA	71,593	15,750	8,734	9,031	2,207	2,146	109,462	1459.50
FF 04 02 36-D03- FAR BANK, ROCK WALL ANCHRS, 40'L											
FF 04 02 36-D03--B02M	Rockbolts,1.75"Drill&Install55'L	8250.00	LF	561,632	123,559	68,519	70,849	17,316	16,837	858,712	104.09
FF 04 02 36-D03--B02N	Rockbolts,1.75"Grouting Part30'L	790.00	CF	197,289	43,404	24,069	24,888	6,083	5,915	301,647	381.83
FF 04 02 36-D03--B02O	Rockbolts,1.75"Testing/Stres55'L	150.00	EA	138,665	30,550	16,942	17,518	4,281	4,163	212,319	1415.46
FF 04 02 36-D03--B02P	Rockbolts,1.75"Grouting Part25'L	658.00	CF	172,059	37,853	20,991	21,705	5,305	5,158	263,070	399.80

Tri-Service Automated Cost Engineering System (TRACES)
PROJECT ITRJF1: FOLSOM IFA, AUX SPILLWAY, 4GATES - IFA - Concept Plans
AUX SPILLWAY, 4 GATES2
** PROJECT INDIRECT SUMMARY - CSI ITEM **

Fri 09 Mar 2007
Eff. Date 01/26/07

TIME 07:19:50
SUMMARY PAGE 19

		QUANTITY	UOM	TOTAL DIRECT	MOOH	HOOH	PROF	AINQ FEE	BOND	TOTAL COST	UNIT COST
TOTAL FAR BANK, ROCK WALL ANCHOR, 40'L		150.00	EA	1,069,845	235,366	130,521	134,959	32,984	32,073	1,635,748	10904.99
FF 04 02 36-005- FAR WALL,FOUNDATION SURFACE PREP											
FF 04 02 36-005--A02A	FO; Pick & Clean Rock Surface	1840.00	SY	10,569	2,325	1,289	1,333	326	317	16,160	8.78
FF 04 02 36-005--A02C	FO; Water Blast Surface	1840.00	SY	6,356	1,442	800	827	202	197	10,024	5.45
FF 04 02 36-005--A03D	FO; Slush Grout / Gunite	1840.00	SY	63,913	14,061	7,797	8,063	1,971	1,916	97,720	53.11
FF 04 02 36-005--A03F	FO; Dental Concrete	250.00	CY	40,329	8,916	4,945	5,113	1,250	1,215	81,968	247.87
TOTAL FAR WALL,FOUNDATION SURFACE PREP		1840.00	SY	121,168	26,745	14,831	15,336	3,748	3,645	185,872	101.02
FF 04 02 36-007- FAR BANK, CONC RETAINING WALL											
FF 04 02 36-007--B03A	Far Bank Wall, Formwork 10 Batr	71357.00	SF	1,111,225	244,470	135,569	140,179	34,260	33,314	1,699,017	23.81
FF 04 02 36-007--B03C	Far Bank Wall, Reinforcement	831265.00	LB	1,266,545	278,640	154,518	159,772	39,049	37,970	1,936,495	2.33
FF 04 02 36-007--B03D	Far Bank Walls, Concrete Placemt	9700.00	CY	1,450,844	319,184	177,009	183,021	44,731	43,496	2,218,285	228.69
TOTAL FAR BANK, CONC RETAINING WALL		9700.00	CY	3,828,614	842,295	467,096	483,972	118,040	114,780	5,853,798	603.49
FF 04 02 36-010- FAR WALL, DRAINAGE 8"D PERF PIPE											
FF 04 02 36-010--C02C	Far Wall, 8" Dia Drain Pipe	750.00	LF	15,051	3,311	1,836	1,899	464	451	23,012	30.68
FF 04 02 36-010--E02C	Far Wall 3-Gravel Around 8"Pipe	112.50	ECY	5,955	1,310	726	751	184	179	9,105	80.93
TOTAL FAR WALL, DRAINAGE 8"D PERF PIPE		750.00	LF	21,006	4,621	2,563	2,650	648	630	32,117	42.82
FF 04 02 36-011- FAR BANK, BACKFILL											
FF 04 02 36-011--A02C Far Bank, Gravel Fill		19000.00	ECY	287,969	63,353	35,132	36,327	8,878	8,633	440,293	23.17
TOTAL FAR BANK, BACKFILL		19000.00	ECY	287,969	63,353	35,132	36,327	8,878	8,633	440,293	23.17
TOTAL STILLING BASIN,OFFSITE RIVER BANK		750.00	LF	7,779,055	1,711,172	948,923	981,184	239,806	233,183	11,892,325	15856.43
FF 04 02 42 CONCRETE DAM, EARTH & ROCK FILL											
FF 04 02 42-A01- DAM, EMBANKMENT TO LEFT WING WDAM											
FF 04 02 42-A01--A02A	Embankment Impervious Fill Frm->R1	21000.00	ECY	1,135,245	249,754	138,500	143,209	35,001	34,034	1,735,743	82.65
FF 04 02 42-A01--A02C	Embankment Rip Rap Bedding	1000.00	ECY	33,488	7,367	4,086	4,224	1,032	1,004	51,201	51.20
FF 04 02 42-A01--A02E	Embankment Rip Rap	2000.00	ECY	131,390	28,906	16,030	16,575	4,051	3,939	200,889	100.44
TOTAL DAM, EMBANKMENT TO LEFT WING WDAM		24000.00	CY	1,300,122	286,027	158,615	164,008	40,084	38,977	1,987,833	82.83
FF 04 02 42-A03- DAM, ROADWAY SURFACING, 24'WIDE											

LABOR ID: CALMI EQUIP ID: NAT99B Currency DOLLARS CREW ID: FITRAC

		QUANTITY	UOM	TOTAL DIRECT	FOOH	WOCH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 42-A03--A02A	LW Dam, Base Course 6" Thk	120.00	CY	5,573	1,226	680	703	172	167	8,521	71.01
FF 04 02 42-A03--A02B	LW Dam, Asphaltic Concrete 2"Thk	40.00	SCY	6,909	1,520	843	872	213	207	10,563	264.08
FF 04 02 42-A03--A02C	LW Dam, Road Stripping	183.00	LF	465	102	57	59	14	14	710	3.88
TOTAL DAM, ROADWAY SURFACING, 26'WIDE		183.00	LF	12,946	2,848	1,579	1,633	399	388	19,794	108.17
TOTAL CONCRETE DAM, EARTH & ROCK FILL		14103.00	CY	1,313,069	288,875	160,194	165,441	40,483	39,265	2,007,628	142.35
FF 04 02 43 FLOOD WALL-IN DAM EARTH SECTION											
FF 04 02 43-003A ID FLOOD WALL, CONCRETE SLAB											
FF 04 02 43-003A-B03A D1 Flood Wall-Slab, Formwork		1132.00	SF	11,680	2,570	1,425	1,473	360	350	17,858	15.78
FF 04 02 43-003A-B03C D1 Flood Wall-Slab, Reinforcment		10950.00	LB	15,360	3,379	1,874	1,938	474	460	23,484	2.14
FF 04 02 43-003A-B03D D1 Flood Wall-Slab, Conc Placmnt		73.00	CY	15,329	3,372	1,870	1,934	473	460	23,437	321.06
TOTAL ID FLOOD WALL, CONCRETE SLAB		73.00	CY	42,368	9,321	5,169	5,345	1,306	1,270	64,780	887.39
FF 04 02 43-004A ID FLOOD WALL, CONCRETE WALL											
FF 04 02 43-004A-003A D1 Flood Wall-Wall, Formwork		3113.00	SF	30,319	6,670	3,699	3,825	935	909	46,357	14.89
FF 04 02 43-004A-003C D1 Flood Wall-Wall, Reinforcment		8700.00	LB	12,204	2,685	1,489	1,539	376	366	18,659	2.14
FF 04 02 43-004A-003D D1 Flood Wall-Wall, Conc Placmnt		58.00	CY	9,879	2,173	1,205	1,246	305	296	15,104	260.41
TOTAL ID FLOOD WALL, CONCRETE WALL		58.00	CY	52,401	11,528	6,393	6,610	1,616	1,571	80,120	1381.37
FF 04 02 43-004C ID FLOOD WALL,CONCRETE WALL COAT											
FF 04 02 43-004C-003F D1 Flood Wall, Anti-graffiti Ctg		1981.00	SF	14,185	3,121	1,731	1,789	437	425	21,689	10.95
TOTAL ID FLOOD WALL,CONCRETE WALL COAT		1981.00	SF	14,185	3,121	1,731	1,789	437	425	21,689	10.95
FF 04 02 43-005- ID FLOOD WALL, BACKFILL											
FF 04 02 43-005--K02A D1 Backfill, Random		35.00	BCY	629	138	77	79	19	19	962	27.48
FF 04 02 43-005--K02B D1 Backfill, Filter Material		1127.00	BCY	56,684	12,471	6,915	7,151	1,748	1,699	86,668	76.90
FF 04 02 43-005--K02C D1 Backfill, Slope Protection RS		136.00	BCY	8,233	1,811	1,004	1,039	254	247	12,588	92.56
TOTAL ID FLOOD WALL, BACKFILL				65,546	14,420	7,997	8,269	2,021	1,965	100,218	
TOTAL FLOOD WALL-IN DAM EARTH SECTION		283.00	LF	174,502	38,390	21,289	22,013	5,380	5,231	266,806	942.78
FF 04 02 44 FLOOD WALL- OUTSIDE OF DAM SECTN											
FF 04 02 44-001- GD SITE WORK											

	QUANTITY UOM	TOTAL DIRECT	FOOH	HOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 44-001--A02A D1 Security Fencing	100.00 LF	16,258	3,577	1,983	2,051	501	487	24,857	248.57
FF 04 02 44-001--A02B D1 Traffic Control	0.25 MO	9,947	2,193	1,216	1,257	307	299	15,238	60953.93
FF 04 02 44-001--A02C D1 Silt Fence	500.00 LF	3,026	666	369	382	93	91	4,627	9.25
TOTAL OD SITE WORK	500.00 LF	29,250	6,435	3,569	3,690	902	877	44,723	89.45
FF 04 02 44-002- OD FLOOD WALL, EXCAVATION									
FF 04 02 44-002--K02A D1 Stripping/Exc, Haul 2mi Disp$	205.00 BCY	2,360	519	288	298	73	71	3,608	17.60
FF 04 02 44-002--K02C D1 Excavtion, Haul 2mi Disp Site	515.00 BCY	5,928	1,304	723	748	183	178	9,064	17.60
FF 04 02 44-002--K02E D1 Trench Exc,Haul 2mi Disp Site	37.00 BCY	426	94	52	54	13	13	651	17.60
TOTAL OD FLOOD WALL, EXCAVATION		8,714	1,917	1,063	1,099	269	261	13,323	
FF 04 02 44-003A OD FLOOD WALL, CONCRETE SLAB									
FF 04 02 44-003A-B03A D1 Flood Wall-Slab, Formwork	2000.00 SF	17,091	3,760	2,085	2,156	527	512	26,131	13.07
FF 04 02 44-003A-B03C D1 Flood Wall-Slab, Reinforcement	16852.00 LB	23,639	5,200	2,884	2,982	729	709	36,142	2.14
FF 04 02 44-003A-B03D D1 Flood Wall-Slab, Conc Placmnt	130.00 CY	27,291	6,004	3,330	3,443	841	818	41,727	320.98
TOTAL OD FLOOD WALL, CONCRETE SLAB	130.00 CY	68,021	14,965	8,299	8,581	2,097	2,039	104,001	800.01
FF 04 02 44-004A OD FLOOD WALL, CONCRETE WALL									
FF 04 02 44-004A-D03A D1 Flood Wall-Wall, Formwork	3500.00 SF	52,029	11,446	6,348	6,563	1,604	1,560	79,550	14.46
FF 04 02 44-004A-D03C D1 Flood Wall-Wall, Reinforcement	13241.00 LB	18,573	4,086	2,266	2,343	573	557	28,398	2.14
FF 04 02 44-004A-D03D D1 Flood Wall-Wall, Conc Placmnt	102.00 CY	17,369	3,821	2,119	2,191	536	521	26,557	260.36
TOTAL OD FLOOD WALL, CONCRETE WALL	102.00 CY	87,972	19,354	10,733	11,097	2,712	2,637	134,505	1318.68
FF 04 02 44-004C OD FLOOD WALL,CONCRETE WALL COAT									
FF 04 02 44-004C-D03F D1 Flood Wall, Anti-graffiti Ctg	3500.00 SF	25,062	5,514	3,058	3,162	773	751	38,319	10.95
TOTAL OD FLOOD WALL,CONCRETE WALL COAT	3500.00 SF	25,062	5,514	3,058	3,162	773	751	38,319	10.95
FF 04 02 44-005- OD FLOOD WALL, BACKFILL									
FF 04 02 44-005--K02A D1 Backfill, Random	61.00 BCY	1,096	241	134	138	34	33	1,676	27.48
FF 04 02 44-005--K02B D1 Backfill, Filter Material	1991.00 BCY	100,141	22,031	12,217	12,633	3,087	3,002	153,111	76.90
FF 04 02 44-005--K02C D1 Backfill, Slope Protection RS	241.00 BCY	14,607	3,214	1,782	1,843	450	438	22,334	92.67
TOTAL OD FLOOD WALL, BACKFILL		115,844	25,486	14,133	14,614	3,572	3,473	177,121	
FF 04 02 44-006- OD ASPHALT, TOP OF DIKE									

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	QUANTITY UOM	TOTAL DIRECT	FOOH	HOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 44-006--A02A D1 Existing Demo	1930.00 BCY	65,394	14,387	7,978	8,249	2,016	1,960	99,984	51.81
FF 04 02 44-006--A02F D1 Base Course 6" Thk	1450.00 CCY	63,729	14,020	7,775	8,039	1,965	1,911	97,439	67.20
FF 04 02 44-006--A02G D1 Asphalt Concrete 2" Thk	480.00 ECY	108,554	23,882	13,244	13,694	3,347	3,254	165,975	345.78
TOTAL OD ASPHALT, TOP OF DIKE	8670.00 SY	237,677	52,289	28,997	29,982	7,328	7,125	363,398	41.91
TOTAL FLOOD WALL- OUTSIDE OF DAM SECTN	500.00 LF	572,540	125,959	69,850	72,225	17,652	17,165	875,390	1750.78
FF 04 02 51 CONCRETE DAM, NON OVERFLOW SECT									
FF 04 02 51-A01- DAM NON OVERFLOW, MASS CONCRETE									
FF 04 02 51-A01--A03A Dam Non O Mass, Surf Prep ?????	23800.00 SF	115,421	25,393	14,081	14,560	3,559	3,460	176,474	7.41
FF 04 02 51-A01--A03A Dam Non O Mass, Ext Formwork	147375.00 SF	8,041,492	1,769,128	981,062	1,014,418	247,928	241,081	12,295,110	83.43
FF 04 02 51-A01--A03B Dam Non O Mass, Gallry Wall Form	10000.00 SF	570,096	125,421	69,552	71,916	17,577	17,091	871,653	87.17
FF 04 02 51-A01--A03C Dam Non O Mass, Gallry Ceil Form	4200.00 SF	245,471	54,004	29,947	30,966	7,568	7,359	375,315	89.36
FF 04 02 51-A01--A03D Dam Non O Mass, Gallry StairForm	275.00 SF	33,969	7,473	4,144	4,285	1,047	1,018	51,938	188.87
FF 04 02 51-A01--A03E Dam Non O Mass, Gallry TrnchForm	525.00 SF	27,269	5,999	3,327	3,440	841	818	41,693	79.41
FF 04 02 51-A01--A03F Dam Non O Mass, Contraction Jts	5.00 EA	4,297	945	524	542	132	129	6,571	1314.14
FF 04 02 51-A01--A03G Dam Non O Mass, Waterstop	6834.00 LF	52,473	11,544	6,402	6,619	1,618	1,573	80,230	11.74
FF 04 02 51-A01--A03H Dam Non O Mass, Reinforcement	227500.00 LB	512,371	112,722	62,509	64,635	15,797	15,361	783,396	3.44
FF 04 02 51-A01--A03I Dam Non O Mass, Conc Placement	92830.00 CY	1,376,891	302,916	167,981	173,692	42,451	41,279	2,105,209	22.68
TOTAL DAM NON OVERFLOW, MASS CONCRETE	92830.00 CY	10,979,751	2,415,545	1,339,530	1,385,074	338,518	329,148	16,787,585	180.84
FF 04 02 51-A03- DAM NON OVERFLOW, ROADWAY SLAB									
FF 04 02 51-A03--A03A Dam NRoad Slab, Formwork	255.00 SF	1,770	389	216	223	55	53	2,706	10.61
FF 04 02 51-A03--A03C Dam NRoad Slab, Reinforcement	21875.00 LB	30,684	6,751	3,744	3,871	946	920	46,915	2.14
FF 04 02 51-A03--A03D Dam NRaod Slab, Conc Placement	168.00 CY	82,110	18,064	10,017	10,358	2,532	2,462	125,543	747.28
TOTAL DAM NON OVERFLOW, ROADWAY SLAB	168.00 CY	114,565	25,204	13,977	14,452	3,532	3,435	175,165	1042.65
FF 04 02 51-A05- DAM NON OVERFLOW, SIDEWALK SLAB									
FF 04 02 51-A05--A03A Dam NSideW Slab, Formwork	185.00 SF	25,507	5,612	3,112	3,218	786	765	39,000	210.81
FF 04 02 51-A05--A03C Dam NSideW Slab, Reinforcement	2971.00 LB	4,167	917	508	526	128	125	6,372	2.14
FF 04 02 51-A05--A03D Dam NSideW Slab, Conc Placement	30.00 CY	12,305	2,707	1,501	1,552	379	369	18,814	627.15
TOTAL DAM NON OVERFLOW, SIDEWALK SLAB	30.00 CY	41,980	9,236	5,122	5,296	1,294	1,259	64,186	2139.53
FF 04 02 51-A07- DAM NON OVERFLOW, PARAPET WALLS									
FF 04 02 51-A07--A03A Dam NParapet Walls, Formwork	2972.00 SF	36,394	8,007	4,440	4,591	1,122	1,091	55,645	18.72
FF 04 02 51-A07--A03C Dam NParapet Walls, Reinforcemt	7440.00 LB	10,436	2,296	1,273	1,317	322	313	15,957	2.14
FF 04 02 51-A07--A03D Dam NParapet Walls, Conc Placem	55.00 CY	11,665	2,566	1,423	1,471	360	350	17,835	324.27

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		QUANTITY UOM	TOTAL DIRECT	FOOH	WOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
TOTAL DAM NON OVERFLOW, PARAPET WALLS		55.00 CY	58,495	12,869	7,136	7,379	1,803	1,754	89,436	1626.11
FF 04 02 51-A09- DAM NON OVERFLOW,ASSOCIATED ITEM										
FF 04 02 51-A09--A01A	Dam Non O Mass,Gallry Sump Pump	2.00 EA	85,770	18,869	10,464	10,820	2,644	2,571	131,139	65569.70
FF 04 02 51-A09--A02D	Dam NRaod Slab, Road Drains	2250.00 LF	22,284	4,903	2,719	2,811	687	668	34,072	15.14
FF 04 02 51-A09--A09D	Dam NRaod Slab, Stripping	500.00 LF	1,058	233	129	133	33	32	1,618	3.24
FF 04 02 51-A09--A10A	Dam ,Expansion Jts	175.00 LF	1,355	298	165	171	42	41	2,071	11.83
FF 04 02 51-A09--B15A	Dam Non O Mass,Gallry Sump Pump	2.00 EA	85,770	18,869	10,464	10,820	2,644	2,571	131,139	65569.70
FF 04 02 51-A09--C02D	Dam Parapet Wall,Guard Rail1.5'	250.00 LF	19,908	4,380	2,429	2,511	614	597	30,439	121.76
FF 04 02 51-A09--C02F	Dam Parapet Wall,Guard Rail3.5'	250.00 LF	22,939	5,047	2,799	2,894	707	688	35,073	140.29
TOTAL DAM NON OVERFLOW,ASSOCIATED ITEM			239,086	52,599	29,168	30,160	7,371	7,168	365,552	
TOTAL CONCRETE DAM, NON OVERFLOW SECT		93083.00 CY	11,433,876	2,515,453	1,394,933	1,442,361	352,519	342,783	17,481,925	187.81
FF 04 02 52 CONCRETE DAM, OVERFLOW SECTION										
FF 04 02 52-A01- OVERFLOW SEC DAM, INVERT SLAB										
FF 04 02 52-B01- OVERFLOW SEC DAM, GATE PIERS										
FF 04 02 52-B01--B03A	Gate Piers, Ext Formwork	117189.00 SF	1,630,954	358,810	198,976	205,742	50,284	48,895	2,493,662	21.28
FF 04 02 52-B01--B03H	Gate Piers, Reinforcement	1871625 LB	4,636,835	1,020,104	565,694	584,927	142,959	139,010	7,089,529	3.79
FF 04 02 52-B01--B03I	Gate Piers, Conc Placement	11287.00 CY	2,027,920	446,142	247,406	255,818	62,523	60,796	3,100,605	274.71
TOTAL OVERFLOW SEC DAM, GATE PIERS		11287.00 CY	8,295,709	1,825,056	1,012,076	1,046,487	255,766	248,702	12,683,796	1123.75
FF 04 02 52-B01C OVERFLOW SEC DAM, GATE PIER NOSE										
FF 04 02 52-B01C-B03H	Gate Pier Nose, Steel Plates	295960.00 LB	1,806,544	397,440	220,398	227,892	55,698	54,159	2,762,132	9.33
TOTAL OVERFLOW SEC DAM, GATE PIER NOSE		295960.00 LB	1,806,544	397,440	220,398	227,892	55,698	54,159	2,762,132	9.33
FF 04 02 52-E01- OVERFLOW SEC DAM, BREAST MONOLIT										
FF 04 02 52-E01--B03A	Breast Wall, Ext Formwork	39319.00 SF	2,196,104	483,143	267,925	277,034	67,708	65,838	3,357,752	85.40
FF 04 02 52-E01--B03C	Breast Wall, Elevated SlabForm	6160.00 SF	126,134	27,750	15,388	15,912	3,889	3,781	192,854	31.31
FF 04 02 52-E01--B03D	Breast Wall, Scaffolding 34'6	2094.00 CCF	219,007	48,182	26,719	27,627	6,752	6,566	334,853	159.91
FF 04 02 52-E01--B03H	Breast Wall, Reinforcement	591500.00 LB	1,465,404	322,389	178,779	184,858	45,190	43,932	2,240,543	3.79
FF 04 02 52-E01--B03I	Breast Wall, Conc Placement	11830.00 CY	1,541,392	339,106	188,050	194,444	47,523	46,210	2,356,725	199.22
TOTAL OVERFLOW SEC DAM, BREAST MONOLIT		11830.00 CY	5,548,042	1,220,569	676,861	699,874	171,052	166,328	8,482,727	717.05
FF 04 02 52-G01- OVERFLOW SEC DAM, VORTEX BREAKER										

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		QUANTITY	UOM	TOTAL DIRECT	FOOH	MOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 52-G01--B03A	Vortex Wall, Ext Formwork	17776.00	SF	235,691	51,852	28,754	29,732	7,267	7,066	360,362	20.27
FF 04 02 52-G01--B03C	Vortex Wall, Elevated SlabForm	9285.00	SF	201,830	44,403	24,623	25,460	6,223	6,051	308,589	33.24
FF 04 02 52-G01--B03D	Vortex Wall, Scaffolding 50'H	4643.00	CCF	390,647	85,942	47,659	49,279	12,044	11,711	597,283	128.64
FF 04 02 52-G01--B03H	Vortex Wall, Reinforcement	251409.00	LB	622,850	137,027	75,988	78,571	19,203	18,673	952,312	3.79
FF 04 02 52-G01--B03I	Vortex Wall, Conc Placement	1545.00	CY	351,514	77,333	42,885	44,343	10,838	10,538	537,451	347.86
TOTAL OVERFLOW SEC DAM, VORTEX BREAKER		1545.00	CY	1,802,532	396,557	219,909	227,386	55,574	54,039	2,755,997	1783.82
FF 04 02 52-J01- OVERFLOW SEC DAM,ASSOCIATED ITEM											
FF 04 02 52-J01--A05A	HANDRAILS - MECH DECK	552.00	LF	82,448	18,139	10,059	10,401	2,542	2,472	126,059	228.37
TOTAL OVERFLOW SEC DAM,ASSOCIATED ITEM				82,448	18,139	10,059	10,401	2,542	2,472	126,059	
TOTAL CONCRETE DAM, OVERFLOW SECTION		24662.00	CY	17,535,275	3,857,760	2,139,304	2,212,040	540,632	525,700	26,810,711	1087.13
FF 04 02 53 SPILLWAY RADIAL GATES &EQUIPMENT											
FF 04 02 53-A---	RADIAL GATES,23'WX33.5'HX90H SUB	6.00	EA	0	0	0	0	0	0	0	0.00
TOTAL RADIAL GATES,23'WX33.5'HX90H SUB		6.00	EA	0	0	0	0	0	0	0	0.00
FF 04 02 53-A01- TRUNNION CONCRETE BEAM											
FF 04 02 53-A01--B03A	Trunnion Beam, Ext Formwork	25200.00	SF	479,075	105,397	58,447	60,434	14,770	14,362	732,486	29.07
FF 04 02 53-A01--B03C	Trunnion Beam,Elevated Beam Form	1656.00	SF	22,081	4,858	2,694	2,785	681	662	33,760	20.39
FF 04 02 53-A01--B03D	Trunnion Beam, Scaffolding 34'H	563.00	CCF	58,452	12,903	7,156	7,399	1,808	1,758	89,477	158.28
FF 04 02 53-A01--B03H	Trunnion Beam, Reinforcement	373930.00	LB	926,388	203,805	113,019	116,842	28,562	27,773	1,416,409	3.79
FF 04 02 53-A01--B03I	Trunnion Beam, Conc Placement	389.00	CY	74,555	16,402	9,096	9,405	2,299	2,235	113,992	293.04
TOTAL TRUNNION CONCRETE BEAM		370.00	CY	1,560,752	343,365	190,412	196,886	48,120	46,791	2,386,325	6449.53
FF 04 02 53-A03A RADIAL EQUIP OPERATNG CONC DECK											
FF 04 02 53-A03A-B03A	Tr Equip Beam, Ext Formwork	1656.00	SF	27,923	6,143	3,407	3,522	861	837	42,694	25.78
FF 04 02 53-A03A-B03C	Tr Equip Beam,Elevated Beam Form	830.00	SF	11,067	2,435	1,350	1,396	341	332	16,921	20.39
FF 04 02 53-A03A-B03D	Tr Equip Beam, Scaffolding 34'H	747.00	CCF	77,844	17,126	9,497	9,820	2,400	2,334	119,021	159.33
FF 04 02 53-A03A-B03H	Tr Equip Beam, Reinforcement	92500.00	LB	229,163	50,416	27,958	28,908	7,065	6,870	350,381	3.79
FF 04 02 53-A03A-B03I	Tr Equip Beam, Conc Placement	184.00	CY	36,311	7,988	4,430	4,581	1,119	1,089	55,517	286.17
TOTAL RADIAL EQUIP OPERATNG CONC DECK		185.00	CY	382,308	84,108	46,642	48,227	11,787	11,461	584,534	3159.64
FF 04 02 53-A03B RADIAL EQUIP &TR PROTECTION CONC											
FF 04 02 53-A03B-A03A	EQ&TRU P,Precast Conc Slab Plank	560.00	CY	892,675	196,388	108,906	112,609	27,522	26,762	1,364,863	2437.25

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	QUANTITY UOM	TOTAL DIRECT	FOOH	SOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
TOTAL RADIAL EQUIP &TR PROTECTION CONC	14470.00 SF	892,675	196,388	108,904	112,609	27,522	26,762	1,364,863	94.32
FF 04 02 53-A05- RADIAL GATES, ACCESS LADDERS									
FF 04 02 53-A05--A05A Radial Gates, Catwalks,	6.00 EA	426,282	93,782	52,006	53,775	13,143	12,780	651,768	108627.97
FF 04 02 53-A05--A05C Radial Gates, Ladder/Platforms	750.00 VLF	124,780	27,452	15,223	15,741	3,847	3,741	190,783	254.38
FF 04 02 53-A05--A05E Radial Gates, Handrailing	1190.00 LF	128,604	28,293	15,690	16,223	3,965	3,856	196,631	165.24
TOTAL RADIAL GATES, ACCESS LADDERS	6.00 SET	679,666	149,527	82,919	85,739	20,955	20,376	1,039,181	173196.88
FF 04 02 53-C01- RADIAL GATES, 23.5'W X 33.5'H									
FF 04 02 53-C01--A02A Radial Gate,Set/Remov Safety Net	6.00 EA	32,310	7,108	3,942	4,076	996	969	49,400	8233.37
FF 04 02 53-C01--A05A Radial Gates, Purchased	1194514 LB	8,761,358	1,927,499	1,068,886	1,105,228	270,122	262,662	13,395,755	11.21
FF 04 02 53-C01--A05C Radial Gates, Assembly in place	6.00 EA	1,283,089	282,280	156,537	161,859	39,559	38,446	1,961,791	326965.08
FF 04 02 53-C01--Z07G Paint Gates Fl-A-Z, Epoxy-F Zinc	19200.00 SF	219,069	48,195	26,726	27,635	6,754	6,566	334,947	17.45
TOTAL RADIAL GATES, 23.5'W X 33.5'H	6.00 EA	10,295,826	2,265,082	1,256,091	1,298,798	317,432	308,645	15,741,893	2623649
FF 04 02 53-C03- RADIAL GATES, TRUNNION GUIDES									
FF 04 02 53-C03--C05A Radial Guides, Install	12.00 EA	875,182	192,540	106,772	110,402	26,983	26,238	1,338,117	111509.76
FF 04 02 53-C03--E03A Radial Guides,Grout Around Guide	0.26 CY	62,389	13,726	7,612	7,870	1,924	1,870	95,391	373204.09
TOTAL RADIAL GATES, TRUNNION GUIDES	12.00 SET	937,571	206,266	114,384	118,273	28,906	28,108	1,433,508	119459.01
FF 04 02 53-C05- RADIAL GATES, TRUNNIONS									
FF 04 02 53-C05--A05A Trunnion Anchors, Tendons	72.00 EA	1,542,149	339,273	188,162	194,539	47,546	46,233	2,357,882	32748.36
FF 04 02 53-C05--A05C Trunnion Bases, Install	12.00 EA	790,639	173,941	96,458	99,738	24,376	23,703	1,208,854	100737.84
FF 04 02 53-C05--A05E Trunnion Forged Housing, Install	12.00 EA	1,154,543	253,999	140,854	145,643	35,596	34,613	1,765,248	147104.00
FF 04 02 53-C05--A05F Trunnion Bushing & Pins, Install	12.00 EA	267,287	58,803	32,609	33,718	8,241	8,013	408,671	34055.90
TOTAL RADIAL GATES, TRUNNIONS	12.00 EA	3,754,617	826,016	458,063	473,637	115,759	112,562	5,740,655	478387.90
FF 04 02 53-C07- RADIAL GATES,OPERATING EQUIPMENT									
FF 04 02 53-C07--A15A HG Hydraulic Cylinders	12.00 EA	3,902,496	858,549	476,105	492,292	120,318	116,995	5,966,756	497229.66
FF 04 02 53-C07--A15C HG Hydraulic Power Supply, 40HP	6.00 EA	1,064,367	234,161	129,853	134,268	32,816	31,909	1,627,373	271228.91
FF 04 02 53-C07--A15E HG 4" Piping,Energy Distribution	1200.00 LF	78,205	17,205	9,541	9,865	2,411	2,345	119,571	99.64
FF 04 02 53-C07--B09A Radial Gate Seals, 6 EA	6.00 EA	448,641	98,701	54,734	56,595	13,832	13,450	685,953	114325.52
FF 04 02 53-C07--D13A Radial Gate Instrumentation	12.00 EA	216,779	47,691	26,447	27,346	6,684	6,499	331,445	27620.45
TOTAL RADIAL GATES,OPERATING EQUIPMENT	6.00 SET	5,710,487	1,256,307	696,679	720,367	176,061	171,198	8,731,099	1455183

		QUANTITY	UOM	TOTAL DIRECT	FOOH	HOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 53-E07-	RADIAL GATES, POWER TO DAM										
FF 04 02 53-E07--A16A	Transformer @ Existing Dam	1.00	EA	0	0	0	0	0	0	0	0.00
FF 04 02 53-E07--A16B	Power & Trench,Dam->Spillway MCC	2850.00	LF	411,556	90,542	50,210	51,917	12,489	12,338	629,252	220.79
FF 04 02 53-E07--A16C	Spillway MCC,300A Service,1Mains	12.00	EA	102,868	22,631	12,550	12,977	3,172	3,084	157,281	13106.78
	TOTAL RADIAL GATES, POWER TO DAM	2850.00	LF	514,424	113,173	62,760	64,894	15,660	15,422	786,534	275.98
FF 04 02 53-E09-	RADIAL GATES, ELECTRICAL SYSTEM										
FF 04 02 53-E09--A16A	Electrical Runs between Motors	2850.00	LF	163,567	35,985	19,955	20,634	5,043	4,904	250,086	87.75
FF 04 02 53-E09--A16C	Electrical Runs & Conn to Motors	2850.00	LF	476,598	104,852	58,145	60,122	14,694	14,288	728,698	255.68
FF 04 02 53-E09--A16E	Initial Elec Run to First Motor	2850.00	LF	1,065,830	234,483	130,031	134,452	32,861	31,953	1,629,609	571.79
FF 04 02 53-E09--A16G	Electrical Field Testing	8.00	CWA	3,483	766	425	439	107	104	5,326	665.76
	TOTAL RADIAL GATES, ELECTRICAL SYSTEM	4.00	EA	1,709,477	376,085	208,556	215,647	52,705	51,249	2,613,720	435620.04
	TOTAL SPILLWAY RADIAL GATES &EQUIPMENT	4.00	EA	26,437,805	5,816,317	3,225,412	3,335,076	815,107	792,594	40,422,311	6737052
FF 04 02 54	SPILLWAY BULKHEAD,SLOTS & HOISTS										
FF 04 02 54-F01-	BULKHEAD, HOIST PLATFORMS										
FF 04 02 54-F01--A05A	Bulkhead Platforms, Metals ?x?	1770.00	SF	426,244	93,774	52,002	53,770	13,142	12,779	651,710	368.20
FF 04 02 54-F01--A05E	Bulkhead Platforms, Handrailing	354.00	LF	39,941	8,787	4,873	5,039	1,231	1,197	61,069	172.51
	TOTAL BULKHEAD, HOIST PLATFORMS	1770.00	SF	466,186	102,561	56,875	58,808	14,373	13,976	712,779	402.70
FF 04 02 54-F02-	BULKHEAD, DEWATERING BULKHEAD										
FF 04 02 54-F02--A05A	Bulkhead, Sliding, Purchase	897100.00	LB	7,812,777	1,718,811	953,159	985,566	240,877	234,224	11,945,414	13.32
FF 04 02 54-F02--B05A	Bulkhead, ?'W X ?'H Instal	6.00	EA	55,491	12,208	6,770	7,000	1,711	1,664	84,844	14140.63
	TOTAL BULKHEAD, DEWATERING BULKHEAD	6.00	EA	7,868,269	1,731,019	959,929	992,566	242,587	235,887	12,030,258	2005043
FF 04 02 54-F03-	BULKHEAD, EMBEDDED GUIDE SLOTS										
FF 04 02 54-F03--A05C	Bulkhead, Embedd Guidebeams ? EA	112912.00	LB	1,386,946	305,128	169,207	174,960	42,761	41,580	2,120,583	18.78
FF 04 02 54-F03--A05D	Bldhd Guides,Grout Around Guide	26.00	CY	87,188	19,181	10,637	10,999	2,688	2,614	133,306	5127.16
	TOTAL BULKHEAD, EMBEDDED GUIDE SLOTS	7.00	EA	1,474,133	324,309	179,844	185,959	45,449	44,194	2,253,889	321984.11
FF 04 02 54-F04-	BULKHEAD, HOIST LIFTING SYSTEM										
FF 04 02 54-F04--A02B	Equip Mod 7 Ea Decks Anchorages	122.00	EA	31,056	6,832	3,789	3,918	957	931	47,484	389.21
FF 04 02 54-F04--A15A	Equip Mod Operating Mach Purchas	6.00	SET	6,947,014	1,528,343	847,536	876,352	214,184	208,269	10,621,697	1770283

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		QUANTITY	UOM	TOTAL DIRECT	FOOH	HOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 54-F04--B15A	Equip Mod SiteConstr-Interm Pier	5.00	ASY	199,873	43,972	24,385	25,214	6,162	5,992	305,598	61119.50
FF 04 02 54-F04--B15C	Equip Mod Site Constr-End Piers	2.00	ASY	74,525	16,395	9,092	9,401	2,298	2,234	113,945	56972.54
FF 04 02 54-F04--C15A	Equip Mod Install on Piers	7.00	ASY	197,006	43,341	24,035	24,852	6,074	5,906	301,214	43030.58
TOTAL BULKHEAD, HOIST LIFTING SYSTEM		6.00	SET	7,449,474	1,638,884	908,836	939,736	229,676	223,332	11,389,937	1898323
TOTAL SPILLWAY BULKHEAD,SLOTS & HOISTS		6.00	EA	17,258,061	3,796,773	2,105,483	2,177,070	532,085	517,389	26,386,862	4397810
FF 04 02 55 BRIDGES, SUPERSTR & DECK,6 SPANS											
FF 04 02 55-A01- PRECAST,PRESTRESS GIRDERS,30 EA											
FF 04 02 55-A01--A03A	Precast Prestress Girders, 30 EA	430.00	CY	718,154	157,994	87,615	90,594	22,141	21,530	1,098,027	2553.55
FF 04 02 55-A01--A03C	Install Precast Girders, 30 EA	30.00	EA	217,912	47,941	26,585	27,489	6,718	6,533	333,178	11105.92
TOTAL PRECAST,PRESTRESS GIRDERS,30 EA		430.00	CY	936,065	205,934	114,200	118,083	28,860	28,063	1,431,205	3328.38
FF 04 02 55-A03- BRIDGE ROADWAY CONCRETE SLAB,6"											
FF 04 02 55-A03--B03A	Dam Bridge Slab, Formwork	144.00	SF	979	215	119	124	30	29	1,497	10.40
FF 04 02 55-A03--B03C	Dam Bridge Slab, Reinforcement	15630.00	LB	21,924	4,823	2,675	2,766	676	657	33,522	2.14
FF 04 02 55-A03--B03D	Dam Bridge Slab, Conc Placement	127.00	CY	46,250	10,175	5,642	5,834	1,426	1,387	70,714	556.80
TOTAL BRIDGE ROADWAY CONCRETE SLAB,6"		121.00	CY	69,153	15,214	8,437	8,724	2,132	2,073	105,732	873.82
FF 04 02 55-A05- BRIDGE SIDEWALK CONCRETE SLABS											
FF 04 02 55-A05--B03A	Dam Br SideW Slab, Formwork	126.00	SF	857	188	105	108	26	26	1,310	10.40
FF 04 02 55-A05--B03C	Dam Br SideW Slab, Reinforcement	2123.00	LB	2,978	655	363	376	92	89	4,553	2.14
FF 04 02 55-A05--B03D	Dam Br SideW Slab,Conc Placement	20.00	CY	7,961	1,751	971	1,004	245	239	12,171	608.57
TOTAL BRIDGE SIDEWALK CONCRETE SLABS		20.00	CY	11,795	2,595	1,439	1,488	364	354	18,034	901.72
FF 04 02 55-A07- BRIDGE PARAPET CONCRETE WALLS											
FF 04 02 55-A07--B03A	Dam BrParapet Walls, Formwork	2124.00	SF	20,064	4,414	2,448	2,531	619	602	30,677	14.44
FF 04 02 55-A07--B03C	Dam BrParapet Walls, Reinforcemt	5317.00	LB	7,458	1,641	910	941	230	224	11,403	2.14
FF 04 02 55-A07--B03D	Dam BrParapet Walls, Conc Placem	40.00	CY	7,369	1,621	899	930	227	221	11,267	281.67
TOTAL BRIDGE PARAPET CONCRETE WALLS		40.00	CY	34,891	7,676	4,257	4,401	1,076	1,046	53,347	1333.68
FF 04 02 55-A09- BRIDGE ASSOCIATED GENERAL ITEMS											
FF 04 02 55-A09--A01-	Dam NRaod Slab, Road Drains	32.00	LF	225	49	27	28	7	7	344	10.75
FF 04 02 55-A09--A02-	Dam NRaod Slab, Expansion Jts	280.00	LF	1,472	324	180	186	45	44	2,250	8.04
FF 04 02 55-A09--A03-	Dam Parapet Wall,Guard Rail1.5'	177.00	LF	14,095	3,101	1,720	1,778	435	423	21,551	121.76

LABOR ID: CALW EQUIP ID: NAT99B Currency DOLLARS CREW ID: FITRAC

** PROJECT INDIRECT SUMMARY - CSI ITEM **

		QUANTITY	UOM	TOTAL DIRECT	FOOH	HOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 55-A09--A04-	Dam Parapet Wall,Guard Rail3.5'	177.00	LF	16,241	3,573	1,981	2,049	501	487	24,832	140.29
FF 04 02 55-A09--A09D	Dam NRoad Slab, Stripping	177.00	LF	222	49	27	28	7	7	339	1.92
TOTAL BRIDGE ASSOCIATED GENERAL ITEMS		117.00	LF	32,255	7,096	3,935	4,069	994	967	49,316	421.50
TOTAL BRIDGES, SUPERSTR & DECK,6 SPANS		4516.00	SF	1,084,159	238,515	132,267	136,765	33,426	32,503	1,657,635	254.39
FF 04 02 60 ASSOCIATED GENERAL,SECURITY ITEM											
FF 04 02 60-A01- SECURITY, FIBER OPTIC LINE											
FF 04 02 60-A01--A16A	Fiber Optic Line, Main Dam to Sp	2850.00	LF	344,451	75,779	42,023	43,452	10,620	10,326	526,651	184.79
TOTAL SECURITY, FIBER OPTIC LINE		2850.00	LF	344,451	75,779	42,023	43,452	10,620	10,326	526,651	184.79
FF 04 02 60-F03- SECURITY, ELEC INSTRUMENTATION											
FF 04 02 60-F03--B03A	Elec SEC Inst,Scaffolding Gate	1.00	EA	34,005	7,481	4,149	4,290	1,048	1,019	51,992	51992.33
FF 04 02 60-F03--B03C	Elec SEC Inst,Resident Office	1.00	EA	34,005	7,481	4,149	4,290	1,048	1,019	51,992	51992.33
FF 04 02 60-F03--B02E	Elec SEC Inst,BCH Flip Bucket Ga	1.00	EA	34,005	7,481	4,149	4,290	1,048	1,019	51,992	51992.33
FF 04 02 60-F03--S03C	Security Instrumentation Cables	2150.00	LF	18,990	4,178	2,317	2,396	585	569	29,035	13.50
TOTAL SECURITY, ELEC INSTRUMENTATION		3.00	EA	121,005	26,621	14,763	15,265	3,731	3,628	185,012	61670.56
FF 04 02 60-F09- SECURITY, RESIDENT OFFICE RM EQP											
FF 04 02 60-F09--S02L	Control Room Security Furnishing	1.00	EA	40,335	8,874	4,921	5,088	1,244	1,209	61,671	61670.56
TOTAL SECURITY, RESIDENT OFFICE RM EQP		1.00	EA	40,335	8,874	4,921	5,088	1,244	1,209	61,671	61670.56
FF 04 02 60-F11- SECURITY, CCTCT INSTRUMENTATION											
FF 04 02 60-F11--S02N	Security CCTCT Instr Monitoring	14.00	EA	109,670	24,127	13,380	13,835	3,381	3,288	167,681	11977.21
FF 04 02 60-F11--S02O	F/O Service Poles	30.00	EA	44,403	9,769	5,417	5,601	1,369	1,331	67,890	2262.99
FF 04 02 60-F11--S02P	CCTCT Cable Runs	4000.00	LF	37,391	8,226	4,562	4,717	1,153	1,121	57,169	14.29
TOTAL SECURITY, CCTCT INSTRUMENTATION				191,463	42,122	23,359	24,153	5,903	5,740	292,740	
FF 04 02 60-F2FF SECURITY,CHUTE LIGHTING &CAMERAS											
FF 04 02 60-F2FF-A16A	24 lightpoles along chute	24.00	EA	482,570	106,165	58,874	60,875	14,878	14,467	737,830	30742.91
FF 04 02 60-F2FF-B16A	4 PTZ Cameras and wiring	4.00	EA	126,202	27,764	15,397	15,920	3,891	3,783	192,957	48239.23
TOTAL SECURITY,CHUTE LIGHTING &CAMERAS		4.00	EA	608,772	133,930	74,270	76,795	18,769	18,251	930,787	232696.69

LABOR ID: CALN07 EQUIP ID: NAT99B Currency in DOLLARS CREW ID: FITRAC

		QUANTITY	UOM	TOTAL DIRECT	FOOH	WOOH	PROF	AIRQ FEE	BOND	TOTAL COST	UNIT COST
FF 04 02 60-F2FQ	SECURITY, CAMERA TESTING8										
FF 04 02 60-F2FQ-S02A	Security Equip, Test Camera	27.00	EA	25,211	5,546	3,076	3,180	777	756	38,546	1427.62
TOTAL	SECURITY, CAMERA TESTING8	27.00	EA	25,211	5,546	3,076	3,180	777	756	38,546	1427.62
FF 04 02 60-H01-	SECURITY, ENTRANCE GATE, CL										
FF 04 02 60-H01--S02F	Gate & Hydraulic Gate Motor	1.00	EA	53,731	11,821	6,555	6,778	1,657	1,611	82,152	82152.38
FF 04 02 60-H01--S02G	Parking Metal Bollards 4'L 12"di	6.00	EA	3,977	875	485	502	123	119	6,081	1013.57
FF 04 02 60-H01--S02H	Security Videos Camera	3.00	EA	61,827	13,602	7,543	7,799	1,906	1,854	94,532	31510.50
FF 04 02 60-H01--S02I	Enclosured Pullboxes	2.00	EA	3,044	670	371	384	94	91	4,654	2327.06
TOTAL	SECURITY, ENTRANCE GATE, CL	1.00	EA	122,580	26,968	14,955	15,463	3,779	3,675	187,419	187419.42
FF 04 02 60-H03-	SECURITY, ACCESS GATES,CHAIN LNK										
FF 04 02 60-H03--S02H	Security Videos Camera	3.00	EA	61,827	13,602	7,543	7,799	1,906	1,854	94,532	31510.50
FF 04 02 60-H03--S02K	Gates, Double Swing, Chain Link	3.00	EA	38,678	8,509	4,719	4,879	1,193	1,160	59,138	19712.59
FF 04 02 60-H03--S02L	Gates, Access Controls	3.00	EA	21,230	4,668	2,589	2,677	654	636	32,445	10814.86
TOTAL	SECURITY, ACCESS GATES,CHAIN LNK	3.00	EA	121,726	26,780	14,851	15,355	3,753	3,649	186,114	62037.95
FF 04 02 60-H05-	SECURITY, FENCING 6'H, CHAIN LNK										
FF 04 02 60-H05--A02A	Security Fence 6'H Chain Link	5000.00	LF	182,602	40,172	22,277	23,035	5,630	5,474	279,191	55.84
TOTAL	SECURITY, FENCING 6'H, CHAIN LNK	5000.00	LF	182,602	40,172	22,277	23,035	5,630	5,474	279,191	55.84
TOTAL	ASSOCIATED GENERAL,SECURITY ITEM			1,758,144	386,792	214,494	221,786	54,206	52,708	2,688,130	
TOTAL	AUXILARY SPILLWAY, 23'W X 33.5'H	6.00	EA	252,459,742	55541143	30800088	31847291	7,783,614	7,568,638	386,000,516	64333419
TOTAL	DAM8	1.00	EA	252,459,742	55541143	30800088	31847291	7,783,614	7,568,638	386,000,516	386000516
TOTAL	NEW AUXILIARY SPILLWAY,6EA GATES	1.00	LF	252,459,742	55541143	30800088	31847291	7,783,614	7,568,638	386,000,516	386000516

Attachment C3 – Project Annual Cost
Folsom Dam Joint Federal Project
Engineering Documentation Report

PROJECT: FOLSOM DAM, 6 - 23'X33' STG's USACE COST PORTION
LOCATION: California — **U. S. ARMY CORPS OF ENGINEER**
INTEREST RATE: 4.875% — **SACRAMENTO DISTRICT**

ITEM	COST ($)
Effective Price Level (EPL) 1-Oct-2006	
A. INVESTMENT COST	
1. FEDERAL TOTAL	438,904,000
2. NON-FEDERAL TOTAL	263,261,000
TOTAL PROJECT INVESTMENT	**$702,165,000**
B. ANNUAL COSTS	
1. FEDERAL TOTAL	23,579,000
2. NON-FEDERAL TOTAL	14,301,000
TOTAL ANNUAL COST	**$37,880,000**

DETAILED ESTIMATE OF ANNUAL COST

ITEM		COST ($)
Effective Price Level (EPL) 1-Oct-2006		
A. INVESTMENT COST		
1. FEDERAL		
a. First Cost		444,000,000
Less 04. Dams Sunk Cost(Not Subject to IDC)		(9,610,000)
Less 06. Fish & Wildlife Sunk Cost(Not Subject to IDC)		(407,000)
Less 30. PED Sunk Cost(Not Subject to IDC)		(44,400,000)
Less 31. S&A Sunk Cost(Not Subject to IDC)		(1,535,000)
b. Interest During Construction		50,856,000
TOTAL		$438,904,000
2. NON-FEDERAL		
a. First Cost		239,000,000
b. Interest During Construction		24,261,000
TOTAL		$263,261,000
TOTAL PROJECT INVESTMENT		**$702,165,000**
B. ANNUAL COSTS		
1. FEDERAL		
a. Interest and Amortization:		
Interest @	4.875%	21,397,000
Amortization @	0.497%	2,182,000
Amortization Period	50	
TOTAL		$23,579,000
2. NON-FEDERAL		
a. Interest and Amortization:		
Interest @	4.875%	12,834,000
Amortization @	0.497%	1,309,000
Amortization Period	50	
c. Maintenance And Operation:		94,000
04--- Dams	94,000	
d. Replacement Costs:		64,000
04--- Dams	64,000	
TOTAL		$14,301,000
TOTAL ANNUAL COST		**$37,880,000**

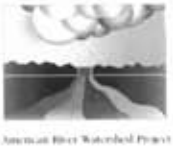
DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION	INTEREST RATE (%)
		Effective Price Level (EPL) 1-Oct-2006					
	FEDERAL COSTS						
04---	DAMS						
	(Sunk Cost Not Subject to IDC)	68,000	Oct-2003	Oct-2004			
		6,008,000	Oct-2004	Oct-2005			
		3,534,000	Oct-2005	Oct-2006			
04---	DAMS	529,010,000	Jun-2010	Jun-2014	Jun-2014	53,699,139	4.875
06---	FISH & WILDLIFE FACILITIES						
3---	WILDLIFE FACILITIES & SANCTUARIES	86,000	Oct-2004	Oct-2005			
	(Sunk Cost Not Subject to IDC)	321,000	Oct-2005	Oct-2006			
30---	PLANNING, ENGR. & DESIGN	295,000	Oct-91	Oct-92			
	(Sunk Cost Not Subject to IDC)	653,000	Oct-92	Oct-93			
		916,000	Oct-93	Oct-94			
		823,000	Oct-94	Oct-95			
		509,000	Oct-95	Oct-96			
		316,000	Oct-97	Oct-98			
		320,000	Oct-98	Oct-99			
		2,367,000	Oct-99	Oct-2000			
		4,965,000	Oct-2000	Oct-2001			
		5,247,000	Oct-2001	Oct-2002			
		6,996,000	Oct-2002	Oct-2003			
		8,277,000	Oct-2003	Oct-2004			
		6,873,000	Oct-2004	Oct-2005			
		5,843,000	Oct-2005	Oct-2006			
30---	PLANNING, ENGR. & DESIGN	52,043,000	Oct-2006	Jun-2010	Jun-2014	16,748,525	4.875
		3,448,000	Jun-2010	Jun-2014	Jun-2014	350,002	4.875
31---	CONSTRUCTION MANAGEMENT	11,000	Oct-2003	Oct-2004			
	(Sunk Cost Not Subject to IDC)	941,000	Oct-2004	Oct-2005			
		583,000	Oct-2005	Oct-2006			
31---	CONSTRUCTION MANAGEMENT	42,547,000	Jun-2010	Jun-2014	Jun-2014	4,318,892	4.875
CASH CONTRIBUTION		239,000,000	Jun-2010		Jun-2014	24,260,589	
TOTAL FEDERAL COST		**$444,000,000**				**$50,855,969**	
	NON-FEDERAL COSTS						
CASH CONTRIBUTION		239,000,000	Jun-2010		Jun-2014	24,260,589	4.875
TOTAL NON-FEDERAL		**$239,000,000**				**$24,260,589**	

DETAILED ESTIMATE OF M & O COSTS & REPLACEMENT COSTS

Effective Price Level (EPL) 1-Oct-2006

ACCOUNT NUMBER	ITEM	ANNUAL COST ($)	FACTOR (%)	M&O COST ($)	PROJECT LIFE YRS	ITEM LIFE YRS	FACTOR (%)	REPLACEMENT COST
04---	Dams							
	Outlet Works							
	Gates Rehab @25year	0	1.5	0	50	25	0.0213	52175
	Gates Rehab @25year	0	1.5	0	50	50	0.0050	12170
	O&M and Inspection	62503	1.5	94145				
	Dams			94145				64345
	SUMMARY							
04---	Dams			94145				64345
	TOTAL			**$94,145**				**$64,345**



Post Authorization Change Report

American River Watershed Project

Folsom Dam Modification and
Folsom Dam Raise Projects

Appendix D
Real Estate



US Army Corps of Engineers

Sacramento District
South Pacific Region

March 2007

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CHAPTER 1.0
REAL ESTATE PLAN

1.1 INTRODUCTION

This report, prepared in accordance with ER 405-1-12, 12-18, Real Estate Plan, provides information on real estate requirements for changes made to two authorized projects: the Folsom Modification Project and the Folsom Dam Raise Project. Proposed changes to both of these projects are for the improvement of flood management on the lower American River, primarily through structural modifications to the existing Folsom Dam and appurtenant facilities. Proposed project alternatives are designed to (1) provide increased dam outlet capacity, (2) increase surcharge flood damage reduction storage, and (3) meet dam safety requirements.

Previous studies include the Supplemental Information Report for the American River Project, completed in March of 1996, which supplemented the American River Watershed Investigation of April 1991; the Second Addendum to the Supplemental Information Report, Lower American River WRDA 1999 Common Features; the Information Paper, American River Watershed, California, August 1999; the Additional Information – Folsom Dam Flood Control Storage & Downstream Levees, January 2000 Report; and the Second Addendum to the Supplemental Information Report (SIR), completed in February of 2001. Real estate requirements for the other elements of the dam raise project remain as identified in previous reports.

1.2 NON-FEDERAL SPONSOR

The Non-Federal sponsor for the Folsom Modification and Folsom Dam Raise Projects is The Reclamation Board of the State of California. The Sacramento Flood Control Agency (SAFCA) is a local cost-sharing partner with the Reclamation Board of the State of California.

1.3 AUTHORITY

Authorization to construct a dam on the American River was included in the Flood Control Act of 1944. Construction of Folsom Dam was initiated in 1948 and completed in 1956. The storms of 1986 raised concerns over the adequacy of the existing flood damage reduction system resulting in the December 1991 American River Watershed Investigation Feasibility Report. Congressional guidance was forthcoming in the 1993 Defense Appropriations Act, authorizing additional studies to develop solutions to the flood problems. This study effort was documented in the March 1996 American River Watershed Project, California, Supplemental Information Report (1996 SIR). The 1996 SIR described multiple alternative plans, of which certain levee and other flood system improvements were "common" to all alternatives. In the 1996 Water Resources Development Act (WRDA), Congress authorized only a portion of the 1996 SIR recommended plan. The authorized elements became known as "Common Features." While efforts moved forward to further develop and implement the Common Features, discussions continued on ways to achieve higher levels of flood protection for Sacramento.

Under Section 101(a) (6) of the Water Resources Development Act of 1999 (Public Law 106-53), Congress authorized physical modifications at Folsom Dam, consistent with the descriptions provided in the United States Army Corps of Engineers (Corps) Supplemental Information Report for the American River Watershed Project, California, dated March 1996, as modified by the Folsom Dam Modification Report New Outlets Plan, dated March 1998, prepared by the Sacramento Area Flood Control Agency (SAFCA).

Headquarters, United States Army Corps of Engineers, provided guidance on the intent of this authorization, directing that a decision document be prepared to support the authorized project. A Limited Reevaluation Report (LRR) was prepared in August 2001. The primary purpose of the LRR was to demonstrate that the authorized operational and structural modifications to Folsom Dam were economically justified, technically sound, and environmentally acceptable.

As part of the reevaluation effort, the design of the authorized plan was examined to determine if enlarging the eight existing river outlets would result in a cost savings compared to constructing new outlets beneath the emergency spillway and constructing a new stilling basin downstream of the emergency spillway. As a result of this evaluation, a plan to enlarge the eight existing river outlets was developed with the outlets designed to allow for concurrent spillway releases.

Following the publication of the LRR document in 2001, constructability and operability reviews of the enlarged gates proposed in the LRR prompted additional design refinements. These refinements were documented in a final LRR report dated November 2003, which was submitted to the Assistant Secretary of the Army and approved in January 2004.

1.4 PROJECT LOCATION

The project area for the Folsom Modification Project and Folsom Dam Raise Project includes Folsom Dam and Reservoir and inflowing rivers and streams from the American River watershed, which covers about 2,100 square miles northeast of Sacramento, including portions of Placer, El Dorado, and Sacramento counties. Runoff from the basin flows through Folsom Reservoir into the lower American River and through the Sacramento metropolitan area. The river has a system of levees along both banks and leveed floodways. Folsom Dam is located at the confluence of the North and South forks of the American River, near the City of Folsom, approximately 29 miles upstream from the City of Sacramento.

1.5 BACKGROUND

In February 1986, major storms in northern California caused flood flows in the American River basin. The unprecedented high outflows from Folsom Dam and Reservoir, and the high flows in the Sacramento River, caused water levels to rise above the design freeboard of levees protecting the Sacramento area. A feasibility-scope investigations report (American River Watershed Investigation Feasibility Report) completed by the Corps in December 1991 later confirmed the flood threat and identified potential alternatives to address flooding problems, and surfaced possible dam safety issues at Folsom Dam. The report resulted in Congressional

authorization in 1993 for improvements to the levees in the Natomas area of Sacramento and guidance on further studies.

The Water Resources Development Act (WRDA) of 1999, along with supplemental documentation, identified potential modifications to Folsom Dam that would allow operators to achieve the objective release of 115,000 cubic feet per second (cfs) earlier in a flood event, and enhance the use of surcharge storage space in the reservoir through modifications to the emergency spillway and related operational changes; the project was termed the Folsom Modification Project. In the Energy and Water Development Appropriations Act of 2004, Congress authorized a plan to raise Folsom Dam; the Folsom Dam Raise Project would provide flood benefits while also resolving certain dam safety issues. Because of delays and technical problems associated with implementing the Folsom Modification Project authorized in WRDA 1999, compatibility with the potential to raise Folsom Dam, and ongoing dam safety issues at Folsom, there is now an emphasis on considering the individual projects together.

As part of the Energy and Water Development Appropriations Act of 2006, (P.L. 109-103, § 128) Congress directed that the Secretary of the Army and Secretary of the Interior collaborate on activities to maximize flood damage reduction improvements and dam safety needs at Folsom Dam. This authorization has been instrumental for both the Corps and Reclamation to work together in developing the Joint Federal Project (JFP).

1.6 PROJECT INFORMATION

The Folsom Facility consists of a gravity-type main concrete dam, left and right earth embankment wing dams, an auxiliary earthfill dam (Mormon Island Auxiliary Dam), and eight earth embankment dikes located around the rim of the reservoir.

The existing Federal Project (Folsom Dam and Lake), was constructed by the Corps as part of the Central Valley Project. The project consists of 15,717.47 acres in Fee Title and 270.63 acres of Easements. The dam and reservoir are a multipurpose flood damage reduction project with water supply components.

After construction, the Corps turned the project over to the Bureau of Reclamation for control, custody, and operation. The project lands were then leased to the State of California, Department of Parks and Recreation (DPR), except an area known as the Reclamation Zone. The lease is subject to use of project lands for reclamation and other Central Valley Project purposes pursuant to Federal Reclamation Laws and Acts of June 17, 1902 (32 Stat. 388), and acts supplementary thereto and amendatory thereof.

DPR holds title to lands adjacent to the Federally owned lands. These Federal and State owned lands are managed jointly by DPR as the Folsom Lake State Recreation Area.

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CHAPTER 2.0
ALTERNATIVE PLANS

2.1 PROPOSED ENGINEERING REFINEMENT ALTERNATIVE PLANS

Changes in project costs and regional bidding climate, and the shifting to priority status of Folsom Dam in Reclamation's dam safety program, necessitated refining the current authorized designs and approaches of providing levels of flood damage reduction, and satisfying dam safety criteria of the probable maximum flood (PMF). A joint Federal approach was taken between the Corps and Reclamation in refining design alternatives and in utilizing authorities for both flood damage reduction and dam safety to develop a base joint federal plan.

Numerous conceptual alternatives were considered. From these conceptual alternatives, the following array of action technical alternatives was developed.

2.1.1 No Action Condition

Under this alternative, the Federal Government would take no further action to reduce flood damages in the Sacramento area, other than those actions that are currently underway. This primarily includes (1) continuing of the 400,000 to 670,000 acre-foot variable space flood pool operation at Folsom Reservoir, (2) completing the Common Features project along the American River, (3) completing seismic retrofit work at Folsom facilities, (4) constructing a new bridge just west of Folsom Dam, and (5) modification of the L.L. Anderson Spillway by Placer County Water Agency. This alternative would also include Reclamation constructing an emergency fuseplug spillway project near Folsom Dam. It also includes a modification to the Folsom Dam Flood Control Diagram that was adopted by SAFCA and Reclamation in 2004. Under this plan, Folsom Dam and Reservoir, along with downstream levee improvements, would provide Sacramento with protection against the 100-year computed design flood event.

It is important to distinguish the existing condition with the future without project condition as it pertains to the PMF pool elevation. Under the existing condition, which does not pass the PMF, the PMF pool elevation would be 483.3 feet. Under the future without-project condition, which has a Reclamation fuse plug structure that passes the PMF, the PMF pool would be 477.6 (see Table 2-1).

TABLE 2-1
COMPARISON OF PERTINENT ELEVATIONS

	Existing Condition	Future-Without Project Condition
Top of Dam	480.5	480.5
Maximum Flood Pool	466.0	466
0.5% Chance Pool Elevation	474.6	474.6
PMF Pool Elevation	483.3	477.6

For Folsom Reservoir, the authorized top of flood pool is at reservoir water surface elevation 466 feet. Without a project, the current Probable Maximum Flood (PMF) reservoir elevation, with induced surcharge (space above flood pool), is 483.3 feet. For perspective, the pool elevation associated with a 200-year flood event would be at elevation 474.6 feet assuming a maximum outflow of 160,000 cfs. Folsom Dam currently is unable to safely pass the PMF without overtopping the dam, because the top of dam is 480.5 feet. The emergency fuse plug would be constructed to pass the PMF near the south abutment of the main Folsom Dam.

Despite downstream levee improvements, outflows from Folsom Dam greater than 115,000 cfs would continue to be limited to very infrequent flood events. This would mean that for most large events, Folsom Dam would remain unable to release a sustained emergency flow of 160,000 cfs, and therefore not utilize improved downstream channel capacity.

In accordance with policy at the time, real estate interests were defined to be the top of flood pool elevation plus 10 feet of elevation. The original take line for associated real estate was determined to be at elevation 476.0 feet (1950 Definite Real Estate Report). No revised take line is proposed since there is no change to the top of flood pool elevation and no new policy guidance has been developed that requires any other method of determining the guide take line.

2.1.2 Alternative A – Eight Main Dam Outlets and Fuseplug Spillway

This alternative consists of three major features: (1) enlarging six of the existing outlets and constructing two new outlets at Folsom Dam, (2) constructing two new outlets along the upper outlet tier, and (3) constructing an emergency fuseplug spillway. The resulting outlet modifications would provide for a release of 115,000 cfs at a water-surface elevation in Folsom Reservoir of 418 feet. The fuseplug spillway would be completed to address passage of the PMF. This alternative also includes modification of the flood damage reduction storage space in Folsom Reservoir to a variable space ranging from 400,000 to 600,000 acre-feet.

2.1.3 Alternative B – Six Submerged Tainter Gate Auxiliary Spillway

This alternative includes construction of a new gated auxiliary spillway southwest of Folsom Dam. The auxiliary spillway would be constructed at the same location as the emergency fuseplug spillway described in Alternative A, but in addition to passing the PMF, it would also significantly contribute to reducing flood damages along the American River. Major features include (1) an 1,100 foot-long approach channel beginning in Folsom Lake, (2) control structure, including six 33-foot 1-inch high by 23-foot-wide submerged tainter flood gates at sill elevation 368 feet, (3) 3,000-foot-long spillway chute with a bottom width of about 169 feet, and (4) stilling basin in the American River. It also includes modification of the flood damage reduction storage space in Folsom Reservoir to a variable space ranging from 400,000 to 600,000 acre-feet.

2.1.4 Alternative C – Six Submerged Tainter Gate Auxiliary Spillway, 3.5-Foot Dam Raise, and Three Emergency Spillway Gate Replacements

This alternative includes construction of a new gated auxiliary spillway southwest of Folsom Dam (similar to Alternative B), raising Folsom Dam and Reservoir by 3.5 feet, and replacing the three emergency spillway gates at Folsom Dam. It also includes modification of the flood damage reduction storage space in Folsom Reservoir to a variable space ranging from 400,000 to 600,000 acre-feet.

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

This alternative would be similar to Alternative C except it includes raising Folsom Dam by 7 feet (comparable to the authorized Folsom Dam Raise Project). The raise would be a combination of raising the concrete monolith and embankments and adding a parapet wall. In addition, it includes (1) replacement of existing spillway gates, (2) modification of spillway and bridge piers, (3) replacement of the spillway bridge and (4) modification of the elevator tower. It also includes modification of the flood damage reduction storage space in Folsom Reservoir to a variable space ranging from 400,000 to 600,000 acre-feet.

2.2 REFINED AUTHORIZED PROJECTS

Alternative C was identified as the Selected Plan. The Selected Plan provides the greatest benefits of all the alternatives considered, has a high likelihood of successfully providing the identified accomplishments, and is highly supported by the non-Federal sponsor. The Refined Authorized Projects (RAP) includes the Selected Plan as well as two Other Features. The Other Features include (1) ecosystem restoration components and (2) a permanent bridge increment. The RAP is considered functionally equivalent to a combination of both the Folsom Modification Project and the Folsom Dam Raise Projects.

The Selected Plan would increase the release capacity at Folsom Dam earlier in the flood event, thereby reducing flood risk to areas downstream of Folsom Dam. The construction of the 6STG would increase project discharge capacity at a lower pool elevation with no increase in pool elevation. This allows a lowering of the maximum pool and for a decrease in the need for use of surcharge storage space in the reservoir. The PMF pool elevation would be lowered from 483.3 feet to 480.2 feet with the Selected Plan, and to 476.2 with the 6STG (JFP). For perspective, the flood pool elevation associated with the 200-year flood event would be lowered from elevation 474.6 feet to 466.3 feet and limiting the maximum discharge to 160,000 cfs. Raising Folsom Dam 3.5 feet to 484.0 feet would allow for holding discharges longer at 160,000 cfs, thereby controlling events larger than the 200-year by limiting them to a maximum discharge of 160,000 cfs, the downstream capacity, by creating additional flood damage reduction space in the reservoir. The authorized top of flood pool would remain at reservoir water surface elevation 466 feet (see Table 2-2). In accordance with guidelines for take line requirements, the current (and future without-project) take line at 476 feet (top of flood pool elevation plus 10 feet) is the same or greater than the maximum pool elevation during a controlled flood event with the Selected Plan. For the Selected Plan, the controlled event does not exceed the existing real estate

take line at 476 feet as established in the Sacramento District's "Definite Project Report, Real Estate Section" dated 24 February 1950 for the Folsom Dam and Reservoir.

The 6 STG Element of the Selected Plan is also referred to as the Joint Federal Project or JFP. Both the Corps and Reclamation have an interest in this project as it satisfies Corps flood damage reduction objectives and Reclamation hydrologic risk (dam safety) objectives. Since the JFP meets both objectives, both agencies will participate in the project, constructing this project jointly. Both agencies have agreed that each would fund and construct its respective portions of the JFP.

A percent cost distribution between dam safety and flood damage reduction was developed, and all the work items of the JFP were distributed into a Corps work package and a Reclamation work package. The procedure is described elsewhere in this PAC. Each agency will fund and construct its own work package through its existing authorities. Each agency will treat its work package as its project to construct.

The responsibility to provide LERRDs is generally that of the Corps' Non-Federal Sponsor and is cost shared in accordance with the cost sharing provisions established in the Water Resources Development Act (WRDA). In identifying the items to be accomplished in each Federal agencies work packages, it was determined to be more equitable for the USBR to provide and/or perform the tasks generally associated with LERRDs, as they are the Federal agency having jurisdiction over the Folsom Dam project on which theses activities are to take place. **The USBR performance of these work items does not affect or lessen the cost share of the Corps' Non-Federal Sponsor**. What would have been considered LERRDs under WRDA is now to be accomplished by Reclamation through its work packages and its own authorities, and the Reclamation work package requirements are listed as follows.

- Accomplishment of environmental mitigation.
  Note: Under new guidance (CEWW-P, Cost Sharing Lands Associated with Fish and Wildlife Mitigation, 19 September 2006)," LERRs are cost shared as construction elements." The non-Federal sponsor's share of the cost would be the same irrespective of whether the environmental mitigation real estate requirements are included in the COE or the USBR work packages.

- Relocation of a 42-inch water pipeline (Natomas Pipeline) that provides raw water from Folsom Reservoir to the City of Folsom and California Department of Corrections water treatment plants, and water for the Corps resident office fire protection system. This aboveground pipeline is operated and maintained by Reclamation. The chute alignment for the auxiliary spillway would cross a portion of the existing aboveground pipeline. Approximately 600 feet of the existing Natomas pipeline would be relocated in kind as an aboveground pipeline. In addition, the 8-inch-diameter fire protection pipeline and the metering station that services the Corps resident office would need to be relocated.

- Relocation of the Sacramento Municipal Utility District's (SMUD) 12-kV power line that provides power to the resident office. The 12-kilovolt (kV) service was

formerly an abandoned 115 kV Pacific Gas and Electric Company (PG&E) power line. Five wood poles and approximately 1,500 feet of conductor would require relocation if the office building remains in use during the spillway construction. If the building is relocated, the power line would be decommissioned.

- Relocation of the 4,160-volt power line that serves Reclamation's yard on the right abutment. Seven poles and approximately 2,000 feet of conductor would be relocated.

Although these LERRDs are required for the JFP as a whole to function, they are in the Reclamation work package, and are Reclamation's responsibility. Reclamation will provide these LERRDs using its own regulations and procedures. Other than a Right-of-Entry to construct, there are no LERRDs identified in the Corps work packages for the JFP. Again, it must be noted that the USBR performance of these work items does not affect or lessen the fiscal cost sharing of the Corps' Non-Federal Sponsor.

TABLE 2-2
COMPARISON OF PERTINENT ELEVATIONS FOR SELECTED PLAN

	Existing Condition	Future-Without Project Condition	6STG	Selected Plan
Top of Dam	480.5	480.5	480.5	484
Maximum Flood Pool	466.0	466.0	466.0	466.0
0.5% Chance Pool Elevation	474.6	474.6	466	466
PMF Pool Elevation	483.3	477.6	476.2*	480.2

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CHAPTER 3.0
REAL ESTATE REQUIREMENTS

Real estate interests for water storage are not required for the Joint Federal Project as the project is located on Federal land.

The Real estate requirement for the Folsom Dam Raise portion of the project is identified below. As explained in Sections 2.1.1 and 2.2 above, it has been determined that there would be no change in flood pool elevation in Folsom Reservoir with the Selected Plan. The controlled event does not exceed the existing real estate take line at 476 feet.

- ***Right-of Entry*** – Required to access and to perform work on existing Federal Project lands, Rights-of-Entry will be negotiated with the Bureau of Reclamation along with approval by the State of California, Department of Parks and Recreation (DPR).

3.1 MITIGATION

Preliminary indications are that approximately 11.16 acres are required for environmental mitigation features associated with the 3.5' Folsom Dam Raise Project, which is not part of the JFP, thus the features associated with the proposed raise are not included in the work packages of the JFP, and as such will be the performance responsibility of the Corps' Non-Federal Sponsor. The land cost, estimated to be around $200,000, associated with this requirement is identified in the Construction cost summary as per new *guidance (CEWW-P Cost Sharing Lands Associated with Fish and Wildlife Mitigation, 19 September 2006) "LERRs are cost shared as construction elements*." The administrative costs are provided in Table 3-2.

3.2 DISPOSAL/BORROW SITES

The volume of excavation is relatively small; therefore, it is anticipated that disposal would be on Federal property using an assumed average haul distance of approximately 0.5 miles. New riprap, filter material, and backfill would be imported from a local source.

3.2 FEDERAL LANDS

Folsom Dam and Reservoir are owned in Fee by the United States of America. The lands, however, are leased to the State of California, Department of Parks and Recreation (DPR), except an area known as the Reclamation Zone. The lease is subject to use of project lands for reclamation and other Central Valley Project purposes pursuant to Federal Reclamation Laws and Acts of June 17, 1902 (32 Stat. 388), and acts supplementary thereto and amendatory thereof.

DPR holds title to lands adjacent to the Federally owned lands. These Federal and State owned lands are managed jointly by DPR as the Folsom Lake State Recreation Area.

3.3 SPONSOR OWNED LANDS

The non-Federal sponsor, (The Reclamation Board of the State of California and its cost-sharing partner, Sacramento Area Flood Control Agency), does not own property within the project boundaries.

3.4 PUBLIC OWNED LANDS

The State of California, Department of Parks and Recreation, holds title to lands adjacent to the Federally owned lands. These Federal and State owned lands are managed jointly by DPR as the Folsom Lake State Recreation Area.

3.5 PRIVATE OWNERSHIP

It has been determined that the existing flood pool elevation of Folsom Lake will remain the same; therefore, no additional property is required. None of the privately owned parcels surrounding the lake will be impacted.

3.6 NAVIGATIONAL SERVITUDE

There are no lands within the project area that are subject to the applications of navigational servitude.

3.7 PUBLIC LAW 91-646 RELOCATIONS AND BENEFITS

There are no PL 91-646 relocations associated with the project.

3.8 BASELINE COST ESTIMATE FOR REAL ESTATE

The JFP Administrative costs and the Folsom Dam Raise Mitigation Administrative costs, for acquiring Rights-of-Entry, meeting attendance, monitoring real estate activities, certifying for construction, etc., were estimated by the Sacramento District Real Estate Division, taking into consideration that its involvement with the project will continue for several years. The real estate activities and administrative costs shown in **Tables 3-2** are not related to and do not include the cost of work being done under USBR's work packages. A summary of the Draft Real Estate Baseline Cost Estimate for each is shown separately below in **Table 3-1** and **Table 3-2**.

TABLE 3-1
JFP BASELINE COST ESTIMATE

Federal Administrative Costs	Non-Federal Administrative Costs
$148,200	$187,200

1. *Includes contingencies.*

TABLE 3-2
3.5-FOOT FOLSOM DAM RAISE MITIGATION BASELINE COST ESTIMATE

Federal Administrative Costs	Non-Federal Administrative Costs
$130,200	$170,200

1. *Includes contingencies*

3.9 MAP

A real estate map showing the original take line at 476 feet is shown in **Plate 1.**

3.10 MINERAL INTERESTS/ACTIVITY

No marketable mineral rights will be encountered or impacted in any of the features addressed in this Real Estate Plan.

3.11 HAZARDOUS, TOXIC, OR RADIOACTIVE WASTE (HTRW)

Geotechnical explorations have identified unconsolidated material that consists of debris from the original dam construction located in areas below the dam. While no known contamination was noted in the study area which could affect the project, there are two potential HTRW sites present at the Project Site and about 70 HTRW sites within the Environmental Site Assessment Study Area in various agency databases. This material and other HTRW issues are addressed in the NEPA document for this project.

3.12 3.5-Foot Raise Facility/Utility Relocations

The Folsom Lake State Recreation Area (SRA) has seven access roads to established facilities surrounding Folsom Lake; three of the access roads cross the axes of dams or dikes at the following high points between abutments and natural grade: Beal's Point, Granite Bay, and Folsom Point. Public access to the recreation facilities would need to be maintained during construction.

The following facilities and utilities in the SRA would either be temporarily relocated or could possibly be permanently relocated. Further engineering studies will identify the owners of the affected relocations.

3.12.1 Granite Bay

A paved spur road from the second lake access forms part of the crest of Dikes 2 and 3 and proceeds to the lake and lake facilities. This spur is 1,395 feet long and would have to be at

least temporarily relocated and then reconstructed on the crest or permanently relocated. A third lake access is provided by an existing paved road that crosses Dike 2 near the right abutment, and proceeds to the lake and lake facilities. Lake access also is provided by a paved road that forms the crest of Dike 1 and wraps around the right abutment of the dike to the lake. The crest of this dike is 2,060 feet long; the crest road would have to be at least temporarily relocated and then reconstructed on the crest, or be permanently relocated.

3.12.2 Utilities

Raising the dam and dikes by 3.5-foot will have a minor impact on existing utilities. Impacted utilities include electricity, water, and wastewater facilities.

3.12.2.1 Electricity

Several power lines and utility poles would require relocation during construction including power lines running beneath the boat launch area in front of Dike 3. In order to sort and crush borrow material, processing plants would need to be established in several areas around Folsom Reservoir. The processing plants would have the option of either using diesel powered generators or extending existing electricity infrastructure. If existing electricity infrastructure is used, this could require the construction or relocation of existing infrastructure such as towers, power lines, or poles.

Several overhead power lines cross the entrance of Granite Bay. During construction, large vehicles may need to have these power lines raised in order to safely pass under them. In instances when overhead lines could create obstacles for construction vehicles, agencies will likely temporarily raise the power lines with large poles in order to avoid utility relocations and interruptions in service.

3.12.2.2 Water

Construction and borrow activities may require the relocation of existing water infrastructure, including:

- An existing 3-inch water main that serves the entrance kiosk and restroom facilities at the boat launch at Folsom Point.
- Water pipelines running beneath the boat launch area in front of Dike 3 that provides water service to the restrooms at the boat launch.

3.12.2.3 Wastewater

Construction activities to provide crest protection at Dike 4 could require the relocation of an existing sewer pipeline that runs through the upper right abutment of Dike 4 and out towards Auburn-Folsom road. Borrow activities in the vicinity of Folsom Point could require the relocation of an existing sewer line that serves the restroom facilities at the boat launch.

3.12.3 Facility/Utility Relocations Summary

Construction planning and sequencing would be performed so that existing utilities would not be impacted by Folsom JFP construction activities.

> "Any conclusion or categorization contained in this real estate plan, or elsewhere in this project report, that an item is a utility or facility relocation to be performed by the non-Federal sponsor as part of its LERRD responsibilities is preliminary only. The Government will make a final determination of the relocations necessary for the construction, operation, or maintenance of the project after further analysis and completion and approval of final attorney's opinions of compensability for each of the impacted utilities and facilities."

3.13 ATTITUDE OF LANDOWNERS AND COMMUNITY

The project has the wide support of the population that lives in the areas that would be afforded greater protection by the project.

3.14 ACQUISITION SCHEDULE

A detailed acquisition schedule is shown on **Table 3-3**. The local non-Federal sponsor has reviewed and codeveloped this schedule. The local non-Federal sponsor will be directed to begin real property acquisition for the project only after the PCA is fully executed. They are aware of the risks of initiating the acquisition process in advance of the PCA being executed.

TABLE 3-3
REAL ESTATE ACQUISITION SCHEDULE

Activity	Corps Start	Corps Finish	NFS Start	NFS Finish
Receipt of preliminary drawings from Engineering/PM	12/07	09/08		
Receipt of final drawings from Engineering/PM	10/08	10/09		
Execution of PCA	September 2008			
Formal transmittal of final drawings & instruction to acquire LERRDS	10/09	10/09		
Conduct landowner meetings			04/09	05/09
Prepare/review mapping & legal descriptions	02/09	03/09		
Obtain/review title evidence			05/08	06/08
Obtain/review tract appraisals			04/09	07/09
Conduct negotiations			08/09	09/09
Perform closing			10/09	01/10
Prepare/review any necessary eminent domain documents			N/A	N/A
Perform eminent domain proceedings			N/A	N/A
Obtain possession			N/A	N/A
Complete/review PL 91-646 benefit assistance[1]	N/A	N/A		
Conduct/review facility and utility relocations	01/10	02/10	09/09	10/09
Certify all necessary LERRDS are available for construction	05/10	05/10		
Prepare and submit credit requests			06/10	06/10
Review/approve or deny credit requests	07/10	09/10		
Establish value for creditable LERRDS in F&A cost accounting system				

Key:
Corps = Corps of Engineers
NFS = Non-Federal Sponsor
PCA = Project Cooperation Agreement
PL = Public Law
LERRDS = lands, easements, rights-of-way, utility or public facility relocations, and dredged or excavated material disposal areas

Note:
1. If necessary.

3.15 SPONSORS' ABILITY TO ACQUIRE

The non-Federal Sponsor of the Folsom Modification and Folsom Dam Raise projects include The Reclamation Board of the State of California and the Sacramento Flood Control Agency (SAFCA). The Reclamation Board, through the Department of Water Resources (DWR), has the ability to acquire the necessary rights in real estate for the flood damage reduction project. DWR has an experienced right-of-way staff and the power of eminent domain pursuant to Water Code Section 8590, et seq., and Code of Civil Procedures Section 1230.010, et seq. DWR has an experienced right-of-way staff, which has acquired lands for numerous flood control projects since implementation of the Water Resources Development Act of 1986. DWR acquired the necessary LERRDs for the WRDA-96 Common Features, a cost-shared project of which this would be an outgrowth. With this prior experience, the DWR right-of-way staff has directly applicable experience to this project and will be an asset in accomplishing the acquisition. SAFCA also has the power of eminent domain through the SAFCA Joint Exercise of Powers Agreement adopted on September 26, 1989, and the SAFCA Act signed by the Governor on August 10, 1990. SAFCA does not have a right-of-way staff; any right-of-way work performed by SAFCA would be contracted.

The sponsors have been advised of Public Law 91-646 requirements and the requirements for documenting expenses for credit purposes. A checklist showing the sponsors' ability to acquire, and a certified financial plan will be prepared to document their abilities.

FOLSOM MODIFICATIONS AND FOLSOM DAM RAISE PROJECTS

SPONSOR: The Reclamation Board of the State of California

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? **Yes**

b. Does the sponsor have the power of eminent domain for this project? **Yes**

c. Does the sponsor have "quick-take" authority for this project? **No**

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? **No**

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? **Yes (Federal)**

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including Public Law 91-646, as amended? **No**

b. If the answer to II.a. is "yes," has a reasonable plan been developed to provide such training? **N/A**

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? **Yes**

d. Is the sponsor's project in-house staffing level sufficient considering its other workload, if any, and the project schedule? **Yes**

e. Can the sponsor obtain contractor support, if required, in a timely fashion? **Yes**

f. Will the sponsor likely request Corps assistance in acquiring real estate? **No**

II. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? **Yes**

b. Has the sponsor approved the project real estate schedule/milestones? **Yes**

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other projects? **Yes**

b. With regard to this project, the sponsor is anticipated to be: State of California Reclamation Board, Department of Water Resources.

