APPENDIX C

ENGINEERING APPENDIX

to

Supplemental Plan Formulation Report / EIS / EIR

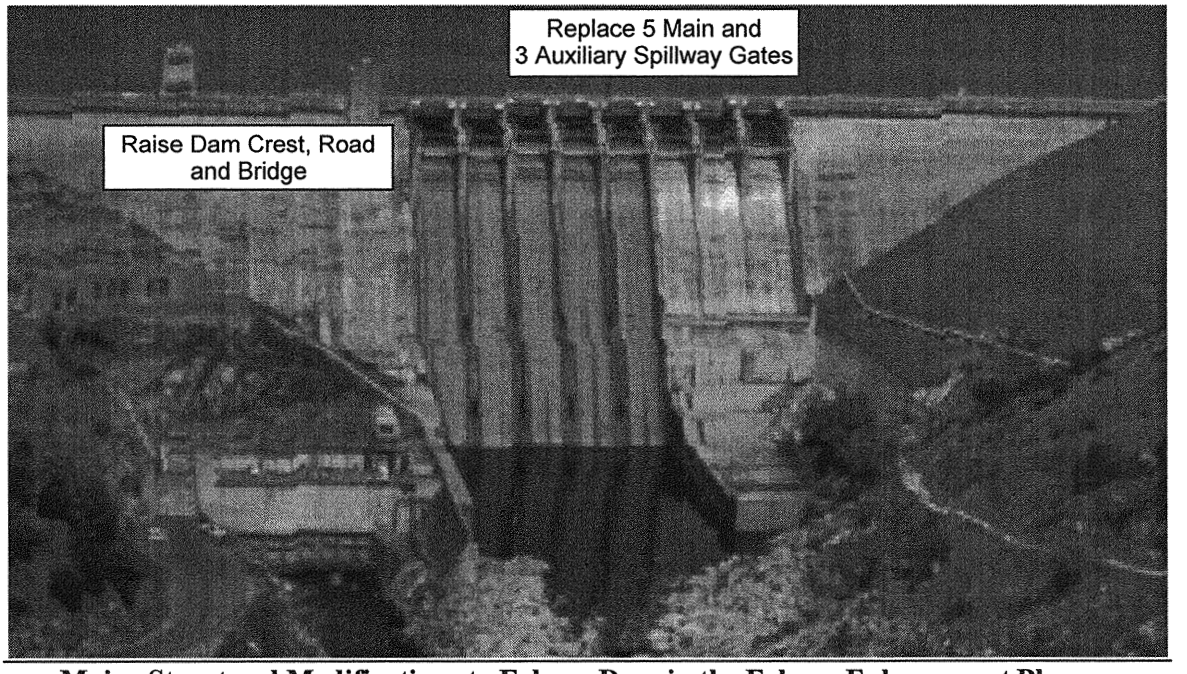
*

AMERICAN RIVER WATERSHED LONG-TERM STUDY

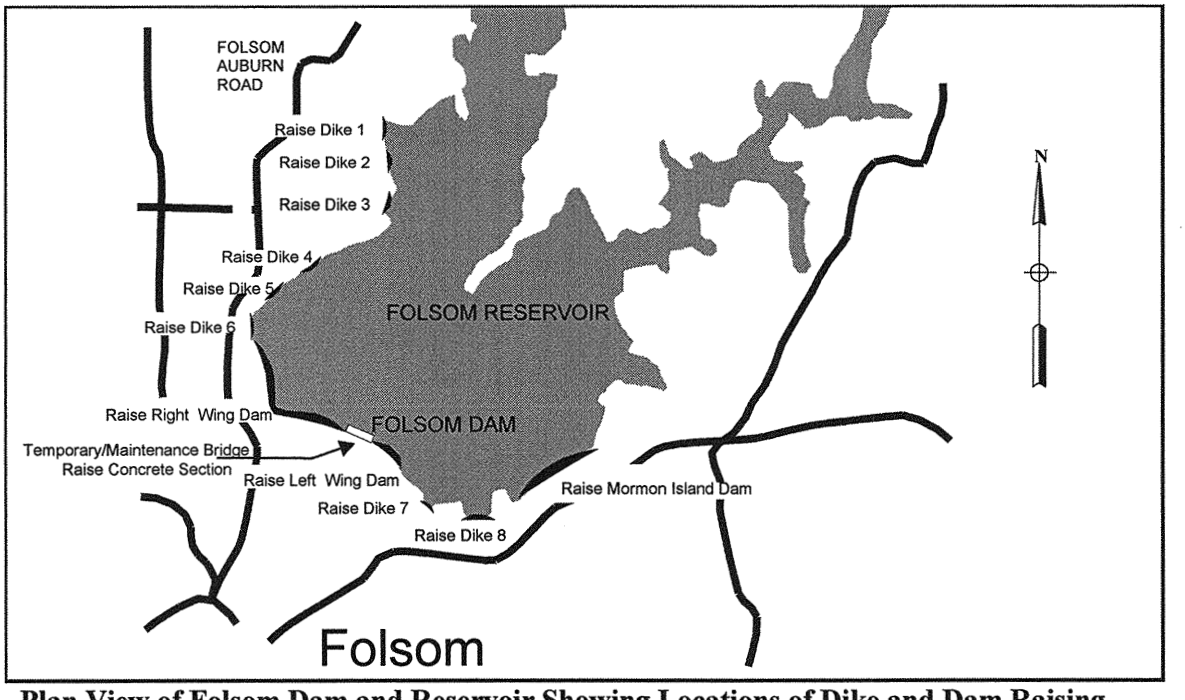
September 2001

US ARMY CORPS
OF ENGINEERS
Sacramento District

FOLSOM ENLARGEMENT PLAN



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.

A. GENERAL

1. INTRODUCTION

The major floods of 1986 revealed the inadequacies of Sacramento's existing flood control system and the urgent need for an upgrade to provide protection appropriate for this major metropolitan area. As described in Section 1.4, "Background," which follows, significant work has been and will be accomplished to reduce the risk of flooding from the American River. This work is the product of agreements and partnerships between numerous agencies and organizations, notably the U.S. Army Corps of Engineers (Corps), the State of California Reclamation Board (Reclamation Board), the Sacramento Area Flood Control Agency (SAFCA), and the U.S. Bureau of Reclamation (Bureau). After this work is completed, in 2007, the Sacramento area will have its flood risk reduced to approximately a 1-in-164 chance in any given year. Although this protection will be substantial, the substantial loss of life and property that would result from uncontrolled American River flows justifies continued study and further improvements to Sacramento's flood control system.

The Lower American River floodplain has significant natural ecosystem assets that have become increasingly valued in California. The proximity of surface and subsurface river flows and water from tributary runoff provide opportunities to improve riparian woodlands, wetlands, and floodplain grasslands along the Lower American River.

This Appendix presents the engineering alternatives for providing a comprehensive solution to the area's flood control problems and contributing to the restoration of the Lower American River. The plans described supplements the 1991 American River Watershed Investigation Feasibility Report and the 1996 American River Watershed Project Supplemental Information Report (SIR). This report integrates plan formulation with documentation of environmental effects. This report is also a supplemental environmental impact statement/supplemental environmental impact report (SEIS/SEIR). The SEIS/SEIR is supplemental to the 1991 and 1996 studies. The SEIS satisfies the requirements of the National Environmental Policy Act (NEPA), and the SEIR satisfies the requirements of the California Environmental Quality Act (CEQA).

Purpose and Need

Purpose

The Corps, the Reclamation Board, and SAFCA—the sponsors of the American River Watershed Long-Term Study—are seeking to plan, design, and implement a flood damage reduction project that would significantly decrease the risk of flooding along the main stem of the American River in the Sacramento area. The objective of the Reclamation Board and SAFCA is to reduce the risk of flooding to the maximum extent possible. This has been traditionally expressed as a minimum of being able to pass the 200-year flood with freeboard. The Corps' policy is to provide increased flood damage reduction consistent with applicable Federal planning principles and guidelines that focus on identifying and providing financial assistance for the plan that maximizes national economic development (known as the NED Plan) while protecting the nation's environment. The NED Plan describes the maximum net economic benefits as determined by average annual flood damages avoided less average annual costs.

Need

The need for an increased level of flood protection arose in February 1986 when major storms in northern California caused record floodflows in the American River watershed. Outflows from Folsom Dam, together with high flows in the Sacramento River, caused the river stage to rise above the design freeboard, or safety margin, of levees protecting the city of Sacramento. This storm event was the largest documented storm of record. Emergency repair work was required at several locations along the Garden Highway and in the Pocket area of Sacramento. If these storms had lasted much longer, major sections of the levee likely would have failed, causing probable loss of human life and billions of dollars in damages.

In January 1997, extreme rainfall in the Upper American River watershed again revealed the need for increased flood protection. The high level of rainfall in the Sierra Nevada resulted in record flows in both the Sacramento and the San Joaquin Rivers. Several gaging stations used to measure the water level in streams and rivers recorded the largest precipitation peaks in the history of their operation. The effects of the 1986 and 1997 storms raised concerns over the adequacy of the existing flood control system, which led to a series of investigations of the need to provide additional protection for Sacramento.

Authorization

The basic authority for the overall study is the Flood Control Act of 1962 (Public Law [PL] 87-874), as follows:

> 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.

Although this authorization applies to the overall study of the American River watershed, specific direction for the current effort is provided by Section 566 of the Water Resources Development Act (WRDA) of 1999 (PL 106-53):

SEC. 566. FOLSOM DAM AND RESERVOIR ADDITIONAL STORAGE AND ADDITIONAL FLOOD CONTROL STUDIES.

(a) FOLSOM FLOOD CONTROL STUDIES-

(1) IN GENERAL- The Secretary, in consultation with the State of California and local water resources agencies, shall undertake a study of increasing surcharge flood control storage at the Folsom Dam and Reservoir.

