

CHAPTER 4.0

PLAN FORMULATION AND SCREENING OF FLOOD DAMAGE REDUCTION MEASURES

4.1 Plan Formulation Process

The plan formulation process consists of these basic tasks:

- Establish specific objectives for implementing a plan to resolve the identified flood and ecosystem restoration problems and opportunities and, as possible, other related water resource needs.
- Define constraints and criteria for formulating an implementable plan.
- Develop measures to solve the identified flood control and ecosystem restoration problems. Evaluate how well these measures satisfy the planning objectives. Eliminate those measures that do not satisfy the objectives.
- Develop alternatives from single or combined measures.
- Evaluate the alternatives and select alternative(s) that best meet planning criteria and maximize benefits over costs.

4.2 Planning Objectives

Because a serious flood problem still exists in the Sacramento area, there is a need for additional flood protection. There is also the need to preserve and restore fish and wildlife habitat and to increase incidental recreation, water supply, and hydropower. The following planning objectives were developed and used in the formulation of flood protection and ecosystem restoration alternatives to address these needs:

- Reduce flood damages in the Sacramento urban area from overflows of the American River. In this regard, the non-Federal sponsors' objective is a high degree of protection appropriate to the extensive potential damage and loss of life that would ensue from an American River flood. This goal is often described as reducing the flood risk to no greater than a 1-in-200 chance of flooding in any given year.
- Restore degraded ecosystem structure, function, and dynamic processes in the American River watershed.

4.3 Planning Constraints and Criteria

4.3.1 Constraints

Fundamental to plan formulation is an understanding of the constraints on the current studies. Following are the major constraints:

- The scope of the measures to be studied is defined by Section 566, Water Resources Development Act of 1999 (Section 566).
- Dam raise measures must be solely for flood control, as stipulated in Section 566.
- Disruptions to the normal operation of Folsom Dam for water supply, hydropower, and flood control must be avoided.
- Folsom Dam safety must not be reduced. For dam raise measures involving major modifications to Folsom Dam, additional dam safety features must be provided so that the dam can meet Federal dam safety requirements with respect to passing the probable maximum flood (PMF).
- Flood protection from existing flood damage reduction projects must not be reduced.
- Disturbance of habitat of threatened and endangered species must be minimized.
- Numerous laws, regulations, executive orders, and policies must be considered, including the National Environmental Policy Act (NEPA), the Fish and Wildlife Coordination Act, the Clean Air Act, and the Clean Water Act.

4.3.2 Criteria

The planning process establishes four criteria for consideration in formulating alternatives: completeness, effectiveness, efficiency, and acceptability. As the planning process continues, these criteria will be applied to alternatives.

4.4 Flood Damage Reduction Measures

The Long-Term Study is supplemental to the 1991 Feasibility Study and the 1996 Supplemental Information Report (SIR). These previous efforts developed and analyzed a full array of alternatives for flood control for Sacramento. The basic findings of the previous efforts remain valid. This study, as directed by Section 566, provides additional information on two previously-authorized alternatives: (1) increasing conveyance capacity through downstream levee modification, and (2) increasing flood storage through raising Folsom Dam.

In addition, this study examines increasing flood storage at Folsom Reservoir through advance release of water based on storm forecasting. This measure would take advantage of the increased early release capacity that will be available after the low-level outlets are enlarged, as

well as improvements in storm-forecasting technology. This measure would be in addition to a prerelease that is part of the without-project condition in the flood management plan update. The difference is that this more aggressive prerelease would require authorization because of an identified cost or effect on other project purposes. Both non-Federal sponsors requested that this measure be added to the Long-Term Study.

4.4.1 Measures Not Being Pursued

For background information, this section provides a description of measures formulated, but not implemented, in the previous studies and explains why they have not been pursued. These flood control measures are organized into two categories. The first category is measures that enable Folsom Dam to increase flood releases to allow higher floodflows to pass safely through or around the Sacramento area. The second category is measures that allow an increase in total system flood storage.

Increase Folsom Dam Flood Releases

The goal of this group of flood control measures is to allow higher floodflows to pass safely through or around the Sacramento area to the Sacramento River and the Sacramento-San Joaquin River Delta. The release of higher floodflows from Folsom Dam would allow better management of the flood control storage space in Folsom Reservoir and would enable the system to control larger floods. Each of these measures relies on releasing a higher volume of floodflow more frequently past Sacramento. These higher releases would translate to higher water surface elevations downstream. The downstream levee modifications that are part of the American River Long-Term Study belong to this class of alternatives.

Increase Objective Release through Setback Levees. One means of increasing channel capacity down the Lower American River is to set back the levees to allow the higher flows at a lower water surface elevation and lower main channel velocities. Two approaches were examined to address the benefits and effects of setback levees. The first was a continuous setback levee from the mouth to approximately river mile (RM) 11. Above this point, natural high ground and channel configurations limit the effectiveness of setback levees. The second approach was to analyze smaller, site-specific setbacks where flow constrictions exist in the river that would yield significant hydraulic benefits.

Continuous levee setbacks would be between 2,000 and 3,600 feet total (left and right) distance from the existing levees. Approximately 3,500 acres of land would be affected on the north side of the river and 2,700 acres on the south side by the proposed continuous setback levees.

All buildings in the floodway defined by the realigned levees would be removed. All bridges would be raised and extended to the realigned levees; bridge abutments and embankments would be relocated to permit unobstructed flow in the Lower American River. Areas previously occupied by buildings, transportation ramps, railroad embankments, and roads would be graded to match the surrounding natural topography. New overbank areas defined by realigned levees would be planted with native vegetation, producing additional wildlife habitat. Extensive modifications to, or relocation of, existing infrastructure would be required.

Costs for this measure range from \$1.1 billion to \$6.7 billion (1996 costs). This measure was deleted from formulation into an alternative plan primarily because of the high construction costs, significant amounts of relocations, and high socioeconomic effects.

Increase Objective Releases through Flood Control Bypass South of Sacramento. This flood control measure would allow increased releases from Folsom Reservoir through a flood control bypass system used in combination with the existing flood control project on the Lower American River. The bypass would move floodwater south of the Sacramento metropolitan area to the Sacramento-San Joaquin River Delta. The main component of the bypass would be Deer Creek and the Cosumnes River floodways. These floodways were chosen because they are relatively undeveloped. The bypass was designed to control runoff from a storm with a 1-in-200 chance of occurring in any year in combination with a variable flood control operation at Folsom Dam and the current objective release of 115,000 cfs from Folsom Reservoir. More frequent flood events up to approximately a 1-in-100 chance of occurring in any year could be controlled by the without-project system without bypass releases.

The flood control bypass system would consist of gated outlet works at Mormon Island Dam, a concrete channel or tunnel system to convey the floodwater to the Deer Creek floodway, channel and levee modifications along Deer Creek and the Cosumnes and Mokelumne rivers, and floodways through the Delta to the San Joaquin River. Approximately 30 miles of improved levees would be constructed west of Highway 99, along the Cosumnes River to the Franklin pond, and control structures provided to reduce backwater effects.

