SHASTA LAKE
WATER RESOURCES INVESTIGATION

INITIAL ALTERNATIVES INFORMATION REPORT

June 2004

MISSION STATEMENT

"To develop an implementable plan primarily involving the enlargement of Shasta Dam and Reservoir to promote increased survival of anadromous fish populations in the upper Sacramento River and increased water supply reliability, and to the extent possible through meeting these objectives, include features to benefit other identified ecosystem, flood control, and related water resources needs."

U.S. Bureau of Reclamation, Mid-Pacific Region

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SHASTA LAKE WATER RESOURCES INVESTIGATION
EXECUTIVE SUMMARY

The primary purpose of this Initial Alternatives Information Report is to describe the formulation of initial alternatives to address planning objectives of the Shasta Lake Water Resources Investigation (SLWRI).

BACKGROUND

The Shasta Dam and Reservoir Project was completed in 1944 by the United States Department of the Interior, Bureau of Reclamation, Mid-Pacific Region (Reclamation), and serves the purposes of flood control, irrigation water supply, municipal and industrial (M&I) water supply, hydropower generation, fish and wildlife conservation, and navigation. The 602-foot-high Shasta Dam (533 feet above streambed) and 4.55-million-acre-foot (MAF) reservoir are located on the upper Sacramento River in Northern California, about 9 miles northwest of the City of Redding.

As a result of increases in demands for water supplies and attention to ecosystem needs in the Central Valley of California, in 2000, Reclamation reinitiated a feasibility-scope investigation to evaluate the potential of enlarging Shasta Dam. The SLWRI is being conducted under the general authority of Public Law 96-375 (1980).

Major existing projects that influence the SLWRI include Reclamation's Central Valley Project (CVP), the State of California's State Water Project (SWP), and the United States Army Corps of Engineers (Corps) Sacramento River Flood Control Project. In addition, two ongoing programs in the Central Valley significantly influence the SLWRI: the Central Valley Project Improvement Act and California Bay-Delta Program (responsible for implementing the CALFED Bay-Delta Program).

PROBLEMS AND NEEDS

The primary study area for the SLWRI encompasses Shasta Dam and Reservoir; inflowing rivers and streams, including the Sacramento River, McCloud River, Pit River, and Squaw Creek; and the Sacramento River downstream to about the Red Bluff Diversion Dam (RBDD). Because of the potential influence of a modified Shasta Dam on other programs and projects, primarily in the Central Valley, an extended study area also includes the Sacramento River and San Joaquin River watersheds, including the Sacramento-San Joaquin Delta. Major identified water and related resources problems and needs in the primary study area include the following:

- **Anadromous Fish Survival –** Due to a number of environmental factors, the population of chinook salmon has declined in the Central Valley. To address this problem on the Sacramento River, various actions have been undertaken ranging from establishing minimum flow requirements in the river to making structural changes at Shasta Dam. However, a residual need still exists for effective actions to benefit salmon, especially in dry and critically dry years.

- **Water Supply Reliability –** Demands for water in California exceed available supplies. As the population of the Central Valley grows, the ability to maintain a healthy and vibrant industrial and agricultural economy will become increasingly difficult as the demand for adequate water supply becomes more acute.

- **Other Resources Needs –** Other identified problems and needs include the growing demands for new energy sources in California; the need for restoring environmental values in the Shasta Lake area and downstream along the Sacramento River; and the need for additional flood control along the upper Sacramento River.

STUDY OBJECTIVES AND MISSION STATEMENT

Identified problems and needs in relation to the study authority were translated into primary and secondary (opportunity) planning objectives:

- **Primary Objectives –** The SLWRI will formulate alternatives specifically to address the following:
  - Increase the survival of anadromous fish populations in the Sacramento River, primarily upstream from the RBDD.
  - Increase water supplies and water supply reliability for agricultural, M&I, and environmental purposes to help meet future water demands, with a focus on enlarging Shasta Dam and Reservoir.
- **Secondary Objectives –** To the extent possible through pursuit of the primary planning objectives, the SLWRI will include as opportunities features to help accomplish the following:
  - Preserve and restore ecosystem resources in the Shasta Lake area and along the upper Sacramento River.
  - Reduce flood damages along the Sacramento River.
  - Develop additional hydropower capabilities at Shasta Dam.

Based on identified problems and needs, relationships to other programs and projects, and Federal planning guidance, the following Mission Statement was developed:

> *To develop an implementable plan primarily involving the enlargement of Shasta Dam and Reservoir to promote increased survival of anadromous fish populations in the upper Sacramento River and increased water supply reliability, and to the extent possible through meeting these objectives, include features to benefit other identified ecosystem, flood control, and related water resources needs.*

RESOURCES MANAGEMENT MEASURES

A resources management measure is a feature or activity that addresses a specific planning objective. About 35 management measures were identified to address the primary objectives of the SLWRI and nearly 30 measures were identified to address the secondary planning objectives. Of the management measures for the primary planning objectives, seven were selected to be considered further for potential inclusion in alternative plans. Five measures to address the secondary objectives also were identified to be added, if possible and appropriate, to alternative plans. **Table ES-1** summarizes the 12 water resources management measures carried forward to address the primary and secondary planning objectives.

TABLE ES-1
RETAINED MEASURES TO ADDRESS PLANNING OBJECTIVES

Primary Planning Objectives	Resources Management Measure	
Anadromous Fish Survival	Restore Spawning Habitat	Restore abandoned gravel mines along the Sacramento River.
	Modify TCD	Make additional modifications to Shasta Dam for temperature control.
	Enlarge Shasta Lake Cold Water Pool	Enlarge Shasta Dam and Reservoir to increase the cold water pool in the lake to benefit anadromous fish.
	Increase Minimum Flows	Modify the storage and/or release operations of Shasta Dam and Reservoir to benefit anadromous fish.
Water Supply Reliability	Increase Conservation Storage	Increase conservation storage space in Shasta Reservoir by raising Shasta Dam.
	Reoperate Shasta Dam	Increase the effective conservation storage space in Shasta Reservoir by increasing the efficiency of reservoir operation for water supply reliability.
	Perform Conjunctive Water Management	Develop conservation groundwater storage near the Sacramento River downstream from Shasta Dam.
Secondary Planning Objectives	**Resources Management Measure**	
Ecosystem Restoration	Restore Shoreline Aquatic Habitat	Construct shoreline fish habitat around Shasta Lake.
	Restore Tributary Aquatic Habitat	Construct instream fish habitat on tributaries to Shasta Lake.
	Restore Riparian Habitat	Restore riparian and floodplain habitat along the upper Sacramento River.
Flood Damage Reduction	Modify Flood Control Operations	Update Shasta Dam and Reservoir flood management operations.
Hydropower	Modify Hydropower Facilities	Modify existing/construct new generation facilities at Shasta Dam to take advantage of increased head.
Key: TCD – temperature control device		

CONCEPT PLANS

Twelve concept plans were formulated from the management measures in **Table ES-1**. Because a vast array of potential measure combinations and sizes exists, the approach was not to develop an exhaustive list of concepts. Instead, the purpose of this phase of the formulation process was (1) to explore an array of different strategies to address the primary planning objectives, constraints, and criteria, and (2) to identify concepts that may warrant further development into initial alternatives and then detailed alternative plans. These concepts were intended to promote discussion and provide a background for the formulation of initial alternatives and alternative plans in the remainder of the feasibility study, with input from participating agencies, stakeholders, and the public.

The concept plans were formulated to represent the range of potential actions for addressing the objectives of the SLWRI. First, two sets of concepts were developed that focus on a single primary planning objective: anadromous fish survival (AFS) or water supply reliability (WSR). Second, a set of concepts was developed that includes a mixture of measures to address both primary and secondary objectives, termed combined objective (CO) concepts. The concept plans are highlighted below and summarized in **Table ES-2.**

Each concept plan includes raising Shasta Dam by 6.5, 18.5, or 200 feet. Consequently, each concept would likely include some degree of physical modification to the temperature control device (TCD) and hydropower facilities at Shasta Dam, and revision of reservoir operating guidelines for water supply, flood control, and/or fisheries. The degree and details of these measures will be evaluated in future studies.

Concepts Focused on Anadromous Fish Survival – The three AFS concepts focus primarily on anadromous fish survival in the upper Sacramento River, but each contributes somewhat to water supply reliability. In developing these concepts, it was important to determine (1) how each measure addressing anadromous fish survival could be combined, and (2) how their potential benefits compared. Consequently, the various dam raises were not a significant factor because progressively higher raises would be expected to produce proportionally greater benefits to anadromous fish. Accordingly, each concept plan includes raising Shasta Dam 6.5 feet and enlarging the reservoir by 290,000 acre-feet, but the concepts differ in how the additional storage would be used to benefit anadromous fish.

- **AFS-1 – Increase Cold Water Assets with Shasta Operating Pool Raise (6.5 Feet) –** This concept focuses on increasing the pool of cold water in Shasta Lake to maintain cooler water temperatures in the upper Sacramento River. It consists of raising Shasta Dam 6.5 feet (raising the gross pool by 8.5 feet, and enlarging total storage in the reservoir by 290,000 acre-feet to 4.84 MAF). AFS-1 also includes increasing the minimum operating pool at Shasta by 290,000 acre-feet to ensure a larger seasonal carryover storage volume for use the following year. In addition, this concept includes further investigation of and potential modifications to the TCD at Shasta Dam to achieve efficient use of the expanded cold water pool.

TABLE ES-2
COMPARISON OF CONCEPT PLANS

	Concept Focus	Anadromous Fish Survival (AFS)			Water Supply Reliability (WSR)				Combined Objectives (CO)				
		AFS-1	AFS-2	AFS-3	WSR-1	WSR-2	WSR-3	WSR-4	CO-1	CO-2	CO-3	CO-4	CO-5
Measures													
Shasta Dam Raise (feet)		6.5	6.5	6.5	6.5	18.5[1]	200	18.5[1]	6.5	18.5[1]	18.5[1]	6.5	18.5[1]
Anadromous Fish Survival	Enlarge Shasta Lake Cold Water Pool	X	-	-	-	-	-	-	-	-	-	-	-
	Increase Minimum Flows	-	X	X	-	-	-	-	-	-	X	-	-
	Restore Spawning Habitat	-	-	X	-	-	-	-	X	X	X	X	X
	Modify TCD	Changes to the existing TCD likely would be part of any alternative that included physically modifying Shasta Dam.											
Water Supply Reliability	Increase Conservation Storage	-	-	-	X	X	X	X	X	X	X	X	X
	Reoperate Shasta Dam[2]	-	-	-	X	X	X	X	X	X	X	X	X
	Perform Conjunctive Water Mgmt.	-	-	-	-	-	-	X	-	-	-	X	X
Secondary Objectives	Restore Aquatic and/or Riparian Habitat	-	-	-	-	-	-	-	-	-	-	X	X
	Modify Flood Control Operations	Changes to flood control operations and hydropower facilities likely would be part of any alternative that included physically modifying Shasta Dam; degree and details will be determined in future studies.											
	Modify Hydropower Facilities												
Accomplishments													
Contribution to Primary Objectives													
Aquatic Habitat (acres)[3]		-	170	320	-	-	-	-	150	150	320	150	150
Average Annual Salmon Increase		860	370	370	410	1,110	10,620	1,020	370	1,110	980	410	1,020
Water Supply Reliability (1,000 acre-ft/year)[4]		Incidental	20	20	72	125	703	146	72	125	90	89	146
Contribution to Secondary Objectives													
Ecosystem Restoration[5] (acres)		-	-	-	-	-	-	-	-	-	-	>500	>500
Flood Control Benefits[6]		-	-	-	-	-	Major	-	Minor	Minor	Minor	Minor	Minor
Hydropower Generation (GWh /year)		51	32	32	15	44	2,250	44	15	44	61	12	44
Cost													
First Cost ($million)		282	282	292	282	408	5,250	459	292	418	418	356	483
Annual Cost ($million)		19	19	20	19	28	383	32	20	29	29	25	34
Unit Cost[7] ($/acre-foot)		-	270	270	270	225	550	220	265	220	230	260	220

Key: GWh/year – gigawatt hours per year TCD – temperature control device

Notes:
[1]Precise raise to be determined in continuing investigations.
[2]Potential for marginal increase in water supply reliability through reservoir reoperation. Magnitude to be determined in further evaluations.
[3]Includes habitat increase through restoring spawning and rearing areas and through increasing minimum flows consistent with the Anadromous Fish Restoration Program (AFRP).
[4]Increased water supply yield based on drought year conditions with Banks Pumping Plant at 6,660 cfs.
[5]Includes restoring riparian and wetland floodplain habitat along Sacramento River and resident fish habitat around Shasta Lake; acreages to be determined in future studies.
[6]All plans that include enlarging Shasta Reservoir can provide incidental flood control benefits. A potential exists for marginal increases in flood control through reservoir reoperation (to be determined in future studies). Larger increases in storage in Shasta Lake have the potential for significant benefits.
[7]Based on portions of annual cost potentially creditable to water supply reliability divided by increase in water supply reliability.

- **AFS-2 – Increase Minimum Anadromous Fish Flow with Shasta Enlargement (6.5 Feet) –** This concept focuses on increasing minimum seasonal flows for anadromous fish in the upper Sacramento River. The concept consists of raising Shasta Dam 6.5 feet and enlarging Shasta Reservoir by 290,000 acre-feet. The additional storage would be dedicated to helping increase seasonal minimum flows in the upper Sacramento River, to the extent possible, consistent with recommendations in the January 9, 2001, Federal Final Restoration Plan for the Anadromous Fish Restoration Program (AFRP). This concept also could result in a slightly larger cold water pool, and provide incidental benefits to water supply reliability.