V. Coordination:

a. Has this assessment been coordinated with the sponsor? **Yes**

b. Does the sponsor concur with this assessment? **Yes**

Prepared by:

_____
Dee La Sala
Realty Specialist
Acquisition Branch

Date _____

Reviewed and Approved by:

_____
Sharon Caine
Chief, Real Estate Division

Date _____



Post Authorization Change Report

American River Watershed Project

Folsom Dam Modification and
Folsom Dam Raise Projects

Appendix E
Economics



US Army Corps of Engineers

Sacramento District
South Pacific Region

March 2007

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CHAPTER 1.0
INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

The purpose of this analysis is to determine the benefits and project performance statistics associated with alternative outlet, gate, and dam height modifications to Folsom Dam. In this current risk-based analysis, it is assumed that the authorized Common Features (Water Resources Development Act (WRDA) of 1999) on the Lower American River are completed and are part of the without-project condition.

This current analysis serves as a supplement to a series of documents on the American River Watershed, to include the 1996 Supplement Information Report, which first identified a version of the Folsom Dam Modification as a possible alternative. The most recent document with economic risk-based analysis of Folsom Dam is the American River Folsom Modifications Limited Reevaluation Report (LRR) Economics Appendix, revised in November 2003. Unless otherwise noted, all references to prior studies in this appendix are to the November 2003 revised economics appendix. Values in this document represent October 2006 price levels, a 50-year period of analysis, and the Fiscal Year 2007 Federal discount rate of 4 7/8 percent.

1.2 PRIOR REPORTS

Much of the economic data in previous American River Watershed planning reports have their beginnings in the initial 1991 American River Watershed Investigation Feasibility Report. The floodplains and depth of flooding currently being used in the economic analysis are from this 1991 report. The selected plan from that document was a detention dam at Auburn providing over 500,000 acre-feet of flood storage and reducing the flood risk for Sacramento to a 1 in 200 chance in any given year (using pre-risk-based evaluation methodologies). This project was not authorized by Congress and two of many incremental projects to follow were adopted to help reduce flood damages in the Sacramento area. These were the Sacramento Area Flood Control Agency (SAFCA) North Area Levee Project (Natomas) and Re-operation of Folsom Dam from 400,000 acre-feet of fixed space to a variable 400,000/670,000 acre-feet.

The next report was the 1996 Supplemental Information Report (SIR). The 1996 SIR was the first document to use a risk-based methodology for determining economic benefits on the American River. The economic inventory was revised for this study to include structures not included in the 1991 report (but out of the Federal Emergency Management Agency (FEMA) 100-year floodplain). The SIR identified three final alternatives: the Stepped Release, Folsom Modifications, and Detention Dam plans. The Detention Dam, which reduced flood risk along the American River to a less than 1 in 500 chance of flooding in any given year, was determined to be the National Economic Development (NED) plan but not recommended in the Chief's Report. Instead, a less controversial Common Features alternative was authorized. This alternative included "features" that were part of all three final alternatives and would not preclude selection at a future time of any of the three. Completion of the Common Features was expected at the time to provide Sacramento with "100-year protection"; this term is no longer used in Corps guidance.

In 1999, the Water Resources Development Act (WRDA) authorized additional levee improvements to supplement the 1996 Common Features and authorized a modified version of the Folsom Modifications Plan identified in the 1996 SIR. WRDA 99 also authorized additional study of flood damage reduction measures beyond the Folsom Modifications.

For economic analysis, three documents resulted from this authorization:

- Common Features LRR, completed in 2001
- Folsom Modifications LRR, revised November 2003
- American River Long Term Study, completed in 2002

The biggest change in the economic analysis was the reevaluation documented in the Folsom Modifications LRR, which was incorporated into the other two reports. During the reevaluation, a new inventory was gathered based on the original 1991 Feasibility Report floodplains but with new structure counts and valuations. The new inventory was completed in 2000. Damage estimates were developed for the first time on the American River using economic uncertainties in the model.

The Common Features report was split into two areas:

- The Lower American River levee improvements, which are functional, and enable the American River to pass the 100-year event[1]
- The Natomas area, which required significant reformulation and development of a General Reevaluation Report (GRR), which was not completed at the time of this report.

The Long Term Study recommended a 7-foot raise of Folsom Dam, providing both additional flood damage reduction and dam safety (enabling the facility to pass 100 percent of the probable maximum flood (PMF)).

The Folsom Modifications revised economics report (November 2003) identified the recommended project as new and enlarged existing outlets capable of releases of 115,000 cfs and improvements allowing for the use of surcharge storage up to elevation 474 feet. First costs for this project were estimated at approximately $215 million with annual benefits of $32 million and annual costs of $16 million providing a benefit-to-cost ratio of 2.0 to 1. This project was estimated at the time to reduce the risk of flooding to a 1 in 140 chance in any year.

1.3 REASONS FOR COMBINING AUTHORIZATIONS AND PROJECT PURPOSES

In this appendix, project elements from both the Folsom Modifications and the Long Term study (Folsom Dam Raise) are being considered not only for the purpose of flood damage reduction but also for dam safety. During the design refinements for Folsom Modifications, it was believed that due to significant increases in the cost estimates, the authorized project may

[1] FEMA certification for the American River was not obtained using the Corps' standard risk-based analysis methodology. This study was initiated prior to Corps guidance regarding conditional non-exceedence probability, and a waiver permited the Sacramento District to route the base flood (computed 100-year probability event) and evaluate in conjunction with FEMA freeboard consideration.

not be optimal or even economically feasible. Various outlet configurations, both in number and location, were evaluated. During this preliminary analysis, it appeared that adding operational gates to the proposed United States Department of the Interior, Bureau of Reclamation (Reclamation), dam safety auxiliary spillway may provide a more efficient way to meet two project purposes. From this analysis, a Joint Federal Project (JFP) including a new auxiliary spillway and operational submerged tainter gates was identified.

1.4 GOALS OF THE JOINT FEDERAL PROJECT

The Folsom Joint Federal Project was intended to meet not only the objectives of the Corps but Reclamation and the local sponsor as well. As mentioned, this economic analysis includes elements of three authorizations, the Folsom Modification and Folsom Dam Raise projects, and Reclamation's dam safety project.

The objectives of the Joint Federal-Project (JFP) in terms of economic outputs and project performance are:

1) Reduce flood damages as effectively and efficiently as possible within a limited schedule and without complete reformulation.
   a) More flood damage reduction measured in both lower residual damage and annual exceedence probability is desired.
   b) Net benefits need to be positive (annual benefits exceed annual costs) for all alternatives considered.
   c) Any selected alternative will be on the "rising limb" of the net benefit curve (relative to project performance). In other words, for Federal planning objectives, no smaller plan (at lower cost) would provide greater net benefits.
2) Safely pass the 200-year design flow event without levee failure (based on design non-risk-based criteria).
3) Pass the PMF without placing the dam structure in danger of failure.

This appendix documents revisions to the economics since the Folsom Modifications 2003 report, discusses limitations to the analysis, and describes results and successes of various alternatives at meeting the three goals listed above.

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CHAPTER 2.0
ASSUMPTIONS AND REVISIONS TO THE WITHOUT-PROJECT ECONOMICS

2.1 PURPOSE AND SCOPE

During the week of August 10th 2006, an Economic Advisory Panel of senior U.S. Army Corps of Engineers (Corps) economists met in Sacramento to discuss economic issues related to the Combined Project and identify what could be done to improve the analysis for the Joint Federal Project (JFP). The group noted 13 recommendations for the analysis (see **Attachment 1**). Many of these require significant inputs from the Project Delivery Team (PDT) and cannot be completed within the schedule of the Post Authorization Change (PAC) Report. The PDT is currently working on two tracks to address these recommendations:

1) Those that require limited effort will be included in this appendix for the PAC Report
2) Those that require detailed analysis will be deferred to a new Economic Reevaluation Report

2.2 WITHOUT-PROJECT ASSUMPTIONS FOR THE PAC REPORT

In addition to the assumption of the Common Features being in place, following the recommendations of Economic Advisory Panel, the base economic condition will include the dam safety component as the first increment of Federal action. Reclamation has a recommended stand-alone dam safety project that includes an auxiliary spillway and fuseplug to pass the PMF. Any alternative that meets both flood damage reduction objectives and can pass the PMF will remove the need for the stand-alone dam safety project, providing a potential cost savings benefit.

For this PAC, the assumption for economic purposes is that the downstream impacts will be no greater than from the completed Common Features project. No downstream inventory will be collected or project performance evaluated for downstream reaches. The study area will remain as described in the 2003 Folsom Modifications LRR. Detailed evaluation of downstream impacts will be deferred to the Economic Reevaluation Report.

In the 2003 Folsom Modifications report, residential without-project damages were determined using FEMA-based curves from 1988. The Economic Advisory Panel recommended replacing these curves with curves developed by the Institute of Water Resources (IWR) in 2004 that can be found in Economic Guidance Memorandum EGM 04-01. This change has been incorporated in the current analysis and is reflected in the revised without-project residential damages in this appendix.

Past economic analysis for this study has focused on National Economic Development (NED). The recommendation of the Economic Advisory Panel, to be consistent with EC 1105-2-409, was to broaden the focus to include some evaluation of the other three accounts; Regional Economic Development (RED), Other Social Effects (OSE), and Environmental Quality (EQ).

Further discussion of these three accounts will be deferred to the Economic Reevaluation Report, including a discussion of the following Other Social Effects:

- Population at risk
- Loss of life potential

Several factors that contribute to the damage functions for emergency costs, public utilities and infrastructure were revised for this PAC report analysis. Costs for dewatering and levee repairs were also added to the without-project condition.

Recommended economic revisions deferred to the Economic Reevaluation Report include:

- New without-project floodplains
- New economic inventory
- New study impact areas to potentially include downstream
- Non-residential content surveys to address changes in content values (or percentages to structures) and potential content damages by depth
- Recommendations requiring non-economic PDT lead:
  - Reexamine potential operations, maintenance, repair, replacement & rehabilitation (OMRR&R) savings from gate replacement
  - Address uncertainties in cost
  - System risk and completeness of alternative plans

2.3 ECONOMIC REEVALUATION REPORT – REVISION OF THE WITHOUT-PROJECT CONDITIONS

As mentioned in **Section 2.2**, many of the recommendations of the Economic Advisory Panel cannot be completed in time for this PAC report and have been deferred to the concurrent Economic Reevaluation Report. Hydrologic and hydraulic revisions are currently being finalized, including development of new floodplains. The critical economic tasks that will lead to revised without-project damage estimates include: a) development of new structural inventory, b) new area-specific non-residential content values and content depth-damage functions, and c) revised emergency costs that address "lessons learned from post-Katrina" and more accurately reflect catastrophic urban losses. In addition to NED losses, the other accounts to include RED and OSE will be included in the Economic Reevaluation Report. These revised without-project estimates for the ERR are scheduled to be completed by April 30, 2007.

2.4 STUDY AREA – ECONOMIC REACHES

For the 2003 LRR, the inventory was grouped geographically into four economic reaches, the Downtown Area, Rancho Cordova, South Sacramento, and North Sacramento (the 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 floodplain can be seen in **Figure 2-1**.



FIGURE 2-1
STUDY AREA AND STUDY REACHES

2.5 INVENTORY

2.5.1 Residential

The structural inventory completed for the 2003 LRR was not modified for this current analysis. The original floodplains, developed in 1989 for the 1991 Feasibility Study, included 100-year and 400-year frequency delineations with depths delineated for the 80-, 100- and 400-year floods for 93 different subareas. 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 different frequencies (the original 100-year would be equal to 70-year current and the original 400-year would be around 600-year current). The original floodplains were digitized and used for developing the inventory utilizing digital parcel data. The inventory represents all residential structures in the floodplain, including new development up to the year 2000. All new development was adjusted for elevation to guarantee that there are no economic losses associated with any new development within the 100-year floodplain. **Table 2-1** shows the number of residential units by land use and reach.

TABLE 2-1
NUMBER OF STRUCTURES BY LAND USE AND REACH

Reach	Residential Units	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**

2.5.2 Commercial- Industrial-Public

The updated inventory includes the original 1989-1990 inventory plus revisions from both the 1996 SIR and the 2003 LRR. This inventory was a complete count (without sampling) and is representative of conditions as of 2000. **Table 2-1** shows the number of commercial, industrial, and public structures by area.

2.5.3 Valuation of Structure and Content

All structure values were revised using Marshall & Swift Valuation to October 2006 prices for the Sacramento area. The values in **Table 2-2** were based on M&S price revisions, which were based on depreciated replacement values found in the Folsom Modifications Report 2001. Each structure in the report had a unique structure value taken from the assessor data. To verify and adjust those values to represent depreciated replacement values in (at the time current) October 2000 prices, a sample of 365 residential and 200 non-residential structures were valued in detail based on field visitation, square footage, estimated depreciation, and Marshall & Swift

dollars per square foot (SF) based on use, class, and type. For the residential sample, the range was from a low of $23,000 (700 SF poor) to a high of $384,000 (4,700 SF very good) for the structure value. The commercial sample had a larger range from $45,000 to $27,000,000. These values were then compared to the recorded improvement value for each observation in the sample and factors were determined based on these and applied to the population. For this 2006 PAC report, these 2000 values were brought forward using M&S Comparative Cost Multipliers for Sacramento.

Nonresidential content values were determined as a percentage of the structure value. Residential contents were originally set at 50 percent by district convention but with the use of the EGM 04-01 curves, content value is not used in the damage calculations. Nonresidential contents ranged from 24 percent to 209 percent of structure value depending on use category and were taken from the original 1991 feasibility study (primary source: New Orleans District, Lake Pontchartrain). In the economic reevaluation, one of the critical tasks is to conduct surveys (within the floodplain area) to revise content percentages.

Structure and content values for each reach and category are listed in **Table 2-2** with a total of over $38 billion.

TABLE 2-2
VALUE OF DAMAGEABLE PROPERTY ($ MILLIONS)

Land Use	Area Reach				Total
	Downtown	North Sacramento	Rancho Cordova	South Sacramento	
Residential					
Structures	2,702	2,115	1,246	7,364	13,427
Contents	1,350	1,057	623	3,684	6,714
Commercial					
Structures	1,929	1,635	470	2,330	6,364
Contents	2,180	1,847	538	2,652	7,217
Industrial					
Structures	30	19	34	206	289
Contents	34	19	36	214	303
Public					
Structures	1,211	382	29	1,167	2,789
Contents	505	162	23	611	1,301
TOTAL	**9,942**	**7,236**	**2,999**	**18,228**	**38,405**

Note:
1. *October 2006 Price Levels.*

2.6 WITHOUT-PROJECT DAMAGES

Primary revisions to the without-project single event damages from the 2003 report include:

- Increased valuations shown in **Table 2-2**
- Revised residential depth-damage functions
- Revisions to emergency costs

On average, these changes led to an increase in damages for individual events by about 50 percent over the level estimated in the 2003 report. Damages by each category were estimated based on the original 80-, 100-, and 400-year depths (but assigned new frequencies as identified in the current hydrology & hydraulic studies) from the original 1991 study. These damages were then linked to a common index point for all reaches and tied to stages within the channel. Damages for intermediate stages between the original events were interpolated based on discharges to complete the stage damage functions. Note that revisions to emergency costs were limited to temporary relocation assistance based on the number of people evacuated and average costs and durations seen during past floods in Northern California. These estimates do not include any of the type of catastrophic losses seen from Katrina and probably significantly underestimate the true emergency costs that a metropolitan area such as Sacramento would see from a major flood event. As mentioned, emergency cost revisions will be one of the critical tasks of the Economic Reevaluation Report.

The revised single index point (all reaches combined) by category Stage Damage functions is shown in **Table 2-3**. The mean and standard deviation damages in this table represent the economic input into the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) model. Note that the stages in Table 2-3 represent the exterior elevation (within the river channel using infinite channel height in the model) and not the interior flood depths. HEC-FDA needs to link the damages based on this stage (elevation) in the channel to frequency, based on the stage-discharge function to determine the exceedance probability-damage function. The link between the exterior stage and the flood plain depths was made by comparing the common outflow-stage relationship based on the (original 1991 100-year and 400-year) outflows connected to the original flood plains. The actual depths in the flood plain ranged from 1 to 20 feet depending on event and location. Total event damages would be just over $10 billion for the original 100-year event (about 70-year current) and over $20 billion for the 400-year event (about 600-year current).

TABLE 2-3
WITHOUT-PROJECT STAGE AND EVENT EXCEEDENCE PROBABILITY DAMAGE FUNCTIONS ($ BILLIONS)

Stage in Feet	Event Exceedence Probability		Res.	Com.	Ind.	Public	Auto-Road	Emer. Costs	Total Mean
43.14	0.0167	Mean	0	0	0	0	0	0	**0**
		Std. Dev.	0	0	0	0	0	0	
43.79	0.0157	Mean	5.672	1.332	0.017	0.582	0.027	0.030	**7.660**
		Std. Dev.	0.664	0.206	0.002	0.090	0.004	0.005	
49.45	0.0108	Mean	6.936	1.861	0.039	0.748	0.238	0.330	**10.152**
		Std. Dev.	0.665	0.232	0.004	0.093	0.031	0.051	
56.34	0.0075	Mean	8.421	3.530	0.169	1.123	0.356	0.387	**13.986**
		Std. Dev.	0.699	0.387	0.018	0.123	0.039	0.060	
67.77	0.0053	Mean	10.046	4.517	0.206	1.320	0.472	0.443	**17.004**
		Std. Dev.	0.756	0.449	0.021	0.130	0.047	0.069	
73.55	0.0019	Mean	10.941	5.971	0.253	1.598	0.650	0.519	**19.932**
		Std. Dev.	0.717	0.505	0.022	0.135	0.054	0.081	
74.73	0.0015	Mean	11.134	6.202	0.258	1.639	0.650	0.519	**20.402**
		Std. Dev.	0.732	0.526	0.022	0.140	0.054	0.081	

Note:
1. *October 2006 Price Levels.*
2. *Stage represents the elevation within the channel at the common index point.*

2.6.1 Hydraulic and Geotechnical Data

The stage-discharge and levee failure relationships (PNP/PFP – Probable Non-Failure and Probable Failure Points) have changed slightly (to reflect a move in location of the index point) from the 2003 study, and represent without-project conditions that include the completion of the Common Features. In the model, no damages occur below a stage of 48.6 feet (represents elevation within the channel – not depths in the flood plain), which is the PNP for the study. The existing relationships were entered into the HEC-FDA model and adjusted for the shift in index point. For the PAC analysis documented in this report, the stage-discharge and levee failure relationships are the same under both with and without-project conditions. New stage-discharge relationships and new geotechnical data are currently being developed for the Economic Reevaluation Report that will consider various levee breaks at multiple locations. PNP/PFP for the PAC analysis are listed below and the stage-discharge function with uncertainty is displayed in **Table 2-4**.

- PNP = 48.6 feet 15 percent Probability of Levee Failure
- PFP = 49.6 feet 85 percent Probability of Levee Failure

TABLE 2-4
STAGE-DISCHARGE WITH UNCERTAINTY

Discharge (cfs)	Stage (feet)	Error Limits in Stage (feet)			
		-2 Standard Deviation	-1 Standard Deviation	+1 Standard Deviation	+2 Standard Deviation
2,500	15.69	14.98	15.34	16.04	16.40
6,600	18.57	17.74	18.15	18.99	19.40
12,000	22.04	21.05	21.54	22.54	23.03
30,000	28.56	27.28	27.92	29.20	29.84
50,000	33.46	31.96	32.71	34.21	34.96
70,000	37.18	35.51	36.34	38.02	38.85
90,000	40.11	38.31	39.21	41.01	41.91
115,000	43.14	41.20	42.17	44.11	45.08
145,000	46.23	44.23	45.23	47.23	48.23
160,000	47.64	45.64	46.64	48.64	49.64
180,000	49.33	47.33	48.33	50.33	51.33
192,000	50.51	48.51	49.51	51.51	52.51
210,000	52.01	50.01	51.01	53.01	54.01
234,000	53.93	51.93	52.93	54.93	55.93
300,000	59.68	57.68	58.68	60.68	61.68
375,000	65.85	63.85	64.85	66.85	67.85
560,000	74.73	72.73	73.73	75.73	76.73

Note:
1. Stage represents the elevation within the channel at the common index point.

2.6.2 Hydrologic Data

For this PAC analysis, both the exceedence probability discharge and regulated inflow-outflow relationships were revised from the November 2003 LRR. New relationships were provided for use in the model. For the current evaluation, the model was run with varying regulated inflow-outflow relationships (provided by the Sacramento District Water Management Section) to represent the different project configurations. The hydrologic relationships used in the models to simulate project conditions for each alternative can be found in **Attachment 2** of this appendix.

2.6.3 HEC-FDA Model Results – Without-Project Conditions

In past studies on the American River, the MONTE program was used for flood damage analysis. Currently, HEC-FDA is the standard risk-based flood damage analysis model used at the Corps. For the PAC, the risk-based model used is HEC-FDA version 1.3. Advantages of using the HEC-FDA model for this study instead of MONTE include:

- Consistency with Corps Reporting Requirements (MONTE does not provide all results required to meet the Corps planning guidance found in Engineering Regulation ER-1105-2-101 and Engineering Manual EM-1110-2-1619)
- Widespread acceptance throughout the Corps (compliant with EC 1105-2-407 Planning Models Improvement Program: Model Certification, specifically section 5.a.1)
- HEC-FDA uses the same basic relationships as MONTE
- HEC-FDA allows for stage-damage curves by separate reach and by damage category to be entered into a single model or study file. For this PAC analysis analysis, separate damage curves were entered based on category, but for the single index point without individual reaches.

Expected annual damages (EAD) for the without-project conditions are shown in **Table 2-5**.

TABLE 2-5
WITHOUT-PROJECT EXPECTED ANNUAL DAMAGES FROM HEC-FDA
($ MILLIONS)

	Damage Category						Total Damages
	Residential	Commercial	Industrial	Public	Auto/Roads	Emergency Costs	
Without-Project	115.4	53.8	2.3	15.7	5.7	5.3	198.2

Note:
1. October 2006 Price Levels.

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CHAPTER 3.0
WITH-PROJECT BENEFITS

Flood damage reduction benefits are measured by comparing the without-project expected annual damages to the with-project residual damages for various alternatives. Project conditions and reducing the frequency and/or magnitude of damages are entered into the economic model and benefits equate to the difference between without- and with-project EAD.

3.1 HEC-FDA MODEL RESULTS (WITH-PROJECT CONDITIONS FOR PRELIMINARY ALTERNATIVES)

During the PAC analysis, various routings were provided by Sacramento District's Water Management Section for running project conditions in HEC-FDA. Many of these preliminary routings were used to help determine project sizing and to help establish which measures were required to safely pass the PMF. These preliminary alternatives basically fit into two categories:

1) Measures that allowed for greater discharges at lower than existing elevations in the storage pool
2) Measures that provided a larger effective flood control pool in the reservoir

The following list includes the measures or increments examined at a preliminary reconnaissance level of detail.

A. New or enlarged outlets on the Main Folsom Dam - Looked at variation in the number of enlarged outlets from 2 to 10. The eight-outlet configuration was determined to be equivalent, in terms of targeted project performance, to the Folsom Dam Modifications authorized in 1999.
B. New submerged tainter gates located at the proposed auxiliary spillway - The PDT looked at a range of sizes and number of submerged tainter gates up to a total of six.
C. Replacement of emergency and or main gates - Allows for greater use of available flood control space- Looked at replacing either the three emergency gates or all eight emergency and main gates
D. Dam raises up to 7 feet - Provides greater flood space

Components from the four categories above were mixed and matched in an iterative process to create an array of about 60 preliminary alternatives, and HEC-FDA was run to determine their relative effectiveness in terms of general flood damage reduction and project performance. Increments or added measures that did not significantly increase performance or failed to meet targeted objectives such as passing the PMF were dropped (see **Table 3-1** in **Attachment 3**). The results of these preliminary runs are not comparable to the current detailed HEC-FDA analysis and are not included in this document.

During this preliminary analysis, an alternative with six submerged tainter gates was identified as the Joint Federal Project (JFP), which met the objectives mentioned in **Section 1.4** of this appendix.

3.2 WITH PROJECT CONDITIONS - DETAILED ALTERNATIVE ANALYSIS

More detailed analysis was performed on a smaller set of plan alternatives including the previously authorized (Folsom Modification and Folsom Dam Raise) plans and a potentially more optimal array (in terms of efficiency) of alternatives that also met the two non-NED dam safety objectives (safely pass the 1 in 200 design flow event and safely pass the PMF). A flood damage reduction only plan was also included to compare as functionally equivalent to the JFP for use in the cost allocation. Further refinement of additional alternative components for full optimization will be completed as part of the Economic Reevaluation Report when more detailed data is developed.

The descriptions of the final array of alternatives are listed below:

- No-Action – The future without-project condition includes completed Common Features and reoperation to 400,000/670,000[2]
- Alternative A– Eight Main Dam Outlets and Fuseplug Spillway
- Alternative B – Six Submerged Tainter Gate Auxiliary Spillway
- Alternative C – Six Submerged Tainter Gate Auxiliary Spillway, 3.5-Foot Dam Raise, and Three Emergency Spillway Gate Replacements
- Alternative D – Six Submerged Tainter Gate Auxiliary Spillway, 7-Foot Dam Raise, and Eight Emergency and Service Spillway Gate Replacements

In addition to the five alternatives in the final array, the following configurations were analyzed in terms of benefits and project performance for comparison to the original authorizations for the Folsom Modifications and Dam Raise:

- 10 Outlets - The authorized Folsom Modifications project consisting of Ten Main Dam Outlets without surcharge storage- During the study, it was determined that constructing the final two outlets would be very high risk, adding unreasonable costs to the project. The benefits and project performance numbers for the 10 outlets are only included for comparison purposes
- 10 Outlets + 7.0-Foot Raise - Adds the authorized 7-Foot Dam Raise, and Eight Emergency and Service Spillway Gate Replacements to the 10 Outlets and is included only for comparison, not as part of the final array of alternatives.

[2] Re-operation of Folsom for this analysis is considered part of the future without project condition. Any costs of permanent re-operation are part of the without project condition and would not be included as a project cost. In addition, any resource benefits under the with project conditions of reducing re-operation from 400/670k to 400/600k have not been estimated or included. Changes in variable operation could be considered under other project conditions in the future and a more detailed resource analysis could be included in further study of re-operation.

- 8 Outlets + 7.0 Foot Raise - Adds the authorized 7-Foot Dam Raise, and Eight Emergency and Service Spillway Gate Replacements to Alternative A, included only for comparison, not as part of the final array of alternatives.
- Single Purpose Flood Damage Reduction Only – Four Large Submerged Tainter Gate (26' X 33') Auxiliary Spillway- Developed as a Flood Damage Reduction only equivalent to Alternative B, this plan would not address Dam Safety but will be used as part of the cost allocation computations.

Similar to the without-project condition, these alternatives were evaluated using the HEC-FDA model with outputs for expected annual damages, annual benefits, and project performance. HEC-FDA also can compare single event damages based on exceedence probabilities **Table 3-1** shows single event damages by event for each alternative.

TABLE 3-1
EXCEEDENCE PROBABILITY DAMAGE FUNCTIONS (FROM HEC-FDA)

ALTERNATIVE	EXCEEDENCE PROBABILITY						
	0.020	0.010	0.007	0.005	0.004	0.002	0.001
No Action	1	3,896	11,875	13,201	13,958	14,468	14,860
Alternative A- 8 Outlets	0	359	1,665	7,777	9,835	10,984	12,988
Alternative B – 6STG	0	361	1,668	5,370	7,092	8,368	10,174
Alternative C – 6STG+3.5ft Dam Raise+3E Gates	0	359	1,665	1,781	2,824	7,608	9,583
Alternative D – 6STG+7ft Dam Raise+8S&E Gates	0	359	1,665	1,668	4,071	8,872	10,370
Prior Authorized Plans							
10 Outlets	0	359	1,665	5,772	7,165	8,752	10,480
10 Outlets + 7ft Dam Raise+8S&E Gates	0	361	1,668	1,718	2,963	3,224	3,572
8 Outlets + 7ft Dam Raise+8S&E Gates	0	359	1,665	1,888	3,639	5,287	6,925
FDR Only- 4STG(26x33)	0	361	1,667	4,901	6,934	9,041	10,604

Note:
1. *October 2006 Price Levels, Values in $ Millions.*

HEC-FDA provides additional statistical output for benefit calculation (satisfying the guidance found in ER 1105-2-101) on a probabilistic basis that is not part of the standard output of MONTE. Expected annual benefits and the probability benefits exceed the indicated value are shown in **Table 3-2** for each of the four alternatives and the four comparison plans.

TABLE 3-2
EXPECTED ANNUAL DAMAGES AND BENEFITS FROM HEC-FDA ($ MILLIONS)

Alternative	Expected Annual Damage			Probability Benefits Exceed Indicated Value		
	Without-Project	With-Project	NED Benefits	75 %	50 %	25 %
Final Array of Alternatives						
Alternative A- 8 Outlets	198.2	113.5	84.7	58.9	80.1	105.6
Alternative B – 6STG	198.2	108.3	89.9	62.5	85.0	112.0
Alternative C – 6STG+3.5ft Dam Raise+3E Gates	198.2	91.1	107.1	73.7	101.0	133.8
Alternative D – 6STG+7ft Dam Raise+8S&E Gates	198.2	79.3	118.9	81.5	112.2	148.9
Comparison of Prior Authorized Plans (for comparison purposes only)						
10 Outlets	198.2	108.2	90.0	62.5	85.1	112.2
10 Outlets + 7ft Dam Raise+8S&E Gates	198.2	83.4	114.8	78.9	108.2	143.9
8 Outlets + 7ft Dam Raise+8S&E Gates[2]	198.2	88.4	109.8	75.7	103.6	137.4
Flood Damage Reduction Only- 4STG(26x33)	198.2	109.0	89.2	62.1	84.4	111.2

Note:
1. *October 2006 Price Levels.*
2. *7ft Dam Raise+8S&E Gates (authorized Folsom Dam Raise Project assuming Folsom Modification is in place).*

3.3 PROJECT PERFORMANCE

In addition to damages estimates, HEC-FDA reports flood risk in terms of project performance. Three statistical measures are provided as part of HEC-FDA output. Based on the revised ER 1105-2-101 (January 2006), only two of these statistics are required to describe performance risk in probabilistic terms. These include annual exceedence probability and long-term risk.[3] These two statistics are described below.

[3] Conditional Non-Exceedence Probability is the third performance statistic provided as part of the HEC-FDA output but is not included in this report. ER 1105-2-101 also describes reporting annual exceedence probability (AEP) with associated estimates of uncertainty. The current HEC-FDA model does not provide this data, and AEP with uncertainty has not been estimated for this study. The Corps currently does not have an approved risk-based model capable of providing this output consistent with the guidance.

- Annual exceedence probability (AEP) measures the chance of having a damaging flood in any given year.
- Long-term risk provides the probability of having one or more damaging floods over a period of time.

Table 3-3 shows both AEP and long-term risk for each of the alternatives in the final array.

TABLE 3-3
PROJECT PERFORMANCE – ALTERNATIVES

Alternative	Annual Exceedence Probability	Long-Term Risk (years)		
		10	30	50
Final Array of Alternatives				
No Action	0.0124	11.8 %	31.3 %	46.5 %
Alternative A – 8 Outlets	0.0068	6.6 %	18.5 %	28.9 %
Alternative B – 6STG	0.0064	6.2 %	17.6 %	27.5 %
Alternative C – 6STG+3.5ft Dam Raise+3E Gates	0.0054	5.3 %	15.1 %	23.8 %
Alternative D – 6STG+7ft Dam Raise+8S&E Gates	0.0047	4.6 %	13.3 %	21.1 %
Comparison of Prior Authorized Plans (for comparison purposes only)				
10 Outlets	0.0065	6.3 %	17.7 %	27.7 %
10 Outlets + 7ft Dam Raise+8S&E Gates	0.0050	4.9 %	14.1 %	22.4 %
8 Outlets + 7ft Dam Raise+8S&E Gates	0.0053	5.2 %	14.7 %	23.3 %
Flood Damage Reduction Only- 4STG(26x33)	0.0065	6.3 %	17.7 %	27.7 %

3.4 OBJECTIVES: PASSING 200-YEAR EVENT AND PMF

In addition to reducing flood damages, two additional dam safety objectives of any alternative are to:

- Pass the 200-year design flow event
- Pass the PMF

Table 3-4 shows which alternatives can safely pass the PMF and can pass design flow events that are greater than the 200-year event. The single purpose flood damage reduction only is shown for use in Separable Cost Remaining Benefits (SC-RB) analysis.

TABLE 3-4
DESIGN FLOW EVENT & PMF

Alternative	Pass Indicated Design Flow Event (Without Uncertainty)	Safely Pass the PMF
No Action	90-year	NO
Alternative A – 8 Outlets	180-year	YES (with FUSE)
Alternative B – 6STG	200-year	YES
Alternative C – 6STG+3.5ft Dam Raise+3E Gates	240-year	YES
Alternative D – 6STG+7ft Dam Raise+8S&E Gates	275-year	YES
Flood Damage Reduction Only-4STG(26x33)	200-year	NO

3.5 BENEFITS PRIOR TO THE BASE YEAR

Project components that become functional in reducing flood damages prior to completion of the entire plan will provide benefits prior to the base year and need to be amortized and included in the average equivalent benefits. Construction schedules and completion dates along with routings for intermediate measures are required to complete this section, but were not available at the time of preparation of this preliminary report. Analysis of benefits prior to base year is deferred to the economic reevaluation.

3.6 FUTURE CONDITIONS

For this PAC study, future without-project hydrology, hydraulics, and economic inventory was not considered to be significantly different than the current existing conditions. Within the without-project flood plains Sacramento is built out, allowing for no future growth. Therefore, damages shown in **Table 3-2** represent both existing and future conditions. For comparison over the period of analysis, all benefit values were discounted using the Fiscal Year 2007 discount rate of 4.875 percent over the 50-year period. These computed average annual equivalent values are equal to the benefit values shown in **Table 3-2** for each alternative.

CHAPTER 4.0
BENEFIT-COST ANALYSIS – NET BENEFITS

NED benefits from **Table 3-2** are compared with annual economic costs of the alternatives analyzed in **Table 4-1**. These alternatives safely pass the PMF, provide flood damage reduction benefits, and all but Alternative A provide savings in dam safety costs by eliminating the need to construct Reclamation's auxiliary spillway with fuseplug (as proposed in their single purpose dam safety plan). As shown in **Table 3-4**, alternatives B, C, and D pass the 200-year design flow. **Table 4-1** shows both the total annual costs and those economic costs attributable to the flood damage reduction increment of the plan.

TABLE 4-1
AVERAGE ANNUAL EQUIVALENT NED BENEFITS AND COSTS OF FLOOD DAMAGE REDUCTION

Alternative	Project First Costs	Annual FDR Benefits	Total Annual Costs	FDR Annual Costs[3]	Net Benefits FDR	Benefit/ Cost Ratio
Alternative A – 8 Outlets	630	84.7	33.0	33.0	51.7	2.6
Alternative B – 6STG	876	89.9	45.3	35.2	54.7	2.6
Alternative C – 6STG+3.5ft Dam Raise+3E Gates	988	107.1	50.1	40.0	67.1	2.7
Alternative D – 6STG+7ft Dam Raise+8S&E Gates	1,439	118.9	83.9	73.8	45.1	1.6

Key:
FDR = Flood Damage Reduction

Notes:

1. *October 2006 Price Levels, Values in $ Millions.*
2. *50-year period of analysis and FY07 4-7/8 percent discount rate.*
3. *Flood Damage Reduction costs are based on total project cost minus the annual costs of a single purpose dam safety project equal to $10.6 million in annual costs. These annual costs include O&M and interest during construction for each alternative.*
4. *The project first costs for Alternative A excludes the $200 million cost of the stand alone single purpose dam safety project (Fuse Plug).*

. These costs include O&M and interest during construction for each alternative.

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ATTACHMENT 1
FOLSOM JOINT FEDERAL PROJECT ECONOMICS ADVISORY PANEL

Following a meeting with SPK, the Bureau of Reclamation, and HQ on 24 June 2006, David Moser, CEWRC-IWR, was asked to assemble a team of economists to assist the Folsom Dam Joint Federal Project team in meeting a December deadline for submission of a Draft PAC Report. Subsequently, an Ad-hoc team of Corps economists was formed to review the economic analysis of the Folsom JFP.

The Economics Advisory Panel Team members included:

- Dr. Dave Moser, IWR
- Jim Conley, SPD
- Brian Harper, IWR
- Carol Hollaway, IWR
- Kevin Knight, SPN
- Mitch Laird, LRL
- Brian Shenk, NWP

The team met at SPK from 8-10 August 2006. The team's mission was to provide peer support with the intent of reviewing procedures, products, and underlying assumptions and to discuss other economic benefit categories available to the effort. The team looked at the plan formulation and assumptions that have shaped the current study. A teleconference was held with Keven Lovetro and Brian Maestri, MVN, during the effort.

Project information was presented by:

- Kurt Keilman, Tetra Tech Inc.
- Ignatius Anyanwu, SPK
- Gary Bedker, SPK
- Dan Tibbetts, SPK
- Bob Carl, HEC

The team submitted the following recommendations for consideration.

1. Impacts beyond the current study boundary need to be assessed. Downstream impacts need to be evaluated so that induced flood damages, and potential mitigation costs, are captured in the benefit-cost calculations.

2. Examine system risk of the multiple components of the regional flood damage reduction system - lesson learned from Katrina. Total system performance depends upon individual components performing at their design level of reliability. Will the system

perform as expected? Do design criteria and design standards for individual components assure system reliability? Performance of the existing system must be adequately assessed in order for base conditions to be established. Potential benefits of project improvements are uncounted if reliability of the existing system is overstated relative to actual performance.

3. The proposed plans need to be reviewed for completeness. Incremental fixes as presented in the existing analysis may foreclose future opportunities for a more comprehensive solution. In other words, a partial plan now takes benefits off the table for later improvements.

4. It was noted that floodplain maps are almost 20 years old. The economic analysis will be current only if the H&H and geotech input data are current. Any limitations of the engineering inputs compromise the quality of the economic analysis. Until the engineering data can be brought up to date, uncertainties in the existing data should be evaluated and captured in the analysis.

5. The analysis is NED-centric and should be broadened to display the four accounts as described in EC 1105-2-409 and the P&G. Such an analysis would evaluate potential loss of life, social and cultural consequences of flooding, and ecological impacts. These impacts are not typically measured in monetary terms and do not contribute to the benefit-cost ratio (BCR); however, they may play an important role in plan selection. The Folsom JFP team is working towards this objective and is encouraged to continue. Volume VII of the IPET report presents a model framework. Another example can be found in the Louisiana Coastal Protection & Restoration (LaCPR) risk-informed decision process that is being developed.

6. Ensure that the economic inputs reflect current conditions – particularly with respect to development and changed land use since the last structure inventory was conducted. For example, a survey should be conducted to validate content values (and resulting content damage functions) for non-residential structures.

7. Project feasibility is much more sensitive to cost uncertainties than benefit uncertainties. Cost uncertainties should be addressed. Estimates are volatile in response to perceived risks and complexity of the construction process.

8. The economic analysis should differentiate between economic costs and financial costs if they are different due to market power. The BCR should be calculated using NED costs, a reflection of opportunity costs. The P&G require that costs be based on opportunity costs of the project inputs. Investment in a market analysis may be warranted. Further discussion of this issue can be found in ER 1105-2-100, App D, Section D-3.

9. Replace FIA Damage functions with generic curves found in EGM 04-01. FIA curves limit structure damage to no more than 50 percent of structure value, even at 20 feet of water depth. The standard curves in EGM 04-01 are believed to be a more accurate predictor of damages. The EGM states "The generic functions developed and provided in

this EGM represent a substantive improvement over other generalized depth-damage functions such as the Flood Insurance Administration (FIA) Rate Reviews."

10. Develop damage function for public utilities and other infrastructure not already accounted for in the analysis. (Note: Event duration could reach 2 months). Katrina demonstrated that public utility damages could increase total physical damages by 20 percent. Post-Katrina recovery also shows that levee repairs could add an additional 10 percent to this total.

11. Examine base condition assumptions regarding OMRR&R of gates and other components of the existing project. Replacement of these features may be treated as advanced maintenance in the economic analysis. For example, if gate replacement would occur in 2015 without the project, a portion of with-project cost or OMRR&R would be offset by this avoided future cost.

12. Sunk costs should not be included in the BCR calculations.

13. The base condition should include the dam safety component as the first increment of Federal action, in order to appropriately identify flood damage reduction economic benefits and economic costs.

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ATTACHMENT 2
HYDROLOGIC DATA USED IN HEC-FDA MODEL

For the HEC-FDA model and all alternative runs, the same exceedence probability discharge functions were used. Below is the probability function as displayed in HEC-FDA.

Statistics of Logs for LP III

Mean (M):	4.5810
Standard Deviation (S):	0.4300
Skew (G):	-0.0770
Equivalent Record Length (N):	100

Plot...

Tabulate...

American River Folsom Mods

Discharge-Probability Function Report for WITHOUT PROJECT (Analytical)

Exceedance Probability	Discharge (cfs)	Confidence Limit Curves Discharge (cfs) 95%	75%	25%	5%
0.9990	1603	1018	1234	2017	2311
0.9900	3601	2520	2930	4322	4819
0.9500	7319	5542	6228	8461	9233
0.9000	10630	8355	9237	12077	13055
0.8000	16628	13577	14761	18576	19901
0.7000	22887	19082	20550	25360	27066
0.5000	38592	32761	34967	42599	45478
0.3000	64627	54621	58305	72015	77593
0.2000	87980	73484	78735	99140	107806
0.1000	134390	109551	118370	154520	170719
0.0400	210011	165738	181163	247661	278998
0.0200	279400	215460	237487	335350	382876
0.0100	360499	272019	302205	439850	508453
0.0040	487544	358154	401804	606912	712245
0.0020	600500	432827	488962	758181	899272
0.0010	729157	516179	586979	933015	1117784

Transform Flow – Regulated Inflow-Outflow Relationships

Changes in with project conditions for all the alternatives were simulated in the model by modifying the inflow outflow curves in the HEC-FDA. All other inputs remain the same for each alternative. HEC-FDA input is entered as 1) most likely, 2) minimum and 3) maximum outflow. Model runs for HEC-FDA were based on the relationships shown below.

1 in X chance per year	WITHOUT-PROJECT				8OUT (Alternative A)			
	Peak Unregulated Inflow	Mean Peak Discharge	Minimum Peak Discharge	Maximum Peak Discharge	Peak Unregulated Inflow	Mean Peak Discharge	Minimum Peak Discharge	Maximum Peak Discharge
1.01569	5000	3500	3500	4242	5000	3500	3500	4242
1.2977	20002	17823	17385	20133	20002	17823	17385	20133
1.4393	25004	22280	21210	24267	25004	22280	21210	24305
1.5655	29000	22882	22882	24268	29000	22648	22648	25594
1.8517	37002	22953	22953	24310	37002	22648	22183	35548
2	40722	22987	22987	24336	40722	22648	22625	25752
5	90369	23905	23905	29553	90369	50208	50000	54221
10	136522	27853	27853	49696	136522	101606	75749	101606
15	167533	52518	52518	70144	167533	102183	97461	115000
20	191482	71978	71978	84572	191482	103518	103518	115000
25	211227	91220	91220	101344	211227	115000	115000	115000
30	228145	106603	106603	115000	228145	115000	115000	115000
35	243016	115000	115000	115000	243016	115000	115000	115000
40	256328	115000	115000	115000	256328	115000	115000	115000
45	268407	115000	115000	115000	268407	115000	115000	115000
50	279485	115000	115000	115000	279485	115000	115000	115000
60	299276	115000	115000	115960	299276	115000	115000	115000
70	316636	133044	115000	151970	316636	115000	115000	115000
80	332148	160000	118982	160000	332148	115000	115000	115000
90	346204	160000	150141	196043	346204	115000	115000	115000
100	359078	240000	160000	240000	359078	115000	115000	115000
110	370972	240000	160000	240000	370972	160000	115000	160000
120	382040	240000	204435	240000	382040	160000	115000	160000
130	392399	255432	240000	265977	392399	160000	135000	160000
140	402144	288125	240000	295662	402144	160000	160000	160000
150	411351	315547	240000	323117	411351	160000	160000	160000
160	420081	346850	240000	346850	420081	160000	160000	160000
170	428387	364879	271190	376333	428387	160000	160000	160000
180	436312	385514	290319	398094	436312	160000	160000	210395
190	443894	419707	317559	429234	443894	175912	160000	237616
200	451163	438116	337325	441126	451163	228533	160000	265382
210	458146	458146	354551	458146	458146	259433	160000	312955
220	464869	464869	369380	464869	464869	273444	199318	330475
230	471351	471351	394549	471351	471351	297861	221317	341462
240	477611	477611	405916	477611	477611	319870	235664	362285
250	483665	483665	431032	483665	483665	341516	266729	389561
275	497992	497992	474981	497992	497992	401100	297491	423796
300	511307	506546	487545	507222	511307	435128	341468	457852
350	535457	512295	503588	512295	535457	494007	444237	494007
400	556967	518044	509462	518721	556967	496437	475823	496437
450	576401	525186	515283	525186	576401	509594	495660	509594
500	594159	532961	521877	533418	594159	512944	507246	512944
550	610531	541465	529874	541465	610531	519727	512986	519727
PMF	890916	900627	900627	900627	890916	732335	727483	788807

1 in X chance per year	8OUT+7.0DR+8G				4STG (26x33) (Single Purpose FDR Only)			
	Peak Unregulated Inflow	Mean Peak Discharge	Minimum Peak Discharge	Maximum Peak Discharge	Peak Unregulated Inflow	Mean Peak Discharge	Minimum Peak Discharge	Maximum Peak Discharge
1.01569	5000	3500	3500	4242	5000	3500	3500	4242
1.2977	20002	17823	17385	20133	20002	17823	17385	20133
1.4393	25004	22280	21210	24305	25004	22280	21210	24305
1.5655	29000	22648	22648	24525	29000	22648	22648	24525
1.8517	37002	22648	22183	24871	37002	22648	22183	24871
2	40722	22648	22625	24993	40722	22648	22625	24993
5	90369	50208	50000	54221	90369	50208	50000	54221
10	136522	102860	82951	102860	136522	115000	84067	115000
15	167533	104105	93298	115000	167533	115000	115000	115000
20	191482	111238	103692	115000	191482	115000	115000	115000
25	211227	115000	108650	115000	211227	115000	115000	115000
30	228145	115000	115000	115000	228145	115000	115000	115000
35	243016	115000	115000	115000	243016	115000	115000	115000
40	256328	115000	115000	115000	256328	115000	115000	115000
45	268407	115000	115000	115000	268407	115000	115000	115000
50	279485	115000	115000	115000	279485	115000	115000	115000
60	299276	115000	115000	115000	299276	115000	115000	115000
70	316636	115000	115000	115000	316636	115000	115000	115000
80	332148	115000	115000	115000	332148	115000	115000	115000
90	346204	115000	115000	115000	346204	115000	115000	115000
100	359078	115000	115000	115000	359078	115000	115000	115000
110	370972	115000	115000	122819	370972	160000	115000	160000
120	382040	115000	115000	141298	382040	160000	115000	160000
130	392399	121200	115000	158764	392399	160000	135000	160000
140	402144	129400	116023	162473	402144	160000	160000	160000
150	411351	147192	124180	172459	411351	160000	160000	160000
160	420081	160000	133400	204039	420081	160000	160000	160000
170	428387	160000	148153	233274	428387	160000	160000	160000
180	436312	189960	160000	273731	436312	160000	160000	160000
190	443894	215414	160000	307998	443894	160000	160000	195395
200	451163	241748	180470	334312	451163	160000	160000	241507
210	458146	276267	201479	346313	458146	201668	160000	269490
220	464869	314006	225482	357632	464869	235476	160000	285319
230	471351	339677	232377	358049	471351	266910	186276	289297
240	477611	347259	254853	369559	477611	293140	205067	326252
250	483665	351741	286576	375897	483665	330387	238792	366878
275	497992	367322	347076	382030	497992	377745	285439	401100
300	511307	380695	360343	394693	511307	435128	340672	435128
350	535457	398229	377228	416890	535457	481559	420747	481559
400	556967	417485	392298	431352	556967	523129	462483	556967
450	576401	435973	413170	442216	576401	576401	506534	576401
500	594159	445950	422681	461618	594159	594159	544670	594159
550	610531	461737	439686	477523	610531	606369	593677	610531
PMF	890916	859253	848963	859253	890916	779120	773224	780483

1 in X chance per year	6STG (Alternative B)				10OUT			
	Peak Unregulated Inflow	Mean Peak Discharge	Minimum Peak Discharge	Maximum Peak Discharge	Peak Unregulated Inflow	Mean Peak Discharge	Minimum Peak Discharge	Maximum Peak Discharge
1.01569	5000	3500	3500	4242	5000	3500	3500	4242
1.2977	20002	17823	17385	20133	20002	17823	17385	20133
1.4393	25004	22280	21210	24305	25004	22280	21210	24305
1.5655	29000	22648	22648	24525	29000	22648	22648	24525
1.8517	37002	22648	22183	24871	37002	22648	22183	24871
2	40722	22648	22625	24993	40722	22648	22625	24993
5	90369	50208	50000	54221	90369	50208	50000	54221
10	136522	115000	84067	115000	136522	115000	84067	115000
15	167533	115000	115000	115000	167533	115000	109893	115000
20	191482	115000	115000	115000	191482	115000	110841	115000
25	211227	115000	115000	115000	211227	115000	115000	115000
30	228145	115000	115000	115000	228145	115000	115000	115000
35	243016	115000	115000	115000	243016	115000	115000	115000
40	256328	115000	115000	115000	256328	115000	115000	115000
45	268407	115000	115000	115000	268407	115000	115000	115000
50	279485	115000	115000	115000	279485	115000	115000	115000
60	299276	115000	115000	115000	299276	115000	115000	115000
70	316636	115000	115000	115000	316636	115000	115000	115000
80	332148	115000	115000	115000	332148	115000	115000	115000
90	346204	115000	115000	115000	346204	115000	115000	115000
100	359078	115000	115000	115000	359078	115000	115000	115000
110	370972	160000	115000	160000	370972	160000	115000	160000
120	382040	160000	115000	160000	382040	160000	115000	160000
130	392399	160000	135000	160000	392399	160000	135000	160000
140	402144	160000	160000	160000	402144	160000	160000	160000
150	411351	160000	160000	160000	411351	160000	160000	160000
160	420081	160000	160000	160000	420081	160000	160000	160000
170	428387	160000	160000	160000	428387	160000	160000	160000
180	436312	160000	160000	160000	436312	160000	160000	160000
190	443894	160000	160000	195395	443894	160000	160000	204232
200	451163	160000	160000	241507	451163	160000	160000	241507
210	458146	169505	160000	269490	458146	182778	160000	269490
220	464869	213882	160000	285319	464869	224165	160000	317548
230	471351	252314	186276	289297	471351	252314	186276	321975
240	477611	280939	205067	326252	477611	280939	205067	359543
250	483665	296855	238792	366878	483665	296855	238792	366878
275	497992	377745	285439	401100	497992	368775	285439	401100
300	511307	411824	340672	435128	511307	411824	340672	435128
350	535457	481559	420747	502926	535457	481559	420747	481559
400	556967	523129	454020	556967	556967	510789	462483	510789
450	576401	576401	518967	576401	576401	522275	496822	522275
500	594159	594159	544670	594159	594159	525716	508328	525716
550	610531	610531	593677	610531	610531	525716	517559	525872
PMF	890916	810818	810434	821326	890916	921292	907425	921292

1 in X chance per year	6STG+3.5DR+3G (Alternative C)				6STG+7.0DR+8G (Alternative D)			
	Peak Unregulated Inflow	Mean Peak Discharge	Minimum Peak Discharge	Maximum Peak Discharge	Peak Unregulated Inflow	Mean Peak Discharge	Minimum Peak Discharge	Maximum Peak Discharge
1.01569	5000	3500	3500	4242	5000	3500	3500	4242
1.2977	20002	17823	17385	20133	20002	17823	17385	20133
1.4393	25004	22280	21210	24305	25004	22280	21210	24305
1.5655	29000	22648	22648	24525	29000	22648	22648	24525
1.8517	37002	22648	22183	24871	37002	22648	22183	24871
2	40722	22648	22625	24993	40722	22648	22625	24993
5	90369	50208	50000	54221	90369	50208	50000	54221
10	136522	115000	84067	115000	136522	115000	84067	115000
15	167533	115000	115000	115000	167533	115000	115000	115000
20	191482	115000	115000	115000	191482	115000	115000	115000
25	211227	115000	115000	115000	211227	115000	115000	115000
30	228145	115000	115000	115000	228145	115000	115000	115000
35	243016	115000	115000	115000	243016	115000	115000	115000
40	256328	115000	115000	115000	256328	115000	115000	115000
45	268407	115000	115000	115000	268407	115000	115000	115000
50	279485	115000	115000	115000	279485	115000	115000	115000
60	299276	115000	115000	115000	299276	115000	115000	115000
70	316636	115000	115000	115000	316636	115000	115000	115000
80	332148	115000	115000	115000	332148	115000	115000	115000
90	346204	115000	115000	115000	346204	115000	115000	115000
100	359078	115000	115000	115000	359078	115000	115000	115000
110	370972	160000	115000	160000	370972	160000	115000	160000
120	382040	160000	115000	160000	382040	160000	115000	160000
130	392399	160000	135000	160000	392399	160000	135000	160000
140	402144	160000	160000	160000	402144	160000	160000	160000
150	411351	160000	160000	160000	411351	160000	160000	160000
160	420081	160000	160000	160000	420081	160000	160000	160000
170	428387	160000	160000	160000	428387	160000	160000	160000
180	436312	160000	160000	160000	436312	160000	160000	160000
190	443894	160000	160000	160000	443894	160000	160000	160000
200	451163	160000	160000	160000	451163	160000	160000	160000
210	458146	160000	160000	160000	458146	160000	160000	160000
220	464869	160000	160000	160000	464869	160000	160000	160000
230	471351	160000	160000	160000	471351	160000	160000	160000
240	477611	160000	160000	210237	477611	160000	160000	160000
250	483665	195784	160000	233229	483665	160000	160000	160000
275	497992	252254	160000	266574	497992	160000	160000	160000
300	511307	300760	211666	313821	511307	193319	160000	236156
350	535457	406164	307835	431276	535457	303211	222457	328643
400	556967	473985	372216	500903	556967	380459	292796	422479
450	576401	518382	454042	541383	576401	464254	346709	490524
500	594159	558062	494709	594159	594159	505636	441729	534352
550	610531	610531	537645	610531	610531	549076	481994	573439
PMF	890916	839626	832728	839650	890916	863342	863342	869516

ATTACHMENT 3
EXCLUSION OF PRELIMINARY ALTERNATIVES

In addition to the eight alternatives listed in the tables in **Section 3** of this appendix, additional preliminary model runs were performed to determine the final array. The following table explains in qualitative terms why many of these were not included.

Alternatives	Reason Excluded from Final Array
2 New Outlets – Main Dam 2 New + 2 Enlarged Outlets – Main Dam 4 Enlarged Outlets – Main Dam 2 New + 4 Enlarged- Main Dam	All were less effective and less efficient than Alternative A consisting of 8 outlets. None of these came close to passing the objective 1 in 200 flow.
Combinations: Both Outlets at Main Dam + submerged tainter gates at the Auxiliary Spillway 2STG + 2OUT 2STG + 4OUT 2STG + 6OUT 4STG + 2OUT 4STG + 4OUT	All less efficient than the 6 STG (Alternative B). None provided greater output than 6 STG.
2STG 3STG 4STG(17x33)	None of these are able to pass the PMF without either construction of upstream storage or inefficient raises of Folsom Dam

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Post Authorization Change Report

American River Watershed Project

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Appendix F
Cost Distribution

US Army Corps of Engineers

Sacramento District
South Pacific Region

March 2007

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CHAPTER 1.0
INTRODUCTION

1.1 BACKGROUND

The U.S. Army Corps of Engineers (Corps) and the U.S. Department of Interior, Bureau of Reclamation (Reclamation) have found that an auxiliary spillway controlled by six submerged tainter gates (6 STG Element, also referred to as the Joint Federal Project or JFP) off the left abutment of Folsom Dam presents an opportunity for both dam safety risk reduction and flood damage reduction. The Corps and Reclamation devised a procedure to equitably divide the construction of the JFP. The Reclamation – Corps partnership to construct the JFP will be implemented through construction work packages. The two agencies will use work packages to assign construction responsibilities, minimize transferring funds between agencies, and complete their respective parts of a complete project.

The Energy and Water Appropriations Act of 2006 (PL 109-103) authorized the Corps and Reclamation to collaborate to maximize flood damage reduction improvements and address dam safety needs at Folsom Dam.

The agencies devised a procedure to calculate a dam safety – flood damage reduction distribution percentage, and used the percentage to distribute work items between the Corps work package and a Reclamation work package. Features included in the Corps work package are not necessarily specific to flood damage reduction, but all costs of the Corps work package are considered flood damage reduction costs, and would be budgeted and cost-shared as such.

This appendix describes the procedure for calculating the cost distribution flood damage reduction– dam safety percentage, using the percentage to determine flood damage reduction and dam safety target costs for work packages, and dividing work items into the work packages so that the costs approximate the target costs and the work reflects dam safety construction for the Reclamation work package and flood damage reduction construction for the Corps work package.

Cost distribution contrasts with cost allocation, because cost allocation is between purposes, and cost distribution assigns costs to dam safety, which is not a purpose. Cost distribution here is development of a percentage may be regarded as assigning costs to different programs or authorities. Neither the Corps nor Reclamation has regulations on cost distribution, but both may rely on their respective cost allocation regulations as appropriate. Reclamation's cost allocation regulations are attached to this appendix.

Development of work packages is summarized in **Chapter 6**. **Chapter 6** includes text on the methodology and principles of distribution of work and work packages. This text will be repeated in Reclamation's report on Folsom dam safety. .

Economic cost may be calculated differently than financial cost. The economic cost of flood damage reduction is compared with the flood damage reduction benefits, to determine economic feasibility. Economic cost is discussed in the main report and the economic appendix.

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CHAPTER 2.0
COST DISTRIBUTION

2.1 PROPORTIONAL METHOD OF COST DISTRIBUTION

A "proportional" method is used to distribute costs of the Six Submerged Tainter Gate Element (6 STG Element), also referred to as the Joint Federal Project (JFP). This distributes costs based on a ratio of the single purpose construction costs to the sum of the single purpose construction costs.

Flood Damage Reduction (FDR) share =
($ single purpose FDR) / [($ single purpose FDR + $ single purpose DS)] X ($ 6STG)

The single purpose dam safety project is a fuseplug spillway. This would safely pass the PMF, but would provide no flood damage reduction. The single purpose flood damage reduction project is identical to the 6 STG Element. Single purpose plans are further discussed below.

The resulting percentages are applied to the construction cost of the 6 STG Element to calculate basic flood damage reduction and dam safety construction costs, which serve as target costs for the work packages. Work packages are then formulated for flood damage reduction and dam safety. The 6 STG Element construction work items are divided among the work packages so that dam safety and flood damage reduction costs are close to the target costs. Once work packages are defined, each agency developed its own cost estimate for its work package.

This procedure is adopted because it best meets the budgeting and construction needs of Reclamation and the Corps. This contrasts from traditional cost allocation which is to equitably assign costs between benefit-generating project purposes. In this case, the flood damage reduction benefits and economic costs are developed independently. This procedure seeks not only equitable costs between flood damage reduction and dam safety, but also a way for the two Federal agencies to partner constructing a single, complete project. The distributed costs to dam safety and flood damage reduction show a savings comparable to the relative dollar contributions of each single purpose plan. This is important in this case because the flood damage reduction single purpose plan has a much greater cost than the single purpose dam safety plan.

2.2 DEVELOPMENT OF COSTS FOR COST DISTRIBUTION

The cost estimates presented herein were developed for the purpose of cost distribution only. They are specifically for cost distribution because the Corps and Reclamation use different cost estimating procedures; thus, Corps estimates and Reclamation estimates are not directly comparable. These costs are, by Corps definition, a reconnaissance-level estimate based on the probable type and size of the project. Each estimate includes construction features, lands and damages, relocations, environmental compliance and required mitigation, engineering and design, construction management, and contingencies. The cost estimate method established reasonable costs sufficient to support the proposed cost distribution process. The estimates were developed using quotes, calculations, unit prices, and historical data as backup.

Cost estimates were prepared previously from different sources. The cost estimates are done for the fuseplug (single purpose dam safety project), and the 6 STG Element (which serves as both the single purpose flood damage reduction project and the JFP). The costs were modified to be comparable to each other. The new, comparable cost estimates were prepared by a third party, Montgomery Watson Harza consultants. A team of cost engineers from Reclamation and the Corps reviewed the cost estimates.

2.3 SIX SUBMERGED TAINTER GATE AUXILIARY SPILLWAY COST

The 6 STG Element is an auxiliary spillway controlled by 6 submerged tainter gates. Other features of the Selected Plan, a 3.5 - foot raise, and replacement of the emergency and service spillway gates, are specific flood damage reduction costs. All dam raise costs are excluded from the cost distribution. The 6 STG Element is both the dual function plan and the least cost single purpose flood damage reduction plan. The cost estimate for cost distribution is discussed in the next section.

2.4 DEVELOPMENT OF LEAST COST SINGLE PURPOSE PLANS

Costs of single purpose plans are input to the proportional method. The least cost single purpose dam safety plan is an auxiliary spillway with a fuseplug, which Reclamation has developed. The fuseplug spillway safety passes the PMF using Reclamation criteria at a least cost, but provides no flood damage reduction benefits. For the purpose of input to the SC-RB analysis, dam safety benefits are considered equal to cost.

The single purpose flood damage reduction project is identical to the 6 STG Element (JFP). The single purpose flood damage reduction has to be a complete project that can be implemented. Thus, this modification to Folsom Dam must meet basic dam safety requirements, and safely pass the full PMF. A purely functional single purpose flood damage reduction project that would only be required to not make hydrologic dam safety any worse would be a smaller spillway and have less gates, but since it would not safely pass the PMF, it is considered not implementable.

This configuration provides $89.9 million in average annual flood damage reduction benefits. This plan reduces risk of flooding to a 1 in 156 annual exceedance.

The 6 STG Element and single purpose plans occupy the same location. This contrasts with typical cost allocation between purposes, for which single purpose plans use different locales. Since this is an evaluation to distribute costs for agency contribution to a single project not involving purposes, it is more appropriate to not use this procedure. Both the District and the Reclamation local offices agreed that each single purpose project should assume that the other single purpose project has not been constructed and is not part of the base condition. This is different than the without-project condition used to evaluate flood damage reduction benefits, which includes the fuseplug spillway.

Single purpose costs are shown in **Table 2-1**. To assure that the costs were comparable to each other, a third party, MWH, under contract to the Corps, developed the cost estimates for the single purpose plans. The cost estimates are less than feasibility level, and are intended for

cost distribution purposes only. The costs were reviewed by a team of Corps and Reclamation engineers and estimators.

The single purpose costs were then further modified to subtract costs that vary between Reclamation and the Corps. The costs were modified as follows:

- Sunk costs incurred by both Reclamation and the Corps were subtracted (these are agency-specific costs).
- Planning, engineering & design (PED) costs were subtracted. PED procedures vary between agencies.
- Construction supervision & administration (S&A) costs were subtracted. S&A procedures vary between agencies. S&A costs include agency-specific costs that do not necessarily reflect a pure construction cost.
- Construction contingencies were subtracted. Contingencies in the third party estimate did not add to the accuracy of comparison of the two estimates.
- Other miscellaneous costs, such as recreation mitigation and allowances for possible contract fees, were subtracted.
- Interest during construction is replaced with a cost escalation allowance, computed from Notice to Proceed to the mid-point of construction. This negates the difference in authorization, appropriation, and budget tasks and time that would skew costs towards flood damage reduction.

The 6 STG Element modified cost for cost distribution is $483.2 million. . The fuse plug modified cost for cost distribution is $123.2 million.

2.5 COST DISTRIBUTION USING THE PROPORTIONAL METHOD

Using the proportional formula shown above, the dam safety percentage is:

Dam Safety (DS) = fuseplug cost / (fuseplug + 6 STG cost);
= 123.2 / 606.37 = 0.2032 = 20 percent

The flood damage reduction percentage using this formula is:

Flood Damage Reduction (FDR) = 6 STG cost / (fuseplug + 6 STG cost);
= 482.17 / 606.37 = 0.7968 = 80 percent

The resulting distribution percentage is 20 percent dam safety, 80 percent flood damage reduction.

TABLE 2-1
MODIFICATIONS OF SINGLE PURPOSE COSTS

Construction Cost Comparisons (w/o Contingencies) ($ Millions)				
Fuseplug				
Table A				
Item	**Costs**	**Cost Adjustments**	**Total**	**Notes**
First Costs:				
Construction	99.596	0.000	99.596	
PED	3.000	-3.000	0.000	PED cost is excluded from total
S&A	13.000	-13.000	0.000	S&A cost is excluded from total
NEPA Mitigation	6.000	0.000	6.000	
Cultural Mitigation	6.000	0.000	6.000	
Security	2.400	0.000	2.400	
Relocations/Restorations	n/a	0.000	0.000	Access roads, utility relocations, site restoration
Sunk Costs	5.000	-5.000	0.000	Sunk cost is excluded from total
Subtotal First Costs	**134.996**	**-21.000**	**113.996**	**Construction costs (w/o contingencies) & specific work (W.P.) package costs.**
Additional Costs:				
Escalation	0.000	9.158	9.158	3% Escalation allowance (from NTP to MPC)
Total	**134.996**	**-11.842**	**123.154**	**Total: Construction Direct/Indirect Costs + Agency-Specific W.P. Costs + Escalation**
6 STG Element				
Table B				
Item	**Costs**	**Cost Adjustments**	**Total**	**Notes**
First Costs:				
Construction	413.173	0.000	413.173	
PED	50.000	-50.000	0.000	PED cost is excluded from total
S&A	58.000	-58.000	0.000	S&A cost is excluded from total
NEPA Mitigation	6.000	0.000	6.000	
Cultural Mitigation	6.000	0.000	6.000	
Security	4.200	0.000	4.200	
Relocations/Restorations	4.789	0.000	4.789	Access Roads, Utility Relocations, Site Restoration
Sunk Costs	55.000	-55.000	0.000	Sunk cost is excluded from total
Subtotal First Costs	**597.162**	**-163.000**	**434.162**	**Construction Costs (w/o contingencies) & Specific Work (W.P.) Package Costs.**
Additional Costs:				
Escalation	0.000	49.010	49.010	3% Escalation allowance (from NTP to MPC)
Total	**597.162**	**-113.990**	**483.172**	**Total: Construction Direct/Indirect Costs + Agency-Specific W.P. Costs + Escalation**

Notes:

1. *October 2006 price level*
2. *All cost items are listed without contingencies.*
3. *Costs developed by a 3rd party, MWH under contract with the Corps.*

2.6 DEVELOPMENT OF WORK PACKAGES

To develop work packages, target costs for each work package were calculated. The percentages are multiplied by the same modified 6 STG Element cost to derive the target costs for the Corps and Reclamation work packages.

The target cost for dam safety is as follows:

Dam Safety (DS) target cost = DS percentage X modified construction cost of the 6 STG Element
= 0.2032 X $483,170,000;
= $98,168,680

The target cost for the flood damage reduction work package is as follows:

FDR target cost = FDR percentage X modified construction cost of the 6 STG Element;
= 0.7968 X $483,170,000;
= $385,000,000

Two work items to construct the JFP, one for the Corps and one for Reclamation, were formulated. Individual work items were distributed between the Corps' flood damage reduction work package and Reclamation's dam safety work package using the following criteria:

- The total costs of the individual work items should match as closely as possible the target costs for each work package.
- The Reclamation work package would include, to the extent possible, the construction of those portions of the 6 STG Element that coincide with fuseplug spillway features. The Corps work package would include the balance of the work, associated with flood damage reduction.
- The distribution of work items should minimize construction risk (e.g., complications from two operations being conducted at the same time at the same place) and increase construction efficiency.
- The packages should minimize problems of one agency interfacing with the previous work of the other agency.
- Construction risk should be balanced between work packages.
- Execution of construction to realize project benefits as quickly as possible.

The work package basic line items, the sum of the cost of the line items, and the original target cost values for flood damage reduction and dam safety are shown in **Table 2.2**.

TABLE 2-2
JOINT FEDERAL PROJECT INITIAL WORK PACKAGES [1]

Cost Account / Features	Reclamation Work Package	Corps Work Package	Notes
Lands	-	-	No lands purchase required
Relocations	42" dia. water pipe relocation		Since the single relocation is part of the Reclamation work package, it is not a flood damage reduction non-Federal sponsor responsibility
Construction & Mitigation	Site preparation, initial, including roads & utilities Chute excavation Stilling basin excavation Control structure, partial excavation foundation remediation Physical site security NEPA/CEQA commitments Environmental mitigation Permitting	Site preparation, follow-on Chute construction Stilling basin construction Control structure remaining excavation construction remaining foundation work Approach channel excavation Permitting Site restoration.	Construction features distributed without contingency costs Contingencies to be added back in to each agency's cost estimate
Planning, Engineering, Design	-	-	Not part of initial construction work package, to be added back in to each agency's cost estimate
Supervision & Administration	-	-	
Sunk Costs	-	-	
Cost of sum of features [3]	$98.8 million	$382.2 million	$481.0 million
Percent	20.54	79.46	100.0
Target costs from Cost Distribution	$ 98.2 million	$385.0 million	$483.2 million
Percent of Target Costs	20.32 percent	79.68 percent	100 percent

Notes:
1. *All costs are for cost distribution and development of work packages only. Each agency has developed a full cost estimate of its work package.*

2.7 CORPS FLOOD DAMAGE REDUCTION WORK PACKAGE COST

Once the work package items were defined as described above, Reclamation and the Corps each developed cost estimates of their respective work packages. Each agency used its own cost engineering, estimating, and cost escalation procedures. Each agency added its costs for construction contingencies, planning, engineering and design, supervision and administration, sunk costs, escalation costs, and other agency specific costs. Each cost is developed to a feasibility level of detail. The Corps work package cost was developed using MCACES. The cost estimate for the Corps work package is in the PAC main report in different chapters. Reclamation is engaged in detailed cost engineering of its work package.

Each agency will treat its work package as its project to construct. Although each work package contains joint features and costs needed for both dam safety and flood damage reduction, the Corps work package cost will be treated as the flood damage reduction cost and the Reclamation work package will be treated as the dam safety cost. For budgetary and reporting purposes, flood damage reduction economic benefits will be compared to the Corps work package cost The Corps will cost share its work package with the non-Federal flood damage reduction sponsor, the State of California. Since the final work packages will not have consistent agency program costs, their costs will not sum to a total cost estimate for the JFP as if it were prepared by a single agency. Rather, the two work packages are individually reported projects.

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CHAPTER 3.0
ALTERNATIVE PROCEDURES

3.1 SEPARABLE COST – REMAINING BENEFIT

The separable cost – remaining benefit (SC-RB) is an alternative method to distribute costs. SC-RB is the established method of allocating costs between purposes in a multipurpose water resources project. For both Reclamation and the Corps, it is the preferred method of assigning costs for multipurpose projects.

Although dam safety is not a purpose, the SC-RB still may be applied for the JFP. Both Reclamation and the Corps have precedents for using SC-RB to distribute project costs between a legitimate water resources purpose and dam safety.

SC-RB is not used to distribute the 6 STG Element costs because it does not fully apply to dividing the project costs between the two agencies. The dam safety element is not a project purpose and has no quantifiable economic benefit associated with it. Since the SC-RB uses benefits in its calculations, it is a less representative method than is the proportional method. The two agencies desired a procedure that would result in a cost savings to both agencies, which could then be enjoyed by their respective non-Federal sponsors. The SC-RB method, however, was not meant to necessarily produce that result, and in this case does not appear to achieve this result.

The SC-RB method does not resolve cost estimating differences or other inequalities in costs. Therefore, costs used as input would likely have to be modified similar to the process shown in **Table 2-1**. There are many alternative modifications of costs that could be input into an SC-RB calculation. A sensitivity analysis was done using different versions of costs with varying modifications to make the dam safety and flood damage reduction single purpose costs more equitable or comparable. The single purpose plans remained a fuseplug for dam safety and the full 6 STG Element for flood damage reduction. The SC-RB produced results between about 10 percent dam safety – 90 percent flood damage reduction and 13 percent dam safety – 87 percent flood damage reduction. If the 10 – 90 percentages were applied to a 6 STG Element spillway costing $821 million, the following savings would occur:

FDR savings: 6 STG cost – FDR share = $821 million – $739 million = $82 million

DS savings: fuseplug spillway cost – DS share = $200 million - $82 million = $118 million

Although both agencies would achieve savings, the savings do not reflect the relative contributions to the project. The expectation is that flood damage reduction being the larger contributor to the 6 STG Element should enjoy a greater savings in cost.

3.2 FUSEPLUG FIRST ADDED

An alternative method is to treat costs of features needed for flood damage reduction as an increment to dam safety. Reclamation is committed to correcting the PMF deficiency, even if

the Corps is unable to participate in a 6 STG Element. Dam safety cost would equal the cost of constructing a dam safety only (fuscplug) spillway. Flood damage reduction cost would equal the total project cost minus the dam safety cost. Using this method, all cost savings would go to flood damage reduction; thus, it is considered not equitable. This method is not used or shown in this report.

PEC 02-01

Reclamation Manual

Directives and Standards
(9) 6/9/95 Pages 1 – 4
NEW RELEASE

Subject: Cost Allocations

Purpose: Establish the requirement that cost allocations are to be performed on Reclamation projects and the legal authority for accomplishing this activity.

Authority:

- PEC P01, Program Economics, Revenues, and Contracts - Final Cost Allocation
- Economic and Environmental Principles and Guidelines for Water and Related
- Land Resources Implementation Studies (P&G).
- Reclamation Project Act of 1939 (Section 9).
- Federal Water Project Recreation Act of 1965, Public Law 89-72, as amended by the Water Resources Development Act of 1974, Public Law 93-251.
- Water Supply Act of 1958, Public Law 85-500.
- Reclamation Reform Act of 1982, Public Law 97-293.
- Fish and Wildlife Coordination Act of 1958, Public Law 85-624.

Contact: Environmental and Planning Coordination, D-5100, Economics Branch, D-8270

1. Need for Cost Allocation.

A. Requirements. Reclamation law and associated policy require an allocation of costs to components or purposes of projects in order to: (1) test financial feasibility of reimbursable components or purposes by a comparison of estimated project costs with anticipated revenues, and (2) after construction, establish and measure compliance with project financial requirements. The primary purpose of the final allocation is to determine the assignment of costs to beneficiaries for repayment. As cost-sharing requirements differ by law among the purposes or components served by a project, a systematic and impartial process of allocation is required to determine and assign those costs that are clearly identifiable with the particular purposes which they serve, and to equitably apportion the remaining costs which jointly serve two or more purposes.

B. Initial Cost Allocation. There are two essential points at which cost allocations are made. An initial allocation is made during plan formulation to provide a preliminary estimate of the financial feasibility of individual project elements and the project as a whole. Thus, in the project planning stage, project costs are allocated to reimbursable and nonreimbursable purposes to test financial feasibility of each purpose by a comparison of estimated costs with anticipated revenues. The reimbursable cost estimates are then used as the basis for negotiation of repayment

contracts, which are subject to the final cost allocation. Coincidentally, the allocation yields an estimate of nonreimbursable costs for the project as a whole, so as to allow judgement as to whether the Federal investment falls within the limits of policy guidelines.

C. Final Cost Allocation. When construction of the project is determined to be substantially complete, a final cost allocation is required. At this point, most postauthorization planning, design, construction, and interest during construction (IDC) costs are known, and operation, maintenance, and replacement (OM&R) costs are more clearly defined. This final allocation, therefore, determines actual reimbursable and nonreimbursable costs and is the basis for assignment of costs to beneficiaries for repayment.

D. Treatment of Purposes. Neither the ability of a particular purpose to repay its cost nor knowledge of a desirable rate will influence the amount of costs allocated to that purpose; therefore, allocated costs and estimated repayment will be determined independently. All project purposes will be accorded comparable treatment in the cost allocation process, as each is entitled to its fair share of the advantages resulting from the plan of development.

2. Responsibility for Cost Allocation.

A. Implementing Agency. Cost allocations will be made by the agency responsible for implementation of a project. Coordination with other agencies having responsibilities for particular purposes will be conducted at all appropriate administrative levels. For Reclamation projects, cost allocations will be performed by Reclamation staff knowledgeable in cost allocation procedures under the direction of the responsible area or regional office. Cost allocations which establish contract terms and conditions and/or result in initiation of repayment will be transmitted by the Regional Directors to the Commissioner's Office for approval. Preliminary cost allocations prepared for planning or other purposes will be approved by the Regional Directors. Annual updates of cost allocation and repayment data included in budget justification documents will be approved by the head of the division in the regional office that has the responsibility for preparing the documents.

B. Documentation. It is important that all elements of the allocation process be carefully documented. This is particularly important in the derivation of benefits, single-purpose alternative (SPA) costs, separable costs, and reimbursable costs.

3. Costs to be Allocated.

A. Costs to be Allocated. National Economic Development (NED) Account costs defined below as total project costs will constitute the costs to be allocated for projects in all stages of planning, construction, and operation. In the allocation process, these costs are adjusted for time of occurrence by the application of appropriate compound interest and annuity factors to derive equivalent present worth monetary values at the beginning of the first year of project service. After allocation, the economic equivalents will be reconstituted and reconciled to the original unadjusted values to satisfy reporting and accounting requirements.

B. Allocations During Construction. After construction begins, costs to be allocated will reflect annual financial statements showing the effects of retirement, replacement, reconstruction, abandonment, maintenance, and other transactions recorded during the period of

construction and operation. Costs used in the allocation are the latest official estimates of Reclamation and cooperating agencies. In feasibility studies, cost estimates for separable costs and SPA's will be at least of appraisal grade.

C. Nondepreciated Costs. Complete, nondeprcciated costs are to be uscd in all phases of the allocation. This will rcquire vigilance during a final allocation due to the fact that some project costs are currcntly accounted for on a depreciated basis by Reclamation financc offices.

D. Documentation. A table showing costs to be allocated will precede the cost allocation in planning rcports. Costs specifically identified with a particular purpose, as well as scparable and joint costs, will be shown with spccific and separable costs listed by component or purpose. Cost constitucnts, i.c., construction, IDC, OM&R, etc., will be separatcly identified.

(1) Deferred Uses and Nonreimbursable Costs. Costs incurred for excess capacity to facilitate subsequent additions, or costs of other provisions for dcfcrred project uses, will be included in the total costs to be allocated and then segregated by allocating directly to the deferred-use category. An example would be costs expended for water storage capacity for anticipated future M&I water demands as authorized undcr the Watcr Supply Act of 1958, as amended. The deferred costs would cncompass all costs applicable to the deferred use or component including both separable costs and joint costs, as appropriate. In similar manner, the nonreimbursable costs for highway improvement and for postauthorization archeological salvage invcstigation will be directly assignccl to thcsc purposes and set aside. This will permit completion of the main cost allocation by standard procedure.

(2) Total Project Costs to be Allocated. All NED costs of project implcmentation are to bc allocated. Costs of project implementation include costs incurred by the responsible Federal entity and, where appropriate, contributcd by other Fedcral or non-Fcderal entities to construct, opcrate, and maintain a project in accordance with sound engineering, economic, and environmental principles. Thesc costs, as dcfined in chapter II, section XII of the P&G, include post authorization planning and design costs; construction costs; construction contingcncy costs; administrative service costs; fish and wildlifc habitat mitigation costs; relocation costs; historical and archeological salvage costs; land, water, and mineral rights costs; environmental enhancement; and OM&R costs.

(3) Non-Federal Costs. Disposition of project costs financed by a non-Federal entity will vary dcpending on the particular cost catcgory. In thc instance of a non- Federal contribution for an add-on purpose which involvcs only stand-alone incremental costs, i.e., for a purpose which does not dcpcnd directly on joint project facilities for its value, thc costs are directly set asidc to that purpose. If benefits (or SPA costs, if applicable) related to thc purpose are included within the allocation, those benefits must also be subtracted out or set aside so as to not influcnce the remaining allocation process.

If a non-Federal contribution is made for a purpose which is an integral part of the project, the contribution is included with other (Federal) costs for thc purpose and carricd through thc allocation process so that the purpose accrues a proportionate share of joint costs. The non-Fcderal contribution would then be included as a segment of non-reimbursable costs at the conclusion of the allocation process.

4. Benefits Used in Cost Allocation. Categories of monetary benefits (or other measures of beneficial use) and computation procedures used for NED objective purposes found in the cost allocation will be the same as those used for project justification (P&G, chapter II). All benefits, SPA costs, and costs for allocation purposes will be placed on a comparable basis in relation to time of occurrence using the same interest rate and period of analysis. Benefits will be capitalized to their present worth (lump-sum) amounts at the first year of project service.

5. Interest Rates. The interest (discount) rate to be used in cost allocation and for the computation of imputed IDC will be the same rate used in the economic analysis of the project (P&G 2.1.2). At the conclusion of the allocation process, IDC allocated to interest-bearing reimbursable purposes will be converted to the amount that would result from computation at the applicable interest rate for repayment of individual purposes. Interest rates for cost sharing or repayment are discussed in additional Program Economics, Revenues, and Contracts Directives and Standards. For authorized projects, the interest rate used for cost allocations will reflect the rate applicable at the time of authorization.

6. Period of Analysis. The period for estimating benefits and costs used in the cost allocation process will be the same as that used in project formulation and evaluation which is the lesser of the economic life of the project, or 100 years beyond the initial date of service (P&G 1.4.12).

PEC P01
Reclamation Manual
Policy (8) 5/2/95
(Minor revisions approved 03/07/2006) Page 1
NEW RELEASE

Subject: Final Cost Allocation

Purpose: Establish the requirement that final cost allocations are to be performed upon completion of construction of a project.

Authority: Reclamation Project Act of 1939, Section 9, as amended.

Contact: Contract Services Office, D-5600

1. Objectives of Final Cost Allocations. A final cost allocation is to be performed when construction of a project is determined to be substantially complete. This allocation will determine reimbursable and non-reimbursable costs and apportion these costs among the various project purposes. The objective is to ensure that costs are allocated to project purposes in accordance with Reclamation law and that reimbursable costs are assigned to the appropriate beneficiaries for repayment. Interim cost allocations performed during the planning and construction of the project may not be used to determine the final repayment obligation.

2. Responsibility for Conducting Final Cost Allocations. Regional Directors should conduct a review of their projects and determine which of them need final cost allocations. They should also establish schedules for completion of these final cost allocations and ensure that sufficient funding is programmed. In addition, priority will be given to maintaining the files for cost allocations and supporting documentation to ensure they are current and accessible. The files should include the supporting documentation to demonstrate how the allocation was derived. The final cost allocation and the supporting documentation should provide the basis for repayment obligations included in contracts and serve as a basis for project reallocations to be performed if water demands and uses change in the future. As future projects are completed, the Regional Directors are to ensure that final cost allocations are performed upon completion of construction.

3. Review of Final Cost Allocations. Regional Directors will review all final cost allocations. Subsequent to this review, the Regional Director will submit the final cost allocation to the Office of Program and Policy Services with a recommendation for review and approval by the Commissioner. Reviews will address technical adequacy and adherence to Reclamation policy.

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Post Authorization Change Report

American River Watershed Project

Folsom Dam Modification and
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Appendix G
Pertinent Correspondence



US Army Corps of Engineers

Sacramento District
South Pacific Region

March 2007

PERTINENT CORRESPONDENCE

This appendix includes correspondence important to the Post Authorization Change Report for the American River Watershed Project. These correspondence include the following:

Date	To	From	Page
12/16/2004	Sacramento Area Flood Control Agency	Bureau of Reclamation	G -3
9/29/2006	Corps of Engineers	Federal Energy Regulatory Commission	G-5
10/05/2006	The Reclamation Board	Sacramento Area Flood Control Agency	G – 7
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3/28/2007	Corps of Engineers	Bureau of Reclamation	G – 13

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United States Department of the Interior

BUREAU OF RECLAMATION
Mid-Pacific Regional Office
2800 Cottage Way
Sacramento, California 95825-1898

IN REPLY
REFER TO:
MP-440
WTR-4.00

DEC 16 2004

Mr. Stein Buer
Executive Director
Sacramento Area Flood Control Agency
1007 Seventh Street, 7th Floor
Sacramento, California 95814

Subject: Contract No. 03-XC-20-0377 Between the United States and Sacramento Area Flood Control Agency Concerning the Operation of Folsom Dam and Reservoir – Central Valley Project, California

Dear Mr. Buer:

Enclosed is an executed original of the subject contract for your records. This contract is effective December 6, 2004, and will terminate on December 31, 2018, or on such earlier date as mutually agreed to between the Bureau of Reclamation and the Agency. Reclamation appreciates the effort expended by the Agency and its representatives relative to this contract.