(2) LIMITATIONS- The study of the Folsom Dam and Reservoir undertaken under paragraph (1) shall assume that there is to be no increase in conservation storage at the Folsom Reservoir.

(3) REPORT- Not later than March 1, 2000, the Secretary shall transmit to Congress a report on the results of the study under this subsection.

(b) AMERICAN AND SACRAMENTO RIVERS FLOOD CONTROL STUDY-

(1) IN GENERAL- The Secretary shall undertake a study of all levees on the American River and on the Sacramento River downstream and immediately upstream of the confluence of such Rivers to assess opportunities to increase potential flood protection through levee modifications.

(2) DEADLINE FOR COMPLETION- Not later than March 1, 2000, the Secretary shall transmit to Congress a report on the results of the study undertaken under this subsection.

Corps headquarters provided the following guidance for implementing Section 566 through a memorandum dated January 18, 2000:

- Prepare a feasibility-level report that addresses increasing the surcharge flood control storage at Folsom Dam and Reservoir assuming no increase in conservation storage at Folsom Reservoir and

- Prepare a feasibility-level report that addresses all the levees on the American River and on the Sacramento River downstream of and immediately upstream of the confluence of such rivers to assess opportunities to increase flood protection through levee modifications.

- An interim report will be prepared to meet the Section 566 requirements for a report on March 1, 2000.

Thus, flood control alternatives considered in this study will focus on increasing Folsom Dam flood control storage, modifying Lower American River and downstream levees, and a combination of modifying Lower American River and downstream levees and increasing Folsom Dam storage.

Study Location

The city of Sacramento is located where the American River joins the Sacramento River. The American River watershed, or drainage basin, covers approximately 2,100 square miles northeast of Sacramento and includes portions of Placer, El Dorado, and Sacramento Counties. Runoff from this basin flows through Folsom Reservoir and passes through Sacramento in a channel controlled by a system of levees. Folsom Dam and Reservoir are part of the Federal Central Valley Project (CVP), California's largest water delivery system.

2. Background

In February 1986, major storms in northern California caused record floodflows in the American River basin. Water releases from Folsom Reservoir, together with high flows in the Sacramento River, caused water levels to rise above the design freeboard, or safety margin, of levees protecting the Sacramento area. Emergency repair work was required at several locations along the Garden Highway and in the Pocket area of Sacramento. Had these storms lasted much longer, major sections of levee likely would have failed, causing probable loss of life and billions of dollars in damages. The effects of the February 1986 storms raised concerns over the adequacy of the existing flood control system, which led to a series of investigations for the purpose of providing additional flood protection to the Sacramento area.

In 1991, the Corps, the Reclamation Board, and SAFCA completed the initial feasibility study for the main stem American River and the Natomas basin. (The Natomas basin is just north of downtown Sacramento, at the confluence of the American and Sacramento Rivers.) The purpose of that study was to define the flood risks to the Sacramento area, develop flood protection alternatives consistent with other water resource needs and opportunities in the study area, and recommend a plan for implementation. Many alternatives were evaluated in that study. The resulting plan, recommended in the 1991 feasibility report, was a flood detention dam just downstream of the confluence of the North and Middle Forks of the American River and levee

improvements in the Natomas basin sufficient to control runoff from a storm with a 1-in-200 chance of occurring in any year.

Following completion of the feasibility report, Congress provided guidance relating to the American River study in Section 9159 of the Department of Defense Appropriations Act of 1993 (PL 102-396). This act authorized the construction of much of the work identified in the Natomas basin as described in the feasibility report. It also directed that additional studies be conducted to identify a project for increased flood protection along the American River. In response to congressional direction, the Corps and its local sponsors, the Reclamation Board and SAFCA, prepared the 1996 SIR to provide information in addition to that presented in the 1991 feasibility report. The SIR was a comprehensive analysis that reformulated measures and alternatives to increase flood protection for Sacramento. The report presented three candidate plans: Folsom Modification Plan, Folsom Stepped Release Plan, and the Detention Dam Plan. The Detention Dam Plan was the National Economic Development (NED) Plan.

In 1996, Congress considered the findings in the 1996 SIR and addressed the desires of local and regional interests. In the WRDA of 1996, Congress authorized the following elements of the plans recommended in the SIR:

- 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 and
- Continued interim reoperation of Folsom Reservoir for variable flood control space

These flood control elements are known as "Common Features." Construction is presently underway to implement these project elements.

In 1999, the Corps, SAFCA, and the Reclamation Board prepared an information paper that provided additional information on four plans that were identified by various interest groups to reduce the flood risks to Sacramento

Under Section 101 of WRDA of 1999, Congress authorized outlet modifications generally consistent with the SIR and the Folsom Dam Modification Plan described in the SAFCA Information Report entitled Next Step for Flood Control along the American River, prepared by SAFCA in March 1998. These modifications at Folsom Dam, which are being refined and designed by the Corps, are

- Enlarging existing river outlets
- Modifying the variable flood control space instituted by Folsom reoperation and
- Modifying surcharge storage.

Construction of these features is expected to be completed in 2008.

Section 101 of WRDA of 1999 also directed that the Folsom Dam Flood Management Plan be updated to take advantage of improved weather forecasting. Studies to update the flood management plan are underway.

Section 366 of WRDA of 1999 authorized modifications to the Common Features project authorized in WRDA of 1996. These modifications primarily consist of the additional strengthening and raising of levees along the American River and Natomas Cross Canal. Construction of these features is expected to be completed in 2003. Detailed design efforts are underway to implement Section 101 and Section 366 project features.

3. PROJECT ALTERNATIVES

Alternative 1: No Action

Description

The No-Action Alternative is the same as the without-project condition and serves as the baseline against which the costs, benefits, and effects of the action plans are evaluated. Under this alternative, Federal government would take no action to implement a specific plan to increase flood protection along the American River beyond what is already authorized. Already authorized flood control projects on the American River include the Common Features Project, Folsom Dam Modification Project, Folsom Dam Re-operation, and Folsom Dam Flood Management Plan update. Additional information on these projects as well as the No-Action Alternative is contained in Chapter 2, "Affected Environment."

With outlet modifications and surcharge storage in place, Folsom Dam will be able to pass only about 70 percent of the PMF. Because Folsom is a major dam upstream of a heavily populated area, dam safety deficiencies are unacceptable for the long term. Even if there were no additional flood control modification done to Folsom Dam, there would be a need to implement dam safety improvements. There is currently no dam safety plan and no funding; therefore, work to correct Folsom Dam's PMF deficiency is part of the without-project condition but is unscheduled.

Operation

Under the existing operating criteria, 400,000 acre-feet of the total storage capacity of 975,000 acre-feet is allocated to flood control. However, the Bureau and

SAFCA have an interim reoperation agreement that allows for operation of the dam to include a variable storage space ranging from 400,000 to 670,000 acre-feet.

Under no action, the variable flood control space reoperation will continue. After Folsom Dam outlet modifications are completed, the variable space will be revised from 400,000–670,000 acre-feet to 400,000–600,000 acre-feet.

The Flood Management Plan update will develop an advance release operation for Folsom Dam that would be adopted as a way to gain additional flood space at little or no cost and no significant environmental impact. The advance release operation has not been fully developed. The Folsom Modification Project must be completed, and the advance release plan needs to be formulated and reviewed. As described in Chapter 2, this Long Term Study developed three alternative advance release scenarios:

- No advance release

- Moderate advance release
  Lower bound: 0 acre-feet
  Most likely: 100,000 acre-feet
  Upper limit: 190,000 acre-feet

- Upper bound advance release
  Lower bound: 100,000 acre-feet
  Most likely: 140,000 acre-feet
  Upper limit: 250,000 acre-feet

For alternative analysis purposes, this study has adopted the moderate advance release scenario. This is currently the greatest advance release that appears implementable without additional cost or environmental impact. The upper limit advance release doesn't appear to be implementable, and is displayed as a check for economic feasibility in the event that existing flood constraints are overcome.

Alternative 2: 3.5-Foot Dam Raise/478-Foot Flood Pool Elevation

Description

Implementation of Alternative 2 would increase the flood control capacity of the dam by raising the height of the dam features, thereby enlarging the flood space available in the reservoir. The PMF maximum reservoir water surface elevation would be 479.0, which represents a 5-foot increase from the without-project condition. The maximum flood pool elevation would be increased from 474 feet to 478 feet. Flood control space would increase by 47,000 acre-feet under this alternative. (The flood pool elevation could be 479 with the physical improvements, but performance and economic benefits are calculated using a 478 flood pool. Thus the flood risk should be somewhat lower and economic benefits slightly higher than what is reported.) The physical height of the dam

would be increased from 480.5 feet to 484 feet. The physical raise would apply to the concrete structure, the earthen wing dams, dikes, and Mormon Island Dam. This would create 5 feet of freeboard to protect the dam from wind and wave runup and to account for some back water that may occur when the top of flood pool encroaches onto the spillway bridge.

Additional work for dam safety consists of lowering the Folsom spillway 6 feet and improving L. L. Anderson Dam (French Meadows reservoir) so that 100% of the PMF would pass safely through the Folsom Dam. The plan components, real estate requirement, operation, accomplishments and residual risk, and plan economics and cost sharing associated with Alternative 2 are described below.

Plan Components

The major structural modifications include

Raise Concrete Dam

The concrete portions of Folsom Dam outside of the spillway area would not need to be raised to accommodate the higher flood pool, since the top of the without-project bridge and dam parapet walls are at elevation 484. However, the vertical joints in these existing walls would be sealed to prevent leakage during extreme floods. The new bridge deck and roadway would remain at the without-project elevation of 480.5 feet.