- **AFS-3 – Increase Anadromous Fish Flow and Restore Aquatic Habitat with Shasta Enlargement (6.5 feet) –** This concept focuses on increasing anadromous fish habitat in the upper Sacramento River through stream flow increases and aquatic habitat restoration. Similar to AFS-2, this concept includes raising Shasta Dam 6.5 feet and increasing seasonal fish flows in the upper Sacramento River. In addition, this concept includes acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create additional aquatic and floodplain habitat to benefit anadromous fish. This concept also could result in a slightly larger cold water pool, and provide incidental benefits to water supply reliability.

Concepts Focused on Water Supply Reliability – Four concepts were formulated that focus on the primary objective of water supply reliability while also benefiting anadromous fish. Unlike the formulation strategy for the three AFS concepts, the most important factor for the WSR concepts was the magnitude of a potential enlargement of Shasta Dam and Reservoir. Accordingly, three of the four concepts below were formulated based on different dam raise options, while the fourth includes conjunctive water management.

- **WSR-1 – Increase Water Supply Reliability with Shasta Enlargement (6.5 feet) –** The focus of this concept is on increasing water supply reliability while contributing to increased anadromous fish survival, consistent with the 2000 CALFED Record of Decision (ROD). Similar to concept AFS-2, this concept consists of raising Shasta Dam 6.5 feet, and enlarging the total storage space in the reservoir by 290,000 acre-feet. However, the additional storage would be operated for water supply reliability, as under existing operational guidelines, helping to reduce estimated future shortages through increasing drought and average year water supply reliability. The increased pool depth and volume could also contribute to maintaining seasonal water temperatures for anadromous fish on the upper Sacramento River.

- **WSR-2 – Increase Water Supply Reliability with Shasta Enlargement (18.5 feet) –** This concept focuses on the likely greatest practical enlargement of Shasta Dam and Reservoir consistent with the goals of the CALFED ROD for the primary purpose of increasing water supply reliability. It consists of raising Shasta Dam 18.5 feet (raising the gross pool by 20.5 feet, and enlarging the total storage space in the reservoir by 636,000 acre-feet to 5.19 MAF). This concept would help reduce estimated future shortages by increasing drought and average year water supply reliability. The increased pool depth and volume also could contribute to maintaining seasonal water temperatures for anadromous fish on the upper Sacramento River.

- **WSR-3 – Increase Water Supply Reliability with Shasta Enlargement (High Level) –** This concept focuses on providing the greatest potential increase in water supply reliability through the largest feasible raise of Shasta Dam. It consists of raising Shasta Dam about 200 feet and enlarging the total storage space in the reservoir by 9.3 MAF to 13.9 MAF. This concept would significantly reduce estimated future shortages through increasing drought and average year water supply reliability. The increased pool depth and volume would greatly contribute to maintaining seasonal water temperatures for anadromous fish on the upper Sacramento River. It could also provide major flood control and hydropower benefits. However, local area socioeconomic, cultural, and environmental conditions would be impacted significantly by this concept.

- **WSR-4 –Increase Water Supply Reliability with Shasta Enlargement (18.5 feet) and Conjunctive Water Management –** This concept focuses on increasing water supply reliability of the CVP and SWP through a combination of conjunctive water management and enlargement of Shasta Dam and Reservoir, consistent with the goals of the CALFED ROD. This concept is similar to WSR-2, but includes a conjunctive water management component consisting primarily of contract agreements between Reclamation and certain Sacramento River basin water users. These agreements would focus on exchanging additional surface supplies in normal water years for reduced deliveries (reliance on groundwater supplies) in dry and critically dry years. The increased pool depth and volume also could contribute to maintaining seasonal water temperatures for anadromous fish in the upper Sacramento River.

Concepts Focused on Combined Objectives - Five concept plans were formulated to represent a reasonable balance between the two primary objectives, while also including components to address the secondary objectives, as appropriate. Two dam raise options were considered for the five CO concepts: 6.5 feet and 18.5 feet. CO concepts are summarized below.

- **CO-1 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (6.5 feet) –** This concept seeks to address both primary planning objectives. For anadromous fish survival, it consists of raising Shasta Dam 6.5 feet to increase the cold water pool, and restoring inactive gravel mines and floodplain habitat along the upper Sacramento River. For water supply reliability, it consists of dedicating additional storage to that purpose, and revising flood control operations to benefit water supply reliability by managing floods more efficiently. The concept also includes further investigation and potential modifications to the existing TCD at Shasta Dam for enhanced temperature management.

- **CO-2 –Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet) –** This concept addresses both primary planning objectives by raising Shasta Dam 18.5 feet to increase the cold water pool for anadromous fish and increase water supply reliability. This concept is similar to CO-1, but with a larger dam raise.

- **CO-3 – Increase Anadromous Fish Flow/Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet) –** This concept addresses both primary planning objectives through a combination of measures. It consists of (1) raising Shasta Dam 18.5 feet, (2) modifying the TCD at Shasta Dam to make efficient use of the expanded cold water pool, (3) restoring inactive gravel mines and floodplain habitat along the Sacramento River, (4) dedicating a portion of the enlarged reservoir storage to increase minimum flows for anadromous fish, consistent with the objectives of the AFRP, and (5) revising the operational rules for flood control to benefit water supply reliability by managing floods more efficiently.

- **CO-4 – Multipurpose with Shasta Enlargement (6.5 feet)**- The goal of this concept is to address both primary planning objectives by raising Shasta Dam 6.5 feet, as identified in the CALFED ROD, in combination with various features to address the secondary objectives. The features are similar to those described for CO-1, with the addition of conjunctive water management. To address the secondary objectives, CO-4 also includes constructing fish habitat in the Shasta Lake area, and restoring one or more riparian habitat areas between Redding and Red Bluff on the Sacramento River.

- **CO-5 – Multipurpose with Shasta Enlargement (18.5 feet) –** This concept also addresses both primary planning objectives by enlarging Shasta Dam 18.5 feet, consistent with the objectives of the CALFED ROD, in combination with various features to address the secondary objectives. Primary features are similar to CO-4, except Shasta Dam would be raised 18.5 feet, enlarging the reservoir by 636,000 acre-feet.

INITIAL ALTERNATIVES

The 12 concept plans described above were compared against four general criteria: (1) completeness, (2) effectiveness, (3) efficiency, and (4) acceptability. A summary of this comparison is included in **Table ES-3**. Based on this comparison, and the ability of plans to address both primary objectives, the required No-Action plan and five initial alternatives were identified for further consideration in the SLWRI. The five initial alternatives are essentially starting points to be used to further formulate detailed plans for evaluation and consideration in the feasibility report and supporting documentation. For example, future detailed alternative plans could include other sizes of raising Shasta Dam (with a likely maximum limit of 18.5 feet) or other measures to help restore the anadromous fishery, should further study demonstrate the potential for their efficient and effective implementation. Initial alternatives include the following:

- **No-Action (No Federal Action)** - Under the No-Action plan, the Federal Government would take no action toward implementing a specific plan to help increase anadromous fish survival opportunities in the upper Sacramento River nor help address the growing water reliability issues in the Central Valley of California through the assistance of Shasta Dam and Reservoir.

TABLE ES-3
SUMMARY COMPARISON OF CONCEPT PLANS

Concept Plans	Comparison Criteria: Completeness	Effectiveness	Efficiency	Acceptability	Recommendation Status and Relative Ranking
AFS-1	Low	Very Low	Very Low	Very Low	Enlarging Shasta for the sole purpose of increasing the cold water pool is **not recommended** for further consideration as a stand-alone plan. Only one primary objective addressed. Very high cost for meeting single objective. Same conclusion for any size raise with similar component measures and intent.
AFS-2	Moderate	Low	Low	Low	Enlarging Shasta primarily to increase winter/spring river flows for anadromous fish is **not recommended** for further consideration as a stand-alone plan. Very high costs for marginal increases in fish survival. Same conclusion for any sized project with similar component measures. However, potential operational changes to increase fish survival are recommended for further study as part of any plan considered.
AFS-3	Moderate	Low	Low	Low	As with AFS-2, **not recommended** for further consideration as a stand-alone plan. High costs for marginal increases in fish survival. However, potential for increased fish habitat downstream from Keswick Dam recommended for further assessment and possible inclusion in future plans.
WSR-1	Very High	Low	Moderate	High	Enlarging Shasta primarily for water supply reliability from 6.5 feet to about 18.5 feet is **recommended** for further development primarily because (1) consistent with goals of the CALFED ROD, (2) high cost-efficiency compared to other new sources, and (3) provides significant incidental benefits to anadromous fish and secondary study objectives.
WSR-2	Very High	Moderate	Very High	High	**Recommended** for further development for reasons similar to WSR-1. Also, enlarging Shasta to maximum extent possible without major relocations maximizes cost-efficiency.
WSR-3	Low	High	Low	Low	**Not recommended** for further consideration. High social and environmental impacts in Shasta Lake area. Very high implementation cost.
WSR-4	High	Moderate	Very High	High	Enlarging Shasta to maximum extent possible without major relocations and including conjunctive water management component is **recommended** for further development. Consistent with goals of the CALFED ROD, and believed to be highly cost-efficient.
CO-1	High	Moderate	Moderate	High	**Not recommended** for further consideration as a stand-alone plan. Major components are redundant with WSR-1 and CO-2, which are recommended for further development.
CO-2	High	High	High	High	Enlarging Shasta to maximum extent possible without major relocations and including features to increase anadromous fish habitat is **recommended** for further development. Recommended primarily because this plan is (1) consistent with goals of the CALFED ROD, (2) highly cost-efficient, and (3) addresses most of the planning objectives.

TABLE ES-3 (CONT.)

Initial Concepts	Comparison Parameters				Recommendation Status and Relative Ranking
	Completeness	Effectiveness	Efficiency	Acceptability	
CO-3	Moderate	Moderate	Moderate	Low to Moderate	For reasons similar to AFS-2 and AFS-3, enlarging Shasta with significant storage space dedicated to increased winter/spring flows for anadromous fish is **not recommended** for further consideration as a stand-alone plan at this time. Very high costs for marginal achievement in meeting objectives. However, potential operational changes to increase fish survival are recommended for further study as part of any plan considered.
CO-4	High	Moderate	Moderate	High	**Not recommended** for further consideration as a stand-alone plan with 6.5-foot raise primarily due to reduced effectiveness and efficiency. Major components are redundant with WSR-1 and CO-5, which are recommended for further development.
CO-5	High	High	High	High	Enlarging Shasta to maximum extent possible without major relocations and including features for conjunctive water management, anadromous fish habitat, and ecosystem restoration is **recommended** for further development. This plan is (1) consistent with goals of the CALFED ROD, (2) highly cost-efficient, and (3) addresses all SLWRI planning objectives.

- **WSR-1 –** Increase Water Supply Reliability with Shasta Enlargement (6.5 feet).
- **WSR-2 –** Increase Water Supply Reliability with Shasta Enlargement (18.5 feet).
- **WSR-4 –** Increase Water Supply Reliability with Shasta Enlargement (18.5 feet) and Conjunctive Water Management.
- **CO-2 –** Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet).
- **CO-5 –** Multipurpose with Shasta Enlargement (18.5 feet).

PROJECT MANAGEMENT AND PUBLIC INVOLVMENT

Overall management of the SLWRI is through a Study Management Team that primarily consists of senior management level representatives from Reclamation, the California Department of Water Resources (DWR), California Bay-Delta Authority, and, as the study progresses, other Federal and State agencies. Primary product delivery for the SLWRI feasibility study and report is managed through the Project Coordination Team, which consists of the Reclamation Project Manager and technical support specialists from participating agencies.

Two main outreach elements to assist in coordinating the study efforts have been established, including (1) technical work group communications and (2) public meetings, workshops, and briefings. A series of briefings for several SLWRI technical work groups, and a public workshop, were held in fall 2003 to discuss the study, its objectives, and resources management measures being considered to address the study objectives. A second public workshop was scheduled for summer 2004 to update stakeholders about the study and review the initial alternatives described in this report. Future public meetings will be held at important points in the investigation, including (1) initiation of the environmental scoping process, likely in spring 2005, (2) after development of a detailed set of alternative plans, and (3) after completion of the draft integrated feasibility report. Public input will be an important part of detailed alternative formulation and selection of a recommended plan.

FUTURE ACTIONS

The next major step in the feasibility study process is to further develop the initial alternatives into a set of detailed alternative plans for a feasibility report. The emphasis of upcoming studies will be on hydraulic and hydrologic system modeling, designs and cost estimates, and environmental impact evaluations and documentation. Major emphasis also will be placed on continued communication of study findings with other agencies, identified stakeholder groups, and involved groups and individuals.

DWR is the non-Federal sponsor for the SLWRI. However, participation by DWR and other State agencies in the study is restricted due to California Public Resources Code 5093.542(c). The Code states that except participation of DWR in studies involving the technical and economic feasibility of enlarging Shasta Dam, "…no department or agency of the state shall assist or cooperate with, whether by loan, grant, license, or otherwise, any agency of the federal, state or local government in the planning or construction of any dam, reservoir, diversion, or impoundment facility that could have an adverse effect on the free-flowing condition of the McCloud River, or on its wild trout fishery." However, for the SLWRI to move forward effectively, DWR and other elements within the state need to take an increasingly active role in future studies, which may require action by the state legislature. In addition, for each potential project purpose of the SLWRI, a non-Federal sponsor must be willing to share the cost of the purpose and, in the case of any ecosystem restoration features, operate and maintain completed project elements. An important factor in future study efforts will be active participation by the State in the study and identification of specific non-Federal sponsoring interests for the project purposes.

Based on completing a draft feasibility report, which will consist of an integrated Federal decision document and Environmental Impact Statement and Environmental Impact Reports in early 2007, it is estimated that the final feasibility report would be completed in mid-2007. With possible Congressional authorization later that year, detailed project design could be initiated in 2008 or 2009, followed by initiation of construction, acquisition of necessary permits, and minor relocations. The construction period would likely range from 4 to 6 years depending on the plan selected.