If you have any further questions, please contact Mr. Rick Johnson, Deputy Area Manager, of our Central California Area Office, Folsom, California, at 916-989-7200 or TDD 916-989-7285.

Sincerely,

FOR

Kirk C. Rodgers
Regional Director

Enclosure

FEDERAL ENERGY REGULATORY COMMISSION
Office of Energy Projects
Division of Dam Safety and Inspections
888 First Street, NE Routing Code: PJ-13
Washington, DC 20426
(202) 502-6734 Office – (202) 219-2731 Facsimile

September 29, 2006

Mr. Donald L. Basham, Chief
Engineering and Construction
Directorate of Civil Works
Headquarters, U.S. Army Corps of Engineers
Attn: CECW-CE
441 G Street, N.W.
Washington, DC 20314-1000

Subject: Coordination of American River Dam Safety Studies

Dear Mr. Basham:

The L.L. Anderson Dam (French Meadows Reservoir), Project 2079-CA is under the regulatory authority of the Federal Energy Regulatory Commission (FERC) and has been identified by the FERC as having inadequate spillway capacity to pass the Probable Maximum Flood (PMF). This determination has been made by the FERC consistent with its regulatory authority, its dam safety regulations, and its dam safety engineering guidelines. L.L. Anderson Dam is upstream of Folsom Dam which we understand is undergoing a coordinated study effort by the U.S. Army Corps of Engineers (USACE) and the Bureau of Reclamation (Reclamation) to correct a dam safety deficiency and examine additional flood control for the American River basin. In addition to L.L. Anderson Dam, there are other dams in the drainage basin above Folsom Dam under FERC dam safety jurisdiction. We are currently completing spillway adequacy studies on these dams and it appears that each can safely pass the required Inflow Design Flood (IDF).

Since there are different regulatory authorities involved with different dams on the American River and its tributaries, those regulatory authorities need to collaborate and coordinate on the work being done concerning dam safety. This collaboration and coordination is in fact the subject of an issue paper being proposed to the Interagency Coordination on Dam Safety for the Federal Agencies to develop coordination guidelines.

In August of 2005 we accepted the PMF study completed by the FERC licensee, Placer County Water Agency (PCWA), for the L.L. Anderson Dam (French Meadows Reservoir). The accepted PMF inflow to the French Meadows Reservoir is 59,100 cfs. Based on our spillway adequacy study it has been determined that, considering the downstream consequences of a potential failure of L.L. Anderson dam, the required IDF is the PMF. We will require that PCWA increase the spillway capacity of L.L. Anderson Dam to safely pass the PMF. Accordingly, PCWA has been directed to summit a plan and schedule to complete the design and construction of dam safety remedial measures to safely pass this IDF.

We understand that the PMF of 59,100 cfs that we approved is slightly less than that calculated by the Corps of Engineers. We believe that given the assumptions used for the many parameters involved with developing a PMF, the difference is within the accuracy of calculations. The design of the spillway remediation at L.L. Anderson Dam will include the routing of the PMF through the French Meadows Reservoir and this will have to be reviewed by FERC before proceeding with the final design for the dam safety remediation. The opportunity remains to discuss any outstanding technical issues.

FERC will continue to keep both the USACE and Reclamation informed as we proceed with the design of the LL Anderson remediation and as we review the ongoing dam safety studies on other dams in the American River basin.

If you have any questions concerning the oversight of the dam safety remedial work for L.L. Anderson Dam or any of the FERC dams on the American River basin, please contact me at (202) 502-6734.

Sincerely,

Constantine G. Tjoumas, P.E.
Director,
Division of Dam Safety and Inspections

SAFCA

Sacramento
Area Flood
Control
Agency

October 5, 2006

Jay Punia, General Manager
Reclamation Board
3310 El Camino Blvd.
Sacramento, CA 95821

SUBJECT: FOLSOM DAM SAFETY AND FLOOD DAMAGE REDUCTION

Mr. Punia:

The Sacramento Area Flood Control Agency (SAFCA) intends to be the local sponsor in partnership with the Reclamation Board as the non-federal sponsor with the United States Army Corps of Engineers on the Folsom Dam Safety and Flood Damage Reduction Project. SAFCA strongly supports this project and is committed to providing our community a minimum of 200-year level of protection. This project will deliver a greater than 200-year level of protection and in a timeline that will bring additional flood protection to our community within a decade.

SAFCA also agrees to work with the Reclamation Board to develop a mutually satisfactory Local Project Cooperation Agreement (LPCA) that will define the exact details of the local cost sharing, project coordination, liability, and operation and maintenance responsibilities.

Please feel free to contact Pete Ghelfi at 874-8733 if you have any questions.

Sincerely,

Stein Buer,
Executive Director

Cc: Robert Charney, DWR
Pete Ghelfi, SAFCA

Office 916-874-7606
FAX 916-874-8239

1007 - 7th Street, 7th Floor
Sacramento, CA 95814-3407

United States Department of the Interior

BUREAU OF RECLAMATION
PO Box 25007
Denver, Colorado 80225-0007

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:

84-44000
PRJ-13.00

NOV 28 2006

Deputy Chief of Civil Works
Headquarters, US Army Corps of Engineers
Attn: CECW-CE
441 G Street N.W.
Washington, DC 20314-1000

Coordination of Folsom Dam Activities, Central Valley Project, California

Dear Mr. Stockton,

The partnership agreement between Reclamation and the US Army Corps of Engineers (USACE) provides for many opportunities for our organizations to collaborate on issues of mutual interest. One such opportunity is the coordination of dam safety and flood damage reduction improvements for Folsom Dam, California where Reclamation is the owner/operator and the Corps has operational flood damage reduction responsibilities under Section VII, Flood Control Act of 1944.

We are aware of Post Authorization Change studies being conducted by the Sacramento District to evaluate the addition of flood damage reduction measures in conjunction with dam safety improvements being evaluated by Reclamation. While some of the design and construction issues will involve decisions that will be local to specific features and contracts, evaluation of the flood hydrology (PMF and other events exceeding the authorized top of flood pool), freeboard and risk assessments will involve Reclamation policy and criteria with respect to the overall safety of the dam. In accordance with the provisions of Section VII, Reclamation recognizes its responsibility and authority to establish such criteria and requirements as may be appropriate for the proposed modifications to Folsom Dam.

To ensure that Reclamation's and Corps' priorities facilitate progress on work and decisions at Folsom Dam, I would like to propose a framework that would enable both agencies to proceed with studies and decisions at Folsom Dam and other American River Watershed projects:

- Reclamation has the authority to make Safety of Dams modifications to dams where the Secretary of the Interior determines such modifications to be reasonably required.

- Reclamation recognizes as a dam owner that it has a responsibility to safely accommodate floods that can be reasonably expected to occur at the dam.

- Any modifications to the dam for flood damage reduction would potentially involve the addition of spillway capacity, modifications or replacement of existing gates and raising the dam to safely pass flood events. Design criteria for such modifications would be the responsibility of Reclamation.

- Routing storm events through Folsom Lake and the existing Folsom Dam when the water surface exceeds the top of authorized flood pool would be within Reclamation's jurisdiction.

- Reclamation has responsibility to establish criteria for features that may be reasonably expected to impact long-term maintenance or operations of the project.

- Reclamation has responsibility to establish criteria for features that may be reasonably expected to impact the security of the dam and/or operating features.

- Reclamation and USACE will keep each other informed of study plans, results, schedules and decisions for Folsom Dam as they are formulated.

- Reclamation and USACE agree to cooperate to the maximum extent possible as the agencies pursue individual and joint design and construction activities.

Reclamation staff looks forward to working with USACE staff as both agencies work to select, design and construct appropriate structures at Folsom Dam. If you have any questions concerning Reclamation's Dam Safety Studies for Folsom Dam, please feel free to contact Mr. Nathan Snorteland 303- 445-2395 or Mr. Larry Hobbs 916- 978-5335.

Sincerely,

David L. Achterberg

David G. Achterberg
Director, Security, Safety and Law Enforcement

STATE OF CALIFORNIA – THE RESOURCES AGENCY ARNOLD SCHWARZENEGGER, GOVERNOR

THE RECLAMATION BOARD
3310 El Camino Ave., Rm. LL40
SACRAMENTO, CA 95821
(916) 574-0609 FAX: (916) 574-0682
PERMITS: (916) 574-0653 FAX: (916) 574-0682

December 15, 2006

Colonel Ronald N. Light
District Engineer
Sacramento District
U.S. Army Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Dear Colonel Light:

This letter is to express The Reclamation Board's (Board) intent to sponsor the proposed Joint Federal action for Folsom Dam as presented in the December 2006 Post Authorization Change Report, American River Watershed Project, Folsom Dam Modifications and Folsom Dam Raise Projects. The Board supports this proposed Joint Federal Action, which intends to (1) reduce the flood risk along the American River, generally equivalent to the extent authorized under the Folsom Dam Modification and Folsom Dam Raise Projects, and (2) safely pass the Probable Maximum Flood at Folsom Dam.

The Board approved this letter of intent at its December 15, 2006 meeting. In a letter dated October 5, 2006 (attached), the Sacramento Area Flood Control Agency (SAFCA) has indicated its strong support and intent to be the local cost-sharing partner of the Board.

Please note that this letter of intent is not an obligation of future appropriations of State funds by the State Legislature. We look forward to working with the U.S. Army Corps, the U.S. Bureau of Reclamation, and SAFCA on this critically important Federal action.

If you have any questions, you may contact Jay Punia, General Manager of the Reclamation Board at (916) 574-0609, or your staff may contact Robert Charney, Project Engineer for the Department of Water Resources' Division of Flood Management, at (916) 574-2010.

Sincerely,

Benjamin F. Carter, President
The Reclamation Board

Attachment

cc: Stein Buer, Executive Director
Sacramento Area Flood Control Association
1007 Seventh Street, 7th Floor
Sacramento, California 95814

United States Department of the Interior

BUREAU OF RECLAMATION
Central California Area Office
7794 Folsom Dam Road
Folsom, California 95630-1799

IN REPLY REFER TO
CC-100
PRJ-3.00

MAR 28 2007

RECEIVED
MAR 29 2007

Colonel Ronald N. Light
Commander
U.S. Army Corps of Engineers
1325 J Street
Sacramento, CA 95814

Subject: Folsom Dam Joint Federal Project Short-Term Evaluation Decision Document

Dear Colonel Light:

Enclosed for your use in the U.S. Army Corps of Engineers Post Authorization Change (PAC) Report is Reclamation's approved Folsom Dam Joint Federal Project Short-Term Evaluation Decision Document. The document represents Reclamation's technical evaluation of the Joint Federal Project and Selected Project in the PAC Report. Reclamation will complete a final technical evaluation concurrently with final design of the JFP and SP.

Sincerely,

Michael R. Finnegan
Area Manager

Enclosure

cc: Mr. Stuart Townsley
U.S. Army Corps of Engineers
1325 J Street
Sacramento, CA 95814

Mr. Charles Riardan
U.S. Army Corps of Engineers
1325 J Street
Sacramento, CA 95814
(w/encl to each)

Folsom Dam
Joint Federal Project / Selected Project Short-Term Evaluation

Dam Safety Program Decisions

I. Background

General Assumptions

All elevations are based on the original design datum (NGVD29).

- Flood control operation is prescribed by the U.S. Army Corps of Engineers (Corps). Although the current authorized Top of Flood Control Reservation is at reservoir elevation 466, a joint agreement between the U.S. Army Corps of Engineers (Corps) and Reclamation has extended flood control operations into the surcharge storage space up to pool elevation 470.

- Above pool elevation 466, the releases within the surcharge storage space are controlled by the Bureau of Reclamation (Reclamation). ***The Bureau of Reclamation will take control of flood routing operations and begin to ramp from a discharge of 160,000 ft^3/s to 360,000 ft^3/s in 50,000 ft^3/s per 30 minute increments (Joint Federal Project – JFP routings).***

- The PMF event for Folsom Dam and Lake was developed in 2001 using Hydrometeorological Report (HMR) 59. The hydrograph was developed based on a North Fork storm centering with no upstream failures. LL Anderson Dam is presumed modified in accordance with the FERC license so as to pass its PMF.

- The PMF event is preceded 8-days in advance by an antecedent flood (72-hours of rainfall) immediately followed by the main flood with a peak inflow of 905,770 ft^3/s and a 5-day volume of 3,206,000 acre-feet. The antecedent flood (50 percent PMF hydrograph) was derived using an HEC-1 model. This process required that each sub-area hydrograph ordinate be reduced by half and routed through the upstream reservoirs and reaches down to Folsom.

- Section 101(a)(6) of the Water Resources Development Act (WRDA) 1999 (Public Law 106-53) specifies that the Secretary of the Army and Secretary of the Interior shall coordinate. Upon completion and improvements to Folsom Dam, the variable space allocated to flood control within the reservoir shall be reduced from the currer interim operating range of 400,000-670,000 acre-feet to 400,000-600,000 acre-feet.

Description of Alternatives

- Joint Federal Project

- o No dam raise
- o Existing spillway service/emergency gates not replaced.
- o Controlled spillway flows are maintained throughout operation (no free flow operation).

Discharges do not increase beyond 160,000 ft^3/s until the pool elevation exceeds the jointly agreed permissible surcharge storage elevation target ***(466.0 ft).***

- Alternative Joint Federal Project (currently called the Selected Plan or SP)
  - o 3.5 ft dam raise
  - o Existing emergency spillway gates are replaced.
  - o Existing service spillway gates are not replaced.
  - o Controlled spillway flows are maintained throughout (no free flow operation).
  - o Discharges do not increase beyond 160,000 ft^3/s until the pool elevation exceeds the storage elevation target ***(471.5.0 ft) at which enhanced flood protection can be provided.***
  - o The service spillway gates could be overtopped for floods approaching the PMF (SP routings). The following is as noted in Reclamation's 2004 Folsom Dam Hydrologic Corrective Action Study report: Although the gates could fail under this condition, any failed gates would likely wash downstream. This is not viewed as a dam safety issue since they would not impede flows through the spillway. Any additional flow generated by failed gates would be relatively small compared to the total flow being discharged.

Recent hydraulic (physical) model studies have shown the gates begin to overtop at a reservoir water surface of about 481.0 feet. Given a 3.5 foot dam raise the maximum reservoir water surface should not be greater than 481.0 feet. If the gates are overtopped it will be by minimal depths.

Summary of Physical Constraints

- All existing-sized (5' x 9') river outlets retain their 60% gate opening restriction during concurrent service spillway gate operation up to 115,000 ft^3/s release.
- Any power units that are assumed operating would become non-functional once the tailwater discharge exceeds 250,000 ft^3/s.
- Emergency tainter gate operations can begin once the tailwater discharge reaches 240,000 ft^3/s or water surface is within 1 ft of overtopping closed emergency gates (RWS El. 470.0).
- For both emergency and service spillway gates, the gate lip cannot be raised beyond 454.5 feet. Therefore, it is physically impossible to open the existing tainter gates enough to go to a free-flow discharge.

Gates test were performed on November 15, 2006 to determine the current and maximum spillway gate openings. The gate was reportedly opened to 40 feet (elevation 457) where it contacted the first limit switch. Operators at the dam believe the gates can be easily modified to be opened to the full opening height of 459.0 feet. Reclamation agrees that orifice flow should be maintained.

- The safe long-term channel capacity of the downstream levees was assumed to be 160,000 ft^3/s.

Proposed Design Operation Criteria

- The minimum freeboard requirement is set at 3 feet per Bureau of Reclamation.
- No power is available for use in the routings. All power units are off-line.
- Releases from Folsom Dam must **not** be greater than the flows produced without the project in place.
- The dam was assumed to be releasing a minimum 2,000 ft^3/s at the start of the routing.
- Two methods are available for routing the PMF:
    - 1) use an antecedent flood starting the routing at the bottom of the flood control pool. (The initial reservoir water surface was assumed to be at elevation 399.63). This established the initial starting conditions for the PMF (around pool elevation El 401) or
    - 2) route the PMF alone starting at normal full pool (466 ft). The second option is appropriate for projects with limited release capabilities.
- All routings reflect the first method which provides 600,000 acre-feet of Flood Control Reservation (also referred to as Flood Control Space) between the initial water surface and the top of joint use at elevation 466
- The PMF event was routed assuming a 4-hour delay in determining outflows until the releases reached 115,000 ft^3/s. This simulates initial delays in computing inflow, scheduling/performing gate changes, solving mechanical problems, or delays in staffing the facility. Once releases reached 115,000 ft^3/s outflows were adjusted based on 1-hour intervals until reaching the top of the surcharge storage space.

  Reclamation used a 30-minute delay interval above RWS elevation 466.0 (JFP) and 471.5 (SP) when discharges begin to ramp above 160,000 ft^3/s. This 30-minute delay interval was used as long as the reservoir was rising.

- Discharge must **not** exceed 160,000 ft^3/s while the reservoir water surface elevation is less than the storage space elevation, ***which provides the desired level of flood protection***.

- The downstream levees were assumed to remain intact throughout the antecedent event.

Proposed Design Operation Criteria (continued)

- Ramp up Rate Limitations.

Discharge is less than or equal to 20,000 ft^3/s	no more than 10,000 ft^3/s during any 2-hour period
Discharge is less than or equal to 160,000 ft^3/s	no more than 30,000 ft^3/s during any 2-hour period
Discharge is greater than or equal to 160,000 ft^3/s	***Releases are to be ramped from 160,000 ft^3/s to 360,000 ft^3/s at 50,000 ft^3/s per 30 minute increment. Discharge above 360,000 ft^3/s should be the lesser of inflow or full discharge capacity.***

Ramp down Rate Limitation:

Outflow is less than or equal to 115,000 ft^3/s	no more than 10,000 ft^3/s during any 2-hour period.
Outflow is greater than 115,000 ft^3/s	Lesser of maximum peak release or 125 percent of inflow while pool elevation greater than 448 feet.

- Above the jointly agreed permissible surcharge storage elevation (466 feet for the JFP routing) at which the desired level of flood protection is reached, ***Discharge should be increased by no more than 50,000 ft^3/s during any 30 minute period for discharges below 360,000 ft^3/s.***

- ***For discharges greater than 360,000 ft^3/s*** releases are limited to inflow or full discharge capacity.

- Releases cannot exceed discharge capacity.

- A ramp-down rate of 10,000 ft^3/s in one hour and no ramp down the next hour is considered acceptable

- The Accelerated Transition rule maximizes use of the downstream objective flow capacity. Releases were increased from 115,000 ft^3/s to 160,000 ft^3/s as soon as the requirements of the accelerated transition zone were met. The requirements of the accelerated transition zone are as follows. Releases may be increased from 115,000 ft^3/s to 130,000 ft^3/s when the current inflow is greater than 200,000 ft^3/s and the 12-hour forecasted inflow is greater than 360,000 ft^3/s. Releases may be increased from 130,000 ft^3/s to 145,000 ft^3/s when the current inflow is greater than 250,000 ft^3/s and the 12-hour forecasted inflow is greater than 370,000 ft^3/s. Releases may be increased from 145,000 ft^3/s to 160,000 ft^3/s when the current inflow is greater than 270,000 ft^3/s and the 12-hour forecasted inflow is greater than 370,000 ft^3/s. The requirement to limit the ramp-up rate to 15,000 ft^3/s per hour or no more than 30,000 ft^3/s during any 2-hour period still applies.

- Fish and Wildlife Service Mitigation Rule. For inflows greater than or equal to 25,000 ft^3/s, less than or equal to 150,000 ft^3/s, limit the release to 60 percent of the inflow or 60 percent of the 12-hour forecasted inflow, whichever is greater. Discontinue this rule once the 12-hour forecast exceeds 150,000 ft^3/s or the reservoir rises above elevation 416.15 (20 percent encroachment).

- For a falling reservoir below elevation 448, releases were computed using an USACE drawdown algorithm which attempts to evacuate the Flood Control Reservation plus inflow in 1 day for each iteration while at the same time reduce the releases from 115,000 ft^3/s in 5,000 ft^3/s increments. The drawdown algorithm succeeds in evacuating most of the Flood Control Reservation below elevation 448 in a little more than 3 days.

- For a falling reservoir with releases at or below 15,000 ft^3/s, the ramp-down rate was limited to 1,000 ft^3/s per hour as defined in the USACE drawdown algorithm.

- Releases are not to be reduced while the reservoir is rising.

II. Decisions

An evaluation of the Joint Federal Project (JFP) Auxiliary Spillway Preliminary Design was performed by the Bureau of Reclamation's (Reclamation) Technical Service Center (TSC). The United States Army Corps of Engineers (USACE) has the lead responsibility for the JFP Auxiliary Spillway. Reclamation will contribute to the overall completion of the JFP Auxiliary Spillway and the Dam Safety Office has requested that Reclamation's TSC review the preliminary design of the JFP Auxiliary Spillway for technical adequacy in a risk framework. The purposes of the evaluation will be to insure that no significant flaws exist in the design that would compromise the safety of the structure or would result in

changes that would significantly increase the cost of the Auxiliary Spillway and that the design meets Reclamation's Public Protection Guidelines.

The short-term evaluation focused on several critical elements of the JFP Auxiliary Spillway. Flood routings were performed to verify the results of the USACE routings and to test the robustness of the Auxiliary Spillway design. An additional routing was performed to evaluate the Selected Plan (SP), which consists of the JFP Auxiliary Spillway, along with a 3.5-foot dam raise and modifications to the existing emergency spillway gates. A structural analysis of the auxiliary spillway control structure was performed, using a three-dimensional finite element model of the structure and the San Salvador earthquake record. Potential rock wedges in the area of the auxiliary spillway control structure were evaluated, based on joint data. The studies culminated in a risk analysis, which was held on November 15 – 17, 2006, and included participants from Reclamation and the USACE.

This Decision Document serves the purpose of documenting the formal evaluation of the USACE's JFP Auxiliary Spillway preliminary design in terms of meeting Reclamation requirements. Reclamation's concurrence with the JFP Auxiliary Spillway preliminary design is given with the following qualifications to be addressed during feasibility and final designs:

1. At least 3 feet of freeboard must be maintained during the 2001 Probable Maximum Flood (PMF) routing.

2. A ramping rate of 50,000 ft^3/s per 30 minute interval should be provided when increasing discharges from 160,000 ft^3/s to 360,000 ft^3/s (the ramping would occur above elevation 466.0 {elevations shown in this document are from the original dam construction and reflect the datum at that time} for the JFP). This will minimize the rate of inundation once the downstream levees fail (presently associated with prolonged releases exceeding 160,000 ft^3/s). This ramping rate matches closely to the rates indicated in the existing Emergency Spillway Release Diagram (ESRD) and rates of increase in spillway discharge that are provided for the Dam Safety Only Fuseplug Auxiliary Spillway. The introduction of a ramping rate for flows between 160,000 ft^3/s and 360,000 ft^3/s and the need to maintain 3 feet of freeboard during routing of the 2001 PMF will require an increase in the total spillway discharge capacity (i.e. discharge capacity increase for the JFP Auxiliary Spillway, the existing spillway or both).

3. A routing performed for the SP, with the assumption that releases would be limited to 160,000 ft^3/s up to reservoir water surface elevation 471.5 (at which point the ramping rate would be implemented) resulted in a maximum reservoir water surface elevation of 481.0. This would result in 3 feet of freeboard on the raised dam crest at elevation 484.0. Holding

releases to 160,000 ft^3/s will surcharge the flood control pool from elevation 466.0 to elevation 471.5.

4. Any changes to the formally allocated flood control space are to be documented and requested in writing.

5. Structural analysis results must be reconfirmed during feasibility and final design of the JFP Auxiliary Spillway control structure.

6. The excavation cut slopes on the right side of the spillway control structure should be steepened from 1.25:1 (rock) and 3.5:1 (common) to ½:1 or steeper (rock) and 1.5:1 (common). Review of the existing drill hole logs indicates that competent rock should exist along most of the cut slope height on the right side of the control structure. Steepening the cut slopes will keep a large buffer between the reservoir and the Left Wing Dam for potential seepage and piping paths associated with the B-shears. It will eliminate the need for an embankment closure section currently in the designs and the associated piping risks. It will allow extending the drainage gallery and draining the rock adjacent to the Left Wing Dam. Finally, it will reduce the excavation and concrete quantities for the JFP Auxiliary Spillway control structure and will reduce the overall cost of the structure.

The following key conclusions are reached regarding Reclamation's short-term evaluation studies for the JFP Auxiliary Spillway.

1. Flood routing studies performed by the USACE and Reclamation indicate that the 2001 PMF can be passed with 3 feet of freeboard if the delay between inflows and the allowed outflow in response to the inflow is established as 30 minutes above reservoir water surface (RWS) elevation 466. This is based on the proposed ESRD developed by the USACE, and using the existing outlet works, the existing spillway and the JFP Auxiliary Spillway (regulated by six 23-foot by 33-foot submerged tainte gates) to pass flood flows. The routing under the above conditions would result in a large jump in outflows (a jump of about 400,000 ft^3/s) above th point where discharges are increased above 160,000 ft^3/s. This increase would occur within a half hour, would result in failure of the downstream levees (estimated to occur for flows between about 160,000 ft^3/s and 200,000 ft^3/s), and would be extremely dangerous to downstream populations that had not been evacuated.

2. A more gradual ramping rate for flows above 160,000 ft^3/s will reduce th rate of inundation once the downstream levees fail. A ramping rate of 50,000 ft^3/s per 30-minute interval when increasing discharges from 160,000 ft^3/s to 360,000 ft^3/s would closely match the rates indicated in

the existing ESRD and would closely match the rate of increase in spillway discharge (for discharges between 160,000 ft^3/s to 360,000 ft^3/s) for the Dam Safety Only Fuseplug Auxiliary Spillway. The introduction of a ramping rate for flows between 160,000 ft^3/s and 360,000 ft^3/s and the need to maintain 3 feet of freeboard during routing of the 2001 PMF will require an increase in the total spillway discharge capacity (i.e. discharge capacity increase for the JFP Auxiliary Spillway, the existing spillway or both). It is estimated that the JFP Auxiliary Spillway capacity would need to be increased by about 4 percent to result in at least 3 feet of freeboard during the 2001 PMF.

3. Robustness studies were performed to test the sensitivity of the JFP Auxiliary Spillway design under a variety of assumptions. The JFP Auxiliary Spillway performed reasonably well, but some of the cases routed resulted in the dam overtopping. A complete set of initial routings was performed with releases held to 160,000 ft^3/s up to elevation 468 at which point releases were increased without a ramping rate up to the inflow value or the spillway capacity (whichever was less). The final set of sensitivity routings consisted of a limited set of scenarios, in which releases were held to 160,000 ft^3/s up to elevation 466, at which point the ramping rate was applied. Some of the final sensitivity routings resulted in dam overtopping. It will be necessary to achieve an increase in spillway capacity in final designs of the JFP Auxiliary Spillway and this will improve the results of the sensitivity routings and possibly eliminate overtopping for some cases. Results of the final sensitivity routings are provided in Table 3 in the Technical Report of Findings Section C.2.

4. A structural analysis of the JFP Auxiliary Spillway control structure performed with the San Salvador earthquake record indicated that the structure will perform well during large earthquakes. Stresses in the structure were generally within allowable limits.

5. A risk analysis was performed for the JFP Auxiliary Spillway, with participants from both Reclamation and the USACE. A comprehensive list of potential failure modes was discussed and five potential failure modes were carried into a second phase, where event trees were developed and risks were estimated.

6. Two of the seismic potential failure modes that were evaluated by event trees (Sliding at the Base of the Concrete Piers and Sliding of the Dam along the Foundation Contact) were found to have risks that were negligible.

7. The two remaining seismic potential failure modes (Failure of the Tainter Gates due to Buckling of the Radial Arms and Failure of the Submerged

Tainter Gate Trunnion Support Beam) could not be estimated directly since analysis and design details were not available. Evaluation of the risks using a hypothetical design indicates that if the design for both features is based on the P5 ground motions and a full reservoir, risks are likely to be below Reclamation's Public Protection Guidelines.

8. The expected risk from the hydrologic potential failure mode (Failure of Wedge in Right Ridge) is estimated to be 4.0E-3. This estimate is based on preliminary data and analysis but it indicates that modifications should be considered to the design to reduce the risk of this potential failure mode. Key factors that lead to this conclusion are: Excavation for the JFP Auxiliary Spillway would place the reservoir against the abutment in close proximity to the Left Wing Dam. There is a high probability that a wedge could be formed by the B and D joint sets in the right ridge to the right of the Auxiliary Spillway control structure. This failure mode requires that the reservoir be above elevation 470 (in order to develop significant uplift pressures on the joints) and that the wedge at least partially underlie the Left Wing Dam. If the wedge were to slide, it is almost certain that the Left Wing Dam would be breached.

The following technical recommendations are made based on Reclamation's short-term evaluation studies for the JFP Auxiliary Spillway and should be considered when developing final designs.

1. Provisions should be made to address a potential failure mode associated with sliding of the right abutment ridge (leading to failure of the Left Wing Dam) under flood conditions. Foundation treatment in the right ridge adjacent to the control structure should be pursued (such as grouting the ridge and extending the drainage gallery up the right abutment of the control structure). This will reduce the chance of a potential failure of a wedge in the right ridge, leading to an erosion failure of the Left Wing Dam.

2. Provisions should be made to address the potential failure of the submerged tainter gates (STG) during seismic loading, with the P5 groun motions used as a minimum design earthquake along with a full reservoi

3. Provisions must be made to address the potential failure of the STG trunnion supports during seismic loading, with the P5 ground motions used as a minimum design earthquake along with a full reservoir.

4. Particular attention should be given to the joint and connection details between key interfaces in the JFP Auxiliary Spillway control structure during final design, including the base of the control structure piers and the connection between the trunnion support beams and the piers.

5. Provisions should be made during final designs to address the potential overtopping of the facility. During the robustness checks, some routings encroached on the 3 feet of required freeboard. The results of these routings were close enough to be acceptable at the feasibility design level recognizing that the JFP will be reviewed after final designs are complete.

The following technical recommendations are made based on Reclamation's short-term evaluation studies for the SP Auxiliary Spillway and should be considered when developing final designs.

1. Provisions should be made to address a potential failure mode associated with sliding of the right abutment ridge (leading to failure of the Left Wing Dam) under flood conditions. Foundation treatment in the right ridge adjacent to the control structure should be pursued (such as grouting the ridge and extending the drainage gallery up the right abutment of the control structure). This will reduce the chance of a potential failure of a wedge in the right ridge, leading to an erosion failure of the Left Wing Dam.

2. Provisions should be made to address the potential failure of the submerged tainter gates (STG) during seismic loading, with the P5 ground motions used as a minimum design earthquake along with a full reservoir.

3. Provisions must be made to address the potential failure of the STG trunnion supports during seismic loading, with the P5 ground motions used as a minimum design earthquake along with a full reservoir. Particular attention should be given to the joint and connection details between key interfaces in the JFP Auxiliary Spillway control structure during final design, including the base of the control structure piers and the connection between the trunnion support beams and the piers.

The Dam Safety Program Decisions and the key findings of the JFP/SP Short-Term Evaluation and Risk Analysis are summarized in the Decision Document. "Short –Term" is used to denote initial studies related to the JFP/SP Auxiliary Spillway preliminary design. These Decisions are in accordance with the Policy on Dam Safety Decision Making in the *Reclamation Manual*. The *Guidelines for Achieving Public Protection in Dam Safety Decision Making*, dated June 15, 2003, were used for this decision making process.

The following supporting documents have been prepared by Reclamation's Technical Service Center:

- Folsom Dam Joint Federal Project - Short-Term Evaluation – Flood Routings, Technical Memorandum No. FOL-8130-JFP-2006-1

- Folsom Dam Joint Federal Project - Short-Term Evaluation – 3-D LS-DYNA Analysis, Technical Memorandum No. FOL-8130-JFP-2006-2
- Folsom Dam Joint Federal Project - Short-Term Evaluation – Risk Analysis Report, Technical Memorandum No. FOL-8130-JFP-2006-3

This document concludes the work on the JFP/SP Short-Term Evaluation.

III. New SOD Recommendation(s)

There are no new SOD Recommendations resulting from this decision document.

IV. Prior Incomplete SOD Recommendation(s) Addressed by this Document

None.

V. New O&M (SOD-related) Recommendation(s)

None.

VI. Prior Incomplete O&M Recommendation(s) (SOD-related) Addressed by this Document

None

Folsom Dam
Joint Federal Project Short-Term Evaluation
Decision Maker's Concurrence

The decision makers accept the technical findings and recommendations and concur that this decision document has been prepared in accordance with the Policy on Dam Safety Decision Making (FAC P02) in the *Reclamation Manual*.

Concurred:

Michael Finnegan, Manager
Central California Area Office — 3/29/07 Date

Kirk C. Rodgers, Director
Mid-Pacific Region — 3/28/07 Date

Bruce Muller, Chief
Dam Safety Office — 3/26/07 Date

Folsom Dam
Joint Federal Project Short-Term Evaluation

Technical Report of Findings

I. Summary of Results

A. Description of Joint Federal Project Auxiliary Spillway

The Joint Federal Project (JFP) consists of a proposed Auxiliary Spillway constructed on the left abutment of the existing Left Wing Dam. The new Auxiliary Spillway would regulate releases through a concrete gravity control structure with 6 submerged tainter gates (STG) into a reinforced concrete lined spillway chute and stilling basin, discharging directly into the American River downstream of the existing Folsom Dam. The concrete control structure would consist of six bays separated by five piers. Each 23-foot-wide by 33-foot-high bay would have an invert at elevation 368.0 and house a STG. The top of each pier would support a bridge across the JFP Auxiliary Spillway with a bridge deck at elevation 480.5 and the top of an upstream parapet wall at elevation 484.0. At reservoir water surface (RWS) elevation 477.5, the JFP Auxiliary Spillway has a discharge capacity of 50,800 ft^3/s per bay, or 304,800 ft^3/s for all six bays. The Selected Plan (SP) consists of the JFP Auxiliary Spillway, a 3.5-foot dam raise and modifications to the existing emergency spillway gates.

B. Consequence Assessment

1. Population at Risk - A detailed consequences of dam failure study was prepared in 2001 [1] for the existing Folsom Dam and dikes . This study evaluated downstream consequences associated with different failure modes for different Folsom Facility features. The 2000 census data were used in this study. This risk assessment concentrated on failure of the new JFP concrete structure, the JFP Auxiliary Spillway piers and gates, and the Left Wing Dam for a case where flow resulting from sliding of an abutment block in the ridge between the concrete section of the JFP and the existing wing dam could potentially cause the embankment to erode. Population at risk (PAR) for a failure of the JFP Auxiliary Spillway can be estimated from PAR determined for the existing concrete dam and wing dams. Failure of the JFP concrete section would have a much smaller breach discharge and would result in less PAR than failure of the existing concrete dam section. No PAR was estimated for a partial breach of the existing concrete dam that would simulate a breach of the JFP concrete section. Estimates of possible discharge for complete failure of one to three JFP monoliths indicated the discharge would be within the existing spillway discharge capacity, and PAR associated with current maximum spillway releases was used. Risks were estimated for sudden failure of one or more spillway gates. The PAR associated

with these scenarios is dependent on the number of gates that fail, and the reservoir elevation at the time of failure. The PAR was estimated from the risk analysis for the existing spillway gates [2] by equating scenarios with similar outflow.

2. Loss of Life Estimates – Loss of Life for failure of the Left Wing Dam was estimated to be 2007 people in the dam failure study performed in 2001. This value was used during this risk analysis. Estimates for failure of the JFP concrete section were developed using a breach outflow of between 190,000 ft^3/s and 570,000 ft^3/s, depending on the number of monoliths that failed (1 to 3). Since the range of breach discharge was within the existing discharge capacity at Folsom Dam, loss of life was estimated to be the pre-failure value associated with maximum spillway discharge. The 2001 dam failure study estimated a loss of life of between 90 and 370 people would occur from large discharges failing the downstream levees before failure of the wing dam. Loss of life values for gate failures were estimated from values used in a 2001 risk analysis [2] of the existing spillway gates at Folsom Dam. In this analysis loss of life was calculated for different discharges resulting from a variety of gate failure scenarios. The discharge versus loss of life values in the previous study were compared to discharge for differing JFP gate failure scenarios. Loss of life for gate failures varies from approximately 2 for 1 gate failing at a low RWS elevation to 250 for 6 gates failing at a high RWS elevation.

C. Loads, Analysis and Structural Response

1. Earthquake Ground Motions and Load Probabilities - In an attempt to better address residual risk at higher seismic loadings for failure modes at Folsom Dam, earthquake records were provided by Reclamation's Seismotectonic and Geophysics Group (86-68330) [3]. These records were chosen to represent a range of earthquakes and to approach the physical limit of seismic loading that could occur at Folsom Dam. These records included the P5 record, the San Salvador record and the Extreme Unfiltered record. The San Fernando record was obtained from the USACE to represent a more frequent event for which the structure would be expected to suffer little damage.

The exceedance probabilities for each of these events, based on peak ground accelerations and 0.2 second spectral accelerations, are given in Table 2 below. The natural period of the JFP structure and piers falls within this range.

Table 2 – Ground Motions

	Exceedance Probability	
Record	**PGA**	**0.2 S_A**
San Fernando	1/5,500	1/5,500
50k UHS (MCEx1.3)	-	-
P5	1/27,000	1/21,000
MCEx1.5	1/33,000	1/45,000
San Salvador	1/160,000	1/120,000
Extreme	1/990,000	1/260,000

2. Reservoir Operations – Flood routings were performed to verify the ability of the JFP to ensure that the USACE flood damage reduction goal is met (at least 200-year flood protection) and that Reclamation's goal of safely passing the PMF with at least 3 feet of freeboard is met.

Reclamation has developed an EXCEL spreadsheet to route floods through Folsom dam and to verify the USACE's reservoir operations models. The spreadsheet incorporates the discharge capacities from the JFP Auxiliary Spillway in combination with the existing spillways and outlet works. The spreadsheet allows Reclamation to route floods using the new reservoir operations proposed by the USACE as well as perform sensitivity study routings.

Presently the official top of flood pool is RWS elevation 466.0. Control of the reservoir would be transferred from the USACE to Reclamation once this elevation is exceeded. Discharge within the flood control pool is restricted, by the USACE, to the assumed long term safe downstream channel capacity of 160,000 ft^3/s. Using the six JFP STG (23-feet-wide by 33-feet-high), and the proposed reservoir operations, Reclamation has routed the PMF and 200-year recurrence flood to verify the USACE baseline JFP flood routings. The USACE baseline assumption is that there will typically be a 1 hour delay from the time the inflow into the reservoir occurs, the RWS elevation is determined and the required discharge is calculated to the time the new discharge is actually set at the dam. It was also assumed that adjustments are made each hour. This 1 hour delay was used whenever the reservoir was within the flood control pool and discharges were greater than 115,000 ft^3/s. The USACE assumes a 4 hour delay in setting the discharge for discharges below 115,000 ft^3/s. This delay was also followed during the routing. When the reservoir is above the proposed flood control pool (RWS elevation 466) smaller delays were also used. A 30-minute delay is believed to be practical during large flood events when all required operational personnel are in place and rapid operation of the gates is expected. The results are as follows:

- With 30-minute delay above RWS 466 feet (1-hour delay below RWS 466 feet), and a ramping rate above RWS 466, Reclamation's maximum RWS is 478.13 feet.

Routings with a 30-minute delay in setting discharge above the proposed flood control pool (RWS elevation 466) and no ramping rate pass the PMF with 3 feet of freeboard. There is a concern about outflow ramping up from 160,000 ft^3/s to over 500,000 ft^3/s in 1 hour or less (levee overtopping would rapidly occur with large overtopping depths).

To reduce the concerns about the very large initial ramping rate for the first few hours after discharge is allowed above 160,000 ft^3/s, a ramping rate of no more than 100,000 ft^3/s per hour below discharges of 360,000 ft^3/s is proposed. A 50,000 ft^3/s per 30-minute increase is proposed when a 30-minute delay is used in the routing. No ramping rate restriction was applied to the next time increment with discharges above 360,000 ft^3/s. The purpose of the ramping rate is to try and reduce the downstream impacts when increasing the releases from 160,000 ft^3/s to maximum discharge. It is believed that implementing a ramping rate of this type immediately after the levees begin to overtop and fail will reduce the loss of life during extreme flood events, by allowing people caught in the inundation boundaries to seek an evacuation route before being hit by even larger flows. This ramping rate restriction will allow for some of the evacuation and warning time that is incorporated in the existing Emergency Spillway Release Diagram. The existing Emergency Spillway Release Diagram has a target long term safe downstream channel capacity of 115,000 ft^3/s and a ramp up to 160,000 ft^3/s (short term safe downstream channel capacity) for extreme floods. Discharge is not allowed to exceed 160,000 ft^3/s until 6 hours have passed since discharges have risen above 115,000 ft^3/s and the RWS elevation is above 470.0 feet. When discharge is allowed above 160,000 ft^3/s it cannot be increased above 200,000 ft^3/s until the RWS is above elevation 472.0. All of these ramping restrictions allow additional time for warning and evacuation. The proposed ramping rate more closely matches previous Reclamation routings using the current ESRD. Routings were performed to investigate the effect of the proposed ramping rate on the maximum RWS elevation attained in PMF routings. Implementation of a ramping rate above discharges of 160,000 ft^3/s will require additional discharge capacity from the JFP Auxiliary Spillway. Modifications required to include a ramping rate are not expected to result in excessive changes to the JFP Auxiliary Spillway's configuration or designs (required increase in capacity for the JFP Auxiliary Spillway would be about 4 percent).

Routings were performed for the JFP Auxiliary Spillway using the current FCD and ESRD. These routings resulted in a maximum RWS elevation 480.94 using a 1-hour delay throughout routings and the ramping rate incorporated within the existing ESRD. Using a 30-minute delay and no ramping rate restriction above RWS elevation 468, the maximum RWS elevation was 477.17.

Several additional flood routings were performed to test the robustness of the JFP Auxiliary Spillway using the baseline gate size of 23 by 33 feet and to compare the JFP Auxiliary Spillway to the DSO fuseplug alternative. The results are summarized in Table 3 (reflecting the final assumptions for the JFP flood routings). Routings were performed using the proposed ramping rate above discharges of 160,000 ft^3/s. Routings were performed with a 30-minute delay.

Routings were performed for 110 percent of the PMF, the 2001 PMF with 1 service gate out of service, and for three scaled historical floods. The JFP Auxiliary Spillway as currently envisioned could not pass 110 percent of the PMF without dam overtopping. The JFP Auxiliary Spillway could not pass the PMF with 1 service spillway gate out of service without dam overtopping. Several critical scaled historic flood hydrographs were routed using the JFP Auxiliary Spillway. All of the scaled historic floods could be passed without overtopping the dam. Details of all the JFP flood routings are included in TM No. FOL-8130-JFP-2006-1 [4].

Table 3 – Additional PMF Routings

Flood Event	Initial RWS (feet)	Maximum RWS (feet)	Maximum Outflow (ft^3/s)
PMF with 30-min delay above El 466 with 1 service spillway gate out	**399.63**	**480.64***	**778,654***
110% PMF with 30-min delay above El 466	**399.63**	**481.67***	**853,851***
1963 Scaled historical event 24-hr intense storm duration 30-min delay above El 466	**399.63**	**478.42**	**822,826**
1986 Scaled historical event 24-hr intense storm duration 30-min delay above El 466	**399.63**	**478.46**	**823,425**
1997 Scaled historical event 12-hr intense storm duration 30-min delay above El 466	**399.63**	**477.99**	**815,979**

*** Does not include discharge over the existing dams and dikes.**

A routing was performed for the Selected Plan (SP), which consists of the JFP Auxiliary Spillway, a 3.5 foot dam raise and modifications to the existing emergency spillway gates. The routings were performed with the assumption that releases would be limited to 160,000 ft^3/s up to reservoir water surface elevation 471.5 (at which point the ramping rate would be implemented) resulted in a maximum reservoir water surface elevation of 481.0. This would result in 3 feet of freeboard on the raised dam crest at elevation 484.0. Holding releases to 160,000 ft^3/s will surcharge the flood control pool from elevation 466.0 to elevation 471.5.

3. **Dynamic Structural Analysis** – An analysis of the JFP Auxiliary Spillway control structure was performed using the LS-DYNA computer program

[5]. The control structure was analyzed for static loads that included gravity and normal reservoir at elevation 466. The analysis did not include reservoir load on the radial gates. It was assumed that the upstream bulkhead gates would be closed and reservoir load was applied to the entire upstream face of the structure. The ground motions from the 1986 San Salvador earthquake were used for the dynamic loading of the concrete structure. This ground motion provided the largest response for the existing concrete dam of the motions provided by Reclamation seismologists, and would be expected to cause the largest response for the new control structure.

The frequencies of the control structure in the upstream-downstream direction and of the center pier in the cross-canyon direction were determined by applying a sine pulse to the finite element model and measuring the response of selected nodes. The fundamental frequencies of the control structure (in the upstream-downstream direction) and the center pier (in the cross-canyon direction) are 7.04 and 8.21 Hz, respectively.

The dynamic analysis of the Folsom Dam Auxiliary Spillway Control Structure was performed using LS-DYNA. The maximum displacement at the crest of the dam is 0.55 inches in the upstream-downstream direction while the maximum displacement of the center pier is 0.38 inches in the cross-canyon direction. Due to the geometry of the structure stress concentrations are possible in locations where features intersect, such as the piers and headwalls, piers and slab and piers and beams. Stresses were investigated in these locations with the following results:

- Maximum tensile stresses in the piers along the downstream edge of the headwall were about 300 to 400 lb/in^2
- Maximum tensile stress in the piers along the lower edge of the headwall were about 300 lb/in^2
- Maximum vertical tensile stresses in the piers at the upstream and downstream edges of the base slab were about 400 lb/in^2 and 500 lb/in^2, respectively
- Maximum vertical tensile stress in the piers near the center of the base slab was about 50 lb/in^2
- Maximum vertical tensile stress at the heel and toe of the slab were about 100 lb/in^2 and 550 lb/in^2, respectively
- Maximum horizontal tensile stress in the upper and lower (trunnion) beams were about 400 lb/in^2 and 600 lb/in^2, respectively.

Nowhere in the structure were tensile stresses found to exceed the estimated dynamic tensile strength of the modern concrete that would be used to construct the structure. Therefore, for the loads analyzed, the elastic limit of the reinforcement would not be exceeded.

A limit-equilibrium sliding stability analysis using the computer program GRAVDAM was performed to evaluate overall structural stability under all loading conditions. This model was also used to evaluate post-earthquake

stability in the unlikely event that the base cracked completely through. A composite two-dimensional section was developed by adjusting the unit weight of the concrete material to account for the openings. Using a cohesion of 200 lb/in^2, a friction angle of 50 degrees, and a 67 percent effectiveness for the drains at the base of the structure, calculated factors of safety exceed 8 even with the reservoir as high as elevation 477. With the base cracked completely through, zero drain effectiveness, and a friction angle of 45 degrees, the estimated factor of safety exceeds 1.5 when the currently proposed 8 degree upstream slope to the base excavation is included. Thus, global sliding instability is unlikely.

D. Potential Failure Modes

The following failure modes were identified and addressed as part of the Conceptual Design Risk Analysis [6].

Failure Mode 1 - Sliding of Rock Wedge in Right Ridge Adjacent to Spillway Control Structure under Flood Loading - This potential failure mode involves the sliding of a rock wedge that could develop in the right ridge adjacent to the JFP Auxiliary Spillway control structure, potentially underlying the end of the Left Wing Dam. The wedge would form along the intersection of B and D joint sets and has the potential to daylight downstream in a steep area of the abutment slope. For this failure mode to develop, the reservoir would need to be above elevation 470. This is necessary to develop significant uplift pressures on the wedge. The wedge would need to be at least partially located underneath the left wing dam. Failure of the wedge would lead to an uncontrolled release of the reservoir through the area where the wedge was originally located, causing erosion and the rapid breach of the Left Wing Dam.

Failure Mode 2 – Seismic Failure of Spillway Tainter Gates due to Buckling of Radial Arm - This potential failure mode involves the failure of the spillway gates during seismic loading. The failure would occur as a result of gate arm buckling under hydrodynamic loading, with the buckling caused by a combination of axial and bending stresses in the radial gate arms. The gate arm buckling would be sudden and there are no mitigating factors if the critical loading occurs.

Failure Mode 3 – Seismic Cracking and Sliding at the Base of the Concrete Spillway Piers – This potential failure mode involves sliding of the spillway crest structure along the base of the spillway piers. The sliding would initiate during a large earthquake as a result of static and hydrodynamic loads in the direction parallel to the centerline of the spillway. The failure mode requires that cracking initiates at the base of the pier and eventually propagates through the entire base. Sliding would lead to an uncontrolled release through the area of the displaced monoliths.

Failure Mode 4 – Seismic Failure at the Tainter Gate Concrete Trunnion Support Beam - This potential failure mode involves the seismic failure of the trunnion support beams for the top-seal tainter gates. This could occur at the connection of the trunnion beams with the piers, or through the beams themselves.

Since design details were not available, it was unclear exactly how loads from the trunnions would be transferred to the trunnion support beam.

Failure Mode 5 – Seismic Sliding of the Dam along the Foundation Contact – This potential failure mode involves the sliding of the Auxiliary Spillway control structure concrete monoliths along the foundation contact. Cracking and sliding of monoliths could lead to the development of large uplift pressures at the base of the structure and post-earthquake instability. If monoliths continue to slide after the earthquake, a significant breach would occur through the area originally occupied by the failed monoliths.

A number of additional potential failure modes were considered by the risk analysis team but were not carried forward into the risk estimating process. A list of the additional failure modes considered can be found in the risk analysis report [6]. The failure modes were not pursued because they were not considered plausible or because it was the belief of the risk analysis team that current design practice would result in designs with risks below Reclamation's Public Protection Guidelines [7].

II. Findings

The following findings are based on the results provided in the source document(s) and summarized in this decision document. The findings are made in accordance with *The Guidelines for Achieving Public Protection in Dam Safety Decision Making*, dated June 15, 2003 [7] (refer to the attached summary f-N chart).

Reclamation's public protection guidelines for annual failure probability should be compared against the total annual failure probability based on the sum of all load categories, whereas the evaluation for annualized loss of life should be based on the total results for each load case separately. The total annual probability of failure for all load categories is estimated at 9.2E-6, well below the Guideline value. It should be noted that this probability of failure estimate is for the Auxiliary Spillway failure modes only and is not comprehensive in considering all failure modes for Folsom Dam.

The estimated mean seismic risk (annualized loss of life) for all identified potential seismic failure modes of 4.1E-4 (again, only considering failure modes for the Auxiliary Spillway) is below Reclamation's Guideline value. Key factors that lead to this conclusion are:

- The three dimensional analysis of the control structure performed by Reclamation indicated that the structure performs well for large earthquake loads with stresses that are within the capacity of the concrete structure.

- Two of the seismic failure modes that were evaluated by event trees (Sliding at the Base of the Concrete Piers and Sliding of the Dam along the Foundation Contact) were found to have risks that were negligible.

- The two remaining seismic failure modes (Failure of the Tainter Gates due to Buckling of the Radial Arms and Failure of the Tainter Gate Trunnion Support Beam) could not be estimated directly since analysis and design details were not available. Evaluation of the risks using a hypothetical design indicates that if the design for both features is based on the P5 earthquake ground motions and a full reservoir, risks are likely to be well below Reclamation's Public Protection Guidelines.

The risk from the hydrologic failure mode (Failure of Wedge in Right Ridge) is estimated to be 4.0E-3 (again only considering failure modes for the Auxiliary Spillway). This estimate is based on preliminary data and analysis but it indicates that modifications should be considered to the design to reduce the risk of this failure mode. Key factors that lead to this conclusion are:

- There is a high probability that a wedge could be formed by the B and D joint sets in the right ridge to the right of the Auxiliary Spillway control structure.

- If large uplift forces develop on continuous wedge planes as a result of reservoir loading caused by the Auxiliary Spillway excavation geometry, the likelihood of sliding is high.

- If the sliding wedge were to underlie the Left Wing Dam, it is almost certain that the Left Wing Dam would be breached.

The excavation cut slopes on the right side of the spillway control structure should be steepened from 1.25:1 (rock) and 3.5:1 (common) to ½:1 (rock) and 1.5:1 (common). Review of the existing drill hole logs indicates that competent rock should exist along most of the cut slope height on the right side of the control structure. Steepening the cut slopes will keep a large buffer between the reservoir and the Left Wing Dam for potential seepage and piping paths associated with the B-shears. It will eliminate the need for an embankment closure section currently in the designs and the associated piping risks. It will allow extending the drainage gallery and draining the rock adjacent to the Left Wing Dam. The combination of drainage along with grouting in the right ridge will reduce the failure probability of a wedge in this area. Finally, it will reduce the excavation and concrete quantities for the JFP Auxiliary Spillway control structure and will reduce the overall cost of the structure.

The current configuration of the JFP Auxiliary Spillway can pass the 2001 PMF with 3 feet of freeboard, provided that the delay in response to reservoir inflows is reduced in the routings from 1 hour to 30 minutes once the reservoir reaches elevation 466. This requires a large increase in spillway releases (about 400,000 ft^3/s) in the initial hour after discharges exceed 160,000 ft^3/s. This sudden jump

would be dangerous to downstream populations and as a result a ramping rate of 50,000 ft^3/s for each 30 minute interval should be provided when increasing discharges from 160,000 ft^3/s to 360,000 ft^3/s. This will minimize the rate of inundation once the downstream levees fail and more closely match warning and evacuation intervals included in the existing ESRD.

Ramping operations above elevation 466.0 will require modifications to the JFP Auxiliary Spillway to increase discharge in order to maintain 3 feet of freeboard during the 2001 PMF routing.

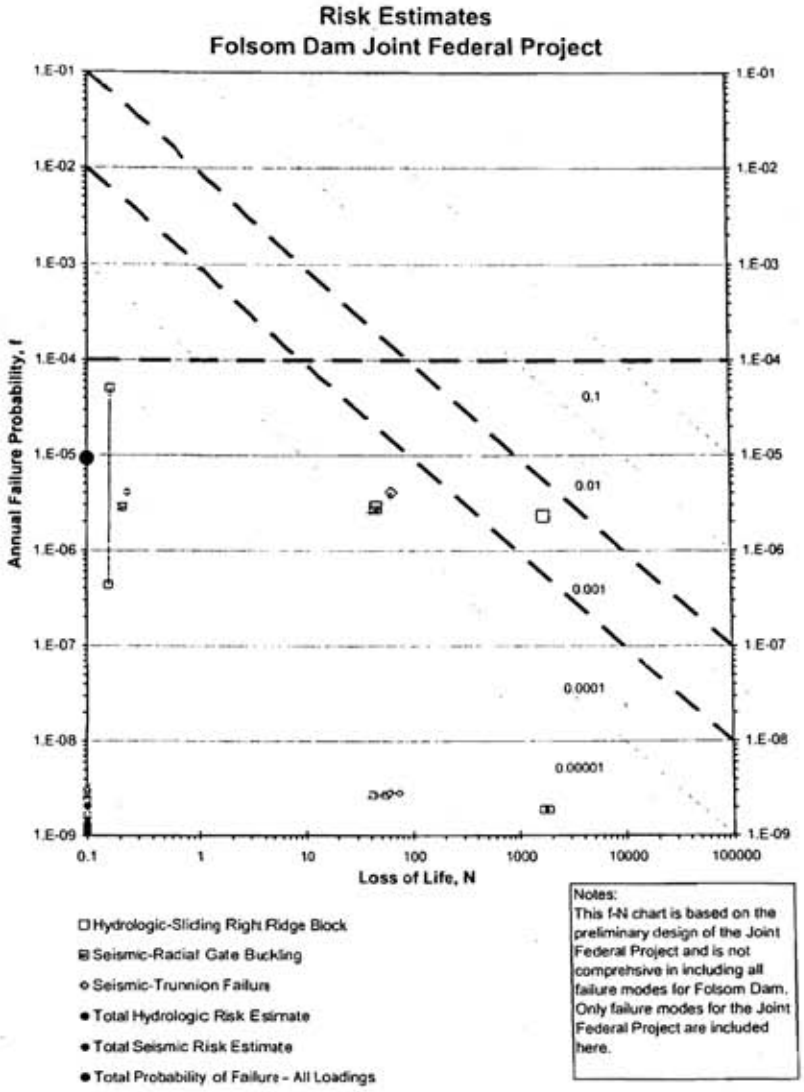
Robustness studies were performed to test the sensitivity of the JFP Auxiliary Spillway design under a variety of assumptions. The JFP Auxiliary Spillway performed reasonably well. Most of the routings with the JFP Auxiliary Spillway resulted in maximum RWS elevations that did not overtop the embankment dams/dikes, with some exceptions (see Table 3). Enlarging the JFP Auxiliary Spillway gates to increase discharge will likely result in less of the sensitivity routings leading to dam overtopping.

III. Benefits of New Recommendations

n/a

IV. Responses to Prior Incomplete Recommendations

n/a


Risk Estimates
Folsom Dam Joint Federal Project
Annual Failure Probability, f
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
0.1
1
10
100
1000
10000
100000
Loss of Life, N
0.1
0.01
0.001
0.0001
0.00001
Hydrologic-Sliding Right Ridge Block
Seismic-Radial Gate Buckling
Seismic-Trunnion Failure
Total Hydrologic Risk Estimate
Total Seismic Risk Estimate
Total Probability of Failure - All Loadings
Notes:
This f-N chart is based on the preliminary design of the Joint Federal Project and is not comprehensive in including all failure modes for Folsom Dam. Only failure modes for the Joint Federal Project are included here.

A DSAT (Dam Safety Advisory Team) Meeting was held on November 30, 2006.

The DSAT members have provided technical advice regarding the appropriateness of the proposed results, findings, and recommendations; and provided advice to the Dam Safety Office regarding the relative urgency and priority of implementing the recommendations or other follow-on activities. This advice was provided for the purpose of obtaining a level of consistency between projects.

Participants in the DSAT meeting are provided below.

DSAT meeting participants	Organization	Organization code	Role
William Fiedler	Waterways & Conc Dams	86-68130	Presenter
Ernie Hall	Waterways & Conc Dams	86-68130	Presenter
Phoebe Percell	Waterways & Conc Dams	86-68130	Presenter
Thomas Hepler	Waterways & Conc Dams	86-68130	DSAT Member
Gregg Scott	Structural Analysis	86-68110	DSAT Member
Pete Shaffner	Engineering Geology	86-68320	DSAT Member
Rick Benik	Waterways & Conc Dams	86-68130	Team Member
Brian Becker	Dam Safety Office	84-44000	Decision Maker

Participants by phone	Organization	Organization code	Role
Drew Lessard	Central California Area Office		
Larry Hobbs	Mid Pacific Regional Office		

References

[1] "Folsom Dams and Dikes, California – Estimating Consequences of Dam or Dike Failure", Bureau of Reclamation, Prepared by Wayne Graham, Technical Service Center, Denver, Colorado. July 2001.

[2] "Folsom Dam Spillway Risk Analysis – Gates and Piers Under Seismic Loading," TM No. FS-8130-TM-RA-2001-1, Bureau of Reclamation, Technical Service Center, Denver, Colorado, September 2001.

[3] "Hazard Curves and Uniform Hazard Response Spectra, Folsom Dam, Auburn-Folsom South Unit, American River Division, Central Valley Project, California," TM No. D-8330-2004-16, Bureau of Reclamation, Technical Service Center, Denver, Colorado, September 2, 2004.

[4] Folsom Dam Joint Federal Project, Short Term Evaluation, Flood Routings, Technical Memorandum No. FOL-8130-JFP-2006-1

[5] Folsom Dam Joint Federal Project, Short Term Evaluation, 3-D LS-DYNA Analysis, Technical Memorandum No. FOL-8130-JFP-2006-2

[6] Folsom Dam Joint Federal Project, Short Term Evaluation, Risk Analysis Report, Technical Memorandum No. FOL-8130-JFP-2006-3

[7] "Guidelines for Achieving Public Protection in Dam Safety Decision Making," Bureau of Reclamation, April 4, 1997



Post Authorization Change Report

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Folsom Dam Modification and
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Appendix H
U.S. Army Corps of Engineers 12 Actions for Change: Improving Our Nation's Infrastructure



US Army Corps of Engineers

Sacramento District
South Pacific Region

March 2007

U.S. ARMY CORPS OF ENGINEERS 12 ACTIONS FOR CHANGE: IMPROVING OUR NATION'S INFRASTRUCTURE

The "12 Actions for Change" are a set of actions that the Corps will focus on to transform its priorities, processes, and planning. These were identified by the Corps and other investigative teams analyzing the performance of the Greater New Orleans Hurricane Protection System. They point to the need to transform the way the Corps serves the Nation and its Armed Forces. These 12 Actions were developed from that analysis and from other internal and external examinations of the Corps in the recent past. The Corps will use the 12 Actions to guide ongoing and future work, and to ensure the Corps is an organization that is adaptable, flexible, and responsive to the needs of the Nation.

The 12 Actions for Change fall within three overarching themes: effectively implement a comprehensive systems approach; communication; and reliable public service professionalism. Following is a description of how the Folsom Modification Project and Folsom Dam Raise Project, as described in the Post Authorization Change Report, account for and contribute towards each of the 12 Actions for Change.

Effectively Implement a Comprehensive Systems Approach: Comprehensively design, construct, maintain, and update engineered systems to be more robust, with full stakeholder participation.

1. Employ integrated, comprehensive and systems-based approach.

The Folsom Modification Project and Folsom Dam Raise Project are part of the overall American River Watershed Project, which consists of a number of authorized projects that work together to reduce the risk of flooding to the Sacramento area as well as to restore ecosystem values along the American River and to address transportation needs in the vicinity of the City of Folsom. Though the projects were authorized separately over the years, they have origins in a comprehensive investigation of the American River Watershed (American River Watershed Investigation, 1991). That investigation, as well as all subsequent ones up to and including the current Post Authorization Change (PAC) Report, included extensive public and agency participation which encompassed close coordination with downstream and upstream interests as well as evaluation of system wide benefits and adverse effects to physical, biological, and socioeconomic resources. In order to verify the recommendations of this PAC Report, a parallel investigation, the Economic Reevaluation Report, is underway updating the hydrology, hydraulic, and economic information that has been the basis for the American River Watershed Project components for almost 20 years. Corps HQUSACE, South Pacific Division Region, which is also the Corps Center of Expertise for Flood Damage Reduction, as well as a collection of experts in economics and cost engineers both internal and external to the Corps, have been engaged in review throughout development of the PAC Report.

2. Employ risk-based concepts in planning, design, construction, operations, and major maintenance.

In accordance with Corps regulations, risk-based analysis has been undertaken for hydrology, hydraulic, geotechnical, and economic evaluations for all aspects of the current PAC Report and for the Economic Reevaluation Report. Risk communication is employed to more accurately articulate both risk reduction and residual risk.

3. Continuously reassess and update policy for program development, planning guidance, design, and construction standards.

Development of the PAC Report included application of current Planning and Engineering guidance. It is the District's first formal application of External Peer Review (EC 1105—2-408). Local objectives were considered in the PAC Report and the Economic Reevaulation report is addressing the for four accounts set forth in the Water Resource Development Principles and Guidelines, including a quantified assessment of Other Social Effects and Regional Economic Development (Planning in a Collaborative Environment, EC 1105-2-409).

4. Employ dynamic independent review.

Seamless and Formal Independent Technical Review were undertaken throughout development of the current PAC Report and is continuing for the Economic Reevaluation Report. The ITR team primarily comprised experts from other Corps districts, and was supplemented by contractors. A project briefing was held via VTC early on to provide an overview to the ITR team, and a field trip overview was offered and ultimately conducted for one interested ITR team member. Onboard review/issue resolution sessions were held twice in Sacramento, once prior to release of the draft PAC Report and once prior to submittal of the final PAC Report. A separate team was convened for External Peer Review.

5. Employ adaptive planning and engineering systems.

The American River Watershed Project consists of a collection of authorized project components, some of which have been implemented (Common Features) and some of which are being updated via further investigation (Natomas Common Features and Folsom Reoperation). For example, an Early Flood Warning System was constructed for the Sacramento River area. Project components, such as Natomas Common Features, are being adjusted based on updates to previously authorized project components.

6. Focus on sustainability.

The Refined Authorized Projects were developed to be compatible with both the existing and planned downstream levee improvements as well as with any future projects the local sponsors may wish to pursue for a greater reduction of flood risk. The plan is consistent with the Corps Environmental Operating Principles:

- **Environmental Operating Principles:** The Corps has reaffirmed its commitment to the environment by formalizing a set of "Environmental Operating Principles" applicable to all its decision-making and programs. These principles foster unity of purpose on environmental issues, reflect a new tone and direction for dialogue on environmental matters, and ensure that employees consider conservation, environmental preservation, and restoration in all Corps activities. By implementing these principles, the Corps will continue its efforts to develop scientific, economic, and sociological measures to judge the effects of its projects on the environment and to seek better ways of achieving environmentally sustainable solutions.

- **Achieve Environmental Sustainability.** An environment maintained in a healthy, diverse, and sustainable condition is necessary to support life.

  The focus of work at the Folsom Dam area instead of, for example, creation of new upstream storage, minimizes environmental impacts in the watershed. The Folsom Dam Raise Project includes an authorized ecosystem restoration project that will contribute to reestablishing native floodplain habitat and processes along the Lower American River, thereby benefiting an array of Federal and State special status species. Mitigation for the Refined Authorized Project has been coordinated with appropriate resource agencies. The Refined Authorized Projects have less adverse effects than if the Corps and Reclamation had independently implemented flood damage reduction and dam safety projects.

- **Consider Environmental Consequences.** Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of Corps programs and act accordingly in all appropriate circumstances.

  The focus of work at the Folsom Dam area instead of, for example, creation of new upstream storage, minimizes environmental impacts in the watershed. The Folsom Dam Raise Project includes an authorized ecosystem restoration project that will contribute to reestablishing native floodplain habitat and processes along the Lower American River, thereby benefiting an array of Federal and State special status species. Mitigation for the Refined Authorized Project has been coordinated with appropriate resource agencies. The Refined Authorized Projects have less adverse effects than if the Corps and Reclamation had independently implemented flood damage reduction and dam safety projects.

- **Seek Balance and Synergy.** Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.

  The project achieves balance between public safety for the community with improved risk management and, in addition to the authorized ecosystem restoration project, minimal environmental effects relative to the Corps and Reclamation working independently of each other or in relation to new upstream storage.

- **Accept Responsibility.** Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that effect human health and welfare and the continued viability of natural systems.

  The Corps and Reclamation, while addressing their respective authorities and programs, have worked together to be more efficient from an overall Federal perspective.

- **Mitigate Effects.** Seek ways and means to assess and mitigate cumulative effects to the environment; bring systems approaches to the full life cycle of our processes and work.

  Compliance with environmental laws and regulations has been documented in an Environmental Impact Statement/Environmental Impact Report developed by Reclamation in cooperation with the Corps. Reasonable mitigation for impacts has been identified as appropriate. Cumulative impacts are disclosed. The Refined Authorized Projects have less adverse effects than if the Corps and Reclamation had independently implemented flood damage reduction and dam safety projects.

- **Understand the Environment.** Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and effects of our work.

  The project was developed with extensive input from Corps and partnership experts, as well as consultant staff, and with the appropriate resource agencies.

- **Respect Other Views**. Respect views of individuals and groups interested in Corps activities, actively listen, and learn from their perspective in the search to find innovative win-win solutions to the Nation's problems, solutions that also protect and enhance the environment.

  The local and regional communities have been active in the project development, for which public workshops were held to solicit involvement. The local objective in flood damage reduction, though somewhat different from the Federal objective, was recognized to be important in local decision making and was identified and characterized throughout the project refinement process.

7. Review and inspect completed works.

The Refined Authorized Projects address the Nation's highest priority dam safety issue in Reclamation's Safety of Dams Program, which is Folsom Dam. By addressing both the dam safety problem and flood-related problems in the region through collaboration, the Corps and Reclamation have increased efficiency in managing the Nation's assets.

8. Assess and modify organizational behavior.

The Refined Authorized Projects were developed with an unprecedented level of coordination with Reclamation. This was necessary because both agencies had projects planned for the same location; when the opportunity came to review planned work for the area for efficiencies, the Corps and Reclamation worked together to develop a project that satisfied the requirements of both agencies. Collaborative project development team meetings were regularly held with the internal Corps team and the project partners to ensure shared information and timely response. For further facilitated internal coordination, an American River Design Branch was created that consisted of the engineering design team, who were collocated. Most elements of the American River Team ultimately sat relatively close to each other, which greatly enhanced coordination.

9. Effectively communicate risk.

The American River Project partnership has worked to improve risk communication. A few years ago, the State of California published an issue paper that described the flood risk in the northern and central California regions. SAFCA periodically mails a publication to residents in the floodplain that gives updates on project efforts and residual risk. The Corps has worked to improve the understanding by local media of regional flood risk to ultimately improve the understanding of the general public.

10. Establish public involvement risk reduction strategies.

Though SAFCA has an initial goal of attaining and maintaining FEMA certification of the project at the 100-year level, the ultimate goal of this local sponsor is significant flood risk reduction for the 200-year frequency event. This goal is published by SAFCA and the affected community is assessed to fund projects.

11. Manage and enhance technical expertise and professionalism.

The American River Project is a large and significant study and design effort that has spanned 20 years. In order to ensure that the incredibly complex technical project history is understood by the current project team, former Corps employees have been retained to work on this PAC and to mentor newer team members. Additionally, seasoned resources from other Corps districts have been engaged in the project as part of independent technical review, external peer review, and served as the director of the overall American River Program.

12. Invest in research.

The Economic Reevaluation is specifically undertaking research to develop Regional Economic Development and Other Social Effects benefits. This is an area that had not previously been investigated for the American River Project.

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Folsom Dam Modification and Folsom Dam Raise Projects



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Folsom Dam Modification and Folsom Dam Raise Projects



US Army Corps of Engineers

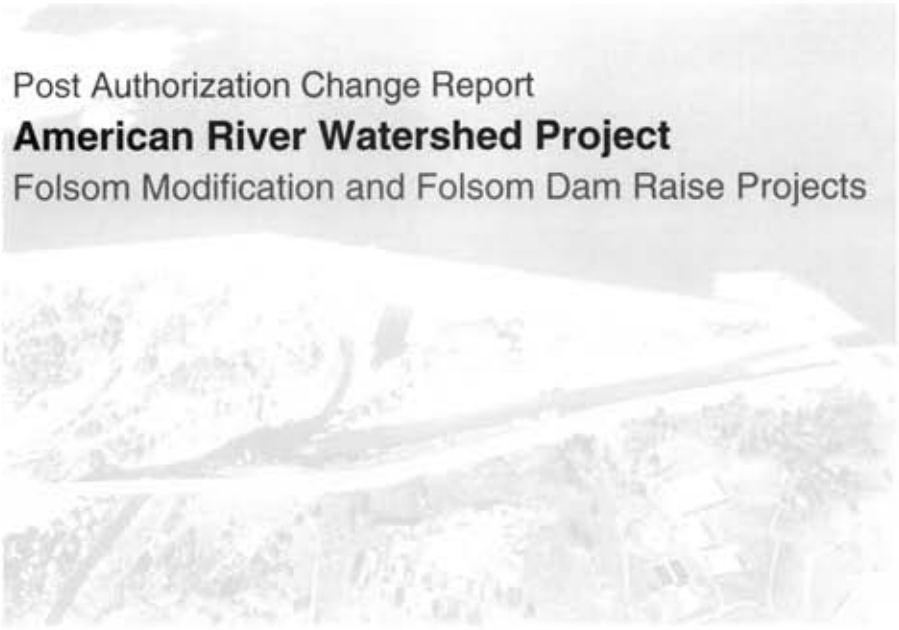
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EXECUTIVE SUMMARY

ES.1 PURPOSE AND SCOPE OF REPORT

The purpose of this *Post Authorization Change* (PAC) *Report* is to document changes to two authorized projects: the Folsom Modification Project and Folsom Dam Raise Project. Both projects share an objective of improving flood management on the lower American River, primarily through structural modifications to the existing Folsom Dam and appurtenant facilities. This *PAC Report* describes recommended changes to these authorized projects. It is anticipated that these changes will reduce flood risk to areas along the American River, California, generally equivalent to the flood risk reduction intended to be provided by the Folsom Modification Project and Folsom Dam Raise Project. Similar to the Folsom Dam Raise Project, changes will include provisions to meet the United States Department of the Interior, Bureau of Reclamation's (Reclamation), objective of passing the Probable Maximum Flood (PMF) at Folsom Dam. The PMF is the flood discharge that would result from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably considered possible in a region. The updated information in this *PAC Report* is to be part of a single, joint project that addresses in a more efficient and effective manner the objectives of the United States Army Corps of Engineers (Corps) previously authorized flood damage reduction projects and Reclamation's dam safety concerns.

This *PAC Report* is intended to accomplish the following:

- Demonstrate consistency of a refined project with existing congressional project authorizations.
- Report on changes to project accomplishments and benefits, and Federal interest in a refined project.
- Serve as a basis for new Project Cooperation Agreements (PCA), as needed, between the Federal Government and local sponsors.
- Seek revision for authorized project cost for the Folsom Modification Project from Congress, as appropriate.

ES.2 BACKGROUND

In February 1986, major storms in Northern California caused record flood flows in the American River basin. Record high outflows from Folsom Dam and Reservoir, together with high flows in the Sacramento River, resulted in water levels rising above the design freeboard of levees protecting the Sacramento area. It was clear after the 1986 storm event that Sacramento was a city at significant risk of flooding, and major efforts would be needed to reduce the potential of catastrophic flooding and damages. These concerns led to a series of investigations and subsequent authorizations of projects to help reduce the level of flood risk to the Sacramento area and address safety issues at Folsom Dam. A time line of pertinent studies, authorizations, and appropriations is included in **Figure ES-1**.

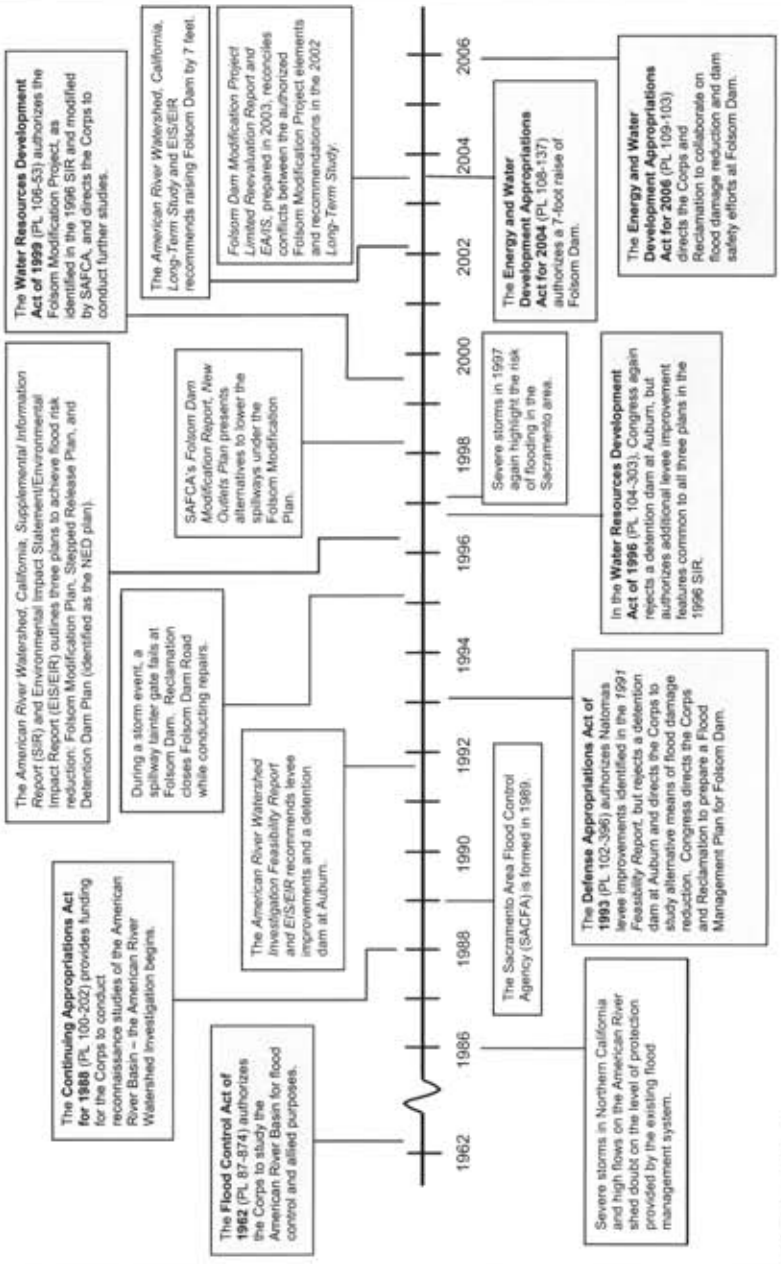


FIGURE ES-1
TIME LINE OF PERTINENT STUDIES, AUTHORIZATIONS, AND APPROPRIATIONS

Studies have shown that serious flood risks exist in the Sacramento area downstream along the American River to its confluence with the Sacramento River. Within the Sacramento area, a major flood could affect more than 400,000 people by causing flood inundation damages to over 110,000 structures. This would amount to about $20 billion in damages. The estimated average annual equivalent flood damages in the Sacramento area would be about $200 million.

The two projects of paramount interest in this *PAC Report* are the Folsom Modification Project and Folsom Dam Raise Project. Both projects have changed from their initial formulation and authorization. The Folsom Modification Project primarily includes features to improve the efficiency and effectiveness of the existing flood control outlet works at Folsom Dam and flood control storage in Folsom Reservoir. The Folsom Dam Raise Project was intended to be constructed following implementation of the Folsom Modification Project. The Folsom Dam Raise Project primarily includes enlarging the flood control storage space in Folsom Reservoir, features to meet Reclamation's objective of passing the PMF, and features to help restore the ecosystem downstream from Folsom Dam. The Folsom Modification and Folsom Dam Raise projects, in combination with other authorized elements downstream from the dam (Common Features), were expected to reduce the risk to Sacramento of flooding to an annual exceedence probability (AEP) of 0.0057 (a 1 in 175 chance in any 1 year). Because of escalating costs and technical problems, the Folsom Modification Project has been delayed. Because of this delay, associated impacts to the Folsom Dam Raise Project, and Reclamation's effort to address dam safety issues at Folsom, there is now an emphasis on reconsidering the individual projects on a more integrated basis. The Energy and Water Development Appropriations Act of 2006 (see **ES.3 Authorities**, below) directed the Corps and Reclamation to collaborate on flood damage reduction and dam safety at Folsom Dam. This *PAC Report* was prepared in part to respond to Congress's request.

As a companion to the *PAC Report*, Reclamation and the Corps cooperated in preparation of the Reclamation *2007 Final Folsom Dam Safety/Flood Damage Reduction Environmental Impact Statement/Environmental Impact Report* (EIS/EIR). Reclamation is the lead Federal agency, with participation by the Corps as a cooperating agency. The document discloses potential environmental impacts of action alternatives meeting Corps flood damage reduction and Reclamation dam safety objectives. The *EIS/EIR* includes information being developed by Reclamation as part of ongoing designs and construction of dam safety improvements at Folsom Dam under the Reclamation Safety of Dams Program. The Reclamation *2006 Draft Folsom Dam Safety/Flood Damage Reduction Draft EIS/EIR* was circulated for public review, in conjunction with the Corps *Draft PAC Report*, from 1 December 2006 until 26 January 2007. Public meetings were held on 9 and 10 January 2007 to allow the public and interested agencies the opportunity to provide oral and written comments. The Corps intends to adopt the *2007 Final Folsom Dam Safety/Flood Damage Reduction EIS/EIR* to satisfy requirements of the National Environmental Policy Act for changes to the originally authorized Folsom Modification and Folsom Dam Raise projects, as appropriate.

ES.3 AUTHORITIES

The basic authorities addressed in this *PAC Report* are as follows:

- **Folsom Modification Project** – Section 101(a) (6) of the Water Resources Development Act (WRDA) of 1999, Public Law (PL) 106-53, provides authorization for the Folsom Modification Project. It directed the Corps to implement a project to modify Folsom Dam and Reservoir generally as described in a March *1996 American River Watershed, California, Supplemental Information Report* by the Corps, and as modified by a March *1998 Folsom Dam Modification Report, New Outlets Plan*, by the Sacramento Area Flood Control Agency (SAFCA). The total authorized cost was $150 million.

- **Folsom Dam Raise Project** – Section 128 of the Energy and Water Development Appropriations Act of 2004 (PL 108-137) directed the Secretary of the Army to carry out a project for flood damage reduction and ecosystem restoration, as described in a Corps *Chief of Engineers Report*, dated November 2002, at a total cost of $257.3 million. Included in the Folsom Dam Raise Project authority are provisions for the expedited design and construction of a new bridge at Folsom and ecosystem restoration.

- **Project Collaboration and Auxiliary Spillway** – Section 128 of the Energy and Water Development Appropriations Act of 2006 (PL 109-103) directed the Secretary of the Army and the Secretary of the Interior to collaborate on authorized activities to maximize flood damage reduction improvements and address dam safety needs at Folsom Dam. Pursuant to this legislation, the Secretaries are to consider reasonable modifications to existing authorized activities, including an auxiliary spillway.

ES.4 AUTHORIZED PROJECTS

Major features of the Folsom Modification Project and Folsom Dam Raise Project are summarized below:

- **Folsom Modification Project** – The Folsom Modification Project is described in the Corps November 2003 *American River Watershed, California, Folsom Dam Modification Project, Final Limited Reevaluation Report and Environmental Assessment/Initial Study*. This project primarily consists of two major features: (1) outlet works modifications and (2) emergency spillway gate replacement for surcharge storage. Under the outlet works feature, eight existing outlet works would be enlarged and two new outlets would be added. The surcharge storage component would include replacing three emergency spillway tainter gates, revising the emergency spillway release diagram, and raising the impervious core in Mormon Island Auxiliary Dam and in several dikes around the lake. The project would be operated to achieve the objective release of 115,000 cubic feet per second (cfs) earlier in a flood event, and enhance the use of surcharge storage space in the reservoir through modifications to the emergency spillway and related operational changes. The non-Federal project sponsor for the Folsom Modification Project is the State of California through the Department of Water Resources (DWR). SAFCA is a co-

sponsor with DWR, and agreed to enter into a cost-sharing agreement with Reclamation to pay for any portion of the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) costs related to the new flood damage reduction features.

- **Folsom Dam Raise Project** – The Folsom Dam Raise Project is described in the Corps November 2002 *American River Watershed, California, Long-Term Study, Final Supplemental Plan Formulation Report/Environmental Impact Statement/Environmental Impact Report*. This project consists of raising the main dam and associated wing dams, dikes, and other appurtenances by 7 feet. The Folsom Dam Raise Project would provide flood benefits while also resolving certain dam safety issues associated with passing the PMF. This project would eliminate the need for replacing the three emergency spillway tainter gates considered in the Folsom Modification Project. The State of California, through DWR, is also the non-Federal project sponsor for the Folsom Dam Raise Project. SAFCA is a co-sponsor and would be responsible for OMRR&R costs. In addition, SAFCA is the non-Federal sponsor for the ecosystem restoration component of the project and the City of Folsom is the sponsor for the Folsom Dam Bridge.

ES.5 REFINED AUTHORIZED PROJECTS

The process for identifying refinements to the authorized projects included evaluating and selecting a plan to jointly address the Corps' authorized flood damage reduction projects and Reclamation's dam safety issues. This was accomplished in the following steps: (1) identifying specific project objectives and constraints, (2) identifying alternative components and combinations of components to meet these objectives, (3) evaluating and comparing these alternatives, and (4) selecting refined authorized projects for implementation.