Lower Spillway

Both the main spillway and the emergency spillway crest would be lowered 6 feet, from 418 to 412 feet elevation. The increased spillway capacity would be available for extremely unusual events when additional water must be released to avoid dam overtopping and failing. The spillway lowering would be accomplished by over-excavation of the existing concrete portion of the dam.

Replace Spillway Gates

All eight spillway radial gates would require replacement under this plan. The new gates would be approximately 69 feet high, 11 feet taller than the without-project condition gates. The top-of-gate elevation in the closed position would be 481 feet providing 2 feet of freeboard on a design flood pool elevation of 479 feet.

To accommodate the additional height and loading, the without-project condition piers would require extension and strengthening, and new radial gate trunions would be located on the top of the new pier extensions. New high-strength, post-tensioned steel tendons would be cored and grouted into the pier/dam section to provide for trunion anchorage. New hoisting motors and chains and new catwalks also would be required.

Modify Spillway Bridge Piers

The spillway bridge piers would require modification under this plan. The piers would be raised and extended on the downstream face of the dam to anchor the new larger radial gates. Installation of post-tensioned tendons to anchor the piers to the mass concrete of the overflow section also would strengthen the piers.

Preliminary engineering analysis has been performed for both the existing and raised conditions of the dam. This analysis concludes that severe concrete cracking and weakening of the reinforcing steel in the concrete section of the dam can be expected during large earthquake ground motions in the cross-canyon direction. However, if the piers are sufficiently constrained by the new spillway bridge superstructure, the cracking would be less severe and the load could be redistributed without weakening of the reinforcing steel.

Replace Spillway Bridge

The existing eight-span spillway bridge consists of two riveted steel plate girders with a composite concrete deck, each approximately 34 feet wide by 50 feet long. The existing bridge would require removal and replacement due to the higher flood control pool and spillway gates. The new bridge would be a prestressed concrete multiple box girder bridge of approximately the same dimensions as the existing bridge, with one through traffic lane in each direction.

Extend Stilling Basin

Extension of the spillway stilling basin and side walls approximately 60 feet is required to ensure proper stilling basin function and adequate energy dissipation of the larger flows and higher heads of the new design flood and PMF. This component also would include rock excavation, shaping, and stabilization to improve flow patterns in the vicinity of the stilling basin.

Raise Embankment Dams and Dikes

The concrete dam section and the left and right embankment wing dams and dikes would be raised to elevation 484 feet. This would be accomplished with a 3.5-foot-high reinforced concrete crest wall, faced with riprap matching the existing embankment slope. The embankment dams and dikes around the perimeter of the reservoir must be raised. The existing impervious cores in Mormon Island Dam and dikes 5 and 7 would have a slurry wall constructed down to elevation 466 feet; therefore, the cores of these dam and dike features would be raised to elevation 479 feet and connected to the crest wall foundation.

Improve Newcastle Powerhouse

During very rare floods, there would be the potential to inundate a portion of the Newcastle Powerhouse, a public utility owned and operated by the Pacific Gas and Electric Company. This powerhouse is on the northwest shoreline of Folsom Reservoir. To mitigate this effect, a floodwall would be constructed around the powerhouse, and the access road would be raised. The wall would be approximately 7 feet high and constructed of reinforced concrete. Further study is required to explore the feasibility of floodproofing or other nonstructural measures to address the powerhouse.

Borrow Areas and Haul Routes

Two borrow sites have been identified that provide the suitable embankment material. A maximum of 90 acres of land would be excavated at the Peninsula site, located between the North and South Forks of the American River. Approximately 23,000 cubic yards of material would be taken from this site. A maximum of 140 acres of land would be excavated at the Mississippi Bar site, located just upstream and northeast of Nimbus Dam. Approximately 42,100 cubic yards of material would be taken from this site. The haul distance and route to the Peninsula are 2 to 3 miles and embankment would be barged across Folsom Lake to the dikes and dams. The haul distance and route to the Mississippi Bar borrow site are 5 miles and the route travels north up Main Street, east on Madison Avenue, north on Greenback Lane, and north on Auburn Folsom Road, and to the right wing dam on Folsom Dam Road.

Location of Construction Staging Areas

The construction staging areas would be located immediately adjacent to the landside of the existing embankment dams and dikes. The locations were selected based on existing topography and environmental conditions to minimize environmental effects.

Construct Minimum Permanent Bridge

During construction of a dam raise, the spillway bridge would be closed to daily traffic, and a minimum permanent bridge, approximately ¼ mile in length, would be constructed southeast of the dam and merge with the existing Folsom Dam road near the left wing dam abutment. The bridge would be aligned to provide an alternate route of transportation across the American River and to ensure that no conflicts occur with existing Folsom Dam operation. Construction of the bridge is intended to mitigate short-term traffic effects during construction of the dam raise modifications. After completion of the dam raise, traffic would revert back to the spillway bridge at the discretion of the Bureau. The minimum permanent bridge would then be used by the Bureau for its operations; the public traffic would use this bridge when the dam is closed as required for normal dam and spillway operation and maintenance.

Mooney Ridge Flood Easement

The 478-foot maximum flood pool elevation related to this dam raise would inundate the lower portion of backyard areas of seven residences in the Mooney Ridge subdivision. The expected annual probability that the properties would be1 chance in 170. The proposed mitigation would be to construct a new dike to protect the backyards. Alternative mitigation is under review. Two examples are (1) purchase of a flood easement on the properties may be less expensive and would avoid the visual intrusion of a dike and (2) a berm that fills the property thereby giving the homeowners a flat yard and would not adversely affect the ascetics. A decision will be made pending consultation with the property owners.

Enlarge L. L. Anderson Dam Spillway

L. L. Anderson Dam is owned by PCWA and is located on the Middle Fork of the American River above Folsom Dam. The embankment dam has inadequate spillway capacity and would overtop and fail during a PMF event. This failure would add approximately 250,000 cfs to the PMF at Folsom Dam. Providing for passage of that additional flow at Folsom Dam would cost considerably more than modifying L. L. Anderson Dam and spillway for safe passage of the PMF.

The dam is fitted with parapet walls ranging in height from 1 to 3 feet along the left and right sides of the dam crest. The wind setup and wave runup for the project is 3.6 feet. The spillway consists of an ogee crest at elevation 5,244.5 feet discharging to a rock-lined exit channel. The spillway crest is gated with two tainter gates 20 feet wide by 18.5 feet high. The spillway discharges to a trapezoidal exit channel 50 feet wide. At approximately 300 feet downstream of the spillway, the exit channel drops 44 feet into an escape channel at a right angle to the exit channel. The escape channel is approximately 1,000 feet long and varies in bottom width from 25 feet at the upstream end to 50 feet at the downstream end. Downstream of the escape channel, there is an additional 800 feet of channel work before the spillway flows return to the Middle Fork of the American River.

The following modifications are proposed for L. L. Anderson Dam:

- The existing two-tainter-gate (20 feet wide by 18.5 feet high) ogee crest control structure would be removed.

- A new three-tainter-gate (27 feet wide by 18.5 feet high) ogee crest control structure would be constructed at the entrance to the spillway channel.

- The existing rock excavated spillway channel would be deepened (approximately 23 feet) and extended (approximately 100 feet) to connect to the new control structure as a side-channel spillway.

- The existing downstream spillway escape channel would be widened at two constriction points.

- The existing parapet crest wall would be raised to 5,276.6 ft and extended to provide adequate freeboard during the PMF event. The material excavated would most likely be stored at the staging area used during construction of L. L. Anderson Dam or at the downstream end of the spillway.

Additional Structural Work

The gantry crane would be temporarily relocated from the top of the dam while the spillway bridge is raised. The reach of the upper crane on the gantry would need to be enlarged to handle spillway gate stop logs. Alternatively, the gantry crane could be removed and replaced with a portable crane.

The penstock wheel gates would require that the hydraulic power units and controls be relocated to the appropriate heights. The penstock inlet temperature shutters would be extended upward commensurate with the physical dam raise.

Real Estate Requirement

Under Alternative 2, private property would be affected at the Mooney Ridge site, and at some sites around the reservoir, drainages and feeder streams would be affected. At Mooney Ridge, a new dike would be built to protect the backyards pending consultation with the landowners. The landowners may prefer to allow the infrequent inundation of the lower 6–12 feet in elevation of their backyards. If this were the case, flood easements would be purchased from the property owners. PG&E's Newcastle Power Plant also may be affected. The power plant is on Federal project land. To avoid effects on the power plant, a protecting parapet wall would be built around the plant. At the 478-foot top-of-flood-pool elevation, it is unlikely that there would be any impact on roadways at Browns Ravine or on Salmon Falls Road.

Implementation of Alternative 2 would not require a significant amount of borrow material to modify existing dikes. Two borrow sites have been identified: one owned by the Federal government and one owned by the State of California. It is anticipated that both sites would be used. Use of existing project resources for borrow material would result in significant savings; however, as a cost share partner, the State would be credited the fair market value of the borrow material contributed from State lands above the 486-foot-elevation project take line.

Another real estate requirement would be lands for environmental mitigation.

Operation

The operations plan for Folsom Dam regulates the reservoir storage space available for flood control and water releases from the dam. Implementation of Alternative 2 would increase the flood storage capacity of the dam by 47,000 acre-feet and would revise the dam reoperation variable flood space to a total range of 447,000–647,000 acre-feet.