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ACRONYMS AND ABBREVIATIONS

Accord	Bay-Delta Accord
ACID	Anderson Cottonwood Irrigation District
AF	acre-feet
AFRP	Anadromous Fish Restoration Program
AFS	anadromous fish survival
Agreement	Sacramento Valley Water Management Agreement
AIR Com	Area Impact and Restoration Communication
Bay-Delta	San Francisco Bay/Sacramento-San Joaquin River Delta
BCWC	Battle Creek Water Conservancy
BLM	United States Department of the Interior, Bureau of Land Management
BMP	best management practice
BO	Biological Opinion
CALSIM	California Water Allocation and Reservoir Operations Model
CalTrout	California Trout
CBDA	California Bay-Delta Authority
CCWD	Contra Costa Water District
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
cfs	cubic feet per second
CO	combined objectives
COA	Coordinated Operations Agreement
Corps	United States Army Corps of Engineers
CRMP	Coordinated Resource Management Plan
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVRWQCB	Central Valley Regional Water Quality Control Board
Delta	Sacramento-San Joaquin River Delta
DMC	Delta-Mendota Canal
DWR	California Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
elevation	elevation in feet above mean sea level
EPA	United States Environmental Protection Agency
ERP	Ecosystem Restoration Program
ESA	Endangered Species Act
EWA	Environmental Water Account
FERC	Federal Energy Regulatory Commission
FWUA	Friant Water Users Authority
GIS	geographic information system
GWh	gigawatt-hour
I-5	Interstate 5
IAIR	Initial Alternatives Information Report
IDC	interest during construction

ISO	Independent Systems Operator
JPOD	joint point of diversion
M&I	municipal and industrial
MAF	million acre-feet
msl	mean sea level
MSMR	Mission Statement Milestone Report
MW	megawatt
NAVD	North American Vertical Datum
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Environmental Restoration
NMFS	National Marine Fisheries Service, now NOAA Fisheries
NO	nitrogen oxide
NOAA	National Oceanic and Atmospheric Administration
NODOS	North of Delta Offstream Storage
NPDES	National Pollutant Discharge Elimination System
NRDC	Natural Resources Defense Council
O&M	operations and maintenance
O_3	ozone
OCAP	Operations Criteria and Plan
P&G	Federal Water Resources Council Principles and Guidelines
PCT	Project Coordination Team
PG&E	Pacific Gas and Electric
PL	Public Law
Plan	Strategic Agency and Public Involvement Plan for the SLWRI
PM_{10}	particulate matter
PPA	Preferred Program Alternative
RBDD	Red Bluff Diversion Dam
RCC	roller-compacted concrete
RCD	Resource Conservation District
Reclamation	United States Department of the Interior, Bureau of Reclamation
Reclamation Board	Reclamation Board of the State of California
RHJV	Riparian Habitat Joint Venture
ROD	Record of Decision
RWQCB	Regional Water Quality Control Board
SCE	Southern California Edison
SDIP	South Delta Improvements Program
SLWRI	Shasta Lake Water Resources Investigation
SMT	Study Management Team
SMUD	Sacramento Municipal Utility District
SRCA	Sacramento River Conservation Area
State	State of California
STNF	Shasta-Trinity National Forest
STNFLRMP	Shasta-Trinity National Forest Land Resource Management Plan
SVAB	Sacramento Valley Air Basin
SWAG	Sacramento Watersheds Action Group

SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TCD	temperature control device
TNC	The Nature Conservancy
Tribal Com	Tribal Communication
TU	temperature unit
UPRR	Union Pacific Railroad
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
WCB	Wildlife Conservation Board of CDFG
WSCC	Western Systems Coordinating Council
WSR	water supply reliability
WSR Com	Water Supply and Reliability Communication
WUE	water use efficiency

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CHAPTER I
INTRODUCTION

In 2000, the United States Department of the Interior, Bureau of Reclamation, Mid-Pacific Region (Reclamation), reinitiated a feasibility-scope investigation focusing on evaluating the potential of enlarging Shasta Dam. The dam would be enlarged primarily for increased water supply reliability and water quality improvement, with the potential to consider limited hydropower generation and flood damage reduction. This investigation is being conducted at the direction of Congress and supports other and ongoing Federal interests within the study area described below.

A Mission Statement Milestone Report (MSMR) for the Shasta Lake Water Resources Investigation (SLWRI) was completed in March 2003. The MSMR outlines the resource problems, study objectives, and mission statement for the SLWRI, and sets forth several concepts to address the identified problems.

PURPOSE AND NEED FOR ACTION

The purpose of the SLWRI is to develop an implementable plan primarily involving modifying Shasta Dam and Reservoir to promote increased survival of anadromous fish populations in the upper Sacramento River; promote increased water supply reliability to the Central Valley Project (CVP); and to the extent possible through meeting these objectives, include features to benefit other identified ecosystem, flood control, and related water resources needs.

STUDY AREA LOCATION AND DESCRIPTION

The primary study area for the SLWRI is Shasta Dam and Reservoir; inflowing rivers and streams, including the Sacramento River, McCloud River, Pit River, and Squaw Creek; and the Sacramento River downstream to about the Red Bluff Diversion Dam (RBDD). **Plate 1** is a map showing the primary study area within the Sacramento River Basin. **Plate 2** shows the Shasta Reservoir area. The RBDD was chosen as the downstream boundary of the primary study area because it is the point at which releases from Shasta Dam begin to have a negligible effect on Sacramento River water temperatures, and the river landscape changes to a broader, alluvial stream system.

Due to the potential influence of a modification of Shasta Dam on other programs and projects in the Central Valley, an extended study area includes areas that could be affected by a potential enlargement of Shasta Dam and Reservoir. The extended study area primarily includes the Sacramento River watershed, American River Basin, Sacramento-San Joaquin River Delta (Delta), and San Joaquin River Basin. California’s Central Valley is home to more than 4 million people and a wide variety of fish and wildlife, including about 180 special-status plant and animal species. The river basins provide drinking water to over two-thirds of Californians. The robust economy of this region centers on an agricultural industry that is a major source of reliable, high-quality crops marketed to the nation and the world.

Shasta Dam and Reservoir are located on the upper Sacramento River in Northern California, as shown in **Figure I-1**, about 9 miles northwest of the City of Redding (see **Plate 1**); the entire reservoir is within Shasta County. Shasta Lake has about 400 miles of shoreline. The reservoir controls runoff from about 6,420 square miles. The four major tributaries to Shasta Lake are the Sacramento River, McCloud River, Pit River, and Squaw Creek, in addition to numerous minor tributary creeks and streams.

- **Upper Sacramento River –** The upper Sacramento River drains an area of roughly 430 square miles. Its headwaters include portions of Mount Shasta and the Trinity and Klamath mountains. It flows south for approximately 40 miles before entering Shasta Lake.

- **McCloud River –** The McCloud River basin drains an area of about 600 square miles. Its headwaters are at Colby Meadows near Bartle. The river flows southwesterly for approximately 50 miles to its terminus at Shasta Lake.

- **Pit River –** The Pit River watershed is located in northeastern California and southeastern Oregon. The north and south forks of the Pit River drain the northern portion of the watershed. The north fork of the Pit River originates at the outlet of Goose Lake and the south fork originates in the south Warner Mountains at Moon Lake in Lassen County. The Pit River is joined by the Fall River in Shasta County. The Pit River has 21 named tributaries, totaling about 1,050 miles of perennial stream and encompassing approximately 4,700 square miles.

- **Squaw Creek –** The Squaw Creek watershed is located east of Shasta Lake and drains 103 square miles. It flows to the southwest through generally steep terrain.

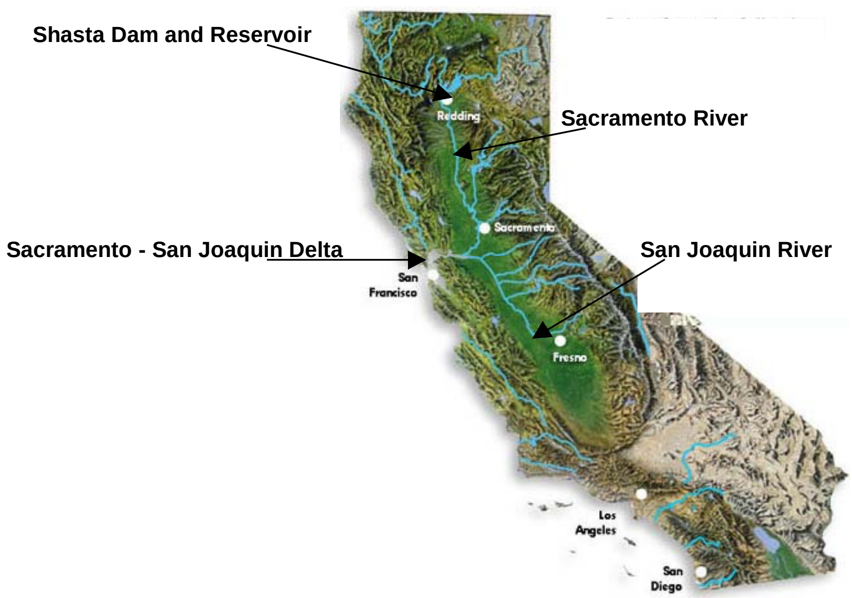

Figure I-1 – Shasta Dam and Reservoir are located north of Redding on the Sacramento River.

Figure I-2 – Shasta Dam under construction, looking from east to west.

Most of the outflow from Shasta Dam travels south in the Sacramento River to the Delta. From the Delta, flows mingle with runoff primarily from the San Joaquin River watershed and flow to the Pacific Ocean through San Francisco Bay. The total drainage area of the Sacramento River at the Delta is about 26,300 square miles. The average annual runoff volume to the Delta from the Sacramento River watershed is about 17.2 million acre-feet (MAF). This represents about 62 percent of the total 27.8 MAF inflow to the Delta.

Shasta Dam was constructed from September 1938 to June 1945. Storage of water in Shasta Lake began in December 1943. Gates, valves, and other items of finish work, deferred during World War II, were completed following the war and the project was placed in full operation in April 1949. Approximately 37 miles of the Union Pacific Railroad (UPRR) main line to Portland, Oregon, and 21 miles of U.S. Highway 99 (I-5) were relocated around the reservoir during this period. When constructed, Shasta Dam was the second highest and second largest concrete dam in the world. It was exceeded only by Boulder Dam (Hoover Dam) in height and by Grand Coulee Dam in volume; however, many dams now rank above it in both respects.

Shasta Reservoir delivers about 55 percent of the total annual water supply developed by the CVP. The Shasta Dam and Reservoir project was constructed by Reclamation as an integral element of the CVP for six purposes: irrigation water supply, municipal and industrial (M&I) water supply, flood control, hydropower generation, fish and wildlife conservation, and navigation. Shasta Lake also supports vigorous water-oriented recreation. For flood control, Reclamation operates the facility in accordance with guidelines provided by the United States Army Corps of Engineers (Corps). All outflows from Shasta Dam flow into and through Keswick Reservoir, located about 5 miles west of Redding. Keswick Reservoir also receives inflows from Whiskeytown Reservoir on Clear Creek.

Figure I-3 – Today, Shasta Dam (shown here), and Friant Dam on the upper San Joaquin River, are two of the primary features of the CVP.

STUDY AUTHORIZATION

On August 30, 1935, in the Rivers and Harbors Bill, an initial amount of Federal funds was authorized for constructing Kennett (now Shasta) Dam. Fundamental authorization for the SLWRI derives from the 1980 Public Law (PL) 96-375. This law authorized the Secretary of the Interior to engage in feasibility studies relating to (1) enlarging Shasta Dam and Reservoir, or constructing a replacement dam on the Sacramento River and (2) using the Sacramento River to convey water from an enlarged dam. The Central Valley Project Improvement Act (CVPIA) of 1992 (PL 102-575) is another piece of legislation pertinent to the SLWRI because of its influence on water supply deliveries, river flows, and related environmental conditions in the primary and extended study areas.

PURPOSE AND SCOPE

The primary purpose of this Initial Alternatives Information Report (IAIR) is to describe the formulation of initial alternatives to address planning objectives established for the SLWRI. From these initial alternatives, detailed alternative plans will be developed in the remainder of the feasibility study.

The scope of the report includes the following topics:

- Description of existing and likely future water resources and related conditions in the study area, and related problems, needs, and opportunities being addressed in the study.
- Development of planning objectives to address identified problems, needs, and opportunities, and a Mission Statement to support these planning objectives.
- Identification of the planning constraints, guiding principles, and criteria for the feasibility study.
- Identification and evaluation of individual water resources management measures to address each of the planning objectives.
- From the identified management measures, formulation of a set of concept plans that represent a range of actions that could address the planning objectives.
- From the concepts, identification of a recommended set of initial alternatives to be further developed in the feasibility study.
- Identification of potential major future actions for the feasibility study.

This IAIR will be used as an initial component of the feasibility report. Conclusions and recommendations regarding further evaluations are expected to evolve as the study progresses.

REPORT ORGANIZATION

In addition to this chapter, the IAIR is organized into five sections:

1. Chapters II, III, and IV highlight related studies, projects, and programs; define existing and projected future without-project water resources and related conditions; and describe fundamental problems being addressed in the investigation.
2. Chapter V describes the plan formulation process; defines planning objectives for the investigation; identifies planning constraints, principles, and criteria; and includes the Mission Statement for the investigation.
3. Chapter VI describes potential resources management measures that could address the planning objectives and highlights those measures carried forward for inclusion into concept plans.