ES.5.1 Project Objectives and Constraints

The specific objectives for a plan to address both the authorized flood management projects and dam safety issues at Folsom Dam are as follows:

- Primarily from the results of approved studies and authorized projects to date, develop a modification of Folsom Dam and Reservoir capable of reducing flood damages to areas along the American River, California, generally functionally equivalent to the flood risk reduction intended to be provided by the authorized Folsom Modification and Folsom Dam Raise projects.
- Ensure that a refined project provides for the following:
  - Includes features to pass the PMF.
  - Allows and accounts for early implementation of the Folsom Dam Bridge.
  - Retains the capability to implement ecosystem restoration features, as authorized for the Folsom Dam Raise Project.
- Meet the minimum community goal, as articulated by SAFCA, of having a project capable of safely passing the 200-year computed design flood event.

Three major constraints related to project authorization, project area, and applicable laws, regulations, and policies were identified. In addition, a series of supporting constraints was also identified to help identify potential refinements to the authorized projects.

ES.5.2 Alternative Plan Consideration

The No-Action Plan and four action alternative plans were identified to address the project objectives consistent with the identified constraints. These plans include various combinations of features (identified in prior and recent engineering studies) and provide varying levels of flood risk reduction, as described below.

- **No-Action Plan** – Under this plan, the Federal Government would take no further action to reduce flood damages in the Sacramento area, other than those actions currently underway. This primarily includes (1) continuation of the 400,000 to 670,000 acre-foot variable space flood pool interim operation agreement at Folsom Reservoir, (2) completion of the Common Features (primarily levee improvements) project along the American River, (3) completion of seismic retrofit work at Folsom facilities, (4) construction of a new bridge just west of Folsom Dam, and (5) modification of the L.L. Anderson Dam spillway by Placer County Water Agency (PCWA). This alternative would also include Reclamation constructing an emergency fuseplug spillway project near Folsom Dam for hydrologic dam safety purposes. It also includes modification of the Folsom Dam Flood Control Diagram adopted by Reclamation and SAFCA in 2004. Under this plan, Folsom Dam and Reservoir, along with downstream levee improvements, would provide Sacramento with protection against the 100-year computed design flood event.

- **Alternative A – Eight Main Dam Outlets and Fuseplug Spillway** – This alternative consists of three major features: (1) enlarging six of the eight existing outlets (two lower tier outlets and all four upper level outlets), (2) constructing two new outlets along the upper outlet tier, and (3) constructing an emergency fuseplug spillway. The fuseplug spillway would be completed to address passage of the PMF. This alternative also includes modification of the flood control storage space in Folsom Reservoir to a variable space ranging from 400,000 to 600,000 acre-feet.

- **Alternative B – Six Submerged Tainter Gate Auxiliary Spillway** – This alternative includes constructing a new gated auxiliary spillway southwest of Folsom Dam. The auxiliary spillway would be at the same location as the emergency fuseplug spillway described in Alternative A, but in addition to passing the PMF, it would also significantly contribute to reducing flood damages along the American River. Major features include (1) a 1,100-foot-long approach channel beginning in Folsom Lake, (2) a control structure, including six submerged tainter flood gates 33 feet high by 23 feet wide at a sill elevation of 368 feet above mean sea level (msl), (3) a 3,000-foot-long spillway chute with a bottom width of about 169 feet, and (4) a stilling basin in the American River. It also includes modification of the flood control storage space in Folsom Reservoir to a variable space ranging from 400,000 to 600,000 acre-feet.

- **Alternative C – Six Submerged Tainter Gate Auxiliary Spillway, 3.5-Foot Dam Raise, and Three Emergency Spillway Gate Replacements** – This alternative includes

constructing a new gated auxiliary spillway southwest of Folsom Dam (similar to Alternative B), raising Folsom Dam and Reservoir by 3.5 feet, and replacing the three emergency spillway tainter gates at Folsom Dam. It also includes modifying the flood control storage space in Folsom Reservoir to a variable space ranging from 400,000 to 600,000 acre-feet.

- **Alternative D – Six Submerged Tainter Gate Auxiliary Spillway, 7-Foot Dam Raise, and Eight Emergency and Main Dam Spillway Gate Replacements** – This alternative is similar to Alternative C except that it includes raising Folsom Dam by 7 feet (comparable to the authorized Folsom Dam Raise Project). The raise would be a combination of raising the concrete monolith and embankments and adding a parapet wall. In addition, it includes (1) replacing five main dam spillway gates and three emergency spillway gates, (2) modifying the spillway and bridge piers, (3) replacing the spillway bridge, and (4) modifying the elevator tower. It also includes modifying the flood control storage space in Folsom Reservoir to a variable space ranging from 400,000 to 600,000 acre-feet. The estimated performance, first and annual costs, annual flood damage reduction benefits, and net benefits of this and the other action alternative plans are summarized in **Table ES-1**.

TABLE ES-1
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	0.0068	0.0064	0.0054	0.0047
1 in X Chance in Any Year	1 in 147	1 in 156	1 in 185	1 in 213
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	33.0	45.3	50.1	83.9
Flood Damage Reduction (less dam safety)	33.0	35.2	40.0	73.8
Annual Flood Damage Reduction Benefits ($ millions)	84.7	89.9	107.1	118.9
Net Annual Flood Damage Reduction Benefits ($ millions)	51.7	54.7	67.1	45.1
Residual Damages ($ millions)	113.5	108.3	91.1	79.3
Percent Damage Reduction	43	45	54	60

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 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.*

ES.5.3 Alternative Plan Evaluation and Selection

To assist in identifying a 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). Completeness is a determination of whether a plan includes all elements necessary to realize planned effects. Effectiveness is the extent to which an alternative can alleviate problems and achieve the project objectives. 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. Acceptability is the workability and viability of a plan with respect to its potential acceptance by other Federal agencies, State and local governments, public interest groups, and individuals.

On the basis of this comparison of the alternatives, Alternative C was identified as the Selected Plan. This is primarily because Alternative C would closely meet the objectives and accomplishments of the Folsom Modification and Folsom Dam Raise projects, is functionally equivalent to those projects, incorporates dam safety risk reduction, would provide the greatest net benefits of all the alternatives considered, and is highly supported by the non-Federal sponsors.

ES.5.4 Selected Plan and Refined Authorized Projects Description

The Selected Plan (Alternative C above) includes constructing a six submerged tainter gate auxiliary spillway, raising Folsom Dam 3.5 feet, replacing three emergency spillway gates, and modifying the flood control storage space. The Refined Authorized Projects (RAP) include the Selected Plan along with two Other Features: ecosystem restoration (part of the authorized Folsom Dam Raise Project), and a permanent bridge replacement increment. **Figure ES-2** shows the major components of the RAP. Through the combination of the elements shown in the figure, the RAP addresses the specific objectives outlined above to achieve flood damage reduction and improve dam safety. The non-Federal project sponsor for the flood damage reduction portion of the RAP is the State of California through DWR. SAFCA is a co-sponsor with DWR and will enter into a cost-sharing agreement with Reclamation to pay for any portion of the OMRR&R costs related to the new flood damage reduction features.

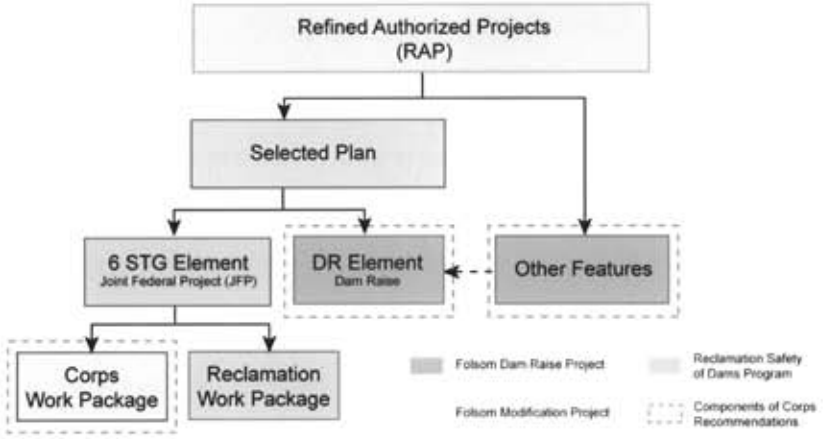


FIGURE ES-2
COMPONENTS AND RESPONSIBILITIES OF THE REFINED AUTHORIZED PROJECTS
In the RAP, Other Features are companion to the DR Element of the Selected Plan. Corps and Reclamation Work Packages make up the 6 STG Element.

ES.5.5 Accomplishments

The primary accomplishments of the RAP are as follows:

- **Flood Damage Reduction** – With the RAP, the existing level of flood risk to much of Sacramento (expressed as AEP) would be reduced from 0.0124 to 0.0054 (from a 1 in 81 chance in any year to a 1 in 185 chance). The RAP 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 240-year design flood event. This exceeds the minimum requirement of SAFCA and The Reclamation Board of the State of California (The Reclamation Board). The RAP would control a flood with a 3-day inflow volume to Folsom Reservoir of about 50 percent larger than the floods of record (1986 and 1997) in the American River basin.

  It is important to understand that the RAP is the next critical step for reducing the threat of flooding in Sacramento. With the RAP in place, a significant flood risk would still remain for the community. It is estimated that the RAP could reduce existing flood damages by about 54 percent.

- **Probable Maximum Flood** – With the RAP in place, the PMF in the upper American River watershed could be passed through Folsom Dam and Reservoir without danger of a major structural failure. Ability to pass the PMF would not reduce the frequency of

major flooding along the American River; however, it would reduce the potential of catastrophic overtopping and potential failure of Folsom Dam and appurtenant structures.

- **Other Features** – The RAP would also preserve the potential to implement ecosystem restoration features authorized by the Folsom Dam Raise Project along the lower American River. In addition, the RAP would be constructed consistent with the expedited implementation of a permanent bridge just downstream from Folsom Dam. The bridge will allow safe and efficient transportation from east Folsom to areas north of the American River near Folsom Reservoir.

ES.5.6 Major Features

As can be seen in **Figure ES-2**, the major feature of the RAP consists of the Selected Plan. The Selected Plan includes (1) an auxiliary spillway with six submerged tainter gates (6 STG Element) and (2) Folsom Dam raise (DR Element).

E.5.6.1 6 STG Element

The 6 STG Element consists of the auxiliary spillway with six submerged tainter gates and variable flood space operation.

- **Auxiliary Spillway with Six Submerged Tainter Gates** – A new auxiliary spillway with six submerged tainter gates would be located southwest of Folsom Dam. Features of the auxiliary spillway include (1) a 1,100-foot-long approach channel beginning in Folsom Lake, (2) a control structure, including six submerged tainter flood gates, (3) a 3,000-foot-long spillway chute with a bottom width of about 169 feet, and (4) a stilling basin in the American River. The control structure would be operated collectively with spillway gates on Folsom Dam to manage flood flows from Folsom Reservoir. These components of the Selected Plan are referred to in supporting documentation as the Joint Federal Project, or JFP. **Figure ES-3** shows a conceptual rendering of the auxiliary spillway and appurtenances in relation to the existing Folsom Dam.

  Both Reclamation and the Corps are to participate in the construction of the JFP. The relative amount of participation is based upon the relative cost of a single purpose dam safety project (a fuseplug spillway) and a single purpose flood damage reduction project (the same as the 6 STG Element). The value of participation is about 20 percent Reclamation (dam safety) and 80 percent Corps (flood damage reduction). The individual work items to construct the spillway were distributed into two work packages – one to be constructed by Reclamation to address dam safety (Reclamation Work Package), and one to be constructed by the Corps to address flood damage reduction (Corps Work Package). The work packages are based on the cost distribution and on increased engineering and construction efficiencies.

  As shown in **Figure ES-2**, each agency is to treat its work package as its project to construct. Although the project contains joint flood damage reduction and dam safety features and costs, the Corps Work Package will be the flood damage reduction cost and the Reclamation Work Package will be the dam safety cost. The cost of the Corps Work

Package is reported below. The cost of the Reclamation Work Package is under development.

- **Flood Space Operations** – The RAP also includes changing 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.

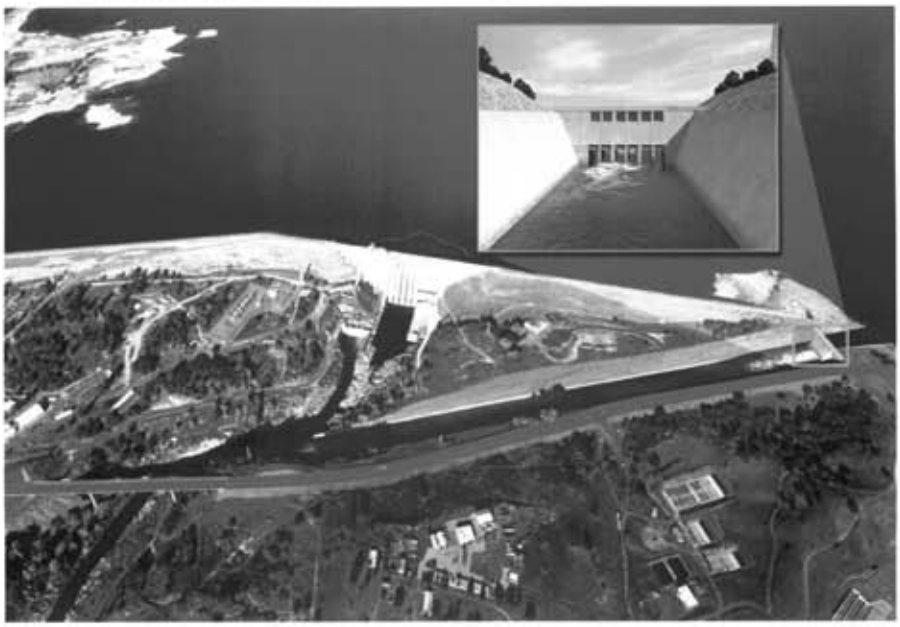


FIGURE ES-3
CONCEPTUAL RENDERING OF THE AUXILIARY SPILLWAY, SUBMERGED TAINTER GATE STRUCTURE, AND APPURTENANT FACILITIES

E.5.6.2 DR Element

As highlighted below, the DR Element for the Selected Plan primarily includes replacement of the emergency spillway gates and a 3.5-foot Folsom Dam raise. Further, the Other Features component of the DR Element includes ecosystem restoration and a bridge increment.

- **Spillway Gate Replacement** – Replacement of the three existing emergency spillway gates at Folsom Dam with 42-foot-wide by 59-foot-high tainter gates. This would allow 2 feet of freeboard for the emergency spillway tainter gates (in a closed position) when the reservoir is operated to maintain controlled releases of up to 160,000 cfs (emergency objective release).

- **Folsom Dam Raise** – Raising Folsom Dam and appurtenant facilities by 3.5 feet would result in an increase in flood storage capacity in Folsom Reservoir for flood damage reduction uses by approximately 46,200 acre-feet. This would be above (to elevation 474 feet above msl) the current authorized flood pool storage of 1.02 million acre-feet associated with a pool elevation of 470 feet above msl. This increase would be within the existing project boundary for Folsom Reservoir. Primary features of the raise would include raising the Mormon Island Auxiliary Dam and auxiliary dikes around Folsom Reservoir by 3.5 feet.

The 6 STG Element provides all of the performance and functionality that would have been achieved by the outlet works modifications of the authorized Folsom Modification Project. Additionally, the DR Element provides much of the performance and functionality that would have been provided by the authorized Folsom Dam Raise Project. It is important to note that under the authorized projects, the dam safety component rested with the Folsom Dam Raise Project. However, the 6 STG Element not only provides a significant increase in the reduction of flood risk along the lower American River, but it also resolves the PMF issues at Folsom by augmenting the existing spillway release capacity. Accordingly, the dam safety component of the authorized projects is included in the 6 STG Element and will be implemented by Reclamation as part of the Reclamation Work Package (see **Figure ES-2**).

ES.5.7 Operation, Maintenance, Repair, Replacement, and Rehabilitation

Physical operation of the enlarged Folsom Dam and Reservoir and emergency gates would be as under existing conditions. Timing and duration would be modified based on an updated Water Control Manual. The auxiliary spillway and gating system would require additional OMRR&R support. The non-Federal sponsor would enter into an agreement with Reclamation, as necessary, to facilitate the non-Federal sponsor's OMRR&R activities.

ES.5.8 Economics

Table ES-2 summarizes the total costs and benefits associated with the Selected Plan and RAP. As shown, the estimated first cost for the RAP is $973.7 million, excluding the cost of the Reclamation Work Package. The portion of this cost for flood damage reduction (Selected Plan) is $848.2 million. The estimated average annual cost of the Selected Plan is $43.5 million. Excluding potential benefits for the Folsom Dam Bridge and ecosystem restoration, the total estimated average annual benefits for the RAP associated with flood damage reduction are $107.1 million. The resulting net average annual flood damage reduction benefits for the RAP are $63.8 million.

As can be seen in **Table ES-2**, costs for the Selected Plan are different than the cost of Alternative C in **Table ES-1**. This is primarily because the costs for the Selected Plan and RAP were developed to a greater level of detail than the costs used to compare alternatives.

TABLE ES-2
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	75.1	8.9	84.0
Total	702.2	101.3	803.5
Annual Cost (Selected Plan) [3,4]			
Interest and Amortization	37.7	5.5	43.2
Operation and Maintenance	0.2	0.1	0.3
Subtotal	37.9	5.6	43.5
Annual Flood Damage Reduction Benefits	89.9	17.2	107.1
Net Annual Flood Damage Reduction Benefits	52.0	11.6	63.6
Benefit-to-Cost Ratio for Flood Damage Reduction	2.4	3.1	2.5

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.*

Table ES-2 also shows costs for a temporary bridge and a permanent bridge. The bridge costs are separated in this way to identify which portion of the new bridge cost at Folsom would be allocated to the Folsom Dam Raise Project cost, and which would be a local transportation betterment. The Folsom Dam Raise Project includes a temporary bridge to support the dam raise during its construction. All costs in excess of the temporary bridge cost that are needed to build a permanent bridge are treated as a separate increment in the Other Features portion of the DR Element (permanent bridge increment). The bridge is under construction and therefore the costs are sunk costs and are not part of the Folsom Dam Raise Project economic cost. The cost structure and cost-sharing of the bridge are discussed in detail in the Corps *2006 Folsom Dam Raise, Folsom Bridge Post Authorization Decision Document.* The bridge is scheduled to be completed in January 2009.

Figure ES-4 shows a breakdown of the first costs of the RAP according to the two major elements of the Selected Plan. The figure also shows how those costs are further allocated and apportioned between flood damage reduction and dam safety, and between Federal and non-Federal responsibilities.

ES.5.9 Implementation

Table ES-3 contains an implementation schedule for the Selected Plan portion of the RAP. A number of approvals/reviews are required to implement the Selected Plan portion of the RAP. Approvals allowing initiation of construction are expected to be obtained by June 2007.

The 6 STG Element (or JFP) would be implemented through the Corps Work Package, focusing on flood damage reduction features, and the Reclamation Work Package, focusing on dam safety features. Efforts related to ecosystem restoration features are being continued, as authorized, as part of the Folsom Dam Raise Project. The bridge is currently being constructed at Folsom Dam, also as part of the Folsom Dam Raise Project.

As indicated in **Table ES-3**, Reclamation may begin construction of its Work Package before all Corps flood damage reduction approvals are in place; construction could begin in September 2007. Initiation of the Corps Work Package is not expected until spring 2010. Almost 7 years would be required for construction of the 6 STG Element. Construction of the DR Element would be phased to begin well after the beginning of construction of the 6 STG Element. Construction of all project phases resulting in project accomplishments for flood damage reduction is not scheduled until 2016.

Project implementation depends in part on execution of several PCAs. Likely PCA requirements are described below in **Section ES.7**.

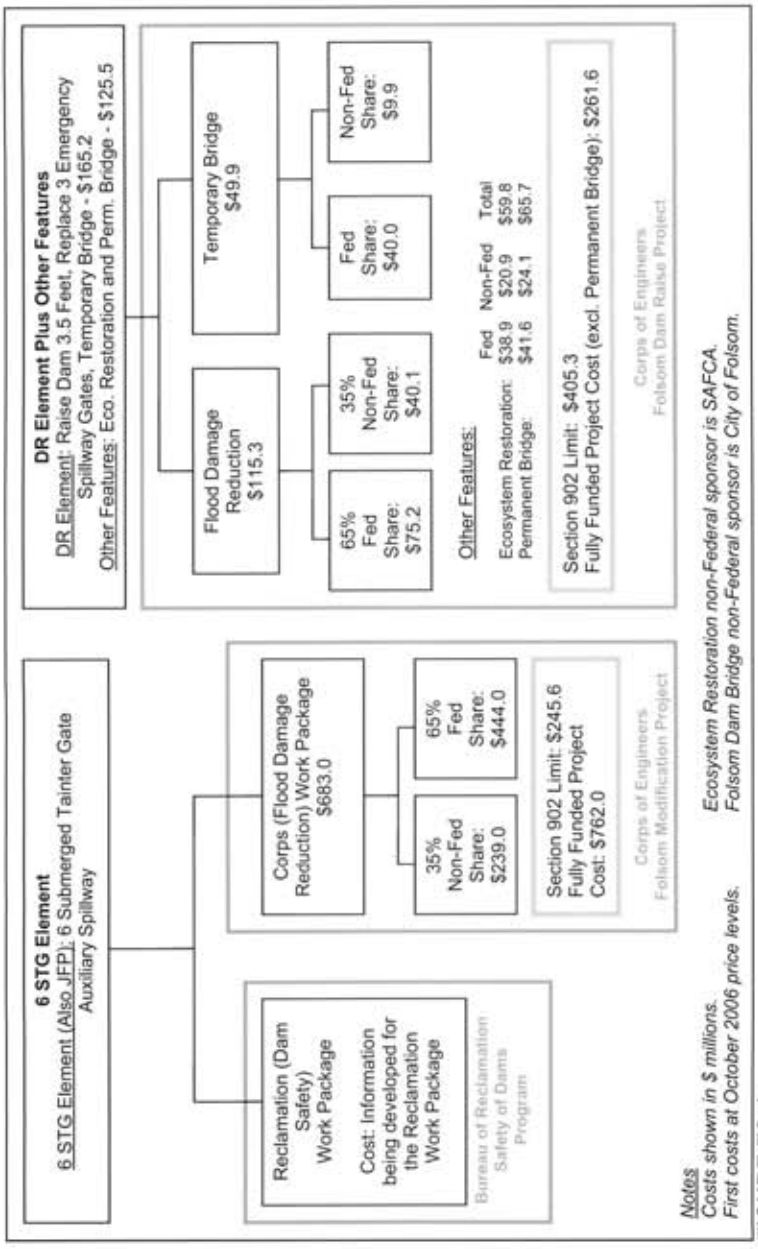


FIGURE ES-4
SUMMARY OF COSTS FOR THE REFINED AUTHORIZED PROJECTS ACCORDING TO ELEMENT

TABLE ES-3
IMPLEMENTATION SCHEDULE OF 6 STG ELEMENT AND DR ELEMENT

Task Name	Start Date	Finish Date
Project Approval Activities		
PAC & EIS/EIR Final Reports	In progress	June 2007
Folsom Modification & Related Activities[1]		
6 STG Element Construction		
-Reclamation Work Package	September 2007	2010
-Corps Work Package	2010	2014
Folsom Dam Reoperation & Forecast-Based Release		
-Decision Document & EIS/EIR	January 2007	June 2008
Folsom Dam Raise[2]		
Folsom Bridge Construction	February 2007	January 2009
Folsom Dam Raise Construction	2014	2016
Ecosystem Restoration Construction	2016	2019

Key: DR = dam raise; EIS/EIR = Environmental Impact Statement/Environmental Impact Report; PAC = Post Authorization Change; STG = submerged tainter gate

Notes:

1. *A more detailed schedule for activities related to the 6 STG Element is included in **Appendix C – Joint Federal Project Engineering Design Report**.*
2. *A more detailed schedule for activities related to the Folsom Dam Raise Project is included in **Appendix B – Folsom Dam Raise Project Engineering Design Report**.*

ES.6 CHANGES FROM AUTHORIZED PROJECTS

Changes from the existing authorized projects are summarized below:

- **Changes in Scope** – The functionality of the 6 STG and DR elements of the RAP is considered equivalent to that of the authorized Folsom Modification Project and Folsom Dam Raise Project. It should be noted that there is a recommended deletion of (1) the surcharge storage component of the Folsom Modification Project, and (2) the L.L. Anderson Dam component of the Folsom Dam Raise Project. Surcharge storage components would no longer be needed for flood damage reduction with the 3.5-foot dam raise and gate modification. L.L. Anderson Dam modifications are being accomplished independently by PCWA.
- **Changes in Location** – There has been no fundamental change in the location of the authorized projects. Whereas construction for the Folsom Modification Project focused on the main dam itself, the gated auxiliary spillway component of the RAP would occur adjacent to the dam.
- **Changes in Purpose** – The purpose of the RAP remains focused on flood damage reduction, an authorized project purpose. The RAP also includes a goal to resolve hydrologic dam safety issues at Folsom, similar to the Folsom Dam Raise Project. Ecosystem restoration and the Folsom Bridge, included in the authorized Folsom Dam Raise Project, continue to be implemented and are included in the RAP.
- **Changes in Designs** – The primary reasons for design changes between the authorized projects and RAP are recent findings that the auxiliary gated spillway would be a more effective and efficient method of evacuating the flood space in Folsom Reservoir earlier

in a storm event, while also resolving hydrologic dam safety issues at Folsom Dam. **Table ES-4** summarizes design changes between the authorized projects and the RAP. All other features would remain unchanged.

TABLE ES-4
SUMMARY OF PROJECT COMPONENTS[1]

Item	Folsom Modification Project (2003 LRR)[2]	Folsom Dam Raise Project (2004 E&WDAA)	Refined Authorized Projects (RAP)	
			6 STG Element	DR Element[3] and Other Features
FOLSOM DAM				
Main Dam				
Main Concrete Dam	–	Raise dam crest 7.0 feet	–	–
Wing Dams	–	Raise wing dams 7.0 feet	–	Raise wing dams 3.5 feet
Spillway & Stilling Basin	Construct additional anchorage for spillway stilling basin	Enlarge spillway stilling basin	–	–
Outlets	• Enlarge 8 existing outlets (9'4" by 14' upper tier & 9'4" by 12' lower tier) • Construct 2 new upper tier outlets • Construct eyebrow deflectors on all outlets	–	–	–
Emergency Gates	Replace 3 emergency spillway tainter gates with 42' by 59' tainter gates (new top of gate elevation of 476.0 feet above msl)	Replace 3 emergency spillway tainter gates with 66' high tainter gates (new top of gate elevation of 484.0 feet above msl)	–	Replace 3 emergency spillway tainter gates with 42' by 59' tainter gates (new top of gate elevation of 476.5 feet above msl)
Main Spillway Gates	–	Replace spillway gates	–	–
Dikes				
Mormon Island Auxiliary Dam	–	Raise dike 7.0 feet	–	Raise dike 3.5 feet
Dike 5	–	Raise dike 7.0 feet	–	Raise dike 3.5 feet
Dike 7	–	Raise dike 7.0 feet	–	Raise dike 3.5 feet
Other Dikes	–	Raise dikes 7.0 feet	–	Raise dikes 3.5 feet
Auxiliary Spillway	–	–	Auxiliary spillway with 6 STGs (33' high by 23' wide) at gate sill elevation 368 feet above msl	–
OTHER FEATURES				
Folsom Bridge	–	Construct a temporary and permanent bridge downstream from Folsom Dam	–	Advanced implementation of Folsom Dam Bridge
L.L. Anderson Dam Spillway Modification	–	Modify L.L. Anderson Dam spillway at French Meadows Reservoir	–	L.L. Anderson Dam spillway modification will be implemented by Placer County Water Agency separately from the DR Element
Ecosystem Restoration	–	Implement ecosystem restoration features to benefit the lower American River	–	Ecosystem restoration efforts continue as authorized

Key: – = does not apply; DR = dam raise; E&WDAA = Energy and Water Development Appropriations Act; LRR = Limited Reevaluation Report; msl = mean sea level; STG = submerged tainter gate

Notes:

1. *Assumes objective release of 160,000 cfs for a sustained time (currently being evaluated) as part of flood operations for without-project conditions.*
2. *Plan described in the Corps November 2003 American River Watershed, California, Final Limited Reevaluation Report and Environmental Assessment/Initial Study (2003 LRR).*
3. *Dam Raise Element includes a 3.5-foot raise of the wing dams and dikes; the main dam crest will not be raised.*

- **Changes in Total Project First Costs** – Changes in total project first costs are shown in **Table ES-5**. The authorized first cost for the Folsom Modification Project in Section 101(a) of WRDA 1999 is $150 million. That cost was updated in the Corps *2003 Folsom Dam Modification Project, Final Limited Reevaluation Report* to $214.1 million ($183.8 million for the outlet works modification and $30.3 million for surcharge storage). After updating to October 2006 price levels, the cost is $242.5 million. The authorized first cost for the Folsom Dam Raise Project in Section 128 of the Energy and Water Development Appropriations Act of 2004 is $257.3 million. The Corps *2002 Chief of Engineers Report* on the Folsom Dam Raise Project presented an updated first cost of $248.6 million ($297.7 million updated to October 2006 price levels).

TABLE ES-5
SUMMARY COMPARISON OF COSTS AND BENEFITS ($ MILLIONS)

Item	Authorized Projects					Refined Authorized Projects (2006 Price Levels)		
	Folsom Modification		Folsom Dam Raise		Combined Projects	6 STG Element (Corps Work Package)	DR Element and Other Features	Total
	2003 LRR[1]		2002 Chief of Engineers Report[2]					
	2003 Price Levels	2006 Price Levels	2001 Price Levels	2006 Price Levels	2006 Price Levels			
First Cost								
Flood Damage Reduction	214.1	242.5	128.2	153.5	396.0	683.0	165.2	848.2
Other Features	0	0	120.4[3]	144.2[3]	144.2[3]	[5]	125.5[6]	125.5[6]
Total	**214.1**	**242.5**[4]	**248.6**	**297.7**[4]	**540.2**[4]	**683.0**	**290.7**	**973.7**
Annual Cost (Flood Damage Reduction)	15.6	17.7	10.2	12.2	29.9	37.9[7]	5.6[7]	43.5[7]
Annual Benefits (Flood Damage Reduction)	31.2	35.3	19.2	23.0	58.3	89.9	17.2	107.1
Net Benefits	15.6	17.6	9.0	10.8	28.4	52.0	11.6	63.6
Benefit-to-Cost Ratio	2.0	2.0	1.9	1.9	1.9	2.4	3.1	2.5
Key:	DR = dam raise LRR = Limited Reevaluation Report				STG = submerged tainter gate			

Notes:

1. *Corps 2003 American River Watershed, California, Folsom Dam Modification Project, Final Limited Reevaluation Report and Environmental Assessment/Initial Study, November.*
2. *Corps 2002 Chief of Engineers Report, American River Watershed, California, Long-Term Study, 5 November.*
3. *Includes ecosystem restoration and dam safety at $27.4 million and $93 million, respectively, at 2001 price levels, and $32.8 million and $111.4 million, respectively, at 2006 price levels.*
4. *Total cost of the authorized projects repriced to current price levels would be significantly greater at about $1,390 million ($655 million for Folsom Modification Project and $737 million for Folsom Dam Raise Project).*
5. *Plan elements to be accomplished under Reclamation Safety of Dams Program.*
6. *Includes ecosystem restoration (continued increment) at $59.8 million and permanent bridge increment at $65.7 million.*
7. *Annual costs from* ***Table ES-2****.*

The combined first cost of the authorized projects at prices updated to 2006 price levels is $540.2 million. In comparison, the total first cost for the RAP is $957.7 million (less costs for dam safety) and the total cost for the Selected Plan portion of the RAP is $842.4 million. The changes in total and project-related costs are due to changes in features attributed to each project and updating of costs to current price levels.

- **Change in Cost Allocation – Table ES-6** shows a comparison of first costs between both project purposes for the authorized projects (at base condition price levels) and the RAP at October 2006 price levels.

TABLE ES-6
SUMMARY COMPARISON OF COST ALLOCATION BY PROJECT PURPOSE INCLUDING DAM SAFETY FUNCTION ($ MILLIONS)

Item	Authorized Projects[1]						Refined Authorized Projects (2006 Price Levels)					
	Folsom Modification (2003 prices)		Folsom Dam Raise (2001 prices)		Combined (at indicated prices)		6 STG Element (Corps Work Package)		DR Element and Other Features		Total	
	First Cost	% of Total	First Cost	% of Total	First Cost	% of Total	First Cost	% of Total	First Cost	% of Total	First Cost	% of Total
Flood Damage Reduction	214.1	100	128.2	52	342.3	74	683.0	100	165.2[2]	57	848.2	87
Ecosystem Restoration[3]	0	0	27.4	11	27.4	6	0	0	59.8	20	59.8	6
Dam Safety	0	0	93.0	37	93.0	20	[4]	0	0	0	[4]	0
Permanent Bridge[5]	–	–	–	–	–	–	0	0	65.7	23	65.7	7
Total	**214.1**	**100**	**248.6**	**100**	**462.7**	**100**	**683.0**	**100**	**290.7**	**100**	**973.7**	**100**

Key: – = does not apply; DR = dam raise; STG = submerged tainter gate

Notes:

1. *Combination of costs at the time of authorization and/or last updated (Corps 2003 American River Watershed, California, Folsom Dam Modification Project Final Limited Reevaluation Report and Environmental Assessment/Initial Study – Outlet Works Modification only). Total combined first cost updated to October 2006 price levels would be $540.2 million.*
2. *Includes features cost-shared at 65 percent Federal and 35 percent non-Federal, as well as temporary bridge cost, which includes a Corps-budgeted dam safety cost that is subject to Reclamation determination of which part, if any, may be subject to reimbursement by the Central Valley Project.*
3. *Continued increment in Refined Authorized Projects (RAP). Not a part of Selected Plan.*
4. *Reclamation Dam Safety Work Package to be accomplished under the Reclamation Safety of Dams Program.*
5. *Advanced construction increment and temporary bridge increment as part of RAP. Not a part of Selected Plan.*

- **Changes in Cost Apportionment – Table ES-7** compares the apportionment of first costs to Federal, non-Federal, and dam safety categories. All costs are shown at October 2006 price levels. The total costs portion of the Selected Plan for dam safety would be the responsibility of Reclamation under that agency's Safety of Dams Program. The apportionment of costs changed primarily because the 6 STG Element resolves hydrologic dam safety issues at Folsom; dam safety was originally addressed under the Folsom Dam Raise Project authority.

TABLE ES-7
SUMMARY COMPARISON OF COST APPORTIONMENT BY PROJECT PURPOSE INCLUDING DAM SAFETY

Item	Authorized Projects [1] (2006 price levels)					Refined Authorized Projects (RAP) (2006 price levels)				
	Federal [2]	Non-Federal	Subtotal	Dam Safety [3]	Total	Federal [2]	Non-Federal	Subtotal	Dam Safety [3]	Total
	Folsom Modification Project					6 STG Element (Corps Work Package)				
First Cost										
Flood Damage Reduction	157.6	84.9	242.5	–	242.5	444.0	239.0	683.0	–	683.0
Dam Safety	–	–	–	–	0	–	–	–	[4]	[4]
Total	157.6	84.9	242.5	–	242.5	–	239.0	683.0	–	683.0
Percent – Flood Damage Reduction	65	35	100	–	100	65	35	100	–	100
Percent – Total Cost	65	35	100	–	100	65	35	100	–	100
	Folsom Dam Raise Project					DR Element				
First Cost										
Flood Damage Reduction	100.4	53.1	153.5	–	153.5	115.2[5]	50.0[5]	165.2	–	165.2
Dam Safety	–	–	–	111.4	111.4	–	–	–	–	–
Ecosystem Restoration	21.3	11.5	32.8	–	32.8	38.9	20.9	59.8	–	59.8
Permanent Bridge	–	–	–	–	–	41.6	24.1	65.7	–	65.7
Total	121.7	64.6	186.3	111.4	297.7	195.7	95.0	290.7	–	290.7
Percent – Flood Damage Reduction	65	35	100	–	100	70[5]	30[5]	100	–	100
Percent – Total Cost	41	22	63	37	100	67	33	100	–	100
	Combined Projects					Total RAP				
First Cost										
Flood Damage Reduction	258.0	138.0	396.0	–	396.0	559.2	289.0	848.2	–	848.2
Dam Safety	–	–	–	111.4	111.4	–	–	–	[4]	[4]
Ecosystem Restoration	21.3	11.5	32.8	–	32.8	38.9	20.9	59.8	–	59.8
Permanent Bridge	–	–	–	–	–	41.6	24.1	65.7	–	65.7
Total	279.3	149.5	428.8	111.4	540.2	639.7	334.0	973.7	[4]	973.7
Percent – Flood Damage Reduction	65	35	100	–	100	66	34	100	–	100
Percent – Total Cost	52	28	79	21	100	66	34	100	–	100

Key: – = does not apply; DR = dam raise; STG = submerged tainter gate

Notes:

1. *The cost of the authorized projects repriced to current price levels would be significantly greater than shown in this table, at about $1,390 million ($655 million for the Folsom Modification Project and $737 million for Folsom Dam Raise Project).*
2. *Corps of Engineers' budgetary responsibility.*
3. *Reclamation Safety of Dams Program item.*
4. *Plan elements to be accomplished under the Reclamation Safety of Dams Program.*
5. *Includes features cost-shared at 65 percent Federal and 35 percent non-Federal, as well as temporary bridge cost of $21.5 million that is subject to Reclamation determination of which part, if any, may be subject to reimbursement by Central Valley Project water or power contractors.*

- **Changes in Local Cooperation Requirements** – After the *PAC Report* is approved, and pending funding, design would proceed at Federal expense. This effort will be based on the PCAs between the Department of the Army and the non-Federal sponsors. The Department of the Army will enter into a PCA with the State of California and possibly SAFCA for the Folsom Modification Project, and with the State of California and SAFCA for the Folsom Dam Raise Project, at which time, the non-Federal share of design phase would be recouped. The Department of the Army and the City of Folsom have signed a separate PCA for Folsom Bridge.
- **Environmental Commitments** – The Reclamation *2007 Final Folsom Dam Safety and Flood Damage Reduction EIS/EIR* analyzed alternatives that address Reclamation dam safety objectives, as well as addressing Corps flood damage reduction objectives, as discussed in this *PAC Report*. In addition, an *EIS/EIR* for the Corps *2002 American River Watershed, California, Long-Term Study* fully evaluated potential impacts associated with a Folsom Dam raise of 3.5 feet. There has been no fundamental change in the types of impacts and required mitigation between the authorized projects and the RAP. Potentially significant adverse effects have been identified for geology and soils, traffic, water quality, fisheries, cultural resources, recreation, and noise. Implementation of proposed mitigation measures, as described in the *2007 EIS/EIR*, would reduce these impacts to less than significant levels. An environmental commitment of mitigation, to be implemented prior to, or concurrent with, construction activities, would be required to reduce potentially significant impacts for vegetation and wildlife, and special-status species.

ES.7 12 ACTIONS FOR CHANGE

The "12 Actions for Change" are a set of actions that the Corps will focus on to transform its priorities, processes, and planning. These actions were identified by the Corps and other investigative teams analyzing the performance of the Greater New Orleans Hurricane Protection System. They point to the need to transform the way the Corps serves the Nation and its Armed Forces. These 12 Actions were developed from that analysis and from other internal and external examinations of the Corps in the recent past. The Corps will use the 12 Actions to guide ongoing and future work, and to ensure the Corps is an organization that is adaptable, flexible, and responsive to the needs of the Nation. The 12 Actions for Change fall within three overarching themes: effective implementation of a comprehensive systems approach; communication; and reliable public service professionalism. The Folsom Modification Project and Folsom Dam Raise Project account for and contribute to the 12 Actions.

ES.8 CONCLUSIONS AND RECOMMENDATIONS

This evaluation provides pertinent conclusions and a list of Federal and non-Federal responsibilities for implementation of the Selected Plan, as included in the RAP. In addition, based on the findings presented in this report and supporting documents, the following recommendations are presented:

- Approval of the RAP as the plan that responds to the relevant authorities.
- Approval of dividing the 6 STG Element of the Selected Plan into two work packages that will be constructed by the Corps and Reclamation separately.
- Approval and forwarding to Congress a request for an increased new authorized cost for the Folsom Modification Project.
- Use of this document to support the PCAs for implementing those project features identified to be implemented by the Corps.
- Implement, as planned, separable ecosystem restoration project features.
- Continued implementation of the permanent Folsom Bridge Project.
- A further investigation of project features to address the significant residual flood risk to the greater Sacramento metropolitan area.

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ACRONYMS AND ABBREVIATIONS

	12 Actions	United States Army Corps of Engineers 12 Actions for Change
A	AEP	annual exceedence probability
	ARWI	American River Watershed Investigation
B	BMP	best management practice
C	CEQA	California Environmental Quality Act
	CERCLA	Comprehensive Environmental Response, Compensations, and Liability Act
	CFR	Code of Federal Regulations
	cfs	cubic feet per second
	CNP	conditional nonexceedence probability
	Corps	United States Army Corps of Engineers
	CVP	Central Valley Project
D	DR	dam raise
	DWR	California Department of Water Resources
E	EA	Environmental Assessment
	EDS&A	engineering, design, supervision, and administration
	EIR	Environmental Impact Report
	EIS	Environmental Impact Statement
	elevation xxx	elevation in feet above mean sea level
	EQ	environmental quality
	ESRD	Emergency Spillway Release Diagram
F	FEMA	Federal Emergency Management Agency
	FERC	Federal Energy Regulatory Commission
	FONSI	Finding of No Significant Impact
	FY	fiscal year
H	HEP	Habitat Evaluation Procedure
I	IS	Initial Study
J	JFP	Joint Federal Plan
	kW	kilowatt
L	LERRD	lands, easements, rights-of-way, relocations, and disposal areas

	LOP	level of protection
	LRR	Limited Reevaluation Report
M	M&I	municipal and industrial
	MCACES	microcomputer-aided cost engineering system
	MIAD	Mormon Island Auxiliary Dam
	MND	Mitigated Negative Declaration
	MOA	memorandum of agreement
	msl	mean sea level
N	NED	national economic development
	NEMDC	Natomas East Main Drainage Canal
	NEPA	National Environmental Policy Act
	NO_x	nitrogen oxides
O	OMRR&R	operate, maintaintenance, repair, replacement, and rehabilitatation
	OSE	other social effects
P	P&G	Federal Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
	PAC	Post Authorization Change
	PADD	Post Authorization Decision Document
	PASS	Project Alternative Solutions Study
	PCA	Project Cooperation Agreement
	PCWA	Placer County Water Agency
	PED	preconstruction, engineering, and design
	PL	Public Law
	PMF	Probable Maximum Flood
	PMS	Probable Maximum Storm
R	RAP	Refined Authorized Projects
	Reclamation	United States Department of the Interior, Bureau of Reclamation
	RED	regional economic development
S	SAFCA	Sacramento Area Flood Control Agency
	SIR	Supplemental Information Report
	SMAQMD	Sacramento Municipal Air Quality Management District
	STG	submerged tainter gate

	SWP	State Water Project
T	The Reclamation Board	The Reclamation Board of the State of California
U	USFWS	United States Fish and Wildlife Service
W	WRDA	Water Resources Development Act

CHAPTER 1.0
INTRODUCTION

1.1 PURPOSE AND SCOPE OF REPORT

The purpose of this *Post Authorization Change* (PAC) *Report* is to document changes to two authorized projects: the Folsom Modification Project and the Folsom Dam Raise Project. Both projects share an objective of improving flood management on the lower American River, primarily through structural modifications to the existing Folsom Dam and appurtenant facilities. This *PAC Report* describes recommended changes to these authorized projects. It is anticipated that these changes will include reducing flood risk to areas along the American River, California, generally equivalent to the flood protection intended to be provided by combining the existing authorized Folsom Modification Project with the Folsom Dam Raise Project. It is also anticipated that the recommended changes will include provisions to meet the United States Department of the Interior, Bureau of Reclamation's (Reclamation), objective of passing the Probable Maximum Flood (PMF) at Folsom Dam. The updated information is to be presented as part of a single, joint project that addresses the objectives of the United States Army Corps of Engineers' (Corps) previously authorized flood damage reduction projects and Reclamation's dam safety concerns in a more efficient and effective manner.

This *PAC Report* is intended to accomplish the following:

- Demonstrate consistency of a refined project with existing congressional project authorizations
- Report on changes to project accomplishments and benefits, and Federal interest in a refined project
- Serve as a basis for new Project Cooperation Agreements (PCA), as needed, between the Federal Government and local sponsors
- Seek revision for authorized project cost for the Folsom Modification Project from Congress, as appropriate

As a companion to the *PAC Report*, Reclamation is preparing information to support designs and construction of dam safety improvements at Folsom Dam as part of Reclamation's Safety of Dams program. Some of the actions described in the Folsom Modification and Folsom Dam Raise projects are independent of, or in addition to, elements incorporated into the Refined Authorized Projects (RAP) described in **Chapter 4**; these include static and seismic modifications, which are being implemented solely by Reclamation and are considered part of the without-project condition for this PAC (see **Chapter 3**).

Reclamation, as the lead Federal agency, with participation by the Corps as a cooperating agency, has prepared the *2007 Final Folsom Dam Safety and Flood Damage Reduction Environmental Impact Statement/Environmental Impact Report* (EIS/EIR), which discloses potential environmental impacts of action alternatives meeting Reclamation dam safety and Corps flood damage reduction objectives. The action alternatives include features that would

address Reclamation's dam safety objectives and the Corps' flood damage reduction objectives jointly, as well as features that would exclusively address dam safety, security, or flood damage reduction objectives. Project features are expected to be constructed jointly by Reclamation and the Corps. The increments or features that exclusively address dam safety or flood damage reduction would be constructed by the appropriate agencies. Since the *EIS/EIR* alternatives include additional features not addressed in the *PAC Report*, the *EIS/EIR* perspective contrasts with the *PAC Report*, resulting in a different without-project condition.

The Reclamation *Draft Folsom Dam Safety and Flood Damage Reduction EIS/EIR* (2006c) was circulated for public review, in conjunction with the draft Corps *PAC Report* (2006d), from 1 December 2006 until 26 January 2007. Public meetings were held on 9 and 10 January 2007 to allow the public and interested agencies the opportunity to provide oral and written comments. The Corps intends to adopt the *2007 Final Folsom Dam Safety and Flood Damage Reduction EIS/EIR* (Reclamation) to satisfy the requirements of the National Environmental Policy Act (NEPA) for changes to the originally authorized Folsom Modification and Folsom Dam Raise projects, as appropriate.

1.2 FOLSOM DAM AND RESERVOIR

Folsom Dam and Reservoir are located downstream from the confluence of the north and south forks of the American River, near the City of Folsom. Folsom Dam is located approximately 20 miles northeast of Sacramento. Folsom Reservoir has a capacity of 977,000 acre-feet with a surface area of 11,450 acres.

Originally authorized in 1944 as a 355,000-acre-foot flood control unit, Folsom Dam was reauthorized in 1949 as a larger, multiple-purpose facility. The Corps constructed Folsom Dam and transferred it to Reclamation for coordinated operation as an integral part of the Central Valley Project (CVP). Construction of the dam began in October 1948 and was completed in May 1956. Water was first stored in February 1955.

Folsom Dam is a concrete gravity dam 340 feet high and 1,400 feet long. The main section is flanked by two earthfill wing dams. The right wing dam is 6,700 feet long and 145 high, and the left wing dam is 2,100 feet long and also 144 feet high. In addition to the main section and wing dams are one auxiliary dam and eight smaller earthfill dikes. All retention structures have a crest elevation of 480.5 feet (National Geodetic Vertical Datum of 1929) above mean sea level (msl). The concrete dam has a solid parapet wall with a top elevation of 484 feet. (For the remainder of the report, all elevations given are in feet above or below msl, unless otherwise stated.) Folsom Reservoir's normal operating pool is 977,000 acre-feet with a reservoir water surface at elevation 466 feet. The design surcharge pool is 1,084,780 acre-feet at reservoir water surface elevation 475.4 feet, with 5.1 feet of existing freeboard.

1.3 BACKGROUND

In February 1986, major storms in Northern California caused record flood flows in the American River basin. Record high outflows from Folsom Dam and Reservoir, together with high flows in the Sacramento River, resulted in water levels rising above the design freeboard of

levees protecting the Sacramento area. It was clear after the 1986 storm event that Sacramento was a city at significant risk of flooding, and major efforts would be needed to reduce the potential of catastrophic flooding and damages. Soon after the 1986 flood, feasibility-scope investigations were initiated by the Corps with support from The Reclamation Board of the State of California (The Reclamation Board) and local cities and counties (and later, from the Sacramento Area Flood Control Agency, or SAFCA). An initial *American River Watershed Investigation* (ARWI) *Feasibility Report and EIS/EIR* was completed by the Corps in December 1991. This report confirmed the flood threat, identified potential alternatives to help address flooding problems, and surfaced possible dam safety issues at Folsom Dam. As described below, this report resulted in congressional authorization in 1993 for improvements to levees in the Natomas area of Sacramento and guidance on further studies. Later supplements to the *1991 ARWI Feasibility Report* have resulted in further recommendations for improvements to local levees, the operation of Folsom Dam and Reservoir, and flood warning and evacuation planning. However, a residual need remains to provide higher levels of flood protection to the Sacramento area.

The Water Resources Development Act (WRDA) of 1999, along with supplemental documentation, identified potential modifications to Folsom Dam that would allow operators to achieve the objective release of 115,000 cubic feet per second (cfs) earlier in a flood event, and enhance the use of surcharge storage space in the reservoir through modifications to the emergency spillway and related operational changes; the project was termed the Folsom Modification Project. In the Energy and Water Development Appropriations Act of 2004, Congress authorized a plan to raise Folsom Dam; the Folsom Dam Raise Project would provide flood benefits while also resolving certain dam safety issues associated with passing the PMF. Because of delays and technical problems associated with implementing the Folsom Modification Project authorized in WRDA 1999, compatibility with the potential to raise Folsom Dam, and ongoing dam safety issues at Folsom, an emphasis now exists on considering these individual projects together.

1.4 HISTORY

This section summarizes the history of flood management, studies, and actions in the American River basin leading to preparation of this *PAC Report*. Discussion begins with major flood damage reduction actions following the floods of February 1986.

1.4.1 1986 Through 1993 Defense Appropriations Act

It is estimated that major sections of levees along the American and Sacramento rivers would likely have failed if the storms of February 1986 had lasted longer. These failures would potentially have resulted in significant loss of life, immediate loss of billions of dollars in property damages, and additional billions of lost dollars in regional impacts and restoration costs. The 1986 storms raised concerns over the adequacy of the existing flood damage reduction system protecting Sacramento. These concerns led to a series of investigations and subsequent authorizations of projects, beginning with the ARWI, to help increase the level of flood protection to the Sacramento area and address safety issues at Folsom Dam. A time line of pertinent studies, authorizations, and appropriations is included in **Figure 1-1**.

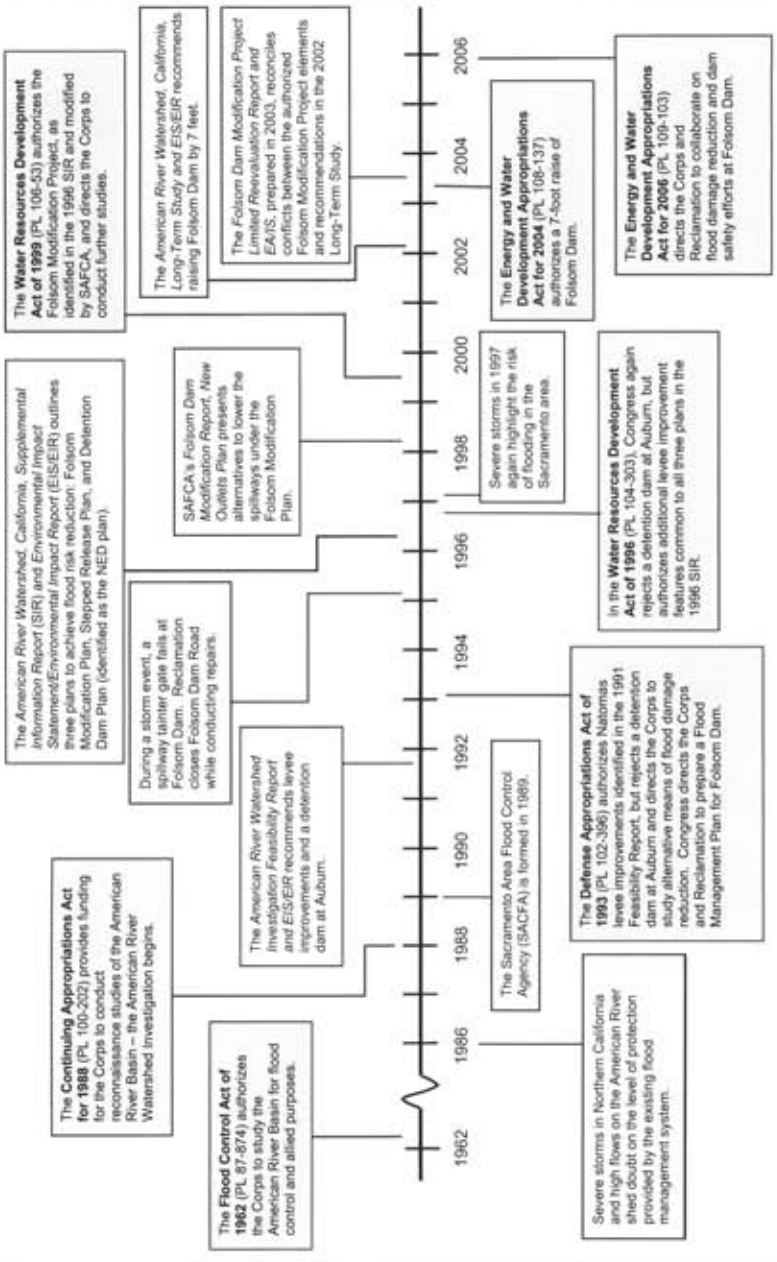


FIGURE 1-1
TIME LINE OF PERTINENT STUDIES, AUTHORIZATIONS, AND APPROPRIATIONS

The first major document addressing flood management on the American River was the *ARWI Feasibility Report*, dated December 1991 (Corps). This report included a decision document, *EIS*, and *EIR*. The *EIS/EIR* was completed to satisfy both the requirements of NEPA and the California Environmental Quality Act (CEQA).

Major conclusions of the *1991 ARWI Feasibility Report* were that (1) a serious flood threat existed for the Sacramento area from the American and Sacramento rivers, (2) a series of alternative plans was capable of helping to reduce the threat of flooding that included improvements to the levee system, modification of Folsom Dam and Reservoir, and new upstream storage, and (3) strong non-Federal support existed for implementing these improvements. The plan recommended in the *1991 ARWI Feasibility Report* was a flood detention dam on the North Fork American River and levee improvements in the Natomas area of Sacramento sufficient to control runoff from storms occurring, on average, about once every 200 years. This level of protection (LOP) was chosen by The Reclamation Board and SAFCA as a minimum of flood protection that they would support.

Project Performance Statistics

Performance of flood projects can be characterized in different ways. Flood project performance was historically characterized by the Corps using a "level of protection" concept. Level of protection (LOP) expresses the average return period, in years, of the largest storm event that can be safely accommodated by a project. A 100-year LOP means that on average, over a very long period of time, flooding would happen about once every 100 years.

More recently, the Corps has adopted risk-based analysis to more accurately describe flood performance and risk. The following terms are typical outputs of risk-based analysis:

- **Annual exceedence probability (AEP) –** AEP expresses the probability that a project will perform satisfactorily given any storm that may occur. It is the statistical probability that a specific capacity or target stage will be reached or exceeded in any given year, expressed as a chance or percent probability.
- **Conditional non-exceedence probability (CNP) –** CNP expresses estimated project reliability given the occurrence of a storm of a specific frequency - for example, the probability that a project will safely contain a storm event with a 2 percent chance of occurring in any given year. For levees, CNP includes both the chance of capacity exceedence and the chance of failure at a lesser stage.

Many studies and reports prepared for the American River Watershed Investigation prior to the mid-1990s estimated project performance in terms of a single event or LOP. For this reason, LOP is often used in the description of previously authorized projects discussed in this *PAC Report*. However, current risk-based techniques are used in describing and comparing current alternatives or proposed changes to the authorized projects. While LOP and risk-based measures such as AEP and CNP seem similar, they cannot be directly compared.

This PAC Report

Characterizing flood threat, or project performance, for analytical purposes as a single event is not allowed under current Corps risk-based guidance. For example, the 100-year event (single design event LOP) is distinct from the 1 in 81 chance in any given year (risk-based analysis project performance under Corps criteria). However, the non-Federal sponsors for the authorized projects have found that describing flood conditions in Sacramento in terms of a single event is a convenient way of imparting information about project performance. The non-Federal sponsors have established safely passing the 200-year computed design event as a minimum objective of any potential project change considered. Accordingly, efforts are made in this *PAC Report* to characterize the ability of alternatives considered for achieving the non-Federal objective as well as defining performance in terms consistent with Corps guidance.

After completion and processing of the *1991 ARWI Feasibility Report*, Congress provided guidance relating to the American River study in Section 9159 of the 1993 Defense Appropriations Act (see Existing Project Authorizations section below). As shown in **Figure 1-1**, this Act authorized construction of the Natomas features described in the *1991 ARWI Feasibility Report*. In addition, the Act directed that additional studies and consulting activities be undertaken to further develop a flood protection plan for Sacramento.

1.4.2 1991 American River Watershed Investigation Feasibility Report Through Water Resources Development Act of 1996

Following completion of the *1991 ARWI Feasibility Report*, and resulting Congressional guidance in the 1993 Defense Appropriations Act, additional studies were undertaken to further review the flood problems and develop additional solutions. This second major study effort was documented by the Corps, The Reclamation Board, and SAFCA in the March *1996 American River Watershed Project, California, Supplemental Information Report* (1996 SIR). This report included a decision document and *EIS/EIR*.

Major conclusions of the *1996 SIR* were similar to the *1991 ARWI Feasibility Report*: (1) a serious flood threat existed for the Sacramento area, (2) a series of alternative plans existed that were capable of helping reduce the threat of flooding, and (3) strong non-Federal support existed for implementing these improvements. In addition, it was described in the *1996 SIR* that Folsom Dam could only pass between about 70 to 75 percent of the PMF. Even though flooding would be severe if Folsom Dam could pass the PMF, it would be increasingly catastrophic if the dam were overtopped during such an event. Following is a summary of the three basic alternatives described in the *1996 SIR*:

- **Folsom Modification Plan** – This plan was formulated to achieve the greatest benefits to flood damage reduction while minimizing impacts to existing systems and environmental resources. Its primary features included (1) a minor increase in variable flood control space in Folsom Reservoir, (2) modifications to the main spillway, spillway gates, and outlets at Folsom Dam, (3) modifications to use of surcharge storage in Folsom Reservoir, (4) construction of a slurry wall in about 24 miles of existing levees along the lower American River to increase the reliability of the 115,000 cfs objective release, and (5) strengthening of about 12 miles of levees along the Sacramento River to help protect the Natomas area. At that time, it was estimated that this plan would provide about a 1 in 180 annual exceedence probability.
- **Folsom Stepped Release Plan** – This plan was formulated to provide at least a 200-year LOP goal, identified by The Reclamation Board and SAFCA, but without new upstream storage or any additional increase in seasonal flood space in Folsom Reservoir. Its primary features included (1) modifying the main spillway, spillway gates, and outlets at Folsom Dam, (2) modifying use of surcharge storage in Folsom Reservoir, (3) increasing the objective release from Folsom Dam to 145,000 cfs and 180,000 cfs, depending on reservoir inflows, (4) constructing levee, channel, and other improvements, including a slurry wall in existing levees along the lower American River to handle the increased objective release, (5) modifying the Sacramento Weir and Bypass and Yolo Bypass to accommodate the increased objective release, (6) strengthening about 12 miles of levees

along the Sacramento River to help protect the Natomas area, and (7) constructing recreation and environmental restoration facilities along the American River Parkway. At that time, it was estimated that this plan would provide about a 1 in 235 annual exceedence probability.

- **Flood Detention Dam Plan** – This plan was formulated to provide a very high level of flood protection to Sacramento. Its primary features included (1) constructing a flood detention dam on the North Fork American River, (2) constructing a slurry wall in about 24 miles of existing levees along the lower American River to increase the reliability of the 115,000 cfs objective release, (3) strengthening about 12 miles of levees along the Sacramento River to help protect the Natomas area, and (4) reducing the flood control storage space in Folsom Reservoir to pre-1995 conditions (returning the flood space to 400,000 acre-feet). At that time, it was estimated that this plan would provide about a 500-year LOP.

The plan recommended in the *1996 SIR* was the Flood Detention Dam Plan. It was also noted in the *1996 SIR* that a decision on how to best resolve the PMF issue at Folsom would be deferred until an independent decision was made on a long-term flood protection project for Sacramento. This is because it was determined that the scope of a resolution of the PMF issue would greatly depend on the long-term project selected for implementation.

After completion and processing of the *1996 SIR*, Congress authorized only a portion of the recommended plan. The authorized elements became known as the "Common Features" because they consisted of levee and other flood system improvements common to all three of the alternatives put forth in the *1996 SIR*. Authorization for the Common Features was contained in Section 101 of WRDA 1996 (see Existing Project Authorizations section below). The Common Features include constructing (1) 24 miles of slurry wall in the levees along the lower American River, (2) approximately 12 miles of levee modifications to help protect the Natomas area, (3) three telemetered stream flow gages upstream from Folsom Reservoir, and (4) modifications to the flood warning system along the lower American River.

1.4.3 Water Resources Development Act of 1996 Through 2002 Long-Term Study

While efforts moved forward to further develop and implement the Common Features, discussions continued on ways to achieve higher levels of flood protection for Sacramento. These discussions and related activities culminated in Congressional action as part of WRDA 1999 (see Existing Project Authorizations section below). WRDA 1999 included two applicable authorizations (1) Folsom Dam Modifications and (2) American River and Sacramento River levee improvements.

- **Folsom Dam Modifications** – This is the fundamental authorization for the Folsom Modification Project. Section 101(a) of WRDA 1999 included five major actions. The first was (1) modification of Folsom Dam and appurtenant facilities generally, as described for the Folsom Modification Plan in the *1996 SIR* (see above), but as further modified by a subsequent report by SAFCA titled *Folsom Dam Modification Report, New Outlets Plan*, dated March 1998. The authorization also included (2) reducing the variable flood space in Folsom reservoir, (3) delegating responsibility to the Secretary of

the Interior to make up any lost water due to a variable flood control space interim operation, (4) defining what significant impacts to recreation due to flood operations means at Folsom, and (5) updating a flood management plan authorized in the 1993 Defense Appropriations Act to consider forecast-based operations at Folsom.

- **American and Sacramento River Levee Improvements** – Section 366 of WRDA 1999 further modifies the WRDA 1996 authorization with specific direction related to levee modifications. As shown in the authorization language (see Project Authorizations section below), this authorization identified levee improvements at various locations along the American River, Natomas Cross Canal, and Sacramento River. Work directed in this section of WRDA is important to the current effort because it would allow for Folsom Dam to increase outflows to 160,000 cfs for a sustained time (currently being evaluated) without a high probability of levee failure along the lower American River.

The Corps undertook detailed studies to refine project features of the Folsom Modification Project authorized in WRDA 1999. The Corps updated features of the Folsom Modification Project to provide the maximum flood risk reduction in a manner consistent with the Folsom Dam Raise Project, as described in the Corps *2002 American River Watershed, California, Long-Term Study* (2002 Long-Term Study). Specifically, refinements were needed to resolve conflicts between project features relating to gate modifications. The results of these efforts were published in the Corps *2003 Folsom Dam Modification Project Final Limited Reevaluation Report and Environmental Assessment/Initial Study* (2003 LRR).

While detailed efforts continued to develop a functional plan to modify Folsom Dam under Section 101 of WRDA 1999, and to implement actions defined in Section 366 of WRDA 1999, the Corps, The Reclamation Board, and SAFCA continued to formulate plans for higher levels of flood protection in Sacramento. These efforts culminated in the *2002 Long-Term Study*, dated February 2002. This is an integrated *Feasibility Report* (combined decision document and *EIS/EIR*). Major conclusions of this report were that (1) a serious residual flood threat remains to the Sacramento area, (2) there continues to be a series of alternative plans capable of further reducing the threat of flooding, (3) net benefits for an upstream detention dam would likely continue to exceed those of other alternatives, and (4) strong non-Federal support continues to exist for implementing improvements in flood damage reduction. The *2002 Long-Term Study* did not include a specific recommendation. However, on 5 November 2002, based on findings in the *2002 Long-Term Study Feasibility Report*, a *Chief of Engineers Report* was signed that recommended a 7-foot raise in the height of Folsom Dam. This dam raise, which included provisions for making advanced releases from Folsom Reservoir to create additional flood space, would, in addition to reducing the chance of flooding to about 1 in 213 in any year, also resolve hydrologic dam safety issues at Folsom. Without the advanced release provision, the project would reduce the risk of flooding to about 1 in 164 in any year. The project would also include enlarging the spillway at L.L. Anderson Dam, implementing ecosystem restoration and habitat improvement along the American River, and building a temporary bridge just downstream from Folsom Dam.

A project to implement the above *2002 Long-Term Study*, as defined in the *2002 Chief of Engineers Report*, was authorized by Congress under Section 128 of the Energy and Water

Development Appropriations Act of 2004 (see Existing Project Authorizations section below). This is also the fundamental authorization for the Folsom Dam Raise Project.

1.4.4 Subsequent Guidance

As part of the Energy and Water Development Appropriations Act of 2006 (Public Law (PL) 109-103), Congress provided further guidance on implementation of the Folsom Dam permanent bridge. Also as part of the 2006 Act, Congress directed that the Secretary of the Army and Secretary of the Interior collaborate on authorized activities to maximize flood damage reduction improvements and dam safety needs at Folsom Dam. This authorization has been instrumental for both the Corps and Reclamation to work together in developing a single project that addresses both flood damage reduction and dam safety in an effective and efficient manner. Specifically, PL 109-103 directed the Secretaries to consider reasonable modifications to the existing authorized activities, including an auxiliary spillway.

1.5 EXISTING PROJECT AUTHORIZATIONS

This section summarizes relevant congressional authorizations, appropriations, and guidance related to flood damage reduction and dam safety projects at Folsom Dam.

1.5.1 Flood Control Act of 1944

The Flood Control Act of 1944 (PL 78-534) authorized construction of Folsom Dam, as proposed by the State of California Water Plan. Under this authorization, Folsom Dam was to be constructed as a 335,000-acre-foot reservoir for the purpose of flood control, with outlet facilities for future power generation. This authorization was expanded in 1949 under the American River Basin Development Act. The 1944 Act states the following:

> *The Folsom Reservoir on the American River, California, is hereby authorized substantially in accordance with the plans contained in House Document Numbered 649, Seventy-eighth Congress, Second Session, with such modifications thereof as in the discretion of the Secretary of War and the Chief of Engineers may be advisable, at an estimated cost or $18,474,000.*

1.5.2 American River Basin Development, California Act of 1949

The American River Basin Development, California Act of 1949 (PL 81-356) provided final authorization for Folsom Dam and Reservoir as a 1,000,000-acre-foot facility. The Act states the following:

> *The Central Valley project, California, authorized by section 2 of the Act of Congress of August 26, 1937 (50 Stat. 850), is hereby reauthorized to include the American River development as hereinafter described, which development is declared to be for the same purposes as described and set forth in the Act of congress of August 26, 1937 (50 Stat. 850).*

Sec. 2. The American River development shall consist of: Folsom Dam and Reservoir having a storage capacity of approximately one million acre-feet, to be constructed by the Corps of Engineers at such point below the confluence of the North Fork and the South Fork of the American River near the city of Folsom, California, as the Secretary of the Army and the Chief of Engineers after consultation with the Bureau of Reclamation and other appropriate State, Federal, and local agencies may find most advisable; and the following features for the development and use of water, to be constructed, operated, and maintained by the Secretary of the Interior through the Commissioner of Reclamation: A hydroelectric power plant with a generating capacity of approximately one hundred and twenty thousand kilowatts, and necessary hydroelectric afterbay power plants and necessary electric transmission lines to the nearest practical interconnection with the Central Valley project transmission system; a storage dam with a capacity of approximately forty thousand acre-feet to be located on Sly Park Creek, a tributary of the North Fork of Consumnas River, with necessary appurtenant works, including a diversion dam on Camp Creek, tunnel, conduit, and canals for the delivery of water to lands in El Dorado County, and incidental works appurtenant thereto. The Secretary of the Interior, through the Bureau of Reclamation, is hereby further authorized and directed to conduct the necessary investigations, surveys, and studies for the purpose of developing plans for disposing of the water and electric power which would be made available by the project, including studies of such supplemental works and equipment as may be required to maintain a firm supply of electric energy, and render reports thereon which would set forth the works required for such disposition, together with findings as to their engineering and financial feasibility, including a study of the water resources and requirements of the entire American River watershed and the areas serviceable therefrom, and particularly of a diversion canal at the highest feasible level extending southerly from Folsom Reservoir as will permit the maximum beneficial use of the water for irrigation of the lands lying under said canal in El Dorado and Sacramento Counties; a diversion canal at the highest feasible level for the purpose of securing the maximum beneficial use of the water in Placer County extending northerly from such reservoir to a point on the Bear River in the vicinity of Sheridan, California, and a conduit or conduits with necessary pumping plants and supplemental works extending from the most feasible diversion point on the Central Valley project, California, to serve lands and municipalities in Contra Costa, Alameda, Santa Clara, San Joaquin, and San Benito Counties.

Nothing in this Act shall be construed by implication or otherwise as an allocation of water and in the studies for the purposes of developing plans for disposal of water as herein authorized the Secretary of the Interior shall make recommendations for the use of water in accord with State water laws, including but not limited to such laws giving priority to the counties and areas of origin for present and future needs.

Said studies and the reports thereon shall be submitted to the proper State authorities under the procedure provided for in the Flood Control Act of 1944 (Public Law 534, Seventy-eighth Congress, second session).

Folsom Dam and Reservoir, upon completion of construction by the Corps of Engineers, to the extent where water from said reservoir is ready to be turned either into the power plant or conduits, shall be transferred to the Bureau of Reclamation for operation and maintenance under the supervision of the Secretary of the Interior together with the other features of the American River development herein authorized for construction by the Bureau of Reclamation, all in accordance with the Federal reclamation laws (Act of June 17, 1902, 32 Stat. 388, and Acts amendatory thereof or supplementary thereto). After the transfer as provided herein, the dam shall be operated for flood control in accordance with criteria established by the Secretary of the Army as provided for in section 7 of the Flood Control Act of 1944 (Public Law 534, Seventy-eighth Congress, second session).

Sec. 3. In locating and designing the works authorized for construction by section 2 of this Act the Secretary of the Army and the Chief of Engineers, the Secretary of the Interior and the Commission of Reclamation shall give due consideration to the report set forth in Bulletin Numbered 26 of the Division of Water Resources of the Department of Public Works of the State of California, and shall consult the local interests to be affected by the construction and operation of said works, through public hearings or in such other manner as in their discretion may be found best suited to a maximum expression of the views of such local interests.

Sec. 4. The Secretary of the Interior is directed to cause the operation of said works to be coordinated and integrated with the operation of existing and future features of the Central Valley project in such manner as will effectuate the fullest and most economic utilization of the land and water resources of the Central Valley project of California for the widest possible public benefit.

Sec. 5. There are hereby authorized to be appropriated, out of any money in the Treasury not otherwise appropriated, such sums as are necessary to carry out the purposes of this Act.

1.5.3 Flood Control Act of 1962

The basic authority for the ARWI is in the Flood Control Act of 1962, PL 87-874. As a result of this study, the Common Features, Folsom Modification, and Folsom Dam Raise projects were developed and authorized. The 1962 authorization states the following:

The Secretary of the Army is hereby authorized and directed to cause surveys for flood control and allied purposes, including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects, to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its territorial possessions, which include the following named localities……..Sacramento River Basin and streams in northern California

draining into the Pacific Ocean for the purposes of developing, where feasible, multipurpose water resource projects, particularly those which would be eligible under the provisions of title III of Public Law 85-500.

1.5.4 Reclamation Safety of Dams Act of 1978 and 1984 Amendment

Reclamation's Safety of Dams Program was officially implemented by PL 95-578 (1978), as amended by PL 98-404 (1984). Sections 1 through 4, which deal with the general provisions of the Act, are included below:

To authorize the Secretary of the Interior to construct, restore, operate, and maintain new or modified features at existing Federal reclamation dams for safety of dams purposes.

Be it enacted by the Senate and the House of Representatives of the United States of America in Congress assembled, That this Act shall be cited as the "Reclamation Safety of Dams Act of 1978."

Sec. 2. In order to preserve the structural safety of Bureau of Reclamation dams and related facilities, the Secretary of the Interior is authorized to perform such modifications as he determines to be reasonably required. Said performance of work shall be in accordance with the Federal reclamation laws (Act of June 17, 1902, 32 Stat. 388, and Acts amendatory or supplementary thereto).

Sec. 3. Construction authorized by this Act shall be for purposes of dam safety and not for the specific purposes of providing additional conservation storage capacity or of developing benefits over and above those provided by the original dams and reservoirs. Nothing in this Act shall be construed to reduce the amount of project costs allocated to reimbursable purposes heretofore authorized.

Sec. 4. (a) Costs heretofore or hereafter incurred in the modification of structures under this Act, the cause of which results from age and normal deterioration of the structure or from nonperformance of reasonable and normal maintenance of the structure by the operating entity shall be considered as project costs and will be allocated to the purposes for which the structure was authorized initially to be constructed and will be reimbursable as provided by existing law.

With respect to the $100,000,000 authorized to be appropriated the Reclamation Safety of Dams Act of 1978, costs heretofore, or hereafter incurred in the modification of structures under this Act, the cause of which results from new hydrologic or seismic data or changes in the state-of-the-art criteria deemed necessary for safety purposes shall be non-reimbursable and non-returnable under the Federal Reclamation law.

With respect to the additional $650,000,000 authorized to be appropriated in The Reclamation Safety of Dams Act Amendments of 1984, costs incurred in the modification of structures under this Act, the cause of which results from new

hydrologic or seismic data or changes in state-of-the-art criteria deemed necessary for safety purposes, shall be reimbursed to the extent provided in this subsection.

(1) Fifteen percent of such costs shall be allocated to the authorized purposes of the structure, except that in the case of Jackson Lake Dam, Minidoka Project, Idaho-Wyoming, such costs shall be allocated in accordance with the allocation of operation and maintenance charges.

(2) Costs allocated to irrigation water service and capable of being repaid by the irrigation water users shall be reimbursed within 50 years of the year in which the work undertaken pursuant to this Act is substantially complete. Costs allocated to irrigation water service which are beyond the water users' ability to pay shall be reimbursed in accordance with existing law.

(3) Costs allocated to recreation or fish and wildlife enhancement be reimbursed in accordance with the Federal Water Project Recreation Act (79 Stat. 213), as amended.

(4) Costs allocated to the purpose of municipal, industrial, and miscellaneous water service, commercial power, and the portion of recreation and fish and wildlife enhancement costs reimbursable under the Federal Water Project Recreation Act, shall be repaid within 50 years with interest. The interest rate used shall be determined by the Secretary of the Treasury, taking into consideration average market yields on outstanding marketable obligations of the United States with remaining periods to maturity comparable to the applicable reimbursement period during the month preceding the fiscal year in which the costs are incurred. To the extent that more than one interest rate is determined pursuant to the preceding sentence, the Secretary of the Treasury shall establish an interest rate at the weighted average of the rates so determined.

(d) The Secretary is authorized to negotiate appropriate contracts with project beneficiaries providing for the return of reimbursable under this Act: Provided, however, That no contract entered into pursuant to this Act shall be deemed to be a new or amended contract for the purposes of section 203(a) of Public Law 97-293.

1.5.5 Continuing Appropriations Act for 1988

Direction for the Corps reconnaissance study was included in the 1987 Appropriations Act (PL 99-591). Direction for additional study, which became the ARWI, was included in committee language accompanying the fiscal year (FY) 1988 Continuing Appropriation Act (PL 100-202, dated, 22 December 1987):

...The conferees are aware that recent information presented by the Corps and the Bureau in a series of three fact-finding hearing in Sacramento reveals that the region may be under a greater threat from serious flooding than was previously believed. It is also clear that any improvement which may be made to increase the

level of flood control on the American River may not by itself alleviate the flood danger to the northern part of Sacramento County east and west of the Natomas East Main Drainage Canal, which includes the Natomas area and the Dry Creek watershed. The conferees therefore urge the Corps of Engineers to examine potential flood control improvement to the Natomas and the Dry Creek watershed concurrent to the Corps' evaluation of improving protection on the American River. The conferees further recognized that there may be additional flood protection afforded by a primarily peak-flow flood control facility (the so-called "dry dam") on the North Fork of the American River above Folsom. The conferees therefore direct the Corps of Engineers to include further assessments of the relationship between such a peak-flow flood control facility and the operation of Folsom Dam as they may pertain to incidental water, power and recreational benefits. Within this assessment, the Corps should include its analysis of the current and projected water supply demands in the American River basin.

1.5.6 Defense Appropriations Act of 1993

Authorization for the American River Watershed Project was provided in 1992 in Section 9159 of the Defense Appropriations Act for FY 1993 (PL 102-396), as follows:

SEC. 9159. SACRAMENTO AND AMERICAN RIVERS FLOOD CONTROL PROJECT, CALIFORNIA: PRECONSTRUCTION ENGINEERING AND DESIGN; NATOMAS LEVEE CONSTRUCTION.

(a) CONTINUATION OF ENGINEERING AND DESIGN. – The Secretary of the Army is directed to reevaluate the project for flood control and recreation, Sacramento and American Rivers, California, as described in the feasibility report of the Chief of Engineers, entitled the "American River Watershed Investigation," dated July 1, 1992, subject to the provisions of this section.

(b) NATOMAS LEVEE FEATURES. –

(1) CONSTRUCTION. – The Secretary of the Army is authorized and directed to construct the Natomas levee features of the project as described in the feasibility report referred to in subsection (a), subject to entering into appropriate local cost-sharing agreements from the non-Federal sponsors of the project, provided that such construction does not encourage the development of deep flood plains.

(2) CREDIT FOR CERTAIN NON-FEDERAL WORK. – The Secretary of the Army shall credit against the non-Federal share of the cost of construction under paragraph (1), or reimburse the non-Federal sponsors, for any planning and construction work performed by the non-Federal sponsors to protect the Natomas area which is commenced prior to the Army Corps of Engineers' receiving appropriations to initiate such construction and which is consistent with the feasibility report referred to in subsection (a).

(c) GATING AND EXPANDABILITY REPORT. – In carrying out the reevaluation described in subsection (a) and in consultation with the State of California, the local non-Federal sponsors, and other interested groups, the Secretary of the Army is directed within one year after the date of the enactment of this Act, to submit to the Committee on Public Works and Transportation of the House of Representatives and the Committee on Environment and Public Works of the Senate a report which:

(1) analyzes the outlet design of the flood control dam proposed as a feature of the project referred to in subsection (a), including an analysis of various configurations and capacities of gates (including a completely ungated configuration, a partly ungated configuration, emergency gates, operational gates, or a combination thereof) to ensure the safety of the flood control dam itself, to provide for system safety, to minimize small event flooding of the Auburn Canyon, and to minimize damages to the vegetation, soils, and habitat in the canyon; and

(2) includes further analysis as to whether any feature or characteristic of the flood control dam would preclude its efficient expansion for water, power, or other purposes, and whether the design would create any greater difficulty for an expanded dam to meet seismic requirements than a multipurpose dam would otherwise encounter, and further assessment of the extra costs attributable to installation into an expanded dam such penstocks, operational gates and other features of a multipurpose dam which would not be included in an expandable dam lacking advanced features.

(d) REPAYMENT OF DESIGN WORK. – The non-Federal share of the costs of the design and reevaluations described in subsection (a) shall not be required to be repaid until after the execution of the agreement required by section 103(j) of the Water Resources Development Act of 1986 and immediately prior to the initiation of construction of the project or the appropriate separable element.

(e) SPECIAL EVALUATION REPORTS. –

(1) In carrying out the reevaluation described in subsection (a) and in consultation with the State of California, the local non-Federal sponsors, and other interested groups, the Secretary of the Army shall perform further evaluation of, and, within twelve months after the date of the enactment of this Act, submit to the Committee on Public Works and Transportation of the House of Representatives and the Committee on Environment and Public Works of the Senate a report on, other features and operational procedures that should be implemented in a coordinated plan to provide flood protection sufficiently high for a major urban area subject to risk of frequent floods causing great economic, environment, and social damage. The report shall specifically address, at minimum, the following:

(i) The reliability, costs, environmental impacts, and public safety risks associated with increasing objective flows in the Lower American River

above the 115,000 cubic feet per second design capacity, as well as the costs and impacts of permanent reoperation of Folsom Reservoir at different levels of increased flood storage, including the appropriate alternatives for sharing costs associated with Folsom Dam.

(ii) The costs and benefits of lowering the spillway at Folsom Dam in order to improve the dam's ability to pass a maximum probable flood and improve its operational flexibility for flood control.

(iii) The costs and benefits of transferring flood control obligations from the Folsom Reservoir to a new flood control facility at Auburn, increasing the Folsom Reservoir's capability for water supply.

(iv) The costs and benefits of utilizing existing and increased flood space in the upstream reservoirs to enhance the flood control capability at Folsom Dam and of establishing offstream storage in Deer Creek, alone or in combination with the alternatives referenced in paragraphs (i) and (ii) of this subsection.

(2) The Secretary of the Army shall further consult with, and solicit the views of, the National Academy of Engineering on the contingency assumptions, hydrological methodologies used in the preparation of the American River Project, and other engineering assumptions and methodologies influencing the scope and formulation of the American River flood control alternatives. Such consultation shall also solicit the views of the National Academy of Engineering on the merits of normalized use of reservoir surcharge space in a flood control regime for Sacramento. Any opinions with respect to these and other issues rendered by the National Academy of Engineering shall be made available to the public and included in the reports transmitted to Congress pursuant to this section.

(f) FOLSOM DAM. –

(1) IN GENERAL. – Congress recognizes the urgency of ensuring that Folsom Dam is operated correctly, safely, efficiently and prudently for flood control purposes. The Secretary of the Interior (in consultation with the Sacramento Flood Control Agency and the Secretary of the Army) shall operate Folsom Dam to provide the maximum level of flood protection.

(2) FLOOD MANAGEMENT PLAN. – (A) Not later than one year after the date of enactment of this ACT, and consistent with existing law, the Secretaries of the Army River and Folsom Dam that ensures prompt, reliable, and full utilization of the flood control capability at Folsom Dam and other existing water resources development projects located in the American River watershed, California. Consistent with existing law, the plan should maximize the flood control capability within Folsom Dam's flood space reservation. The plan shall also identify opportunities and make recommendations to improve the stream gauge network and flood forecast system for the upper American River watershed.

The plan should also recognize that reservoir releases need to be made as quickly as possible in anticipation of incoming flow and in accordance with existing documents: "1959 Reservoir Regulations, Appendix II, the Corps Master Manual, Sacramento River Basin Reservoir Regulation Manual, Folsom Dam/Reservoir, American River: October 1, 1956," revised March 1959.

(B) The components of the inflow forecasting system and revised flood release rules and practices, and hydrographic and flood frequency models shall give due deference to the National Academy of Engineering findings developed pursuant to subsection (e)(2) of this section.

1.5.7 Water Resources Development Act of 1996

Corps authorization for the American River Watershed Common Features project is provided by Section 101 of WRDA 1996 (PL 104-303). Pertinent sections of this authorization are provided below. Additional guidance is contained in WRDA 1999.

SEC. 101. Project Authorizations

(a) PROJECTS WITH CHIEF'S REPORTS. Except as provided in this subsection, the following projects for water resources development and conservation and other purposes are authorized to be carried out by the Secretary substantially in accordance with the plans, and subject to the conditions, described in the respective reports designated in this subsection:

(1) American River Watershed, California.

(A) IN GENERAL. The project for flood damage reduction, American and Sacramento Rivers, California: Report of the Chief of Engineers, dated June 27, 1996, at a total cost of $56,900,000, with an estimated Federal cost of $42,675,000 and an estimated non-Federal cost of $14,225,000, consisting of

(i) approximately 24 miles of slurry wall in the levees along the lower American River;

(ii) approximately 12 miles of levee modifications along the east bank of the Sacramento River downstream from the Natomas Cross Canal;

(iii) 3 telemeter stream flow gauges upstream from the Folsom Reservoir; and

(iv) modifications to the flood warning system along the Lower American River.