Water releases from the dam are made through eight gated outlets at the lower level of the dam, five main spillway gates, and three auxiliary spillway gates (used only in emergencies). Releases are restricted by the capacity of discharge structures and by the existing operation criteria that limits the increases in release rates. The lower level outlet capacity will be 115,000 cfs (with Folsom Modifications project); after inflows exceed this outflow capacity, the reservoir begins to fill. The outflow rate remains at 115,000 cfs until the water level reaches the spillway crest, at which time spillway releases from the main gates can begin. The current operations plan restricts the maximum rate of increase to 15,000 cfs per hour until outflow reaches the 115,000 cfs objective release limit. Increased releases are limited to 15,000 cfs per hour to minimize erosion damage to levees and banks due to sudden large increased while the objective release limit is set to prevent flows that exceed the safe carrying capacity of the downstream river channel. The maximum emergency release rate is 160,000 cfs with a maximum duration of 48 hours. The reservoir water surface raise from 474 feet to 478 feet would occur at infrequent intervals; the duration of a water surface above 474 would be at most 1 day.

Alternative 3: 7 Foot Dam Raise / 482-Foot Flood Pool Elevation

Description

The plan components under Alternative 3 would be essentially the same as under Alternative 2, apportioned up to the 482-foot maximum flood pool elevation which represents an 8-foot increase from the without-project condition and a 12-foot increase from the existing condition. No further raising of the flood space may be made without major stabilization work to the dam (see Alternative 4 below). This alternative plan will increase flood control and correct the dam safety problem so that the PMF would be passed without dam failure. An increase in the dam's water storage capacity of 96,000 acre-feet in additional flood control space would result under implementation of this plan. This alternative would increase the physical height of the dam 8.5 feet, raising it from a dam crest elevation of 480.5 feet to a top of wall elevation of 487.5 feet. The raise would allow a PMF water surface of 484.5 feet plus 3 feet of freeboard for wind and wave and possible backwater from spillway flow encroachment on the spillway bridge. Additionally, L. L. Anderson Dam (French Meadows reservoir) spillway would be widened to reduce the PMF inflow to Folsom Dam. The plan components, real estate requirement, operation, accomplishments and residual risk, and plan economics and cost sharing associated with Alternative 3 are described below.

Plan Components

The plan components under Alternative 3 would be essentially the same as under Alternative 2, apportioned up to the 482-foot maximum flood pool elevation. These components work together to effectively raise the physical height of the dam from 480.5

feet to 489 feet which includes the parapet wall. The spillway would not be lowered under this plan. Additionally, L. L. Anderson Dam (French Meadows reservoir) would be modified to accommodate the PMF.

Replace Spillway Gates

All eight spillway radial gates would require replacement under this plan. The new gates would be approximately 66 feet high, 8 feet taller than the gates under the without-project condition. The top-of-gate elevation would be 484.0 feet, providing 2 feet of freeboard on a design flood control pool elevation of 482.0 feet.

To accommodate the additional height and loading, the existing piers would require extension and strengthening, and new trunions would be located on the top of the new pier extensions. New high-strength, post-tensioned steel cables would be cored and grouted into the pier/dam section to provide for trunion anchorage. New hoisting motors and chains, and new catwalks would also be required.

Modify Spillway Bridge Piers

The spillway bridge piers would require modification under this plan. The piers would be raised and extended downstream to anchor the new larger radial gates. Additionally, the piers would be strengthened by installing post-tensioned tendons to anchor the piers to the mass concrete of the overflow section.

Replace Spillway Bridge

This alternative would include essentially the same replacement bridge as for Alternative 2. The existing eight-span spillway bridge would require replacement commensurate with the higher dam elevation. The new bridge would be approximately 400 feet long and 35 feet wide with one through traffic lane in each direction.

Raise Concrete Dam

The concrete portions of Folsom Dam outside of the spillway area would be raised to accommodate the higher flood control pool. This raise would be accomplished through a combination of raising the dam crest and constructing a 3.5-foot parapet wall. The new top-of-dam elevation would be 489 feet, and the top of the roadway elevation would be 486.5 feet.

Extend Stilling Basin

Work to extend the stilling basin would be identical to that described for Alternative 2.

Raise Embankment Dams and Dikes

As with the concrete dam section, the left and right embankment wing dams beyond the center concrete section would need to be raised. Sections of embankment dams and dikes around the perimeter of the reservoir that must be raised in direct relationship to the dam raise to accommodate higher water storage elevations. These embankments and dikes would be raised and expanded with a combination of earthfill and a 3½-foot-high reinforced concrete crest wall, faced with riprap matching the existing embankment slope. The existing impervious core in Mormon Island Dam and dikes 5 and 7 would have a slurry wall constructed down to elevation 466 feet after the dam has been raised; therefore, the cores of these dam and dike features would be raised to elevation 485.5 feet and connected to the crest wall foundation.

Improve Newcastle Powerhouse

During very rare floods, there would be the potential to inundate a portion of the Newcastle Powerhouse, a public utility owned and operated by the Pacific Gas and Electric Company. This powerhouse is on the northwest shoreline of Folsom Reservoir. To mitigate this effect, a floodwall would be constructed around the powerhouse and the access road would be raised. The wall would be approximately 12 feet high and constructed of reinforced concrete. Further study is required to explore the feasibility of floodproofing or other nonstructural measures to address the powerhouse.

Modify Elevator Tower

The dam elevator tower would require modification under this plan. Tower modifications include raising the elevator roadway lobby, adding a floor to the top of the tower, relocating the elevator machinery up one floor, and modifying the elevator controls.

Borrow Areas and Haul Distances

Two borrow sites have been identified to supply suitable embankment material as discussed in the description of the previous plan. A maximum of 90 acres of land would be excavated at the Peninsula site, located between the North and South Forks of the American River. Approximately 55,300 cubic yards of material would be taken from this site. A maximum of 140 acres of land would be excavated at the Mississippi Bar site, located just upstream and northeast of Nimbus Dam. Approximately 277,000 cubic yards of material would be taken from this site. The haul distance and route to the Peninsula are 2 to 3 miles and embankment would be barged across Folsom Lake to the dikes and dams. The haul distance and route to the Mississippi Bar borrow site are 5 miles and the route travels north up Main Street, east on Madison Avenue, north on Greenback Lane, and north on Auburn Folsom Road, and to the right wing dam on Folsom Dam Road.

Location of Construction Staging Area

All construction staging areas would be located immediately adjacent to the landside of existing earthen dams and dikes to minimize disturbance of outlying environmental resource areas.

Construct Minimum Permanent Bridge

During construction of a dam raise, the spillway bridge would be closed to daily traffic, and a minimum permanent bridge, approximately ¼ mile in length, would be constructed southeast of the dam and merge with the existing Folsom Dam road near the left wing dam abutment. The bridge would be aligned to provide an alternate route of transportation across the American River and to ensure that no conflicts occur with existing Folsom Dam operations. Construction of the bridge is intended to mitigate short-term traffic effects during construction of the dam modifications. After completion of the dam raise, and with the permission of the Bureau, traffic would be routed back onto the spillway bridge. The minimum permanent bridge would then be used by the Bureau for its operations; the public traffic would use this bridge only when the dam is closed for gate and spillway maintenance.

Raise Folsom Dam Road East of Dam

Approximately one-third of a mile of Folsom Dam Road southeast of the left wing dam is at an elevation below 480.5 feet. This section of road would be inundated before the reservoir surface reached the operating flood control pool of 482 feet. To keep the road passable while Folsom Dam is under a flood operation, approximately one-third of a mile of road would be raised in place. The alignment would be within project lands, so no new rights-of-way would be required.

Mooney Ridge Flood Easement

The raise in lake elevation would affect seven residential parcels in the Mooney Ridge subdivision, where the lower portion of steep backyard areas would be inundated temporarily. The inundations would be very infrequent and of a short duration. The proposed mitigation would be to construct a new dike to protect the backyards. Alternative mitigation is under review. Two examples are (1): purchase of a flood easement on the properties may be less expensive and would avoid the visual intrusion of a dike; and (2): a berm that fills the property thereby giving the homeowners a flat yard and would not adversely affect the ascetics. A decision will be made pending consultation with the property owners.

Enlarge L. L. Anderson Dam Spillway

Work on the L. L. Anderson Dam spillway would be identical to that described for Alternative 2.

Additional Structural Work

The gantry crane would be temporarily relocated from the top of the dam while the spillway bridge is raised. The reach of the upper crane on the gantry would need to be enlarged to handle spillway gate stop logs. Alternatively, the gantry crane could be removed and replaced with a portable crane.

The penstock wheel gates would require that the hydraulic power units and controls be relocated to the appropriate heights. The penstock inlet temperature shutters would be extended upward commensurate with the physical dam raise.

Real Estate Requirement

Under Alternative 3, private property would be affected at the Mooney Ridge site, and at 12 sites around the reservoir, the waters would extend to the boundaries of the current project. For the most part, the areas that would be affected are drainages and streams that feed into the reservoir. At Mooney Ridge, a new dike would be constructed to protect the backyards. A flood easement may be purchased from the property owners if this is the owner's indicated preference. PG&E's Newcastle Power Plant also would be affected. The power plant lies on Federal project land. To avoid effects on the power plant, a protecting parapet wall would be built around the plant. At the 482-foot flood pool elevation, impacts on roadways at Browns Ravine and Salmon Falls Road would be minimal. Analysis is ongoing to determine whether structural mediation or alternative routes would be required.

Real estate requirements for borrow material and environmental mitigation would be similar to those under Alternative 2.

Operation

The operations plan for Folsom Dam regulates the reservoir storage space available for flood control and water releases from the dam. Under the existing operating criteria, 400,000 acre-feet of the total storage capacity of 975,000 acre-feet are allocated to flood control. However, the Bureau and SAFCA have an interim reoperation agreement that allows for operation of the dam to include a variable storage space ranging from 400,000 to 600,000 acre-feet. Implementation of Alternative 3 would increase the flood storage capacity of the dam by 95,000 acre-feet, for a total range of 495,000 to 695,000 acre-feet.