4. Chapters VII and VIII describe the formulation of concept plans and identification of initial alternatives for further development in the feasibility study.
5. Chapters IX through XII include special topics, information on study management and public involvement, future actions needed to complete interim documents and the final feasibility report, and a summary of findings.

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CHAPTER II
RELATED STUDIES, PROJECTS, AND PROGRAMS

This chapter presents the related activities of various Federal and State agencies and numerous local working groups and private organizations in the study area. Many of these entities, including Reclamation, the California Bay-Delta Authority (CBDA), and the Corps, are performing current studies, projects, and programs that are important to the SLWRI.

BUREAU OF RECLAMATION

As the owner and operator of Shasta Dam and Reservoir, Keswick Dam and Reservoir, and various related components of the CVP in the study area, Reclamation has a significant effect on environmental resources in the region. Ongoing projects or continuing programs relevant to the primary study area are described below.

Central Valley Project

Shasta Dam and Reservoir are key elements of the CVP. President Franklin Roosevelt approved the CVP, including the Kennett (Shasta), Friant, and Contra Costa (Delta) divisions, on December 2, 1935. The CVP is the largest surface water storage and delivery system in California, with a geographic area covering 35 of the State of California's (State) 58 counties. The project includes 20 reservoirs, with a combined storage capacity of approximately 11 MAF; 8 powerplants and 2 pump-generating plants, with a combined generation capacity of approximately 2 million kilowatts; and approximately 500 miles of major canals and aqueducts. The CVP supplies water to more than 250 long-term water contractors in the Central Valley, the Santa Clara Valley, and the San Francisco Bay Area. **Plate 3** shows the locations of major CVP facilities, rivers that are controlled or affected by the operation of CVP facilities, and the CVP service area. Shasta Reservoir delivers about 55 percent of the total annual water supply developed by the CVP.

Approximately 90 percent of CVP water is delivered to agricultural users, including prior water rights holders. The CVP has the potential to supply about 7 MAF annually to agricultural and M&I customers and for environmental purposes. Of this 7 MAF, about 6.2 MAF would be for agricultural uses, 0.5 MAF for urban uses, and 0.3 MAF for wildlife refuges. Municipal customers include the cities of Redding, Sacramento, Folsom, Tracy, and Fresno; most of Santa Clara County; and the northeastern portion of Contra Costa County. The CVP also provides flood control, navigation, power, recreation, and water quality benefits.

Operational Influences

CVP operations are influenced by general operating rules, regulatory requirements, and facility-specific concerns and requirements. Inflow and release requirements are the principal elements influencing reservoir storage. Operational decisions consider not only conditions at individual reservoirs, but also downstream flow conditions and conditions at other project reservoirs. Storage space south of the Delta that only can be filled with water exported from the Delta is a major operational consideration involving the geographic distribution of water in storage. Other factors that influence the operation of CVP reservoirs include flood control requirements, carryover storage objectives, lake recreation, power production capabilities, cold water reserves, and pumping costs.

Rivers below some CVP dams support both resident and anadromous fisheries and recreation. While resident fisheries are slightly affected by release fluctuations, anadromous fisheries (e.g., salmon and steelhead) are the most sensitive and are present year-round downstream of some CVP facilities. Maintaining water conditions favorable to spawning, incubation, rearing, and out-migration of juvenile anadromous fish is one of the main objectives of CVP operations. CVP operations are coordinated to anticipate and avoid streamflow fluctuations during spawning and incubation whenever possible.

Operation of the CVP is affected by several regulatory requirements and agreements. Prior to passage of the CVPIA, operation of the CVP was affected by State Water Resources Control Board (SWRCB) Decisions 1422 and 1485 (D-1422 and D-1485), and the Coordinated Operations Agreement (COA). D-1422 and D-1485 identify minimum flow and water quality conditions at specified locations that are to be maintained in part through operation of the CVP. The COA specifies the responsibilities shared by the CVP and California's State Water Project (SWP) for meeting the requirements of D-1485. In December 1994, representatives of the State and Federal governments and urban, agricultural, and environmental interests agreed to implementation of a San Francisco Bay/Sacramento-San Joaquin River Delta (Bay-Delta) protection plan through the SWRCB that would protect the ecosystem of the Bay-Delta Estuary. The Draft Bay-Delta Water Control Plan, released in May 1995, superseded D-1485. Coordinated operations of the CVP and SWP continue to be based on the COA.

Operation Divisions

CVP operations are divided into eight divisions. Operations north of the Delta include the Trinity, Shasta, and Sacramento River divisions, known collectively as the Northern CVP System. Those south of the Delta, and the Delta, West San Joaquin, and San Felipe divisions are known collectively as the Southern CVP System. Both the Eastside and Friant divisions are operated independently of the remainder of the CVP due to the nature of their water supplies and service areas. The Northern and Southern CVP Systems are operated as an integrated system, and demands for water and power can be met by releases from any one of several facilities. Demands in the Delta and south of the Delta can be met by the export of excess water in the Delta, which can result from releases from northern CVP reservoirs. Operational decisions are based on a number of physical and hydrological factors that change depending on conditions.

CVP Water Users

During development of the CVP, the United States entered into long-term contracts in the Central Valley with many major water rights holders, who belong to three major groups: (1) Sacramento River Settlement Contractors, (2) San Joaquin River Exchange Contractors, and (3) Water Service Contractors.

Members of Sacramento River Settlement Contractors primarily claim water rights on the Sacramento River. Because of the significant influence on flows in the Sacramento River, controlled by Shasta Dam, these water right claimants entered into contracts with Reclamation.

Most of the agreements established the quantity of water the contractors are allowed to divert from April through October without payment to Reclamation, and a supplemental CVP supply allocated by Reclamation.

San Joaquin River Exchange Contractors are contractors who receive CVP water from the Delta via the Mendota Pool. Under exchange contracts, the parties agreed not to exercise their San Joaquin River water rights in exchange for a substitute CVP water supply from the Delta. These exchanges allowed for water to be diverted from the San Joaquin River for use by water service contractors in the San Joaquin Valley and Tulare Lake Basin.

Before construction of the CVP, many irrigators on the west side of the Sacramento Valley, on the east and west sides of the San Joaquin Valley, and in the Santa Clara Valley relied primarily on groundwater. With completion of CVP facilities in these areas, irrigators signed agreements with Reclamation for delivery of CVP water as a supplemental supply. Several cities also have similar contracts for M&I supplies; these irrigators and cities are known as CVP Water Service Contractors. CVP water service contracts are between the United States and individual water users or districts and provide for an allocated supply of CVP water to be applied for beneficial uses.

Prior Studies of Enlarging Shasta Dam

Several studies have been conducted since the early 1960s to assess the feasibility of increasing storage space at Shasta Reservoir. The most significant studies occurred in the late 1970s and early 1980s. Evaluations of raising Shasta Dam considered structural modifications, environmental and related impacts, water supply and hydropower benefits, costs, and Federal interest. In November 1978, Reclamation produced for Congress an appraisal-level cost evaluation for enlarging Shasta Reservoir. Subsequent to this report, Congress directed Reclamation to engage in a feasibility study with the California Department of Water Resources (DWR) regarding enlarging Shasta Lake. Most studies were completed in the early 1980s as part of PL 96-375, culminating with a final "wrap-up report," completed in 1988. This report concluded that although enlarging Shasta Dam appeared feasible, a low demand for new supplies existed at that time.

No further action was taken on the potential project until the mid-1990s when Reclamation initiated an appraisal-level study that culminated in May 1999. The CVPIA was a major impetus for the appraisal study. The Shasta Dam and Reservoir Enlargement Appraisal Assessment reviewed estimated costs for a range of enlargement options and identified critical issues that would affect project feasibility. Three dam raises were considered in the study and documented in the appraisal report: 202.5 feet (high-level option), 102.5 feet (intermediate-level option), and 6.5 feet (low-level option). Studies concluded that raises up to 202.5 feet are technically feasible but higher raises would involve an increasing number of relocations and environmental impacts. The report recommended that additional studies be conducted that focus on low-raise options.

Central Valley Project Improvement Act

The CVPIA was signed into law in October 1992 to address conflicts over water rates, irrigation land limitations, and environmental impacts of the CVP. This legislation mandates changes in management of the CVP, particularly for protection, restoration, and enhancement of fish and wildlife. The CVPIA also addresses the operational flexibility of the CVP and methods to expand the use of voluntary water transfers and improved water conservation. The general purposes of the CVPIA, as identified by Congress in Section 3402, include the following:

- Protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River basins of California.
- Address impacts of the CVP on fish, wildlife, and associated habitats.
- Improve the operational flexibility of the CVP.
- Increase water-related benefits provided by the CVP to the State of California through expanded use of voluntary water transfers and improved water conservation.
- Contribute to the State of California's interim and long-term efforts to protect the Bay-Delta Estuary.
- Achieve a reasonable balance among competing demands for CVP water, including water requirements for fish and wildlife, agriculture, M&I, and power contractors.

The CVPIA redefined the purposes of the CVP to include protection, restoration, and enhancement of fish, wildlife, and associated habitats and protection of the Bay-Delta Estuary as having equal priority with other purposes. The CVPIA identified numerous specific measures and programs to meet the new project purpose and also directed the Secretary of the Interior to operate the CVP consistent with these purposes. Sections of the CVPIA important to the SLWRI include those focused on dedication of a portion of CVP yield to be used for environmental purposes; the Anadromous Fish Restoration Program (AFRP), which included a goal of doubling natural production of anadromous fish in Central Valley rivers and streams; the Restoration Fund; urban water reliability; water transfers; refuge water supplies; restoration of the San Joaquin, Trinity, and Stanislaus rivers; and a stakeholder process. Several specific projects include improvements to the intakes at the Coleman National Fish Hatchery on Battle Creek; installation of a temperature control device (TCD) on Shasta Dam; removal of McCormick-Saeltzer Dam on Clear Creek; land acquisition and watershed planning on Battle Creek; and a spawning gravel replenishment program.

The combined total amount of water dedicated to the environment by CVPIA suggests an annual amount of up to 1.2 MAF. This includes reallocation of the 800,000 acre-feet contained in Section 3406 (b)(2) of the CVPIA (commonly called (b)(2) water), dedicated inflows to wildlife refuges of 250,000 acre-feet (called Level 2 Refuge water), and Trinity Reapportion water amounting to 150,000 acre-feet. However, after accounting for system operation flexibility, the total impact of the CVPIA for CVP contractors is estimated to amount to a reduction of 585,000 acre-feet annually. It is estimated in the CVPIA Programmatic Environmental Impact Report (EIR) that reduced water supplies and other CVPIA provisions would result in increased groundwater overdraft, fallowing of agricultural land, loss of jobs, and loss of over $150 million in annual agricultural revenues. Most of this loss would be the result of the reduction in water supplies.

Implementation of the CVPIA (b)(2) provision has been a contentious process, marked by conflict between State and Federal parties, and substantial litigation. The primary dispute has been whether (b)(2) water translates into an automatic reduction in exports under water supply contracts. In May of 2003, Reclamation released a final decision on the implementation of Section 3406 (b)(2). The decision incorporates parts of an earlier decision (United States Department of the Interior 1999 Final Decision), modifies other decisions, and adds new components. The intent of these changes was to simplify and clarify the accounting process for (b)(2) water uses and to integrate (b)(2) water dedication and management with CVP operations for other CVP purposes. The decision is divided into sections that address calculations of yield, accounting processes, modifications of CVP operations, water banking and transfers/exchanges of water, water to meet the 1995 Bay-Delta Water Quality Control Plan and Federal Endangered Species Act (ESA) of 1978 obligations, shortage criteria, and coordination.

CVP Water Supply Improvement Plan

Section 3408 (j) of the CVPIA directed the Secretary of the Interior to prepare a plan to increase the yield of the CVP. This section directs the Secretary to develop a least-cost plan to increase the yield of the CVP by an amount equal to that dedicated to fish and wildlife under the CVPIA. This plan was also intended to assist the State in meeting its future water needs. Further, appropriate cost-sharing arrangements to implement the CVP Water Supply Improvement Plan were to be recommended. A preliminary least-cost yield increase plan was completed by Reclamation in 1995 that identified cost and supply estimates for a number of new water supply and management options, including groundwater storage, land fallowing, conservation and reuse, and surface storage. The plan did not, however, propose a specific CVP yield increase. Reclamation is currently preparing a supplement to the 1995 plan.

CVPIA Contract Renewal Process

In accordance with Section 3404(c) of the CVPIA, Reclamation is negotiating long-term water service contracts. It is anticipated that as many as 111 CVP water service contracts, located within the Central Valley, may be renewed during this negotiation process. As part of this process, Reclamation is also negotiating renewal of 55 interim water service contracts.

Operations Criteria and Plan

In March 2004, Reclamation and DWR prepared a Long-Term CVP and SWP Operations Criteria and Plan (OCAP) to address how the CVP and SWP would be operated in the future as several proposed projects come on-line and as water demands increase. This document is a revision of the previous 1992 OCAP release. It incorporates numerous additional constraints and criteria that have arisen since 1992. Several incorporations include the 2000 Trinity Record of Decision (ROD), AFRP flow objectives, the 1993 Winter Run Biological Opinion (BO), the revised decision on CVPIA Section 3406(b)(2) water, the Environmental Water Account (EWA), and the Joint Point of Diversion (JPOD).

Red Bluff Diversion Dam Fish Passage Improvement Program

Figure II-1 The Red Bluff Diversion Dam on the Sacramento River, looking west.