(B) CREDIT TOWARD NON-FEDERAL SHARE. The non-Federal interest shall receive credit toward the non-Federal share of project costs for expenses that the non-Federal interest incurs for design or construction of any of the features authorized under this paragraph before the date on which Federal funds are made

available for construction of the project. The amount of the credit shall be determined by the Secretary.

(C) INTERIM OPERATION. Until such time as a comprehensive flood damage reduction plan for the American River watershed has been implemented, the Secretary of the Interior shall continue to operate the Folsom Dam and Reservoir to the variable 400,000/670,000 acre-feet of flood control storage capacity and shall extend the agreement between the Bureau of Reclamation and Sacramento Area Flood Control Agency with respect to the watershed.

(D) OTHER COSTS. The non-Federal interest shall be responsible for

(i) all operation, maintenance, repair, replacement, and rehabilitation costs associated with the improvements carried out under this paragraph; and

(ii) 25 percent of the costs incurred for the variable flood control operation of the Folsom Dam and Reservoir during the 4-year period beginning on the date of the enactment of this Act and 100 percent of such costs thereafter.

1.5.8 Water Resources Development Act of 1999

WRDA 1999 (PL 106-53) includes further guidance on the American River Common Features and Folsom Modification projects. Following is information on each.

Common Features

Section 366 of WRDA 1999 includes further direction for Common Features:

b. Section 366 - American and Sacramento Rivers, California.

(a) IN GENERAL. The project for flood damage reduction, American and Sacramento Rivers, California, authorized by section 101(a)(1) of the Water Resources Development Act of 1996 (110 Stat. 3662-3663), is modified to direct the Secretary to include the following improvements as part of the overall project:

(1) Raising the left bank of the non-Federal levee upstream of the Mayhew Drain for a distance of 4,500 feet by an average of 2.5 feet.

(2) Raising the right bank of the American River levee from 1,500 feet upstream to 4,000 feet downstream of the Howe Avenue Bridge by an average of 1 foot.

(3) Modifying the south levee of the Natomas Cross Canal for a distance of 5 miles to ensure that the south levee is consistent with the level of protection provided by the authorized levee along the east bank of the Sacramento River.

(4) Modifying the north levee of the Natomas Cross Canal for a distance of 5 miles to ensure that the height of the levee is equivalent to the height of the south levee as authorized by paragraph (3).

(5) Installing gates to the existing Mayhew Drain culvert and pumps to prevent backup of floodwater on the Folsom Boulevard side of the gates.

(6) Installing a slurry wall in the north levee of the American River from the east levee of the Natomas east Main Drain upstream for a distance of approximately 1.2 miles.

(7) Installing a slurry wall in the north levee of the American River from 300 feet west of Jacob Lane north for a distance of approximately 1 mile to the end of the existing levee.

(b) COST LIMITATIONS. Section 101(a)(1)(A) of the Water Resources Development Act of 1996 (110 Stat. 3662) is amended by striking "at a total cost of" and all that follows through "$14,225,000," and inserting the following: "at a total cost of $91,900,000, with an estimated Federal cost of $68,925,000 and an estimated non-Federal cost of $22,975,000,"

(c) COST SHARING. For the purposes of Section 103 of the Water Resources Development Act of 1986 (33 U.S.C. 2213), the modifications authorized by this section shall be subject to the same cost sharing in effect for the project for flood damage reduction, American and Sacramento Rivers, California, authorized by Section 101(a)(1) of the Water Resources Development Act of 1996 (110 Stat. 3662).

Folsom Modification

Section 101(a) (6) of WRDA 1999 (PL 106-53) provides authorization for the Folsom Modification Project, as follows:

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 effect 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.

1.5.9 Energy and Water Development Appropriations Act of 2002

Section 209 of the Energy and Water Development Appropriations Act of 2002 (PL 107-66) amended WRDA 1999 related to the replacement of water supply losses caused by interim operation of Folsom Dam and Reservoir for increased flood damage reduction. Pertinent sections are presented below:

SEC. 209. (a) Section 101(a)(6)(C) of the Water Resources Development Act of 1999, Public Law 106–53, is amended to read as follows:

(C) MAKEUP OF WATER SHORTAGES CAUSED BY FLOOD CONTROL OPERATION. —

(i) IN GENERAL. — 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 make up 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.

(ii) COST SHARING. — Seventy-five percent of the costs of the replacement water provided under clause (i) shall be paid for on a non-reimbursable basis by the Secretary of the Interior at Federal expense. The remaining 25 percent of such costs shall be provided by the Sacramento Area Flood Control Agency.

(iii) LIMITATION. — To the extent that any funds in excess of the non-Federal share are provided by the Sacramento Are Flood Control Agency, the Secretary shall reimburse such non-Federal interests for such excess funds. Costs for replacement water may not exceed 125 percent of the current average market price for raw water, as determined by the Secretary of the Interior.

1.5.10 Energy and Water Development Appropriations Act of 2004

The Energy and Water Development Appropriations Act for 2004 (PL 108-137) provided the following in pertinent part:

Section 128. AMERICAN RIVER WATERSHED, CALIFORNIA.

(a) IN GENERAL—The Secretary of the Army is authorized to carry out the project for flood damage reduction and environmental restoration, American River Watershed, California, substantially in accordance with the plans, and subject to the conditions, described in the Report of the Chief of Engineers dated November 5, 2002, at a total cost of $257,300,000, with an estimated Federal Cost of $201,200,000 and an estimated non-Federal cost of $56,100,000; except that the Secretary is authorized to accept funds from State and local governments and other Federal agencies for the purpose of constructing a permanent bridge instead of the temporary bridge described in the recommended plan and may construct such permanent bridge if all additional cost for such bridge, above the $36,000,000 provided for in the recommended plan for bridge construction, are provided by such governments or agencies.

(b) EXPEDITING BRIDGE DESIGN AND CONSTRUCTION—The Secretary, in cooperation with appropriate non-Federal interests, shall immediately commence appropriate studies for, and the design of, a permanent bridge (including an evaluation of potential impacts of bridge construction on traffic patterns and identification of alternatives for mitigating such impacts) and, upon execution of a cost-sharing agreement with such non-Federal interest, shall proceed to construction of the bridge as soon as practicable; except that such studies, design and construction shall not adversely affect the schedule of design or construction of authorized project for flood damage reduction.

Section 134. BRIDGE AUTHORIZATION. There is authorized to be appropriated $30,000,000 for the construction of the permanent bridge in section 128(a).

1.5.11 Energy and Water Development Appropriations Act of 2006

PL 109-103, the Energy and Water Development Appropriations Act for 2006, provided further direction regarding actions at Folsom Dam. Pertinent sections of the act relating to the Folsom Modification and Folsom Dam Raise projects are included below:

> *SEC. 128. American River Watershed, California (Folsom Dam and Permanent Bridge) -*
>
> *(a) COORDINATION OF FLOOD DAMAGE REDUCTION AND DAM SAFETY- The Secretary of the Army and the Secretary of the Interior are directed to collaborate on authorized activities to maximize flood damage reduction improvements and address dam safety needs at Folsom Dam and Reservoir, California. The Secretaries shall expedite technical reviews for flood damage reduction and dam safety improvements. In developing improvements under this section, the Secretaries shall consider reasonable modifications to existing authorized activities, including a potential auxiliary spillway. In conducting such activities, the Secretaries are authorized to expend funds for coordinated technical reviews and joint planning, and preliminary design activities.*
>
> *(b) SECRETARY'S ROLE.—Section 134 of Public Law 108–137 (117 Stat. 1842) is modified to read as follows:*
>
> *''SEC. 134. BRIDGE AUTHORIZATION.*
>
> *''There is authorized to be appropriated to the Secretary of the Army $30,000,000 for the construction of the permanent bridge described in section 128(a), above the $36,000,000 provided for in the recommended plan for bridge construction. The $30,000,000 shall not be subject to cost sharing requirements with non-Federal interests.''*
>
> *(c) CONFORMING CHANGE.—Section 128(a) of Public Law 108– 137 (117 Stat. 1838) is modified by deleting ''above the $36,000,000 provided for in the recommended plan for bridge construction,'' and inserting in lieu thereof the following: ''above the sum of the $36,000,000 provided for in the recommended plan for bridge construction and the amount authorized to be appropriated by section 134, as amended.''*
>
> *(d) MAXIMUM COST OF PROJECT.—The costs cited in subsections (b) and (c) shall be adjusted to allow for increases pursuant to section 902 of Public Law 99–662 (100 Stat. 4183). For purposes of making adjustments pursuant to this subsection, the date of authorization of the bridge project shall be December 1, 2003.*
>
> *(e) EXPEDITED CONSTRUCTION.—The Secretary, in coordination with the Secretary of the Interior and affected non-Federal officials (including the City of Folsom, California), shall expedite construction of a new bridge and associated*

roadway authorized in Public Law 108–137. The Secretary, to the extent practicable, may construct such work in a manner that is compatible with the design and construction of authorized projects for flood damage reduction and dam safety. The Secretary and the Secretary of the Interior shall expedite actions under their respective jurisdictions to facilitate timely completion of construction.

(f) REPORT TO CONGRESS.—The Secretary of the Army, in consultation with the Secretary of the Interior and non-Federal interests, shall report to Congress within ninety days of the date of enactment of this Act, and at four-month intervals thereafter, on the status and schedule of planning, design and construction activity.

1.6 PROJECT SPONSORS

Non-Federal sponsors for flood damage reduction elements of the RAP are expected to be The Reclamation Board and SAFCA. Reclamation would likely continue to perform operations, maintenance, repair, replacement, and rehabilitation activities related to Folsom Dam and appurtenant facilities, with cost sharing by SAFCA. The City of Folsom is the non-Federal sponsor for the permanent bridge, and is responsible for the associated cost; however, a Federal contribution is authorized. The State of California and SAFCA, as flood damage reduction sponsors, will contribute funds for the bridge through the City of Folsom.

1.7 FUNDING HISTORY

1.7.1 Folsom Modification Project

The funding history for the Folsom Modification Project is shown in **Table 1-1**.

TABLE 1-1
FEDERAL FUNDING HISTORY OF FOLSOM MODIFICATION PROJECT
($ MILLIONS)

Federal Funding Category	Fiscal Year	Allocations	Expenditures
Preconstruction, Engineering, and Design	All	6.7	6.7
Construction[1]			
	2001	4.7	4.5
	2002	5.9	5.2
	2003	6.5	7.0
	2004	-1.2	-1.2
	2005	7.5	7.7
	2006	6.2	3.9
Total Construction[1]		29.6	27.1
Total		36.3	33.8

Note:
1. *Funding designations reflect congressional budgetary nomenclature, and not necessarily actual construction costs.*

1.7.2 Folsom Dam Raise Project

The funding history for the Folsom Dam Raise Project is shown in **Table 1-2**.

TABLE 1-2
FEDERAL FUNDING HISTORY OF FOLSOM DAM RAISE PROJECT ($ MILLIONS)

Federal Funding Category	Fiscal Year	Allocations	Expenditures
Preconstruction, Engineering, and Design	All	16.1	16.1
Construction			
	2004	3.3	3.0
	2005	7.9	6.9
	2006	11.1	9.3
Total Construction [1]		22.4	19.3
Total		38.5	35.4

Note:
1. *Funding designations reflect Congressional budgetary nomenclature, and not necessarily actual construction costs.*

1.8 REPORT ORGANIZATION

This *PAC Report* is organized into nine chapters, as follows:

- **Chapter 1, Introduction** – Describes the purpose and scope of this *PAC Report*, background and history, and fundamental authorizations relevant to the authorized Folsom Modification and Folsom Dam Raise projects.
- **Chapter 2, Project Area Description** – Describes the project area location and existing flood damage reduction system, focusing on Folsom Dam and Reservoir, residual flood problems, dam safety issues, and pertinent without-project conditions.
- **Chapter 3, Description of Authorized and Related Projects** – Summarizes the authorized Folsom Modification Project, Folsom Dam Raise Project, dam safety issues at Folsom Dam, and other pertinent ongoing projects and programs.
- **Chapter 4, Authorized Project Refinement** – Describes project objectives, major alternatives considered, the rationale for selection of a plan, and identification of a refined project for continued implementation of the authorized projects.
- **Chapter 5, Changes from Authorized Project Plans** – Compares the authorized Folsom Modification Project and the Folsom Dam Raise Project to the refined project.
- **Chapter 6, Joint Federal Participation** – Provides the cost distribution for the Joint Federal Project (JFP) and summarizes components of Corps and Reclamation work packages.
- **Chapter 7, Implementation** – Describes the cost distribution, cost appropriation and other implementation considerations for the Selected Plan and the RAP.

- **Chapter 8, Conclusions and Recommendations –** Summarizes key findings and recommendations.
- **Chapter 9, References –** Contains sources used in preparing this *PAC Report*.

This report also contains a set of supporting appendices. The appendices include Engineering Design Reports for the Folsom Modification Project, Folsom Dam Raise Project, and the selected project to address both flood damage reduction and dam safety at Folsom Dam. Additional appendices include the following:

- Real Estate
- Economics
- Cost Distribution
- Pertinent Correspondence
- United States Army Corps of Engineers 12 Actions for Change

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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 of the City of Sacramento and includes portions of Placer, El Dorado, and Sacramento counties. **Plate 1** illustrates the project area within the Sacramento River Watershed, and **Plate 2** shows the Folsom Dam and Reservoir area.

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. As mentioned, improvements underway as a part of the Common Features Project along the lower American River, as authorized by the Water Resources Development Act (WRDA) of 1999, will meet the intent of the authorization to safely pass the emergency flood release of 160,000 cubic feet per second (cfs) from Folsom Dam.

2.2.1 Folsom Dam and Reservoir

Folsom Dam, as described in **Chapter 6**, is a multipurpose project operated by the United States Department of the Interior, Bureau of Reclamation (Reclamation), as a part of the Central Valley Project (CVP). The dam regulates runoff from about 1,860 square miles of drainage area and has a storage capacity of 977,000 acre-feet at its gross pool at reservoir water surface elevation 466 feet. The top of the main dam is at elevation 480.5 feet, and the crest of the 392-foot-long spillway is at elevation 418 feet. The current maximum reservoir elevation, with induced surcharge, is 475.4 feet. The Folsom Dam spillway design flood, 1946 Probable Maximum Flood (PMF), set the above maximum reservoir elevation. Folsom Dam can not contain the current (2001) PMF within the designated surcharge flood space. The objective release for flood damage reduction from the dam to the lower American River is 115,000 cfs, with an emergency release of 160,000 cfs for a sustained time (currently being evaluated) without a high probability of levee failure along the lower American River.

Normal operation releases flow through three penstocks, located on the right side of the main Folsom Dam, that provide power generation and downstream water supply deliveries. The combined capacity of the three penstocks is 8,000 cfs but this capacity is not relied on for flood damage reduction operations. Flood damage reduction releases are made from eight gated low-level outlets, five gated principal spillway bays, and three gated emergency spillway bays (see **Plates 3** and **4**). During flood events, initial releases from the reservoir are made through the penstocks and the gated outlets up to spillway crest elevation 418.0 feet. The outlets can pass

24,800 cfs at pool elevation 418.0 feet. An existing operational restriction limits opening of the existing outlet gates to 60 percent when the existing spillway service tainter gates are making releases.

2.2.2 American and Sacramento River Systems

2.2.2.1 Nimbus Dam

Nimbus Dam and its reservoir, Lake Natoma, are about 6 miles downstream from Folsom Dam. Lake Natoma (8,760 acre-feet) acts as a power afterbay to Folsom and is a diversion dam for the Folsom South Canal. Nimbus Dam, because of its small capacity, has essentially no regulatory effect on flood flows in the American River. Nimbus Dam has a release capacity of 300,000 cfs, sufficient to pass the maximum objective release from Folsom Dam under normal operations (115,000 cfs), but insufficient to pass the maximum design discharge capacity from Folsom Dam (567,000 cfs).

2.2.2.2 Levees

Project levees downstream from Folsom Dam are shown in **Plate 5** (from the Corps March *1996 Supplemental Information Report* (1996 SIR)) and are listed below:

- **American River Levees** – Federal project levees extend from the mouth of the American River upstream to the Mayhew Drain on the south bank, and to the Carmichael Bluffs on the north bank. On the south bank, non-Federal levees, constructed by local developers, extend upstream from the Mayhew Drain to Sunrise Boulevard.
- **Natomas East Main Drainage Canal (NEMDC) Levees** – The west levee, extending upstream about 13 miles from the American River, protects Natomas from high water surface elevations in the NEMDC. The east levee extends upstream about 4 miles and protects Rio Linda.
- **Arcade Creek and Dry Creek Levees** – Levees extend along both sides of Arcade Creek from the NEMDC to high ground about 2 miles upstream, and along lower Dry Creek.
- **Sacramento River Levees** – The levees along the Sacramento River were designed to carry 107,000 cfs from the Fremont Weir to the American River and 110,000 cfs downstream from the American River.

2.2.2.3 Sacramento Weir

In 1918, the United States Army Corps of Engineers (Corps) built the Sacramento Weir upstream from the Sacramento River and American River confluence, immediately west of Sacramento. This weir has 48 removable gates and a net crest length of 1,830 feet. The weir diverts high flows from the Sacramento River into the Yolo Bypass via the Sacramento Bypass. When flows from the American River are high enough, some of the American River water flows upstream through the Sacramento River channel to the weir. The California Department of Water Resources (DWR) maintains and operates the weir.

This is the only weir in the Sacramento River system with gates that allow it to be operated during flood events. The weir is operated to limit flood stages in the Sacramento River to project design levels, to reduce sediment in the Sacramento River channel downstream from the weir, and to make maximum use of the flood-carrying capacity of the Sacramento River channel downstream from the weir.

2.2.2.4 Yolo Bypass

The Yolo Bypass is a leveed floodway through the natural overflow Yolo Basin on the west side of the Sacramento River between Verona and Rio Vista near Suisun Bay, and immediately west of the metropolitan area of Sacramento. The bypass runs generally north to south and extends from the Fremont Weir downstream to Liberty Island, a distance of nearly 70 miles. The bypass is a feature of the Sacramento River Flood Control Project, which began operation in the 1930s.

During high flows in the Sacramento River, floodwater enters the Yolo Bypass over the Fremont Weir and over the Sacramento Weir and Bypass and is conveyed south around the metropolitan area of Sacramento. Floodwaters reenter the Sacramento River upstream from Rio Vista.

2.3 FLOOD PROBLEMS

Current estimates are that below Folsom Dam, with the existing levee system, there is about a 1 in 81 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 over $40 billion in damageable property. Should this occur, estimated damages would be about $20 billion. The average annual equivalent damages in the Sacramento area is about $200 million.

2.3.1 Folsom Dam Release Capacity

The existing Folsom Dam has limited capability to make objective flood releases until the reservoir is significantly encroached. To make flood releases of 115,000 cfs, the reservoir must rise above the spillway crest elevation of 418 feet. A maximum of 24,800 cfs can be released through the low-level outlets when the reservoir level is at the spillway crest elevation. Operational considerations generally preclude spillway discharges until the reservoir level reaches elevation 423.6 feet, at which time the main spillway service gates are opened. The objective release capacity of 115,000 cfs is reached when the reservoir level reaches about elevation 447 feet. This flow is a combination of flows through the outlets (at 60 percent open) and the five primary spillway gates. Due to potential cavitation problems, the outlet gate openings are reduced to 60 percent when the spillway gates are opened.

If the reservoir water surface continues to rise, releases would increase flow up to the emergency release flow of 160,000 cfs. If the reservoir continues to rise and surpasses the

470-foot elevation, the current Emergency Spillway Release Diagram (ESRD) dictates that the release would increase above 160,000 cfs.

2.3.2 Folsom Dam Emergency Spillway Release Conditions

There is an existing emergency spillway release capacity deficiency due to dam safety concerns; this deficiency has resulted in restricted operation of the three gated emergency spillway bays. The existing ESRD requires regulation of emergency spillway flows prior to reaching the minimum 240,000 cfs flow. Folsom Dam cannot be operated according to the existing requirements of the ESRD because of structural safety deficiencies.

The major concern is the potential for erosion below the emergency spillway chute and adjacent areas. It has been identified that even small flows could cause severe erosion below the emergency spillway. Continuous flows without sufficient tailwater may allow this erosion to migrate back towards the dam. Discharges in the range of 240,000 cfs to 300,000 cfs have been estimated to provide sufficient tailwater elevation to reduce the effects of erosion downstream from the emergency spillway. Due to these concerns, the emergency spillway gates should not be operated until the discharges from the main spillway gates reach a minimum range of 240,000 cfs to 300,000 cfs.

2.3.3 Levees

The chance of levee failure and resulting 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. Damage in the lower American River (within the levee system) can occur at flows less than the objective release (115,000 cfs). The potential for levee failure and catastrophic damages due to flooding in Sacramento is magnified by the area's dependence on high earthen levees. When high levees fail, rapid flooding of the adjacent areas usually results in a significant risk to the population. Since a single weak spot in the system could cause a breach and potentially uncontrolled, life-threatening flooding, special attention must be given to the design, construction, operation, and maintenance of the levee systems.

The physical capacity of the American River to safely transport flows depends on the downstream levee system. The lower American River levees were designed to pass the most severe conditions of either a flow of 115,000 cfs with 5 feet of freeboard on the levee, or 152,000 cfs with 3 feet of freeboard on the levee. Normal flood operations at Folsom Dam would limit downstream flows to 115,000 cfs. During large storm events, American River flows are routed into the Yolo Bypass via the Sacramento Weir. With completion of the Common Features Project, it is estimated that the outflows from Folsom Dam could be increased to as much as 160,000 cfs for a sustained time (currently being evaluated) without a high probability of levee failure along the American River.

2.4 DAM SAFETY RISKS

2.4.1 Probable Maximum Flood

The PMF is used to determine the hydrologic safety of dams. Both Federal- and State-sponsored dam projects use the PMF to design spillway capacities. The PMF is the flood discharge that would result from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably considered possible in a region. The PMF does not have an assigned frequency. All prior PMF estimates for basins in California have equaled or exceeded the 0.1-percent-chance exceedence event for peak, 1-day, and 3-day volumes taken from calculated frequency curves.

Folsom Dam and Reservoir were designed to pass an estimate of the largest likely inflow event when they were constructed. However, with updated hydrology, it has been determined that Folsom Dam's existing spillway capacity is inadequate to protect the dam in the event of an extreme flood in combination with reservoir surcharging to the dam/dike crest elevation of 480.5 feet. As mentioned, it is estimated that currently the Folsom Dam spillway can pass between 70 to 75 percent of the PMF.

In October 1996, Reclamation determined a new PMF for the American River basin based on a new Probable Maximum Storm (PMS) using Hydrometeorological Report No. 58 (National Weather Service, 1998). Following the flood of January 1997, the Corps computed a new, mean 3-day PMF flow. This computation of a revised PMF incorporated rain-on-snow loss rates modeled from the January 1997 event. The resulting mean 3-day flow is greater than the 0.1-percent-chance exceedence event when compared to the flow-frequency curves presented in this report. The PMF results in a peak inflow to Folsom Dam of approximately 1,183,000 cfs.

Determination of Folsom Dam's capacity to pass the PMF is dependent on operational assumptions such as antecedent reservoir conditions, and how many gates are open. A contributing factor to the PMF is failure of L.L. Anderson Dam (French Meadows Reservoir). This is a hydropower and recreation dam owned by Placer County Water Agency (PCWA). L.L. Anderson Dam is to be modified by PCWA to pass the Federally identified PMF (see **Appendix G – Pertinent Correspondence**); the resultant PMF at Folsom Dam would be reduced to 906,000 cfs. Folsom Dam would pass 85 percent of the PMF if L.L. Anderson Dam was modified and Folsom structural dam safety modifications were in place. It is important to note that widespread flooding would also occur with floods much more frequent than the PMF.

2.4.2 Seismic and Static Retrofit

Both the Corps and Reclamation have determined that the various facilities at Folsom Dam and Reservoir require structural improvements to increase overall public safety. Reclamation has identified, under its Safety of Dams Program, the need for expedited action to reduce not only hydrologic but static and seismic risk conditions. The identified risks are among the highest of all dams in Reclamation's inventory, and Folsom Dam is among Reclamation's highest priorities within its Safety of Dams Program. Reclamation's primary interest for participating in a project meeting the needs of both Corps and Reclamation is to realize cost-sharing benefits of a combined project.

The objectives of the seismic and static retrofit are as follows:

- Expeditiously reduce the risk of structural failure during a potential seismic (earthquake) event in accordance with Reclamation's Public Protection Guidelines.
- Expeditiously reduce the risk of structural failure during a potential static (seepage) event in accordance with Reclamation's Public Protection Guidelines.

Several structural actions are described below. These actions are to be implemented independent of further actions on a recommended plan.

2.5 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 0.0124 (about a 1-in-81 chance of occurrence in any 1 year). Although the 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 areas subject to major flooding from levee failure along the American River, as a result of high releases from Folsom Dam, have been identified in several Corps reports, such as the *1991 American River Watershed Investigation Feasibility Report*, the *1996 SIR*, and the *2003 Folsom Dam Modification Final Limited Reevaluation Report*.

Following is a summary of several without-project future conditions that are important in identifying a selected plan and implementing a potential project:

- 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

It should be noted that the without-project condition being considered in the 2007 *Environmental Impact Statement/Environmental Impact Report* (EIS/EIR) prepared jointly by Reclamation and the Corps differs from the without-project condition considered in this *Post Authorization Change* (PAC) *Report*. This is because the scope of the joint *EIS/EIR* includes not only the potential work to address flood damage reduction issues, but Reclamation's structural dam safety actions and additional work needed for security at Folsom Dam. This *PAC Report* assumes that Reclamation will move forward with dam safety and security improvements at Folsom Dam independent of any flood damage reduction actions, and thus considers Reclamation's dam safety improvements as part of the without-project condition.

2.5.1 Interim Operation

Folsom Dam was originally constructed with a fixed seasonally designated flood control storage space of 400,000 acre-feet.

Currently, an interim operation agreement, authorized by Congress, exists between Reclamation and the Sacramento Area Flood Control Agency (SAFCA). This interim agreement for the operation of Folsom Dam states that the flood control storage space in the reservoir is to be changed to an available variable space ranging from 400,000 acre-feet to 670,000 acre-feet (400/670), depending on the amount of creditable vacant space in five identified significant existing upstream reservoirs within the upstream American River Watershed (see **Plates 1** and **6**). The drainage basins above these nonflood damage reduction reservoirs have accounted for a minimum of 14 percent of the unregulated inflows into Folsom Reservoir during major flood events. As these upstream reservoirs' creditable spaces are filled, the variable flood space at Folsom Reservoir can increase to as much as 670,000 acre-feet.

In WRDA 1996, Congress directed the Secretary of the Interior to continue interim operation at Folsom Dam and Reservoir until a comprehensive flood control plan for the American River Watershed was implemented.

Section 101(a) (1) (c) of WRDA 1996 (PL 104-303)

AMERICAN AND SACRAMENTO RIVERS, CALIFORNIA.

"The Secretary of the Interior shall continue to operate the Folsom Dam and Reservoir to the variable 400,000/670,000 acre-feet of flood control storage capacity as an interim measure and extend the agreement between the Bureau of Reclamation and the Sacramento Area Flood Control Agency until such time as a comprehensive flood control plan for the American River Watershed has been implemented."

Based on this authorization, the Corps' without-project condition for this report includes a continued interim operation by Reclamation and SAFCA of 400/670 indefinitely (current agreement ends in 2018).

The authorization for the Folsom Modification Project directs the Corps to change the existing interim operation from the current 400/670 to a 400,000 acre-foot to 600,000 acre-foot (400/600) variable flood space operation once the Folsom Modification Project has been implemented. Therefore, the with-project condition for this report includes a permanent reoperation of 400/600 (see **Chapter 4**).

Section 101(a) (6) of WRDA 1999 (PL 106-53)

AMERICAN AND SACRAMENTO RIVERS, CALIFORNIA...

(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.

A permanent reoperation study is currently being developed in conjunction with the American River Watershed Project. A decision on permanent reoperation has not been made, but it is anticipated to be approved prior to completion of the Six Submerged Tainter Gate Element (6 STG Element) of the Selected Plan described in **Chapter 4.** The permanent reoperation study will focus on identifying environmental impacts and costs as well as providing a repayment strategy and repayment responsibility of potential water supply losses resulting from the reoperation. A revision to the existing water control manual will be developed in coordination and collaboration with all partners prior to completion of the auxiliary spillway, applying all available science, engineering, and applicable authorizations.

2.5.2 Common Features

Common Features consist of levee and other flood management improvements authorized in WRDA 1996 and WRDA 1999. The Common Features generally include (1) levee modification along both banks of the lower American River, (2) levee modifications along the east bank of the Sacramento River downstream from the Natomas Cross Canal, (3) installation of telemetered streamflow gages upstream from Folsom Reservoir and modifications to a flood warning system along the lower American River, and (4) continued interim reoperation of Folsom Dam and Reservoir flood control storage capacity. Below is a summary of the Common Features included in the 1996 and 1999 authorizations. The current schedule is for the Common Features Project to be completed by the end of 2007.

2.5.2.1 Water Resources Development Act of 1996 Common Features

- Approximately 19 miles of slurry wall in the levees along the lower American River.
- Approximately 12 miles of levee modifications along the east bank of the Sacramento River downstream from the Natomas Cross Canal.
- Three telemetered stream flow gages upstream from Folsom Reservoir.
- Modifications to the flood warning system along the lower American River.
- Continued interim operation of Folsom Dam and Reservoir to the variable 400,000/670,000 acre-feet of flood control storage capacity.

2.5.2.2 Water Resources Development Act of 1999 Additions to Common Features

The Common Features shown below have been refined from the descriptions given in WRDA 1999 by the *2002 2nd Addendum* to the March *1996 SIR* (Corps):

- Raising the non-Federal levee on the left bank of the river upstream from the Mayhew Drain for a distance of 4,300 feet by an average of 2.5 feet.

- Raising the right bank of the American River levee from 1,500 feet upstream to 12,000 feet downstream from the Howe Avenue Bridge by an average of 1 foot.
- Installing a closure structure with gates near the mouth of Mayhew Drain, and adding flap gates to existing culverts and an additional flap-gated culvert under Folsom Boulevard.
- Reshaping the landside levee side slope of the north levee of the American River to provide a 2H to 1V slope from 500 feet upstream to 1,300 feet upstream from State Highway 160.
- Constructing a 4-foot-deep toe drain along the landside levee toe of the north levee of the American River. Repair work will extend from 300 feet west of Jacob Lane to Harrington Way and from 800 feet upstream of River Walk Way to 700 feet downstream from Arden Way.

2.5.3 Seismic Retrofit

As mentioned, potential modifications associated with improving seismic and static conditions that would be accomplished as part of the without-project condition include seismic work at Mormon Island Auxiliary Dam (MIAD), seismic work at the main concrete dam, and improving static conditions at the main concrete dam, the right and left wing dams, and the eight dikes. Work on the main concrete dam would prevent the concrete monoliths from sliding along the foundation contact during a large earthquake. Additional seismic modifications would include reinforcement of the existing spillway piers and gates.

Sand filters would be constructed within the downstream part of the earthen structures (right wing dam, left wing dam, MIAD, and eight dikes) to better control seepage and piping. All earthen structures would be raised to provide up to a minimum of 3 feet of additional freeboard to the existing facilities for Safety of Dams concerns through the placement of additional earthen material, construction of concrete walls, or a combination of the two measures, along the crest of the facilities. In addition, MIAD would be strengthened against deformation of the foundation and movement of the dam during a severe seismic event by either jet grouting or excavation and replacement of upstream foundation materials, followed by a massive overlay placed on the downstream portion of the dam.

2.5.4 Bridge

The existing Folsom Dam Road, which is a two-lane, undivided road about 2.3 miles long, connects Folsom-Auburn Road to the west of the American River with East Natoma Street to the east. Folsom Dam Road had become an important traffic link in the Sacramento region that, prior to the road closure, supported traffic volumes of about 16,000 vehicles per day.

The original proposal to raise Folsom Dam included construction of a temporary vehicle bridge to provide a detour during construction for public traffic that normally used Folsom Dam Road to cross the American River. In Energy and Water Development Appropriations Acts for 2004 and 2006 subsequent appropriation language, Congress directed the Corps to construct a permanent bridge in lieu of a temporary bridge, in coordination with a non-Federal sponsor, and

provided subsequent direction, respectively. The City of Folsom is the non-Federal sponsor for the permanent bridge.

The selected permanent bridge alternative consists of a prestressed concrete, cast-in-place segmental box girder structure. The bridge span and concrete abutments will be approximately 935 feet long. Two support piers will be placed above the mean river water level in the riverbank areas. The bridge span will have an estimated clearance of 180 feet from the river (top of deck to mean river surface). The bridge will be constructed by using the balanced cantilever method for post-tensioned, cast-in-place, segmental concrete bridges. It will be capable of carrying four lanes of traffic, plus a bike path.

The roadway also will consist of four lanes of traffic plus a bike path. New signaled intersections will be constructed at Folsom-Auburn Road and East Natoma Road.

2.5.5 Fuseplug Spillway for Probable Maximum Flood

In the without-project condition considered for this *PAC Report*, Reclamation would address the dam safety hydrologic risk of passing the PMF event by construction of an emergency fuseplug spillway on the south (left) abutment and downstream from the left wing dam. As mentioned, the current dam spillway and outlets do not have sufficient capacity for managing the predicted PMF flows and require the additional discharge capacity provided by an auxiliary spillway.

The new fuseplug spillway for dam safety would include an approach channel on the water side of the control section and a fuseplug embankment structure, as shown in **Plate 7**. Reclamation designed the fuseplug embankment sections to consist of a zoned embankment with an impervious core, an internal coarse shell zone, and erosion protection on the upstream face (see **Plate 8**). The goal is that the fuseplug embankment sections would erode in a predictable manner when the reservoir elevation exceeds the elevation of a pilot channel. The multiple embankment sections of the fuseplug would allow progressive passage of larger floods up to the PMF flow. Downstream from the fuseplug embankment sections, a partially lined chute would convey spillway flows to the American River.

2.5.6 L.L. Anderson Dam Spillway Modification

The work required to correct the L.L. Anderson Dam spillway deficiency is regulated by the California Division of Safety of Dams and by the Federal Energy Regulatory Commission (FERC). FERC has determined that PCWA is to modify L.L. Anderson Dam to pass the PMF under the without-project condition (see **Appendix G**).

CHAPTER 3.0
DESCRIPTION OF AUTHORIZED AND RELATED PROJECTS

3.1 FOLSOM MODIFICATION PROJECT

The Folsom Modification Project was authorized in the Water Resources Development Act (WRDA) of 1999. The authorized plan included the elements of the Folsom Modification Plan described in the Corps *1996 American River Watershed, California, Supplemental Information Report* (1996 SIR), as modified in the 1998 Sacramento Area Flood Control Agency (SAFCA) Information Paper *Folsom Dam Modification Report, New Outlets Plan.*

Because the project authorized in WRDA 1999 differed from the plan presented in the *1996 SIR*, the Draft *Folsom Modification Project Environmental Assessment/Initial Study* (EA/IS) was prepared in 2001 to document environmental effects of the authorized elements (Corps and Reclamation). At the same time, additional studies were conducted, as directed by WRDA 1999, which were documented in the February 2002 *American River Watershed Long-Term Study Final Supplemental Plan Formulation Report/Environmental Impact Statement/Environmental Impact Report* (EIS/EIR) (2002 Long-Term Study). To reconcile differences between the Folsom Dam modification features presented in the *2001 EA/IS* and the *2002 Long-Term Study*, the *Folsom Dam Modification Project Final Limited Reevaluation Report and EA/IS* (2003 LLR) was prepared in 2003. Since preparation of the *2003 LRR*, and completion of construction plans for those elements, additional studies and authorization of the Folsom Dam Raise Project have identified further changes to the Folsom Modification Project.

Following is a summary of the project authorized in WRDA 1999, refinements described in the *2003 LRR*, and additional changes subsequent to the *2003 LRR*.

3.1.1 Project Authorized in Water Resources Development Act of 1999

The *1996 SIR* features of the Folsom Modification Plan included lowering the main spillway by 15 feet, replacing the main spillway tainter gates, and enlarging the eight existing outlets. However, a tainter gate failure in 1995 that closed Folsom Dam Road for several months during repairs prompted SAFCA to evaluate alternative plans that would increase release capacity without the traffic and operational effects of lowering the spillway. SAFCA's 1998 *Folsom Dam Modification Report, New Outlets Plan,* proposed several modifications to the previously defined project. On the basis of the *1996 SIR* and SAFCA's recommendations in the 1998 report, the Folsom Modification Project authorized in WRDA 1999 (Section 101(a) (6)) included several significant features: enlarging the eight existing outlets (without lowering the main spillway), constructing five new sluiceways under the emergency spillway, and constructing a new emergency spillway stilling basin. The authorization also provided for permanent modification to the flood control storage space in Folsom Reservoir. In combination, the outlet and spillway modifications and permanent reoperation would achieve an objective release capacity of 115,000 cubic feet per second earlier than under without-project conditions. It was estimated that with the above features in place, along with completion of construction of the American River Common Features Project, the flood risk would be lowered from a 1 in 85 chance in any year to a 1 in 140 chance in any year.

The 1999 authorization also included a separate provision for the United States Department of the Interior, Bureau of Reclamation (Reclamation), to enter into an agreement with SAFCA regarding the impacts created by a permanent reoperation of Folsom Dam and Reservoir. In the agreement, 100 percent of the water needed (to the extent that the water is available) to make up for water shortages caused by the operation or impacts to recreation at Folsom Reservoir would be the responsibility of Reclamation. The authorization also defined the meaning of a significant impact to recreation. In addition, the authorization directed the United States Army Corps of Engineers (Corps) and Reclamation to update the Flood Management Plan authorized in the Department of Defense Appropriations Act of 1993. That update was to reflect forecast-based operational changes at Folsom Dam and Reservoir for flood damage reduction. This would include an attempt to gain additional flood storage space through advance release of stored water based on forecast and inflow of large storms in accordance with the provisions identified in the Department of Defense Appropriations Act of 1993 Section 9159(f)(2) and again in WRDA 1999 Section 101(a)(6) (B and E).

3.1.1.1 Benefits and Costs

The Folsom Modification Plan presented in the *1996 SIR* (which differs somewhat from the authorized Folsom Modification Project, as noted above) was estimated to reduce the probability of flooding due to levee failure to a 1 in 180 chance in any given year. Benefits and costs presented in the *1996 SIR* are as follows: total first cost of $399 million, average annual benefits of $98 million, average annual costs of $44 million, and net annual benefits of $54 million (1995 price levels).

The total first cost of the Folsom Modification Project elements, as authorized, was estimated as $150 million in WRDA 1999. This difference is due in part to authorized design changes proposed in the 1998 SAFCA report (i.e., modifying existing outlets in lieu of lowering the spillway by 15 feet) and because the values in the *1996 SIR* include downstream levee modifications and other project elements that were either not authorized or were authorized separately.

3.1.1.2 Cost-Sharing

Of the $150 million total estimated cost reported in WRDA 1999, the estimated Federal share was $97.5 million and non-Federal share was $52.5 million.

In accordance with Federal cost-sharing requirements for flood damage reduction projects set forth in WRDA 1996, project costs were apportioned 65 percent Federal and 35 percent non-Federal; non-Federal sponsors would bear all costs related to operations and maintenance, repair, replacement, and rehabilitation (OMRR&R) of flood control facilities. Reclamation and SAFCA have entered into an agreement that Reclamation is responsible for OMRR&R and SAFCA will pay for these costs upon completion of the Folsom Modification Project. Non-Federal sponsors would also be responsible for lands, easements, rights-of-way, and relocations.

3.1.2 2003 Folsom Dam Modification Project Final Limited Reevaluation Report

The *2003 LRR* reconciled conflicts between the authorized Folsom Modification Project elements and recommendations in the *2002 Long-Term Study*. As directed by Congress in WRDA 1999, the plan identified in the *2002 Long-Term Study* included raising Folsom Dam, modifying downstream levee improvements, and implementing other elements necessary to meet current Federal dam safety standards. Recommendations from the *2002 Long-Term Study* that were authorized by Congress in the Energy and Water Development Appropriations Act for fiscal year 2004 included raising the dam by 7 feet (mini-raise), spillway modifications at L.L. Anderson Dam, a permanent bridge downstream from Folsom Dam, and modification of emergency release operations to permit surcharge. These authorized features, which make up the Folsom Dam Raise Project (described later in this chapter), carry design implications for the previously authorized Folsom Modification Project, as described below.

Under the Folsom Dam Raise Project, all eight existing spillway tainter gates would be modified, spillway bridge piers would be modified, and the spillway bridge would be replaced. If the Folsom Modification Project were implemented first, as authorized, gate modifications would need to be made twice. Consequently, the *2003 LRR* refined the elements related to increasing release capacity to be consistent with gate modifications in the *2002 Long-Term Study*. These changes included the following:

- Construct two new upper tier outlets
- Enlarge the four existing upper tier outlets to 9 feet, 4 inches, by 14 feet, and the four existing lower tier outlets to 9 feet, 4 inches, by 12 feet
- Modify existing main spillway stilling basin

In addition, for the surcharge storage aspect of the project, the three emergency spillway tainter gates would be replaced with larger gates, as authorized, but the design would permit future expansion of these gates should the Folsom Dam Raise Project be authorized and implemented.

Table 3-1 summarizes the originally authorized elements, modified features in the *2003 LRR*, and other subsequent changes to the Folsom Modification Project. It is important to note that it is the features and their respective costs described in the *2003 LRR* for which changes are described in this *PAC Report*.

TABLE 3-1
COMPARISON OF AUTHORIZED AND REFINED AUTHORIZED PROJECTS FEATURES, FOLSOM MODIFICATION PROJECT

Function	Project Features in 1996 SIR[1]	Authorized Project Features (WRDA 1999[2])	Project Features in 2003 LRR[3]	Recent Design Considerations (2003 to present)
Increase Release Capacity (115,000 cubic feet per second objective release)	Lower spillway crest by 15 feet	In lieu of lowering the spillway, construct 5 new outlets under the emergency spillway (two 7' x 14' slide gates per outlet)	Add 2 new upper tier outlets (9'4" x 14')	Construct new, auxiliary spillway with up to 6 submerged tainter gates (23' wide by 33' high)
	Enlarge 8 existing main dam outlets to 6' x 12'	Enlarge 8 existing main dam outlets to 6' x 12'	Enlarge 8 existing main dam outlets to 9'4" x 14' (4 upper tier outlets), and 9'4" x 12' (4 lower tier outlets)	
			Construct stilling basin modification with additional anchorage of apron slab	Construct new stilling basin downstream from auxiliary spillway
Modify Use of Surcharge Storage	Raise impervious core in Mormon Island Auxiliary Dam, Dike 5, and Dike 7	No change from *1996 SIR*	No change from *1996 SIR*	Modified use of surcharge storage would not be necessary with implementation of the Folsom Dam Raise Project; modifications to existing emergency spillway tainter gates still under consideration as part of Folsom Dam Raise Project
	Modify surcharge operation to provide additional flood space	No change from *1996 SIR*	No change from *1996 SIR*	
	Construct parapet wall at Newcastle Powerhouse	No change from *1996 SIR*	No parapet wall required	
	Raise penstock gate hoists and relocate hydraulic pumps	No change from *1996 SIR*	No change from *1996 SIR*	
	Replace 3 emergency spillway tainter gates with 42' x 59' tainter gates (new top of gate elevation of 476 feet)	No change from *1996 SIR*	Design tainter gate foundations to permit expansion in future, if Folsom Dam Raise Project is implemented	
	Top-seal existing spillway tainter gates	No change from *1996 SIR*	Top-seal not used (not technically feasible)	
Revise Interim Operation (permanent reoperation)	Reduce variable space allocated to flood control from 400-670 TAF to 400-600 TAF	No change from *1996 SIR*	No change from *1996 SIR*	No change from *1996 SIR*
Update Folsom Dam Flood Management Plan	Revise plan to reflect operational capabilities provided by outlet modifications, surcharge storage space, and improved forecasting	No change from *1996 SIR*	No change from *1996 SIR*	No change from *1996 SIR*
Key:	LRR = Limited Reevaluation Report SIR = Supplemental Information Report		TAF = thousand acre-feet WRDA = Water Resources Development Act	

Notes:
1. *American River Watershed Project, California, Supplemental Information Report, Corps, March 1996.*
2. *Section 101(a) (6) of Water Resources Development Act of 1999 (PL 106-53).*
3. *American River Watershed, California, Folsom Dam Modification Project, Final Limited Reevaluation Report and Environmental Assessment/Initial Study, Corps, November 2003.*

3.1.2.1 Benefits and Costs

The estimated costs and benefits for the Folsom Modification Project, as presented in the *2003 LRR*, are summarized in **Table 3-2**. Note that in the *2003 LRR*, the benefits and costs associated with the outlet works modifications were presented separately from those associated with the modified use of surcharge storage; this is because features associated with modifying surcharge space would not be required if the Folsom Dam Raise Project were authorized and implemented. The project features, costs, and benefits for the outlet works modification portion of the project are used as the basis for comparison in this *PAC Report*. Congress did not authorize the Folsom Dam Raise Project until after the *2003 LRR* was completed. The plan described in the *2003 LRR* would reduce the potential of flooding in Sacramento to about a 1 in 140 chance in any year.

TABLE 3-2
BENEFITS AND COSTS FOR FOLSOM MODIFICATION PROJECT FEATURES AS PRESENTED IN 2003 LRR ($ MILLIONS) [1]

Item	Outlet Works Modifications [2]	Modified Use of Surcharge Space	Total
First Cost [3]			
Lands and Damages	0	0	**0**
Relocations	0	0	**0**
Construction	140.3	25.1	**165.4**
Environmental Mitigation	0	0	**0**
EDS&A	43.5	5.2	**48.7**
Total	**183.8**	**30.3**	**214.1**
Investment Cost			
Total First Cost	183.8	30.3	**214.1**
Less PED Accrued	-3.9	0	**-3.9**
Interest During Construction	48.1	1.8	**49.9**
Total	**228.0**	**32.1**	**260.1**
Annual Cost [3]			
Interest & Amortization	13.7	1.9	**15.6**
Operation and Maintenance	0	0	**0**
Total	**13.7**	**1.9**	**15.6**
Annual Flood Damage Reduction Benefits [4]	**26.0**	**5.2**	**31.2**
Net Annual Benefits	**12.3**	**3.3**	**15.6**
Benefit-Cost Ratio	**1.9**	**2.7**	**2.0**

Key: EDS&A = engineering, design, supervision, and administration
LRR = Limited Reevaluation Report
PED = preconstruction, engineering, and design

Notes:

1. *American River Watershed, California, Folsom Dam Modification Project, Final Limited Reevaluation Report and Environmental Assessment/Initial Study, Corps, November 2003.*
2. *The first and annual cost, as well as benefits of the outlet works, is used as the basis of comparison in this PAC Report in* ***Chapter 5****.*
3. *October 2003 price levels.*
4. *50-year period of analysis and a 5-5/8 percent discount rate.*

3.1.2.2 Cost-Sharing

Federal and non-Federal cost-sharing requirements for the Folsom Modification Project did not change in the *2003 LRR*; in accordance with Federal cost-sharing requirements for flood damage reduction projects, costs were apportioned 65 percent Federal and 35 percent non-Federal. Of the estimated $183.8 million first cost, the Federal contribution was estimated as $139.5 million and the non-Federal contribution as $74.6 million at October 2003 price levels.

Following release of the *2003 LRR*, a Project Cooperation Agreement (PCA) for the Folsom Modification Project was executed on 30 March 2004. Under the PCA, The Reclamation Board of the State of California (The Reclamation Board) and SAFCA are the non-Federal sponsors.

3.1.3 Changes Since Authorization and 2003 Limited Reevaluation Report

Plans and specifications for the Folsom Modification Project were prepared in 2003 and 2004. It was decided as part of this process, in about March 2004, to divide the project into an upper tier contract (with six outlets) and a lower tier contract (with four outlets). Proposals were received in March 2005 for the upper tier outlets. The amount of the proposals exceeded the fully funded authorized costs (Section 902 limit) and the project solicitation was subsequently canceled in January 2006. The high bid estimates were largely due to key elements of high risk placed on the contractor, limited competition, and significant escalation in the cost of construction materials.

Consequently, dam operations and performance and alternate structural methods to achieve the flood damage reduction provided by the outlet modifications were reexamined. Subsequent studies also found that modification of the two outboard lower tier outlets was infeasible, and offered only a marginal increase in performance. Most recently, a gated auxiliary spillway has been identified as a viable "functionally equivalent" alternative to outlet modifications (see **Chapter 4**). The auxiliary spillway would be less costly because it would not entail the construction risk associated with the outlet modifications. In addition, material excavated from the auxiliary spillway site could be used for static and seismic dam safety improvements proposed by Reclamation. The new auxiliary spillway with submerged tainter gates would allow greater prereleases in anticipation of a large flood in a functionally similar manner to enlarging the existing outlets and constructing new outlets. Also, Reclamation identified a fuseplug with spillway that provided an opportunity for collaboration with the Corps on flood improvements at the dam.

Recent studies and direction related to the Folsom Modification Project have sought to jointly address the objective of flood damage reduction and dam safety. An engineering *Project Alternative Solutions Study* (PASS) was conducted jointly by the Corps and Reclamation in 2005 that examined five alternative auxiliary spillway and outlet modification combinations. Each scenario would pass the computed 200-year flood event (in combination with the Folsom Dam Raise Project, described below). It is estimated that the auxiliary spillway currently under evaluation would meet both the flood damage reduction improvement goals and Reclamation's dam safety goals related to passing the Probable Maximum Flood (PMF).

Although the structural features of the Folsom Modification Project have changed over time, the scope of the authorized project remains focused on increasing the release capacity at Folsom Dam.

3.2 FOLSOM DAM RAISE PROJECT

As mentioned, the Folsom Dam Raise Project was authorized in 2003 in the Energy and Water Development Appropriations Act of 2004 based on recommendations contained in the November *2002 Chief of Engineers Report*. This project is based on the findings in the *2002 Long-Term Study*. Following is a summary of the authorized project and changes to the project since authorization.

3.2.1 Authorized Project

The Folsom Dam Raise Project consisted of the following major elements:

- Raise Folsom Dam, wing walls, and dikes by 7 feet
- Construct a temporary or permanent bridge downstream from Folsom Dam
- Modify L.L. Anderson Dam spillway at French Meadows Reservoir
- Implement ecosystem restoration features to benefit the lower American River

As authorized, the Folsom Dam elements involve raising the main concrete section of the dam, adding a 3.5-foot parapet wall, raising the earth embankments on either side of the dam, adding larger spillway radial gates, and raising Mormon Island Auxiliary Dam (MIAD) and the eight dikes around the lake by about 7 feet. In addition, the existing spillway stilling basin would be extended about 60 feet to provide adequate energy dissipation. These modifications would add about 95,000 acre-feet of flood storage capacity to the reservoir. A permanent bridge would reroute traffic from Folsom Dam Road during and after construction of the dam raise.

Modifications to L.L. Anderson Dam, located on the Middle Fork of the American River at French Meadows Reservoir, would involve enlarging the spillway to allow safe passage of the PMF; these improvements would reduce impacts to Folsom Dam from a potential failure of L.L. Anderson Dam.

The project authorized in 2003 differs from the project recommended in the *2002 Long-Term Study* in that Congress approved construction of a permanent bridge rather than a temporary bridge. A permanent bridge would mitigate for the closure of Folsom Dam Road during construction, while also providing greater security for the dam. The Corps September *2006 American River Watershed Project, California, Folsom Dam Raise, Folsom Bridge Final Post Authorization Decision Document/Environmental Impact Statement/Environmental Impact Report* (PADD) documented the change from a temporary to a permanent bridge feature.

The authorized project includes ecosystem restoration features. These features include construction of automated temperature control shutters (existing shutters are operated manually)

at Folsom Dam to benefit American River fisheries, and active habitat restoration at two sites along the lower American River – Woodlake Restoration Site and Bushy Lake Restoration Site.

3.2.1.1 Benefits and Costs

Table 3-3 includes relevant information on estimated costs and benefits from the February *2002 Long-Term Study, 2002 Chief of Engineers Report,* 2004 authorization language (cost only), and Corps May *2006 American River Watershed Project, California, Draft Folsom Dam Raise, Folsom Bridge PADD.* From the table, the total first cost has ranged from about $219 million at 2001 price levels to approximately $363 million at 2005 price levels. Primary reasons for these cost increases have been the addition of a permanent bridge at Folsom as well as overall price level changes.

TABLE 3-3
SUMMARY OF BENEFITS AND COSTS AS AVAILABLE FOR FOLSOM DAM RAISE PROJECT ($ MILLIONS)

Item	2002 Long-Term Study [1]	2002 Chief of Engineers Report [2]	Authorized Project [3]	Folsom Dam Raise, Folsom Bridge Report [4]
	October 2001 Price Levels	October 2001 Price Levels	October 2003 Price Levels	October 2005 Price Levels
First Cost				
Flood Damage Reduction	99.0	128.2	--	272.6
Ecosystem Restoration	27.3	27.4	--	33.1
Dam Safety	92.6	93	--	[5]
Permanent Bridge	Not included	Not included	--	57.2
Total	218.9	248.6	257.3	362.9
Annual Cost Flood Damage Reduction	**7.8**	**10.2**	--	--
Annual Flood Damage Reduction Benefits	**19.2**	**19.2**	--	--
Net Benefits	**11.4**	**9.0**	--	--
Benefit-to-Cost Ratio	**2.5**	**1.9**	--	--

Note:

1. *Costs and benefits for recommended plan from the Corps February 2002 American River Watershed, California, Long-Term Study.*
2. *Authorized project cost estimate as described in the 5 November 2002 Chief of Engineers Report for the Long-Term Study.*
3. *Authorized cost cited in the 2004 Energy and Water Development Act.*
4. *Corps May 2006 American River Watershed Project, California, Draft Folsom Dam Raise, Folsom Bridge Post-Authorization Decision Document.*
5. *Costs for dam safety included as part of identified cost for flood damage reduction.*

The project identified in the *2002 Long-Term Study* and *2002 Chief of Engineers Report* included provision to address dam safety and temporary impacts to transportation across Folsom Dam. The authorized project also included separate provisions for a permanent bridge. **Table 3-4** is from the above-referenced 2006 Corps *PADD* report and shows total costs for various project components based on October 2005 price levels.

As mentioned, the Folsom Modification Project and Common Features alone would reduce the risk of flood damages to a 1 in 140 chance in any year. However, in combination with the Folsom Dam Raise Project, risk of flood damages would be reduced to about a 1 in 175 chance in any given year.

TABLE 3-4
SUMMARY COSTS FOR FOLSOM DAM RAISE PROJECT FEATURES ($ MILLIONS) [1]

Item	Folsom Dam Raise	Permanent Bridge [2]	L.L. Anderson	Ecosystem Restoration	Total
First Cost					
Lands and Damages	0.9	8.1	0	1.10	**10.1**
Relocations	2.8	4.0	0	0	**6.8**
Construction	152.0	68.9	11.3	24.6	**256.8**
Environmental Mitigation	4.9	3.0	0	0	**7.9**
Cultural Resources	1.9	0.5	0	1.1	**3.5**
EDS&A	30.2	11.8	3.4	6.3	**51.7**
PED Sunk Costs	18.3	7.8	0	0	**26.1**
Total First Cost	**211.0**	**104.1**	**14.7**	**33.1**	**362.9**

Key:
EDS&A = engineering, design, supervision, and administration
PED = preconstruction, engineering, and design

Notes:

1. *Costs in October 2005 price levels as reported in Corps May 2006 American River Watershed Project, California, Draft Folsom Dam Raise, Folsom Bridge Post Authorization Decision Document.*
2. *Bridge costs include $46.9 million as the cost of a temporary bridge and $57.2 million as the remaining cost for the permanent bridge increment.*

3.2.1.2 Cost-Sharing

The Folsom Dam Raise Project includes both flood damage reduction and ecosystem restoration purposes. In accordance with Federal cost-sharing requirements for flood damage reduction projects, costs allocated to flood damage reduction were apportioned 65 percent Federal and 35 percent non-Federal. Non-Federal sponsor(s) would be responsible for all lands, easements, rights-of-way, and relocations. For the ecosystem restoration elements of the project, the non-Federal sponsor(s) would be responsible for 35 percent of the costs allocated to ecosystem restoration.

Of the $257.3 million total cost listed in Section 128 of PL 108-137, the Federal share was $201.2 million and the non-Federal share was $56.1 million. PL 108-137 also authorized the Secretary of the Army to accept funds from local, State, and other Federal agencies for construction of a permanent bridge, should the cost of a permanent bridge exceed the $36 million for a temporary bridge included in the recommended plan. This act also authorized an additional $30 million as a Federal contribution towards the permanent bridge. In fall 2005, the Energy and Water Development Appropriations Act of 2006 (PL 109-103) authorized $30 million in Federal funds for the permanent bridge, and the $36 million assigned to the temporary bridge could be inflated, as prescribed in Section 902 of PL 99-662.

The September *2006 Final PADD* reports the total cost of the bridge as $110.7 million. Of this total, the temporary bridge cost is $47.8 million (current estimate of $49.9 million) and the balance for the permanent bridge is $62.9 million (current estimate of $65.7 million). The original $30 million Federal contribution to the permanent bridge was increased.

The $47.8 million for the temporary bridge was part of the Folsom Dam Raise Project cost. This cost was split between dam safety and flood damage reduction. As part of the authorized project, the flood damage reduction portion would be cost-shared with The Reclamation Board and SAFCA. Local funds contributed to the temporary portion of the bridge cost are credited towards the local share of the Folsom Dam Raise Project as a whole. The dam safety portion is budgeted as a Federal cost.

The permanent portion of the bridge cost, including all lands, easements, rights-of-way, and relocations, is the responsibility of the City of Folsom, with the exception of the $41.5 million Federal contribution authorized by Congress. Local sponsors for the project include The Reclamation Board, SAFCA, and the City of Folsom (for the permanent bridge component only). OMRR&R related to Folsom Dam would continue to be performed by Reclamation; these costs would be shared by SAFCA under an initial cost-sharing agreement. The City of Folsom would assume all responsibilities for OMRR&R of the bridge component.

3.2.2 Changes Since Authorization

Since authorization, the Folsom Dam Raise Project has been subject to cost increases due to increases in construction material costs, safety and security considerations at the dam, and a decrease in the availability of contractors. Modifications to the L.L. Anderson spillway have been dropped from further consideration in the plan because the Federal Energy Regulatory Commission has jurisdiction to resolve the dam safety issues as a separate project. Efforts are moving forward on activities to design and advance implementation of the Folsom Bridge. The bridge is scheduled for completion in December 2008. Major efforts on raising Folsom Dam have continued but at a slower pace due to the likely need to consider any dam raise along with further features to modify Folsom Dam. In addition, recent studies related to the Folsom Dam Raise Project have sought compatibility and greater efficiency between the flood damage reduction projects and Reclamation's dam safety objectives at Folsom Dam. The 2005 engineering *PASS* examined various combinations of outlet modifications and dam raises to pass the computed 200-year inflow design event. Of the alternatives considered, a 7-foot dam raise in combination with a new auxiliary spillway was selected for more detailed analysis in a second phase of engineering studies, titled *PASS II*, which was completed in 2006 (Corps and Reclamation).

PASS II indicated that the cost of the 7-foot dam raise is higher than reported in the *2002 Long-Term Study*. Due to the higher estimated cost of a 7-foot dam raise, The Reclamation Board and SAFCA have expressed interest in exploring alternatives to raising the dam. In addition, a smaller, 3.5-foot dam raise (in combination with a new auxiliary spillway) has also been considered.

3.3 FOLSOM DAM SAFETY PROJECTS

Folsom Dam and Reservoir are important surface storage elements of the Central Valley Project (CVP). Reclamation operates the CVP to provide water supplies for agricultural, municipal and industrial (M&I), and environmental purposes. This section describes the features and operation of the American River Division, Folsom Dam Unit, of the CVP, and dam safety issues at Folsom Dam that Reclamation is seeking to address.

3.3.1 American River Division, Folsom Dam Unit

The CVP was created under the Central Valley Project Act in 1933 and became subject to Reclamation under the Rivers and Harbors Act in 1937. The American River Division of the CVP provides water for irrigation and M&I use, recreation, and hydroelectric power. The American River Division facilities consist of the Folsom Dam Unit, Sly Park Unit, and Auburn-South Unit. The Folsom Unit consists of Folsom Dam, Folsom Reservoir, the Folsom Powerplant, Nimbus Dam and Lake Natoma, Nimbus Powerplant, and Nimbus Fish Hatchery.

Folsom Dam was originally authorized for construction in the Flood Control Act of 1944 as a reservoir with 355,000 acre-feet of capacity for flood control purposes. As part of the American River Division Authorization Act in 1949, construction of Folsom Dam was reauthorized with an enlarged capacity of 1,000,000 acre-feet. In addition, the reauthorization added a 162,000-kilowatt (kW) powerplant, with Lake Natoma to serve as a regulating reservoir for the powerplant. The authorization for construction of Lake Natoma and Nimbus Dam included Nimbus Powerplant, with a 13,500 kW production capacity, and Nimbus Fish Hatchery. The Corps completed construction of Folsom Dam in 1956, at which time Reclamation took over OMRR&R of the facility. Current capacity of the reservoir and related details are described in **Chapter 2**.

3.3.2 Dam Safety

Reclamation's Safety of Dams program was officially implemented in 1978 with passage of the Reclamation Safety of Dams Act, PL 95-578, and was amended in 1984 by PL 98-404. The program receives appropriations annually on a Nation-wide basis, and then establishes priorities that are subject to changes by Congress and by the Office of Management and Budget. The Safety of Dams program has recognized Folsom Dam as its top safety priority. The inability of Folsom Dam to pass the PMF event is a dam safety risk recognized by the Corps, Reclamation, and State of California Division of Safety of Dams. Under Section 128 of the Energy and Water Development Appropriations Act of 2006 (PL 109-103), the Corps and Reclamation were directed to collaborate on activities to address dam safety and to reduce flood damage at Folsom Dam and Reservoir, and to consider reasonable modifications to existing authorized activities, including the auxiliary spillway.

Limited storage and release capacity and structural issues are concerns of the Folsom Dam Unit. The current state of these issues is described in **Chapter 2**. To address the risk to PMF dam safety, Reclamation intends to move forward with construction of a new fuseplug spillway if the Corps does not implement a flood damage reduction project. Material from excavation for the spillway would be used to construct dam safety features at MIAD.

The predicted flows of the PMF could be accommodated by the construction of an emergency fuseplug spillway in combination with the existing facilities. The spillway would mitigate the PMF through increased ability to control reservoir capacity. The ability to pass the PMF would reduce the risk of overtopping and failure of the embankment dams and dikes. This solution addresses all of the embankment features, but would have the most potential benefit for the right wing dam, left wing dam, and MIAD. The structure of the emergency fuseplug spillway is described in **Section 2.5.5** of this report; the fuseplug is shown in plan view in **Plate 7,** with a detailed view of the fuseplug in **Plate 8**. Reclamation's current plans call for excavation for the emergency fuseplug spillway to begin in 2007. Construction of the static and seismic dam safety improvements would begin in 2010 and be completed in 2014.

3.4 PROJECT COLLABORATION AND AUXILLARY SPILLWAY

As discussed above, two authorized projects of the Corps, the Folsom Modification Project and Folsom Dam Raise Project, share an objective of reducing flood risk on the lower American River primarily through structural modifications to the existing Folsom Dam and appurtenant facilities. Concurrently, Reclamation was working to implement its Reclamation Safety of Dams program for safety improvements at the Folsom facility. One of Reclamation's dam safety objectives was for the dam to pass the PMF. The timing of both of these Federal efforts created an opportunity to develop a more efficient and cost effective joint plan that addressed both flood damage reduction and dam safety objectives in a single project.

As noted, Congress directed the Corps and Reclamation to collaborate to maximize flood damage reduction and address dam safety at Folsom Dam in the Energy and Water Development Appropriations Act of 2006 (PL 109-103). PL 109-103 directed the Corps and Reclamation to consider reasonable modifications to the existing authorized activities, including an auxiliary spillway.

CHAPTER 4.0
AUTHORIZED PROJECT REFINEMENT

4.1 REFINEMENT PROCESS

As mentioned, Congress authorized both the Folsom Modification Project and the Folsom Dam Raise Project to help decrease the level of flood risk for Sacramento. The Folsom Dam Raise Project was also to resolve hydrologic dam safety issues at Folsom and provide ecosystem restoration opportunities along the lower American River. In addition, Congress authorized reasonable modifications to the authorized activities, including an auxiliary spillway to address both flood damage reduction and hydraulic dam safety, in the Energy and Water Development Appropriations Act of 2006 (Public Law (PL) 109-103). Currently, (1) no project has been implemented, (2) the United States Department of the Interior, Bureau of Reclamation (Reclamation), fully intends to resolve dam safety concerns at Folsom, and (3) it appears likely that a project that would best address both the flood damage reduction and dam safety issues would include an auxiliary spillway. For these reasons, and in accordance with congressional direction in PL 109-103 for the Secretaries of the Army and Interior to collaborate on authorized activities to maximize flood damage reduction improvements, and address dam safety needs at Folsom, there is a need to review, update, and refine existing information to identify a project to meet the needs of the two agencies and local interests. The basic process followed to identify this project in this *Post Authorization Change* (PAC) *Report* consisted of these steps:

- Given residual flood problems along the American River, major efforts accomplished to date to address the flood and related issues (Folsom Modification, Folsom Dam Raise, and Folsom Dam Safety issues), and desires of the non-Federal project sponsors, develop/refine a specific set of project objectives.

- Develop a set of project constraints to be used to identify and compare alternative elements that address the objectives.

- Identify the available set of potential project plans capable of meeting the project objectives consistent with the identified constraints and criteria.

- Compare the identified alternatives and identify actions for recommended implementation.

4.2 PROJECT OBJECTIVES

Major efforts have been made since the February 1986 flood to identify and document flood and related water resources problems in the American River Watershed. In addition, a series of detailed feasibility-scope studies has been conducted, each of which has resulted in congressional authorization of incremental actions to address the serious flood threat to much of the Sacramento area. Project objectives are as follows:

- Primarily from the results of approved studies and authorized projects to date, develop a modification of Folsom Dam and Reservoir capable of reducing flood damages to areas

along the American River, California, generally functionally equivalent to the flood risk reduction intended to be provided by the authorized Folsom Modification and Folsom Dam Raise projects.

- Ensure that the identified refined project provides for the following:
  - Includes features to pass the Probable Maximum Flood (PMF).
  - Allows and accounts for early implementation of the Folsom Dam Bridge.
  - Retains the capability to implement ecosystem features, as authorized for the Folsom Dam Raise Project.

- Meet the minimum community goal, as articulated by the Sacramento Area Flood Control Agency (SAFCA), of having a project capable of safely passing the 200-year computed design flood event.

As described in **Chapter 1**, single event references such as the above objective of passing the 200-year computed design flood event are not used as part of the United States Army Corps of Engineers (Corps) risk-based guidance for project development. However, this objective is considered by the non-Federal sponsor to be important and a convenient way of imparting information about project performance. Accordingly, efforts are made in this *PAC Report* to characterize the ability of alternatives considered in achieving the non-Federal objective as well as defining performance in terms consistent with Corps guidance.

4.3 CONSTRAINTS

To help guide identification and further development of a project that jointly addresses the objectives of the Corps and Reclamation, several project constraints were developed. Some of the constraints are fairly rigid, and include congressional direction; current applicable laws, regulations, and policies; and physical conditions such as topography, hydrology, and other physical limiting factors. Several major constraints are described below:

- **Project Authorization** – As mentioned, the Energy and Water Development Act of 2006 directed the Secretary of the Army and Secretary of the Interior to collaborate on activities to maximize flood damage reduction and improve dam safety needs at Folsom Dam. Earlier authorizations (see Existing Project Authorizations section in **Chapter 1**) identified actions associated with modifications to Folsom Dam and Reservoir, as well as other system improvements, to accomplish specific flood damage reduction and dam safety goals in the Sacramento area.

- **Project Area** – The primary project area for which reduced flood risk is being addressed is the lower American River. Potential alternatives to be considered in the *PAC Report* will be limited, consistent with the findings of numerous previous Federal studies and the various project authorizations described in **Chapter 1** for modifications to Folsom Dam and Reservoir.

- **Laws, Regulations, and Policies** – Numerous laws, regulations, executive orders, and policies need to be considered, including, but not limited to, the Clean Water Act, Clean

Air Act, Endangered Species Act, and Federal and State environmental compliance regulations.

Various other constraints also need to be considered to help guide development of a selected plan. These relate to economic justification, environmental compliance, technical standards, etc. Also, many of the constraints relate to local policies, practices, and conditions. Following are several additional constraints identified to help develop a selected plan:

- A selected plan is to be cost effective; that is, it should be economically feasible - producing economic annual benefits greater than average annual costs.
- To allow for maximum Federal financial participation, a selected plan needs to be shown to produce economic benefits on the ascending limb of the net benefit curve.
- A selected plan should be functionally equivalent to the originally authorized projects.
- A selected plan needs to address each of the project objectives.
- A selected plan should avoid significant hydrologic impacts to areas downstream from the American River.
- A selected plan should strive to either avoid potential adverse impacts to environmental resources, or to include features to mitigate unavoidable impacts through enhanced designs, construction methods, and/or facilities operations.
- A selected plan should not result in significant adverse impacts to existing water supplies, recreation facilities, hydropower generation, or related water resources conditions.
- A selected plan is to be developed and evaluated based on a 50-year period of analysis.
- First costs are to reflect current prices and price levels, and annual costs are to include a Federal discount rate and allowance for interest during construction. There are three levels of cost estimates to be considered; each is to be used for different purposes in the analysis. Following are the three cost estimate levels and the purpose for which they are to be used:
  - **Cost Distribution** – Cost estimates were prepared for various modifications of Folsom Dam and auxiliary spillway configurations to develop a method to be used to distribute costs primarily between the purpose of flood damage reduction and the function of dam safety. This distribution method is described in **Appendix F - Cost Distribution**. It uses cost estimates developed to a level of specificity sufficient to distinguish between the purposes/function, and adequate for application to any alternatives identified for implementation.
  - **Alternatives Comparison** – Cost estimates were developed for numerous alternatives for the purpose of identifying which alternative or combination of alternatives best addressed the scope of the two authorized projects. These estimates

are to a feasibility level of development. They are appropriate to adequately describe the relative differences in costs, and sufficient for use in the economic comparison of the alternatives.

- **Selected Plan** – Detailed microcomputer-aided cost engineering system (MCACES) cost estimates were developed for the plan selected and described at the end of this chapter. These estimates are also to a feasibility level of development but include additional detail sufficient to support the recommendation contained in this *PAC Report*.

4.4 POTENTIAL FEATURES

Numerous structural and nonstructural measures that could contribute to helping reduce flood damages primarily to areas of Sacramento along the American River have been exhaustively developed in various prior studies and reports. Many of these features, especially related to levee improvements, flood management, and evacuation planning, have been incorporated into various plans and implemented in previous projects. In addition, previous evaluations have found that further increases to downstream levee capacity would be less efficient at reducing flood risk compared to improvements at Folsom Dam.

From the measures identified in previous studies and projects, following is a brief summary of several of the most significant potential plan features that have been identified as possible components for addressing the project objectives. Again, these are not the only potential features to address the project objectives. However, they are the significant features primarily associated with modifications of Folsom Dam and Reservoir found in previous studies to have the greatest potential to benefit flood damage reduction, and/or dam safety.

4.4.1 Increase Objective Release

This feature consists of increasing the objective release from Folsom Dam of 115,000 cubic feet per second (cfs) to about 180,000 cfs, similar to that for the Stepped Release Plan in the Corps *1996 Supplemental Information Report* (1996 SIR) for the American River Watershed Investigation (ARWI). It is estimated that Folsom Dam, with the existing objective release of 115,000 cfs, can control floods with up to about a 1 in 81 chance of occurring in any year. For larger events, greater outflows are required to maintain the allowable flood control space in the reservoir. As a result of levee modifications (Common Features Project described in **Chapter 2**) being made in accordance with the Water Resources Development Act (WRDA) of 1996 and WRDA 1999, the safe channel-carrying capacity of the American River will be increased to about 160,000 cfs. This feature would require further modifications, primarily to levees and related flood damage reduction facilities along the lower American River and further downstream, to accommodate the increased flow from Folsom Dam. Although this feature would depend on a change in the operation of Folsom Dam and Reservoir, it would also require major system modifications significantly divergent from the existing authorizations; therefore, this feature was not considered further.

4.4.2 Replace Main Spillway Gates

The *1996 SIR* included lowering the spillway crest of the five bays of the main spillway at Folsom Dam by about 15 feet through removing existing concrete from each bay. It also included replacing the existing spillway tainter (radial arm) gates with larger (higher) gates. This work would allow releases through each spillway to be made sooner during a flood, thus increasing the effectiveness of the flood storage space behind the dam. This feature was included as part of the Folsom Modification Plan in the *1996 SIR*. It was accordingly included in the WRDA 1999 authorization but was subsequently deleted from consideration during more detailed planning and design evaluations as part of the Corps *2003 American River Watershed, California, Folsom Dam Modification Final Limited Reevaluation Report and Environmental Assessment/Initial Study* (2003 LRR). However, should Folsom Dam be raised over about 3.5 feet, the existing main spillway gates would need to be replaced. Accordingly, a feature to lower the spillway was eliminated from alternatives for a potential selected plan, but replacing the spillway tainter gates was retained for alternatives requiring a significant raise of Folsom Dam.

4.4.3 Modify Outlets

This feature includes enlarging six of the eight existing outlets and constructing two new outlets. A major feature in the 1999 authorized project called for enlarging the eight existing outlets and constructing five new outlets under the emergency spillway. In the *2003 LRR*, the plan was changed to enlarging the eight existing outlets and constructing two new lower tier outlets. However, during subsequent evaluations, it was determined that while physically feasible, because of major difficulties associated with constructing the two new outlets while maintaining a full or nearly full reservoir pool, the estimated cost to accomplish this feature would be prohibitive. This feature was retained for consideration, as appropriate, in alternatives for a potential Selected Plan.

4.4.4 Modify Folsom Flood Space

This feature includes increasing the seasonal flood control storage space in Folsom Reservoir. In 1995, an interim operation agreement was reached between Reclamation and SAFCA to increase the seasonal flood space in Folsom Reservoir from 400,000 acre-feet to a space varying from 400,000 to 670,000 acre-feet. This seasonal increase significantly increases the ability of Folsom Reservoir to accommodate storm flood events. As part of the authorization for the Folsom Dam Modifications in WRDA 1999, this variable space could be reduced to 400,000 to 600,000 acre-feet once the modifications were completed (see **Plate 9**). The authorized Folsom Dam Raise Project (Energy and Water Development Appropriations Act of 2004) included an increase in this flood storage capacity of 95,000 acre-feet. The concept of modifying Folsom flood space was retained for inclusion in alternatives to determine a potential Selected Plan.

4.4.5 Surcharge Storage

Folsom Reservoir has approximately 14.5 feet of freeboard above the gross pool elevation of 466 feet. A portion of this freeboard has occasionally been "encroached" upon

during flood operations. This space above gross pool is called "surcharge" space. This feature consists of crediting much of the surcharge space to regular flood operations. This would primarily include (1) changing the release diagram for the emergency spillway, (2) replacing the three existing emergency spillway tainter gates with larger (higher) gates, (3) raising the penstock hydraulic control pumps and controls, and (4) raising the height of the impervious core in Dikes 5 and 7 and Mormon Island Auxiliary Dam (MIAD). This feature was included as part of the Folsom Modification Plan in the *1996 SIR*. It was also included in the WRDA 1999 authorization and retained for more detailed evaluations as part of the *2003 LRR*. **Plate 10** illustrates the differences between the existing and replaced emergency spillway gating necessary for this feature. As mentioned, the Folsom Dam Raise Project negated the need for replacing the three existing emergency spillway tainter gates as part of the Folsom Dam Modification Project. Accordingly, structural measures to allow further use of surcharge storage were eliminated from further consideration. However, reservoir operations relying on the use of surcharge storage space remains an effective measure for flood damage reduction and was retained for consideration in all alternatives.

4.4.6 Advanced Release

Section 101(a)(6)(E) of WRDA 1999 directed the Corps and Reclamation to update the flood management plan to reflect operational capabilities created by the Folsom Dam Modification Project and improved weather forecasts. This innovative means of further reducing the risk of flooding involves eliminating reliance on simple rule curves that respond to reservoir surface elevation and observed inflow, and instead making flood operation decisions based on inflow forecast by measuring precipitation in the watershed or, alternatively, based on precipitation forecasts by observing incoming storms. Watershed precipitation forecasts could allow for releases as many as 3 days in advance. The effect of advance release is to create additional flood space in Folsom Reservoir by temporarily reducing water supply storage. Because forecast-based operation is still being formulated, and is not yet approved by the Corps or Reclamation, it is uncertain how this operation will be performed. Accordingly, forecast-based operation was not specifically considered further in reservoir operation scenarios for alternative plans in this *PAC Report*. However, the Corps intends to pursue assessing the potential to improve flood operations at Folsom Dam and Reservoir using forecast-based operations.

4.4.7 Raise Folsom Dam

This feature primarily includes increasing the height of Folsom Dam. In addition to flood damage reduction benefits, this concept could also resolve hydrologic dam safety issues at Folsom Dam, passing the PMF. Various dam raise options up to 30 feet have been considered in previous studies. As previously mentioned, however, in the Energy and Water Development Appropriations Act of 2004, Congress authorized a plan to raise Folsom Dam consistent with the *Chief of Engineers Report* dated 5 November 2002. This report called for raising the dam 7 feet, replacing five main dam spillway gates and three emergency spillway gates, and modifying various reservoir area dikes (see **Plate 11**). Other dam raise options, ranging from 3.5 feet to 12 feet, were considered in supporting studies. A project to raise Folsom Dam, as authorized, would also include enlarging the existing spillway at L.L. Anderson Dam (the *2002 Long-Term*

Study and *2002 Chief of Engineer's Report* made the L.L. Anderson feature dependent on the Federal Energy Regulatory Commission (FERC) and California Department of Water Resources (DWR)); ecosystem restoration and habitat improvements; and building a permanent bridge just downstream from Folsom Dam. Subsequent studies have determined that modifications of L.L. Anderson Dam will be accomplished independently of any actions associated with further efforts to address flood problems on the American River. In addition, construction of the Folsom Dam Permanent Bridge was authorized for advance construction in the Energy and Water Development Appropriations Act of 2004. Raising Folsom Dam, and associated project elements, as authorized in the Energy and Water Development Appropriations Act of 2004, was retained for inclusion in alternatives to determine a potential Selected Plan.

4.4.8 Auxiliary Spillway

This feature consists of the construction of an auxiliary spillway southwest of the existing Folsom Dam (**Plate 12**). This spillway was site-adapted from DWR's Oroville Dam flood control structure primarily to provide enhanced flood damage reduction and hydrologic risk reduction. For flood damage reduction, this feature primarily includes (1) an approach channel beginning in Folsom Lake, (2) control structure, including six submerged tainter gates, (3) a spillway chute, and (4) stilling basin in the American River. This feature was developed following a determination in approximately 2004 that new outlets and enlarging the existing eight outlets would cost significantly more than previously estimated, and that the 902 limitation would be exceeded. This feature was retained for consideration in alternatives to determine a potential Selected Plan.

The auxiliary spillway would address the flood damage reduction objective and would be capable of addressing hydrologic dam safety issues at Folsom. An alternative to the auxiliary spillway described above that addresses dam safety only has been designed by Reclamation. This would involve construction of an "emergency fuseplug" control structure (in lieu of the six submerged tainter gate control structure) and spillway, designed to be used only during extremely rare events. The fuseplug spillway alignment is shown in **Plate 7**; various plan, profile, and section views of the fuseplug sections and spillway are included in **Plate 8**. The fuseplug would be constructed of embankment materials near the upstream end of the structure and designed to erode at a predicted rate during a PMF event. This feature is a major element of the No-Action Plan and is included in one of the action alternative plans.

4.5 ALTERNATIVES

From the above features identified for further consideration, numerous conceptual alternatives were developed (see **Appendix A - Folsom Modification Project Engineering Design Report** and **Appendix B - Folsom Dam Raise Project Engineering Design Report**), some of which addressed only flood damage reduction objectives (**Appendix A**) and others that addressed both flood damage reduction and dam safety objectives (**Appendix B**). From these conceptual alternatives, and in coordination with representatives from Reclamation, SAFCA, and DWR, four action alternative plans that addressed both flood damage reduction and dam safety objectives were developed by the Corps. These action alternative plans, along with the No-Action Plan, are described below. The action alternative plans are believed sufficient to cover

the viable range of possible actions. The primary method used in the development of alternatives was to consider, in various combinations, the features retained for further consideration from **Section 4.4**. From these combinations, numerous potential action alternative plans were developed; however, those listed below are considered to be the most likely to continue to be economically feasible, closely meet the objectives and accomplishments of the two authorized projects, and provide the greatest net benefits, and could be supported by the non-Federal sponsor. All of the action alternative plans address the project objectives and constraints above. Each would result in a reduction of flood damages along the American River. In addition, each would include provisions to pass the PMF, as defined by the Corps and Reclamation. All of the action alternative plans allow for early implementation of the Folsom Dam Bridge and retain the capability for inclusion of ecosystem restoration features. In addition, all of the action alternative plans retain the ability for further improvements in flood protection, including a further raise of Folsom Dam and Reservoir.

4.5.1 No-Action Plan

This alternative plan consists of the Federal Government taking no further action to reduce flood damages in the Sacramento area. It does assume, however, completion of flood damage reduction efforts currently underway, as described in **Chapter 2**. As mentioned, this primarily includes (1) continuing the 400,000 to 670,000 acre-foot variable space flood pool interim operation at Folsom, (2) completing the Common Features Project along the American River, (3) implementing seismic and static retrofit work at Folsom facilities, (4) constructing a new permanent bridge just west of Folsom Dam, (5) constructing an emergency fuseplug spillway project to pass the PMF near the south abutment of the main Folsom Dam, and (6) modification of the L.L. Anderson Dam spillway by Placer County Water Agency.

As part of the interim operation above, and described in **Section 2.5**, this alternative plan also includes a temporary modification to the Folsom Dam Flood Control Diagram adopted by Reclamation and SAFCA. This modification was agreed to by the two interests under a contract dated 6 December 2004 (see Reclamation transmittal letter in **Appendix G – Pertinent Correspondence**). Basically, this modification includes the following:

- Limit the outflow from Folsom Dam to a maximum of 145,000 cfs while the lake level is below elevation 470 feet. Outflows greater than 115,000 cfs would be limited to very infrequent flood events.

- Use 100 percent gate openings for the eight 5-foot by 9-foot outlet gates in conjunction with the use of the service spillway, if required. This operation would be limited to very infrequent flood events after total outflows exceed 115,000 cfs.

Once the Common Features Project is completed, it is expected that the above interim operation actions would no longer be needed.

It is important to compare the existing conditions with the No-Action Plan as it pertains to the PMF pool elevation. Under the existing conditions, the PMF pool elevation would be 483.3 feet (2.8 feet above top of dam). **Table 4-1** compares pertinent elevations under the existing

conditions and the No-Action Plan. Under the No-Action Plan, and with the fuseplug spillway in place, the PMF pool would be 477.6 feet.

TABLE 4-1
COMPARISON OF PERTINENT ELEVATIONS FOR THE EXISTING CONDITIONS AND NO-ACTION PLAN (feet)

Item	Existing Conditions	No-Action Plan (with fuseplug spillway)
Top of Dam	480.5	480.5
Maximum Authorized Flood Pool Elevation	466.0	466.0
0.5% Chance Pool [1] Elevation	474.6	474.6
PMF Pool Elevation	483.3	477.6

Key: PMF = Probable Maximum Flood

Note:
1. Pool elevation equal to that reached under the non-Federal sponsors' design flood event objective.