Because the Delta in the vicinity of Interstate 5 (I-5) and the Cosumnes and Mokelumne rivers would already be at capacity (or flooded) when increased releases from Folsom Dam would be required, major improvements would be necessary to prevent American River water from making the situation worse. Part of Bouldin, Deadhorse, and Staten Islands would be converted to a floodway. Approximately 50 to 90 miles of levee improvements would be required for nearby islands to ensure that American River floodflows would not induce flooding to adjacent areas. The estimated construction cost is \$2.1 billion, and the average annual cost is approximately \$206 million.

This measure was eliminated from further study because of its estimated high costs, potential significant environmental and related effects associated with new levee and channel construction, and high socioeconomic effects associated with land requirements and the large number of relocations.

Increase Total System Flood Storage

Increasing the total amount of storage available could enhance flood control in the Sacramento area. Additional flood control storage space could be developed both in the American River watershed, including modifications to Folsom Dam, and in nearby watersheds. The increased storage could increase Folsom Dam's ability to control larger floods by either providing more storage in Folsom Reservoir or by combining upstream storage with Folsom Dam storage.

Acquire Flood Control Storage in Existing Upstream Reservoirs. Five reservoirs in the upper American River watershed—Loon Lake, Ice House, Union Valley, French Meadows, and Hell Hole—provide 90 percent of the existing storage capacity upstream from Folsom Reservoir. However, the five reservoirs drain only a small portion of the upper American River basin and control only a limited volume of runoff. Under existing conditions, no more than 200,000 acre-feet of space in the upstream reservoirs are creditable to flood control for Sacramento with Folsom reoperation. The percentage of existing volume dedicated to flood control varies at each reservoir, so that the active flood control volume would not be greater than the dam's PMF volume.

Under this measure, up to 509,000 acre-feet of space in the five reservoirs mentioned above would be acquired and the space converted to flood control. These reservoirs were built exclusively for water supply and power generation. On the basis of cost estimates for other projects, the cost of modifying each of the outlet works for flood control operation would be between \$10 million and \$20 million. Studies show that acquisition of this space from the utility companies that own the dams would cost between \$350 million and \$700 million. In addition, because of the high location of the reservoirs in the watershed, this space would be unable to substantially improve the flood protection afforded to Sacramento. This measure was not considered further primarily because of the significant high cost to acquire the space and modify the outlet works, because the measure would provide no discernible increase in flood protection benefits over the without-project condition, and because these reservoirs are privately owned and dedicated to other purposes.

Construct Multiple Small Upstream Detention Facilities. This measure involves constructing numerous small flood control detention dams throughout the American River watershed to reduce peak inflows into Folsom Lake. Fifteen small detention reservoirs were sited in the Upper American River watershed based on topographic and watershed data.

The 15 dams could control the peak runoff from approximately 15 percent of the watershed. Each dam would be approximately 100 feet high and could control approximately 20 square miles of runoff. The dams would be ungated, with sluices designed to capture peak runoff and store floodflows up to three days to allow peak downstream flows to pass Sacramento. A typical dam would be provided with spillways to allow excess flows to overtop the dam without threatening its safety. The footprint of this dam would cover approximately 5 acres. The maximum reservoir would inundate approximately 200 acres.

Aggregate material for constructing the dams would be obtained from quarry sites developed near the dam sites. Approximately five quarries would need to be developed, with each covering approximately 50 acres. The project would generate approximately 100 additional daily truck trips. This temporary construction traffic would damage approximately 150 miles of existing roads that would need to be repaired.

Construction on all 15 dams could be completed in approximately 8 years at a cost of approximately \$900 million.

Construction of numerous small-capacity dams on upper basin streams could provide a minor increase in flood protection, but not at economically feasible costs. Based on existing

conditions in the basin and results of studies of similar concepts in other basins, this measure was viewed as impractical. Several small dams could not provide the same or even a similar increase in flood protection as that provided by one large facility located lower in the watershed. Furthermore, the cost associated with constructing several smaller facilities and the cumulative environmental effects from them would significantly exceed the cost and effects from one facility. This measure was deleted from further consideration because of the relatively small influence such dams would have on the downstream floodflows and the higher economic and environmental costs.

Use Offstream Storage on Deer Creek. The American River is one of many west-flowing, roughly parallel rivers that drain the headwaters and slopes of the Sierra Nevada. Interbasin transfer of water has often been used to meet water-related needs. A similar concept also could be used to solve flood problems. The American River is located between the watersheds of the Bear/Feather Rivers to the north and the Cosumnes/Mokelumne Rivers to the south. Additional flood control storage may be provided in other basins near Folsom Reservoir. The topography to the north generally increases in elevation in the area near Folsom Reservoir. This topography combined with the greater distance to the Bear/Feather Rivers makes this option impracticable. Deer Creek, a tributary of the Cosumnes River, comes within 10 miles of Folsom Reservoir. Water could be conveyed from Folsom Reservoir to Deer Creek via gravity flow. Therefore, this option was considered for offstream storage.

This measure would provide additional storage by diverting floodwaters from the American River watershed to the adjacent Cosumnes/Mokelumne Rivers system. Floodflows would be stored temporarily in a detention basin on Deer Creek and released into the Delta via the Cosumnes and Mokelumne Rivers after flood peaks would had passed on those rivers. The measure would be composed of several features:

- Outlet works adjacent to the west side of Folsom Reservoir's Mormon Island Dam.
- A connecting channel extending from the Folsom Reservoir outlet works to the detention basin approximately 8 miles to the south; the channel and outlet works capacity would be 140,000 cfs.
- A 600,000 acre-foot flood detention basin to store diverted floodflows from the American River; the 141-foot-high, random-fill earth embankment dam that would create this basin would extend 5-1/2 miles; approximately 12,000 acres of land would be inundated.
- Channel modifications and revetment protection would be provided along lower Deer Creek, Cosumnes River, and the Delta to accommodate extended flood releases of up to 10,000 cfs. Additional flowage easements would be acquired to compensate for the higher and more frequent releases.

Releases to the detention basin would not be made from Folsom Reservoir until the objective release of 115,000 cfs was reached. On the average, storms with an exceedance interval of 100 years or less would be controlled by Folsom Reservoir and would not require

diversions to the Deer Creek detention basin. After diversions commence, the maximum diversion of 140,000 cfs would be made until the Folsom Reservoir pool begins falling or the detention basin fills. The estimated construction cost for the Deer Creek facilities is \$1.6 billion.

This measure was dropped from further study because (1) it is costly (roughly three times the cost of new storage for similar flood protection in the American River watershed); (2) significant residential and commercial development is taking place in the basin area, more is expected, and it would be adversely affected; and (3) high environmental and related effects are attributable to project construction and operation. Moving floodwaters from the American River to the Cosumnes River basin creates problems because of high flows and induced flooding. It may not be possible to completely mitigate the effects of adding large volumes of water to south Sacramento and San Joaquin counties.