The RBDD, which is owned and operated by Reclamation, is located on the Sacramento River about 2 miles southeast of the city of Red Bluff. The 52-foot-high, 740-foot-long dam, and 3,900-acre-foot lake are elements of the CVP and designed to provide irrigation water to areas in Tehama, Glenn, and Colusa counties via the Tehama-Colusa and Corning canals. Although a fish ladder is located on each abutment of the dam, ineffective fish passage at the dam has been identified as contributing to the decline in populations of anadromous fish in the upper Sacramento River. Various studies and constructed test projects have been completed that focus on reducing impacts to anadromous fish while maintaining irrigation diversion capabilities at the dam; however, additional studies are ongoing.

The Red Bluff Diversion Dam Fish Passage Improvement Project on the Sacramento River is a cooperative effort led by Reclamation and the Tehama-Colusa Canal Authority. The project consists of developing a long-term solution to relieve conflicts between fish passage and agricultural diversion needs. The two primary fish passage issues associated with the RBDD are (1) the delay and blockage of adults migrating upstream, and (2) impedance and losses of juveniles emigrating downstream. The reach of the Sacramento River upstream of RBDD is the primary spawning habitat for the endangered winter-run chinook and the fall- and late fall-run chinook salmon. Fish ladders located on each abutment of the dam have been ineffective, limiting access to remaining spawning habitat between Keswick Dam and Red Bluff. Predation is also problematic in Lake Red Bluff.

Five alternative plans were developed to improve fish passage at the RBDD. Public comment on those plans ended in November 2002 for the Draft Environmental Impact Statement/ Environmental Impact Report (EIS/EIR) released in August 2002. The environmental document is scheduled for completion at the end of 2004. The schedule has been delayed pending completion of the Reclamation OCAP process.

Trinity River Restoration Plan

Trinity Dam and Lake are located about 24 miles north west of Redding. Construction of Trinity Dam was completed in 1962. The dam is an earthfill structure 538 feet high with a crest length of 2,450 feet. Trinity River drains an area of about 3,000 square miles. Trinity Dam and Reservoir has a capacity of nearly 2.5 MAF. The Trinity River Division of the CVP, which includes Trinity and Whiskeytown dams, conveys water from the Trinity River to the Sacramento River basin for export to water-deficient areas of the Central Valley.

In December 2000, the Secretary of Interior issued a ROD documenting the selection of actions necessary to restore and maintain the anadromous fishery in the Trinity River. This ROD was the culmination of a nearly 20-year process of detailed scientific efforts. The Trinity ROD implements a component of the CVPIA (Section 3406(b)(23)) intended to meet Federal trust responsibilities for protecting the fishery resources of the Hoopa Valley Tribe, and to meet the fishery restoration goals of PL 98-541 (October 24, 1984). The ROD adopts a preferred alternative that includes restoration and perpetual maintenance of the Trinity River's fishery resources that would result in rehabilitation of the river itself through restoration of the attributes that produce a healthy, functioning alluvial river system. The preferred alternative reduced the average annual export of Trinity River water from 74 percent of the flow to 52 percent. The Trinity ROD is a general statement of policy regarding the issues of water flow in both the Trinity River and Sacramento River mainstems. It is acknowledged to have a broad effect on both rivers' ecosystems and potentially significant economic effects within the Sacramento River and Trinity River basins. Major components of the selected course of action include (1) a variable annual instream flow for the Trinity River, (2) physical channel rehabilitation, (3) sediment management, including supplementation of spawning gravels, (4) watershed restoration efforts, and (5) river infrastructure improvements.

Battle Creek Restoration Project

Reclamation, in partnership with the Pacific Gas and Electric Company (PG&E), National Oceanic and Atmospheric Administration (NOAA) Fisheries, formerly National Marine Fisheries Service (NMFS), United States Fish and Wildlife Service (USFWS), and the State of California Department of Fish and Game (CDFG), is working to restore major reaches of Battle Creek. The Battle Creek Salmon and Steelhead Restoration Project provides for a private and public sector partnership focused on restoring the winter-run, spring-run, fall- and late-fall-run chinook salmon and steelhead, all of which are already listed or proposed for protection under the Federal and State ESAs. This partnership will create the framework for restoring one of the most important anadromous fish spawning streams in the Sacramento Valley while maintaining a pollution-free renewable energy resource for electric customers of California. Numerous natural and man-made barriers exist in the Battle Creek watershed that prevent access to valuable cold water spawning grounds. Actions will include removing dams, constructing fish screens and ladders, and augmenting flows to increase salmonid habitat. Restoration actions are expected to enhance and re-establish 43 miles of habitat and should increase all salmon and steelhead runs. Steelhead escapement is expected to increase the most under restored conditions; it is predicted that the adult steelhead population will increase by 5,700, which will more than double the average run in the Sacramento River above Red Bluff. The gain of 2,500 adult winter- and spring-run chinook salmon also would appreciably increase the total run sizes of these species. Various Federal, State, and local entities, including USFWS and the Western Shasta Resource Conservation District, are implementing different phases of the project. Construction of initial features began in 2002.

Sacramento River Diversion Feasibility Study (Sacramento River Water Supply Reliability Study)

Reclamation and Placer County Water Agency are conducting the Sacramento River Diversion Feasibility Study. The purpose of the study is to develop a plan to implement the objectives of the Water Forum Agreement for the American River Watershed, which includes pursuing a water diversion project from the Sacramento River to help meet future water supply needs of the Placer-Sacramento Region and to promote ecosystem restoration along the lower American River. The study is being conducted under provisions in Section 103 to PL 106-554.

BUREAU OF LAND MANAGEMENT

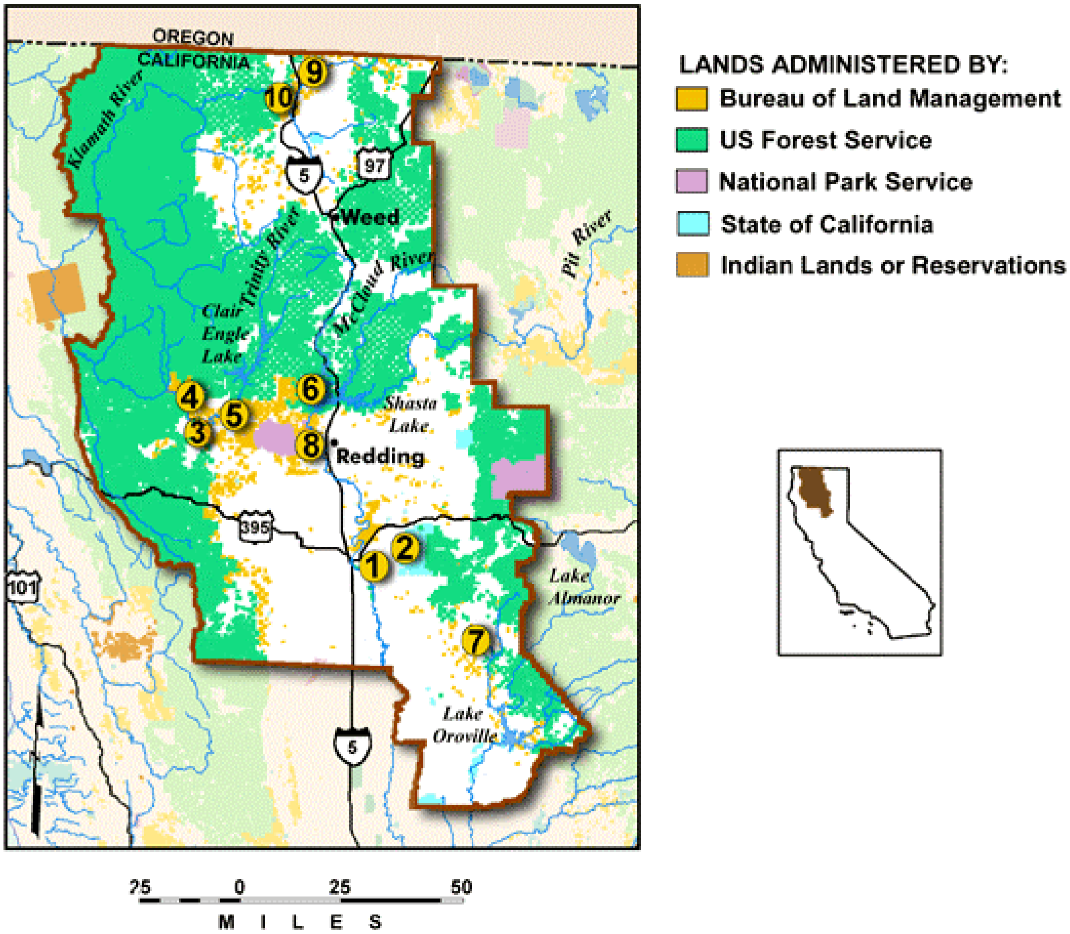
The United States Department of the Interior, Bureau of Land Management (BLM) is responsible for the administration of natural resources, lands, and mineral programs on approximately 250,000 acres of public land in Northern California. BLM lands within the study area, shown in **Figure II-2**, are located predominantly west of the Sacramento River, and include the 17,000-acre Sacramento River Bend area south of Jelly's Ferry, and off-highway vehicle areas near Shasta Lake. BLM has been involved in numerous restoration and conservation projects in area watersheds, including the Clear Creek Floodplain Restoration Project. BLM is also a responsible party in implementation of the Northwest Forest Plan.

Over 40,000 acres of public lands along the Sacramento River between Redding and Red Bluff have been proposed for designation as National Conservation Areas. Designation as a National Conservation Area would prevent construction of dams or other instream infrastructure, and ensure continued public access to the lands. Other areas that have been proposed for National Conservation Area or National Wilderness designations within the primary study area include the Backbone/Sugarloaf wilderness area, the Girard Ridge area (northeast of Shasta Lake), the Devil's Rock area adjacent to Squaw Creek near Shasta Lake, and the Beegum area in the Cottonwood Creek watershed. The BLM determined that 25 miles of the Sacramento River and about 7 miles of Paynes Creek are eligible for National Wild and Scenic River status, and BLM acquired roughly 17,000 acres in the Sacramento River Bend management area. Congressional action is required to confirm these proposed designations.

UNITED STATES FISH AND WILDLIFE SERVICE

USFWS has participated in numerous projects and programs within the study area, many related to species listed under the Federal ESA. The upper Sacramento River is recognized as critical habitat for endangered winter-run chinook salmon and other threatened or endangered species. Activities include investigations at the Coleman National Fish Hatchery, the Battle Creek Restoration Program, Clear Creek Restoration Program, Anderson Cottonwood Irrigation District (ACID) Program, and RBDD Fish Passage Improvement Project. USFWS is also instrumental in implementing the AFRP and Northwest Forest Plan, providing scientific research, monitoring, environmental compliance, and restoration planning support.

The CVPIA included fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic use, and fish and wildlife enhancement as a project purpose equal to power generation. Section 3406(b)(1) of the CVPIA directs the implementation of a program that makes all reasonable efforts to at least double natural production of anadromous fish in California's Central Valley streams on a long-term, sustainable basis. The major resulting program to accomplish this goal is the AFRP administered by USFWS. The AFRP includes the following general objectives:



Source: Bureau of Land Management web site http://www.blm.ca.gov/redding.
Figure II-2 – Lands administered by BLM and other public agencies.

- Improve habitat for all life stages of anadromous fish through provision of flows of suitable quality, quantity, and timing, and improved physical habitat.
- Improve survival rates by reducing or eliminating entrainment of juveniles at diversions.
- Improve the opportunity for adult fish to reach their spawning habitats in a timely manner.
- Collect fish population, health, and habitat data to facilitate evaluation of restoration actions.
- Integrate habitat restoration efforts with harvest and hatchery management.
- Involve partners in implementing and evaluating restoration actions.

To help restore the overall ecosystem function of the upper Sacramento River as part of the AFRP, a number of potential actions have been proposed. Among them are increasing minimum objective flows in the river downstream from Keswick Dam, primarily during the winter and spring, from the current minimum flow of 3,250 cubic feet per second (cfs) to over 5,000 cfs.

NOAA FISHERIES

United States Department of Commerce, NOAA Fisheries, is involved in comprehensive recovery planning for listed salmonid species in the Central Valley. NOAA Fisheries is required under the Federal ESA to assess factors affecting the species, identify recovery criteria, identify the entire suite of actions necessary to achieve these goals, and estimate the cost and time required to carry out the actions.

NOAA Fisheries has designated Critical Habitat for the Federally listed winter-run chinook salmon to be the Sacramento River from Keswick Dam downstream to the Golden Gate Bridge. The Central Valley recovery planning domain also includes Central Valley spring-run chinook salmon, Central Valley steelhead, and also Federal candidate species fall/late fall-run chinook salmon. Clear, Cow, Bear, Battle, and Cottonwood creeks have been identified as Essential Fish Habitat. The Proposed Recovery Plan for Sacramento River Winter-Run Salmon, August 1997, presents restoration goals and actions, some of which would be applied within the SLWRI study area. Proposed elements include the following:

- **Provide suitable water temperatures for spawning, egg incubation, and juvenile rearing between Keswick Dam and Red Bluff –** Actions include operating the CVP to consistently attain water temperature objectives; operating and maintaining temperature control curtains at Whiskeytown and Lewiston reservoirs; and regulating the river and reservoir system using a comprehensive temperature monitoring program and model.

- **Reduce pollution in the Sacramento River from Iron Mountain Mine –** Actions include alleviating pollution problems from the mine during winter-run incubation periods; treating and/or controlling heavy metal waste prior to discharge to the Sacramento River; diluting heavy metal waste discharges through effective water management; eliminating scouring of toxic metal-laden sediments in Spring Creek and Keswick reservoirs; and monitoring metal concentrations and waste flows.