The authorized top of flood pool at Folsom Reservoir is at reservoir water surface elevation 466 feet. With the No-Action Plan, the current PMF reservoir elevation, with induced surcharge (space above flood pool), is 477.6 feet. For perspective, the pool elevation associated with a 200-year flood event would be at elevation 474.6 feet (outflows greater than 350,000 cfs). Folsom Dam currently is unable to pass the PMF without overtopping the dam because the top of dam is 480.5 feet. The emergency fuseplug would be constructed to pass the PMF near the south abutment of the main Folsom Dam.

Despite downstream levee improvements, Folsom Dam operations would not change significantly and therefore would not use improved downstream channel capacity.

In accordance with policy at the time, real estate interests were defined to be the authorized top of flood pool elevation plus 10 feet of elevation. The original take line for associated real estate was determined to be at elevation 476.0 feet.

Under the No-Action Plan, much of the Sacramento area would have protection from the 100-year single event flood. This equates to a flood with an annual exceedence probability (AEP) of 0.0124 (about a 1 in 81 chance in any 1 year). The estimated expected annual damages in Sacramento are about $198.2 million (October 2006 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 E – Economics**.

4.5.2 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. More detailed information on this feature is contained in the Corps *2003 LRR* for the authorized Folsom Dam Modification Project. The second major feature is the emergency fuseplug spillway (see **Plates 7** and **8**). 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.

4.5.2.1 Accomplishments

The primary accomplishments of this action alternative plan are flood damage reduction and dam safety.

- **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 from 0.0124 to 0.0068 (from a 1 in 81 chance in any year to a 1 in 147 chance). 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 6.6 percent chance of flooding with this plan versus about a 12 percent chance under existing conditions. Within the span of a 30-year home mortgage, it is estimated that there would be an 18.5 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 28.9 percent chance of being flooded versus a 47 percent chance under the existing project. With this plan, average annual equivalent flood damages would be reduced by approximately 43 percent to about $114 million.

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)	0.0124 (1 in 81) [1]	0.0068 (1 in 147)	0.0064 (1 in 156)	0.0054 (1 in 185)	0.0047 (1 in 213)
Long-Term Risk (%)					
10 Years	11.8	6.6	6.2	5.3	4.6
30 Years	31.3	18.5	17.6	15.1	13.3
50 Years	46.5	28.9	27.5	23.8	21.1

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

The floods of 1986 and 1997 were the largest events in the American River basin over the period of record (1905 to date). Both these events had a 0.014 probability of occurrence in terms of the unregulated 3-day inflow volume. These events are about two-thirds of the 3-day unregulated inflow volume for the maximum flood that can be controlled with the following action alternative plans. Historically, peak discharge from Folsom Dam has not exceeded 135,000 cfs. This plan, as well as all the action alternative plans, would control a flood with a 3-day volume approximately 50 percent greater than the 1986 and 1997 events.

- **Probable Maximum Flood** – This plan and the other action alternative plans would provide the ability for the PMF to be passed through Folsom Dam and Reservoir.

- **Other Benefits** – Similar to the other action alternative plans considered, this plan would allow early implementation of the Folsom Dam Bridge and ecosystem restoration features, and future raising of Folsom Dam for increased flood protection.

4.5.2.2 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 4.3** above, cost estimates were developed for each of the action alternative plans considered in this *PAC Report*. These estimates are at a level of detail sufficient to adequately compare the costs of each alternative and relative differences in costs between each alternative The estimated total first cost for this plan is $630 million. The portion of the annual cost attributable to flood damage reduction only is $33.0 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 E**. Based on information from **Appendix E**, 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 $84.7 million.

4.5.3 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 in Alternative A, above (see **Plate 12**). 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 (see **Plates 12** and **13**). 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.

4.5.3.1 Accomplishments

The primary accomplishments of this action alternative plan are increased flood damage reduction and improved features for PMF dam safety.

- **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 from 0.0124 to 0.0064 (from a 1 in 81 chance in any year to a 1 in 156 chance). 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 6.2 percent chance of being flooded over the course of 10 years, a 17.6 percent chance in 30 years, and a 27.5 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 $198 million would be reduced by approximately 45 percent to about $108 million.

- **Probable Maximum Flood** – With this plan, and including reservoir emergency operating criteria developed by the Corps, it is estimated that Folsom Dam would pass the PMF.

- **Other Benefits** – Similar to the other action alternative plans considered, this plan would also allow early implementation of the Folsom Dam Bridge and ecosystem restoration features, and future raising of Folsom Dam for increased flood protection.

4.5.3.2 Economics

- **Costs** – The estimated first cost for this plan is $876 million. The estimated annual cost for the flood damage reduction component is $35.2 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 analysis, $200 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 $89.9 million.

4.5.4 Alternative C – 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.

4.5.4.1 Accomplishments

The primary accomplishments of this action alternative plan are increased flood damage reduction and improved features for PMF dam safety.

- **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 from 0.0124 to 0.0054 (from a 1 in 81 chance in any year to a 1 in 185 chance). 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 5.3 percent chance of being flooded over the course of 10 years, a 15.1 percent chance in 30 years, and a 23.8 percent chance in 50 years (see **Table 4-2**). 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 would be reduced by approximately 54 percent to about $91 million.

- **Probable Maximum Flood** – With this plan, the PMF could be passed through Folsom Dam and Reservoir.

- **Other Benefits** – This plan would also allow, as other increments, early implementation of the Folsom Dam Bridge and ecosystem restoration features.

4.5.4.2 Economics

- **Costs** – The estimated first cost for this plan is $988 million. The total annual cost attributable to flood damage reduction is estimated at $40.0 million.

- **Benefits** – Excluding potential benefits for the Folsom Dam Bridge and ecosystem restoration, the total estimated average annual benefits for this plan are $107.1 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.

4.5.5 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 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.

4.5.5.1 Accomplishments

The primary accomplishments of this action alternative plan are increased flood damage reduction and improved features for PMF dam safety.

- **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 from 0.0124 to 0.0047 (from a 1 in 81 chance in any year to a 1 in 213 chance). 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 4.6 percent chance of being flooded over the course of 10 years, a 13.3 percent chance in 30 years, and a 21.1 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 1986 and 1997 historic flood events. With this plan, the average annual equivalent flood damages would be reduced by approximately 60 percent to about $79 million.

- **Probable Maximum Flood** – With this plan, Folsom Dam and Reservoir could pass the PMF.

- **Other Benefits** – Similar to the other action alternative plans considered, this plan would allow early implementation of the Folsom Dam Bridge and ecosystem restoration features.

4.5.5.2 Economics

- **Costs** – The estimated first cost for this plan is $1,439 million. The total annual cost attributable to flood damage reduction is estimated at $73.8 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 $118.9 million.

4.6 COMPARISON OF ACTION ALTERNATIVES

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. Below is a description of each criterion and its application. **Table 4-3** shows the comparison of the four action alternative plans based on their relative ability to address each of the four criteria. As can be seen in the table, and described below, each alternative was assigned a relative ranking ranging from very low to very high for each criterion. Each comparison criterion for the action alternative plans in the table received the same weighting and resulted in an overall relative ranking. This overall ranking was used, along with other information, to identify the Selected Plan.

Because this *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.

TABLE 4-3
SUMMARY COMPARISON OF ACTION ALTERNATIVE PLANS

Action Alternative Plans	Comparison Criteria				Status and Relative Ranking
	Completeness	Effectiveness	Efficiency	Acceptability	
A – Eight Main Dam Outlets & Fuseplug Spillway - Modify Folsom Outlets (six), Construct Two Additional Outlets, and Construct Emergency Fuseplug Spillway	Considered complete. However, low level of reliability to effectively modify existing and new outlets at Folsom Dam. Also, reduced level of reliability for safe operation of fuseplug in spillway.	Relatively low increase in helping reduce flood damages. Can pass the PMF.	High net economic benefits.	Very low potential for non-Federal sponsorship (does not meet minimum performance goal).	Although very high net economic benefits, Alternative A is **not identified** for further consideration as the Selected Plan. Very low potential for non-Federal sponsorship.
Relative Rank	*Moderate*	*Low*	*High*	*Very Low*	*Low to Moderate*
B – Six Submerged Tainter Gate Auxiliary Spillway – Construct a New Auxiliary Spillway with Six Submerged Tainter Gates	Considered complete. Likely meets functional equivalency requirements and very high reliability as it depends primarily on auxiliary spillway with operable gates and appurtenant facilities for overall performance.	Moderately effective in helping reduce flood damages. Can pass the PMF. Highly compatible with new bridge and future actions for higher levels of flood protection and other project goals.	High net economic benefits.	High potential for non-Federal sponsorship as it meets minimum goal of passing at least the 200-year computed design flood event.	Although highly efficient, Alternative B is **not identified** for further consideration as the Selected Plan. This is primarily because Alternative C can accomplish a higher level of flood protection than Alternative B and can provide greater net economic benefits.
Relative Rank	*High*	*Moderate*	*High*	*Very High*	*High*
C – Six Submerged Tainter Gate Auxiliary Spillway, 3.5-Foot Dam Raise, & Three Emergency Spillway Gate Replacements – Construct a New Auxiliary Spillway with Six Submerged Tainter Gates, Raise Folsom Dam 3.5 Feet, and Replace Three Emergency Spillway Gates	Similar to Alternative B.	Relatively high effectiveness in meeting project objectives for flood damage reduction. Can pass the PMF. Highly compatible with new bridge and future actions for higher levels of flood protection and other project goals.	Very high net economic benefits when compared with other alternatives considered.	High potential for non-Federal sponsorship as it meets minimum goal of passing at least the 200-year computed design flood event.	**Identified** as the Selected Plan. Highest overall relative ranking of alternatives considered.
Relative Rank	*High*	*High*	*Very High*	*Very High*	*High to Very High*
D – Six Submerged Tainter Gate Auxiliary Spillway, 7-Foot Dam Raise, & Eight Emergency and Service Spillway Gate Replacements – Construct a New Auxiliary Spillway with Six Submerged Tainter Gates, Raise Folsom Dam 7 Feet, and Replace Eight Emergency and Main Dam Service Spillway Gates	Similar to Alternative B.	Relatively high effectiveness in meeting project objectives for flood damage reduction. Can pass the PMF. Highly compatible with new bridge and future actions for higher levels of flood protection and other project goals.	Low net economic benefits when compared with other alternatives.	Relatively low potential for non-Federal sponsorship, primarily because the plan is expensive.	**Not identified** as the Selected Plan. This is primarily due to low economic justification and relatively low potential for sponsorship by non-Federal interests.
Relative Rank	*High*	*High*	*Low*	*Low*	*Moderate*

Key: PMF = Probable Maximum Flood

4.6.1 Completeness

Completeness is a determination of whether a plan includes all elements necessary to realize planned effects. It is also an indication of the degree that the intended benefits of the plan depend on the actions of others. The major subcriteria selected for this evaluation include (1) consistency, (2) future actions, and (3) physical implementability. Consistency here is primarily a measure of an alternative's ability to address the project objectives and to be functionally equivalent to the authorized Folsom Modification and Folsom Dam Raise projects. Functional equivalency can be measured in terms of (1) project accomplishments, such as level of flood damage reduction, (2) net economic benefits, and (3) performance. Performance would include factors such as the ability to maintain the objective release from Folsom Dam to the American River under similar conditions within Folsom Reservoir.

The Folsom Modification Project, as amended by the *2003 LRR*, was previously estimated to increase the level of flood protection to a 1 in 140 chance in any given year. The Folsom Dam Raise Project, assuming implementation of the Folsom Modification Project, would increase the level of flood protection to a 1 in 175 chance in any give year (see **Table 5-9** in **Chapter 5** for additional information). As shown in **Table 4-4**, each of the action alternative plans would provide increases in annual expected exceedence of at least 1 in 140. Further, all but one (No-Action) of the alternative plans would result in net economic benefits of at least $40 million. However, the alternative most superior for this subcriterion would be Alternative C. This is primarily because functionally, this alternative would be considered the closest equivalent to the Folsom Modification and Folsom Dam Raise projects.

A subcriterion of future actions refers to the ability of an alternative to be reliably implemented and operated with no future actions required other than normal operation, maintenance, repair, replacement, and rehabilitation (OMRR&R). It is believed that all of the alternatives considered could be fully implemented. Physical implementabilty refers to the relative ability to construct the project. As mentioned, following completion of the Folsom Modification Project described in the *2003 LRR*, it was determined that the cost to construct outlet works modifications, as defined for that plan, would be significantly more costly than expected. Although not anticipated during planning for that project, it was determined that the actual physical implementability of the project was much lower than anticipated. Of the alternatives above, it is believed that Alternatives B and C would provide the highest level of confidence because they do not include further modification of the Folsom Dam outlets, and do not include raising Folsom Dam over 3.5 feet, which inherently includes other factors of uncertainty.

4.6.2 Effectiveness

Effectiveness is the extent to which an alternative can alleviate problems and achieve the project objectives. As can be seen in **Table 4-4**, each of the action alternatives considered can provide increased levels of flood protection greater than a 1 in 140 chance in any year, which was the level identified for the Folsom Modification Project. In addition, each of the alternatives can pass the PMF. There is a potential for lower adverse impacts under extremely rare flood events to areas downstream from Folsom Dam for alternatives that do not include an emergency

fuseplug spillway. In addition, each of the alternatives effectively allows (as other increments) implementation of a new Folsom Dam Bridge and downstream environmental accomplishments.

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	0.0068	0.0064	0.0054	0.0047
1 in X Chance in Any Year	1 in 147	1 in 156	1 in 185	1 in 213
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	33.0	45.3	50.1	83.9
Flood Damage Reduction (less dam safety)	33.0	35.2	40.0	73.8
Annual Flood Damage Reduction Benefits ($ millions)	84.7	89.9	107.1	118.9
Net Annual Flood Damage Reduction Benefits ($ millions)	51.7	54.7	67.1	45.1
Residual Damages ($ millions)	113.5	108.3	91.1	79.3
Percent Damage Reduction	43	45	54	60

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.*

4.6.3 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. Included in **Table 4-4** is an estimate of net economic benefits for each of the alternatives. **Figure 4-1** is a plot of net benefits for each alternative. 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. Future evaluations will need to establish a cost

appropriate for passing the PMF. It is believed that 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 185 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.

4.6.4 Acceptability

Acceptability is the workability and viability of a plan with respect to its potential acceptance by other Federal agencies, State and local governments, and public interest groups and individuals. As mentioned, both the State of California, through The Reclamation Board, and SAFCA will be the non-Federal sponsors for the Selected Plan. Also, as mentioned, both entities have identified that passing the 200-year computed design flood event is a primary request for their participation. As can be seen in **Table 4-4**, Alternatives B, C, and D all are capable of passing the 200-year computed design flood event. On the basis of coordination with the non-Federal sponsors, they prefer Alternative C. These entities may not support Alternative D, as it would result in greater costs to them.

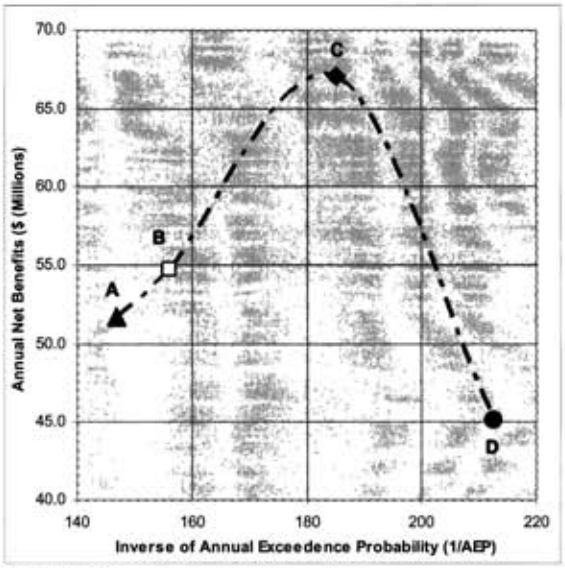


FIGURE 4-1
RELATIONSHIP OF PERFORMANCE TO NET BENEFITS FOR ALTERNATIVES CONSIDERED

For the purposes of this evaluation, a major part of determining functional equivalency is the relationship of the authorized projects to alternative plans based on AEP. 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 (see **Table 5-9** in **Chapter 5**) of the originally authorized projects is 0.0057 (1 in 175 chance of occurrence in any year). Using updated system operation modeling, it is currently estimated that the cumulative AEP of the projects is 0.0053 (1 in 187 chance equivalency). As shown in **Table 4-4**, of the four action alternative plans, Alternative C compares most closely to the originally authorized projects. The AEP for Alternative C is nearly the same as that of the originally authorized projects. Accordingly, this plan is considered to be functionally equivalent to the authorized projects.

4.6.5 Result

As described above and listed in **Table 4-3**, Alternative C is identified as the Selected Plan. This is because Alternative C would provide a reduction in flood risk similar to the Folsom Modification and Folsom Dam Raise Projects, is functionally equivalent to those projects, incorporates dam safety risk reduction, and meets local objectives, while providing the greatest net benefits of all the alternatives considered (including those mentioned above and many other combinations of major project features).

4.7 REFINED AUTHORIZED PROJECTS

The preferred alternative, or 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 primary non-Federal project sponsor for the Selected Plan portion of the RAP is the State of California through DWR. The likely non-Federal sponsor for the Other Features of the RAP would be SAFCA (ecosystem restoration) and the City of Folsom (bridge). SAFCA is a co-sponsor to DWR and will enter into a cost-sharing agreement with Reclamation to pay for any portion of the OMRR&R costs related to the new flood damage reduction features.

It is important to note that, as shown in **Figure 4-2**, this Selected Plan is made up of two fundamental elements: (1) the Six Submerged Tainter Gate Element (6 STG Element) with primary structural components consisting of a new auxiliary spillway with six submerged tainter gates, and (2) the Dam Raise Element (DR Element) with primary structural features consisting of a 3.5-foot dam raise and three emergency spillway tainter gate replacements. The 6 STG Element has been characterized as the Joint Federal Project, or JFP, in recent studies and in **Appendix C - Joint Federal Project Engineering Design Report** of this *PAC Report*. The 6 STG Element can be divided into two efforts: a Corps Work Package and a Reclamation Work Package. These work packages are described in **Chapter 6**.

4.7.1 Accomplishments

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 an AEP of 0.0124 (a 1 in 81 chance in any 1 year) to 0.0059 (a 1 in 185 chance in any 1 year). This plan would control a flood with a 3-day inflow volume to Folsom Reservoir of about 50 percent larger than the floods of record (1986 and 1997) in the American River basin. These flood events each have a probability of occurrence of about 0.014 in terms of the unregulated 3-day inflow volume.

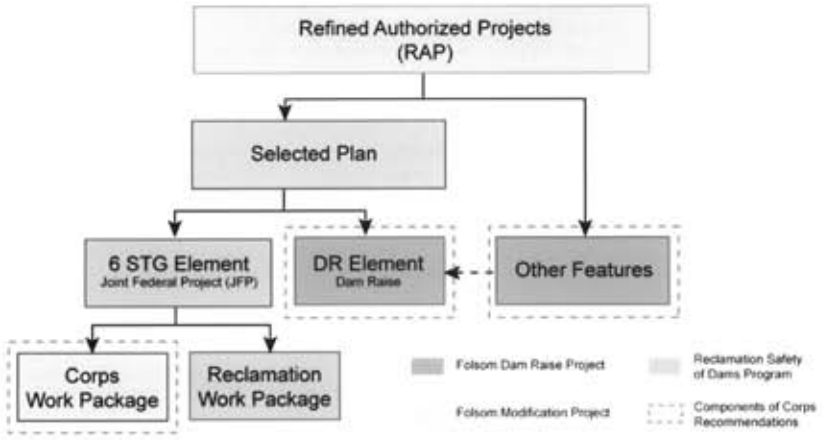


FIGURE 4-2
COMPONENTS AND RESPONSIBILITIES OF THE REFINED AUTHORIZED PROJECTS (RAP)
In the RAP, Other Features are companion to the DR Element of the Selected Plan. The 6 STG Element is divided into Corps and Reclamation Work Packages.

A very important goal of SAFCA is for the American River to safely pass the 200-year computed design flood event without levee failures and without impacting downstream areas. It is estimated that the RAP would exceed this goal. The RAP is considered functionally equivalent to a combination of both the Folsom Modification Project and the Folsom Dam Raise Project, and consistent with provisions of section 128 of PL 109-103. This plan would increase the release capacity at Folsom Dam earlier in the flood event, thereby reducing flood risk to areas downstream from Folsom Dam.

It is estimated that the Selected Plan could reduce average annual equivalent flood damages in Sacramento (currently estimated at $198 million) by about 54 percent. Accordingly, the residual flood damage potential in Sacramento would be reduced to about $91 million.

As mentioned in **Chapter 2**, under the without-project condition, Reclamation intends to address the dam safety hydrologic risk of passing the PMF event at Folsom by constructing an emergency fuseplug spillway on the south abutment and downstream from the south wing dam. This fuseplug would rely on a zoned embankment with an impervious core designed to erode in a predictable manner when the reservoir elevation generally exceeds the elevation of the inlet approach channel. It is important to note that during a PMF event, massive and catastrophic flooding would occur in the Sacramento area. However, there would be significant warning for this event. Without the capability to pass the PMF through the emergency spillway at Folsom Dam, a danger would exist of the dam failing during the PMF and causing additional catastrophic damages throughout the Sacramento area. The submerged tainter gate and auxiliary spillway portion of the RAP would be constructed at the same location as the emergency

fuseplug spillway. A major advantage of the RAP is that not only can the auxiliary spillway provide significant reductions in flood risk, but it can do so while reliably passing the PMF at Folsom Dam, and at a major cost savings over constructing a project to accomplish the two objectives separately.

The RAP would be constructed consistent with the expedited implementation of a new bridge just downstream from Folsom Dam. The bridge would allow safe and efficient transportation from east Folsom to areas north of the American River near Folsom Reservoir. The RAP would also preserve the potential to implement ecosystem restoration features authorized by the Folsom Dam Raise Project along the lower American River.

4.7.2 Major Components

Current design refinements have been made that are both consistent with, and considered functionally equivalent to, the Folsom Modification and Folsom Dam Raise projects. Detailed information on these refinements is contained in **Appendix A**, **Appendix B**, **Appendix C**, and **Appendix D - Real Estate**. Following is a summary of the major components included in the RAP.

4.7.2.1 Flood Control Storage Space

Folsom Reservoir is currently operated under an interim operation agreement with a variable flood control space ranging from 400,000 acre-feet to 670,000 acre-feet. As shown in **Plate 6**, beginning on 1 October of each year, Folsom Reservoir is required to begin maintaining vacant space for flood control. The magnitude of the space requirements depends on incidental vacant storage space in three reservoirs upstream from Folsom – French Meadows, Hell Hole, and Union Valley reservoirs. Consistent with Section 101(a) (6) (B) of WRDA 1999, once the Selected Plan is implemented, the space requirements would change to a variable flood space operation ranging from 400,000 acre-feet to 600,000 acre-feet, as shown in **Plate 9**.

Construction of the 6 STG Element would increase project discharge capacity at a lower pool elevation with no increase in pool elevation. This allows a lowering of the maximum pool and for a decrease in the need for use of surcharge storage space in the reservoir. As shown in **Table 4-5**, the PMF pool elevation would be lowered from 483.3 feet to 480.2 feet with the Selected Plan. This consists of an initial reduction in the PMF pool elevation to 476.2 feet upon completion of the 6 STG Element. The DR Element would result in a raise of this elevation to 480.2 feet, but still well below the new top of dam elevation. For perspective, the authorized flood pool elevation associated with the 200-year flood event would be lowered from elevation 474.6 feet to 466.3 feet, limiting the maximum discharge to 160,000 cfs. Raising Folsom Dam 3.5 feet to 484.0 feet would allow for reducing discharges to 160,000 cfs, thereby controlling events larger than the 200-year design event by limiting discharges to a maximum of 160,000 cfs, the downstream capacity, by creating additional flood control space in the reservoir. The authorized top of flood pool would remain at reservoir water surface elevation 466 feet, as shown in **Table 4-5**. In accordance with guidelines for take line requirements, the current (and No-Action Plan) take line at 476 feet (top of authorized flood pool elevation plus 10 feet) is the same or greater than the maximum pool elevation during a controlled flood event with the Selected Plan.

TABLE 4-5
COMPARISON OF PERTINENT ELEVATIONS FOR EXISTING CONDITIONS, NO-ACTION PLAN, 6 STG ELEMENT, AND REFINED AUTHORIZED PROJECTS (feet)

Item	Existing Conditions	No-Action Plan	6 STG Element	Refined Authorized Projects
Top of Dam	480.5	480.5	480.5	484
Maximum Authorized Flood Pool Elevation	466.0	466.0	466.0	466.0
0.5% Chance Pool Elevation [1]	474.6	474.6	466.0	466.0
PMF Pool Elevation	483.3	477.6	476.2	480.2

Key: PMF = Probable Maximum Flood STG = submerged tainter gate

Note:
1. Pool elevation equal to that reached under the non-Federal sponsors' design flood event objective.

4.7.2.2 Auxiliary Spillway

One of the major structural components of the RAP is an auxiliary spillway. As shown in **Plate 12** and **Figure 4-3**, the spillway would be located southwest of Folsom Dam and would include four major elements. These consist of (1) an approach channel, (2) control structure with six submerged tainter gates, (3) chute, and (4) stilling basin. The approach channel would be approximately 1,100 feet long and would connect Folsom Reservoir to the control structure. The control structure would be operated in concert with spillway gates on Folsom Dam to manage flood flows from Folsom Reservoir. **Plate 13** shows the upstream elevation of the control structure. The structure would include six tainter gates. Each of the six gates would be 33 feet high and 23 feet wide. The gate sill elevation would be 368.0 feet. **Plate 14** shows two sections through the control structure. As can be seen, the auxiliary spillway control gates would be submerged – operated with a capability for the surface on the upstream side of the control structure to be higher than the top of the spillway gate. The auxiliary spillway would also include a 3,000-foot-long chute with a bottom width of about 169 feet and a stilling basin with exit channel to return flows to the American River just downstream from Folsom Dam (see **Plate 12**). Construction of the auxiliary spillway would require excavation of about 2.1 million cubic yards of rock and soil. Additional detailed information on the auxiliary spillway is included in **Appendix A**.

4.7.2.3 Emergency Spillway Gate Replacement

The RAP also includes replacing the three existing emergency spillway tainter gates at Folsom Dam with 42-foot-wide by 59-foot-high tainter gates. This would allow 2 feet of freeboard for the emergency spillway tainter gates (in a closed position) when the reservoir is operated to maintain the objective release.

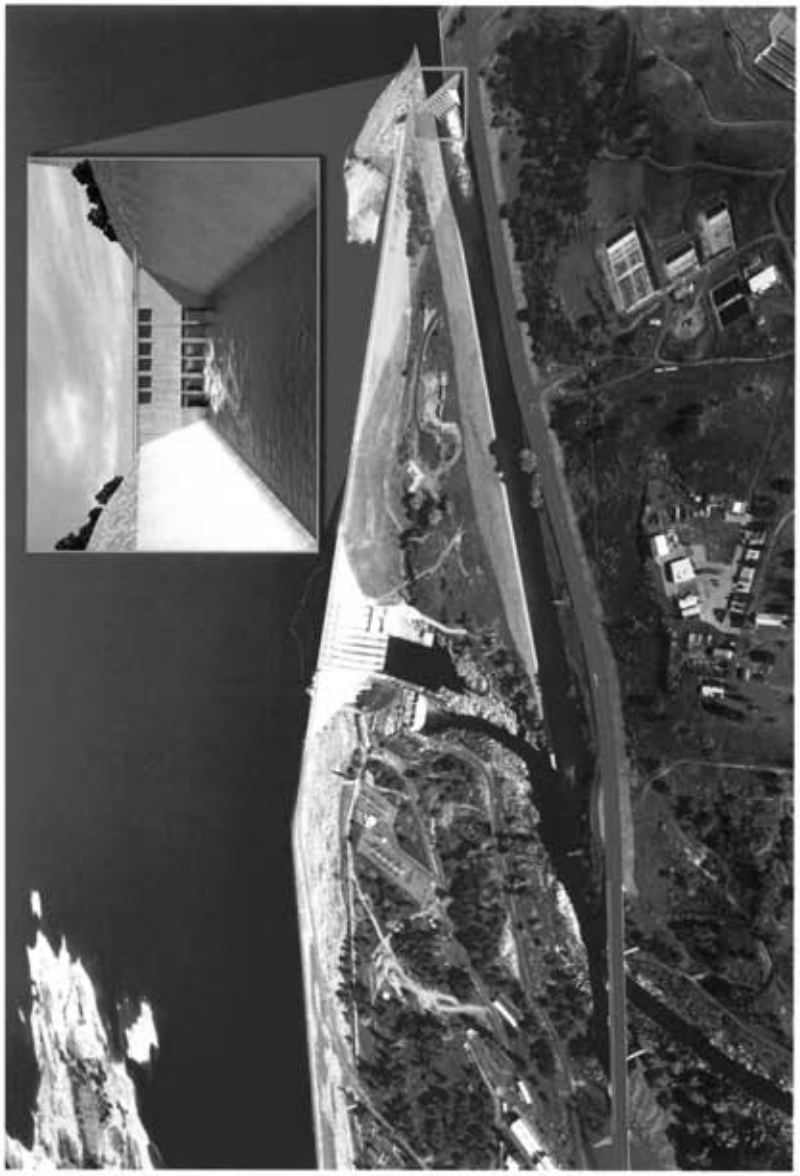


FIGURE 4-3
CONCEPTUAL RENDERING OF THE PERMANENT BRIDGE, AUXILIARY SPILLWAY, SUBMERGED TAINTER GATE STRUCTURE, AND APPURTENANT FACILITIES

4.7.2.4 Raise Folsom Dam 3.5 Feet

Raising Folsom Dam and appurtenant facilities by 3.5 feet would result in an increase in flood storage capacity in Folsom Reservoir for flood damage reduction uses by approximately 46,200 acre-feet. This would be above (to elevation 474 feet msl) the current authorized flood pool storage of 1.02 million acre-feet associated with a pool elevation of 470 feet above msl. Primary features of the raise would include raising MIAD and auxiliary dikes around Folsom Reservoir by 3.5 feet.

4.7.2.5 Other Features

The Other Features are companion to the DR Element of the Selected Plan would include the ecosystem restoration component of the Folsom Dam Raise Project and a permanent bridge increment. The ecosystem restoration component is to be continued. Funds identified for the permanent bridge increment would be combined with those identified for a temporary bridge in the Selected Plan. Implementation of the permanent bridge will commence in advance of the Selected Plan. As mentioned, although a necessary part of the authorized Folsom Dam Raise Project, construction of a new Folsom Bridge is part of the without-project condition.

4.7.2.6 Work Packages

The auxiliary spillway is the principal facility to be constructed as part of the 6 STG Element. Reclamation and the Corps have equitably divided work for the 6 STG Element, or JFP, based on criteria identified in **Chapter 6**. The set of assigned work items that make up the 6 STG Element of the Selected Plan are called work packages. Reclamation's Work Package emphasizes work that will expeditiously implement interim and permanent hydrologic risk reduction and further expedite implementation, construction, and completion of the 6 STG Element. As currently anticipated, Reclamation's Work Package includes excavation of the auxiliary spillway chute, stilling basin, and a portion of the control structure. The Corps' Work Package would then include the remainder of the excavation for the control structure, excavation of the approach channel and construction of the spillway chute, stilling basin, and control structure.

4.7.3 Environmental Considerations

The Selected Plan component of the RAP would generally have impacts primarily associated with temporary construction-related impacts on air quality, noise levels, local traffic, recreational impacts, and water quality during construction. Mitigation measures and best management practices (BMP) proposed in the Reclamation 2007 *Final Folsom Dam Safety and Flood Damage Reduction Environmental Impact Statement/Environmental Impact Report* (2007 EIS/EIR) would reduce all of these impacts to less than significant levels, except air quality. All appropriate permits would be coordinated with the specific agencies and obtained prior to construction. All BMPs, included in the permits, would be implemented and included in the construction plans and specifications. For the temporary short-term increases in air quality emissions, the Corps, Reclamation, and the construction contractors would continue to seek opportunities to reduce construction-related emissions to a less than significant level and will

coordinate with the Sacramento Municipal Air Quality Management District (SMAQMD) prior to and during construction.

Through coordination with the State Historic Preservation Office under Section 106, all cultural resources located within the area of potential effect will be evaluated for inclusion in the National Registry on Historic Places and the California Register of Historic Resources. A memorandum of agreement (MOA) or a programmatic agreement will be developed prior to initiation of construction to mitigate impacts to any identified historic properties or historic resources. The implementation of the agreement document would reduce any identified impacts to historic properties or historic resources to a less than significant level.

4.7.3.1 6 STG Element

Impacts

The primary construction impacts would be those associated with the 6 STG Element in Reclamation's Work Package. Most of these impacts would be related to excavation materials for the spillway and processing/placement of concrete and other materials. Project-related impacts on the physical and social environment are analyzed and discussed in detail in the Reclamation *2007 EIS/EIR*.

Reducing the variable flood control storage space in Folsom Reservoir to between 400,000 acre-feet and 600,000 acre-feet would likely result in beneficial operational impacts to the lake resources. It would reduce some adverse impacts on water supply and power production from the existing operation. An ongoing study will determine actual impacts of permanent reoperation.

Mitigation

Reclamation would be responsible for implementing all mitigation for impacts of constructing the 6 STG Element, with the exception of air quality, and any other permitting requirements (e.g., water quality), which would be the responsibility of each agency for its work package. The Corps, however, as a cooperating agency, will continue to coordinate closely with Reclamation in mitigation planning efforts. The separation of work and project responsibilities is described in more detail in **Chapter 5**.

Impacts to vegetation and wildlife, and special-status species would require mitigation to reduce project impacts to less than significant levels. Reclamation and the United States Fish and Wildlife Service (USFWS) are working together to finalize mitigation for vegetation and wildlife impacts according to the work described in the Reclamation Work Package. Compensation for special-status species would be implemented as described in the project biological opinion.

4.7.3.2 DR Element

Impacts

Construction of the 3.5-foot dam raise would impact approximately 8.46 acres of oak woodland. An increase to maximum reservoir water surface elevation of the reservoir beyond current dam crest elevation is not anticipated in order to provide flood damage reduction

benefits. The maximum reservoir water surface elevation under the RAP would not exceed the existing take line for a 200-year design event, and there would be an anticipated lower maximum water surface elevation than for the without-project condition for all flood events inclusive of a PMF event, eliminating the risk that surrounding properties would be inundated. Therefore, no inundation of surrounding habitats above the without-project condition would be expected.

Because there would be no expected inundation of surrounding habitats above the without-project condition, no property takes, flowage easements, or additional small-scale impoundment features such as dikes or berms beyond the existing take line are included in the Reclamation *2007 EIS/EIR*. The DR Element of the Selected Plan will undergo further design during the Corp's Preconstruction, Engineering, and Design (PED) phase and, if needed, supplemental National Environmental Policy Act/California Environmental Quality Act (NEPA/CEQA) documentation would be prepared.

Mitigation

The Corps would be responsible for implementing all mitigation for impacts of constructing the DR Element. Replacement of 11.16 acres of oak woodland would compensate for this adverse impact. Mitigation acreage was estimated through Habitat Evaluation Procedure (HEP) analysis conducted by USFWS and the Corps and through an incremental cost analysis conducted by the Corps. These estimates are based on the information currently available, and further coordination on mitigation with USFWS would occur during the Corps' PED phase when final design information is available for the dam raise portion of the Selected Plan.

Mitigation for project-related effects on vegetation due to the implementation of the dam raise portion of the Selected Plan would take place at various sites along the American River, in the American River Parkway, downstream from the Sunrise Bridge in areas located upstream from the American River levee system. The sites would be selected in consultation with numerous local agencies, including the Corps, SAFCA, USFWS, Sacramento County Parks Department, and The Reclamation Board. Generally, the sites targeted for mitigation would be sites that County Parks has identified as beneficial for establishment of additional habitat or increasing the habitat quality of degraded areas along the parkway. These habitats would be established and monitored for 3 years.

4.7.4 Operation, Maintenance, Repair, Replacement, and Rehabilitation

For the Selected Plan component of the RAP, physical operation of the enlarged Folsom Dam and Reservoir and emergency gates would be as under existing conditions. Timing and duration would be modified based on an updated Water Control Manual. The auxiliary spillway and gating system would require additional OMRR&R support. The spillway structure includes a grouting gallery and foundation drain. These facilities would need to be monitored and inspected as part of periodic monitoring activities at Folsom Dam. The gate system, including tainter gates and upstream bulkhead gates, would also require periodic inspection, exercise operation, and replacement of sensitive parts such as seals.

Reclamation would continue to operate and maintain the existing portion of Folsom Dam and Reservoir and appurtenant facilities for which it has responsibility today. The non-Federal

sponsor would enter into an agreement with Reclamation, as necessary, to facilitate the non-Federal sponsor's OMRR&R activities.

4.7.5 12 Actions for Change

The 12 Actions for Change are a set of actions that were identified by the Corps and other investigative teams. They point to the need to transform the way the Corps serves the Nation and its Armed Forces. The Corps will use the 12 Actions to guide ongoing and future work, and to ensure the Corps is an organization that is adaptable, flexible, and responsive to the needs of the Nation. The 12 Actions guide the development of projects to ensure that engineered systems are designed, constructed, maintained, and updated to be more robust. The RAP accounts for and contributes to the 12 Actions, as described further in **Appendix H - 12 Actions for Change**.

4.7.6 Economics

Estimates of costs and benefits for the RAP are based on October 2006 price levels, a current discount rate of 4-7/8 percent, and a 50-year period of analysis.

As mentioned in **Section 2.5.1**, a study to identify environmental impacts, costs, and repayment strategy and responsibility for potential water supply losses associated with a permanent reoperation of Folsom Reservoir is being developed. This study on reoperation under without-project conditions is to be completed prior to completion of the 6 STG Element of the Selected Plan. It is estimated that the study will generally confirm previous findings that there is a fairly significant cost related to the continued use of an increase in flood control storage space from conditions that existed prior to implementation of the variable storage space concept in the mid-1990s. As described in the *1996 SIR*, it was estimated at that time that implementation of a variable storage space would result in adverse impacts to CVP and State Water Project (SWP) water supplies, hydropower production, local water supplies, recreation at Folsom Reservoir, and cultural resources around Folsom Lake. It is important to understand, however, that the RAP will likely reduce the amount of the variable space over the without-project conditions; therefore, impacts to the above resources would be reduced. However, impacts would still be greater than prior to implementation of the variable space concept. Since impacts would be reduced with the RAP over conditions without the plan, no mitigation (resources replacement) costs are included in the plan. This information will be included in the permanent reoperation study report.

4.7.6.1 Costs

The estimated first and annual costs for the RAP are included in **Table 4-6**. 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 4-6** is $973.7 million.

The resulting total average annual cost for the Selected Plan component of the RAP attributable to flood damage reduction is $43.5 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.

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	75.1	8.9	84.0
Total	702.2	101.3	803.5
Annual Cost (Selected Plan) [3, 4]			
Interest and Amortization	37.7	5.5	43.2
Operation and Maintenance	0.2	0.1	0.3
Subtotal	37.9	5.6	43.5
Annual Flood Damage Reduction Benefits	89.9	17.2	107.1
Net Annual Flood Damage Reduction Benefits	52.0	11.6	63.6
Benefit-to-Cost Ratio for Flood Damage Reduction	2.4	3.1	2.5

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.*

4.7.6.2 Benefits

As shown in **Table 4-6**, total annual average benefits for flood damage reduction are about $107.1 million (including future growth in the floodplain over the project life).

4.7.6.3 Economic Justification

As **Table 4-6** shows, the estimated net annual flood damage reduction benefits of the RAP are about $63.6 million. The resulting benefit-cost ratio for this plan is 2.5 to 1.

CHAPTER 5.0
CHANGES FROM AUTHORIZED PROJECT PLANS

5.1 CHANGES IN SCOPE

The basic scope of the Folsom Modification Project and Folsom Dam Raise Project has been to accomplish the following:

- Increase the release capacity at Folsom Dam to maintain releases at or below the objective release of 115,000 cubic feet per second (cfs) for large events.
- Increase the flood detention storage space within Folsom Reservoir through operational changes and/or physical modifications at Folsom Dam to delay the onset of excessive releases.

In addition, the United States Department of the Interior, Bureau of Reclamation (Reclamation), has consistently needed to recognize issues related to dam safety at Folsom Dam and Reservoir. Vehicle transportation across Folsom Dam is also a major interest to Reclamation.

Fundamental features included in the Folsom Modification Project authorization to accomplish the above purposes included enlarging the existing eight outlets, constructing two new outlets, constructing a new emergency spillway stilling basin, and permanently modifying the seasonal flood control storage space in Folsom Reservoir. As mentioned, the authorized Folsom Modification Project is similar to the project identified in the Corps *1996 American River Watershed Project, California, Supplemental Information Report* (1996 SIR); instead of lowering and modifying the existing spillway and gates, the project includes new outlets.

To further address the above goals, the authorized Folsom Dam Raise Project included raising the main dam, replacing spillway gates, and improving the wing dams, stilling basin, Mormon Island Auxiliary Dam (MIAD), and various dikes around Folsom Reservoir. To ensure that the improvements would also conform with dam safety needs at Folsom, the project included enlarging the spillway at L.L. Anderson Dam.

As described in **Chapter 4**, the Refined Authorized Projects (RAP) include the Selected Plan plus two Other Features. The Selected Plan comprises two fundamental elements: (1) an auxiliary spillway with six submerged tainter gates (6 STG Element) and (2) raising Folsom Dam (DR Element). The two Other Features consist of ecosystem restoration and a permanent bridge increment, both of which are companion to the DR Element. Describing the Selected Plan and RAP as separate elements presents challenges. As an example, whereas the hydrologic dam safety function of the authorized projects rested in the Folsom Dam Raise Project, as described in **Chapter 6**, this function currently is an important part of the 6 STG Element. Currently, the 6 STG Element is composed of two work packages: the Corps Work Package and Reclamation Work Package. These work packages are summarized in **Chapter 6**. Regardless of how the Selected Plan and RAP are separated, it is important to note that collectively, the scope of the project has not changed from that of the combined authorized projects.

Project scope can be measured in a number of ways. Following is a consideration of scope from the standpoint of annual exceedence probability (AEP), discharge, dam height, and storage capacity.

5.1.1 Annual Exceedence Probability

AEP expresses the probability that the project will perform satisfactorily given any storm that may occur. It is the statistical probability that a specific capacity or target stage will be reached or exceeded in any given year, expressed as a decimal, and/or chance of occurrence. AEP expected at the time of authorization for the Folsom Modification Project was 0.0075 (Corps November *2003 American River Watershed, California, Folsom Dam Modification Project Final Limited Reevaluation Report and Environmental Assessment/Initial Study (*2003 LRR*)*), which equates to a 1 in 140 chance of occurrence in any year. On the basis of updated modeling (2006), the current estimated AEP for the Folsom Modification Project is 0.0065, or a 1 in 154 chance in any year. As shown in **Table 5-1**, it is estimated that the AEP for the 6 STG Element is 0.0064 or a 1 in 156 chance in any year. This constitutes about an 11½ percent increase in flood damage reduction from what was authorized (from 1 in 140 to 1 in 156).

TABLE 5-1
COMPARISON OF 6 STG ELEMENT TO FOLSOM MODIFICATION PROJECT

Attributes	2003 Limited Reevaluation Report [1] Ten-Outlet Plan	Updated Limited Reevaluation Report Ten-Outlet Plan [2]	6 STG Element
Features	Enlarge 8 outlets, construct 2 new outlets	Same features as the 2003 LRR plan	Auxiliary spillway with 6 STG, invert elevation 368 feet
Operation Objective Release [3] Emergency Release [4]	• Begins at 10-year inflow design event, ends at 150-year inflow design event • Release reached at 160-year inflow design event, release not held	• Begins at 10-year inflow design event, ends at 100-year inflow design event • Begins at 110-year inflow design event, ends at 200-year inflow design event	• Begins at 10-year inflow design event, ends at 100-year inflow design event • Begins at 110-year inflow design event, ends at 210-year inflow design event
Resulting Flood Risk, Annual Exceedence Probability ***(1 in X chance in any year)*** [4]	0.00714 *(140)*	0.0065 *(154)*	0.0064 *(156)*
Dam Safety	No significant dam safety function	No significant dam safety function	Passes PMF

Key: PMF = probable maximum flood STG = submerged tainter gate

Notes:

1. *Ten-Outlet Plan is the plan described in the Corps November 2003 American River Watershed, California, Folsom Dam Modification Report Final Limited Reevaluation Report and Environmental Assessment/Initial Study (2003 LRR) without surcharge storage.*
2. *Authorized plan in 2003 LRR updated based on current (2006) reservoir operation modeling process.*
3. *115,000 cubic feet per second (cfs) sustained flow; downstream levees remain intact.*
4. *If flow persists, 160,000 cfs downstream levees are at risk of failure.*

The AEP for the authorized Folsom Dam Raise Project was 0.0050, which equated to a 1 in 175 chance in any year (1 in 200 equivalency based on updated operations), as shown in **Table 5-2**. Assuming the 6 STG Element is in place, current features included in the DR Element are estimated to have an AEP of 0.0054 (1 in 185 chance equivalency), an increase of about 6 percent.

TABLE 5-2
COMPARISON OF DR ELEMENT TO FOLSOM DAM RAISE PROJECT

Attributes	Authorized Plan (Corps 2002 Chief of Engineers Report) 7-foot Raise, Flood Pool at 482 Feet	Updated 7-foot Raise, Flood Pool at 482 Feet[1]	DR Element of Selected Plan: 3.5-foot Raise, Replace 3 Emergency Spillway Gates
Features	• Raise Folsom Dam embankments 7 feet • Raise the top of flood space from elevation 474 to elevation 482	Features are the same as the authorized plan	• Raise Folsom Dam embankments by 3.5 feet • Replace 3 emergency spillway tainter gates with taller gates
Operation	Flood damage reduction achieved by increase in detention of 95,000 acre-feet	Operation changed due to revised routing criteria	• Raise the top of flood space from elevation 470 to elevation 474 • Flood damage reduction achieved by increase in detention of 46,200 acre-feet
Flood Risk, Percent Chance Exceedence (*1 in X chance in any year*)[2, 3]	0.0057 (*175*)	0.0050 (*200*)	0.0054 (*185*)
Dam Safety	Includes dam safety function	No dam safety function	No dam safety function

Key: DR = dam raise

Notes:

1. *Authorized dam raise in Corps 2002 Chief of Engineers Report, updated based on current (2006) reservoir operations modeling processes.*
2. *All performance data (exceedences) and economic benefits are without forecast-based advance release, which is not part of the without-project condition.*
3. *Assumes Folsom Modification Project (6 STG Element) is in place.*

5.1.2 Storage Discharge Capacity

Changes in scope for the Folsom Modification Project features can be measured in terms of hydraulic performance. In this case, hydraulic performance is defined as storage discharge in relation to the reservoir pool elevation at which the discharge can be made. The authorized Folsom Modification Project had a target of being able to discharge 115,000 cfs at elevation 418 feet, which is the existing spillway crest. Current features have the potential to discharge 115,000 cfs at elevation 405 feet. This constitutes a 13-foot decrease in elevation from the authorized project at which the same storage discharge would occur.

It should be noted that at elevation 418 feet, the 6 STG Element with the existing outlets at Folsom would have a design release potential of 173,922 cfs. However, an auxiliary spillway with four submerged tainter gates is the plan that is functionally equivalent to the authorized Folsom Modification project; the additional capacity provided by the two additional submerged tainter gates is necessary for passing the Probable Maximum Flood (PMF). This constitutes a shifting of authority for addressing the PMF from the authorized Folsom Dam Raise Project to

the Folsom Modification Project, but does not constitute a scope change for flood damage reduction for the authorized Folsom Modification Project. Hydraulic performance is not a measure of scope for the Folsom Dam Raise Project because that project would not significantly increase discharge capacity.

From another perspective, the authorized Folsom Modification Project and the 6 STG Element would fundamentally be able to pass a portion of the PMF. As mentioned, the authorized Folsom Modification Project could pass roughly 75 percent of the PMF, while the project with the 6 STG Element could pass 100 percent of the PMF.

5.1.3 Height of Dam Raise

The authorized Folsom Dam Raise project included raising the existing dam 7 feet. Current features include raising the existing dam 3.5 feet. This constitutes a 50 percent decrease in the physical scope of the project. However, the height of the dam raise is not necessarily the most pertinent criterion for measuring scope change associated with the Folsom Dam Raise Project authority. The purpose of the raise is to increase storage space; therefore, it is more appropriate to measure the increased storage space in the reservoir pool due to a dam raise.

5.1.4 Storage Capacity

It is difficult to directly compare the storage space attributable to flood damage reduction between the two authorized projects and the Selected Plan. This is primarily due to dam safety being accommodated in the 6 STG Element of the RAP instead of being part of the authorized Folsom Dam Raise Project.

The original Folsom Modification Project had a usable maximum flood pool elevation of 470 feet without the surcharge storage component. In this application, surcharge is storage in excess of the normal full pool. Normal full pool, or gross pool, corresponds to the top reservoir level allocated for routine flood damage reduction, recreation, water supply, or other authorized storage uses. The maximum surcharge elevation, adopted as a basis for project design, results from routing an extreme flood event through the reservoir. (As a contingency, the surcharge space provides protection against an extraordinarily rare event that could threaten the integrity of the dam itself.) With the surcharge component, the maximum pool elevation was 474 feet. These elevations were based on physical constraints of the existing project and, to some extent, the need to ensure that the project would pass at least the same percentage of the PMF as without the project. The Folsom Dam Raise Project included raising the top of dam to elevation 487.5 feet; considering vacant space necessary for freeboard, the maximum flood pool could be elevation 482 feet. However, because the project would need to pass the PMF, the maximum elevation that could actually be used for flood damage reduction (an outflow of 160,000 cfs or less) was about 478 feet. Accordingly, it could be argued that the actual increase in flood control space was from elevation 474 feet (Folsom Modification Project including surcharge) to elevation 478 feet, which would be about 47,000 acre-feet. However, it is probably more appropriate to attribute the increase of flood control space for the authorized Folsom Dam Raise Project from elevation 470 feet to 478 feet because the Folsom Dam Raise Project incorporated the surcharge component. Therefore, the increase from 470 feet to 478 feet results in an increase of space of about 93,000 acre-feet.

A different method was used to determine the top of the flood pool for the plans described in this *Post Authorization Change* (PAC) *Report*. The Folsom Modification Project has a maximum authorized flood pool (the elevation below which not more than 160,000 cfs can be released) of 466 feet. The Selected Plan would have a maximum flood pool of 474 feet. With a dam raise of 3.5 feet, the total increased space that could be used for flood damage reduction purposes would be about 81,000 acre-feet. This includes 46,200 acre-feet due to the physical dam raise and approximately 35,000 acre-feet resulting from a change in flood operations in Folsom Reservoir.

Routing criteria for the originally authorized Folsom Modification and Folsom Dam Raise projects have been modified from those used for the current features. This limits the ability to compare post authorization changes to the projects as they were originally authorized. Further, gate rating curves will be refined during detailed designs. The comparison information presented in this *PAC Report* is considered appropriate to show the basic comparison of the previous and current features of the authorized projects.

5.2 CHANGES IN LOCATION

The project area for the RAP and its major elements is the same as that of the authorized Folsom Modification Project and Folsom Dam Raise Project. 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 of the City of Sacramento and includes portions of Placer, El Dorado, and Sacramento counties.

The RAP features have locations within the basin similar to those for the authorized projects. Whereas much of the construction effort for the Folsom Modification Project focuses on Folsom Dam, the bulk of construction effort for the 6 STG Element would relate the auxiliary spillway and appurtenant facilities. As shown in **Plate 12**, the new spillway would be located immediately adjacent to the left wing dam at Folsom Dam, about 1,000 feet from Folsom Dam. Considering that the circumference of Folsom Lake is about 75 miles, this is considered to be an insignificant distance. Most of the major features of the Folsom Dam Raise Project and DR Element of the Selected Plan have similar locations.

5.3 CHANGES IN PROJECT PURPOSES

There is no change in purposes from the authorized projects. The two primary purposes of the RAP are the same as for the authorized Folsom Modification and Folsom Dam Raise projects, and include flood damage reduction and ecosystem restoration. The RAP also includes a goal to support Reclamation's resolution of hydrologic dam safety issues at Folsom Dam, similar to the Folsom Dam Raise Project. Again, however, the dam safety component of the RAP rests with the Reclamation Work Package, which is a significant part of the 6 STG Element rather than a part of the DR Element. It is important to note that modification of the L.L Anderson Dam component of the Folsom Dam Raise Project is included in the RAP. L.L. Anderson Dam modifications are being accomplished independently by Placer County Water

Agency (PCWA). In addition, there is recognition that Folsom Bridge is being implemented in advance of the DR Element. The ecosystem restoration purpose is retained as an Other Feature (companion to the DR Element). However, because the analysis presented in this *PAC Report* does not affect the separable ecosystem restoration project features, it is planned that the ecosystem restoration components will continue to be implemented under the Folsom Dam Raise authorization. The new Folsom Bridge, which is part of the Folsom Dam Raise Project, is expected to be implemented before the Selected Plan.

5.4 CHANGES IN DESIGNS

For flood damage reduction, major physical components of the authorized Folsom Modification Project are as described in the 2003 LRR. The originally authorized Folsom Modification Project consisted of two major components: (1) outlet works modification and (2) surcharge storage. The outlet works modification consisted of three basic features: (1) enlarging eight existing outlets and constructing two new outlets, (2) modifying the existing spillway stilling basin, and (3) constructing a flat bulkhead and seal assembly on the upstream face. The surcharge storage components included (1) replacing the three emergency spillway tainter gates, (2) revising the Emergency Spillway Release Diagram to modify surcharge operation, and (3) raising the impervious core in MIAD and Dikes 5 and 7 to allow dependable use of the surcharge storage.

Major physical components of the Folsom Dam Raise Project, as originally authorized, included (1) raising the top of Folsom Dam 7 feet, (2) replacing spillway gates, (3) and making a number of improvements to the stilling basin and reservoir auxiliary dams and dikes. This dam raise would be a combination of raising the concrete monolith and embankments and adding a 3.5-foot parapet wall. Modifications to the L.L. Anderson Dam spillway were also part of the original authorized project; however, these modifications are now to be accomplished by PCWA and are considered part of the future without-project condition of this PAC Report.

The 6 STG Element includes (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 168 feet, and (4) stilling basin in the American River. These features are considered to be functionally equivalent to the authorized work defined for the Folsom Modification Project. The 6 STG Element would not only allow for reduced flood risk but would also satisfy hydrologic dam safety issues at Folsom.

The DR Element primarily includes modifying three emergency spillway gates, and raising various facilities around Folsom Reservoir by 3.5 feet. Companion to the DR Element are the Other Features of the authorized Folsom Dam Raise project, including the Folsom permanent bridge and ecosystem restoration components. Modifications to the L.L Anderson Dam spillway are to be accomplished as a without-project condition.

Table 5-3 compares the basic features for both of the authorized projects and for the RAP. The primary reasons for the design changes are recent findings that the auxiliary gated spillway would be a more effective and efficient method of evacuating the flood space in Folsom Reservoir earlier in a storm event, while also addressing hydrologic dam safety issues at Folsom Dam. **Table 5-4** displays the changes from the authorized projects by feature.

TABLE 5-3
SUMMARY OF PROJECT COMPONENTS [1]

Item	Folsom Modification Project (2003 Limited Reevaluation Report) [2]	Folsom Dam Raise Project (2004 E&WDAA)	Refined Authorized Projects	
			6 STG Element	DR Element [3] and Other Features
FOLSOM DAM				
Main Dam				
Main Concrete Dam	–	Raise dam crest 7.0 feet	–	–
Wing Dams	–	Raise wing dams 7.0 feet	–	Raise wing dams 3.5 feet
Spillway & Stilling Basin	Construct additional anchorage for spillway stilling basin	Enlarge spillway stilling basin	–	–
Outlets	• Enlarge 8 existing outlets (9'4" by 14' upper tier & 9'4" by 12' lower tier) • Construct 2 new upper tier outlets • Construct eyebrow deflectors on all outlets	–	–	–
Emergency Gates	Replace 3 emergency spillway tainter gates with 42' by 59' tainter gates (new top of gate elevation of 476.0 feet above msl)	Replace 3 emergency spillway tainter gates with 66' high tainter gates (new top of gate elevation of 484.0 feet above msl)		Replace 3 emergency spillway tainter gates with 42' by 59' tainter gates (new top of gate elevation of 476.5 feet above msl)
Main Spillway Gates	–	Replace spillway gates	–	–
Dikes				
Mormon Island Auxiliary Dam	–	Raise dike 7.0 feet	–	Raise dike 3.5 feet
Dike 5	–	Raise dike 7.0 feet	–	Raise dike 3.5 feet
Dike 7	–	Raise dike 7.0 feet	–	Raise dike 3.5 feet
Other Dikes	–	Raise dikes 7.0 feet	–	Raise dikes 3.5 feet
Auxiliary Spillway	–	–	Auxiliary spillway with 6 submerged tainter gates (33' high by 23' wide) at gate sill elevation 368 feet above msl	–
OTHER FEATURES				
Folsom Bridge	–	Construct a temporary and permanent bridge downstream from Folsom Dam	–	Advanced implementation of Folsom Dam Bridge
L.L. Anderson Dam Spillway Modification	–	Modify L.L. Anderson Dam spillway at French Meadows Reservoir	–	L.L. Anderson Dam spillway modification will be implemented by Placer County Water Agency separately from the DR Element
Ecosystem Restoration	–	Implement ecosystem restoration features to benefit the lower American River	–	Ecosystem restoration efforts continue as authorized

Key: – = does not apply; DR = dam raise; E&WDAA = Energy and Water Development Appropriations Act; msl = mean sea level; STG = submerged tainter gate

Notes:

1. *Assumes objective release of 160,000 cfs for a sustained time (currently being evaluated) as part of flood operations for without-project conditions.*
2. *Plan described in the Corps November 2003 American River Watershed, California, Folsom Dam Modification Report, Final Limited Reevaluation Report and Environmental Assessment/Initial Study.*
3. *Dam Raise Element includes a 3.5-foot raise of the wing dams and dikes; the main dam crest will not be raised.*

TABLE 5-4
SUMMARY OF AUTHORIZED PROJECTS AND CHANGES

Authorized Feature	Recommended Change	Basis for Change	Changes for Refined Authorized Projects			
			Total Project Cost	Scope	Location or Design	Project Purpose
Folsom Modification Project						
Enlarge 8 existing outlet works	Construct new auxiliary spillway with 6 submerged tainter gates	Auxiliary spillway is a less costly method of attaining basic outputs and addressing dam safety problem (passes the PMF)	Exceeds allowable increases in price level changes	**Annual Exceedence Probability:** Authorized 1 in 140; change to 1 in 156 **Hydraulic Performance:** Authorized discharge 115,000 cfs at elevation 418 feet; change to 115,000 cfs at 405 feet **Annual Benefits:** Authorized $35.3 million (at 2006 price levels); change to $89.9 million **Includes dam safety (PMF)**	No significant change	No change
Add 2 new outlets	Construct new auxiliary spillway with 6 submerged tainter gates					No change
Surcharge storage: Replace 3 emergency spillway tainter gates. Raise impervious core at several dikes, Revise Emergency Spillway Release Diagram.	Revise Emergency Spillway Release Diagram as part of dam raise project	Gate replacement and modification to impervious dam and dike cores no longer needed with raised dam.			No change	No change
Folsom Dam Raise Project						
Raise dam, wing walls and dikes 7 feet	Raise dam, wing walls, and dikes 3.5 feet Modification of 3 emergency spillway tainter gates	Height of raise reduced because auxiliary spillway addresses dam safety problem (raise no longer needed to pass PMF)	Within allowable increases in price level changes	**Annual Exceedence Probability:** Authorized 1 in 175; change to 1 in 185 **Storage:** Authorized: 93 TAF change: 81 TAF **Annual Benefits:** Authorized $23 million (at 2006 price levels); change to $17.2 million **Does not include dam safety (PMF)**	No change in location; design will be refined for smaller dam raise	No change
Construct bridge	No change; separable project from Selected Plan	–		No change	No change	No change
Modify L.L. Anderson spillway	PCWA to resolve dam safety issues via separate project	Revised future without project condition		No change	No change	No change
Implement ecosystem restoration features	No change; separable project from Selected Plan	–		No change	No change	No change

Key:
– = does not apply
cfs = cubic feet per second
PCWA = Placer County Water Agency
PMF = Probable Maximum Flood
RAP = Refined Authorized Projects
TAF = thousand acre-feet

5.5 CHANGES IN TOTAL PROJECT FIRST COST

This section describes the magnitude of changes in first cost and the primary reasons for the changes.

5.5.1 Changes in First Cost

Table 5-5 shows the estimated first costs for the Folsom Modification Project under various conditions. Included in the table are estimates of the first costs as included in the original project as authorization (see Column b) and as presented in the *2003 LRR* (Column a), authorized project cost updated to October 2006 price levels (Column c), and the *2003 LRR* costs updated to October 2006 price levels (Column d). It is important to note that the outlet works modification component of the *2003 LRR* shown in **Table 5-5** (Column d) is being used as the basis for much of the description of the authorized Folsom Modification Project. This is primarily because the physical modifications for the surcharge element of the project would not apply to the RAP and little is known or available about the genesis of the original costs and other supporting information associated with the 1999 authorization. Also included in **Table 5-5** is the estimated cost for the 6 STG Element of the Selected Plan (Column e). This cost is for the flood damage reduction only (Corps Work Package) portion of the Selected Plan. If estimated costs of the authorized project were repriced at 2006 October price levels (e.g., reevaluated using current construction costs), not updated using cost indices, these costs would be much higher and closer to those shown for the RAP in the table. Repricing includes identifying the estimated project cost using current market costs, while cost updating is an escalation of original costs using price indices.

Table 5-6 shows the estimated first costs for the Folsom Dam Raise Project under various conditions. Included is the estimated first cost reported to Congress based on October 2001 price levels (see Column a), the project costs as authorized by Congress based on October 2003 price levels (Column b), and the authorized cost and project cost updated to October 2006 price levels (Columns c and d). Also included is an estimate of the first cost of the DR Element plus the Other Features component of the RAP at October 2006 price levels. It is also important to note that the estimated costs of the authorized project, if it were repriced to October 2006 price levels (not updated by price levels), would be much greater, at nearly $740 million, than the RAP shown in the table.

As shown in **Table 5-7**, the total first cost for the Selected Plan (less the cost for dam safety in the Reclamation Work Package) portion of the RAP is $848.2 million and the total cost of the RAP is $973.7 million. **Table 5-7** was prepared from both **Tables 5-5** and **5-6**. It includes the estimated authorized project cost updated to 2006 price levels, and the estimated cost of the Selected Plan and RAP with their primary elements. The purpose of this table is to compare the authorized project costs at current prices to the current costs of the Corps portions of the Selected Plan and RAP.

TABLE 5-5
TOTAL PROJECT FIRST COST HISTORY – FOLSOM MODIFICATION PROJECT AND REFINED AUTHORIZED PROJECTS INCREMENT ($ MILLIONS)

Item	Project Cost Last Presented to Congress [1] October 2001 Price Levels Column a	Cost Authorized by Congress [2] October 1999 Price Levels Column b	Authorized Cost (Column b) Updated to October 2006 Price Levels [3] Column c	Project Cost (Column a) Updated to October 2006 Price Levels Column d	6 STG Element of Selected Plan (Corps Work Package) [4] October 2006 Price Levels Column e
Outlet Works Modification	183.8 [5]	–	–	208.2 [5]	683.0
Surcharge Storage Modifications	30.3	–	–	34.3	0.0
Total First Cost	**214.1**	**150.0**	**201.1**	**242.5 [6]**	**683.0**
Key:	– = Does not apply			STG = submerged tainter gate	

Notes:

1. *Corps November 2003 American River Watershed, California, Folsom Dam Modification Project, Final Limited Reevaluation Report and Environmental Assessment/Initial Study.*
2. *As cited in Section 101(a) (6) of WRDA 1999 (PL 106-53).*
3. *Authorized cost updated to October 2006 price levels using Civil Works Construction Cost Index System (CWCCIS) per ER 1110-2-1302.*
4. *Does not include costs for dam safety, which are included in the Reclamation Work Package.*
5. *Construct two new low-level outlets and enlarge the eight existing outlets.*
6. *Cost of project repriced to current price levels would be significantly greater at about $655 million ($613 million for outlet works modification and $42 million for surcharge storage facilities).*

TABLE 5-6
TOTAL PROJECT FIRST COST HISTORY – FOLSOM DAM RAISE PROJECT AND REFINED AUTHORIZED PROJECTS INCREMENT ($ MILLIONS)

Item	Project Cost Last Submitted to Congress [1] October 2001 Price Levels Column a	Cost Authorized by Congress [2] October 2003 Price Levels Column b	Authorized Cost (Column b) Updated to October 2006 Price Levels [3] Column c	Project Cost (Column a) Updated to October 2006 Price Levels [4] Column d	DR Element and Other Features of RAP at October 2006 Price Levels [5] Column e
Authorized Project					
Folsom Dam Raise	174.1	–	–	208.5	115.3
L.L. Anderson Spillway Modification	12.1	–	–	14.5 [6]	0
Ecosystem Restoration	27.4	–	–	32.8	59.8 [7]
Temporary Bridge	35.0	–	–	41.9	49.9 [8]
Subtotal	**248.6**	**257.3**	**303.6**	**297.7**	**225.0**
Permanent Bridge Increment	–	–	–	–	65.7
Subtotal Total	**248.6**	**257.3**	**303.6**	**297.7** [9]	**290.7** [10]

Key: – = does not apply DR = dam raise RAP = Refined Authorized Projects

Notes:

1. *Authorized project cost estimate as described in the 5 November 2002 Chief of Engineers Report for the 2002 Long-Term Study (Corps), October 2001 price levels.*
2. *Authorized cost cited in the 2004 Energy and Water Development Appropriations Act, October 2003 price levels.*
3. *Authorized cost updated to October 2006 price levels using Civil Works Construction Cost Index System (CWCCIS) per ER 1110-2-1302.*
4. *Cost estimate of the authorized project updated to October 2006 price levels.*
5. *Cost estimate in RAP at October 2006 price levels.*
6. *Cost of L.L. Anderson Dam spillway modification updated to October 2006 price levels. However, since authorization, it has been determined that Placer County Water Agency would be responsible for the cost to modify the spillway under licensing requirements by the Federal Energy Regulatory Commission and the State of California.*
7. *Revisions to costs for temperature shutters have raised ecosystem restoration costs since publication in the 2002 Chief of Engineers Report (Corps) (see **Chapter 7**).*
8. *Cost of temporary bridge limited by 2006 Energy and Water Development Appropriations Act Section 128.*
9. *Cost of project repriced to current price levels would be significantly greater at about $737 million.*
10. *Includes the cost attributed to the permanent bridge increment, which is the total cost of the bridge at $115.6 million, less the cost of the temporary bridge.*

TABLE 5-7
SUMMARY OF TOTAL FIRST COSTS ($ MILLIONS)

Item	Authorized Project Cost October 2006 Price Levels	Refined Authorized Projects October 2006 Price Levels			
		6 STG Element (Corps Work Package)	DR Element and Other Features	Subtotal Selected Plan [1]	Total [1]
Folsom Modification Project					
Flood Damage Reduction	242.5	683.0	–	683.0	683.0
Dam Safety	0	[2]	–	[2]	[2]
Total	**242.5**	**683.0**	**–**	**683.0**	**683.0**
Folsom Dam Raise Project					
Flood Damage Reduction	–	–	–	–	–
Dam Raise	111.6	–	115.3	115.3	115.3
Temporary Bridge [3]	41.9	–	49.9	49.9	49.9
Dam Safety [4]	111.4	–	–	–	–
Subtotal	264.9	–	165.2	165.2	165.2
Other Features					
Ecosystem Restoration [5]	32.8	–	59.8	–	59.8
Permanent Bridge	–	–	65.7	–	65.7
Subtotal	32.8	–	125.5	–	125.5
Subtotal	297.7	–	290.7	165.2	290.7
Total	**540.2** [6]	**683.0**	**290.7**	**848.2**	**973.7**

Key:
– = does not apply DR = dam raise RAP = Refined Authorized Projects STG = submerged tainter gate

Notes:

1. *Corps portion of the Selected Plan and RAP.*
2. *Plan elements to be accomplished under the Reclamation Safety of Dams Program.*
3. *Cost estimate for the temporary bridge in the 2002 Long-Term Study (Corps) updated to October 2006 price levels. Current plans call for construction of a permanent bridge at significantly greater cost, which is considered a sunk cost in the Selected Plan. Cost estimate for the temporary bridge limited by 2006 Energy and Water Development Appropriations Act, Section 128.*
4. *See Note 3. In addition, the authorized project includes the cost of L.L. Anderson Dam spillway modifications primarily as part of dam safety. L.L. Anderson modifications are excluded from the RAP because it has been determined that Placer County Water Agency would be responsible for the cost to modify the spillway under dam licensing requirements by the Federal Energy Regulatory Commission and the State of California.*
5. *Ecosystem restoration is retained in the RAP but considered as a continued project element.*
6. *Total cost of the authorized projects repriced to current price levels would be significantly greater at about $1,390 million.*

5.5.2 Reasons for Changes in Project First Cost

5.5.2.1 6 STG Element

As can be seen in **Table 5-7**, the estimated first costs, updated to 2006 price levels, of the authorized Folsom Modification Project are about $242.5 million (if repriced at current price levels, this cost would be significantly greater). The estimated first costs for the 6 STG Element of the Selected Plan are about $683.0 million (excluding dam safety), a cost difference of $440.5 million. Changes in costs are attributable to preconstruction, engineering, and design as well as significantly greater construction costs than reflected in price level updates. A major cost component difference between the Folsom Modification Project and the 6 STG Element relates to the significantly different features making up the two project elements. The eight outlets portion of Alternative A, described in **Chapter 4,** would provide a reduction in flood risk similar to the Folsom Modification Project. As mentioned, however, that plan would need to include an emergency fuseplug spillway. The 6 STG Element would provide a significant reduction in flood damages compared with the originally authorized Folsom Modification Project. Further, the Folsom Modification Project would not satisfy the fundamental goals of the non-Federal sponsor. Accordingly, most of the cost increase is due to (1) significant reduction of the chance of flooding in Sacramento and (2) features to pass the PMF.

5.5.2.2 DR Element and Other Features

Also shown in **Table 5-7** is a comparison of the current estimated first cost for the authorized Folsom Dam Raise Project to the DR Element of the Selected Plan and Other Features of the RAP. The estimated first costs for the Folsom Dam Raise Project and the DR Element are about $264.9 million and $165.2 million, respectively (October 2006 price levels). The bulk of the cost reduction is associated with the cost of the raise components in the authorized project attributable to dam safety. Again, however, the cost of the authorized project would be significantly greater if repriced at current price levels. Accordingly, the actual cost reduction is much greater.

The major reason for the cost reduction is that the DR Element includes a 3.5-foot raise instead of the 7-foot raise included in the authorized project. In addition, the Folsom Dam Raise Project included replacing all eight of the spillway tainter gates, whereas the DR Element includes replacing only the three emergency spillway tainter gates.

In addition, **Table 5-7** shows costs for ecosystem restoration and the permanent Folsom Dam Bridge increment of the Folsom Dam Raise Project. Because the analysis presented in this *PAC Report* does not affect the separable ecosystem restoration project features, it is planned that the ecosystem restoration components will continue to be implemented under the Folsom Dam Raise Project authorization.

5.5.2.3 Refined Authorized Projects

As shown in **Table 5-7**, the total estimated first cost of the RAP, including ecosystem restoration and a permanent bridge increment (i.e., Other Features), is $973.7 million (less cost for Reclamation Safety of Dams Program/Reclamation Work Package) while the first cost for the authorized Folsom Modification and Folsom Dam Raise projects combined is $540.2 million (an increase of $433.5 million). As described previously, the bulk of the cost increase relates to the 6 STG Element and is due to the greater cost required to construct the auxiliary spillway. However, the auxiliary spillway referenced in the Energy and Water Development Appropriations Act of 2006 (see **Chapter 1**) provides a significantly greater reduction in flood risk to Sacramento and is also capable of passing the PMF. In addition, authorized project costs updated by price levels only are believed to be significantly underestimated for the actual cost of constructing the authorized project features at current price levels.

It is important to understand that much more is known today about which physical features can be safely implemented at Folsom Dam. It was found that enlarging the existing outlets and constructing the two new outlets would require much more underwater work within Folsom Reservoir, which would significantly increase the difficulty of construction. Based on this knowledge, and the desire to ensure passage of the PMF, the auxiliary spillway concept was identified as part of a *Project Alternative Solutions Study* (PASS) (Corps, Reclamation, The Reclamation Board, and SAFCA, 2005) process. Accordingly, through a combination of designs and costs for the authorized projects, and improved knowledge about project requirements, the current features are estimated to cost less than the authorized features if both were considered for implementation today.

5.6 CHANGES IN PROJECT BENEFITS

Economic output is generally a measure of post authorization changes to scope. The changes in average annual benefits for flood damage reduction are due to changes in price level, interest rate, updated estimated flood damages, evolving without-project conditions, and increasing understanding about hydrologic and levee uncertainties, and other factors used in the risk analysis model. Price levels have changed from October 2003 and October 2001 for the Folsom Modification and Folsom Dam Raise projects, respectively, to October 2006 price levels. The interest rate for the two authorized projects has decreased from 6-1/8 and 5-5/8 percent, respectively, to 4-7/8 percent. The inventory of damageable property was updated to current conditions and significant adjustments have been made to account for revised hydrologic conditions along the American River due to changes in reservoir operations. Flood damages and updated flood damage reduction benefits are described in **Appendix E – Economics**. Because of these factors, estimates of project benefits for the authorized projects are difficult to compare to estimated benefits of the currently recommended features, and are not considered to be a good measure of post authorization changes.

The changes in benefits for each project and major element are summarized in **Table 5-8**. Flood damage reduction benefits in the table for the authorized Folsom Modification and Folsom Dam Raise projects are based on October 2003 and October 2001 price levels, respectively. These benefit values are also updated to October 2006 price levels. The ecosystem restoration benefit for the Folsom Dam Raise Project and DR Element of the Selected Plan is the increase in

average annual habitat units. No change has been made in the estimated number of habitat units potentially generated from the ecosystem restoration component of the Folsom Dam Raise Project. Because the analysis presented in this *PAC Report* does not affect the separable ecosystem restoration project features, it is planned that the ecosystem restoration components will continue to be implemented under the Folsom Dam Raise Project authorization.

TABLE 5-8
CHANGE IN PROJECT BENEFITS

Item		Authorized Projects			Refined Authorized Projects [4]		
		Folsom Modification Project	Folsom Dam Raise Project	Total	6 STG Element	DR Element Plus Ecosystem Restoration	Total
Annual Flood Damage Reduction Benefits	2001/2003 Price Levels ($ millions)	31.2 [1]	19.2 [2]	50.4 [3]	–	–	–
	2006 Price Levels ($ millions)	35.3 [4]	23.0 [4]	58.3 [4]	89.9	17.2	107.1
Annual Habitat Units		–	894	894	–	894	894

Key: – = does not apply; DR = dam raise; STG = submerged tainter gate

Notes:

1. *As presented in the Corps 2003 American River Watershed, California, Folsom Dam Modification Project, Final Limited Reevaluation Report and Environmental Assessment/Initial Study (Outlet Works Modification only).*
2. *As presented in Corps November 2002 Chief of Engineers Report.*
3. *Total of reported benefits values.*
4. *Benefits presented at October 2006 price levels. No additional benefits are attributable to permanent bridge increment.*

As shown in **Table 5-8**, total average annual flood damage reduction benefits for the RAP are estimated at $107.1 million and the combined flood damage reduction benefits for the two authorized projects are about $50.4 million at October 2001 and 2003 prices and $58.3 million at October 2006 prices. Part of the increase in benefits of the RAP over the authorized projects is due to an updated understanding about levee conditions and reservoir operations reflected in the analytical process. Another major reason for the change is that a significant increase has occurred in property units and values within the floodplain. Updating by price levels has not been sufficient to capture this increase. Not only have the number and types of property units increased, but the value of these units has increased. Accordingly, a significant reason for the difference is that price level updates insufficiently reflect actual conditions, similar to that for project cost changes.

Table 5-9 shows the relationship between the collective changes in flood threat among the Folsom Modification Project, Folsom Dam Raise Project, and RAP. The Other Features components of the RAP do not affect flood damage reduction; thus, project performance of the RAP is equal to that of the Selected Plan. As can be seen from **Table 5-9,** and as summarized in **Section 5-1**, the relative difference between what was believed to be the resulting reduction in flood threat from the authorized projects at the time they were authorized is closely comparable to that for the RAP.

TABLE 5-9
COMPARISON OF RELATIVE PROJECT PERFORMANCE

Project	Annual Exceedence Probability (1 in x chance in any year)	
	Without-Project Conditions	With-Project Conditions
Authorized Projects [1]		
Folsom Modification Project [2]	0.0111 (1 in 90)	0.0071 (1 in 140)
Folsom Dam Raise Project [3]	0.0073 (1 in 137)	0.0057 (1 in 175)
Combined Project	0.0111 (I in 90)	0.0057 (1 in 175)
Refined Authorized Projects [4]		
6 STG Element	0.0123 (1 in 81)	0.0064 (I in 156)
DR Element	0.0064 (I in 156)	0.0054 (I in 185)
Selected Plan [5]	0.0123 (1 in 81)	0.0054 (I in 185)

Key: DR = dam raise STG = submerged tainter gate

Notes:

1. *Based on operation modeling at the time of authorization. See **Tables 5-1** and **5-2** for Annual Exceedence Probability under current (2006) operations modeling.*
2. *Assumes Common Features Project is completed, without advanced releases from Folsom Dam.*
3. *Assumes Common Features and Folsom Modification projects are completed, without advanced releases from Folsom Dam.*
4. *Based on current (2006) operations modeling.*
5. *Other Features of the Refined Authorized Projects (RAP) do not affect flood damage reduction.*

5.7 CHANGES IN BENEFIT-COST RATIO

Table 5-10 shows a summary of first costs; average annual flood damage reduction costs, benefits, and net economic benefits; and resulting benefit-to-cost ratios for the Folsom Modification and Folsom Dam Raise projects and the RAP. Information for the two authorized projects is based on data from the *2003 LRR* and *2002 Chief of Engineers Report*, updated to October 2006 price levels and reflecting current interest rates. **Table 5-10** shows that the major elements for flood damage reduction of the RAP are economically feasible even though the cost of the RAP is significantly higher than the updated combined cost for the authorized projects (see **Table 5-5** and **Table 5-6**). The economic benefits and net benefits in **Table 5-10** are compared to annual costs of the authorized and RAP components for flood damage reduction only. At $848.2 million (total first cost less other features ($973.7 million less $125.5 million)), the first cost for the Selected Plan portion of the RAP is about $452.2 million greater than the authorized projects cost ($396 million) updated to 2006 price levels. Even so, the net flood damage reduction benefits are significantly greater than for the authorized projects. The estimated economic benefits for the Other Features in the RAP are estimated to be at least equal to their costs.

TABLE 5-10
SUMMARY COMPARISON OF COSTS AND BENEFITS ($ MILLIONS)

Item	Authorized Projects					Refined Authorized Projects (2006 Price Levels)		
	Folsom Modification		Folsom Dam Raise		Combined Projects	6 STG Element (Corps Work Package)	DR Element and Other Features	Total
	2003 LRR[1]		2002 Chief of Engineers Report[2]					
	2003 Price Levels	2006 Price Levels	2001 Price Levels	2006 Price Levels	2006 Price Levels			
First Cost								
Flood Damage Reduction	214.1	242.5	128.2	153.5	396.0	683.0	165.2	848.2
Other Features	0	0	120.4[3]	144.2[3]	144.2[3]	[5]	125.5[6]	125.5
Total	**214.1**	**242.5**[4]	**248.6**	**297.7**[4]	**540.2**[4]	**683.0**	**290.7**	**973.7**
Annual Cost (Flood Damage Reduction)	15.6	17.7	10.2	12.2	29.9	37.9[7]	5.6[7]	43.5[7]
Annual Benefits (Flood Damage Reduction)	31.2	35.3	19.2	23.0	58.3	89.9	17.2	107.1
Net Benefits	15.6	17.6	9.0	10.8	28.4	52.0	11.6	63.6
Benefit-to-Cost Ratio	2.0	2.0	1.9	1.9	1.9	2.4	3.1	2.5

Key: DR = dam raise; LRR = Limited Reevaluation Report; RAP = Refined Authorized Projects; STG = submerged tainter gate

Notes:

1. *Corps 2003 American River Watershed, California, Folsom Dam Modification Project, Final Limited Reevaluation Report and Environmental Assessment/Initial Study, November.*
2. *Corps 2002 Chief of Engineers Report, American River Watershed, California, Long-Term Study, 5 November.*
3. *Includes ecosystem restoration and dam safety at $27.4 million and $93 million, respectively, at 2001 price levels, and $32.8 million and $111.4 million, respectively, at 2006 price levels.*
4. *Total cost of the authorized projects repriced to current price levels would be significantly greater at about $1,390 million ($655 million for Folsom Modification Project and $737 million for Folsom Dam Raise Project).*
5. *Plan elements to be accomplished under Reclamation Safety of Dams Program.*
6. *Includes ecosystem restoration (continued increment) at $59.8 million and permanent bridge increment at $65.7 million.*
7. *Annual costs from* ***Table 4-5****.*

5.8 CHANGES IN COST ALLOCATION

Table 5-11 shows the cost allocation and percent allocation of first costs among flood damage reduction, ecosystem restoration, dam safety, and the permanent bridge increment of the authorized projects based on price levels at the time of authorization, when last presented to Congress, and the RAP (less dam safety). As mentioned, Reclamation is to implement the dam safety portion of the RAP, as defined in the Reclamation Work Package summarized in **Chapter 6**. In **Table 5-11,** costs for dam safety are not included in the RAP.

TABLE 5-11
SUMMARY COMPARISON OF COST ALLOCATION BY PROJECT PURPOSE INCLUDING DAM SAFETY ($ MILLIONS)

Item	Authorized Projects[1]						Refined Authorized Projects (2006 Price Levels)					
	Folsom Modification (2003 prices)		Folsom Dam Raise (2001 prices)		Combined (at indicated prices)		6 STG Element (Corps Work Package)		DR Element and Other Features		Total	
	First Cost	% of Total	First Cost	% of Total	First Cost	% of Total	First Cost	% of Total	First Cost	% of Total	First Cost	% of Total
Flood Damage Reduction	214.1	100	128.2	52	342.3	74	683.0	100	165.2[2]	57	848.2	87
Ecosystem Restoration[3]	0	0	27.4	11	27.4	6	0	0	59.8	20	59.8	6
Dam Safety	0	0	93.0	37	93.0	20	[4]	0	0	0	[4]	0
Permanent Bridge[5]	–	–	–	–	–	–	0	0	65.7	23	65.7	7
Total	**214.1**	**100**	**248.6**	**100**	**462.7**	**100**	**683.0**	**100**	**290.7**	**100**	**973.7**	**100**
Key:	– = does not apply DR = dam raise						STG = submerged tainter gate					

Notes:

1. *Combination of costs at the time of authorization and/or last updated (Corps 2003 American River Watersehd, California, Folsom Dam Modification Project, Final Limited Reevaluation Report and Environmental Assessment/Initial Study – Outlet Works Modification only). Total combined first cost updated to October 2006 price levels would be $540.2 million.*
2. *Includes features cost-shared at 65 percent Federal and 35 percent non-Federal, as well as temporary bridge cost, which includes a Corps-budgeted dam safety cost that is subject to Reclamation determination of which part, if any, may be subject to reimbursement by the Central Valley Project.*
3. *Continued increment in Refined Authorized Projects (RAP). Not a part of Selected Plan.*
4. *Reclamation Dam Safety Work Package to be accomplished under the Reclamation Safety of Dams Program.*
5. *Advanced construction increment and temporary bridge increment as part of RAP. Not a part of Selected Plan.*

5.9 CHANGES IN COST APPORTIONMENT

The estimated apportionment of costs has been updated for each of the authorized projects to October 2006 price levels. The updated apportionment of the authorized Folsom Modification Project was made following the same procedure contained in the *2003 LRR*, which is different than the procedure used to estimate the apportionment of the RAP (described in **Chapter 7**). The distribution of first costs, based on those shown in **Table 5-5**, was made proportionally to the costs contained in the *2003 LRR*.