Modify Folsom Flood Control Storage Space. This measure would modify the operation of Folsom Reservoir to change the amount of seasonal flood space available in the winter flood season. From a baseline of the SAFCA/Reclamation variable flood control operation (400,000–670,000 acre-feet), variable space operations of 280,000–500,000 acre-feet, 475,000–670,000 acre-feet, and 535,000–835,000 acre-feet were evaluated. These operation scenarios present a range of variable operation plans both higher and lower than the without-project conditions. The 835,000 acre-foot level is considered a maximum limit below which power and water supply operations of the dam would not be possible. The variable operation plans would operate similarly to the SAFCA/Reclamation baseline condition. When 200,000 acre-feet of space are available in upstream reservoirs, Folsom would be maintained at the lower storage level of the range. As the space is filled upstream, increasing amounts of space would be required in Folsom until the higher storage level of each range would be required in Folsom Reservoir.

This measure would trade additional water conservation storage in Folsom Reservoir for seasonal flood control storage. Under the without-project outlet configuration and objective release, only small increases in flood protection could be achieved through increased reoperation levels.

Increasing the variable storage space would have unknown effects on water supply, downstream fisheries, and endangered species. Until the Bureau completes its EIS on existing reoperation, baseline conditions for this measure will not be known. Thus, this measure is currently not implementable.

Raise Folsom Dam and Spillway. This dam raise measure is greater than and fundamentally different from the dam raise measures that are the subject of the Long-Term Study. This measure requires more extensive modifications to Folsom Dam.

This measure consists of increasing flood storage capacity above the existing gross pool by raising Folsom Dam and spillway. Two levels of dam raising were analyzed: 30 feet and 17 feet. The 30-foot raise is thought to be a maximum acceptable increase in reservoir size. The 17-foot raise is the minimum size required to control the PMF flow. A dam raise of 30 feet would increase flood control storage by 366,000 acre-feet; a dam raise of 17 feet would provide an additional 199,000 acre-feet of storage. Usually, the reservoir elevation would remain at current levels (gross pool elevation of 466 feet), and water would rise into the flood for up to 7 days only

in the event of a larger flood, such as a storm with a 1-in-50 chance or greater of occurring in any year.

The dam raise measures would require raising and extending the existing concrete dam section. In addition, the right and left wing dams, Mormon Island Auxiliary Dam, and the eight dikes would need to be raised and lengthened. New 3.5-foot parapet walls would be provided on the earth embankment wing dams, Mormon Island Auxiliary Dam, and Dikes 1–8. The embankment structures would be raised on the downstream (landward) side to avoid the need for drawing down the reservoir for construction. The downstream raise would result in a shift of the dam crest and centerlines. To raise and extend the concrete portion of the dam, the reservoir would need to be drawn down to allow excavation of the adjacent areas to a firm foundation.

Not only would the dam be raised, but the existing 50-foot gates would be replaced with 65-foot-tall gates. These taller gates would improve the spillway capacity so that the dam would be able to pass a PMF safely; they also would improve the normal flood control capacity. The increased spillway capacity also would require enlarging the stilling basin downstream. The cost would be approximately \$655 million for the 30-foot raise and approximately \$456 million for the 17-foot raise.

This measure would increase the amount of flood control storage space in Folsom Reservoir above the current gross pool elevation by raising the dam and related dikes and enlarging the spillway gates. The measure was not carried forward because preliminary studies indicated that the measure was not cost effective. In addition, the costs of providing the increased flood protection are greater than those for other storage measures that provide a similar amount of additional flood protection.

Excavate Folsom Lakebed. This measure would consist of excavating the Folsom lakebed to create more reservoir capacity. Excavating portions of the lakebed would provide increased storage both above and below the existing spillway elevation. To allow comparison with other measures, this discussion examines an excavated volume of 100,000 acre-feet (160 million cubic yards).

The geology of Folsom Reservoir is basically rocky hills with very thin (3- to 4-foot) soil veneer. The only major quantities of removable soil are found in the American River streambed, which is underwater most of the time. Thus, much of the removal would require dredging, which is an expensive and environmentally damaging process. Because dredging is highly expensive, the cost estimate is based on scraping half the volume from soil in the dry portion of the reservoir and excavating half of the volume from rock. The materials would then be placed close by, filling over the hills and valleys to avoid the extreme expense of trucking. The soil removal and storage costs to create 100,000 acre-feet of flood control space are approximately \$2.5 billion.

Because of its very high cost, this measure was not considered further. The environmental effect of disposal is also very high and would further increase this measure's cost.

4.4.2 Measures Evaluated in This Study

Make Additional Advance Release

The additional advance release measure would increase storage space at Folsom Dam by making releases in advance of inflow. Because it would involve changing the operation of the dam, little or no construction would be required. This measure would be a more aggressive operation than the without-project advance release discussed in Chapter 2.0. It would create additional space in the water supply space following forecast of severe inflow by reducing or eliminating the restriction that the water supply space must be refilled. The aggressive advance release would reduce flood risk, but would have heightened risks of downstream effects; it also would have loss of water supply, hydropower, and associated effects. As is the case with the without-project advance release, this measure would be applied only for very infrequent storms severe enough to threaten to exceed Folsom Dam's capacity to contain and control flows.

Potential Modifications. The concept of additional advance release is intended to achieve greater flood control storage space behind Folsom Dam than does the without-project condition advance release by reducing or eliminating the requirement that there be no effect on water supply. The effectiveness of this measure depends on creating additional opportunities for flood control advance release by allowing it to occur for storms that may not refill the water supply space.

Analysis of Additional Advance Release. Operational studies of the without-project advance release found that there is little or no opportunity for additional advance release. The without-project advance release is limited by the outlet and downstream channel capacity. In other words, there would be no instances in which without-project advance release would be curtailed because the water supply space would not be refilled. Thus, this measure was found to be ineffective because there is no opportunity for additional advance release.

Raise Folsom Dam to Increase Flood Storage

This alternative primarily includes enlarging Folsom Dam to increase the flood storage space. Raising Folsom Dam is an attractive alternative because it achieves increased water storage by altering an existing dam. It avoids the environmental effects and community concerns regarding a new dam on the North and Middle Forks of the American River.

Raising Folsom Dam was evaluated in the 1996 SIR. Larger size raises were evaluated, and although a large dam raise would significantly reduce flood damages to the Sacramento area, it would be extremely costly, have significant long-term effects on the environment and recreation, and have significant short-term effects on water supply and traffic. The concept of a "mini-raise," introduced by SAFCA in 1998, was presented as one of four alternatives in the August 1999 information paper. A small raise would consist of adding material on top of the existing dam sections (with local steepening and other features that do not change the current location of the transitions from concrete to embankment). The size of a small raise is limited by increased loads on the embankment retaining walls; reduced stability of the concrete dam (static and dynamic) from increased water pressure and uplift force; added mass at the top of the dam,

which increases seismic loads and stresses; increased seismic loading on the gate piers; and maximum constructible height of the spillway gates.

Potential Modifications. Enlarging Folsom Dam for flood control includes making the eight spillway gates taller, and raising the spillway bridge and parapet wall on the bridge deck. The top of the wall would be the top of the dam. The wing dams, dikes, and Mormon Island Dam would be raised to match the height of the top of the dam in the spillway section. The dikes would be lengthened to tie into local terrain. Dikes 5 and 7 and Mormon Island Dam have impervious cores which would be too costly to raise since a good portion of the crest of the dam would have to be removed to get down to present impervious core zone at elevation 466 feet. The concrete piers between the gates would be replaced with new, taller piers that would also be enlarged to anchor the larger gates. The top of the dam would be five feet above the top of the operational flood control pool. The five feet of freeboard is required to prevent erosion and failure of the dam through wind and wave runup and wave height.