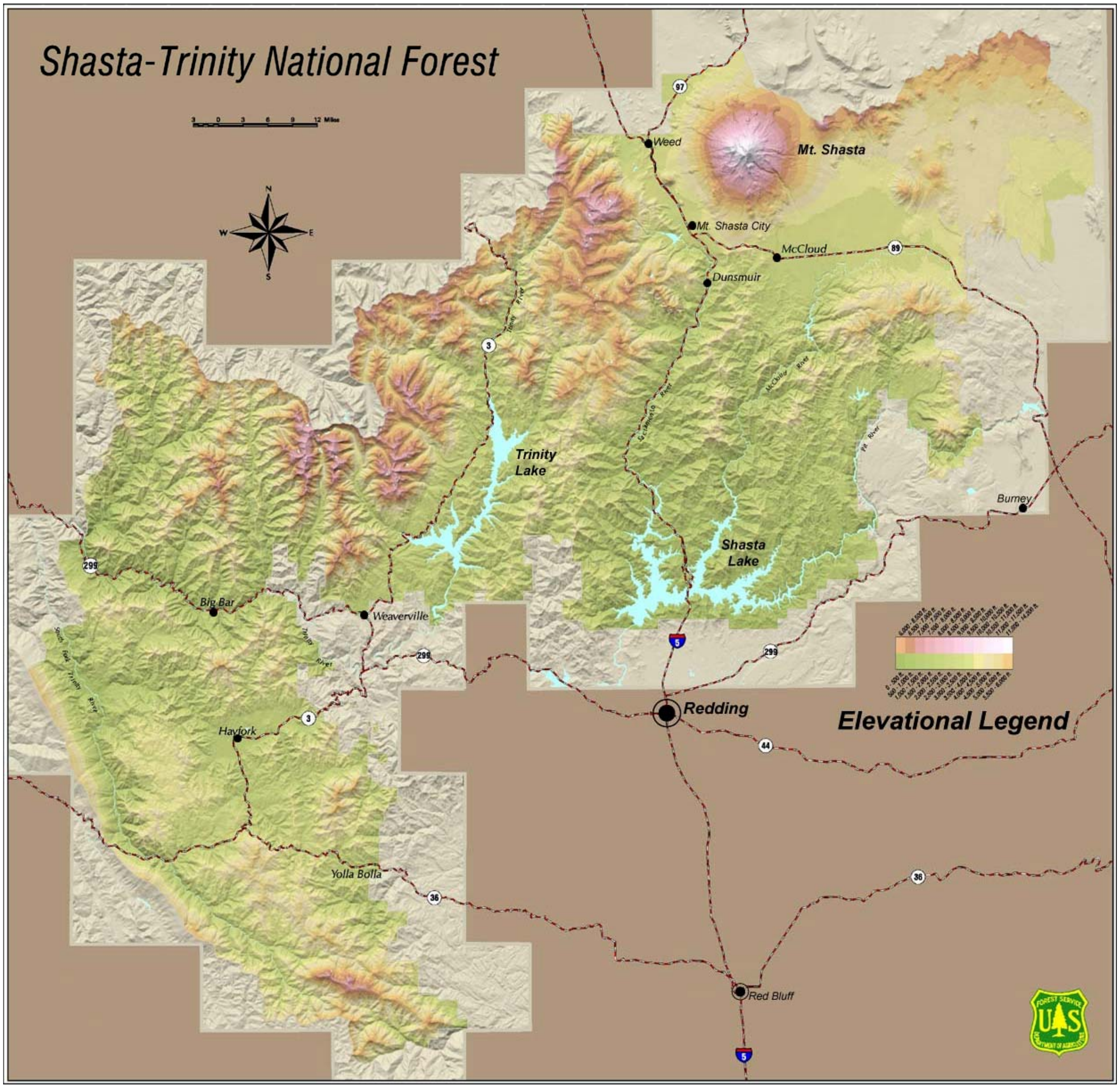
- **Provide optimum flows in the Sacramento River between Keswick Dam and Chipps Island –** Actions include maintaining flows of 5,000 to 5,500 cfs from October through April, when possible; eliminating adverse flow fluctuations by modifying ACID dam operations, or by modifying or replacing the facility; inventorying and assessing water withdrawal sites and taking action to increase streamflows.

- **Protect and maintain gravel resources in the Sacramento River and its tributaries between Keswick Dam and Red Bluff –** Actions include restoring and replenishing spawning gravel in the Sacramento River; implementing a plan to protect natural sources of spawning gravel along the Sacramento River and its tributaries; and controlling excessive silt discharges from tributary watersheds to protect spawning gravel.

Some of these actions are ongoing or are currently under study.

UNITED STATES DEPARTMENT OF AGRICULTURE, FOREST SERVICE

The United States Department of Agriculture, Forest Service (USFS) is responsible for lands within the Shasta-Trinity National Forest (STNF), shown in **Figure II-3**, including the Whiskeytown-Shasta-Trinity National Recreation Area and Shasta McCloud Management Unit. USFS is involved in fire hazard and fuel reduction projects, forest health and ecosystem management, timber sales, conservation planning, wildlife monitoring, recreation facilities, and administration of the Northwest Forest Plan.



Source: Forest Service web site http://www.r5.fs.fed.us/shastatrinity
Figure II-3 – Shasta-Trinity National Forest.

USFS manages the majority of the land and facilities surrounding Shasta Lake. It also owns a 299-acre parcel at the Red Bluff Recreation Area, which is undergoing restoration in cooperation with the Sacramento River Discovery Center. The 1995 Shasta-Trinity National Forest Land Resource Management Plan (STNFLRMP) provides guidance for national forest lands and includes the designation of Riparian Reserves. Riparian Reserves are located along all perennial and intermittent streams and provide special protection to riparian and aquatic values in these areas.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

The United States Environmental Protection Agency (EPA) is involved in remediation and cleanup activities related to the Iron Mountain Mine Superfund site in the Clear Creek drainage, west of the Sacramento River. Acid mine drainage from the former copper mine has significantly impacted the Clear Creek watershed and caused fish kills in the Sacramento River. This site is being addressed through interim emergency actions and long-term remedial phases, focusing on water management, cleanup of major sources in Boulder Creek, the Old Mine/No. 8 Mine, area source acid mine drainage discharges, and sediments. Remedial actions taken to date have significantly reduced acid and metal contamination in surface water. Additional planned activities include construction of an acid mine drainage treatment plant in the Boulder Creek watershed. Participation by other agencies in cleanup activities related to the mine complex is discussed later in this section.

UNITED STATES ARMY CORPS OF ENGINEERS

Numerous projects, programs, and studies by the Corps affect the Sacramento River and its tributaries. Flood control projects range from various dams and reservoirs, hundreds of miles of levee and channel improvements, and a flood bypass system. A report specific to actions at Shasta Dam is Reservoir Regulation for Flood Control, Shasta Dam and Lake, Sacramento River, California (January 1977, as supplemented). This report describes the methods of operation and prescribed regulations for flood control operation of Shasta Dam and Reservoir. Other storage projects in the Sacramento River basin prescribe flood control storage space, including Black Butte Dam on Stony Creek, Oroville Dam on the Feather River, New Bullards Bar Dam on the Yuba River, Indian Valley Dam on Cache Creek, and Folsom Dam on the American River. Within the San Joaquin River basin, flood operation regulations are prescribed by the Corps for 16 dams and reservoirs.

One of many existing reports prepared by the Corps is the March 1999 Post-Flood Assessment. This report was completed following disastrous flooding that occurred throughout the Central Valley during January 1997. The report describes the impact of recent major floods in the Sacramento River and San Joaquin River basins and includes information about operation of major facilities of the flood control system, including Shasta Dam.

A major ongoing study in the Central Valley by the Corps and DWR that would significantly influence flood damage reduction and ecosystem restoration conditions along the Sacramento and San Joaquin rivers is the Sacramento and San Joaquin River basins Comprehensive Study (Comprehensive Study). Through the Comprehensive Study, there is a potential, if approved by

Congress, to significantly change the existing flood management system and help implement many of the projects proposed by CALFED.

CALIFORNIA DEPARTMENT OF WATER RESOURCES

DWR programs and projects that could affect the SLWRI are described in this section.

State Water Project

The SWP was authorized in 1959 and designated to readjust geographical imbalances between California's water resources and water needs. The project extends from Plumas County in the north to Riverside County in the south. Completed project elements include 23 dams and reservoirs, 6 powerplants, 17 pumping plants, and 533 miles of aqueduct. The principal storage feature of the SWP is Lake Oroville, with a gross pool capacity of 3.5 MAF. Lake Oroville is located on the Feather River about 4 miles northeast of Oroville. Water released from Oroville Dam flows though the Feather and Sacramento rivers to reach the Delta. The SWP delivers water to service areas in the Feather River basin, San Francisco Bay area, San Joaquin Valley, Tulare basin, and Southern California. Major SWP conveyance facilities in the Central Valley include the North Bay, South Bay, and California aqueducts. The North Bay Aqueduct diverts water from the north Delta near Cache Slough for agricultural and M&I uses in Napa and Solano counties. The South Bay and California aqueducts carry water from the Delta to the San Francisco Bay area and to southern California, respectively. In the southern portion of the Delta, the Harvey O. Banks Delta Pumping Plant lifts water into the California Aqueduct from the Clifton Court Forebay. At 444 miles, the California Aqueduct is the State's largest and longest water conveyance system, beginning at Banks Pumping Plant and extending to Lake Perris, south of Riverside in southern California. **Plate 3** includes a layout of major SWP facilities.

The SWP has contracted a total of 4.23 MAF for average annual delivery in the San Joaquin River, central coast, and San Francisco and south coast areas. Of this amount, about 2.5 MAF is designated for the Southern California Transfer Area, nearly 1.36 MAF for the San Joaquin Valley, and the remaining 370,000 acre-feet for San Francisco Bay, the central coast, and Feather River areas.

SWP contracts involve the Feather River Settlement Contractors and SWP Contract Entitlements. The Feather River Settlement Contractors are water users who hold riparian and senior appropriative rights on the Feather River. SWP Contract Entitlements are contracts executed in the early 1960s that established the maximum annual water amount (entitlement) that each long-term contractor may request from the SWP.

California Water Plan

The State, through DWR, prepares and publishes the California Water Plan through its Bulletin 160 series. Seven versions of the plan were published between 1966 and 1998. A 1991 amendment to the California Water Code directs DWR to update the plan every 5 years. The Bulletin 160 series assesses California's agricultural, environmental, and urban water needs and evaluates water supplies to quantify the gap between future water demands and supplies. A focus of the 1998 Bulletin is water management actions that could be implemented to improve California's water supply reliability. Estimates of existing and likely future without-project water supplies, demand, and shortages in Chapter III are based on the findings published in the 1998 Bulletin.

Work is underway on an update to the plan. The update is being prepared in a highly collaborative environment with a multimember public Advisory Committee. Key elements of the update will include (1) identifying water management efforts for improving water supplies and minimizing imports from other regions; (2) developing goals and management options; (3) identifying potential evaluation and selection criteria for future system modifications; and (4) identifying indicators and ongoing efforts to monitor and track progress. The update will assess potential impacts and implications of global climate change on California's water system infrastructure and future water supply, quality, and management, including short and long-term recommendations.

CALIFORNIA DEPARTMENT OF FISH AND GAME

CDFG is responsible for managing California's fish and wildlife resources and oversees the restoration and recovery of threatened and endangered species under the California ESA. CDFG participates in conservation planning, environmental compliance and permitting, coordinated resource management planning, and restoration and recovery programs. CDFG is involved in numerous investigations, projects, and monitoring activities in the study area, including fish passage, riparian restoration, and aquatic habitat restoration. The Wildlife Conservation Board (WCB), established under CDFG, administers a capital outlay program for wildlife conservation and related recreation projects. Within the study area, WCB has participated in restoration activities at Turtle Bay, the Nature Conservancy's Lassen Foothills Project, and various local projects in Redding and Red Bluff.

CDFG oversees three mitigation banks in the study area: the Cottonwood Creek, Battle Creek, and Stillwater Plains mitigation banks. CDFG also manages several Wildlife Areas and other properties within the study area, including the following:

- **Battle Creek Wildlife Area, Shasta and Tehama Counties –** 582 acres of riparian forests, marshes, and oak woodland adjacent to the Coleman National Fish Hatchery.
- **Mouth of Cottonwood Creek Wildlife Area, Shasta and Tehama Counties –** 571 acres located at the confluence of Cottonwood Creek and the Sacramento River.
- **Tehama Wildlife Area, Tehama County –** 46,862 acres of oak woodland, rugged canyons, grassland, and chaparral east of Redding near Paynes Creek.
- **Cantara - Ney Springs Wildlife Area, Siskiyou County –** 93 acres of mixed conifer, hardwoods, and riparian vegetation along the upper Sacramento River.
- **Anderson River Park, Shasta County –** 264 acres managed by the City of Anderson.

CALFED BAY-DELTA PROGRAM

The CALFED Bay-Delta Program is a cooperative effort among State and Federal agencies and California's environmental, urban, and agricultural communities. The Governor of California and the President of the United States initiated work on the program in 1995 to address environmental and water management problems associated with the Bay-Delta system. CALFED has taken a broad approach to addressing four problem areas: (1) water quality, (2) ecosystem quality, (3) water supply reliability, and (4) levee system integrity. Many of the problems and solutions in the Bay-Delta system are interrelated. Program implementation began following circulation of the final programmatic EIS/EIR and signing of the ROD in August 2000.

The Preferred Program Alternative (PPA) in the CALFED ROD consists of programmatic elements that set the long-term direction of the CALFED program to meet its Mission Statement[1] and objectives.[2] The PPA has several interrelated programs and includes a series of actions to execute the programs. Implementation of the CALFED programs depends on authorization and funding from participating State and Federal agencies. The PPA is expected to take 25 to 30 years to complete. Implementation is roughly divided into several stages, with Stage 1 lasting 7 years.