Table 5-12 compares the updated estimated apportionment of costs for the Folsom Modification Project to the 6 STG Element in the Selected Plan portion of the RAP. As can be seen in the table, the costs are designated as Federal or non-Federal. As previously mentioned, costs and the apportionment of costs for the Reclamation Safety of Dams Program are being handled separately under the Reclamation Work Package.

Similarly, **Table 5-13** compares the updated estimated apportionment of costs for the Folsom Dam Raise Project and the DR Element plus the Other Features of the RAP. The updated apportionment of the authorized Folsom Dam Raise Project was made following the procedures contained in an economic evaluation and cost apportionment special analysis for the 7-foot raise for the Folsom Dam Raise Project. This special analysis was a supplement to the Corps *2002 Long-Term Study*. It was used to support development of costs and cost apportionment for the recommendation made in the Corps *2002 Chief of Engineers Report*.

Table 5-14 is a summary comparison of costs allocated among the two authorized projects and costs of the RAP. The table summarizes first costs, costs either deleted or continued from the authorized projects, dam safety costs (authorized project only), and related costs. As can be seen from the table, the overall percentages of total costs are very similar for the combined authorized projects and RAP.

TABLE 5-12
SUMMARY COMPARISON OF COST APPORTIONMENT – AUTHORIZED FOLSOM MODIFICATION PROJECT AND 6 STG ELEMENT OF SELECTED PLAN / REFINED AUTHORIZED PROJECTS ($ MILLIONS) [1]

MCACES Account	Item	Authorized Project: Folsom Modification Project [2, 3] Federal	Non-Federal	Total	Refined Authorized Projects: 6 STG Element (Corps Work Package) [4] Federal	Non-Federal	Total
	First Cost						
01	Land & Damages	0	0	0	0	0	0
02	Relocations	0	0	0	0	0	0
08,11	Construction	183.9	0	183.9	538.6	0	538.6
06	Environmental Mitigation [5]	3.4	0	3.4	0.4 [6]	0	0.4 [6]
18	Cultural Resources	0	0	0	0	0	0
30,31	EDS&A	55.2	0	55.2	144.0	0	144.0
	Total	**242.5**	**0**	**242.5**	**683.0**	**0.0**	**683.0**
	Reclamation Safety of Dams Program	–	–	–	[7]	[7]	[7]
	Subtotal	**242.5**	**0**	**242.5**	**683.0**	**0.0**	**683.0**
	5% Cash	(12.1)	12.1	0	(34.1)	34.1	0
	Subtotal	**230.4**	**12.1**	**242.5**	**648.9**	**34.1**	**683.0**
	Cash Adjustment (65% Federal, 35% non-Federal)	(72.8)	72.8	0	(204.9)	204.9	0
	Total	**157.6**	**84.9**	**242.5**	**444.0**	**239.0**	**683.0**
	Percentage	65	35	100	65	35	100

Key: – = does not apply
EDS&A = engineering, design, supervision, and administration
MCACES = microcomputer-aided cost engineering system
STG = submerged tainter gate

Notes:

1. *All costs at October 2006 price levels.*
2. *Based on apportionment of authorized project described in Corps 2003 American River Watershed, California, Folsom Dam Modification Project, Final Limited Reevaluation Report and Environmental Assessment/Initial Study using estimated authorized project costs at October 2006 price levels (see **Table 5-5**).*
3. *Cost of project repriced to current price levels would be significantly greater at about $613 million.*
4. *Based on cost-sharing shown in **Chapter 7**.*
5. *Includes biological mitigation only. Air and water quality mitigation costs are included in construction.*
6. *Environmental mitigation for previous work and treated as a portion of sunk costs.*
7. *Plan elements to be accomplished under the Reclamation Safety of Dams Program.*

TABLE 5-13
SUMMARY COMPARISON OF COST APPORTIONMENT – AUTHORIZED FOLSOM DAM RAISE PROJECT AND DR ELEMENT OF SELECTED PLAN / REFINED AUTHORIZED PROJECTS ($ MILLIONS)

MCACES Account	Item	Authorized Project (2006 Price Levels)					Refined Authorized Projects (2006 Price Levels)				
		Folsom Dam Raise Project [1,2]					DR Element and Other Features [3]				
		Federal	Non-Federal	Subtotal	Dam Safety	Total	Federal	Non-Federal	Subtotal	Dam Safety	Total
	First Cost										
01	Land & Damages	0.6	0.2	0.8	–	0.8	0.2	0	0.2	–	0.2
02	Relocations	0	2.9	2.9	–	2.9	0	0	0	–	0
08,11	Construction	194.3	0	194.3	–	194.3	73.6	0	73.6	–	73.6
06	Environmental Mitigation	4.8	0	4.8	–	4.8	3.0	0	3.0	–	3.0
18	Cultural Resources	1.7	0	1.7	–	1.7	0.8	0	0.8	–	0.8
30,31	EDS&A	44.3	0.7	45.0	–	45.0	37.7	0	37.7	–	37.7
	Sunk PED Cost	15.4	0	15.4	–	15.4	0	0	0	0	0
	Total	**261.1**	**3.8**	**264.9**	–	**264.9**	**115.3**	**0**	**115.3**	**0**	**115.3**
	Reclamation Safety of Dams Prog	(111.4)	0	(111.4)	111.4	–	0	0	0	0	0
	Subtotal	**149.7**	**3.8**	**153.5**	**111.4**	**264.9**	**115.3**	**0**	**115.3**	**0**	**115.3**
	Less Cultural Resources	(1.7)	0	(1.7)	–	(1.7)	(0.8)	0	(0.8)	–	(0.8)
	Subtotal	**148.0**	**3.8**	**151.8**	**111.4**	**263.2**	**114.5**	**0**	**114.5**	**0**	**114.5**
	5% Cash	(7.6)	7.6	0	–	0	(5.7)	5.7	0	–	0
	Subtotal	**140.4**	**11.4**	**151.8**	**111.4**	**263.2**	**108.8**	**5.7**	**114.5**	**0**	**114.5**
	Cash Adjustment (65% Federal, 35% non-Federal)	(41.7)	41.7	0	–	0	(34.4)	34.4	0	–	0
	Subtotal	**98.7**	**53.1**	**151.8**	**111.4**	**263.3**	**74.4**	**40.1**	**114.5**	**0**	**114.5**
	Percentage	65	35	100		100	65	35	100		100
	Cultural Resources	1.7	0	1.7	–	1.7	0.8	0	0.8	–	0.8
	Subtotal	**100.4**	**53.1**	**153.5**	**111.4**	**264.9**	**75.2**	**40.1**	**115.3**	**0**	**115.3**
	Temporary Bridge				–	–	40.0	9.9	49.9[4]	–	49.9[4]
	Total (Selected Plan of RAP)	**100.4**	**53.1**	**153.5**	**111.4**	**264.9**	**115.2**	**50.0**	**165.2**	**0**	**165.2**
	Ecosystem Restoration	21.3	11.5	32.8	–	32.8	38.9	20.9	59.8	–	59.8
	Permanent Bridge	–	–	–	–	–	41.6	24.1	65.7	–	65.7
	Total	**121.7**	**64.6**	**186.3**	**111.4**	**297.7**	**195.7**	**95.0**	**290.7**	**0**	**290.7**

Key: – = does not apply; DR = dam raise; EDS&A = engineering, design, supervision, and administration; MCACES = microcomputer-aided cost engineering system; PED = preconstruction, engineering, and design; RAP = Refined Authorized Projects

Notes:

1. *Based primarily on apportionment of authorized project described in a supplement to the Corps 2002 Long-Term Study (Special Analysis of Folsom Dam Seven-Foot Raise), which supports information in the Corps 2002 Chief of Engineers Report.*
2. *Cost of project repriced to current price levels would be significantly greater at about $737 million.*
3. *Based on cost-sharing shown in **Chapter 7**.*
4. *Includes a Corps-budgeted dam safety cost of $21.5 million that is subject to Reclamation determination of which part, if any, may be subject to reimbursement by the Central Valley Project.*

TABLE 5-14
SUMMARY COMPARISON OF COST APPORTIONMENT BY PROJECT PURPOSE ($ MILLIONS)

Item	Authorized Projects [1] (2006 price levels)					Refined Authorized Projects (RAP) (2006 price levels)				
	Federal [2]	Non-Federal	Subtotal	Dam Safety [3]	Total	Federal [2]	Non-Federal	Subtotal	Dam Safety [3]	Total
	Folsom Modification Project					6 STG Element (Corps Work Package)				
First Cost										
Flood Damage Reduction	157.6	84.9	242.5	–	242.5	444.0	239.0	683.0	–	683.0
Dam Safety	–	–	–	–	0	–	–	–	[4]	[4]
Total	157.6	84.9	242.5	–	242.5	444.0	239.0	683.0	–	683.0
Percent – Flood Damage Reduction	65	35	100	–	100	65	35	100	–	100
Percent – Total Cost	65	35	100	–	100	65	35	100	–	100
	Folsom Dam Raise Project					DR Element				
First Cost										
Flood Damage Reduction	100.4	53.1	153.5	–	153.5	115.2[5]	50.0[5]	165.2	–	165.2
Dam Safety	–	–	–	111.4	111.4	–	–	–	0	0
Ecosystem Restoration	21.3	11.5	32.8	–	32.8	38.9	20.9	59.8	–	59.8
Permanent Bridge	–	–	–	–	–	41.6	24.1	65.7	–	65.7
Total	121.7	64.6	186.3	111.4	297.7	195.7	95.0	290.7	–	290.7
Percent – Flood Damage Reduction	65	35	100	–	100	70[5]	30[5]	100	–	100
Percent – Total Cost	41	22	63	37	100	67	33	100	0	100
	Combined Projects					Total RAP				
First Cost										
Flood Damage Reduction	258.0	138.0	396.0	–	396.0	559.2	289.0	848.2	–	848.2
Dam Safety	–	–	–	111.4	111.4	–	–	–	[4]	[4]
Ecosystem Restoration	21.3	11.5	32.8	–	32.8	38.9	20.9	59.8	–	59.8
Permanent Bridge	–	–	–	–	–	41.6	24.1	65.7	–	65.7
Total	279.3	149.5	428.8	111.4	540.2	639.7	334.0	973.7	[4]	973.7
Percent – Flood Damage Reduction	65	35	100	–	100	66	34	100	–	100
Percent – Total Cost	52	28	79	21	100	66	34	100	0	100

Key: – = does not apply; DR = dam raise; RAP = Refined Authorized Projects; STG = submerged tainter gate

Notes:

1. *The cost of the authorized projects repriced to current price levels would be significantly greater than shown in this table, at about $1,390 million ($655 million for the Folsom Modification Project and $737 million for Folsom Dam Raise Project).*
2. *Corps of Engineers' budgetary responsibility.*
3. *Reclamation Safety of Dams Program item.*
4. *Plan elements to be accomplished under the Reclamation Safety of Dams Program.*
5. *Includes features cost-shared at 65 percent Federal and 35 percent non-Federal, as well as temporary bridge cost of $21.5 million that is subject to Reclamation determination of which part, if any, may be subject to reimbursement by Central Valley Project water or power contractors.*

5.10 CHANGES IN LOCAL COOPERATION REQUIREMENTS

After the *PAC Report* is approved and pending funding, design would proceed at Federal expense upfront. This effort will be based on the Project Cooperation Agreements (PCA) between the Department of the Army and the non-Federal sponsors. The Department of the Army will enter into a PCA with the State of California and possibly the Sacramento Area Flood Control Agency (SAFCA) for the Folsom Modification Project, and with the State of California and SAFCA for the Folsom Dam Raise Project, at which time, the non-Federal share of the design phase would be recouped. The Department of the Army and the City of Folsom have signed a separate PCA for the Folsom Bridge.

5.11 CHANGES IN ENVIRONMENTAL IMPACTS

Following is a summary of the environmental compliance background and impact changes between the authorized projects and the RAP.

5.11.1 Environmental Compliance Background

5.11.1.1 Authorized Folsom Modification Project

In support of the Folsom Modification Project, *Final Environmental Assessments/Initial Studies* (EA/IS) and *Findings of No Significant Impact/Mitigated Negative Declarations* (FONSI/MND) were prepared in 2001 and 2005 that identified potential effects of the authorized project design (enlarging eight existing outlets and constructing two new outlets on the main dam). In these *EA/ISs*, the Corps determined that while proposed modifications would have potentially significant impacts to vegetation and wildlife, special-status species, and air quality, all adverse impacts could be mitigated to less than significant levels. As a result, a *FONSI* and an *MND* accompanied each *EA/IS*.

5.11.1.2 Authorized Folsom Dam Raise Project

An *Environmental Impact Statement/Environmental Impact Report* (EIS/EIR) was completed for the Folsom Dam Raise (Corps *Long-Term Study*) in 2002. This document analyzed the impacts of raising Folsom Dam 7 feet. Potentially significant adverse effects to geology and soils, fisheries, traffic, cultural resources, and water quality were identified. Proposed mitigation measures, such as implementation of best management practices (BMP) and mitigation for impacts to vegetation and wildlife and special-status species, would reduce these impacts to less than significant levels. Adverse impacts that could not be mitigated to less than significant levels were identified for air quality, noise, and recreation.

5.11.1.3 Refined Authorized Projects

Reclamation, as the National Environmental Policy Act (NEPA) lead Federal agency, prepared the *Final Folsom Dam Safety and Flood Damage Reduction EIS/EIR* (2007), with the Corps participating as a cooperating agency. The *EIS/EIR* analyzes alternatives that address Reclamation dam safety objectives, as well as Corps flood damage reduction objectives, as discussed in this *PAC Report*. Potentially significant adverse effects have been identified for

geology and soils, traffic, water quality, fisheries, recreation, cultural resources, and noise. Proposed mitigation measures, such as implementation of BMPs and mitigation for impacts to vegetation and wildlife, special status-species, and air quality, would reduce these impacts to less than significant levels, with the possible exception of recreation.

It should be noted that the without-project condition discussed in the *Final Folsom Dam Safety and Flood Damage Reduction EIS/EIR* prepared jointly by Reclamation and the Corps (2007) differs from the without-project condition considered in this *PAC Report*. This is because the scope of the joint *EIS/EIR* includes not only the potential work to address flood damage reduction issues, but Reclamation's structural dam safety actions and additional work needed for security at Folsom Dam. This *PAC Report* assumes that Reclamation will move forward with dam safety and security improvements at Folsom Dam independent of any flood damage reduction actions, and thus considers Reclamation's dam safety improvements as part of the without-project condition.

Table 5-15 displays the estimated changes in impacts of the Selected Plan as it compares to the authorized Folsom Modification and Folsom Dam Raise projects and the Reclamation constructed emergency fuseplug auxiliary spillway (part of the future without-project condition for the Selected Plan evaluation). It is important to note that the effects associated with the authorized Corps projects (Folsom Modification and Folsom Dam Raise projects) are the impacts identified in the original environmental documents for those projects, and impacts are not updated to a current assessment. It was determined that the original environmental evaluations were an adequate representation of effects for the purposes of comparison of the effects of the Selected Plan.

5.11.1.4 Public Review

Public review of the Corps *Draft PAC Report (*2006d*)* and Reclamation *Draft Folsom Dam Safety/Flood Damage Reduction EIS/EIR (*2006c*)* occurred from 1 December 2006 to 26 January 2007. Public meetings were held on 9 January 2007 and 10 January 2007. Primary subjects of public comment are as follows:

- **Recreation and Economic Impacts** - Comments pertained to the loss of convenient access to recreational opportunities, including hiking, boating, swimming, picnicking, biking, and nature watching, and how this loss could potentially impact businesses and home values in the local area.

- **Public Review Process** - Concerns were expressed about inadequate notification of the proposed project and inadequate notification of the public hearings. Requests were made in a public hearing format for additional meetings, and provision of additional presentation materials.

- **Affected Property** - During the public review period, several written comments were received concerning potential hydraulic impacts to specific properties, along with requests for detailed property impact maps and property acquisition details.

TABLE 5-15
CHANGES IN ENVIRONMENTAL IMPACTS

Resource Area	Change in Impact - Folsom Modification Project	Comparison to Impact of W/O Project Condition (Reclamation Fuseplug Auxiliary Spillway)[1]	Change in Impact – Folsom Dam Raise Project
Water Quality	**Increase** in potential for water quality impacts from in-water blasting and excavation of 900-foot approach channel for auxiliary spillway. **These impacts would be mitigated to less than significant levels** by implementation of BMPs, such as sediment curtains.	Potential for water quality impacts would be similar for Selected Plan auxiliary spillway and fuseplug auxiliary spillway. These impacts would be mitigated to less than significant levels by implementation of BMPs, such as sediment curtains - **no significant change.**	**Decrease** in potential disturbance to water quality due to removal of the need for in-reservoir borrow activities with the 3.5-foot raise.
Air Quality	Authorized Folsom Modification Project would exceed the threshold for NO_x by 112 lbs/day in peak construction activity years. Selected Plan auxiliary spillway (Reclamation dam safety work combined with auxiliary spillway in air quality analysis) would exceed the NO_x threshold by 1,816 lbs/day - an **increase.**	Fuseplug auxiliary spillway would exceed the threshold for NO_x by 1,649 lbs/day. The Selected Plan auxiliary spillway would exceed the NO_x threshold by 167 lbs/day more than the fuseplug auxiliary spillway – **an increase.**	*Long-Term Study*[2] air quality analysis shows that NO_x threshold would be exceeded by 226 lbs/day for a 7-foot raise, and by 246 lbs/day for a 3.5-foot raise – **an increase**. Possible explanations – trucking material from off site for 3.5-foot raise, and shorter construction time; therefore, impacts are more concentrated over fewer years.
Aquatic Resources	**Increase** in potential for water quality impacts from in-water blasting and excavation of 900-foot approach channel for auxiliary spillway. **These impacts would be mitigated to less than significant levels** by implementation of BMPs, such as sediment curtains. Original Mods had some potential for impact to the aquatic habitat (i.e., increased turbidity from concrete excavation and grouting, etc.), but impacts were mitigable as well with BMPs.	In-water work would be similar for the approach channel for the fuseplug auxiliary spillway and the Selected Plan auxiliary spillway – **no significant change.**	**Decrease** in potential disturbance to aquatic habitat due to removal of the need for in-reservoir borrow activities with the 3.5-foot raise.
Terrestrial Vegetation and Wildlife	Area of 7.5 acres compensation implemented for Mods Staging Area. Approximately 39 additional acres would be needed for the auxiliary spillway footprint – **increase.**	Fuseplug auxiliary spillway footprint would require approximately 39 acres compensation – **no change**.	From the *Long-Term Study*,[2] 80 acres of compensation would be needed for a 7-foot raise, and 14 acres would be needed for a 3.5-foot raise – **a decrease.**
Soils	Loss of soil resources through excavation – 3.5 million cubic yards excavated. However, this is a less than significant impact, as the soils are not of high ecological or agricultural value. Also, increased potential for erosion and naturally occurring asbestos disturbance, but these impacts are mitigable to less than significant levels by implementation of BMPs. This is an **increase, but a less than significant impact**.	Fuseplug auxiliary spillway would require approximately 5.8 million cubic yards of excavation. The Selected Plan auxiliary spillway would require approximately 3.5 million cubic yards of excavation – **a decrease**.	**Decrease** in the need for borrow material, as the 3.5-foot raise would likely be a concrete parapet wall, and off-site commercial materials would be used, whereas the 7-foot raise would require borrow from sites within and around the reservoir.
Visual Resources	**Increase** in potential for significant, unavoidable impacts to visual resources due to change in landscape at auxiliary spillway site. Original Mods work would be confined to main dam and not readily visible to the public.	Fuseplug auxiliary spillway would have similar impacts to visual resources – **no change.**	Permanent loss of lake views from trails, shoreline, and residences due to new parapet walls and embankments. No major change from 7-foot raise to 3.5-foot raise. Perhaps a slight **decrease** in impact with a shorter raise, but this may be countered by the fact that a 3.5-foot raise would likely be a parapet wall instead of an earthen raise, which is a more natural-appearing feature.

TABLE 5-15
CHANGES IN ENVIRONMENTAL IMPACTS (CONTINUED)

Resource Area	Change in Impact - Folsom Modification Project	Comparison to Impact of W/O Project Condition (Reclamation Fuseplug Auxiliary Spillway)[1]	Change in Impact – Folsom Dam Raise Project
Transportation and Circulation Element	Authorized Folsom Modification Project (2001 analysis) assumed 200 daily trips for project construction crews and materials would not result in any changes in LOS for local roadways (less than significant impact). Selected Plan auxiliary spillway work (combined with Reclamation dam safety work in analysis) would result in change in LOS in 2 of the years of construction activity – an **increase** in transportation impacts; however, this impact is **mitigable to less than significant levels** with implementation of BMPs.	Fuseplug auxiliary spillway work (combined with Reclamation dam safety work in analysis) would result in change in LOS in 2 of the years of construction activity, similar to effects of construction of the Selected Plan auxiliary spillway – **no significant change.**	Would be 57 peak hour construction trips with 7-foot raise, and 36 peak hour trips with 3.5-foot raise – **a decrease.**
Noise	Noise levels would **increase,** and additional sensitive receptors would be impacted, but **implementation of mitigation measures, such as sound barriers, would reduce impacts to less than significant levels.**	Noise impacts would be similar for the fuseplug auxiliary spillway and Selected Plan auxiliary spillway – **no significant change.**	Noise impacts of a 3.5-foot raise would be less than significant. Borrow activities at Mississippi Bar for a 7-foot raise would have noise impacts on sensitive receptors that could not be mitigated to less than significant levels – a **decrease** in noise impacts.
Cultural Resources	**Increase** in potential for disturbance of cultural resources in auxiliary spillway footprint, as original Mods work would be confined to main dam. Also, construction of an auxiliary spillway may affect the integrity of the dam as a historic resource.	Potential for impacts to cultural resources would be similar for the fuseplug auxiliary spillway and the Selected Plan auxiliary spillway – **no significant change.**	**A decrease** in borrow sites; threfore, decrease in potential for disturbance of cultural resources in reservoir.
Recreation	Potential for significant loss of visitor days and recreation revenues due to construction staging at Folsom Point. This would be an **increase** over original Mods, which would use the staging area below the left wing dam, which is not open to the public.	Fuseplug auxiliary spillway would have the potential for recreation impacts at Folsom Point for 5 years, whereas the Selected Plan auxiliary spillway would have the potential for recreation impacts at Folsom Point for 6 years, due to a longer construction schedule for the Selected Plan auxiliary spillway – **an increase.**	**A decrease** in recreation impacts from in-reservoir borrow and barging of material.
Population and Housing	**No change.**	Fuseplug auxiliary spillway and Selected Plan auxiliary spillway would not have adverse affects on population and housing – **no change.**	From *Long-Term study*,[2] potential short duration, infrequent impacts to 16 properties with 7-foot raise, and to 8 properties with 3.5-foot raise – **a decrease.**
Key:	BMP = best management practice lbs = pounds LOS = level of service	NO_x = nitrogen oxides W/O = without	

Notes:

1. *Impact Analysis for the 6 STG Element includes impacts from all Reclamation Safety of Dams Program work as well; therefore, impacts of Corps portion of auxiliary spillway work alone would be less than described.*
2. *Corps, The Reclamation Board, and SAFCA. 2002. American River Watershed, California, Long-Term Study, Final Supplemental Information Plan Formulation Report/Environmental Impact Statement/Environmental Impact Report. February.*

- **Auburn Dam** - Comments received on the *Draft Folsom Dam Safety and Flood Damage Reduction EIS/EIR* questioned why the Auburn Dam project was not being considered a viable alternative to the modifications being proposed for Folsom Dam.

- **Operations** - Comments were received questioning why the *Draft Folsom Dam Safety/Flood Damage Reduction EIS/EIR* did not address in greater detail operations and proposed changes to the Water Control Manual. Topics of concern included potential downstream impacts, water supply, and existing condition assumptions.

- **Relationship of Safety of Dams, Dam Security, Joint Federal Project, and Flood Damage Reduction** - Several comments relating to the *Draft Folsom Dam Safety and Flood Damage Reduction EIS/EIR* indicated a need for additional explanation as to the components of Folsom Dam Safety/Flood Damage Reduction.

- **Transportation and Circulation** - Comments on the *Draft Folsom Dam Safety and Flood Damage Reduction EIS/EIR* questioned the effects of potential increases in traffic.

- **Noise** - Specific comments included concerns relating to haul trucks, general construction, and increased traffic.

- **Air Quality** - Specific issues included concerns regarding fugitive dust/particulate matter and emissions from construction machinery and vehicles.

Reclamation, with participation from the Corps as a cooperating agency, has finalized the *Folsom Dam Safety and Flood Damage Reduction EIS/EIR* (2007) to clarify areas that received public comment and to respond to those comments, including analyzing potential solutions to minimize recreation and economic impacts of restricting access to Folsom Point and other areas in the Folsom Lake State Recreation Area.

5.11.2 Summary of Environmental Impact Changes

Various categories of changes are revealed when comparing estimated changes in environmental impacts of the Selected Plan to the authorized Folsom Modification and Folsom Dam Raise projects and the Reclamation constructed emergency fuseplug auxiliary spillway, as shown in **Table 5-15**. These categories include (1) increase in environmental impacts that would be mitigated to less than significant levels, (2) decrease in impacts, (3) significant increases in impacts, (4) and increase in impacts due to a change in legal and institutional recognition (cultural resources). Some resources can quantifiably be measured for comparison. Some resources are qualitative; in those cases, the measure for comparison is the significance of the environmental impact.

An increase in impacts that can be mitigated is believed neutral in terms of a change and is not a key measure of change to scope. A decrease in impacts is desirable and the goal of agency policy, and not a key measure of change to scope. In some cases, the Selected Plan appears to have a discernable increase in impacts from the authorized Folsom Modification or Folsom Dam Raise projects; however, if the authorized projects' associated impacts were

"updated," the increase would be minor. The biggest increase in impacts to resources would be due to construction of the 6 STG Element auxiliary spillway. It is important to note that the auxiliary spillway replaces the need for Reclamation to construct an emergency fuseplug spillway, which is considered to be constructed as part of the future without-project condition in this *PAC Report*. The fuseplug spillway would have included similar, yet greater, impacts than construction of the 6 STG Element auxiliary spillway. Therefore, from a Federal perspective, there is no considerable increase in impacts, and this is also not a key measure of change to scope for this project. From a Corps perspective, it is planned that Reclamation would do excavation associated with the 6 STG Element auxiliary spillway; impacts are disclosed in the Reclamation *2007 Final Folsom Dam Safety and Flood Damage Reduction EIS/EIR*. The net environmental impacts of the originally authorized projects, when considering the fuseplug spillway as part of the future without-project condition, are similar to those of the Selected Plan.

CHAPTER 6.0
JOINT FEDERAL PARTICIPATION

6.1 JOINT FEDERAL PROJECT

Previous sections of this *Post Authorization Change Report* have demonstrated that the six submerged tainter gate element (6 STG Element) of the Refined Authorized Projects (RAP) would be effective and efficient in reducing flood damages, and is functionally equivalent to the Folsom Modification Project. In addition, the 6 STG Element would effectively address the United States Department of the Interior, Bureau of Reclamation's (Reclamation), objective of resolving hydrologic dam safety problems at Folsom.

As discussed in **Chapter 4**, the 6 STG Element of the RAP is also referred to as the Joint Federal Project, or JFP. Because of all of the various structural features of projects addressing United States Army Corps of Engineers (Corps) flood damage reduction and Reclamation seismic and hydrologic risk objectives, these agencies have developed the JFP terminology to improve interagency coordination and support development of project agreements.

Both agencies have agreed that each would fund and construct its respective portions of the JFP through its existing authorities. Each agency has an interest in restricting its construction responsibilities and associated construction risk as much as possible to features it would have built if it were constructing its own single purpose project. A procedure was developed to equitably divide costs and related construction responsibilities so that both agencies might enjoy the cost savings inherent in the 6 STG Element (i.e., JFP). Work items, which in aggregate can be considered each agencies' full contribution to a complete project, are called work packages. Each agency will construct its own work package.

The work package procedure is believed to achieve an equitable distribution of construction work and cost. Both agencies and their respective project beneficiaries will realize reduced costs in comparison to independent implementation of single purpose projects. This approach differs from traditional cost allocation in which costs are accumulated and equitably allocated among benefit-generating project purposes. This procedure seeks not only equitable costs between flood damage reduction and dam safety, but also a way for the two Federal agencies to partner in constructing a single complete project.

6.2 SUMMARY OF WORK PACKAGES

Feasibility-level cost estimates have been completed by each agency for its respective work package consistent with each agency's policies and guidelines. As mentioned, the Corps and Reclamation are to implement their work packages as a part of larger comprehensive dam safety or flood damage reduction program modifications to Folsom Dam under respective agency authorities. Each agency is to report only the work and associated cost it is responsible for to meet budgetary and authorization purposes, and exclude the portions not allocated to it in determining its total work and associated costs.

Each agency has assumed responsibility for its work package and will continue working cooperatively through completion of final JFP designs and construction. Reclamation will implement construction of its work packages in stages, with emphasis on completing design features common to the dam safety stand-alone fuseplug auxiliary spillway, consistent with the Reclamation Safety of Dams Program. The Corps, after obtaining project approval, is to implement its work package under the authorized Folsom Modification Project and authority contained in Energy and Water Development Appropriations Act of 2006 (Public Law 109-103). Absent timely Corps approvals, Reclamation has indicated that it intends to undertake work necessary to complete the fuseplug auxiliary spillway, as described in **Chapter 3**.

Although the project contains joint features and costs needed for both flood damage reduction and dam safety, for project implementation and cost-sharing purposes, the Corps Work Package cost will be treated as a flood damage reduction cost, and the Reclamation Work Package will be treated as a dam safety cost. As mentioned, each agency is to report the cost of its work package as that portion of the cost of the JFP attributable to its authorized project purposes. Although engineering and construction considerations have been used to identify major items for inclusion in the work packages, the Reclamation Work Package consists primarily of excavation that would be required for the fuseplug spillway. Thus, the Reclamation Work Package approximates the fuseplug spillway. The Corps Work Package approximates the additional work needed to make a flood damage reduction spillway. Using this rationale, the Corps Work Package may be considered a flood damage reduction cost.

Reclamation's contribution is limited to excavation work. The Corps contribution includes the gate structure and all other additional work for a fuseplug spillway required for flood damage reduction. Following is a summary of each agency's work package.

6.2.1 Reclamation Work Package Summary

Under the Reclamation Work Package, Reclamation would be responsible for excavating the spillway chute, stilling basin, and a portion of the control structure. Primary work tasks would consist of the following:

- Initial site preparation, including roads and utilities
- Chute excavation
- Stilling basin excavation
- Partial control structure excavation
- Initial control structure foundation remediation
- Permitting for Reclamation Work Package
- Physical site security
- National Environmental Policy Act (NEPA)/California Environmental Quality Act (CEQA) mitigation/cultural resources mitigation

6.2.2 LERRD in Reclamation Work Package

The responsibility to provide lands, easements, rights-of-way, relocations, and disposal areas (LERRD) is generally that of the Corps' non-Federal Sponsor and is cost-shared in accordance with the cost-sharing provisions established in the Water Resources Development Act (WRDA) of 1986. Reclamation is to provide and/or perform most of the tasks generally associated with LERRD acquisition. Reclamation's performance of these work items does not affect or lessen the fiscal cost-sharing of the Corps' non-Federal Sponsor. **Appendix D – Real Estate** provides more detailed information on LERRDs associated with the full 6 STG Element, or JFP, of the RAP. The Reclamation Work Package requires the following LERRDs for the project as a whole:

- Accomplishment of environmental mitigation.
- Relocation of a 42-inch water pipeline (Natomas Pipeline) that provides raw water from Folsom Reservoir to the City of Folsom and California Department of Corrections.
- Relocation of the Sacramento Municipal Utility District's 12-kilovolt power line.
- Relocation of the 4,160-volt power line that serves Reclamation's yard on the right abutment.

Although these LERRDs are required for the 6 STG Element (JFP) to be constructed, they are included in the Reclamation Work Package, and are Reclamation's responsibility. Reclamation will provide these LERRDs using its own regulations and procedures. Other than a right-of-entry to construct, no LERRDs are identified in the Corps Work Package.

6.2.3 Corps Work Package Summary

Under the Corps Work Package, major responsibilities include the remainder of excavating the spillway control structure and approach channel, and construction of the chute, stilling basin, and control structure. Primary work tasks would consist of the following:

- Follow-up site preparation
- Stilling basin construction
- Chute construction
- Remaining control structure excavation
- Control structure construction
- Remaining control structure foundation remediation
- Approach channel excavation
- Permitting for the Corps Work Package
- Site restoration

6.2.4 Corps Work Package Cost Estimate

As described above, once work package items were defined, each agency developed its own cost estimate, complete with contingencies, mitigation costs, and program costs for its work package. The Corps developed a new cost estimate for its work package. Costs are in microcomputer-aided cost engineering system (MCACES) format, and in accordance with Corps cost engineering principles and practice. Costs were adjusted back to first costs, with interest during construction added to develop the investment cost. The costs of the Corps Work Package are summarized in **Table 6-1**. Reclamation prepared a cost estimate, using its own cost engineering and program cost procedures, for its Work Package as part of information developed to support the Reclamation Work Package.

TABLE 6-1
FIRST COST OF CORPS WORK PACKAGE FOR 6 STG ELEMENT [1]

Cost Account	First Cost ($ millions)
Lands	0.0
Relocations	0.0
Construction	538.6
Environmental Mitigation[2]	0.4
Cultural Resources	0.0
PED	99.9
S&A	44.1
Total [3]	**683.0**

Key: PED = preconstruction, engineering, and design
S&A = supervision and administration
STG = submerged tainter gate

Notes:

1. *First costs presented at October 2006 price levels.*
2. *Sunk cost is biological mitigation for work area that was constructed preliminary to enlargement of Folsom Dam's low-level outlets.*
3. *Includes sunk costs expended through October 2006, which are $55.9 million. Total costs without sunk costs are $627.1 million.*

6.3 COMMON LANGUAGE

In early 2007, both the Corps and Reclamation developed a written understanding regarding each agency's involvement in the JFP. This written understanding is known as "Common Language." The intent of the common language is to establish common terms, overall project understanding, and information about how each agency intends to proceed toward implementing its responsibilities in the JFP. The following sections of this chapter are the "Common Language" developed jointly by the agencies.

JOINT FEDERAL PROJECT

The consideration of the hydrologic dam safety risk along with the limitations of the existing flood control system in the Sacramento area has recently received increased public attention in the aftermath of the 2005 Gulf Coast hurricanes. Planning of significant standalone improvements for flood protection and dam safety has been underway for some years and the Joint Federal Project (JFP) is the product of a comprehensive effort to identify and implement an alternative meeting Dam Safety and Flood Damage Reduction objectives. The JFP is the result of Federal and local collaboration on multiple agreements and partnerships between numerous agencies and organizations. These organizations are notably the United States Department of the Interior, Bureau of Reclamation (Reclamation), the United States Department of Defense, Army Corps of Engineers (Corps), the State of California Department of Water Resources (DWR) Reclamation Board (Reclamation Board), and the Sacramento Area Flood Control Agency (SAFCA).

Section 128 of the Energy and Water Development Appropriations Act of 2006 (PL 109-103) directed the Secretary of the Interior and the Secretary of the Army to collaborate on authorized activities to expeditiously address dam safety needs and maximize flood damage reduction improvements at Folsom Dam. In accordance with this direction, the two agencies collaboration was developed on the principles of expeditiously improving overall public safety and realizing a distribution of work, costs and savings between Reclamation's Dam Safety Program and the Corp's Folsom Modification and Folsom Dam Raise Projects, which are for the purpose of flood damage reduction.

As directed by Congress and in accordance with each agency's respective congressional authorizations, Reclamation and the Corps have coordinated with the Corp's local project sponsors, Reclamation Board and SAFCA, to develop and implement an optimal alternative. Through the collaborative effort, The Joint Federal Project has been identified as the optimal alternative which meets respective agency objectives and authorities and to serves the public benefit of reducing dam safety hydrologic risks by withstanding the PMF and meeting the flood damage reduction local objective of safely passing the 1 in 200 year or greater design storm. Reclamations findings under the direction provided by PL 109-103 are presented below within its Folsom Dam Modification Report. The Corps findings under PL 109-103 are presented within this PAC report.

The Folsom Facility was constructed by the Corps. Upon completion in 1956, the Folsom Facility was transferred to Reclamation for operation and maintenance (O&M) as an integrated feature of the Central Valley Project (CVP). Both Federal agencies have obligations and interests in relation to the Folsom Facility but differ in respect to Congressional objectives, mandates, authorities, funding, and time lines. Through cooperation, Reclamation and the Corps seek to integrate dam safety improvements with flood damage reduction measures under a single Joint Federal Project. In addition to the JFP, both

agencies will undertake additional separate actions to comprehensively meet their respective agency responsibilities.

The JFP will be executed under a Memorandum for Record between Reclamation and the Corps. The Memorandum for Record will describe how the two agencies will together design and construct the JFP.

The JFP is an auxiliary spillway with six submerged tainter gates. The spillway is comprised of an upstream approach channel, a concrete control structure that regulates releases through submerged tainter gates into a downstream concrete lined spillway chute and stilling basin, before discharging into the American River downstream of the main Folsom dam.

The JFP auxiliary spillway would be located southwest of the existing main concrete dam. Principle features of the new auxiliary spillway include (1) an approximately 1,100 foot-long approach channel beginning in Folsom Reservoir, (2) a concrete control structure, including six submerged tainter gates, (3) a spillway chute approximately 3,000-foot long and (4) a stilling basin which acts as an energy dissipation structure prior to discharges converging with the American River below the main concrete dam. The control structure will operate in conjunction with existing spillway gates on Folsom Dam to manage flood flows from Folsom Reservoir.

Reclamation and the Corps developed an equitable work distribution agreement for execution of the JFP. The work distribution between the two agencies established a number of work packages based on separable features consistent with each agency's responsibilities.. The work distribution of the JFP was determined to be proportional to the costs of separate least-cost, single-purpose dam safety (DS) and flood damage reduction (FDR) alternatives necessary to meet each agency's responsibilities.

AUTHORITIES & AGREEMENTS

Authorities

United States Department of the Interior, Bureau of Reclamation

Authority for Reclamation participation in dam safety activities at Folsom Dam is authorized by the Reclamation Safety of Dams Act of 1978 (Public Law 95-578) and the Reclamation Safety of Dams Act Amendments of 1984 (Public Law 98-404), 2000 (Public Law 106-377), 2002 (Public Law 107-117), and 2004 (Public Law 108-439). Together, these are collectively referred to as the Safety of Dams Act.

United States Army Corps of Engineers

Authority for the Corps participation in flood damage reduction activities at Folsom Dam are under two specific authorizations; (1) Section 101(a) (6) of Water Resources Development Act (WRDA) 1999 (Public Law (PL) 106-53)

provides authorization for the Folsom Modification Project, and (2) Section 128 (a) of the Energy and Water Development Appropriations Act for 2004 (PL 108-137) provides authorization for the Folsom Dam Raise Project.

Joint Project

Authority for the Corps and Reclamation to coordinate and develop a joint project was clarified in Section 128, PL 109-103, the Energy and Water Development Appropriations Act for 2006.

National Agreements

Partnership Agreement

The MOU was established pursuant to the national Partnership Agreement between the Bureau of Reclamation and the U.S. Department of the Army, Assistant Secretary of the Army (Civil Works) executed February 11, 2005.

Memorandum of Agreement

Should any funding exchange be required, it shall be achieved through Support Agreements as detailed in the national Memorandum of Agreement between the U.S. Army Corps of Engineers and the Bureau of Reclamation executed August 22, 2006.

Amended Transfer Agreement

Letter of Agreement (No DA-04-167-eng133) dated May 25, 1955 transferred the Folsom Dam Project to Reclamation for coordination and integration with the Central Valley Project. The Corps and Reclamation responsibilities are further defined in a subsequent amendment to article 4 of that Agreement (dated July 1981).

JOINT FEDERAL PROJECT DEFINITION

The Joint Federal Project (JFP) is explicitly as:

The proposed Joint Federal Project (JFP) consists of an auxiliary spillway adjacent to the existing Folsom Dam. The new auxiliary spillway component is comprised of a reinforced concrete control structure that regulates releases through submerged tainter gates (STGs) into a lined spillway chute and stilling basin, before discharging into the American River.

The Joint Federal Project at Folsom Facility, as currently designed, will consist of six 23' X 33' STGs at invert elevation 368' combined with a concrete lined chute approximately 170' wide and 2,850' in length leading to a dissipation structure.

The JFP, as currently designed, provides a reduction in flood risk of one chance in 156,annually, and meets the local objective of safely passing at least the 200-year design flow without overtopping the downstream levees or exceeding the top of joint use storage. The current JFP design, in conjunction with releases from the existing dam, is capable of passing the Probable Maximum Flood (PMF).

Gate dimensions and invert elevations may be optimized during final design to maximize performance, reduce risk, and/or reduce costs. The optimization will seek to reduce costs while continuing to preserve Flood Damage Reduction Benefits, assure the safety of the public and expedite completion of the dam safety objective of withstanding the passage of the PMF.

REVIEW OF JFP PERFORMANCE OBJECTIVES

*Reclamation has reviewed the current JFP design and assessed the risk reduction effectiveness in accordance with the Policy on Dam Safety Decision Making in the Reclamation Manual. The Guidelines for Achieving Public Protection in Dam Safety Decision Making, dated June 15, 2003, were used for this decision making process. Based on this review, conclusions and recommendations communicated to the Corps in the Folsom Dam Joint Federal Project Short-Term Evaluation Decision Document dated March 28, 2007 (included in **Appendix G – Pertinent Correspondence** of this PAC report) that the project, subject to the identified key findings and recommendations, meets the project technical objectives.*

WORK DISTRIBUTION METHODOLOGY

The dam safety and flood damage reduction percentages guiding the work distribution are based on the proportion of single purpose construction costs to the sum of the two single purpose costs. Work distribution of the JFP was

determined to be proportional to the construction costs of standalone, separate, least-cost, single-purpose alternatives. The Dam Safety (DS) alternative (Fuseplug Auxiliary Spillway) and Flood Damage Reduction (FDR) alternative (6 STG Auxiliary Spillway) included all design elements necessary to meet the specified DS and FDR responsibilities and criteria consistent with the principles and guidelines for their respective purposes.

The work split will be implemented by allocating work packages to Reclamation and the Corps that, in the aggregate, meets the primary objectives of:

- *Reclamation – Expedited Hydrologic Risk Reduction by safely passing the PMF*
- *The Corps – Achieve the local Flood Damage Reduction goal by safely passing at least the 200 - year design flood.*

Each agency will seek funding and cost sharing/cost recovery from its own partners/customers on its own work package. Any required non-federal funding contributions and/or reimbursement will be from the respective agency's project beneficiaries. Costs of the Dam Safety work distribution will not be attributable to the Corps nor to the Corps' partners. Likewise, the costs of the Flood Damage Reduction distribution will not be attributable to Reclamation's Dam Safety Program or to cost recovery with the contracting entities for repayment, under the Safety of Dams Act and other applicable laws.

The following list identifies the cost split methodology mutually developed by the agencies and used to define the equitable agreed upon distribution of work.

1) *Work to be split will involve only the defined JFP. Other features planned or underway at Folsom are either single-purpose dam safety (DS) or single-purpose flood damage reduction (FDR) and are not included. Reclamation and the Corps will implement their allocated work as a part of larger comprehensive Dam Safety or Flood Damage Reduction Program modifications to Folsom Dam under respective agency authorities.*

2) *Both the FDR and DS programs will equitably share in the cost savings realized by collaboration and implementation of the JFP over separate DS and FDR single-purpose projects.*

3) *Each least-cost, DS and FDR single purpose alternative must meet all documented agency policy and guidance.*

4) *Each least-cost, DS and FDR single JFP costs should be adjusted proportional to the costs of the separate least-cost, single-purpose DS and FDR alternatives necessary to meet the specified DS and FDR objectives respectively. Estimates for least-cost, single-purpose alternatives must*

contain all costs that would be required for agency approval and implementation of the single-purpose project.

5) *Each least-cost, single-purpose alternative must meet all documented agency policy and guidance.*

6) *Each least-cost, single-purpose alternative should assume that the other single-purpose project has not been constructed and is not part of the base condition.*

7) *JFP work will be distributed proportional to the construction line item costs of the separate least-cost, single purpose DS and FDR alternatives necessary to meet the specified DS and FDR objectives respectively.*

8) *Construction line item estimates for each least-cost, DS and FDR single purpose alternatives must contain all design elements and estimates of cost that would be required for agency approval and implementation as a single purpose project and single-purpose alternative and the JFP must be based upon the same assumptions, methodologies, unit prices, etc. to make them comparable.*

9) *Once the work split is developed, the work each agency is to perform will conform as closely as possible to the agency's distribution and responsibilities. Each agency will fund and manage its assigned work packages recognizing there are both risks and opportunities associated with the management of those work packages.*

10) *Each agency will seek cost sharing/cost recovery from its own partners/customers on its own work packages. Any required non-federal funding contributions will be from the respective agency's project beneficiaries.*

11) *Reclamation and the Corps will confer and resolve any remaining differences in the split by ensuring consistent application of all estimating factors.*

APPLICATION OF METHODOLOGY

Reclamation and the Corps have equitably divided work based on the construction cost for the 6 Submerged Tainter Gate (6STG) JFP Spillway and a Fuseplug Auxiliary Spillway resulting in an approximate 20% work allocation to Reclamations Safety of Dams Program and 80% allocation to the Corps Flood Damage Reduction Program. The estimate is based on a feasibility level design and construction cost estimate at an effective price level of October 2006.

To accommodate variations in agency estimation methodologies, jointly developed construction cost estimates for each single-purpose alternative were prepared by an engineering consultant. These estimates were reviewed and accepted by both agencies as appropriate for use in determining the proportional work distribution based on equitable the agreed upon cost distribution formula. In determination of construction cost, costs for non contract and/or program costs were excluded from the estimate of overall construction costs to further eliminate potential inequities due to variations in agency program requirements. The costs excluded from the computation were; sunk costs incurred by both Reclamation and the Corps, planning, engineering & design (PE&D), construction supervision & administration (S&A), interest during construction, construction contingencies and other miscellaneous costs such as recreation mitigation and allowances for possible contract fees.

Work package distribution between Reclamation and the Corps was based upon this construction cost estimate with the addition of escalation of costs from notice to proceed to mid-point of construction. The cost formula used to determine percentage for work package distribution is as follows;

$$\text{FDR or DS Work Allocation} = \frac{\$\ \text{Single Purpose FDR or DS}}{(\$\text{Single Purpose FDR} + \$\text{Single Purpose DS})} * 6\text{STG}$$

$$\text{FDR Work Allocation} = \frac{\$\ \text{Single Purpose FDR}}{(\$\text{Single Purpose FDR} + \$\text{Single Purpose DS})} * \text{JFP}$$

$$\text{DS Work Allocation} = \frac{\$\ \text{Single Purpose DS}}{(\$\text{Single Purpose FDR} + \$\text{Single Purpose DS})} * \text{JFP}$$

The method established work package target costs based on a ratio of the single-purpose construction costs to the sum single-purpose construction costs. The resulting percentages were applied to the construction line item costs of the JFP to calculate the basic FDR and DS target construction costs. Working together, both agencies distributed construction line items into two work packages.

The construction line items for the JFP were distributed between the Corps and Reclamation using the following criteria.

- *The total costs of the work items should match as closely as possible the target costs for each work package.*
- *The Reclamation work package would include, to the extent possible, the construction of those portions of the 6 STG Element that coincide with emergency fuseplug auxiliary spillway features. The Corps work package would include the balance of the work, associated with flood damage reduction.*
- *The distribution of work items should minimize construction risk (e.g. complications from two operations being conducted at the same time at the same place) and increase construction efficiency.*
- *The packages should minimize problems of one agency interfacing with the previous work of the other agency.*
- *Construction risk should be balanced between work packages.*

SUMMARY OF WORK PACKAGES

Reclamation and the Corps have determined an optimal division of the work with Reclamation placing emphasis on work which will expeditiously implement interim and permanent hydrologic risk reduction and further expedite implementation, construction and completion of the JFP modification(s). Reclamation and the Corps have identified work packages distributed as follows:

Summary of Reclamation Work Packages

Responsible for excavation of the JFP Chute, Stilling Basin, and a portion of the Control Structure including;

- *Initial Site Preparation including roads and utilities*
- *Chute Excavation*
- *Stilling Basin Excavation*
- *Partial Control Structure Excavation*
- *Initial Control Structure Foundation Remediation*
- *Permitting for Reclamation Work Packages*
- *Physical Site Security*
- *Project NEPA/CEQA/Cultural Resources Commitments*

Summary of Corps Work Packages

Responsible for excavation of the remainder of the excavation of JFP Control Structure and Approach Channel excavation as well as the construction of the Chute, Stilling Basin, and Control Structure including;

- *Follow-up Site Preparation*
- *Stilling Basin Construction*
- *Chute Construction*
- *Remaining Control Structure Excavation*
- *Control Structure Construction*
- *Remaining Control Structure Foundation Remediation*
- *Approach Channel Excavation*
- *Permitting for the Corps Work Packages*
- *Site Restoration*

Feasibility level cost estimates have been completed by each agency for their respective work packages consistent with each agency's policies and guidelines. Reclamation and the Corps will implement their allocated work packages as a part of larger comprehensive Dam Safety or Flood Damage Reduction Program modifications to Folsom Dam under respective agency authorities. Each agency will report only the work and associated cost it is responsible for to meet budgetary and authorization purposes and exclude the portions not allocated to it in determining its total work and associated costs. Within this Modification Report, Reclamation is reporting the estimated costs of completing only the work package elements attributable to Reclamation not the estimated total cost of completing the JFP.

Each agency has assumed responsibility of its work package and will continue working cooperatively through completion of a final JFP designs and construction. Reclamation will implement construction of its JFP work packages in stages, with emphasis on completing design features common to the Dam Safety standalone Fuseplug Auxiliary Spillway, consistent with the Dam Safety Act as the Corps pursues required project authorization. Upon Corps authorization to construct the JFP, Reclamation will undertake the additional allocated work. Absent timely Corps authorization to construct the JFP, Reclamation will undertake the additional work necessary to complete the Dam Safety standalone Fuseplug Auxiliary Spillway.

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CHAPTER 7.0
IMPLEMENTATION

7.1 IMPLEMENTATION TOPICS

This chapter covers implementation considerations for the United States Army Corps of Engineers (Corps) Work Package portion of the auxiliary spillway with six submerged tainter gates (6 STG Element) and the raise of Folsom Dam (DR Element). It also introduces an Economic Reevaluation Study being conducted by the Corps.

Implementation topics include cost-sharing (apportionment) with non-Federal sponsors, cost comparison with Section 902 limits on project costs, and a construction schedule. As discussed in **Chapter 4**, the 6 STG Element would be constructed as part of the Folsom Modification Project. Only the Corps Work Package would be implemented under the Folsom Modification Project. The United States Department of the Interior, Bureau of Reclamation (Reclamation), Work Package is to be constructed under that agency's Safety of Dams Program. Implementation considerations for the Reclamation Work Package are being developed by Reclamation. The DR Element would be part of the Folsom Dam Raise Project together with the Other Features: a permanent bridge and ecosystem restoration. Implementation is discussed in the context of the projects because the projects are budgeted separately and will have separate Project Cooperation Agreements (PCA). **Table 7-1** relates the major elements of the Refined Authorized Projects (RAP) (Selected Plan and Other Features) to their respective authorities.

TABLE 7-1
FEATURES, PURPOSE, AGENCY IMPLEMENTATION

SELECTED PLAN ELEMENTS			
Item	**Features**	**Purpose/Output**	**Agency/Authority or Program**
6 STG Element	Auxiliary Spillway with Six Submerged Tainter Gates	• Flood Damage Reduction • Dam Safety	Corps/ Folsom Modification Project (Corps Work Package) Reclamation/ Safety of Dams Program (Reclamation Work Package)
DR Element	• Raise Dam 3.5 Feet • Replace Three Emergency Spillway Tainter Gates • Construct Temporary Bridge	Flood Damage Reduction	Corps/ Folsom Dam Raise Project
OTHER FEATURES			
Other Previously Authorized Features	Permanent Bridge Increment	Local Transportation	Corps/ Folsom Dam Raise Project
	• Bushy Lake and Woodlake Restoration Sites • Automated Temperature Shutters	Ecosystem Restoration	
Key:	DR = dam raise	STG = submerged tainter gate	

7.2 FOLSOM MODIFICATION PROJECT

7.2.1 6 STG Element Cost-Share

Costs of the Corps Work Package are cost-shared with the non-Federal sponsor using standard cost-share rules for flood damage reduction projects. No lands, easements, rights-of-way, or relocations are required for this work package. Three relocations are included in Reclamation's Work Package; accordingly, it is not the responsibility of the non-Federal sponsor for the flood damage reduction portion of the 6 STG Element, also referred to below as the Joint Federal Project, or JFP. The responsibility to provide all requirements for lands, easements, rights of way, relocations, and disposal areas (LERRD) is typically that of the Corps' non-Federal sponsor. Reclamation's performance of these work items does not affect or lessen the fiscal cost-sharing of the Corps' non-Federal sponsor. The non-Federal sponsor is still responsible for 35 percent of the cost of the project (in this case, the Corps Work Package). The sponsor is required to pay a cash contribution equal to 5 percent of the cost of the structural features.

Included in **Table 7-2** is the estimate of cost for the Corps Work Package of the 6 STG Element, apportioned to Federal and non-Federal categories. As can be seen, of the total cost of $683.0 million, the Federal share is $444.0 million and the non-Federal share is $239.0 million.

TABLE 7-2
6 STG ELEMENT CORPS WORK PACKAGE COST APPORTIONMENT FOR FLOOD DAMAGE REDUCTION ($ MILLIONS)[1]

MCACES ACCOUNT	Item	6 STG Element (Corps Work Package)		
		Federal	Non-Federal	Total[4]
	First Costs			
1	Lands	0.0	0.0	0.0
2	Relocations	0.0	0.0	0.0
08, 11	Construction	538.6	0.0	538.6
6	Environmental Mitigation [2]	0.4	0.0	0.4
18	Cultural Resources	0.0	0.0	0.0
30, 31	EDS&A	144.0	0.0	144.0
	Subtotal	**683.0**	**0.0**	**683.0**
	Less Cultural Resources	0.0	0.0	0.0
	Subtotal	**683.0**	**0.0**	**683.0**
	5 Percent Cash	(34.1)	34.1	0.0
	Subtotal	**648.9**	**34.1**	**683.0**
	Cash Adjustment	(204.9)	204.9	0.0
	Subtotal	**444.0**	**239.0**	**683.0**
	Percent [3]	65	35	100
	Add Cultural Resources	0.0	0.0	0.0
	Total – 6 STG Element [4]	**444.0**	**239.0**	**683.0**
Key:	EDS&A = engineering, design, supervision, and administration MCACES = microcomputer-aided cost engineering system STG = submerged tainter gate			

Notes:
1. *First costs at October 2006 price levels.*
2. *Sunk costs for biological mitigation associated with completed construction of access and turnaround area. Air and water quality mitigation costs are included in construction.*
3. *Percentages are not exactly 65 – 35, but round to these numbers. Federal share slightly higher than 65 percent because of cultural resources.*
4. *Includes $55.95 million in total sunk costs.*

7.2.1.1 Operation, Maintenance, Repair, Replacement, and Rehabilitation Cost

When a Corps project is completed, it is normally turned over to the non-Federal sponsor, who is then responsible for the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project. The 6 STG Element (and the DR Element), however, involve both improvements to existing facilities and implementation of new features on lands owned by the Federal Government and State of California. Consequently, no transfer of "ownership" would occur as a result of implementation of the auxiliary spillway and dam raise. However, for the RAP, the non-Federal sponsor would still be responsible for any increased maintenance costs of both the new and existing pertinent structures.

Operation of Folsom Dam with the auxiliary spillway and raise would be different from existing conditions. The Corps would revise the Water Control Manual for Folsom Dam based on the auxiliary spillway being completed to reflect a new flood control diagram and emergency spillway release diagram. Reclamation, in coordination with the California Department of Water Resources (DWR) Flood Operations Center, would continue to operate Folsom Dam and spillway in accordance with the revised operation manual. Because of the addition of the auxiliary spillway and dam raise, the non-Federal sponsor may need to enter into a new agreement with Reclamation to reflect changes to the overall operation of the Folsom facility, and to reflect any increased operating costs to meet flood control requirements. An OMRR&R agreement would specify tasks each agency would perform. If Reclamation, as operator of the Folsom Dam Industrial Complex, performs all or most of the work, the agreement would specify reimbursement to Reclamation by the non-Federal sponsor.

The non-Federal sponsor would be responsible for the OMRR&R of most of the 6 STG Element (and all OMRR&R associated with the DR Element). OMRR&R responsibilities of Reclamation and the non-Federal flood damage reduction sponsor do not follow the work packages, but are figured on the total, completed, JFP. The rationale used to divide the OMRR&R is that Reclamation OMRR&R responsibility should not exceed the OMRR&R required for a fuseplug spillway. This would be the amount of OMRR&R that Reclamation would have to perform if there were no flood damage reduction interest in an auxiliary spillway. Fuseplug spillway OMRR&R would consist of keeping vegetation growth away from the fuseplug, and keeping the channel clear of debris and vegetation. The annual OMRR&R cost of a fuseplug spillway is less than $50,000 per year and thus falls under the cost estimate level of detail of the feasibility-level cost estimates of this evaluation. The significant JFP OMRR&R cost is for inspecting, testing, operating, maintaining and repairing the six submerged tainter gates. This cost is estimated to average about $160,000 per year. This is a flood damage reduction cost and is the responsibility of the State of California and the Sacramento Area Flood Control Agency (SAFCA). This cost will be more accurately estimated through development of the OMRR&R agreement referred to above.

OMRR&R of environmental mitigation lands is a joint cost that is split between flood damage reduction and dam safety. The flood damage reduction non-Federal sponsor will be responsible for the flood damage reduction portion of this OMRR&R cost and will work with Reclamation to assign these OMRR&R responsibilities, similar to above.

7.2.2 Section 902 Limit of Folsom Modification Project

This section compares the Section 902 maximum project cost limit with the total project fully funded cost. The maximum project cost allowed by Section 902 of the Water Resources Development Act (WRDA) of 1986, as amended, includes the authorized cost (adjusted for inflation), the current cost of any studies, modifications, or actions authorized by the WRDA of 1986 or any later law, and 20 percent of the authorized cost (without adjustment for inflation). The fully funded estimate is the flood damage reduction project first cost inflated through the construction period at the current interest rate. If the fully funded cost exceeds the Section 902 limit, then new authorization would be required.

The Folsom Modification Project Section 902 limit is the flood damage reduction portion of the 6 STG Element (i.e., Corps Work Package portion of the 6 STG Element). On the basis of the estimated first cost of the Corps Work Package of $683 million, updated to current price levels, the fully funded cost is about $762.0 million. As shown jn **Table 7-3**, the Section 902 limit of the Folsom Modification Project is $245.6 million. Therefore, construction of the Corps Work Package would require a project reauthorization to increase the project cost.

TABLE 7-3
SECTION 902 COST LIMIT FOR 6 STG ELEMENT FLOOD DAMAGE REDUCTION ($ MILLIONS)

Computation Process	Cost
1. Authorized amount inflated through construction (fully funded)	
a. Project cost estimate[1] at current price levels	683.0
b. Line a, inflated through construction	762.0
c. Ratio: Line b / Line a	1.1157
d. Authorized cost, at current price level	193.3
e. Authorized cost, inflated through construction (Line c x Line d)	215.6
2. Cost of modifications required by law	0
3. 20 percent of project cost in authorization (.20 x $150 [2])	30.0
4. Maximum cost limited by Section 902 (sum of Lines 1e + 2 + 3)	245.6

Notes:
1. *Authorized Folsom Dam Modifications Project consisting of the 10-main-dam-outlet plan described in the Corps 2003 American River Watershed, California, Folsom Dam Modification Project, Final Limited Reevaluation Report and Environmental Assessment/Initial Study.*
2. *Authorized cost of Folsom Modification Project.*

7.2.3 Report and Project Approvals

Since the cost of the Corps Work Package portion of the 6 STG Element exceeds the Folsom Modification Project authorized cost, reauthorization by Congress is required to increase the project cost. The DR Element is within the scope of the Folsom Dam Raise Project. No further authorization or other congressional action is required to proceed with the DR Element.

Since the 6 STG Element/JFP is within project scope and further authorized by Section 128 of the Energy and Water Resources Appropriations Act of 2006, only a project cost increase is needed. No *Chief of Engineers Report* will be prepared.

As mentioned, Reclamation prepared and circulated a *Draft Folsom Dam Safety and Flood Damage Reduction Environmental Impact Statement/Environmental Impact Report* (EIS/EIR), which became final in March 2007. The Corps intends to issue a Record of Decision on the Corps Work Package and the DR Element in May 2007.

Reclamation's contribution to the 6 STG Element would be through the Reclamation Safety of Dams Program. To proceed with its contribution to the 6 STG Element, Reclamation prepared information to support the Reclamation Work Package, including information to support the construction of an auxiliary spillway with six submerged tainter gates. After approval of a revised Folsom Modification Project, the project would be approved by the Office of Management and Budget. If no action is taken by Congress, approval is implied and Reclamation may proceed with implementation.

7.2.4 Local Support

As mentioned, the non-Federal sponsor for both the Folsom Modification and Folsom Dam Raise projects is the State of California, with SAFCA as a co-sponsor. The City of Folsom is responsible for the permanent bridge portion of the Folsom Dam Raise Project (see **Section 7.3.3.1**). Both the State of California and SAFCA continue to support these projects. Both agencies are aware of their sponsor responsibilities and are able to meet cost-sharing requirements. The non-Federal co-sponsors support the project, as evidenced by letters of intent from the State of California (5 December 2006) and SAFCA (5 October 2006). These letters are contained in **Appendix G - Pertinent Correspondence**.

7.2.5 Sponsor Financial Analysis and Ability to Pay

The State of California has sponsored many Federal projects and has sufficient resources and powers of taxation to fulfill its obligations of sponsorship.

7.2.6 Folsom Modification Project Cooperation Agreement

Review continues of PCAs between the Corps and other signatories required for implementation of the Corps Work Package of the 6 STG Element.

An existing PCA under the Folsom Modification Project was signed in March 2004. Analysis is currently occurring of issues such as whether this PCA can be amended, or whether nonstandard language would be added to achieve project implementation. The non-Federal signatory would be the State of California with SAFCA as a contributing sponsor.

7.2.7 6 STG Element Schedule

As mentioned, a number of approvals/reviews are required to implement the Selected Plan portion of the RAP. In addition, authorization of a new project cost for the Folsom Modification Project (6 STG Element of the Selected Plan) would be required. This would result

in a new 902 limit. Reclamation may begin construction of its work package before all Corps flood damage reduction approvals are in place. Reclamation may begin construction in September 2007. Almost 7 years would be required for construction of the 6 STG Element, as shown in **Table 7-4**. Construction of the DR Element would be phased to begin well after the beginning of construction of the 6 STG Element.

TABLE 7-4
IMPLEMENTATION SCHEDULE OF 6 STG ELEMENT AND DR ELEMENT

Task Name	Start Date	Finish Date
Project Approval Activities		
PAC & EIS/EIR Final Reports	In progress	June 2007
Folsom Modification & Related Activities[1]		
6 STG Element Construction		
-Reclamation Work Package	September 2007	2010
-Corps Work Package	2010	2014
Folsom Dam Reoperation & Forecast-Based Release		
-Decision Document & EIS/EIR	January 2007	June 2008
Folsom Dam Raise[2]		
Folsom Bridge Construction	February 2007	January 2009
Folsom Dam Raise Construction	2014	2016
Ecosystem Restoration Construction	2016	2019

Key: DR = dam raise
EIS/EIR = Environmental Impact Statement/Environmental Impact Report
PAC = Post Authorization Change
STG = submerged tainter gate

Notes:
1. *A more detailed schedule for activities related to the 6 STG Element is included in **Appendix C – Joint Federal Project Engineering Design Report.***
2. *A more detailed schedule for activities related to the Folsom Dam Raise Project is included in **Appendix B – Folsom Dam Raise Project Engineering Design Report.***

7.2.8 Folsom Dam Reoperation

As mentioned, Reclamation's interim operation agreement will end after completion of the Folsom Modification Project (6 STG Element/JFP). The Corps has begun a study that will lead to a decision and National Environmental Policy Act document on this permanent reoperation, and a revised Water Control Manual. The evaluation will include an analysis of alternative operation rules, with accompanying cost-benefit and environmental impact information. This study will also include an analysis of forecast-based releases from Folsom Dam. The cost of the study and the cost and economic benefits of reoperation are not included in the costs and benefits of the RAP.

7.3 FOLSOM DAM RAISE PROJECT

7.3.1 Dam Raise Project Features

The Folsom Dam Raise Project was authorized as a 7-foot dam raise with replacement of all eight gates on the service and emergency spillways, and operation to a top of flood control space at elevation 482 feet. This project was planned for construction after the Folsom Modification Project was in place. As described in **Chapter 4**, a 3.5-foot raise and replacement of the three emergency spillway tainter gates is a more efficient and technically feasible plan. As

mentioned, the 3.5-foot raise is a major part of the DR Element of the Selected Plan described in **Chapter 4**. The 3.5-foot dam raise is also the major design change for the authorized Folsom Dam Raise Project. The estimated cost for the 3.5-foot raise is $115.3 million, or $165.2 million, including the temporary bridge.

Since the 6 STG Element of the Selected Plan would provide passage of the Probable Maximum Flood (PMF), the DR Element would not include dam safety functions or benefits attributable to the Reclamation Safety of Dams Program. All costs associated with the 3.5-foot dam raise and emergency spillway gate replacement are assigned to flood damage reduction. Included in both the 7-foot and 3.5-foot dam raise plans is the cost of the temporary portion of the Folsom Dam Bridge that would be required to divert traffic that could not use Folsom Dam Road during construction. This cost is partially a cost-shared flood damage reduction cost and partially a cost that has been labeled dam safety in the Corps *2006 Folsom Dam Raise, Folsom Bridge Post Authorization Decision Document* (PADD). Allocation assumptions for the temporary bridge will not be applied or otherwise transferred to the dam raise or other components of the DR Element of the Selected Plan.

As mentioned, the DR Element also includes Other Features: permanent increment of the Folsom Dam Bridge and ecosystem restoration. An *EIS/EIR* for that decision was also finalized in 2006 (Corps). Ecosystem restoration was last reported in the *2002 American River Watershed, California, Long-Term Study*. As described in **Chapter 4**, a 7-foot raise is not incrementally justified over the 3.5-foot raise. The 3.5-foot raise may be constructed under the Folsom Dam Raise authority because it is within the overall scope and is economically feasible.

7.3.2 DR Element Cost-Sharing

Table 7-5 shows cost apportionment for the DR Element of the Selected Plan. The temporary bridge is included in the calculation. The temporary bridge cost is considered a sunk cost because of existing commitments and contracts to construct the bridge that are independent of this evaluation. Including the temporary bridge, the DR Element cost is $165.2 million. Of this, $115.2 million is a Federal cost and $50.0 million is a non-Federal cost.

Lands costs for the DR Element, estimated at about $200,000, are for environmental mitigation. Land costs for fish and wildlife mitigation are identified as construction costs under Corps guidance (*CEWW-P, Cost Sharing Lands Associated with Fish and Wildlife Mitigation*, 19 September 2006), which states "ERRs are cost shared as construction elements."

TABLE 7-5
COST APPORTIONMENT OF DR ELEMENT FLOOD DAMAGE REDUCTION ($MILLIONS)[1]

MCACES Account	Item	DR Element		
		Federal	Non-Federal	Total [3]
	First Costs			
1	Lands	0.2	0.0	0.2
2	Relocations	0.0	0.0	0.0
08, 11	Construction	73.6	0.0	73.6
6	Environmental Mitigation			
	EM Lands	0.6	0.0	0.6
	Site Improvements	2.4	0.0	2.4
18	Cultural Resources[2]	0.8	0.0	0.8
30, 31	EDS&A	37.7	0.0	37.7
	Subtotal	**115.3**	**0.0**	**115.3**
	Less Cultural Resources	(0.8)	0.0	(0.8)
	Subtotal	**114.5**	**0.0**	**114.5**
	5 Percent Cash	(5.7)	5.7	0.0
	Subtotal	**108.8**	**5.7**	**114.5**
	Cash Adjustment	(34.4)	34.4	0.0
	Subtotal	**74.4**	**40.1**	**114.5**
	Percent	65	35	100
	Add Cultural Resources	0.8	0.0	0.8
	Subtotal	**75.2**	**40.1**	**115.3**
	Temporary Bridge	40.0	9.9	49.9[4]
	Total - DR Element	**115.2**	**50.0**	**165.2**

Key:
DR = dam raise
EDS&A = engineering, design, supervision, and administration
EM = Environmental Mitigation
MCACES = microcomputer-aided cost engineering system

Notes:
1. *First costs at October 2006 price levels.*
2. *Cultural resources recovery cost.*
3. *Includes sunk cost.*
4. *Includes a Corps-budgeted dam safety cost that is subject to Reclamation determination of which part, if any, may be subject to reimbursement by the Central Valley Project.*

7.3.2.1 Operations, Maintenance, Repair, Replacement, and Rehabilitation Cost

As mentioned, the non-Federal sponsor is responsible for all additional OMRR&R incurred from the 3.5-foot raise and replacement of the three emergency spillway tainter gates. The additional OMRR&R includes periodic clearing of vegetation in proximity to walls, inspection of walls, and periodic coating of walls with protective sealant or paint. Since the three emergency spillway gates replace existing, older gates, no maintenance cost is associated with the gates. The new gates may reduce existing maintenance costs of the old gates. The annual OMRR&R cost is estimated at $120,000. Special OMRR&R considerations at the Folsom Dam Industrial Complex are discussed above in **Section 7.2.1.1**.

7.3.3 Folsom Dam Raise Project Other Features

The authorized Folsom Dam Raise Project included several Other Features requiring separate consideration in relation to the RAP, as summarized below.

7.3.3.1 Folsom Bridge

Folsom Bridge, although part of the Folsom Dam Raise Project, is a distinct Other Feature being funded and constructed separately. Bridge description, costs, and costs distribution are fully presented in the Corps *Folsom Dam Raise, Folsom Bridge PADD*, dated September 2006. The total cost of a new, permanent Folsom Bridge is $115.6 million. The numbers presented herein are first costs at October 2006 price levels. The numbers have been updated since the Corps *2006 Folsom Dam Raise, Folsom Bridge PADD*; those numbers are reported at October 2005 price levels. Of this cost, $49.9 million corresponds to the cost funding for the temporary bridge and the remaining $65.7 million balance is for the permanent increment. The temporary bridge cost represents the cost to divert traffic during construction that otherwise might use Folsom Dam Road to cross the dam. The permanent increment is the cost to make the bridge permanent; the permanent bridge has a traffic purpose, and is treated as a betterment. The temporary bridge and its cost are included in the DR Element of the RAP. The permanent bridge increment is a local betterment and is not cost-shared. The City of Folsom is responsible for the permanent bridge cost; however, a Federal contribution is authorized. This contribution is $41.6 million.

Cost funding for the temporary bridge was distributed between flood damage reduction and dam safety based on the raise's contribution to passing the PMF, in accordance with the Corps *2002 Long-Term Study*. The funding split is 57 percent flood damage reduction and 43 percent dam safety. The Corps would fund that portion of the project assigned to dam safety through Federal appropriations. Reclamation would determine which of these costs, if any, may be subject to reimbursement by Central Valley Project water or power contractors. Such determination would be made in accordance with Reclamation law, policies, standards, directives, and contract obligations. Allocation assumptions for the temporary bridge will not be applied or otherwise transferred to the dam raise or other components of the DR Element of the Selected Plan.

The Folsom Bridge PCA is completed and signed. It establishes the flood damage reduction/dam safety cost split of 57/43 percent. This report does not affect the bridge financing, or other aspects of the bridge. As mentioned, the full cost of the bridge is added to the DR Element to determine the total project cost. The project cost subject to the Section 902 limit, however, excludes the permanent portion of Folsom Dam Bridge. The Folsom Dam Raise Project authorizing language did not specify the cost of the permanent bridge increment.

7.3.3.2 Ecosystem Restoration

The ecosystem restoration portion of the Folsom Dam Raise Project authorization includes riparian and other wetlands restoration of the Bushy Lake and Woodlake sites, and automated temperature control shutters at Folsom Dam. These features have not been revised since the *2002 Long-Term Study* (Corps, the Reclamation Board, and SAFCA). The cost

estimates for all three features have been revised to 2006 price levels. The cost estimate for the temperature control shutters has been further revised to include costs for items that were left out of the previous estimate. The ecosystem cost in the Corps *2002 Chief of Engineers Report* is $27 million. The change to current price levels and revisions to the cost estimate result in a total ecosystem restoration cost of $59.8 million. The non-Federal sponsor for ecosystem restoration is SAFCA. The sponsor continues to support ecosystem restoration. Design efforts are continuing. A construction schedule has not been revised to date.

7.3.3.3 L.L. Anderson Dam

As described in **Chapter 3**, improvements to L.L. Anderson Dam for passage of the PMF are to be completed by Placer County Water Agency. Improvements are a without-project feature.

7.3.4 Section 902 Limit of Folsom Dam Raise Project

This section compares the Section 902 maximum project cost limit with the total Folsom Dam Raise Project fully funded cost. **Table 7-6** lists the items of the Folsom Dam Raise Project that have fully funded costs, the sum of which is to be compared to the Section 902 limit. Not included in the sum is the permanent bridge cost (the increment over the temporary bridge), which has no cost specified in the authorization language. The fully funded cost of the project (minus permanent bridge) is $261.6 million. The Section 902 maximum cost limit calculation is shown in **Table 7-7**. The Section 902 limit is $405.3 million. Therefore, since the project fully funded cost is less than the Section 902 limit, the DR Element would not require a project reauthorization.

TABLE 7-6
FOLSOM DAM RAISE PROJECT FULLY FUNDED COSTS ($ MILLIONS)

Facility	Fully Funded Cost	Comments
Raise of Folsom Dam and Dikes	133.8	Includes replacement of three emergency spillway gates, L.L. Anderson sunk PED costs
Ecosystem Restoration	77.1	Bushy Lake, Woodlake, automated temperature shutters
Temporary Folsom Bridge	50.7	Permanent bridge has no authorized cost and is not included in Section 902 calculations
Total	**261.6**	
Key: PED = preconstruction, engineering, and design		

TABLE 7-7
SECTION 902 COST LIMIT FOR FOLSOM DAM RAISE PROJECT ($ MILLIONS)

	Computation Process	Cost
1.	Authorized amount inflated through construction (fully funded)	
	a. Project cost estimate at current price levels	225.0
	b. Line a, inflated through construction	261.6
	c. Ratio: Line b / Line a	1.1625
	d. Authorized cost, at current price level	304.4
	e. Authorized cost, inflated through construction (Line c x Line d)	353.8
2.	Cost of modifications required by law	0
3.	20 percent of project cost in authorization (.20 x $248.6)	51.5
4.	Maximum cost limited by Section 902 (sum of Lines 1e + 2 + 3)	405.3

7.3.5 Report and Project Approvals

See **Section 7.2.3** for discussion on report and project approvals.

7.3.6 Local Support

See **Section 7.2.4** for discussion on local support.

7.3.7 Sponsor Financial Analysis and Ability to Pay

See **Section 7.2.5** for statement about ability to pay.

7.3.8 Folsom Dam Raise Project Cooperation Agreement

The existing, signed PCA for the bridge is based on the Corps September *2006 Folsom Dam Raise, Folsom Bridge PADD*. The City of Folsom is the non-Federal signatory. The State of California and SAFCA, as flood damage reduction sponsors, will contribute funds for the temporary bridge through the City of Folsom. The PCA was signed in November 2006.

No PCA exists for the Folsom Dam Raise Project. The non-Federal signatory would be the State of California, with SAFCA as a contributing sponsor.

Another potential PCA might be executed for ecosystem restoration work features. The non-Federal sponsor for ecosystem restoration would be SAFCA. A PCA may be executed independent of this *PAC Report* because the features have been previously authorized and have not changed other than a change to costs.

7.3.9 Folsom Dam Raise Project Schedule

As discussed previously, a number of approvals/reviews are required to implement the Selected Plan portion of the RAP. In addition, reauthorization of the Folsom Modification Project would be required. Construction of the DR Element would be phased to begin well after

the beginning of construction of the 6 STG Element. **Table 7-4** shows the construction schedule for the Folsom Dam Raise Project features and the rest of the RAP.

7.4 SUMMARY OF SELECTED PLAN AND OTHER FEATURES

Table 7-8 summarizes cost-sharing of all the features of the Selected Plan and related Other Features of the current Folsom Dam Raise Project. The DR Element corresponds to the Folsom Dam Raise Project. These Other Features would add $125.5 million to the total cost of the Selected Plan. The cost-sharing and authority structure of the Selected Plan elements and Other Features are diagrammed in **Figure 7-1**.

TABLE 7-8
SUMMARY OF COSTS FOR SELECTED PLAN, DAM RAISE PROJECT, AND OTHER FEATURES ($ MILLIONS)[1]

Program/Authority	Federal	Non-Federal	Total	Reclamation Safety of Dams	Total
6 STG Element					
Flood Damage Reduction	444.0	239.0	683.0	0.0	683.0
Safety of Dams	0.0	0.0	0.0	[4]	0.0
Subtotal	444.0	239.0	683.0	[4]	683.0
DR Element and Other Features					
Flood Damage Reduction					
3.5-foot Raise, 3 Emergency Gates	75.2	40.1	115.3	0.0	115.3
Temporary Bridge	40.0[6]	9.9	49.9	0.0	49.9
Subtotal Flood Damage Reduction	115.2	50.0	165.2	0.0	165.2
Other Features					
Ecosystem Restoration	38.9	20.9	59.8	0.0	59.8
Permanent Bridge Increment[5]	41.6[5]	24.1[5]	65.7	0.0	65.7
Subtotal Other Features	80.5	45.0	125.5	0.0	125.5
Total DR Element + Other Features	195.7	95.0	290.7	0.0	290.7
Total Selected Plan[2]	**559.2**	**289.0**	**848.2**	[4]	**848.2**
Total Refined Authorized Projects[3]	**639.7**	**334.0**	**973.7**	[4]	**973.7**

Key:
DR = dam raise
STG = submerged tainter gate

Notes:
1. *First costs at October 2006 price levels.*
2. *Without Other Features.*
3. *With Other Features.*
4. *See information being developed by Reclamation for cost of the Reclamation (Dam Safety) Work Package.*
5. *Folsom Dam Bridge non-Federal Sponsor is City of Folsom. Permanent bridge is a local betterment, and therefore is not cost-shared. However, there is a Federal contribution of $41.6 million towards the permanent bridge.*
6. *Includes $21.5 million that is subject to Reclamation determination of which part, if any, may be subject to reimbursement by Central Valley Project.*

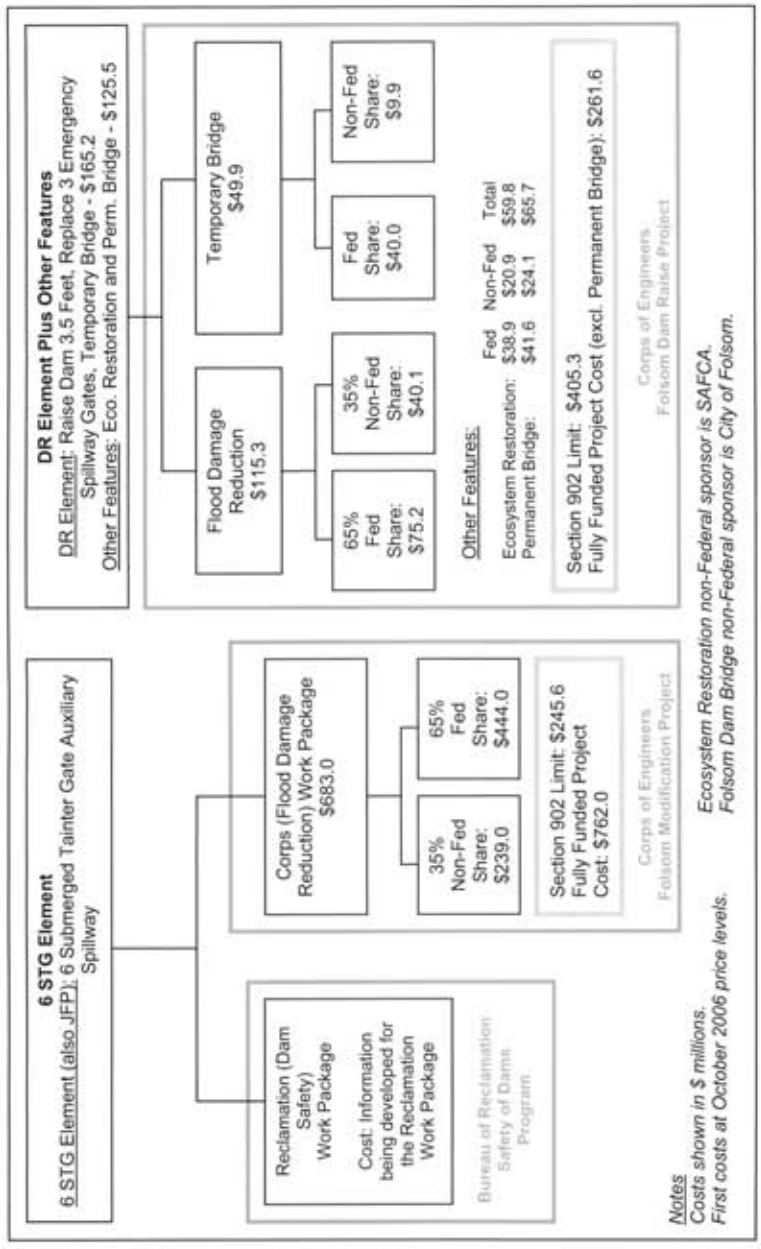


FIGURE 7-1
SUMMARY OF COSTS FOR THE REFINED AUTHORIZED PROJECTS ACCORDING TO ELEMENT

7.5 ECONOMIC REEVALUATION

Projects related to the American River Watershed Project are undergoing a comprehensive economic reanalysis (see **Appendix E – Economics**) by the Corps. This Economic Reevaluation Study is revisiting economic without-project damages and benefits that would accrue from construction of the Selected Plan. This reevaluation is necessary to demonstrate continued Federal interest in the projects so that they may be implemented.

Although the current analysis included in this *PAC Report* is more than adequate for supporting conclusions in **Chapter 8**, a new analysis is needed to confirm Federal interest before funds are budgeted and obligated for construction. The reevaluation is needed because much of the current data is out of date: some Corps standards have changed, and data may no longer meet these standards. The analysis would also provide more definitive determination of project downstream impacts to the Sacramento River and Yolo Bypass.

The analysis will include revisions to without-project hydrology, geotechnical levee analysis, floodplain delineation, damageable property inventory, and potential economic damages. The economic analysis will include accounting for emergency evacuation and other flood-related costs. Benefits in three of the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*, or P&G (WRC, 1983), system of accounts would be developed. The account categories included are national economic development (NED), other social effects (OSE), and regional economic development (RED). The environmental quality (EQ) account will not be included in the reevaluation. The analysis will include an assessment of conditions with the Common Features Project in place (the without-project condition of this current *PAC Report* evaluation), with-project conditions of the 6 STG Element, and the 6 STG Element plus 3.5-foot Folsom Dam raise.

The reevaluation project management plan and schedule have not yet been approved, but the current schedule is to complete the reevaluation by June 2007. Hydrologic analysis is underway and requires a limited amount of work.