The flood control space would effectively be enlarged as the top of the operating flood space is raised. New operating rules would be written so that spillway releases would be based on higher reservoir water surfaces and inflow.

The additional flood space would not be used for water supply during the nonflood season, as stipulated in WRDA of 1999 (see Chapter 1).

To identify the most cost-efficient, Federally-supportable plan, three dam enlargement sizes were developed.

3.5-Foot Dam Raise/478-Foot Flood Pool Elevation. This measure was developed as the lowest potential Folsom Dam raise alternative that would provide meaningful flood damage reduction. This represents the highest dam raise achievable without earthwork construction on the embankments. It is essentially identical to the without-project PMF work described in Chapter 2, except that it would be operated with a higher top of flood pool as described below. The flood control component includes a 3.5-foot physical raise of the spillway gates, bridge, wing dams, and dikes so that the top-of-floodpool elevation would be raised from 474 feet to 478 feet. The top-of-dam elevation would be 484 feet. Dam safety work would include lowering the Folsom Dam spillway six feet and enlarging the spillway at L. L. Anderson Dam. Constructing a temporary construction bridge would mitigate traffic effects; traffic would return to the spillway bridge after construction is complete. This measure would provide an additional 47,000 acre-feet of flood storage and is retained for formulation as Alternative 2.

Seven-Foot Dam Raise/482-Foot Flood Pool Elevation. This is the medium raise of the three dam raise measures. The flood control component includes a 7-foot physical raise of the spillway gates, bridge, wing dams, and dikes so that the top-of-flood-pool elevation would be raised from 474 to 482 feet, and the top-of-dam elevation would be raised from 480.5 feet to 487.5 feet. This is the largest dam raise achievable without the additional cost of stability structures. A normal flood pool of 482 feet is close to the threshold at which stability standards would be exceeded without these structures. Dam safety work would be included in this raise as the top of PMF space would be 484.5 feet elevation. With the addition of three feet of freeboard, this would determine the top of dam at 487.5 feet elevation. This alternative would include

spillway widening at L. L. Anderson Dam. Constructing a temporary construction bridge would mitigate traffic effects; traffic would return to the spillway bridge after construction is complete. This measure would provide an additional 95,000 acre-feet of flood storage. It is retained for formulation as Alternative 3.

Twelve-Foot Dam Raise/487-Foot Flood Pool Elevation. This is the largest dam raise measure that is possible within engineering constraints. The flood control component includes a 12-foot physical raise of the spillway gates, bridge, wing dams, and dikes so that the top-of-flood-pool elevation would be raised from 474 feet to 487 feet, and the top-of-dam elevation would be 492.5 feet. The 487-foot flood pool elevation is above the dam overturning and stability threshold. To counteract these forces, a buttress would be constructed on the spillway's downstream face and anchorage would be placed within the dam. For dam safety, the L. L. Anderson Dam spillway would be widened. This measure would provide an additional 157,000 acre-feet of flood storage. It is retained for formulation as Alternative 4.

Environmental Issues and Concerns. The environmental analysis has evaluated the construction-related and operation-related effects on social and biological resources. Major environmental issues that have been identified include construction-related effects on transportation, air quality, recreation, and endangered species and operation-related effects on recreation and land use. These effects are discussed below.

Dam Safety. As mentioned in Chapter 2.0, Folsom Dam can pass approximately 70 percent of the PMF. With implementation of Folsom Modifications, the dam could pass approximately 75 percent of the PMF. The Bureau operates Folsom Dam, but the Corps is responsible for dam safety. The Corps, Bureau, and the State of California recognize that this is a high-hazard dam upstream of a populated area and that its inability to pass 100 percent of the PMF poses a risk downstream.

The Corps has determined that the dam safety standard applicable to Folsom Dam is that it must pass 100 percent of the PMF. Although action to correct dam safety is authorized, dam safety is not funded or scheduled. The dam safety deficiency will be corrected in the long term. The Corps has developed a plan to correct dam safety that is described in Chapter 2.

Because any dam raise measure would be a major modification, it would include features to allow Folsom Dam to pass the PMF without failure. Thus, all dam raise measures include measures in addition to flood control to correct the PMF deficiency. The larger flood control dam raise measures would increasingly provide larger spillway capacity and thus tend toward correcting PMF deficiency. For this reason, larger flood control dam raise measures would need less additional work to correct the PMF deficiency.

Transportation. A critical issue tied to the implementation of enlargement of Folsom Dam is the disposition of public traffic that travels over the dam via Folsom Dam Road. The two-lane roadway is approximately 2.3 miles long and connects Auburn-Folsom Road on the north side of the American River to East Natomas Road on the south side of the river. Approximately 1,400 feet of the roadway crosses the concrete monoliths of the Folsom Dam and spillway. Approximately 4,000 feet of the remainder of the roadway is on top of or adjacent to the earth embankment section of the dam. The dam roadway was not intended as a public

thoroughfare. It has, however, become an important link from areas east of the dam and north of the city of Folsom to developing areas to the east.

Allowing unrestricted access to the dam and its appurtenances increases the exposure of the structures to sabotage or terrorist attack. In addition, there is a risk of environmental and facility damage from potential spills of hazardous and toxic substances. The Bureau has determined that a new permanent bridge downstream of Folsom Dam would provide improved safety and security at the dam, improved access to conduct O&M activities at the dam, and a transportation bypass of the dam that would be designed to more safely handle existing and future traffic conditions. The Bureau has identified a potential alignment for a new permanent bridge and estimates its cost to be approximately \$42 million.

There are, at present, no authorized plans to construct a new bridge to reduce the potential impacts to Folsom Dam. Closing the Folsom Dam Road to local and through traffic is expected to create regional traffic-related effects, including increased costs for local traffic management, increased travel time (additional vehicle miles per person-hours of delay), and increased vehicle O&M). Based on these significant costs and the current lack of authorization for a replacement bridge, traffic will continue to use Folsom Dam Road in the near to long-term future.

An analysis was conducted to determine the most effective way to mitigate short-term effects on local traffic and related conditions attributable to construction of enlargements to Folsom Dam. The following three options were considered regarding the use of the Folsom Dam roadway during construction to determine the most appropriate method for mitigating, to the extent possible, these effects:

- *Full Closure during Construction.* Under this option, the top-of-the-dam roadway would be completely closed to all traffic, including emergency vehicles. During construction, all vehicles currently using the dam road would be rerouted to other existing river crossings, and Folsom State Park operations would be disrupted. The duration of road closure would range from 29 to 35 months depending on the size of the raise. Regional traffic-related effects, including estimated equivalent costs of local traffic management, vehicle O&M, and delay (additional vehicle miles per person-hours of delay) are expected to range from \$17 million to \$21 million depending on the size of the raise. Because these are regional and local effects, they would not be accounted as a project cost.
- *Partial Closure during Construction.* This option would involve constructing the dam enlargement in phases so as to allow limited use of the dam road during certain stages of construction and specific hours of the day. Partial closure would restrict traffic to a single reversible lane with traffic controls during peak commute hours. During the off-peak hours on weekdays and all day on weekends, the road would be completely closed to traffic. Emergency vehicles would be permitted to cross the Folsom Dam roadway at slow speeds during all closure periods. Operations of Folsom State Park would be hampered, but not disrupted. The duration of full closure would range from 21 to 27 months. The regional traffic costs would be similar to the

full-closure option. In addition, primarily because of the resulting extended construction period and efforts required to sequence construction, actual increased costs could amount to an additional \$10 million. Furthermore, conducting construction while allowing traffic on top of the dam may lead to safety problems.