In 2003, the State of California formed the CBDA to help oversee 23 state and federal agencies working cooperatively to implement the CALFED PPA. The California Bay-Delta Act of 2003 established the CBDA as the new governance structure and charged it with providing accountability, ensuring balanced implementation, tracking and assessing CALFED Program progress, using sound science, assuring public involvement and outreach, and coordinating and integrating related government programs.

CALFED Programs

Major CALFED programs consist of the Conveyance, Water Transfer, Environmental Water Account, Water Use Efficiency, Water Quality, Levee System Integrity, Ecosystem Restoration and Watershed Management, and Storage programs.

- **Conveyance –** The Conveyance Program is aimed primarily at increasing export pumping capacity at SWP facilities in the South Delta from their current limit of 6,680 cfs to 8,500 cfs

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[1] **CALFED Mission Statement -** The mission of the CALFED Bay-Delta Program is to develop a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta system.

[2] **CALFED Objectives -** CALFED developed the following objectives:

- Provide good water quality for all beneficial uses.
- Improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta to support sustainable populations of diverse and valuable plant and animal species.
- Reduce the mismatch between Bay-Delta water supplies and current and projected beneficial uses dependent on the Bay-Delta system.
- Reduce the risk to land use and associated economic activities, water supply, infrastructure, and the ecosystem from catastrophic breaching of Delta levees.

and eventually to 10,300 cfs. Several major projects include new fish screens at the Clifton Court Forebay and Tracy Pumping Plant; operable barriers to improve South Delta water levels and quality; Tracy Fish Test Facility; Delta Cross Channel Reoperation; Clifton Court Forebay/Tracy Pumping Plant Intertie; CVP/SWP Aqueduct Intertie; and San Luis Reservoir Low Point Improvement Project.

- **Water Transfer –** Potential water transfers are being evaluated to minimize the effects of a drought. Work is continuing on promoting an effective water transfer market that protects water rights, the environment, and local economies.
- **Environmental Water Account –**EWA consists of two primary elements: (1) assisting fish population recovery for at risk native fish species, and (2) increasing water supply reliability by reducing uncertainty associated with fish recovery actions. It is aimed at adding flexibility to the State's water delivery system for providing water at critical times to meet environmental needs without water supply impacts on cities, farms, and businesses. EWA gives water managers the tools to acquire, store, transfer, and release water strategically to respond to real-time ecosystem needs. By providing water that otherwise would not be available, EWA helps to resolve one of the Bay-Delta's most fundamental conflicts: the competing water needs of the environment and people. EWA buys water from willing sellers or diverts surplus water when safe for fish, and then EWA banks, stores, transfers, and releases the water as needed to protect fish and to compensate water users. EWA has set a goal of acquiring at least 190,000 acre-feet of water each year through purchases. The CALFED ROD defined EWA as a 4-year program, unless EWA agencies agree to extend the program. A final EIS/EIR was issued in January 2004.
- **Water Use Efficiency –** The goal of the Water Use Efficiency Program is to aggressively make the best use of existing water supplies through defining appropriate water measurement; certifying urban best management practices (BMPs); and refining quantifiable objectives for agricultural water use efficiency. The program supports local water conservation and recycling projects. Savings resulting from the Water Use Efficiency Program will be accomplished through incentive-based, voluntary programs.
- **Water Quality –** The focus of the Water Quality Program is to improve water quality from source to tap for Californians whose drinking water supplies come from the Bay-Delta watershed. The program includes (1) developing source improvements and drainage management programs, (2) investing in treatment technology projects, (3) developing a Bay Area Blending and Exchange Program, (4) facilitating efforts to develop alternative sources of water supply for southern California, and (5) improving dissolved oxygen conditions in the San Joaquin River.
- **Levee System Integrity –** The purpose of the Levee System Integrity Program is to reduce the threat of levee failure and seawater intrusion to protect water supplies, water quality, major roadways, cities, towns, agricultural lands, and environmental and aquatic habitat, primarily in the Delta. The program includes funding for local reclamation districts to reconstruct Delta levees to a base level of protection, develop BMPs for beneficial reuse of dredged material, and refine Delta Emergency Management Plans and a Delta Risk Assessment.

- **Ecosystem Restoration and Watershed Management –** The Ecosystem Restoration Program (ERP) consists of improving the ecological health of the Bay-Delta watershed through restoring and protecting habitats, ecosystem functions, and native species. This program offers funding, coordination, and technical assistance to support local watershed activities. Primary program elements include (1) an annual grant program to fund local projects for habitat restoration, fish passage, invasive species management, and environmental water quality; (2) habitat restoration in the Delta and its tributary watersheds; (3) stream flow augmentation in upstream areas through voluntary water purchases; (4) fish passage improvements through modification or removal of dams, improved bypasses, and ladders; (5) integration of flood management and ecosystem restoration; (6) support for efforts to manage watersheds that affect the Bay-Delta system, development of watershed assessments and plans, and implementation of specific watershed conservation, maintenance, and restoration actions; and (7) management of EWA.

- **Storage –** The Water Storage Program element seeks to develop additional storage capacity to help meet the needs of California's growing population and to provide increased system flexibility for helping to improve water quality and restore ecosystems. The first stage of the program consists of increasing the storage capacity at existing reservoirs and strategically located offstream sites by approximately 950,000 acre-feet and implementing major expansion of groundwater storage for an additional 0.5 to 1.0 MAF.

Surface Water Storage

CALFED product delivery teams have prepared numerous documents on all aspects of CALFED programs. An important document in the storage program element for the SLWRI is the Integrated Storage Investigation Report - Initial Surface Water Storage Screening (August 2000), which assessed and screened numerous potential reservoir sites. Of numerous potential surface water storage projects considered, 12 were retained for more detailed evaluation. Of these 12, DWR and Reclamation were tasked to work with other CALFED agencies to pursue implementation of 5 onstream and offstream projects. The 5 surface water storage projects in the PPA include Enlarge Shasta, In-Delta Storage, Los Vaqueros Reservoir Enlargement, Sites Reservoir (a.k.a. North of Delta Offstream Storage (NODOS)), and Upper San Joaquin River Storage.

- **Enlarge Shasta –** The Enlarge Shasta project in the PPA consists of expanding Shasta Reservoir by approximately 300,000 acre-feet through raising Shasta Dam 6.5 feet. The PPA identifies potential benefits such as increasing the pool of cold water available in Shasta Reservoir to maintain lower Sacramento River temperatures needed by certain fish and to provide other water management benefits, such as water supply reliability.

- **In-Delta Storage –** The Delta Wetlands project would convert two Delta islands comprising 11,000 acres (Webb Tract and Bacon Island) into surface storage facilities and two islands comprising 9,000 acres (Bouldin Island and Holland Tract) into managed habitat. The lead agency for this study is DWR. The two storage islands would provide approximately 220,000 acre-feet of new storage capacity. A prefeasibility scope review of the project was conducted by DWR and Reclamation, which concluded that the original evaluations were generally well planned. However, the project as proposed requires modifications and significant additional analyses. DWR and Reclamation are determining whether any redesign or reconfiguration of the project could make it feasible for public ownership.

- **Los Vaqueros Reservoir Enlargement –** The Los Vaqueros project consists of enlarging the 100,000 acre-foot existing reservoir up to 500,000 acre-feet. The project would help interconnect Bay Area conveyance facilities, and develop stakeholder agreement on integrated operation of water supply facilities. The primary purposes of the project would be to improve the quality and reliability of Bay Area drinking water supplies; improve Delta aquatic resources by reducing the effects of water deliveries from the Delta; provide for additional recreational opportunities in the Los Vaqueros watershed; and provide other benefits to the extent possible. The Contra Costa Water District (CCWD), Reclamation, and DWR are conducting feasibility studies and supporting technical evaluations. The focus of the current studies is on defining alternatives to address identified problems, environmental review, public input and outreach, and operations and water quality modeling. Authority for the Federal feasibility study to consider enlarging Los Vaqueros was contained in Section 215 of PL 108-7 in the 2003 Omnibus Appropriations.

- **Sites Reservoir –** The PPA included a 1.9 MAF Sites Reservoir that would be located on the west side of the Sacramento River, about 60 miles northwest of Sacramento. The ROD concluded that extensive additional effort would be required before a decision could be made to implement the project as part of CALFED. As envisioned, the Sites Reservoir project would serve as an offstream storage reservoir filled primarily through pumped diversions from the Sacramento River and its tributaries during high flow periods. The lead agency for this study is DWR. Primary benefits from the new storage would be increased reliability for water supplies for a significant portion of the Sacramento Valley, enhanced operational flexibility for managing fisheries and water quality, and improved Sacramento River diversion management. The name of the study has been changed to NODOS. Public scoping for NODOS has been completed and planning, environmental, engineering, and related work is underway. Authority for Federal feasibility scope studies for the Sites (or NODOS) project also was contained in Section 215 of PL 108-7.

- **Upper San Joaquin River Basin Surface Storage –** The PPA included a potential storage project on the Upper San Joaquin River. The ROD concluded that extensive additional effort would be required before a decision could be made to implement the project as part of CALFED. Reclamation, in coordination with DWR, is conducting an investigation that includes developing a comprehensive list of water supply alternatives that could add 250,000 to 700,000 acre-feet of new storage in the San Joaquin watershed, primarily through enlarging Millerton Lake at Friant Dam or developing a functionally equivalent project. This project would be designed to contribute to restoration of habitat, improve water quality for the San Joaquin River, and facilitate conjunctive management of water exchanges that improve the water quality of deliveries to urban communities. Other potential benefits would include increased hydropower production and enhanced flood control operation. Authority for Federal feasibility scope studies for the Upper San Joaquin River Storage Project also was contained in Section 215 of PL 108-7.

SACRAMENTO RIVER CONSERVATION AREA PROGRAM

California Senate Bill 1086 called for a management plan for the Sacramento River and its tributaries to protect, restore, and enhance both fisheries and riparian habitat. The Sacramento River Conservation Area Program has an overall goal of preserving remaining riparian habitat and reestablishing a continuous riparian ecosystem along the Sacramento River between Redding and Chico, and reestablishing riparian vegetation along the river from Chico to Verona. The program is to be accomplished through an incentive-based, voluntary river management plan. The Upper Sacramento River Fisheries and Riparian Habitat Management Plan, January 1989, identifies specific actions to help restore the Sacramento River fishery and riparian habitat between the Feather River and Keswick Dam. The Sacramento River Conservation Area Forum Handbook, 2002, is a guide to implementing the program.

The Keswick Dam to Red Bluff portion of the Conservation Area includes areas within the 100-year floodplain, existing riparian bottomlands, and areas of contiguous valley oak woodland, totaling approximately 22,000 acres. The 1989 fisheries restoration plan recommended several actions specific to the study area that have not yet been completed:

- Fish passage improvements at RBDD (under study).
- Potential modification of Spring Creek Tunnel intake for temperature control.
- Spawning gravel replacement program.
- Development of side-channel spawning areas, such as those at Turtle Bay in Redding.
- Structural modifications to the ACID dam to eliminate short-term flow fluctuations.
- Maintaining instream flows through coordinated operation of water facilities.
- Improvements at the Coleman National Fish Hatchery (partially complete).
- Measures to reduce acute toxicity caused by acid mine drainage and heavy metals.
- Various fisheries improvements on Clear Creek (partially complete).
- Flow increases, fish screens, and revised gravel removal practices on Battle Creek.
- Control of gravel mining, improvement of spawning areas, improvement of land management practices in the watershed, and protection and restoration of riparian vegetation along Cottonwood Creek.

IRON MOUNTAIN MINE RESTORATION PLAN

The Iron Mountain Mine Trustee Council, formed by the USFWS, CDFG, NOAA Fisheries, BLM, and Reclamation, developed the Final Restoration Plan for Natural Resource Injuries from Iron Mountain Mine, April 2002. The plan identifies restoration actions to address injuries to, or lost use of, natural resources resulting from acid mine drainage from the Iron Mountain Mine complex. Specific goals of the plan are to restore the following resources affected by toxic mine releases: salmonids, riparian habitat, and instream ecological functions. Proposed actions are located along the Sacramento River and its tributaries between Keswick Reservoir and the RBDD. Injured resources identified in the plan include the following:

- **Anadromous fish –** Fall-run chinook salmon.
- **Instream resources of creeks draining the mine –** Acid mine drainage and toxic metals have sterilized many creeks, including Boulder, Slickrock, Flat, and Spring creeks.
- **Riparian habitat –** Acid mine drainage and toxic metals have severely impacted stream-side soils and habitats along Boulder, Slickrock, Spring, and Flat creeks, resulting in a loss of approximately 39 acres of riparian habitat; stream hydrology also has been altered by diversion dams constructed to collect affected drainage.
- **Lost human-use –** Loss of recreation and other public uses of the land.

Restoration actions were also chosen from those listed in the CALFED ERP, including the following:

- **Fish passage improvements –** Removal of culvert crossings, modification or removal of locally-owned dams and diversions, fish screens, acquisition of water rights from willing sellers to increase flows, and gravel replenishment in the Sacramento River ranging from 10,000 to 20,000 cubic yards annually.
- **Instream habitat restoration –** Large-scale habitat development, including artificial riffles, placement of woody debris, and programs to address turbidity and other water quality impairments.
- **Riparian restoration –** Livestock exclusion fencing, stream bank restoration and plantings, riparian land acquisition from willing sellers, conservation easements, and invasive species management.

RIPARIAN HABITAT JOINT VENTURE

The Riparian Habitat Joint Venture (RHJV) was initiated in 1994 and includes signatories from 18 Federal, State, and private agencies. The RHJV promotes conservation and restoration of riparian habitat to support native bird populations. The three goals of the RHJV include the following:

- Promote an understanding of the issues affecting riparian habitat through data collection and analysis.
- Double riparian habitat in California by funding and promoting on-the-ground conservation projects.
- Guide land managers and organizations to prioritize conservation actions.