Water releases from the dam are made through eight gated outlets at the lower level of the dam, five main spillway gates, and three auxiliary spillway gates (used only in emergencies). Releases are restricted by the capacity of discharge structures and by the existing operation criteria that limits the increases in release rates. The lower level outlet capacity is 115,000 cfs; after inflows exceed this outflow capacity, the reservoir begins to fill. The outflow rate remains at 115,000 cfs until the water level reaches the spillway crest, at which time spillway releases from the main gates can begin. The

operations plan restricts the maximum rate of increase to 15,000 cfs per hour until outflow reaches the 115,000-cfs objective release limit. Increased releases are limited to 15,000 cfs per hour to minimize erosion damage to levees and banks due to sudden large increased outflows while the objective release limit is set to prevent flows that exceed the safe carry capacity of the downstream river channel.

The emergency release operation plan under Alternative 3 and the physical features of the dam would allow for surcharge storage to elevation 490 feet without overtopping the emergency spillway gates while they are in the closed position. Once the water surface reaches the existing surcharge storage space, the dam is operated with the objective of preventing the dam from being overtopped. Emergency release operations include opening the spillways and maintaining a release of 160,000 cfs (the maximum amount the downstream levees can handle) before the reservoir reaches elevation 490 feet. The maximum duration of the emergency release of 160,000 cfs would be 48 hours.

Accomplishments and Residual Risk

Implementation of Alternative 3 would solve the existing dam safety problem because the dam would be able to pass the PMF.

Alternative 4: Twelve-Foot Dam Raise/487-Foot Flood Pool Elevation

Description

This alternative is judged to be the highest raise possible without encountering severe technical problems necessitating removal of the embankment wrap sections, dewatering of the reservoir, foundation work, and extension of the concrete non-overflow sections. As with the other dam enlargement alternatives, flood damages would be reduced by physically enlarging the flood control space behind Folsom Dam. This plan would incorporate most of the project features described under the previous dam raise alternatives with some exceptions. In addition, once the flood pool elevation reaches above approximately elevation 482 feet, preliminary stability analyses indicate that conventional overturning stability criteria would not be satisfied. To satisfy this criterion, additional structural improvement is needed both on the downstream face and within the concrete dam monoliths.

This plan would raise the dam and surrounding dikes by 12 feet, from the existing top of dam crest elevation of 480.5 feet to 492.5 feet. This would provide an increase in the dam's water storage capacity of 157,000 acre-feet. The physical raise provides 5 feet of freeboard for wind and wave run up and possible backwater from spillway flows encroaching on the spillway bridge. The top of the flood space would be increased from 474 feet to 487 feet. Improvements to L. L. Anderson Dam (French Meadows reservoir) to pass the PMF are needed so that Folsom Dam can safely pass the PMF with 5 feet of freeboard. The plan components, real estate requirement, operation, accomplishments

and residual risk, and plan economics and cost sharing associated with Alternative 4 are described below.

Plan Components

The major structural modifications.

Raise Concrete Dam

The concrete portions of Folsom Dam outside of the spillway area would be raised to contain the higher flood pool elevation by removing the top of the concrete nonoverflow sections down the bond break joint at elevation 478.0. This raise could be accomplished through a combination of raising the dam crest with roller compacted concrete, and constructing a 3.5-foot parapet wall, with sealed vertical joints to prevent leakage during extreme floods. The new top-of-dam elevation would be 492.5 feet, and the top-of-the-roadway elevation would be 489 feet. Measures to satisfy the stability criteria include both a concrete buttress on the downstream side of the spillway and post-tension anchors installed in the dam.

Concrete Dam Stability Measures

To satisfy stability criteria for flood pool elevations in excess of approximately 482 feet, additional measures are required, as follows:

- **Buttress**. The downstream face of accessible dam monoliths would be excavated and resurfaced with additional structural concrete to provide the base width needed for each monolith. This would include the main spillway monoliths, as well as the nonoverflow monoliths between the spillway and the right wing dam wrap fill retaining wall.

- **Foundation anchors**. High-capacity rock anchors, consisting of multiple strands of high-strength, prestressed steel tendons, would be drilled and grouted into holes located near the axis of the dam. Location of the anchorage zones and stressing blocks would be staggered vertically to avoid coincidence of the stressed zones. Top anchorage blocks would be located on the spillway crest. Anchorage would extend to galleries or adits in the nonoverflow monoliths. Anchorage would be provided for all monoliths except the last four at each end of the concrete dam section.

Replace Spillway Gates

All eight spillway radial gates would require replacement under this plan. The new gates would be approximately 72 feet high (22 feet taller than the existing gates), with a radius of approximately 65 feet. The top-of-gate elevation in the closed position would be 489.5

feet, providing 2 feet minimum of freeboard on a design flood control pool elevation of 487 feet.

Modify Spillway Bridge Piers

To accommodate the additional height and loading, the existing piers would require extension and strengthening, and new trunions would be located on the top of the new pier extensions. New high-strength, post-tensioned steel cables would be cored and grouted into the pier/dam section to provide for trunion anchorage. New hoisting motors and chains, and new catwalks would also be required.

Replace Spillway Bridge

This alternative would include the same replacement bridge as would Alternatives 2 and 3. The existing eight-span spillway bridge would require replacement commensurate with the higher dam elevation. The new bridge would be approximately 400 feet long and 35 feet wide with one through traffic lane in each direction.

Extend Stilling Basin

Work to extend the stilling basin would be identical to that described for Alternatives 2 and 3.

Raise Embankment Dams and Dikes

As with the concrete dam section, the left and right embankment wing dams beyond the center concrete section would need to be raised and expanded. The embankment dams and dikes around the perimeter of the reservoir that must be raised in direct relationship to the dam raise to accommodate higher water storage elevations. These embankments and dikes would be raised and extended with a combination of earthfill and a reinforced concrete crest wall, faced with riprap matching the existing embankment slope. The existing impervious cores in Mormon Island Dam and dikes 5 and 7 would have a slurry wall constructed down to elevation 466 feet after the dam has been raised; therefore, the cores of these dam and dike features would be raised to elevation 487 feet and connected to the crest wall foundation. A 3½-foot-high concrete parapet wall would be constructed at the top of embankment dams and dikes to prevent wave wash from spilling out of the reservoir. No permanent water storage elevations are planned to reach the parapet wall.

Improve Newcastle Powerhouse

During very rare floods, there would be the potential to inundate a portion of the Newcastle Powerhouse located on the northwest shoreline of Folsom Reservoir. To mitigate this effect, a floodwall would be constructed around the powerhouse and the access road would be raised. The wall would be approximately 16 feet high and constructed of reinforced concrete. Further study is required to explore the feasibility of floodproofing or other nonstructural measures to address the powerhouse.

Modify Elevator Tower

The dam elevator tower would require extensive modification under this plan. Elevator modifications would consist of raising the elevator roadway lobby, adding a floor to the top of the tower, relocating the elevator machinery up one floor, and modifying the elevator controls.

Borrow Areas and Haul Distances

Two borrow sites have been identified that would provide suitable embankment material. A maximum of 90 acres of land would be excavated at the Peninsula site, located between the North and South Forks of the American River. Approximately 140,000 cubic yards of material would be taken from this site. A maximum of 140 acres of land would be excavated at the Mississippi Bar site, located just upstream and northeast of Nimbus Dam. Approximately 855,000 cubic yards of material would be taken from this site for this alternative. The haul distance and route to the Peninsula and Mississippi Bar borrow sites would be the same as those described for Alternatives 2 and 3.

Location of Construction Staging Area

All construction staging areas would be located immediately adjacent to the landside of existing earthen dams and dikes to minimize disturbance of outlying environmental resource areas.

Construct Minimum Permanent Bridge

During construction of a dam raise, the spillway bridge would be closed to daily vehicular traffic, and a minimum permanent bridge, approximately ¼ mile in length, would be constructed southeast of the dam and merge with the existing Folsom Dam road near the left wing dam abutment. The bridge would be identical to that described for Alternative 2.

Raise Folsom Dam Road East of Dam

Approximately one-third of a mile of Folsom Dam Road southeast of the left wing dam is at an elevation below 480.5 feet. This section of road would be inundated before the reservoir surface reached the operating flood control pool of 487 feet. To keep the road passable while Folsom Dam is under a flood operation, about one-third of a mile of road would be raised in place. The alignment would be within project lands, so no new rights-of-way would be required.

Mooney Ridge Flood Easement

The raise in lake elevation would affect 7 residential parcels in the Mooney Ridge area where the lower portion of steep backyard areas would be inundated. In addition the first

floor of one residence could be flooded if waters reach the top of the flood space, at elevation 487 feet. The inundations would be very infrequent and of short duration. The proposed mitigation would be to construct a new dike to protect the backyards. As described in Alternatives 2 and 3, other alternatives to mitigate higher reservoir stages will be explored.

Enlarge L. L. Anderson Dam Spillway

Work on the L. L. Anderson Dam spillway would be identical to that described for Alternatives 2 and 3.

Additional Structural Work

The gantry crane would be temporarily relocated from the top of the dam while the spillway bridge is raised. The reach of the upper crane on the gantry would need to be enlarged to handle spillway gate stop logs. Alternatively, the gantry crane could be removed and replaced with a portable crane.

The penstock wheel gates would require that the hydraulic power units and controls be relocated to the appropriate heights. The penstock inlet temperature shutters would be extended upward commensurate with the physical dam raise.

Real Estate Requirement

Under Alternative 4, habitable structures in the Mooney Ridge area would be affected, and at 12 sites around the reservoir, the waters would extend beyond the boundaries of the current project. For the most part, the areas that would be affected are drainages and streams that feed into the reservoir. At Mooney Ridge, a new dike would be constructed to protect the backyards and structures. PG&E's Newcastle Power Plant also would be affected. The power plant is on Federal project land. To avoid effects on the power plant, a protecting parapet wall would be built around the plant.