- *Temporary Relocation.* Under this option, Folsom Dam would be closed to all traffic during the construction period, and vehicles currently using the dam roadway would be rerouted around the dam via a new detour bridge constructed before the start of construction. This bridge would be designed for lower speeds and steeper grades than the current bridge and would be used only during construction. This option would eliminate most of the effects on the region. However, the cost of the bridge, which is estimated at \$19.5 million, would be added to the total cost of the Folsom Enlargement Plan. An evaluation of various alignments and bridge types has indicated that the minimum cost for a temporary bridge and a permanent maintenance bridge is essentially the same.

Mitigation. Because of the severe effects on the city of Folsom and surrounding area, it is believed, based on coordination with representatives of SAFCA, the Reclamation Board, and other local interests, that implementation of a flood control project without mitigating for traffic effects during construction would be highly unlikely. The partial-closure option would mitigate some of the traffic effects. However, full closure for up to 27 months would be required during modification to the spillway bridge and piers, raising of the concrete dam, and installation of the parapet wall on the wing dams. Because of the long full-closure period, increase in construction costs, and safety issues, the partial-closure option would not be an effective mitigation method.

Constructing a new temporary construction bridge would fully mitigate these traffic effects. The bridge would avoid the costs of additional automobile mileage and time lost by drivers and passengers who would now be obligated to spend additional time traveling a further distance to cross the American River downstream. In addition, costs of traffic management required to set up a detour would be avoided. Benefits of a detour bridge are about \$21 million. Benefits exceed the cost of \$19.5 million, thus, this mitigation is economically justified.

By accommodating existing and projected traffic flows across the dam road, the temporary detour bridge would also avoid the air quality impacts that would result from redirecting this traffic to other bridge crossings in the area. Without the temporary detour bridge, each vehicle trip affected by the road closure would be lengthened in distance and time. Daily emissions of reactive organic gases (ROG's), carbon monoxide (CO), and oxides of nitrogen (NO_x) attributable to these vehicle trips would be significantly greater than the conditions with a temporary detour bridge.

The cost of the detour bridge could be allocated as the flood control interest in either a new permanent bridge that would be designed for existing levels of traffic (estimated cost of \$42 million) or a larger, permanent, full-service bridge that would be designed to handle future levels of traffic. This full-service bridge would be planned, designed and built with local participation. In each case, the incremental cost above the minimum-permanent bridge would be the responsibility of local traffic interests. A new permanent bridge could be constructed in advance of enlargement activities and would fully mitigate construction-related traffic effects. The new

permanent bridge would achieve long-term goals of reducing public safety concerns, security risks, hazardous material risks, and O&M issues associated with replacing traffic across the top of the dam. This bridge, however, would require a local sponsor, and would have to be on-line in time to avoid delay of the construction of a dam raise.

Air Quality. Increasing the height of wing dams and dikes would require the excavation and transportation of large amounts of material, primarily earth and rock from the Peninsula and Mississippi Bar borrow sites. The results of an evaluation of effects on air quality indicate that the daily emissions thresholds for ROG, NO_x, and CO would be exceeded under all dam raise alternatives and that the annual emissions threshold for NO_x would be exceeded. Refining the construction schedule could reduce the daily emissions for ROG, NO_x, and CO below the significance thresholds. Reducing the annual emissions of NO_x to a point below the significance threshold would require purchase of emissions credits.

Recreation. Construction of the wing dam and dikes would disrupt recreation activities in the FLSRA. Specifically, construction would result in the temporary closure of trails that cross the top of some of the dikes. These trails, particularly in the vicinity of Granite Bay and Beals Point, are used year round. Construction would require closure of these trails; however, alternative trails would be created in order to maintain current levels of recreational use throughout the construction phase of the project. Construction activities would not substantially affect other recreation activities in the FLSRA.

Although flood control operation would occur during the off-peak recreation season, operations could result in a long-term adverse effect on recreation by damaging facilities. Buildings located at Granite Bay, Beals Point, and Browns Ravine; boat slips at Browns Ravine; and restrooms at Granite Bay, Beals Point, Browns Ravine, Folsom Point, Salmon Falls, and Beeks Bight also could be damaged. The effect on recreation would be avoided by:

- Modifying the boat slips at Browns Ravine marina to allow the slips to safely float to the maximum reservoir surface elevation during flood storage operations
- Implementing, at non-Federal expense, a flood management program for affected recreational facilities that would include floodproofing these facilities where feasible and providing for post-flood repairs.

Endangered Species. Increasing the flood storage capacity of Folsom Reservoir would require increasing the footprint of wing dams and dikes, excavating material from borrow sites, and constructing a temporary maintenance bridge downstream of Folsom Dam. Some of these activities would result in the loss of elderberry shrubs and in turn directly affect the valley elderberry longhorn beetle (VELB), which is Federally-listed as a threatened species. Surveys conducted in 2001 indicate that elderberry shrubs would be directly affected by construction. Mitigation and compensation measures for loss of elderberry shrubs would be based on the Service's conservation guidelines for VELB (U.S. Fish and Wildlife Service 1999).

Land Use. Storage of floodwater at Folsom Reservoir under the 7-foot and 12-foot enlargement measures would inundate private lands adjacent to the boundary of the FLSRA.

Parcels in the vicinity of Granite Bay, located on the north side of the reservoir, and in Lakeview Estates, located on the south side of the reservoir, would be inundated. A preliminary analysis, based on overlaying the maximum inundation area onto aerial photos, indicates that no structures would be affected. Mitigation proposed for this effect is to conduct a detailed survey of the area that would be inundated and secure flood easements from landowners.

Analysis of Folsom Enlargement Measures. Flood storage at Folsom Dam varies under the three Folsom Dam enlargement measures. Each flood protection measure is effective. If there is no without-project advance release, the flood risk would be reduced from a 1-in-140 chance in any year to between a 1-in-154 chance and a 1-in-196 chance, depending on the size of the enlargement. If there is advance release as estimated by this long-term study, the flood risk would be reduced from a 1-in-164 chance in any year to between a 1-in-189 chance and a 1-in-233 chance. Although all the measures reduce the risk of flooding, only the larger enlargements, with advance release, achieve the community goal of reducing the risk of flooding to less than a 1-in-200 chance of occurrence in any year. All the measures correct Folsom Dam's PMF deficiency and resolve outstanding dam safety problems. In addition, all measures correct the PMF deficiency at L. L. Anderson Dam. Because the dam safety problem at L. L. Anderson Dam would be corrected, its gates could be used for a more extended period to store additional water, thus increasing potential water supply.