CHAPTER 8.0
CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

Major conclusions of this *Post Authorization Change* (PAC) *Report* are as follows:

- The Folsom Modification Project, as originally formulated (10 main dam river outlets), is much more costly than last reported in the *2003 American River Watershed, California, Folsom Dam Modification Project, Final Limited Reevaluation Report and Environmental Assessment/Initial Study (*2003 LRR*)*. Although an effective plan, it is not efficient compared to other engineering solutions, and has high construction risk. The Folsom Modification Project cost exceeds the authorized project cost (as defined by Section 902, Water Resources Development Act (WRDA) of 1986).
- Design studies have found that the Folsom Dam Raise Project (7-foot raise with a 482-foot elevation top of flood pool) is more costly than reported in the Corps *2002 American River Watershed, California, Long-Term Study, Final Supplemental Plan Formulation Report/Environmental Impact Statement/Environmental Impact Report* (2002 Long-Term Study EIS/EIR), and, with the proposed design refinement to the Folsom Modification Project, is not as efficient compared to the other dam raise configurations studied.
- With or without flood damage reduction measures at Folsom Dam, the United States Department of the Interior, Bureau of Reclamation (Reclamation), intends to implement a project to lower structural (seismic and static) and hydrologic (passing the Probable Maximum Flood (PMF)) dam safety risk at Folsom Dam under its Safety of Dams Program. According to Reclamation studies and policy, an emergency fuseplug spillway would pass the PMF.
- The Refined Authorized Projects (RAP) in this *PAC Report* include a Selected Plan consisting of two major elements and two Other Features. The two major elements consist of (1) an auxiliary spillway with six submerged tainter gates (referred to as the 6 STG Element, also known as the Joint Federal Project (JFP)) and (2) raising Folsom Dam 3.5 feet with replacement of the dam's three emergency spillway tainter gates, referred to as the Dam Raise Element (DR Element). Also, two authorized Other Features are companion to the DR Element: a permanent bridge increment and the ecosystem restoration component of the Folsom Dam Raise Project. The RAP consists of the separate Folsom Modification Project and Folsom Dam Raise Project and should be implemented in the order that those projects were originally authorized: essentially the Folsom Modification Project first, then the Folsom Dam Raise Project.
- The 6 STG Element of the RAP would provide flood damage reduction performance similar to the authorized Folsom Modification Project, and would also pass the PMF. The 6 STG Element can be divided into two major components: a Corps Work Package and Reclamation Work Package. The work packages reflect the approximate cost associated with flood damage reduction and dam safety. Work packages are to be budgeted and implemented separately by each respective agency. The first cost of the

Corps Work Package is estimated at $683.0 million. The estimated annual economic cost attributable to flood damage reduction for the Corps Work Package is $37.9 million. The average annual equivalent benefits are $89.9 million. The benefit-to-cost ratio is 2.4. Costs for dam safety are not included in economic costs for flood damage reduction.

- The DR Element, when added to the 6 STG Element, would provide levels of flood risk reduction similar to the combined function of the two authorized projects. The total estimated first cost of the DR Element, including Other Features, is $290.7 million. This includes $165.2 million for flood damage reduction facilities (dam raise, emergency gate replacement, and temporary bridge increment) and $125.5 million for Other Features. Other Features include $65.7 million for a permanent bridge increment and $59.8 million for ecosystem restoration. The estimated average annual economic cost of the DR Element attributable to flood damage reduction is $5.6 million. The incremental increased average annual equivalent benefits and benefit-to-cost ratio are $17.2 million and 3.1, respectively.
- The total first cost of the Selected Plan is $848.2 million. The total first cost of the RAP (including the Selected Plan and Other Features) is $973.7 million. The total annual cost attributable to flood damage reduction is $43.5 million. The average annual equivalent benefits are $107.1 million. The benefit-to-cost ratio is 2.5. The non-Federal share of the total first cost is $334.0 million. The Selected Plan portion of the RAP would result in a reduction of the flood risk in Sacramento from a 1 in 81 chance in any year, to a 1 in 185 chance in any year.
- The 6 STG Element of the Selected Plan is functionally equivalent to the Folsom Modification Project with an annual exceedence probability (AEP) of 1 in 156 and may be built in lieu of the original 10-main-dam-river-outlet plan. The 3.5-foot dam raise and replacement of the three emergency spillway tainter gates is also functionally equivalent to the flood damage reduction purpose of the authorized Folsom Dam Raise Project and has an AEP of 1 in 185. The AEP of the RAP is 1 in 185.
- The Selected Plan has a favorable benefit-to-cost ratio and is functionally equivalent to the originally authorized projects for flood damage reduction and passing the PMF. As described in previous studies, there is a clear Federal interest in the Other Features. Therefore, there remains a Federal interest in implementing the RAP.
- The 6 STG Element cost exceeds the authorized cost of the Folsom Modification Project. On approval of this *PAC Report*, the Corps would request a cost increase reauthorization by Congress for the Folsom Modification Project to implement the project.
- The RAP will be able to pass 100 percent of the PMF. Reclamation will address seismic and static dam risks at Folsom Dam.
- The Folsom Modification Project, as originally authorized, was an assumed without-project condition and a basis for the Folsom Dam Raise Project original authorization. Both of these projects experienced increases in costs during the design phase, calling into question the previous determination that the authorized 7-foot dam raise height was still viable. The 6 STG Element that is part of the refined Folsom Modification Project accomplishes flood damage reduction and the dam safety function that had originally been authorized as part of the Folsom Dam Raise Project, effectively moving that

function from one project to the other. Due to these refinements, the most viable dam raise heights (3.5 and 7 feet) originally investigated in the *2002 Long-Term Study EIS/EIR*, were considered in this *PAC Report* via alternatives C and D. The 3.5-foot raise was determined to be the dam raise height that maximized net benefits and provided flood damage reduction performance similar to the authorized 7-foot raise, and is included in the RAP. The 3-5 foot dam raise in this PAC Report is similar to the 3.5-foot dam raise that was evaluated in the Corps *2002 Long-Term Study EIS/EIR*. Environmental impacts associated with the current 3.5-foot dam raise are considered similar to those described in the *2002 Long-Term Study EIS/EIR*.

- The Energy and Water Development Appropriations Act of 2006 authorized reasonable modifications to the existing authorized activities, including an auxiliary spillway. Accordingly, no additional congressional authorization is necessary to implement the scope of the Corps portion of the RAP.
- The estimated flood damage reduction share of the 6 STG Element of $762.0 million (fully funded) is greater than the authorized project cost of $245.6 million, as provided by Section 902 of WRDA 1986. Therefore, reauthorization would be required to increase the authorized project cost. For the Folsom Dam Raise Project, the fully funded cost of $261.6 million is less than the maximum authorized project cost of $405.3 million. Therefore, the 3.5-foot raise, with replacement of the three emergency spillway tainter gates, needs no reauthorization.
- It is intended that the Folsom Dam Raise authorization remain active to support efforts to reduce the level of flood risk to Sacramento, to support implementation of ecosystem restoration contained in the authorized project, and to complete construction of Folsom Dam Bridge.
- The authorized maximum flood pool elevation of the Folsom Dam Project is elevation 466 feet. Traditionally, it has been the practice to use some of the storage space above elevation 466 for purposes of reducing the flood risk to Sacramento by limiting the outflow from Folsom to 160,000 cubic feet per second (cfs) or less when the pool elevation exceeded elevation 466. This practice was formally described and included in both the Folsom Modification Project and the Folsom Dam Raise Project. Both components of the Selected Plan will continue to rely on using storage above the authorized flood pool elevation of 466 for the purpose of reducing the flood risk to Sacramento and obtaining the performance described in this report.
- An authorized project element to modify the L.L. Anderson Dam spillway for dam safety is being addressed by Placer County Water Agency (PCWA) and is no longer necessary as part of the flood damage reduction and dam safety work by the Corps and Reclamation. In accordance with ER 1105-2-100, Appendix G, section 3,B,3, this feature should be deferred from the authorized Folsom Dam Raise Project.
- The Folsom Dam Raise Project, as authorized in the Energy and Water Appropriations Act for 2004, included development of an updated flood management plan. Opportunities to improve reservoir operations for flood damage reduction via forecast-based operations warrants further study by the Corps.

- The Corps should develop, as part of its Folsom Dam Reoperation Study, an updated Water Control Manual for Folsom Dam. The reoperation study should be completed in time for its application to the completed six submerged tainter gate auxiliary spillway.

- The local sponsors, the State of California and Sacramento Area Flood Control Agency (SAFCA), continue to support the RAP and are capable of carrying out their respective financial and institutional responsibilities. The City of Folsom is the local sponsor for the permanent bridge.

- Reclamation prepared the *2007 Final Folsom Dam Safety and Flood Damage Reduction Environmental Impact Statement/Environmental Impact Report* (2007 EIS/EIR), with cooperation from the Corps. The *2007 EIS/EIR* analyzed alternatives that address Reclamation dam safety objectives and the Corps' flood damage reduction objectives, as described in this *PAC Report*. The Corps intends to adopt Reclamation's *2007 EIS/EIR* to satisfy environmental compliance laws and regulations for the 6 STG and DR elements of the RAP. The nature of impacts associated with raising Folsom Dam facilities 3.5 feet are also evaluated in the Corps *2002 Long-Term Study EIS/EIR*.

- There has been no fundamental change in the types of impacts and required mitigation between the authorized projects and the RAP. Potentially significant adverse effects have been identified for geology and soils, traffic, water quality, fisheries, cultural resources, recreation and noise. Implementation of proposed mitigation measures, as described in the *2007 EIS/EIR*, would reduce these impacts to less than significant levels. An environmental commitment of mitigation, to be implemented prior to, or concurrent with, construction activities would be required to reduce potentially significant impacts for vegetation and wildlife, and special-status species.

- As determined in its work package, Reclamation would be responsible for environmental mitigation for impacts associated with the 6 STG Element. There is no environmental mitigation in the Corps Work Package. The non-Federal sponsors for flood damage reduction will not be responsible for lands, easements, rights-of-way, relocations, or disposal areas (LERRD) for Reclamation's Work Package; despite this, the non-Federal sponsor would share in the same cost amount as if the work packages had been adjusted to move LERRDs into the Corps Work Package. The non-Federal sponsor would be responsible for operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) associated with the 6 STG Element mitigation; this may require a subsequent agreement between the non-Federal partner(s) and Reclamation. The Corps, with the non-Federal partners, would be responsible for environmental mitigation associated with the DR Element.

- The RAP is consistent with, and able to contribute to, the Corps' 12 Actions for Change.

- The RAP would significantly contribute to reduction of the risk of flooding to the Sacramento area. Following implementation of the project, the estimated average annual flood damages would be reduced by 54 percent to $198 million. Additional studies should be conducted to investigate ways to further reduce the risk of flooding to the area.

8.2 FEDERAL AND NON-FEDERAL RESPONSIBILITIES

To implement the Selected Plan, Federal and non-Federal obligations and requirements would be contained in Project Cooperation Agreements (PCA), one each for the Folsom Modification Project and Folsom Dam Raise Project.

8.2.1 Federal Responsibilities

The Corps and Reclamation would perform preconstruction engineering and design studies. Once the PCAs are signed and the non-Federal sponsors have provided cash contributions, LERRDs, and assurances, the Federal Government would construct the project.

The Corps and Reclamation would perform inspections of the project periodically to assess the adequacy of OMRR&R of the completed works.

8.2.2 Non-Federal Responsibilities

The non-Federal sponsor shall, prior to implementation, agree to perform items of local cooperation. Items of local cooperation are specific to the authorized purposes of the projects. The Folsom Modification Project is a flood damage reduction project. The Folsom Dam Raise Project is both a flood damage reduction and ecosystem restoration project. As such, distinct items of local cooperation apply to each of the two authorized projects.

It should be noted that American River Project was initiated prior to the Corps requirement for separate agreements for the design phase. However, a current PCA exists for the Folsom Modification Project; therefore, design phase activities have been cost-shared to date. After the recommendations of this *PAC Report* are approved, pending funding, the Corps, the State of California, and possibly SAFCA will enter into a new or updated PCA to share in the cost of construction. For the Folsom Dam Raise Project, after the recommendations of the *PAC Report* are approved, pending funding, design would proceed with Federal expense upfront. The Corps, the State of California, and possibly SAFCA, will enter into a PCA to share in the cost of construction, at which time the non-Federal share of the design phase costs would be recouped.

It is also important to note that items of local cooperation that address non-Federal responsibilities for OMRR&R will be revised. When a Corps project is completed, it is turned over to the non-Federal sponsor, which is then responsible for OMRR&R of the project. The Selected Plan, however, involves both improvements to existing facilities and implementation of new features on lands owned by the Federal Government and State of California. After construction, the auxiliary spillway would be physically operated and maintained by Reclamation as part of its Folsom Dam Industrial Complex. Thus, no transfer of ownership would occur as a result of implementation of the auxiliary spillway and dam raise. The non-Federal sponsor would be responsible for any increased maintenance costs of both the new and existing pertinent structures. As noted in the following items of local cooperation, items specific to OMRR&R will be revised as the specific methods of non-Federal responsibility for OMRR&R are determined.

8.2.2.1 Folsom Modification Project

Federal implementation of the 6 STG Element would be subject to the non-Federal sponsor agreeing to comply with applicable Federal laws and policies, including, but not limited to, the following:

a. Provide a minimum of 35 percent, but not to exceed 50 percent of total project costs as further specified below:

   i. Provide, during the first year of construction, any funds necessary to pay the full non-Federal share (35 percent) of design costs. It should be noted that the non-Federal sponsors, under an existing PCA for the Folsom Modification Project, are sharing in the cost of design phase;

   ii. Provide, during construction, a contribution of funds equal to 5 percent of total project costs;

   iii. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the project; and

   iv. Provide, during construction, any additional funds necessary to make its total contribution equal to at least 35 percent of total project costs.

b. Shall not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefore, to meet any of the non-Federal obligations for the project unless the Federal agency providing the Federal portion of such funds verifies in writing that expenditure of such funds for such purpose is authorized;

c. Not less than once each year, inform affected interests of the extent of protection afforded by the project;

d. Agree to participate in and comply with applicable Federal floodplain management and flood insurance programs;

e. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 United States Code (USC) 701b-12), which requires a non-Federal interest to prepare a floodplain management plan within 1 year after the date of signing a project cooperation agreement, and to implement such plan not later than 1 year after completion of construction of the project;

f. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking

other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the project;

g. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the level of protection the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function;

h. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law (PL) 91-646, as amended (42 USC 4601-4655), and the Uniform Regulations contained in 49 Code of Federal Regulations (CFR) Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

i. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government (because the 6 STG auxiliary spillway is intended to ultimately be physically operated and maintained by Reclamation as part of the Folsom Dam Industrial Complex, this item will be revised as the specific non-Federal method of accomplishing and paying for the OMRR&R responsibility is determined);

j. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, replacing, or rehabilitating the project;

k. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, replacement , and rehabilitation of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

l. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 CFR Section 33.20;

m. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, PL 88-352 (42 USC 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; 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 all applicable Federal labor standards requirements, including, but not limited to, 40 USC 3141- 3148 and 40 USC 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 USC 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 USC 327 et seq.) and the Copeland Anti-Kickback Act (formerly 40 USC 276c et seq.);

n. Perform, or ensure performance of, 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), PL 96-510, as amended (42 USC 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

o. Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project;

p. Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

q. Comply with Section 221 of PL 91-611, Flood Control Act of 1970, as amended (42 USC 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, PL 99-662, as amended (33 USC 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

8.2.2.2 Folsom Dam Raise Project

Federal implementation of features associated with the Folsom Dam Raise Project would be subject to the non-Federal sponsor agreeing to comply with applicable Federal laws and policies, including but not limited to the following:

a. Provide a minimum of 35 percent, but not to exceed 50 percent of total project costs as further specified below:

   i. Provide, during the first year of construction, any funds necessary to pay the full non-Federal share (35 percent) of design costs allocated by the Government to flood damage reduction;

   ii. Provide, during construction, a contribution of funds equal to 5 percent of total flood damage reduction costs;

   iii. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the flood damage reduction features; and

   iv. Provide, during construction, any additional funds necessary to make its total contribution for flood damage reduction equal to at least 35 percent of total flood damage reduction costs.

b. Provide 35 percent of total ecosystem restoration costs as further specified below:

   i. Provide, during the first year of construction, any funds necessary to pay the full non-Federal share of design costs (35 percent) allocated by the Government to ecosystem restoration;

   ii. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the ecosystem restoration features; and

   iii. Provide, during construction, any additional funds necessary to make its total contribution for ecosystem restoration equal to 35 percent of total ecosystem restoration costs.

c. Shall not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefore, to meet any of the non-Federal obligations for the project unless the Federal agency providing the Federal portion of such funds verifies in writing that expenditure of such funds for such purpose is authorized;

d. Not less than once each year, inform affected interests of the extent of protection afforded by the flood damage reduction features;

e. Agree to participate in and comply with applicable Federal floodplain management and flood insurance programs;

f. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 USC 701b-12), which requires a non-Federal interest to prepare a floodplain management plan within one year after the date of signing a project cooperation agreement, and to implement such plan not later than one year after completion of construction of the flood damage reduction features;

g. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the flood damage reduction features;

h. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the level of protection the flood damage reduction features afford, reduce the outputs produced by the ecosystem restoration features, hinder operation and maintenance of the project, or interfere with the project's proper function;

i. Shall not use the ecosystem restoration features or lands, easements, and rights-of-way required for such features as a wetlands bank or mitigation credit for any another project;

j. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, PL 91-646, as amended (42 USC 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

k. For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the project, or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible

with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government (because the DR Element is intended to ultimately be physically operated and maintained by Reclamation as part of the Folsom Dam Industrial Complex, this item will be revised as the specific non-Federal method of accomplishing and paying for the OMRR&R responsibility is determined);

l. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

m. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

n. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 CFR Section 33.20;

o. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, PL 88-352 (42 USC 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; 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 all applicable Federal labor standards requirements, including, but not limited to, 40 USC 3141- 3148 and 40 USC 3701 – 3708 (revising, codifying, and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 USC 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 USC 327 et seq.) and the Copeland Anti-Kickback Act (formerly 40 USC 276c et seq.);

p. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the CERCLA, PL 96-510, as amended (42 USC 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written

direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

q. Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project;

r. Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

s. Comply with Section 221 of PL 91-611, Flood Control Act of 1970, as amended (42 USC 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, PL 99-662, as amended (33 USC 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

8.3 RECOMMENDATIONS

Based on the findings presented in this report and supporting documents, I recommend approval of the Refined Authorized Projects as the plan that responds to the project authorizations in the Water Resources Development Act of 1999, and the Energy and Water Development Appropriations Acts for 2004 and 2006. This recommendation includes the following:

- **Folsom Modification Project.** In accordance with project authorizations in the Water Resources Development Act of 1999 and the Energy and Water Development Appropriations Act for 2006, approval of the Six Submerged Tainter Gate Element, and the concept of dividing the Six Submerged Tainter Gate Element into two work packages that will be constructed by the Corps and Reclamation separately; approval and forwarding to Congress the request for an increased new authorized cost for the Folsom Modification Project; and use of this document to support the Project Cooperation Agreement(s) to implement those project features identified to be implemented by the Corps subject to Congressional approval of a project cost increase for the Folsom Modification Project.

- **Folsom Dam Raise Project.** In accordance with project authorization in the Energy and Water Development Appropriations Acts for 2004 and 2006, approval of this document for use to support the Project Cooperation Agreement(s) to implement those project features identified to be implemented by the Corps; implement as planned the separable

ecosystem restoration project features; and continue implementation of the permanent Folsom Bridge Project.

I also recommend additional studies to investigate further reduction of the residual risk from flooding to the greater Sacramento metropolitan area, which may be undertaken as part of or coordinated with any future comprehensive investigation of the Sacramento River basin, or a portion thereof.

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 transmitted to the Assistant Secretary of the Army (Civil Works) as proposals for implementation funding and for an increase in the cost for the Folsom Modification Project. However, prior to transmittal, the sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Ronald N. Light
Colonel,
Corps of Engineers
District Commander

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CHAPTER 9.0
REFERENCES

National Weather Service. 1998. Hydrometeorological Report Number 58. Probable Maximum Precipitation for California, Calculation Procedures.

Sacramento Area Flood Control Agency (SAFCA). 1998. Folsom Dam Modification Report, New Outlets Plan. Prepared by Murray, Burns and Kienlen. Sacramento, California. March.

U.S. Army Corps of Engineers (Corps). 1991a. American River Watershed Investigation, California. Feasibility Report. In cooperation with The Reclamation Board and Sacramento Area Flood Control Agency. Sacramento District. Sacramento, California. December.

_____. 1991b. American River Watershed Investigation, California. Draft Environmental Impact Statement/Environmental Impact Report. In cooperation with The Reclamation Board and Sacramento Area Flood Control Agency. Sacramento District. Sacramento, California. December.

_____. 1992. Folsom Dam and Reservoir Reoperation, California. Operation Plan and Environmental Impact Statement. Draft Report. Sacramento, California.

_____. 1996. American River Watershed Project, California. Supplemental Information Report and Final Supplemental Environmental Impact Statement/Environmental Impact Report. In cooperation with The Reclamation Board and Sacramento Area Flood Control Agency. Sacramento District. Sacramento, California. March.

_____. 2001. American River Watershed Project, California. Folsom Modification Project Final Environmental Assessment/Initial Study. In cooperation with the U.S. Bureau of Reclamation. Sacramento, California. August.

_____. 2002a. American River Watershed Project, California. Supplemental Information Report and Final Supplemental Environmental Impact Statement/Environmental Impact Report, 2nd Addendum. In cooperation with The Reclamation Board and Sacramento Area Flood Control Agency. Sacramento District. Sacramento, California.

_____. 2002b. Chief of Engineers Report. American River Watershed, California. Long-Term Study. 5 November.

_____. 2002c. American River Watershed, California. Long-Term Study, Final Supplemental Plan Formulation Report/Environmental Impact Statement/Environmental Impact Report. In cooperation with the Sacramento Area Flood Control Agency and The Reclamation Board. February.

_____. 2003. American River Watershed, California. Folsom Dam Modification Project. Final Limited Reevaluation Report and Environmental Assessment/Initial Study. November.

_____. 2004. Draft Folsom Dam Bridge, Alignment Alternatives Study and Evaluation Report. Sacramento District. Sacramento, California. October.

_____. 2005a. Draft Environmental Site Assessment, Folsom Dam Modification. Sacramento County, California.

_____. 2005b. American River Watershed Project, California. Folsom Dam Modification Project Final Environmental Assessment/Initial Study. In cooperation with the U.S. Bureau of Reclamation. Sacramento, California. March.

_____. 2006a. American River Watershed Project. Draft Folsom Dam Raise, Folsom Bridge Post Authorization Decision Document. Sacramento District. Sacramento, California. May.

_____. 2006b. American River Watershed Project, California. Final Folsom Dam Raise, Folsom Bridge Post Authorization Decision Document and Environmental Impact Statement/Environmental Impact Report. Sacramento District. Sacramento, California. September.

_____. 2006c. American River Watershed Project, California. Draft Folsom Dam Raise, Folsom Bridge Environmental Impact Statement/Environmental Impact Report. Prepared for Corps and City of Folsom. Sacramento, California.

_____. 2006d. Draft American River Watershed Project, California. Post Authorization Change Report, Folsom Modification and Folsom Dam Raise Projects. Sacramento, California. December.

U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, The Reclamation Board, and Sacramento Area Flood Control Agency. 2005. Folsom Dam Flood and Hydrologic Risk Reduction. Project Alternative Solutions Study (PASS) Final Report. Sacramento, California. October.

U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, The Reclamation Board, and Sacramento Area Flood Control Agency. 2006a. Folsom Dam Raise and Auxiliary Spillway Alternative. Project Alternative Solutions Study II (PASS II) Final Report. Sacramento, California. June.

U.S. Department of the Interior, Bureau of Reclamation (Reclamation). 2000. Folsom Dam Bridge Appraisal Report. Mid-Pacific Region. Sacramento, California. March.

_____. 2004. Folsom Dam Road Access Restriction, Draft Environmental Impact Statement. Mid-Pacific Region. Sacramento, California. October.

_____. 2005. Folsom Dam – Safety of Dams Draft Corrective Action Study Scoping Report. Mid-Pacific Region. Sacramento, California. October.

_____. 2006a. Folsom Joint Federal Project Draft Environmental Impact Statement/Environmental Impact Report. Mid-Pacific Region. Sacramento, California. July.

_____. 2006b. Central Valley Project Overview. Available at http://www.usbr.gov/dataweb/html/cvp.html. Accessed August 24, 2006.

_____.2006c. Folsom Dam Safety and Flood Damage Reduction Draft Environmental Impact Statement/Environmental Impact Report. Mid-Pacific Region. In cooperation with United States Army Corps of Engineers, Sacramento District, California Department of Water Resources, The Reclamation Board, and Sacramento Area Flood Control Agency. Sacramento, California. December.

_____. 2007. Folsom Dam Safety and Flood Damage Reduction Final Environmental Impact Statement/Environmental Impact Report. Mid-Pacific Region. In cooperation with United States Army Corps of Engineers, Sacramento District, California Department of Water Resources, The Reclamation Board, and Sacramento Area Flood Control Agency. Sacramento, California. March.

U.S. Water Resources Council (WRC). 1983. Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. March 10.

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Post Authorization Change Report

American River Watershed Project

Folsom Dam Modification and
Folsom Dam Raise Projects

Plates

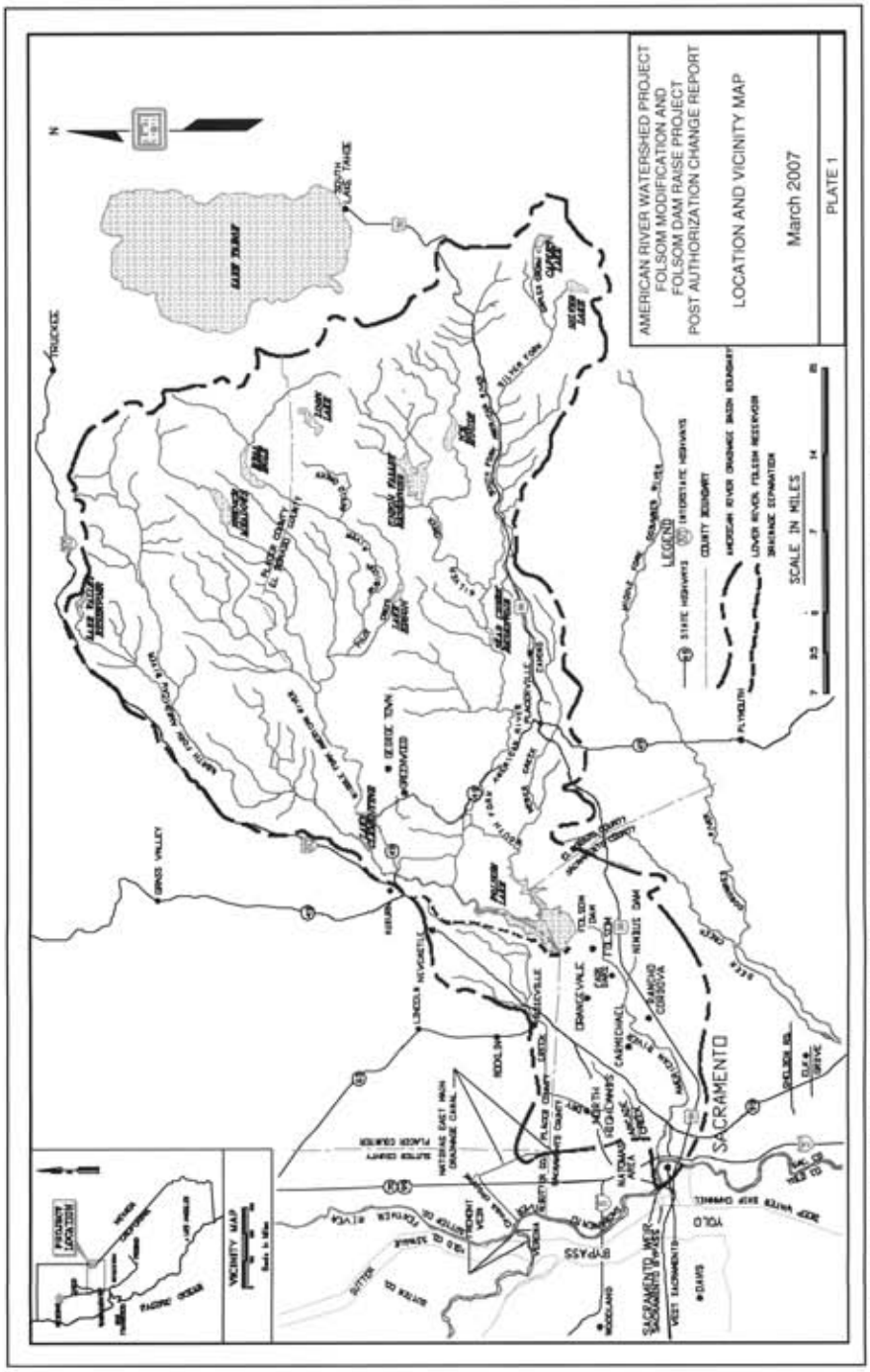
Note – Plates are from various associated documents. Titles and labels might not be consistent to this PAC or EDRs.

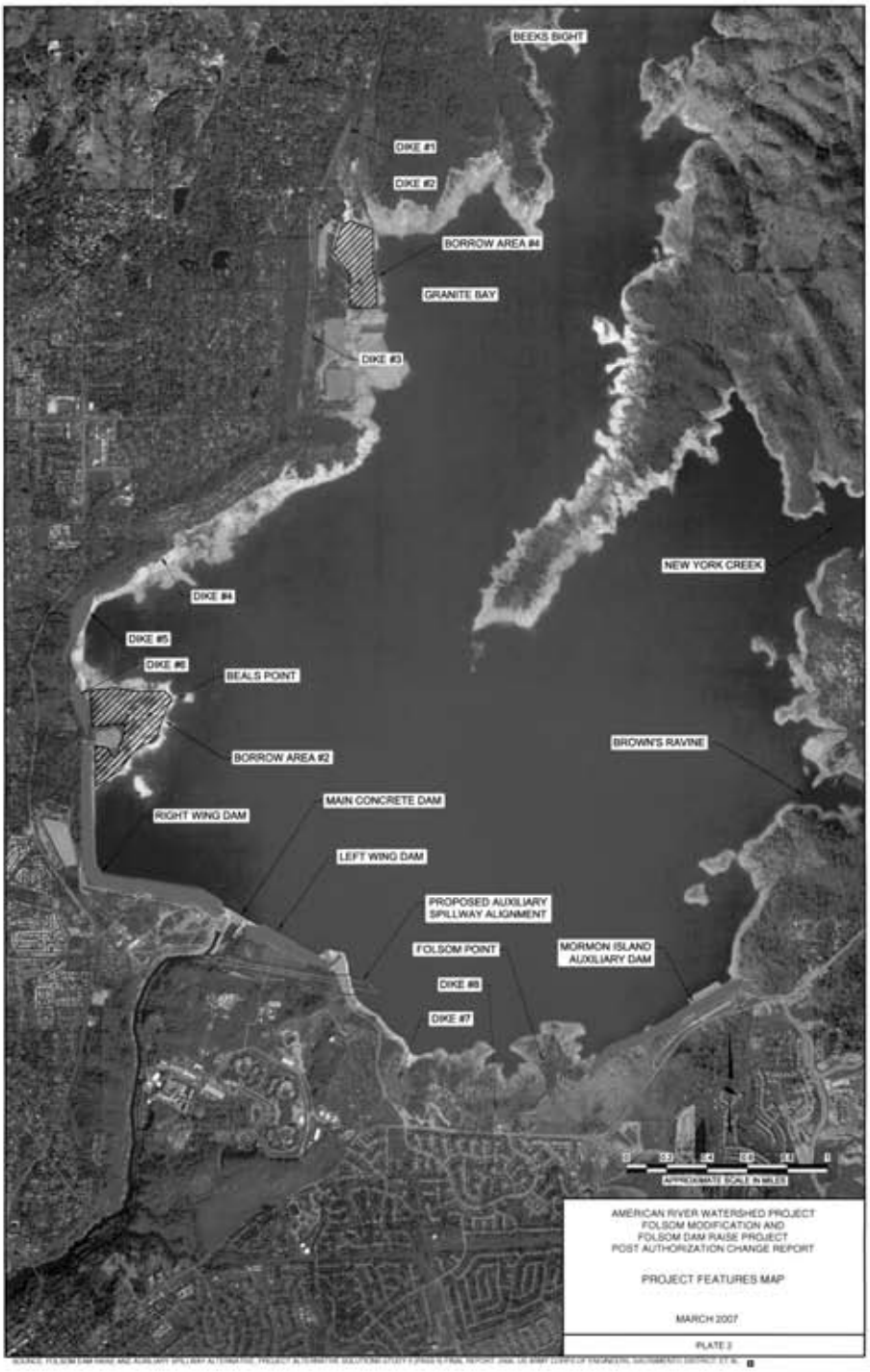


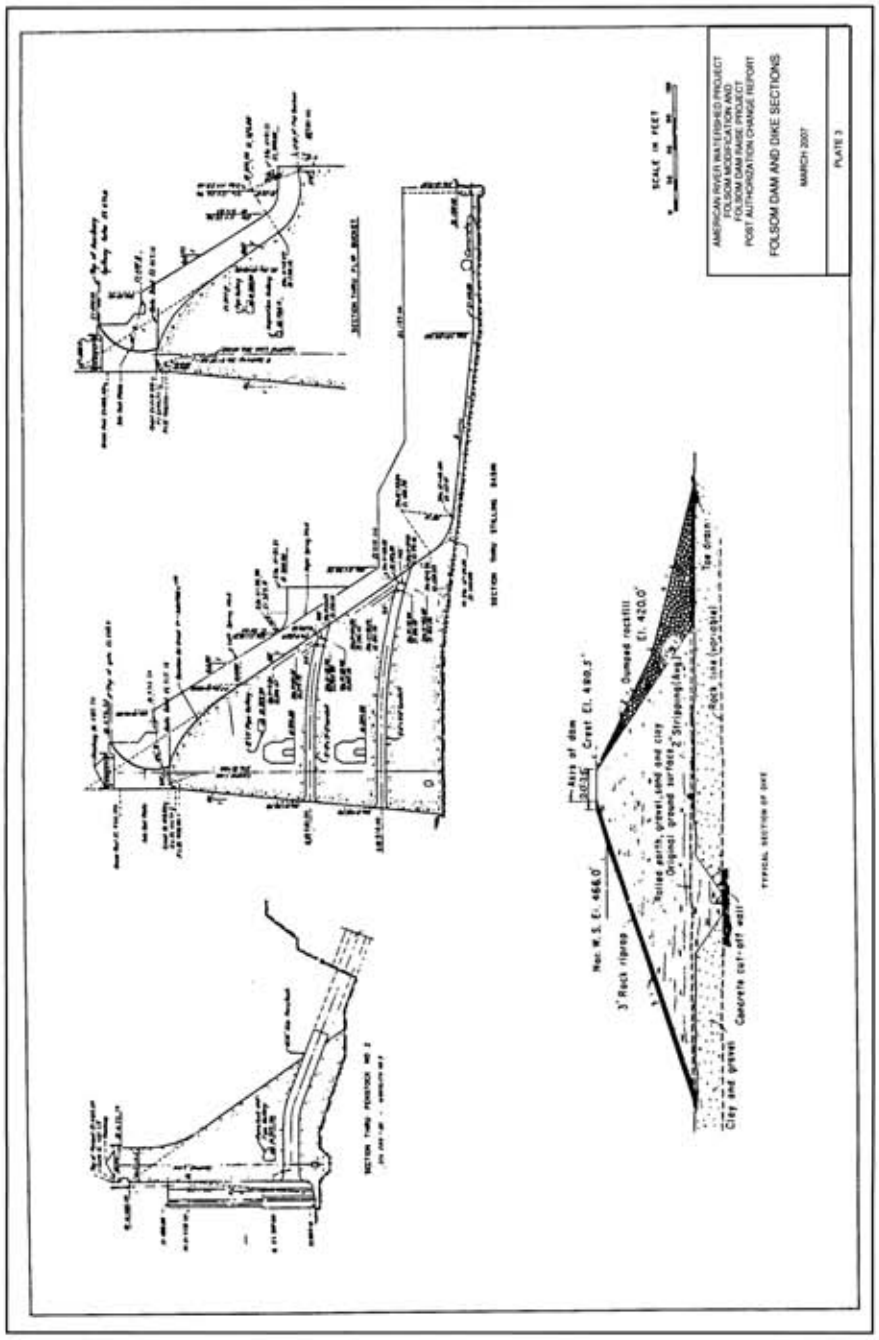
US Army Corps of Engineers

Sacramento District
South Pacific Region

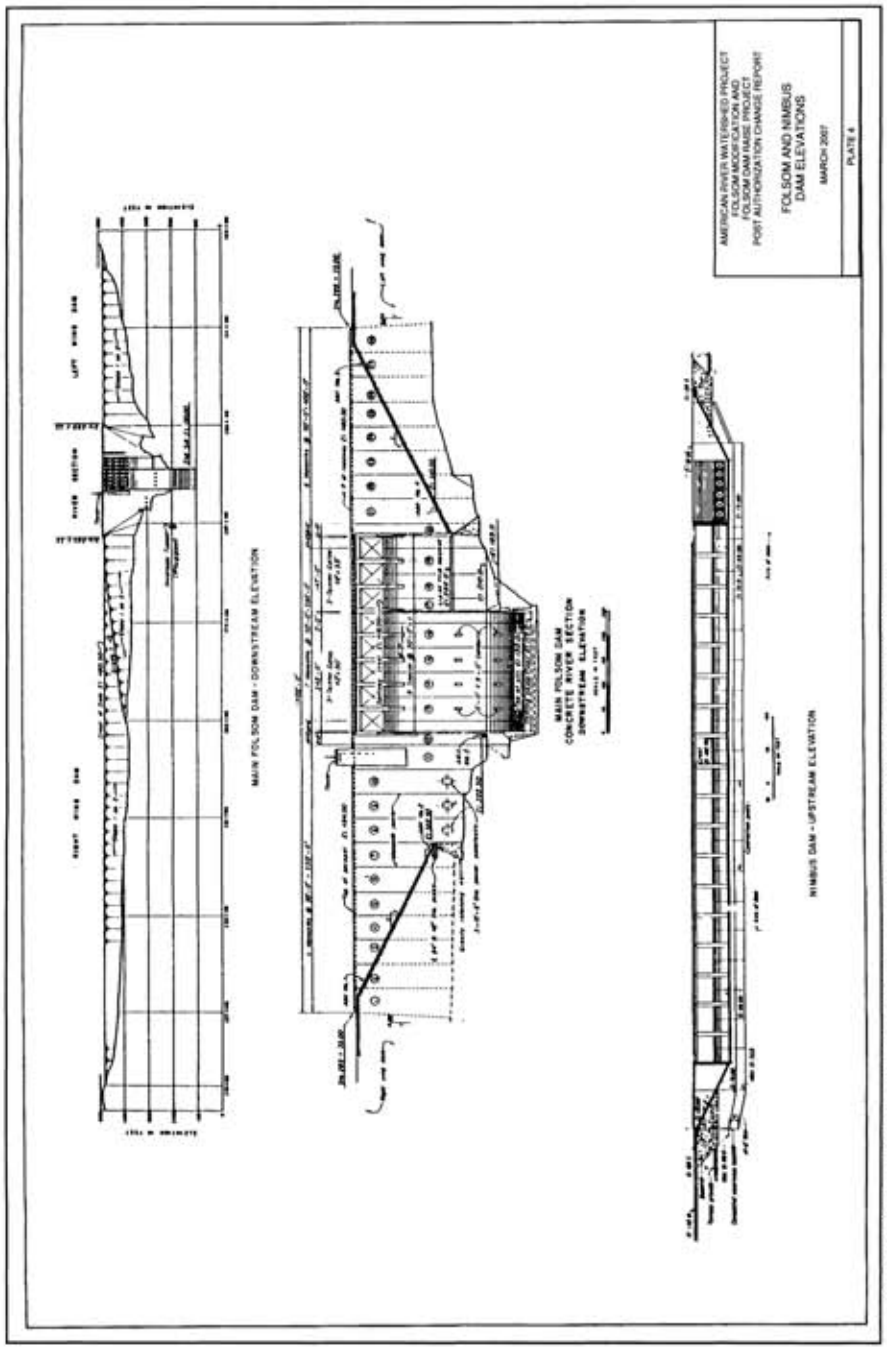
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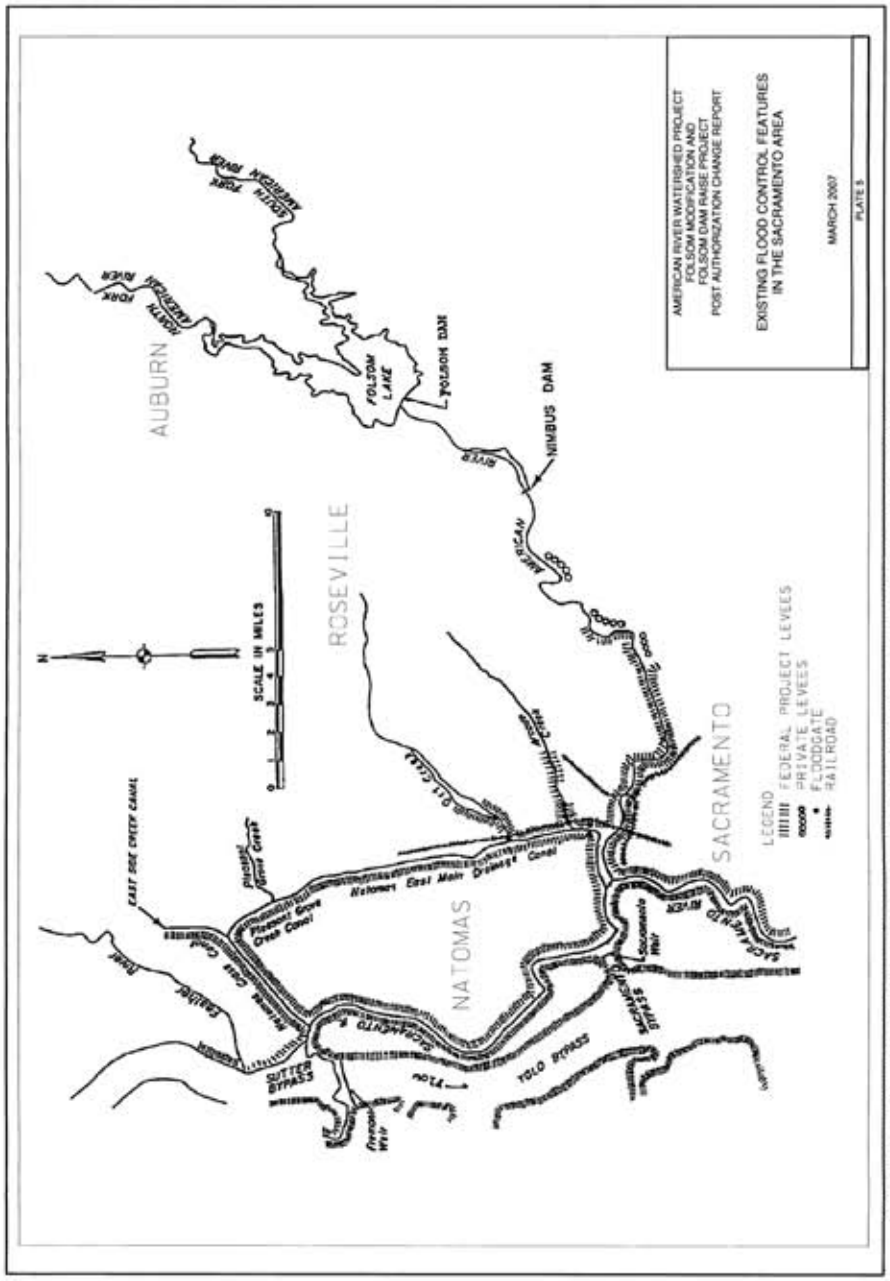

AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION AND
FOLSOM DAM RAISE PROJECT
POST AUTHORIZATION CHANGE REPORT
LOCATION AND VICINITY MAP
March 2007
PLATE 1
LEGEND
SCALE IN MILES
SACRAMENTO
FOLSOM DAM
FOLSOM LAKE
NEVADA CITY
GRASS VALLEY
AUBURN
ROSEVILLE
LINCOLN
DAVIS
WOODLAND
YOLO
PLACER COUNTY
NEVADA COUNTY
SUTTER CO.
YUBA CO.
YOLO CO.
SACRAMENTO CO.
EL DORADO CO.
PLACER CO.
PROJECT LOCATION
VICINITY MAP

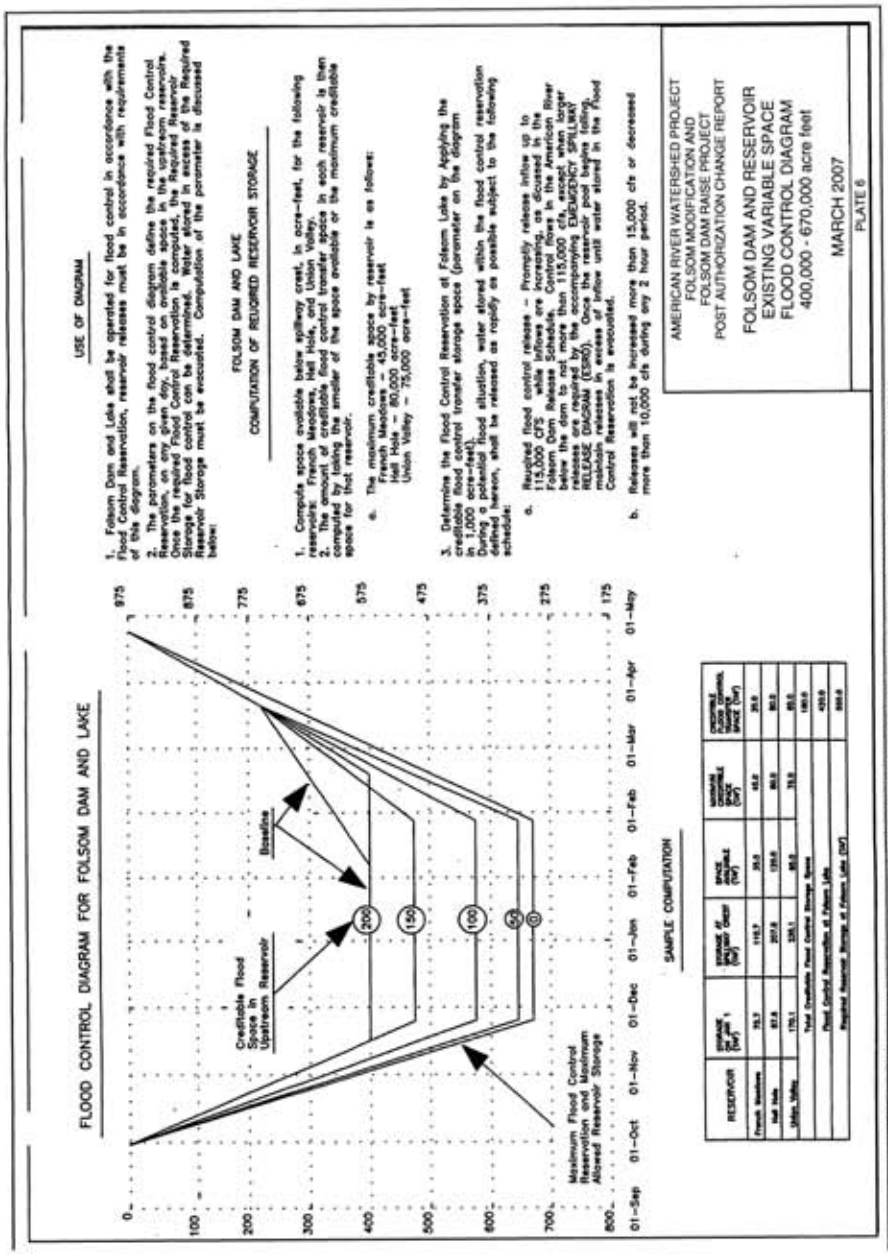

BEEKS BIGHT
DIKE #1
DIKE #2
BORROW AREA #4
GRANITE BAY
DIKE #3
NEW YORK CREEK
DIKE #4
DIKE #5
DIKE #6
BEALS POINT
BORROW AREA #2
BROWN'S RAVINE
MAIN CONCRETE DAM
RIGHT WING DAM
LEFT WING DAM
PROPOSED AUXILIARY SPILLWAY ALIGNMENT
FOLSOM POINT
MORMON ISLAND AUXILIARY DAM
DIKE #8
DIKE #7
APPROXIMATE SCALE IN MILES
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION AND
FOLSOM DAM RAISE PROJECT
POST AUTHORIZATION CHANGE REPORT
PROJECT FEATURES MAP
MARCH 2007
PLATE 3

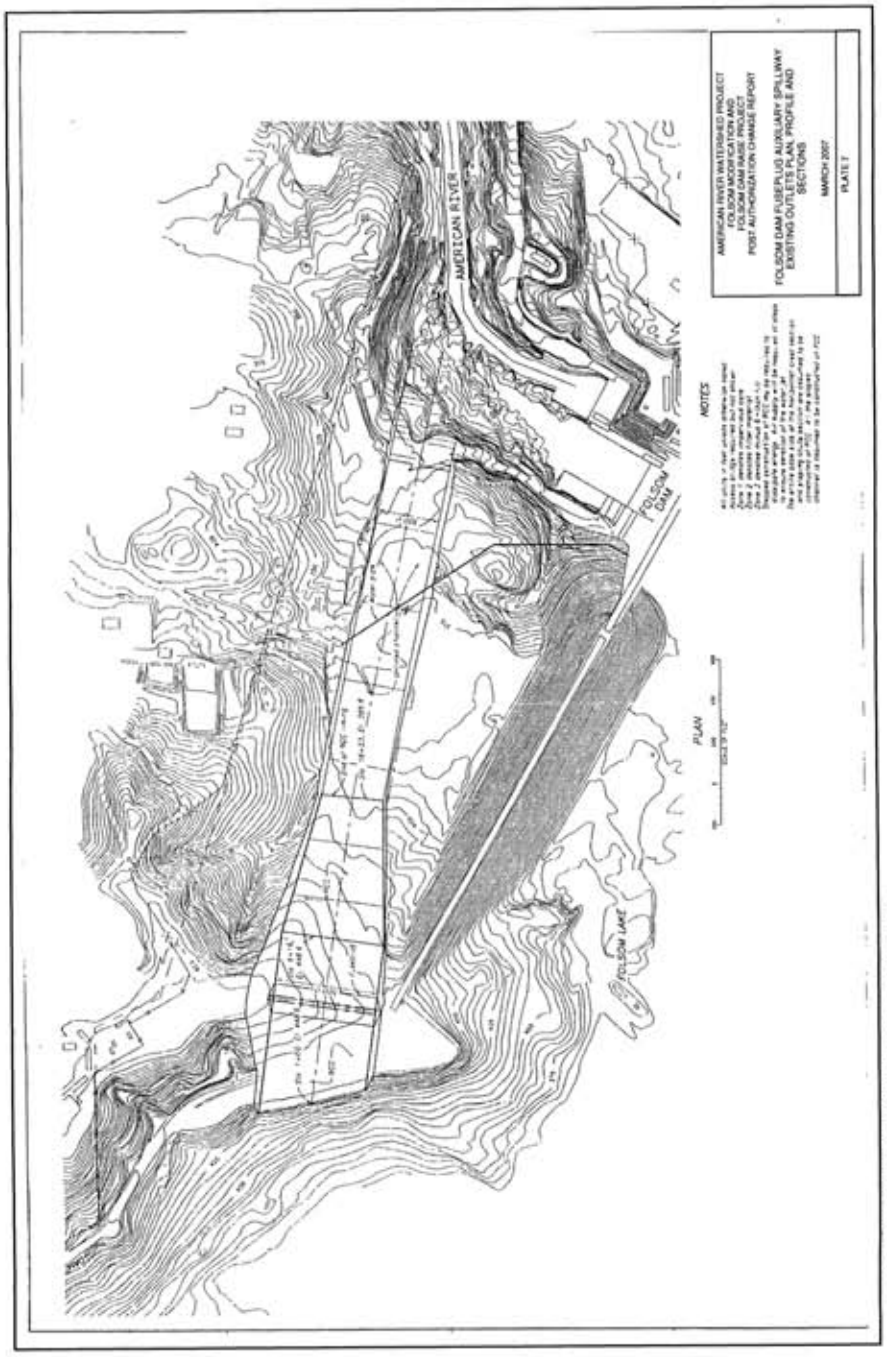


SOURCE: AMERICAN RIVER WATERSHED INVESTIGATION, CALIFORNIA, FEASIBILITY REPORT, 1991, US ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT

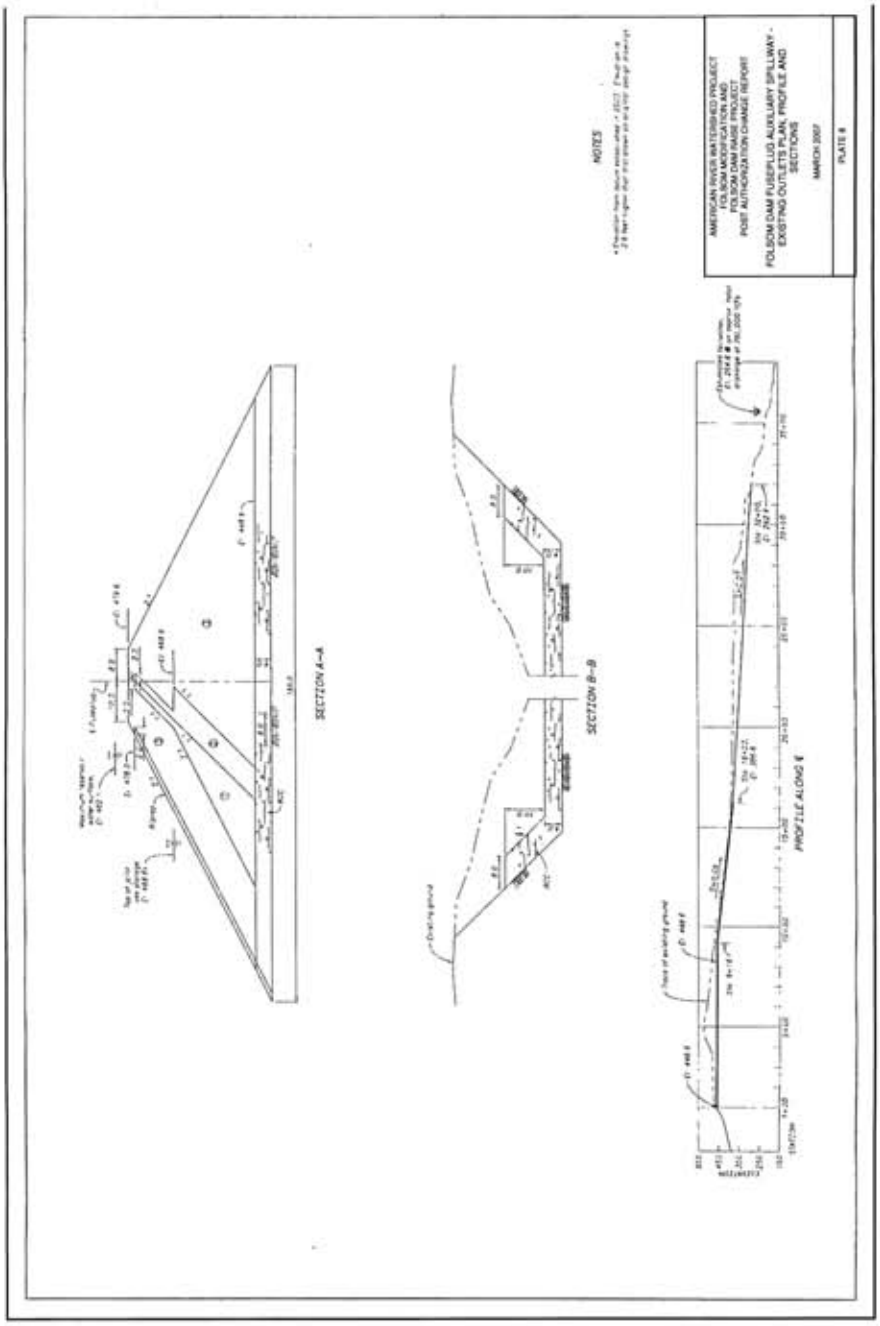

AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION AND
FOLSOM DAM RAISE PROJECT
POST AUTHORIZATION CHANGE REPORT
FOLSOM AND NIMBUS
DAM ELEVATIONS
MARCH 2007
PLATE 4
MAIN FOLSOM DAM - DOWNSTREAM ELEVATION
MAIN FOLSOM DAM
CONCRETE RIVER SECTION
DOWNSTREAM ELEVATION
NIMBUS DAM - UPSTREAM ELEVATION
SOURCE: AMERICAN RIVER WATERSHED INVESTIGATION, CALIFORNIA, FEASIBILITY REPORT, 1991, US ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT


AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION AND
FOLSOM DAM RAISE PROJECT
POST AUTHORIZATION CHANGE REPORT
EXISTING FLOOD CONTROL FEATURES
IN THE SACRAMENTO AREA
MARCH 2007
PLATE 5
LEGEND
FEDERAL PROJECT LEVEES
PRIVATE LEVEES
FLOODGATE
RAILROAD
SCALE IN MILES
AUBURN
ROSEVILLE
NATOMAS
SACRAMENTO
FOLSOM LAKE
FOLSOM DAM
NIMBUS DAM
AMERICAN RIVER
SACRAMENTO RIVER
FEATHER RIVER
SUTTER BYPASS
YOLO BYPASS
EAST SIDE DITCH CANAL
Natomas East Main Drainage Canal
Pleasant Grove Creek Canal
Arcade Creek
Dry Creek
Morrison Creek
Elk Grove
Freeport
Verona
Knights Landing
Colusa
Woodland
Davis
Winters
Vacaville
Fairfield
Suisun Bay
Rio Vista
Isleton
Walnut Grove
Courtland
Hood
Clarksburg
Locke
Ryde
Tyndall
Meadow
Robbins
Sutter
Nicolaus
Pleasant Grove
Roseville
Lincoln
Rocklin
Loomis
Penryn
Newcastle
Auburn
Cool
Greenwood
Georgetown
Coloma
Lotus
Placerville
Shingle Springs
Folsom
Orangevale
Fair Oaks
Carmichael
Citrus Heights
Rancho Cordova
Gold River
Rancho Murieta
Wilton
Galt
Herald
Lodi
Stockton
Elk Grove
Florin
Sloughhouse
Plymouth
Ione
Jackson
Sutter Creek
Amador City
Drytown
Volcano
Pine Grove
Pioneer
Jackson
Martell
Sheridan
Wheatland
Olivehurst
Marysville
Yuba City
Live Oak
Gridley
Biggs
Oroville
Chico
Paradise
Magalia
Durham
Oroville
Thermalito
Forebay
Thermalito
Afterbay
Feather River
Oroville Dam
Lake Oroville
Yuba River
Bear River
North Fork
American River
South Fork
American River
North Fork
Middle Fork
American River
Folsom Lake
Folsom Dam
Nimbus Dam
American River
Sacramento River
Feather River
Sutter Bypass
Yolo Bypass
Natomas East Main Drainage Canal
Pleasant Grove Creek Canal
East Side Ditch Canal
Arcade Creek
Dry Creek
Morrison Creek
Elk Grove
Freeport
Verona
Knights Landing
Colusa
Woodland
Davis
Winters
Vacaville
Fairfield
Suisun Bay
Rio Vista
Isleton
Walnut Grove
Courtland
Hood
Clarksburg
Locke
Ryde
Tyndall
Meadow
Robbins
Sutter
Nicolaus
Pleasant Grove
Roseville
Lincoln
Rocklin
Loomis
Penryn
Newcastle
Auburn
Cool
Greenwood
Georgetown
Coloma
Lotus
Placerville
Shingle Springs
Folsom
Orangevale
Fair Oaks
Carmichael
Citrus Heights
Rancho Cordova
Gold River
Rancho Murieta
Wilton
Galt
Herald
Lodi
Stockton
Elk Grove
Florin
Sloughhouse
Plymouth
Ione
Jackson
Sutter Creek
Amador City
Drytown
Volcano
Pine Grove
Pioneer
Jackson
Martell
Sheridan
Wheatland
Olivehurst
Marysville
Yuba City
Live Oak
Gridley
Biggs
Oroville
Chico
Paradise
Magalia
Durham
Oroville
Thermalito
Forebay
Thermalito
Afterbay
Feather River
Oroville Dam
Lake Oroville
Yuba River
Bear River
North Fork
American River
South Fork
American River
North Fork
Middle Fork
American River
Folsom Lake
Folsom Dam
Nimbus Dam
American River
Sacramento River
Feather River
Sutter Bypass
Yolo Bypass

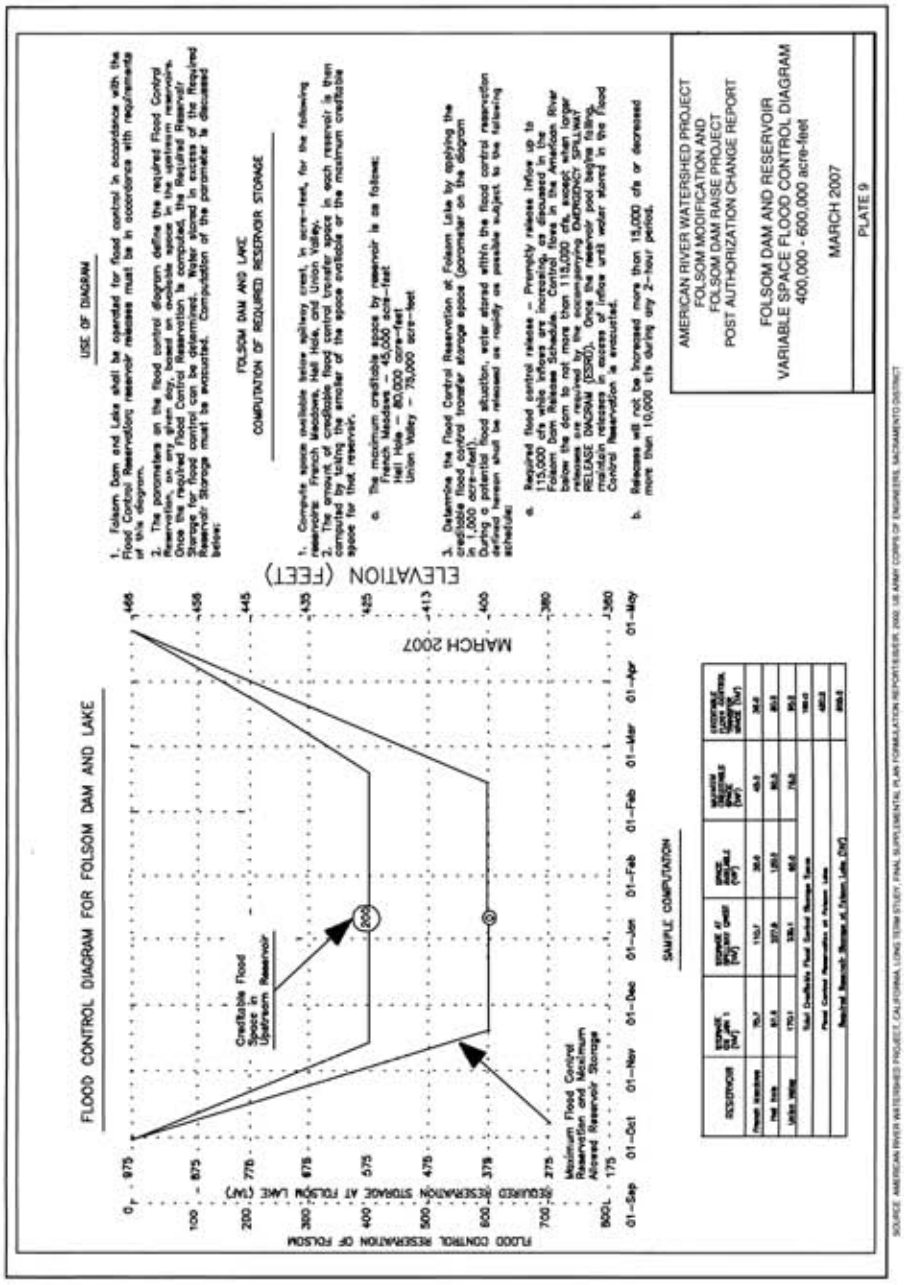

FLOOD CONTROL DIAGRAM FOR FOLSOM DAM AND LAKE
Maximum Flood Control Reservation and Maximum Allowed Reservoir Storage
Creditable Flood Space in Upstream Reservoir
Baseline
200
150
100
50
0
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan
01-Feb
01-Feb
01-Mar
01-Apr
01-May
SAMPLE COMPUTATION
USE OF DIAGRAM
1. Folsom Dam and Lake shall be operated for flood control in accordance with the Flood Control Reservation, reservoir releases must be in accordance with requirements of this diagram.
2. The parameters on the flood control diagram define the required Flood Control Reservation, on any given day, based on available space in the upstream reservoirs. Once the required Flood Control Reservation is computed, the Required Reservoir Storage for flood control can be determined. Water stored in excess of the Required Reservoir Storage must be evacuated. Computation of the parameter is discussed below:
FOLSOM DAM AND LAKE
COMPUTATION OF REQUIRED RESERVOIR STORAGE
1. Compute space available below spillway crest, in acre-feet, for the following reservoirs: French Meadows, Hell Hole, and Union Valley.
2. The amount of creditable flood control transfer space in each reservoir is then computed as being the smaller of the space available or the maximum creditable space for that reservoir.
a. The maximum creditable space by reservoir is as follows:
French Meadows – 45,000 acre-feet
Hell Hole – 60,000 acre-feet
Union Valley – 75,000 acre-feet
3. Determine the Flood Control Reservation at Folsom Lake by Applying the creditable flood control transfer storage space (parameter on the diagram in 1,000 acre-feet).
During a potential flood situation, water stored within the flood control reservation defined hereon, shall be released as rapidly as possible subject to the following schedule:
a. Required flood control release – Promptly release inflow up to 115,000 CFS while inflows are increasing, as dictated in the Folsom Dam Release Schedule. Control flows in the American River below the dam to not more than 115,000 CFS, or such other lesser amount as may be specified in the Folsom Dam EMERGENCY SPILLWAY RELEASE DIAGRAM (ESRD). Once the reservoir pool begins falling, maintain releases in excess of inflow until water stored in the Flood Control Reservation is evacuated.
b. Releases will not be increased more than 15,000 cfs or decreased more than 10,000 cfs during any 2 hour period.
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION AND
FOLSOM DAM RAISE PROJECT
POST AUTHORIZATION CHANGE REPORT
FOLSOM DAM AND RESERVOIR
EXISTING VARIABLE SPACE
FLOOD CONTROL DIAGRAM
400,000 - 670,000 acre feet
MARCH 2007
PLATE 6

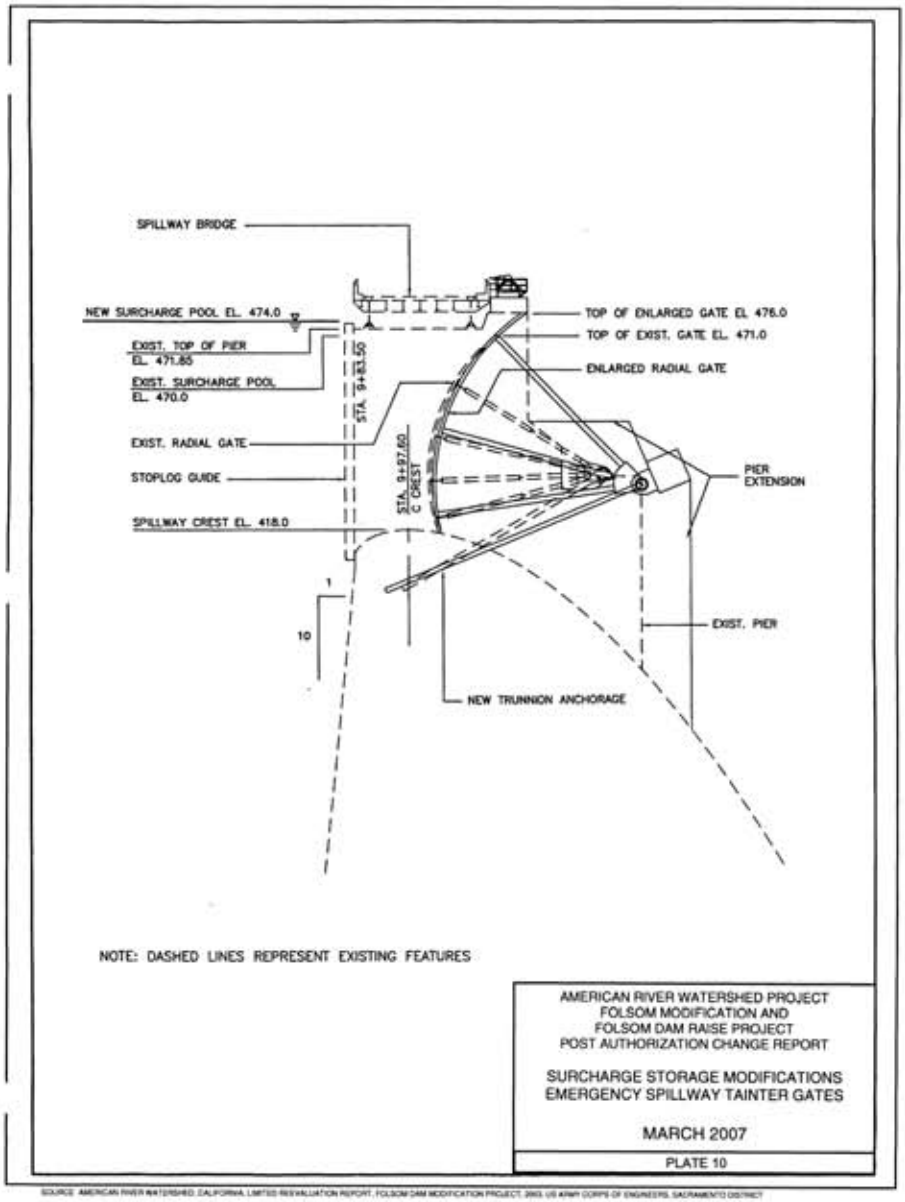


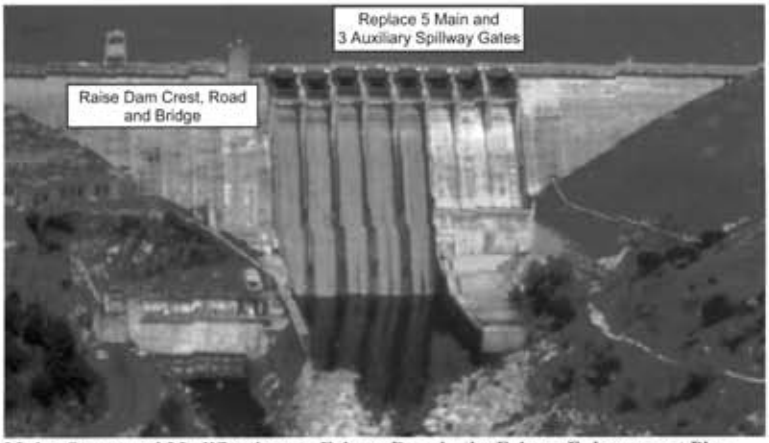
SOURCE: UNITED STATES DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION



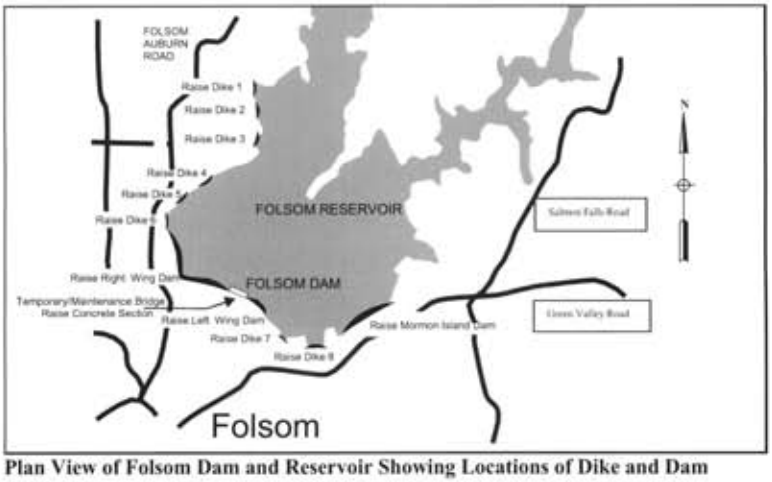
SOURCE: UNITED STATES DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION


FLOOD CONTROL DIAGRAM FOR FOLSOM DAM AND LAKE
USE OF DIAGRAM
FOLSOM DAM AND LAKE
COMPUTATION OF REQUIRED RESERVOIR STORAGE
SAMPLE COMPUTATION
MARCH 2007
ELEVATION (FEET)
FLOOD CONTROL RESERVATION OF FOLSOM
REQUIRED RESERVATION STORAGE AT FOLSOM LAKE (TAF)
Creditable Flood Space in Upstream Reservoir
Maximum Flood Control Reservation and Maximum Allowed Reservoir Storage
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION AND
FOLSOM DAM RAISE PROJECT
POST AUTHORIZATION CHANGE REPORT
FOLSOM DAM AND RESERVOIR
VARIABLE SPACE FLOOD CONTROL DIAGRAM
400,000 - 600,000 acre-feet
MARCH 2007
PLATE 9


SPILLWAY BRIDGE
NEW SURCHARGE POOL EL. 474.0
EXIST. TOP OF PIER EL. 471.85
EXIST. SURCHARGE POOL EL. 470.0
EXIST. RADIAL GATE
STOPLOG GUIDE
SPILLWAY CREST EL. 418.0
STA. 9+83.50
STA. 9+97.60 C CREST
1
10
TOP OF ENLARGED GATE EL 476.0
TOP OF EXIST. GATE EL. 471.0
ENLARGED RADIAL GATE
PIER EXTENSION
EXIST. PIER
NEW TRUNNION ANCHORAGE
NOTE: DASHED LINES REPRESENT EXISTING FEATURES
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION AND
FOLSOM DAM RAISE PROJECT
POST AUTHORIZATION CHANGE REPORT
SURCHARGE STORAGE MODIFICATIONS
EMERGENCY SPILLWAY TAINTER GATES
MARCH 2007
PLATE 10



Major Structural Modifications to Folsom Dam in the Folsom Enlargement Plan.



Plan View of Folsom Dam and Reservoir Showing Locations of Dike and Dam Raising.

AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION AND
FOLSOM DAM RAISE PROJECT
POST AUTHORIZATION CHANGE REPORT

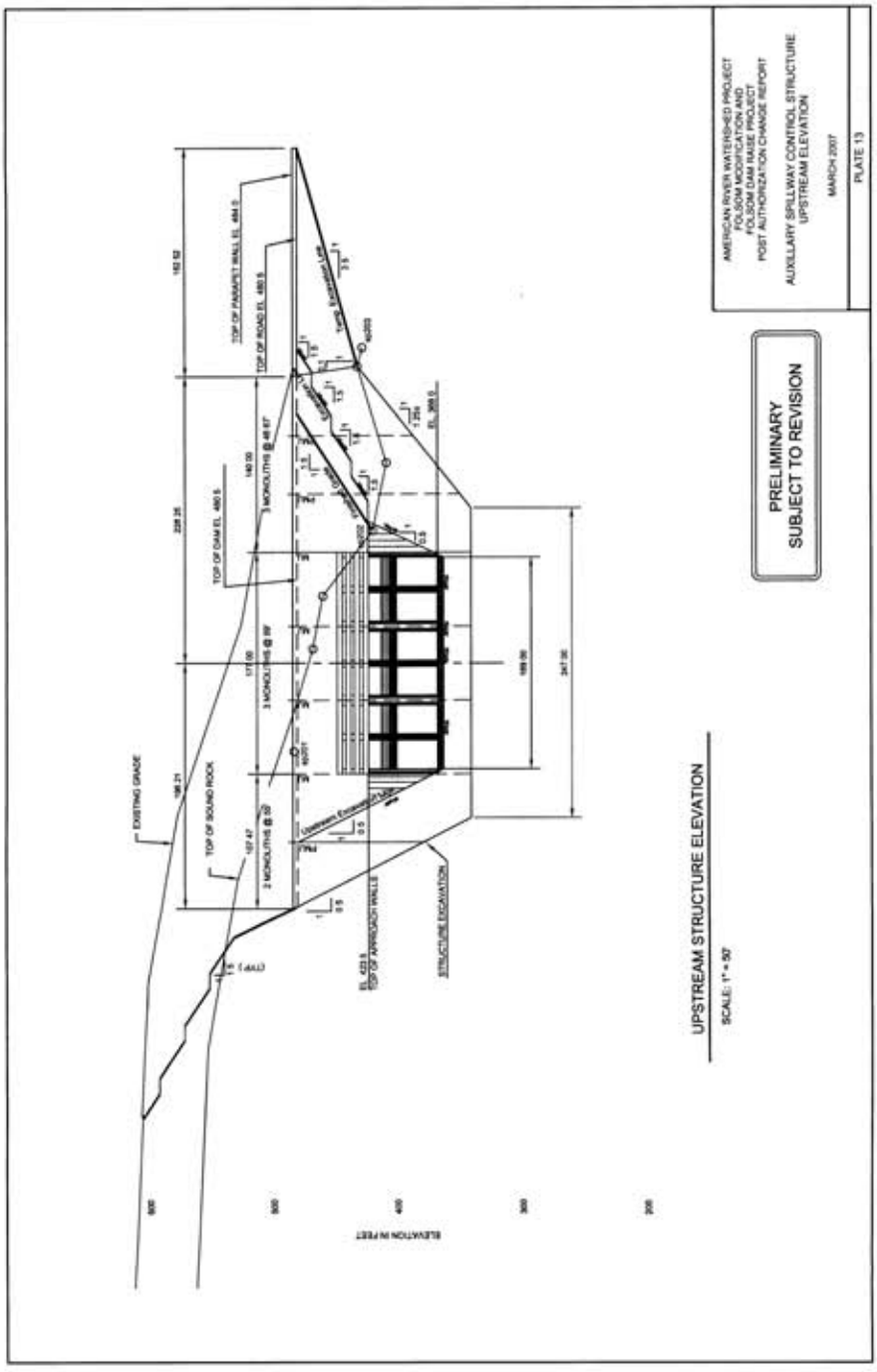
FOLSOM ENLARGEMENT PLAN

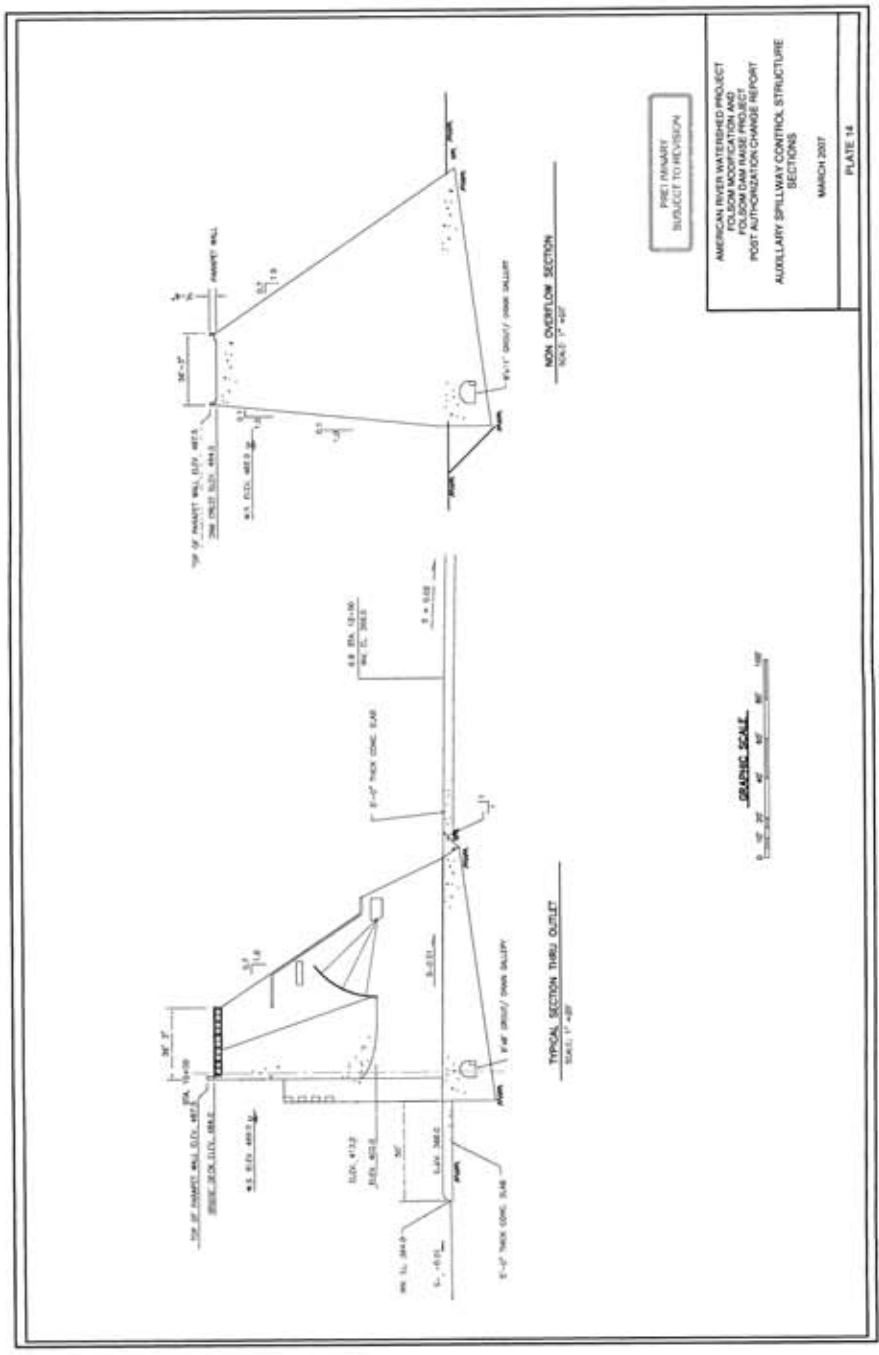
MARCH 2007

PLATE 11

SOURCE: AMERICAN RIVER WATERSHED PROJECT, CALIFORNIA, LONG TERM STUDY, FINAL SUPPLEMENTAL PLAN FORMULATION REPORT ES/EIR, 2002, US ARMY CORPS OF ENGINEERS, SACRAMENTO


RIGHT WING DAM
FUTURE FOLSOM BRIDGE (SEPARATE PROJECT)
STILLING BASIN
MAIN CONCRETE DAM
LEFT WING DAM
FUTURE USACE RESIDENT OFFICE
FUTURE PARKING
CONTROL STRUCTURE
APPROACH CHANNEL
PROPOSED AUXILIARY SPILLWAY ALIGNMENT
CHUTE
FUTURE FOLSOM BYPASS ROADWAY (SEPARATE PROJECT)
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION AND
FOLSOM DAM RAISE PROJECT
POST AUTHORIZATION CHANGE REPORT
MAIN CONCRETE DAM AND
AUXILLARY SPILLWAY PLAN VIEW
MARCH 2007
PLATE 12


AMERICAN RIVER WATERSHED PROJECT
FOLSOM LAKE, CALIFORNIA
FOLSOM DAM RAISE PROJECT
POST AUTHORIZATION CHANGE REPORT
AUXILLARY SPILLWAY CONTROL STRUCTURE
UPSTREAM ELEVATION
MARCH 2007
PLATE 13
PRELIMINARY
SUBJECT TO REVISION
UPSTREAM STRUCTURE ELEVATION
SCALE: 1" = 50'
ELEVATION IN FEET
TOP OF PARAPET WALL EL. 484.5
TOP OF ROAD EL. 480.5
TOP OF DAM EL. 480.5
EXISTING GRADE
TOP OF SOUND ROCK
EL. 423.5
TOP OF APPROACH WALLS
STRUCTURE EXCAVATION
SOURCE: US ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT, 2006


PRELIMINARY
SUBJECT TO REVISION
AMERICAN RIVER WATERSHED PROJECT
FOLSOM MODIFICATION AND
FOLSOM FACILITIES REEST
POST AUTHORIZATION CHANGE REPORT
AUXILLARY SPILLWAY CONTROL STRUCTURE
SECTIONS
MARCH 2007
PLATE 14
NON OVERFLOW SECTION
TYPICAL SECTION THRU OUTLET
GRADING SCALE