Implementation of Alternative 4 also would have an impact on roadways at Browns Ravine and, for short durations, on Salmon Falls Road. Analysis is ongoing to determine whether structural mediation would be required, whether alternative routes would be available and sufficient for the period of inundation, and whether additional lands should be acquired and the road rights-of way modified to ensure that they are not flooded. The reservoir also would inundate portions of streams that feed into the reservoir.

Real estate requirements for borrow material and environmental mitigation would be similar to those under Alternative 2.

Operation

The operations plan for Folsom Dam regulates the reservoir storage space available for flood control and water releases from the dam. Under the existing operating

criteria, 400,000 acre-feet of the total storage capacity of 975,000 acre-feet are allocated to flood control. However, the Bureau of Reclamation and SAFCA have an interim reoperation agreement that allows for operation of the dam to include a variable storage space ranging from 400,000 to 600,000 acre-feet. Implementation of Alternative 4 would increase the flood storage capacity of the dam by 157,000 acre-feet for a total range of 557,000 to 757,000 acre-feet.

Water releases from the dam are made through eight gated outlets at the lower level of the dam, five main spillway gates, and three auxiliary spillway gates (used only in emergencies). Releases are restricted by the capacity of discharge structures and by the existing operation criteria that limits the increases in release rates. The lower level outlet capacity is 115,000 cfs and once inflows exceed this outflow capacity, the reservoir begins to fill. The outflow rate remains at 115,000 cfs until the water level reaches the spillway crest, at which time spillway releases from the main gates can begin. The operations plan restricts the maximum rate of increase to 15,000 cfs per hour until outflow reaches the 115,000-cfs objective release limit. Increased releases are limited to 15,000 cfs per hour to minimize erosion damage to levees and banks due to sudden large increased outflows while the objective release limit is set to prevent flows that exceed the safe carry capacity of the downstream river channel.

The emergency release operation plan under Alternative 4 and the physical features of the dam would allow for surcharge storage to elevation 492 feet without overtopping the emergency spillway gates while they are in the closed position. Once the water surface reaches the existing surcharge storage space, the dam is operated with the objective of preventing the dam from being overtopped. Emergency release operations include opening the spillways and maintaining a release of 160,000 cfs (the maximum amount the downstream levees can handle) before the reservoir reaches elevation 492 feet. The maximum duration of the emergency release of 160,000 cfs would be 48 hours.

Accomplishments and Residual Risk

Implementation of Alternative 4 would solve the existing dam safety problem because the dam would be able to pass the PMF.

Alternative 5: Stepped Release to 160,000 cfs

Description

The Stepped Release Plan primarily consists of raising the objective release and "stepping" releases from Folsom Dam during infrequent floods, depending on the severity of the storm and its effect on storage in Folsom Reservoir. This plan is a stepped objective release from 115,000 to 145,000 cfs, and then stepped to 160,000-cfs emergency release. By limiting the controlled release to 160,000 cfs, only minimal work is needed to modify the levees and bridges in the Lower American River.

This alternative includes extensive mitigation for hydraulic impacts downstream in the Sacramento and Yolo Bypasses.

A major part of this plan is to mitigate for increased flows downstream of the American River in the Yolo Bypass, the Sacramento River below the bypass, and affected tributary sloughs and streams. Increased flows from this stepped release plan would increase water surfaces and increase the risk of levee failure in the Yolo Bypass and lower Sacramento River. Impacts are limited to 145,000 cfs because flows are purposely held to this level until downstream flood conditions are such that increasing above 145,000 cfs would not result in an impact greater than without-project condition. To mitigate for increased flows, the Sacramento Weir and Bypass would be widened, and levees in the Yolo Bypass and sloughs would be raised, and levees along the lower Sacramento River would be modified. The mitigation is designed so that all non-floodway lands will have the same overall risk of flooding as under without-project conditions (with Common Features and Folsom Dam Modifications in place).

This alternative does not include dam safety improvements to Folsom Dam. This alternative can be implemented without modifications to Folsom Dam and spillway to allow passage of the PMF.

Plan Components

Lower American River

Raise and Strengthen Existing American River Levees. A slurry wall or other strengthening measures may be needed along the Lower American River from I-5 to 5,000 feet upstream of the Natomas East Main Drainage Canal.

Levee strengthening by a stability berm and lengthening the levee slope would be constructed on right bank of the American River from the Sacramento River to about the NEMDC. The stability berm would be 7 feet high and extend the levee base about 15 feet on the land side. Some sections of the landside levee slope would be extended so that the slope would be 2 horizontal to 1 vertical.

Erosion protection would be placed along 5.8 miles of the levees so the levees could withstand the higher flow velocities associated with this plan.

It is anticipated that the increased flows would not erode natural channel banks leading to undercutting of levees; thus, bank protection is not required.

New Levees and Floodwalls. No new levees or floodwalls would be needed under this alternative.

Modify Bridges. No bridges would require modification under this alternative

Modify Local Drainage Facilities. The higher water surface elevations caused by the increased releases could adversely affect the operation of many pumping and drainage facilities in the City and County of Sacramento. These facilities collect rainfall runoff from the protected areas of Sacramento and convey it to the American River by pumping or gravity flow. The facilities were evaluated to determine if they are negatively impacted by changes from the Stepped Release Plan. Modifications to drainage facilities are based on impacts from the expected 145,000 cfs objective release profile. Impacts from higher releases are ameliorated by the flood protection provided by the alternative for these less frequent events.

Summary of Drainage Facilities

Type of Facility and Total	Facilities Requiring Modifications
Pumping plants-9	7
Gravity drains-17	2
Drainage channels-4	0[1]
Sumps-11	11

[1] Modifications to Mayhew drain may not be required, depending on modifications to this facility under the Common Features Project.

Four types of modifications to the above facilities were formulated: raise existing pump discharge invert, new pumps and motors, new pump discharge line, and new pump station.

Raise Existing Pump Discharge Invert. The existing pumping plants have pipes passing through the levees. The pipes would be raised so that the low invert elevation would be above the Probable Failure Point (PFP) at that location. This would be done to ensure that the levees could safely pass the objective release without backflow to the land side. The raises vary from 2.2 to 10.5 feet. A minimum of 2 feet of cover is required over the top of the raised discharge lines. This will require the levee crown to be ramped over the discharge lines. The raised pipes will be welded steel lines.

New Pumps and Motors. The increased head on the pumps due to the change in elevation will reduce the capacity of the pumps. The flow rate of the pumps would be reduced, which would cause overloading of the motors. These motors would be replaced with

larger units; in addition the pumps and electrical equipment would be modified to maintain capacity. In some cases, only motors may need to be modified.

New Pump Discharge Line. In some cases, the higher capacity pumps will require construction of a new discharge line through the levee.

New Pump Station. The existing Del Dayo and Tiffany Lane gravity drains would require the addition of new pump stations, pumps, motors, and possibly new discharge lines. At Del Dayo drain, (river mile 11.9) new 36-inch pumps with a 26,900-gpm capacity would be required. Two 36-inch welded steel discharge lines would convey flows to the river channel. At Tiffany Lane drain (river mile 13.2), 2 new 8-inch pumps with a 900-gpm capacity would be required. Two 8-inch welded steel discharge lines would convey flows to the river channel. The new pumping plants would be fenced.

Appropriate modifications to drainage facilities to the American River.

Drainage Facilities Requiring Modifications							
Facility	River Mile/Bank	Owner	Raise Existing Discharge Invert	Modify/Replace Existing Pumps	New Pump(s), Motors	New Discharge Line	New Pump Station
Pumping Plant D-01	11.7 / Right	County of Sacramento	✓				
Pumping Plant D-02	9.0 / Right	County of Sacramento	✓				
Pumping Plant D-05	5.5 / Right	County of Sacramento	✓		✓	✓	
Pumping Plant D-06	10.9 / Left	County of Sacramento	✓	✓			
Pumping Plant D-10	10.0 / Left	County of Sacramento	✓	✓			
Pumping Plant D-11	13.2 / Left	County of Sacramento	✓				
Pumping Plant D-43	10.0 / Right	County of Sacramento	✓	✓			
Del Dayo Gravity Drain	11.9 / Left	County of Sacramento					✓
Tiffany Lane Gravity Drain	13.2 / Left	County of Sacramento					✓
Mayhew Drain Channel	10.9 / Left	County of Sacramento					
Sump 010	4.6 / Left	City of Sacramento	✓	✓			
Sump 058	1.3 / Right	City of Sacramento	✓				
Sump 091	7.4 / Left	City of Sacramento	✓		✓		
Sump 092	8.0 / Left	City of Sacramento	✓		✓		
Sump 095	6.4 / Right	City of Sacramento	✓	✓			
Sump 099	3.9 / Left	City of Sacramento	✓	✓			

Drainage Facilities Requiring Modifications							
Facility	River Mile/Bank	Owner	Raise Existing Discharge Invert	Modify/Replace Existing Pumps	New Pump(s), Motors	New Discharge Line	New Pump Station
Sump 101	6.1 / Left	City of Sacramento	✓	✓			
Sump 109	8.2 / Right	City of Sacramento	✓	✓	✓		
Sump 111	0.9 / Left	City of Sacramento	✓				
Sump 151	3.1 / Right	City of Sacramento	✓	✓			
Sump 152	4.8 / Right	City of Sacramento	✓	✓			

Modify Water Intake Facilities. Several water intake facilities and wells operated by local districts would be affected by higher flow. To mitigate potential damage due to scour or the facilities would be strengthened or armored. Mmodifications to these facilities required for this alternative.