All of the enlargement measures rely on the temporary construction bridge to mitigate effects on public traffic that uses the Folsom Dam spillway bridge. The temporary construction bridge could improve public traffic if it is left in service after the construction phase of the project and is used as a public thoroughfare when the spillway bridge is closed for dam O&M activities. Alternatively, local interests could take the opportunity to seek approval for upgrading the bridge to a full-service bridge sized for existing and future traffic loads.

All the measures are implementable and complete and could be combined with a levee modification measure. This measure does not violate any of the identified planning constraints. The three measures varying the size of Folsom Dam enlargement are retained for formulation into alternatives.

Increase Objective Releases through Levee Modifications

This class of measures allows higher floodflows to pass safely through or around the Sacramento area to the Sacramento River and the San Joaquin-Sacramento Delta. The stepped release alternative was developed as part of the feasibility studies conducted for the 1996 SIR. Formulation of the plan grew out of a desire to develop a project that would provide the most flood protection possible without construction of a new upstream storage structure. Higher floodflow releases from Folsom Dam would allow better management of the flood control storage space in Folsom Reservoir and enable the system to control larger floods. This basic alternative relies on releasing a higher volume of floodflow more frequently past Sacramento. These higher releases would translate to higher water surface elevations downstream.

Existing Conditions and Problems. The existing flood control system is shown on Plate 2-1 and described in detail in Chapter 2.0. The Lower American River levee system is designed to handle a sustained release of only 115,000 cfs. During emergencies, flows may be increased

to as much as 160,000 cfs. The Common Features portion of the American River Watershed Project will improve the consistency of levee materials and generally allow for the emergency release of 160,000 cfs to pass more reliably. Flows above 160,000 cfs, or long-duration flows above 115,000 cfs, would exceed the capacity of the levee system and would substantially increase the probability of levee failure.

The American River flows into the Sacramento River and, with high water in the Sacramento River, into the Sacramento Bypass. The Sacramento Bypass is a contributor to the Yolo Bypass, which protects urban areas and farmland by containing high flows from the Sacramento River and its tributaries.

Potential Modifications. The SIR explored different objective flows of 130,000 cfs, 145,000 cfs, 180,000 cfs, and 235,000 cfs. By itself, increasing the objective release was found to be costly because of extensive mitigation for downstream effects. To contain costs and still provide a significant increase in flood protection to Sacramento, the Stepped Release Plan was formulated. Under this plan, a moderate objective release of 145,000 cfs would be used for more frequent floods, and an 180,000-cfs emergency release would be used for rare, but larger floods. The objective release would be held to 145,000 cfs until Folsom Dam inflow and storage conditions were such that under without-project conditions, flows at the mouth of the American River would be at 180,000 cfs, thus allowing a stepping up to that flow with the project in place without causing an effect.

The increase of the objective release to 145,000 cfs would have an effect on the Sacramento River, which would already be at capacity in large flood events. The Sacramento River and the Yolo Bypass were designed to take the existing 115,000-cfs objective release from the American River. The additional flow would increase flood risk downstream. Because this measure puts additional water downstream, there is an obligation to mitigate for any induced flooding. The least costly mitigation is to direct flows to the Yolo Bypass by widening the Sacramento Weir and Bypass. Sending excess floodflows to the Delta via the Yolo Bypass appears to be more predictable and safer than sending flows down the Sacramento River. There is more damageable property along the Sacramento River than along the Yolo Bypass, and the hydraulics of the north Delta along the Sacramento River are more complex and more difficult to predict. Thus, for the objective release measures, modifying the Sacramento Weir and Bypass is included as a project feature. This modification would increase water surface elevation in the bypasses by approximately 0.5 foot and increase the risk of flooding. Hydraulic effects would extend downstream of the Yolo Bypass to the Sacramento River as far south as Rio Vista.

To mitigate the increase in flood risk, the Sacramento Weir and Bypass would be widened to conduct the increased American River flow into the Yolo Bypass. Selected levees in the Yolo Bypass, the Sacramento River below the Yolo Bypass, and tributary creeks and sloughs would be strengthened so that the overall flood risk would be the same as under preproject conditions. Roughly 13 miles of levee would be strengthened through a combination of slurry walls, stability berms, and drainage modifications.

An alternative method of mitigation is to increase the efficiency of the Yolo Bypass. The bypass may be widened and some obstructions removed to lower the water surface. This could compensate for the additional American River flow. Widening would require purchasing

flowage easements or lands in fee installation of a weir and gates on the Sacramento Deep Water Ship Channel, and the removal or setting back of levees. This method would likely be more expensive than levee modification.

Four different downstream levee modification measures were formulated and are described below.

Stepped Release to 160,000 cfs. This measure retains the current emergency release of 160,000 cfs, thereby reducing the need for additional levee improvements on the Lower American River. For this measure, Lower American River levees and associated infrastructure would be modified to contain a higher objective release of 145,000 cfs. A stepped release would be made from 115,000 cfs to 145,000 cfs depending on Folsom Reservoir surface and inflow. The 145,000-cfs flow would be maintained until downstream conditions at the Sacramento River would be such under without-project conditions that a release of 160,000 cfs would cause no additional effect. At this condition, 160,000 cfs would be released from Folsom Dam. To mitigate the increase in objective release to 145,000 cfs, the Sacramento Weir and Bypass would be widened, and levees in the Yolo Bypass, lower Sacramento River, and tributaries would be strengthened to lower flood risk to without-project conditions. This alternative is retained for formulation as Alternative 5.

Stepped Release to 160,000 cfs and New Outlet at Folsom Dam. This measure is the stepped release to 160,000 cfs with an additional outlet added to Folsom Dam. The 30,000-cfs outlet would eliminate the step from 115,000 cfs to 145,000 cfs. Because the higher release of 145,000 cfs would be made earlier, Folsom Dam would be able to conserve more flood space. This alternative is retained for formulation as Alternative 6.

Stepped Release to 180,000 cfs. This measure increases the emergency release from the existing 160,000 cfs to 180,000 cfs. The higher flow would require additional work on the Lower American River, such as levee raising and the creation of new levees and floodwalls. In addition, Howe Avenue Bridge and Guy West Bridge would need to be raised, and a Southern Pacific Railroad trestle would need to be modified. The downstream hydraulic mitigation work would be similar to that for the measure involving stepped release to 160,000 cfs. This alternative is retained for formulation as Alternative 7.

Stepped Release to 160,000 cfs, No Hydraulic Mitigation. The major cost of all the measures that increase American River conveyance is for hydraulic mitigation downstream. This measure was formulated to avoid downstream mitigation costs. The operation is tailored to take advantage of events with noncoincident high flows on the American and Sacramento Rivers. The objective release step to 145,000 cfs would depend on Sacramento River and Yolo Bypass flows being below capacity. For many large events, American River flow peaks at the Sacramento River well before the Sacramento River peak flow has arrived. The Sacramento River would be monitored at the Verona Gage, located upstream of the American River. As Sacramento River flows increase, the 145,000-cfs objective release would be throttled back to avoid encroaching into the capacity of the Yolo Bypass. A variation of this measure is to add one or more low-level outlets so that as much as 145,000 cfs may be achieved earlier in the storm event, thus passing a greater amount of water through the system ahead of the Sacramento River peak. As with the other measures, levee strengthening and other improvements would be

made to the Lower American River so that the objective release of 145,000 cfs would safely pass. Release would be stepped to 160,000 cfs when flow conditions indicate that there would be no induced downstream flooding.