Water Intake Facilities Modifications			
Facility	Location	Owner	Modification
Fairbairn Water Treatment Plant			
Rossmoor Bar collection wells		Carmichael Water District	
Infiltration wells		Arcade Water District	

Relocate Utilities. Besides the bridges, internal drainage facilities, and water intake facilities, there are many other items in the lower American River under without-project conditions that are not flood control related, but that would require modifications or relocations for higher objective releases. These include recreation facilities, pipelines, roads, bike trails, utilities, fences, signs, and numerous other items.

A review of the levee logs identified many pipelines and other utilities passing through the levees. In general, these would be required to pass through the levee above the PFP profile. Therefore, some will require raising. Some existing pipes passing through the levees below the current design water surface are already not above the high water mark. Whether to raise these will be examined in more detail during final design. Previous study has identified about 50 pipes passing under the levee crowns that would likely need to be raised.

Borrow Sites. Borrow for levee raising and other fill requirements would be taken from a site located just south of Old Placerville Road and west of Mather Field. Additional borrow would be from Port of Sacramento dredge tailings disposal sites.

Construction Staging Areas. Six staging areas used for the Common Features construction would be available for use. Five of the areas are located southeast of Cal Expo: four on the north bank and one on the south bank. One is located just west of Cal Expo.

Downstream from American River

Listed below are components required for hydraulic mitigation. As explained earlier, work would be done to levees in the Sacramento Bypass, Yolo Bypass, Sacramento River, and tributary sloughs to reduce the overall flood risk to without-project conditions.

Modify the Sacramento Weir and Bypass. The Sacramento River south of the American River is at capacity during major storm runoff events. Hydraulic impacts may be more easily mitigated in the Yolo Bypass than the Sacramento River. The Yolo Bypass is broad and can carry larger flow with less increase in stage and that the real estate requirements can be obtained more economically. Accordingly, to ensure that the higher flows from the American River flow into the Yolo Bypass instead of down the Sacramento River, the Sacramento Weir and Bypass would be modified.

The existing Sacramento Weir and Bypass are located on the west side of the Sacramento River (river mile 63) in Yolo County, approximately 3 miles northwest of the City of Sacramento. The weir and bypass are used to divert flood flows from the Sacramento and American Rivers to the Yolo Bypass.

The existing weir is a reinforced concrete structure that is 2,000 feet wide and has 48 bays. It consists of a concrete overflow weir with flashboards and a concrete stilling basin. The structure also supports a reinforced concrete deck for two lanes of vehicular traffic (Sacramento River Road) and a structural steel bridge for one railroad line (Yolo Shortline Railroad). The weir and the bridge piers are supported on pile foundations.

The Sacramento Bypass channel is approximately 9,000 feet long connecting the Sacramento River and the Yolo Bypass.

The additional 30,000 cfs from the higher American River objective release would be directed into the Yolo Bypass by widening the Sacramento Weir and Bypass. It has been determined that it is more efficient to move the higher flows from the American River to the Yolo Bypass because it is easier to mitigate hydraulic impacts in the Yolo Bypass than the Sacramento River.

The Sacramento Weir and Yolo Bypass would have to be widened by 1,000 feet. The new 1,000 feet of weir would have the same section and configuration as the existing weir. The new weir would consist of 25 forty-foot-wide bays and will be located to the north of the existing weir along the alignment of the railroad line.

A temporary railroad line and road would be constructed that bypass the weir construction. The temporary railroad alignment uses 750-foot radii with transition segments. This is the railroad owner's minimum criterion. The speed of the train would be about 15 mph on this temporary bypass. The Sacramento River Road would be connected along a new alignment to the existing road after passing over the new weir.

Upon completion of construction of the new weir, the temporary railroad and road bypasses would be removed.

Widening of the bypass would occur by constructing a new levee on the north bank. A portion of the original Sacramento Bypass north levee would be as borrow material. The lower portion of this levee would be graded and seeded to provide mounds for wildlife habitat. In addition, there is an old landfill that would have to be removed when the bypass is widened. The landfill occupies about 20 acres of land and averages about 5 feet deep.

There would be some relocations required with this work. Two agricultural pumping plants and a gaging station would have to be relocated, along with four buildings.

Sacramento Bypass Borrow Site and Construction Staging Area. The borrow material for this alternative will consist of dredge tailings from the Sacramento Deep Water Ship Channel as well as levee material from existing Bypass north side levee. Staging Areas will be chosen to minimize environmental impacts.

Raise and Strengthen Levees in the Yolo Bypass, Sacramento River, Sloughs. Yolo Bypass and tributary and distributary sloughs levees would be modified as needed.

Widening the Sacramento Weir and Bypass would increase flows in the Yolo Bypass, the Sacramento River downstream in the vicinity of Isleton, and on tributary and distributary sloughs. To reduce the risk of flooding to preproject conditions, selected reaches of levees would be improved. Within a levee reach that protects a hydraulic subarea, levees judged most likely to fail first would be strengthened. As more levees are strengthened, the risk of flooding in the protected subarea falls. Levees would be improved until the resultant risk of flooding has fallen to preproject conditions.

Levees would be improved by constructing slurry walls to cut off seepage through the levee, or by constructing landside berms to increase stability. These actions are intended to raise the probable nonfailure point (PNP). Results of a reevaluation of location and extent of modifications necessary will be provided in the draft report.

Type and Extent of Hydraulic Mitigation Work	
Stream	Levee Raise (miles)
Yolo Bypass	
Cache Creek	
Willow Slough Bypass	
Haas Slough	
Cache Slough	
Miner Slough	
Lindsey Slough	
Snag Slough	
Steamboat Slough	
Sacramento River	

An alternative method of hydraulic mitigation would be to lower the water surface of the Yolo Bypass to pre-project conditions by removing obstructions or widening the bypass. This measure could have less environmental impact, and could be less costly. Widening the Yolo Bypass, however, may require lands and/or easement purchases.

Yolo Bypass and Associated Sloughs, Borrow Sites and Staging Areas. The borrow locations for construction in these downstream areas would be dredge tailing disposal sites at Grand, Decker and Prospect Islands as well as the Sacramento River Deep Water Ship Channel. Staging Areas would be located in environmentally safe areas, such as agricultural fields.

Real Estate Requirement

Lower American River

Lands would be required for environmental mitigation. No additional land requirement has been identified.

Downstream of American River

Real estate acquisition would be required for modifying the Sacramento Weir and widening the Sacramento Bypass by 1,000 feet. Lands also would be required for levee modification for hydraulic mitigation in the Yolo Bypass, Sacramento River, and associated sloughs.

Lands would also be required for environmental mitigation.

Operation

In the stepped operation, the initial step flow is 115,000 cfs, the discharge capacity of the Folsom Dam outlets. Discharge increases as the reservoir stage encroaches into the flood space and reservoir inflow continues to increase. For this plan discharge progressively increases to 145,000 cfs whereas under without-project conditions the discharge is held to 115,000 cfs. Once 145,000 cfs is reached, it is held until flood conditions are such that under without-project conditions flood damages would have begun. At this point, about frequency .0167 or 1 chance in 60 years, discharges would increase to the channel capacity of 160,000 cfs, depending on inflows to and water surface of Folsom Lake. The Lower American River channel and levees would be improved as described above to better accommodate the emergency flow of 160,000 cfs. Hydraulic mitigation features downstream from the American River are based on a release of 145,000 cfs. Although impacts are not severe enough to consider this a taking of property, mitigation is deemed necessary because the Sacramento and Yolo Bypasses are designed for 115,000 cfs maximum flow from the American River, and the additional releases would actively encroach on design capacities and increase flood risk.

Alternative 6: Stepped Release to 160,000 cfs and New Outlet at Folsom Dam

Description

In addition to the Stepped Release to 160,000 cfs, this alternative would include stepping early to 145,000 cfs through the use of new low level outlets that would be added to Folsom Dam as part of this alternative. A new outlet would be added at Folsom Dam to increase the early release capacity from 115,000 cfs to 145,000 cfs. The higher early release would result in conserving flood storage up by stepping to 145,000 cfs earlier than without-project condition. The release would step to 160,000 cfs in a manner similar to that under Alternative 5.
This plan would not include a Folsom Dam safety component.

The plan components, real estate requirement, operation, accomplishments and residual risk, and plan economics and cost sharing associated with Alternative 6 are described below.

Plan Components

This plan would include all the components of Alternative 5. In addition, this plan would include construction of an additional outlet to increase the outlet release capacity from 115,000 cfs to 145,000 cfs. In addition, modifications to the stilling basin and flip buckets located under the auxiliary spillway would be needed. This plan would also likely change the dam operations by modifying release.

Folsom Dam

A new low-level outlet would be added to Folsom Dam to allow the dam to make an earlier release of 145,000 cfs. The outlet consists of a 6-foot by 12-foot gated conduit through the dam, exiting on the auxiliary spillway face and discharging into the spillway stilling basin. Capacity of the outlet would be 30,000 cfs at gross pool. Because of the erosion potential in the impact area below the auxiliary spillway due to the higher release, a plunge pool to dissipate the force of the higher release would be constructed.

Lower American River

Levee improvements, facility modifications, and relocations would be as described for Alternative 5.

Downstream from the American River

Modifications to the Sacramento Weir and Bypass and hydraulic mitigation would be as described for Alternative 5.

Real Estate Requirement

The real estate requirements under Alternative 6 would be the same as under Alternative 5. There may be an additional requirement of a disposal area for excess material generated by modifications to the stilling basin at the auxiliary spillway.