This measure was found to be ineffective because the delay in Sacramento River peak flow compared to the American River could not be relied on to materialize for a sufficiently high percentage of flood instances. Thus the reliability of this measure is unacceptably low.

Environmental Issues and Concerns. The environmental analysis has evaluated the construction-related and operation-related effects on social and biological resources. Major environmental issues that have been identified include construction-related effects on transportation, air quality, recreation, and endangered species and operation-related effects on recreation and land use. These effects are discussed below.

Transportation. The 180,000-cfs stepped release alternative would involve increasing the height of the Howe Avenue Bridge and Guy West Bridge to allow the safe passage of 180,000 cfs. Substantial effects on transportation could occur as the two bridges are raised.

An increase in transit time for motorists using the Howe Avenue Bridge is expected during the construction phase as a result of narrower traffic lanes, presence of construction equipment, and speed restrictions. Substantial increases in congestion and transit time for motorists using Howe Avenue could be avoided by phasing the construction to ensure that four lanes remain open during construction.

Guy West Bridge would be closed during the construction period. Transit time between the California State University, Sacramento, campus and the Campus Commons area is expected to increase because pedestrians and bicyclists would be directed to an alternative route. This alternative route would most likely be the H Street Bridge, located approximately one-half mile downriver from Guy West Bridge. Using this alternative route is not expected to substantially increase the transit time between the campus and Campus Commons because the H Street Bridge is close to Guy West Bridge.

Air Quality. Increasing the heights of levees along the American River, expanding the Sacramento Bypass, and increasing the capacity of the Yolo Bypass would require excavating, transporting, and placing large amounts of earth. Material for strengthening and raising levees along the Lower American River would come from a borrow site in West Sacramento. Material for strengthening and raising levees in the Sacramento and Yolo Bypasses would come from borrow sites in the Yolo Bypass.

The results of an evaluation of air quality effects indicate that the daily emission thresholds for ROG, NO_x, and CO would be exceeded under all dam raise alternatives and that the annual emission threshold for NO_x would be exceeded. Refining the construction schedule could reduce the daily emissions for ROG, NO_x, and CO below the significance thresholds. Reducing the annual emissions of NO_x to a point below the significance threshold would require purchase of emissions credits.

Recreation. Constructing flood control improvements along the Lower American River would adversely affect recreation opportunities in the American River Parkway. The greatest effect on recreation would occur as a result of increasing the height of levees. Trails located on the crest of levees would be closed during construction. Trails located near levees and in the vicinity of staging areas and haul routes also may be closed. Levee construction and other modifications in the parkway would disrupt recreation. The Corps will address this issue by providing adequate notification of trail closures and establishing alternative routes close to the levees during construction.

Special-Status Species. Increasing the conveyance capacity of the Lower American River and the Yolo and Sacramento Bypasses would require excavating material from borrow sites, improving levees, and constructing levees and floodwalls. These activities could adversely affect special-status species, including VELB (Federally-listed as threatened), giant garter snake, Sacramento splittail, delta smelt, and Swainson's hawk (state-listed as threatened).

Elderberry shrubs (*Sambucus sp.*) are known to occur along the American River and in the Yolo Bypass. A number of elderberry shrubs would be affected by construction along the Lower American River. Mitigation and compensation measures for loss of elderberry shrubs would be based on the Service conservation guidelines for VELB (U.S. Fish and Wildlife Service 1999).

The giant garter snake may be present in low numbers in suitable habitat in the Yolo and Sacramento Bypass areas. Construction of levees in the Yolo and Sacramento Bypasses may damage or destroy occupied upland burrows. The Corps will implement measures to avoid, minimize, and compensate for effects on the giant garter snake, including conducting preconstruction surveys and timing construction activities to avoid snakes.

Swainson's hawks are known to occur in portions of the Yolo Bypass and along the Sacramento River. To avoid, minimize, and compensate for disturbance of Swainson's hawks, the Corps will conduct preconstruction surveys for nesting raptors near construction sites. If an active nest is located near the construction area, an appropriate no-disturbance buffer will be established and maintained around the nest site until the young have fledged. If nests of raptors are identified in trees that are to be removed, these trees would be removed between August 15 and March 1.

Analysis of Downstream Levee Modification Measures. All the downstream levee modification measures were found to effectively reduce flooding, except for the stepped release to 160,000 cfs, no hydraulic mitigation. This measure was found to not appreciably reduce flood risk because there is great unreliability that conditions would allow effective stepped releases in advance of Sacramento River high flows. For a significant percentage of flood events, high flows on the American and Sacramento Rivers would be coincident, with no opportunity to increase the objective release beyond the existing 115,000 cfs. Because this measure does not reliably reduce flood risk, it was dropped from alternative formulation.

The three remaining downstream levee measures are effective at reducing the risk of flooding. If there is no without-project advance release, the three remaining downstream levee measures would reduce the flood risk from a 1-in-140 chance in any year to between a 1-in-149

chance and a 1-in-167 chance. If there is advance release as estimated by this Long-Term Study, the flood risk would be reduced from a 1-in-164 chance in any year to between a 1-in-172 chance and a 1-in-196 chance. None of the measures achieve the community goal of protection from a flood with at least a 1-in-200 chance of occurring in any year.

Because there is little or no work required to modify Folsom Dam under any of the stepped release alternatives, there is no opportunity to correct the dam safety deficiency. Thus, the dam safety problem would remain as a post-project condition.

All remaining measures could be implemented and are complete and may be combined with a Folsom Dam enlargement measure. None of these measures violates any of the listed planning constraints. Three measures involving varying configurations of downstream levee work and stepped release were retained for formulation into alternatives.

Construct Flood Control Detention Dam on the North Fork American River

The 1991 Feasibility Report, 1996 SIR, and 1999 information paper presented upstream detention measures that had in common construction of a single-purpose flood control dam below the confluence of the Middle and North Forks, near the city of Auburn. Three detention dams of different sizes are presented below as representative of the detention dam measure:

- A 483-foot-high dam that would impound 545,000 acre-feet was described in the 1991 Feasibility Report as part of the 200-Year Protection Plan. It would be a roller-compacted concrete gravity dam. The reservoir would have a top-of-pool elevation of 865 feet. The inundation area would cover approximately 4,500 acres. Highway 49 crosses the inundation area just below the confluence of the North and Middle Forks. The highway would be relocated with a high-level bridge above the maximum pool elevation (1,000 feet) and would be located as close to the existing route as possible. The flood control space reoperation at Folsom Reservoir would return from the variable space ranging from 400,000 acre-feet to 600,000 acre-feet to a fixed seasonal flood space of 400,000 acre-feet. As discussed in the 1996 SIR, upstream detention would increase benefits to water supply, hydropower, recreation, and fish and wildlife resources at Folsom Dam and in the Lower American River. Folsom Dam would be operated in conjunction with the new detention dam.
- A 498-foot-high dam that would impound 894,000 acre-feet also was described in the 1991 report. This detention dam measure was part of the 400-Year Protection Plan. It also would be a gravity dam of roller-compacted concrete. The reservoir would have a top-of-pool elevation of 942 feet and would inundate 5,450 acres. Like the 483-foot-high dam, it would require relocation of Highway 49. Folsom Dam operation would be revised in a way similar to that described for the 483-foot high dam. The 400-Year Protection Plan was identified as the NED Plan. A dam of similar size was presented in the 1996 SIR as part of the Detention Dam Plan. This plan was found to provide the most effective and efficient reduction in flood damages of all the 1996 SIR alternatives.

- A 350-foot-high dam that would impound 180,000 acre-feet was described in the 1999 Information Paper. This dam was part of the Folsom Modification and Upstream Storage Plan. Similar to the dams discussed above, it would be a roller-compacted concrete gravity dam. The reservoir would have a top-of-pool elevation of 810 feet and would inundate 2,500 acres. Relocation of Highway 49 also would be required. The dam would work in concert with outlet modifications at Folsom Dam to reduce the flood risk to a 1-in-200 chance in any year.

The studies cited in the preceding summary each concluded that upstream detention would be the most efficient and generally the most effective means of controlling flooding on the American River. However, based on the authorizing language for this long-term study, no additional analysis of upstream storage was conducted. Instead, an update of costs and benefits for the 483-foot-high dam described above was prepared. The 483-foot-high dam was chosen because it would provide a significant decrease in flood risk, achieve the community flood protection goal, and may approximate maximum net benefits. With the potential for damages reduced by construction of projects authorized after 1996, the larger detention dam measures may have less benefits than indicated in the 1991 and 1996 reports. No Folsom Dam operation analysis or risk-based analysis was performed using the moderate or upper bound advance release. The detention dam would change inflow to Folsom Dam and lessen the need for advance release as a flood damage reduction measure. However, advance release could be implemented as a means of reducing the fixed seasonal storage allocated to flood control at Folsom Dam. This would further increase the water resource related benefits of the detention dam. Plate 4-1 shows the dam location and reservoir of the 483-foot high, 545,000 acre-foot dam. The environmental effects of this dam were not updated, but are discussed in the 1991 EIS/EIR and the 1996 SEIS/SEIR.

4.5 Combining Measures

Multiple combinations of differently-sized Folsom Dam enlargement and downstream levee modification measures may be formulated. Combination plans in this case are anticipated to be uneconomical because the costs are additive and no special efficiencies are seen by combining storage with conveyance. One combination plan is provided, however, to check for unforeseen effects that might result in a beneficial combination. The one combination plan combines the seven-foot dam raise/482-foot flood pool elevation with the stepped release to 160,000 cfs. These measures were chosen because their costs are moderate and their combination appears most likely among all the measures to produce a feasible combination plan. This measure is analyzed as Alternative 8, Stepped Release to 160,000 cfs and Seven-Foot Dam Raise/482-Foot Flood Pool Elevation, in Chapter 5, "Flood Control Alternatives."

4.6 Alternatives to Be Considered in Detail

Table 4-1 presents a comparison of the additional advance release, Folsom Dam enlargement, and downstream levee modification measures on the basis of flood risk, general costs and benefits, environmental effect, socioeconomic effect, and potential of combining with other measures.

All measures were found to be implementable with the exceptions of the additional advance release measure and the stepped release to 160,000 cfs, no hydraulic mitigation. This former measure is not implementable because the advance release that may be implemented under without-project condition takes full advantage of Folsom Dam's physical ability to make an advance release and no further release is practical. The latter measure does not result in a reduction in flood risk and has a low chance of success because it depends on the proper timing of Sacramento and American River peak flows to be successful.

None of the measures restores plant, fish and wildlife habitat, but ecosystem restoration features may be added to any of these measures later in the plan formulation process.

Folsom enlargement and downstream levee modification measures that were found to be implementable are considered in more detail as alternatives. In addition, a combination of these two measures is further considered as an alternative.

TABLE 4-1. Summary of Flood Control Measures

Measure	Expected Annual Probability of Exceedance (1 in X chance per year)		General Feasibility	Relative Impacts			Status
	No Advance Release	With Advance Release ¹		Environmental	Socio-economic	Potential for Combining with Other Measures	
Without-Project Condition							
No Action	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Folsom Enlargement							
3.5-Foot Dam Raise/478-Foot Flood Pool Elevation	0.0065 (154)	0.0053 (189)	Low feasibility, no major decrease in flood risk	Low	Low	Low economic feasibility of measure likely to result in inefficient combination plan	Retained as an alternative
Seven-Foot Dam Raise/482-Foot Flood Pool Elevation	0.0057 (175)	0.0047 (213)	Good likelihood of feasibility	Low	Low	Can be combined with conveyance measure	Retained as an alternative, also combined with Stepped Release to 160,000
Twelve-Foot Dam Raise/487-Foot Flood Pool Elevation	0.0051 (196)	0.0043 (233)	Good likelihood of feasibility, achieves the greatest reduction in flood risk of all enlargement measures	Low	Low	High cost of measure likely to result in inefficient combination plan	Retained as an alternative
Downstream Levees Modification							
Stepped Release to 160,000 cfs	0.0067 (149)	0.0058 (172)	Low feasibility, high cost for hydraulic mitigation, low decrease in flood risk	Medium	Medium	Can be combined	Retained as an alternative, also combined with 482 Folsom Dam Raise
Stepped Release to 160,000 cfs and New Outlet at Folsom Dam	0.0063 (159)	0.0054 (185)	Low feasibility, similar to Stepped release to 160,000 cfs	Medium	Medium	Can be combined	Retained as an alternative
Stepped Release to 180,000 cfs	0.0060 (167)	0.0051 (196)	Low feasibility, very high cost	Medium	Medium	High cost of measure likely to result in inefficient combination plan	Retained as an alternative
Stepped Release to 160,000 cfs and Throttle Objective Release Back to 115,000 cfs	>0.0072 (140)	>0.0061 (164)	Flood control benefit is very uncertain	Low	Low	N/A	Dropped, does not provide effective flood control
Additional Advance Release (above Upper Bound)							
Additional advance release	0.0071 (140)	0.0061 (164)	Not implementable ²	N/A	N/A	N/A	Dropped, not implementable, no opportunity for additional advance release
Upstream Detention Dam							
Upstream detention 483-Foot High Dam, 545,000 acre-feet basin	0.0019 (526)	N/A ³	Good likelihood of feasibility	High	High	Low, but results in very low residual damages	Evaluated in previous studies, no local support based on prior failures to secure Congressional approval; Federal interest if support materializes

¹ Moderate Advance Release, 0-100,000-190,000, is adopted as the without project condition and upon which recommendations will be made.

² No opportunity to create additional flood control space as without-project advance release takes full advantage of Folsom Dam.

³ Upstream detention would lessen the opportunity for advance release, not calculated.

N/A = Not applicable