Operation

With this plan, the low-level outlets will release up to 145,000 cfs, approximately matching inflow to Folsom Reservoir, without a step at 115,000 cfs. The 146,000-cfs flow would be maintained until Folsom Dam inflow and storage conditions are such that under without-project conditions, flows at the mouth of the American River would be at 160,000 cfs and thus stepping up to that flow with the project in place would not be an impact. Folsom Dam operation would depend on release rules that will govern controlled releases to 145,000 cfs, then to 160,000 cfs. Alternative 6 does not include a dam safety component

.

Alternative 7: Stepped Release to 180,000 cfs

Description

This plan represents the "high end" of a stepped release plan. Similar to Alternative 5, it consists of increasing the objective releases from Folsom Dam during floods from 115,000 to 145,000 cfs, but the emergency release is increased from 160,000 cfs to 180,000 cfs. Releases in excess of 145,000 cfs would depend on the severity of the storm

and its effect on storage in Folsom Reservoir. The levees and some bridges (Howe Avenue and Guy West Bridges) along the Lower American River would need to be modified to accommodate a flow of 180,000 cfs.

Identical to Alternative 5, the increased 145,000-cfs objective release would require extensive downstream mitigation.

This alternative does not include dam safety improvements to Folsom Dam.

The plan components, real estate requirement, operation, accomplishments and residual risk, and plan economics and cost sharing associated with Alternative 7 are described below.

Plan Components

Lower American River

Raise and Strengthen Existing American River Levees. About 13.5 miles of Federal and non-Federal levees along the north and south banks of the American River would be raised. The average raise for both Federal and non-Federal levees would be approximately 2 feet. Levees would be raised on the river side to avoid impacts to land use and development on the land side. The total width of affected areas associated with levee raising would be approximately 30 feet. Of this, permanent impacts due to expansion of the levee base would average 10 feet. There would also be a 10-foot permanent easement and a 10-foot temporary construction easement. The crown width would be maintained.

A total of 1.1 miles of existing levees would be strengthened with a slurry cutoff wall. The levees that require strengthening are on the left bank at Tiffany Farms and Cordova Meadows near river mile 13. The Tiffany Farms levee is a private levee, and the Cordova Meadows levee is a Sacramento County levee. There would also be a 10-foot permanent easement and a 10-foot temporary construction easement.

Levee strengthening by a stability berm and lengthening the levee slope would be constructed on right bank of the American River from the Sacramento River to about the NEMDC. The stability berm would be 7 feet high and extend the levee base about 15 feet on the land side. Some sections of the landside levee slope would be extended so that the slope would be 2 horizontal to 1 vertical.

Erosion protection would be placed along 5.8 miles of the levees so the levees could withstand the higher flow velocities associated with this plan.
It is not anticipated that the increased flows would erode natural channel banks leading to undercutting of levees, thus bank protection is not required.

New Levees and Floodwalls. Work includes constructing 2 miles of new levees and 1.7 miles of floodwalls. An objective release of 180,000 cfs would cause the river to flood areas that are not now flooded at the 160,000-cfs flow. The new levees and walls would protect those areas. The new levees would have an average height of approximately 5 feet, with a crown width of 20 feet and average base of 45 feet. There would be 10-foot-wide permanent easements on both sides of the levee. The total width of affected area associated with the new levees would be approximately 75 feet. New floodwalls would be constructed around Goethe Park and the Nimbus Hatchery. The Goethe Park floodwall would have an average height of 3 feet, with a 10-foot-wide permanent easement and a 6-foot-wide temporary construction easement. The Nimbus Hatchery floodwall would have an average height of 2 feet, with a 10-foot permanent easement, and a 5-foot temporary construction easement. The total width of affected area associated with the Nimbus Hatchery floodwall would be 15 feet.

Modify Bridges. Flows up to 180,000 cfs in the Lower American River channel would be accommodated by raising the height of the Howe Avenue and Guy West Bridges between 3 and 5 feet, and modifying the Union Pacific Railroad (UPRR) trestle.

Howe Avenue Bridge. For the Howe Avenue bridge, a 180,000-cfs flow water surface would be 1.6 feet above the bottom of the bridge (soffit). This would impede flow and cause backwater, raising the water surface 0.5 feet. The Howe Avenue crossing consists of 2 bridges, one for northbound traffic, the other for southbound traffic. Each bridge has 2 lanes.

Howe Avenue bridge would be raised 5.3 feet so the soffit would be at the elevation of the PFP. Nearby bridges over University Avenue and La Riviera Drive would be equally raised. To minimize impacts to traffic, the bridge would be replaced with a new structure at a higher elevation. This approach would allow the existing number of traffic lanes to be maintained throughout the construction period.

- Stage 1 – Construct a new segment of bridge to the planned grade between existing structures.
- Stage 2 – Move southbound traffic to new bridge segment.
- Stage 3 – Demolish the existing southbound bridge.
- Stage 4 – Construct the second segment of the new structure
- Stage 5 – Shift all traffic over to the new segments
- Stage 6 – Demolish the existing northbound bridge

The adjacent overcrossing structures at University Avenue and La Riviera Drive could be raised in the same construction period as the main spans over the American River and would not be subject to the limitation of working within the riverbanks.

Union Pacific Railroad Trestle. The UPRR crossing of the American River near river mile 2.5, upstream of the NEMDC, is a main line owned by UPRR. The right bank trestle of this crossing is about 1,110 feet long and 8 feet wide. It is single track timber pile trestle. This trestle crosses the existing north levee of the American River

approximately 5 feet below the levee crown. The trestle would be inundated during high flows with this plan. Since the velocities are very low in this area, there are no hydraulic or structural problems with leaving the existing structure in place. Therefore, this trestle would not be raised. A flood gate, however, would be constructed where the track crosses the north levee below the levee crown. The structure would be closed whenever there is a potential for high flows along the river. There is also a potential that extreme log and debris loading would overstress some of the piles. To remedy this, the plan includes structural strengthening of the trestle.
Guy West Pedestrian Bridge. This suspension bridge links the Campus Commons neighborhood to the California State University, Sacramento, campus. It is an important and heavily used bicycle and pedestrian commute route across the river, as well as a local landmark. It is owned by the City of Sacramento. The bridge would be raised 3 feet. The operation would uniformly raise the entire suspension span. The bridge approaches would be raised 3 feet and meet the grade of the existing paths. Construction would take about 1 year. Traffic would be rerouted to the H Street bridge, located ½ mile downstream. Traffic would use the existing H Street bridge walkway on the upstream side of the bridge.

Modify Local Drainage Facilities. Pumping stations and drainage facilities that are designed to convey drainage from the landside of levees to the American River with existing 115,000-cfs release would be modified for the 145,000-cfs release. Modifications would be as described for Alternative 5. Other utilities would be relocated above the 145,000-cfs release.

Modify Water Intake Facilities. Required modifications to some water intake facilities located along the American River would be as described for Alternative 5.

Lower American River Utility Relocation. Utility relocation would be about as described for Alternative 5. All relocations, including recreation features, would be identified during final design.

Lower American River Borrow Sites. Borrow sites would be the same as under Alternative 5. .

Lower American River Construction Staging Areas. Construction staging areas would be the same as under Alternative 5.

Downstream from American River

Because the hydraulic mitigation is measured at 145,000 cfs, the features needed downstream from the American River would be the same as for Alternative 5.

Real Estate Requirement

Under Alternative 7, real estate acquisition would be required to support raising and strengthening existing American River levees by 2 feet for approximately 13.5 miles;

providing erosion protection of some levee slopes; constructing 3.7 miles of new levees, floodwalls, or both; raising three bridges; modifying interior drainage facilities; and, downstream of the American River, modifying the Sacramento Weir and widening the Sacramento Bypass by 1,000 feet. The increased flows associated with this alternative also would require levee work in the Yolo Bypass, Sacramento River, and associated sloughs. Real estate requirements for this hydraulic mitigation would be the same as under Alternative 5.

Operation

In the stepped operation, the initial step flow is 115,000 cfs, the discharge capacity of the low-level outlets. Folsom Dam discharge increases as reservoir stage encroaches into the flood space and reservoir inflow increases. For this plan discharge progressively increases to 145,000 cfs whereas under without-project conditions the discharge is held to 115,000 cfs. Once 145,000 cfs is reached, it is held until flood conditions are such that under without-project conditions flood damages would have begun. At this point, about frequency 0.0167 or 1 in 60 year, discharges would increase to the new channel capacity of 180,000 cfs, depending on inflows to and water surface of Folsom Lake. Because conditions below the mouth of the American River for these very rare events would be no worse than with the project, the hydraulic mitigation was limited to the 145,000-cfs release that would be experienced during the more frequent floods.

Because the benefits are less than the costs for the scenario of moderate advance release, Alternative 7 was found to be economically infeasible. Thus, there is no Federal interest in this alternative.

Alternative 8: Stepped Release to 160,000 cfs and 8.5-Foot Dam Raise/482-Foot Flood Pool Elevation

Description

This alternative provides a very high level of flood protection by combining all the features of Alternative 5 with all the features of Alternative 3. Features include dam safety and downstream hydraulic mitigation as described previously. The plan components, real estate requirement, operation, accomplishments and residual risk, and plan economics and cost sharing associated with Alternative 8 are described below.

Plan Components

The plan components under Alternative 8 would be a combination of those under Alternative 5 and Alternative 3.

Real Estate Requirement

The real estate requirements under Alternative 8 would be the same as the combined land requirements under Alternatives 3 and 5.

Operation

Operation of this alternative will be provided in the draft report.

This alternative is not economically justified if advance release is part of the without-project condition. According to this current analysis, if there were no advance release, the benefits would be about equal to the costs, and Alternative 8 would be marginally feasible. Costs for this alternative, however, understated. More detailed cost estimates would show increased costs for bridge raising and mitigation features along the Sacramento River and Steamboat Slough. Also, as the dam raise would be the first increment, the addition of the stepped release as a second increment would not be economically justified. Thus there is no Federal interest in this plan.