RHJV conservation and action plans are documented in the Riparian Bird Conservation Plan, August 2000. The conservation plan targets 14 “indicator” species of riparian-associated birds and provides recommendations for habitat protection, restoration, management, monitoring, and policy. The report notes habitat loss and degradation as one of the most important factors causing the decline of riparian birds in California. RJHV has participated in monitoring efforts within the Sacramento National Wildlife Refuge Complex and other conservation areas. The RHJV's conservation plan identifies Lower Clear Creek as a prime breeding area for Yellow Warblers and Song Sparrows, advocating a continuous riparian corridor along lower Clear Creek. Other recommendations of the conservation plan apply to the SLWRI study area in general.

RESOURCE CONSERVATION DISTRICTS

There are numerous resource conservation districts (RCDs) within the study area. Once known as Soil Conservation Districts, RCDs were established under California law with a primary purpose to implement local conservation measures. Although RCDs are locally governed agencies with locally appointed, independent boards of directors, they often have close ties to county agencies and the National Resource Conservation Service. RCDs are empowered to conserve resources within their districts by implementing projects on public and private lands and to educate landowners and the public about resource conservation. They are often involved in the formation and coordination of watershed working groups and other conservation alliances. In the Shasta Lake and upper Sacramento River vicinity, districts include the Western Shasta County RCD and the Tehama County RCD. To the east are the Fall River and Pit River RCDs, and to the west and north are the Trinity County and Shasta Valley RCDs. Several of the RCDs and their activities relevant to the study area are described in the following sections.

Western Shasta Resource Conservation District

The Western Shasta Resource Conservation District (Western Shasta RCD) is a partner in resource management, watershed management, conservation, and restoration programs within western Shasta County. The Western Shasta Resource Conservation District Strategic Plan for 1999-2003 established strategic areas of focus for the district, one of which is watershed restoration. Recognizing that an important resource issue in the region is anadromous fisheries, the district has also placed emphasis on improving spawning habitat. The Western Shasta RCD has participated in numerous comprehensive watershed analyses in the primary study area, including studies of the Cow Creek, Cottonwood Creek, Squaw Creek, Upper Clear Creek, and McCloud River watersheds. These reports evaluate environmental resource conditions within watersheds, identify problems, and make recommendations for future management actions.

Ongoing restoration work by the Western Shasta RCD includes erosion control and vegetation management; agreements on the timing of water flows from area dams; assist area for local landowners and interested parties in forming watershed groups; spawning gravel injections at strategic locations; isolation of deep gravel pits to eliminate fish stranding; and channel reconstruction at former instream mining locations. Other areas of concern include noxious and nonnative weeds, erosion control, and fire and fuels reduction. The Western Shasta RCD is participating in the following ongoing programs in the primary study area:

- **Lower Clear Creek Floodway Rehabilitation Project –** The Western Shasta RCD has participated in this multiagency channel and floodplain restoration project along the lower reaches of Clear Creek. The project has filled former gravel pits, realigned segments of the channel to a more natural state, revegetated floodplains, and constructed wetlands. Elements of the project that have not yet been funded or completed include channel reconstruction and revegetation at a former gravel mining location; annual spawning gravel injections; erosion control at the Saeltzer Dam site and Sunrise Bluffs; channel realignment at Pirate's Den; and channel regrading to prevent fish stranding.

- **Battle Creek –** The Western Shasta RCD is a local participant in the Battle Creek Community Strategy and is assisting in implementation of the Battle Creek Salmon and Steelhead Restoration Plan. Various program components are yet to be done, including removal of dams, construction of fish screens and ladders, and flow augmentation to increase salmonid habitat.

- **Shasta West Watershed –** The Western Shasta RCD developed a watershed assessment for the Shasta West Watershed that recommended restoration activities along various western tributaries to the Sacramento River. Recommended projects that have not yet been completed include culvert removals along Salt Creek; debris cleanout at Swasey Dam; spawning gravel injections on Middle, Salt, and Olney creeks; and erosion control along various creeks to reduce fine sediment input.

- **Cow Creek –** The Western Shasta RCD recently completed a watershed assessment on Cow Creek and began implementing restoration recommendations. Projects that have not yet been funded or implemented include various fish passage and diversion projects; installation of fish screens on diversions; water quality improvement to address fecal coliform contamination (due to grazing); and instream spawning area restoration.

Tehama County Resource Conservation District

The Tehama County RCD encompasses about 1.7 million acres within Tehama County, excluding the incorporated cities of Red Bluff, Corning, and Los Molinos. Waterways in the district include Battle, Mill, Paynes, and Cottonwood creeks. The mission of the Tehama County RCD is to manage natural resources at a watershed level through the education and cooperation of residents and stakeholders, focusing on upper watershed and riparian health, water quantity, and water quality.

Fall River Resource Conservation District

The Fall River RCD encompasses over 1.1 million acres of land within Lassen, Modoc, Shasta, and Siskiyou counties. The district includes the Fall River, Pit River, Hat Creek, and Burney Creek watersheds. One of the most prominent environmental resource issues in the district is management of erosion and sedimentation, which has significantly impaired aquatic habitat in numerous streams and creeks. Management measures include (1) controlling bank erosion by livestock exclusion fencing, muskrat control, and boat speed regulation enforcement, (2) restoring and protecting high priority stream and meadow systems in Upper Bear Creek and Dry Creek, and (3) performing sediment removal activities on Fall River. The district is participating in the Fall River Restoration Project and received funding in 2000 from the McConnell Foundation to purchase conservation easements.

OTHER PROGRAMS AND PROJECTS

Numerous other Federal, State, and local programs and projects influence development of water resources projects and programs in the Central Valley of California.

Phase 8

After many years of struggling to develop water quality standards for the Delta, the Bay-Delta Accord (Accord) was signed by multiple partners in 1994. The Accord set water quality standards and required SWRCB to determine which water users would be responsible to meet these standards. In 1995, SWRCB adopted a Water Quality Control Plan to implement the Accord. Phases 1 through 7 of the Accord involved San Joaquin Valley matters and other issues. Phase 8, involving Sacramento Valley water users, threatened to derail the Accord through lengthy litigation concerning determination of which entities and individuals would be responsible for meeting the water quality standards. DWR and Reclamation, as operators of State and Federal export projects respectively, have claimed that certain water rights holders in the Sacramento Valley must cease diversions or release water from storage to help meet water quality standards in the Delta. Sacramento Valley water users have claimed that their water use has not contributed to any water quality problems in the Delta, and, as senior water rights holders and water users within the watershed and counties of origin, they are not responsible for meeting these standards.

Rather than continue these adversarial proceedings, Sacramento Valley water users, DWR, Reclamation, and export water users agreed to defer Phase 8 and instead, work in a more cooperative spirit to meet water supply, quality, and environmental needs in areas of origin and throughout California. This cooperation is evidenced in the Sacramento Valley Water Management Agreement (Agreement). The Agreement comprises four successive agreements: (1) Stay Agreement, (2) Short-Term Settlement Agreement, (3) Short-Term Project Implementation Agreements, and (4) Long-Term Agreements. The Agreement includes a process to resolve Phase 8 and related issues, and a set of milestones to implement short- and long-term projects. The Agreement also specifically identifies Sites Reservoir and Shasta Enlargement as potential long-term projects.

During the Short-Term Settlement Agreement, active parties developed a long-term work plan and expanded program to guide implementation of the Long-Term Agreements. The Short-Term Agreement will continue to 2014 or until it is replaced by the Long-Term Agreement. The Short-Term Agreement includes several provisions:

- DWR and Reclamation remain obligated under an SWRCB order to meet Delta water quality standards during the term of the agreement.
- Unmet demands should be met in the Sacramento Valley, including 25,000 acre-feet of CVP water supplies for use along the Tehama-Colusa Canal and assurances that Feather River supplies can be used in the Sutter Bypass/Butte Slough region during dry years.

During development of the Short-Term Agreement, a work plan was developed. The Short-Term Agreement work plan identified and evaluated approximately 45 projects (i.e., projects that could be implemented within 1 to 2 years), including conjunctive management and surface storage reoperation projects. These projects will be developed to provide up to 185,000 acre-feet of capacity during critically dry, dry, and below-normal years. This capacity will be dedicated to two equal blocks. The first block (up to 92,500 acre-feet) will be made available for local use within the local agency boundary. If this water is not needed locally, it will be made available to the CVP and SWP at a negotiated rate. The second block of water (up to 92,500 acre-feet) will be provided to the SWP and CVP, and will be used to provide Water Quality Control Plan relief.

San Joaquin River Restoration

A major study underway in the San Joaquin River Basin is development of a restoration plan for the San Joaquin River below Friant Dam by the Friant Water Users Authority (FWUA) and the National Resources Defense Council (NRDC). As part of this work, FWUA and NRDC have been considering water supply options that could be developed to provide water for restoration needs.

OTHER PROGRAMS AND PRIVATE ORGANIZATIONS

Other programs and private organizations related to the SLWRI are described in this section.

Sacramento Watersheds Action Group

The Sacramento Watersheds Action Group (SWAG) is a nonprofit corporation that secures funding for, designs, and implements projects that provide watershed restoration, streambank and slope stabilization, erosion control, watershed analysis, and road removal. SWAG has successfully worked with local groups, agencies, and organizations to fund and complete restoration projects on the Sacramento River and tributaries downstream from Keswick Dam, including development of the Sulphur Creek Watershed Analysis and Action Plan; the Whiskeytown Reservoir Shoreline Erosion Control Project; the Sulphur Creek Streambank Stabilization and Channel Reconstruction Projects; the Secret Canyon Stream Crossing Restoration Project; and the Lower Sulphur Creek Realignment and Riparian Habitat Enhancement Project. SWAG is a potential local sponsor for watershed restoration actions in the study area.

Sacramento River Watershed Program

The Sacramento River Watershed Program is an effort to bring stakeholders together to share information and work together to address water quality and other water-related issues within the Sacramento River watershed. The group is funded congressionally through the EPA. The program's primary goal is "to ensure that current and potential uses of Sacramento River watershed resources are sustained, restored, and where possible enhanced while promoting the long-term social and economic vitality of the region." Additional goals of the program are to:

- Sustain effective processes to improve watershed quality and protect beneficial uses of water that meet the interests of all stakeholders in the Sacramento River basin.
- Provide dependable and accessible information through scientifically sound monitoring.
- Provide sound information to support decisions and actions of watershed stakeholders.

- Provide and support an effective process that sustains locally led and community-based environmental management that meets State and Federal regulatory requirements in locally appropriate ways.
- Develop a stewardship approach to collaborative, whole watershed management.
- Ensure that the interests represented in development of program policies, programs, and activities reflect the diversity of interests represented by all stakeholders of the watershed.

The Sacramento River Watershed Program manages grants for the Sacramento River Toxic Pollutants Control Program, performs extensive water quality monitoring, data collection, and data management for the watershed, and is instrumental in the study and monitoring of toxic pollutants. Although the program does not implement restoration projects, it is a potential provider of technical information for future water quality improvement programs in the study area.

McCloud River Coordinated Resource Management Plan

Participants and signatories to the McCloud River Coordinated Resource Management Plan (CRMP) include Federal, State, and local government agencies, private landowners, industry, and environmental groups. One principal objectives of the CRMP is to protect the free-flowing nature of the McCloud River. Also of concern is the river's fishery, which supports a significant commercial sport-fishing industry. The CRMP has several active working groups, including a Research and Monitoring group, but specific projects have not been identified at this time.

Pit River Watershed Alliance

The Pit River Watershed Alliance is a collaborative effort between private and public interests and local landowners to improve aquatic habitat in the Pit River watershed. Environmental concerns include water quality, threatened and endangered species, and noxious weeds. Participants include the Fall River, Central Modoc, Pit, and Goose Lake RCDs. The Alliance is a potential partner for environmental restoration actions in the Pit River watershed.

Clear Creek Coordinated Resource Management Plan

The Clear Creek CRMP Group, which consists of stakeholders and local landowners, has been involved since 1995 in planning, implementing, and monitoring multidisciplinary restoration projects to promote anadromous salmonids on Clear Creek. Proposed activities to benefit fishery populations include increasing water releases from Whiskeytown Dam; improving upstream passage for migrating chinook salmon and steelhead to historical habitat; augmenting spawning gravel; restoring sediment transport; and reducing fine sediment input from upland erosion.

Battle Creek Watershed Conservancy

The Battle Creek Watershed Conservancy (BCWC) is actively involved in monitoring actions connected to the Battle Creek Salmon and Steelhead Restoration Project. BCWC participates in numerous working groups associated with projects on Battle Creek, including the Battle Creek Working Group, Adaptive Management Working Group, Coleman National Fish Hatchery meetings, Spring-Run Group, Steelhead Group, and CALFED Watershed Program Workgroup.

BCWC administered the first phase of projects on Battle Creek, including conservation easements, noxious weed controls, and restoration in the lower watershed. The group is a potential partner in future restoration actions in the Battle Creek watershed.

Sulphur Creek Coordinated Resource Management Plan

The mission of the Sulphur Creek CRMP is to promote restoration and enhancement of the Sulphur Creek Watershed near Redding by providing a forum for communication and cooperation among interested individuals, groups, businesses, and local, State, and Federal agencies. Key issues identified by the CRMP include protecting and enhancing the watershed's natural and cultural resources (riparian and upland plant communities, fish and wildlife habitat, water quality); providing education and recreation opportunities in the urbanizing Redding region; and linking the Sulphur Creek watershed with other natural areas and parkways. A watershed analysis revealed that extensive instream mining, road building, and railroad construction within the watershed, and backwater from the Sacramento River, have resulted in channel degradation and deterioration of aquatic and riparian habitat. The CRMP has been part of several streambed restoration projects with financial assistance from SWAG, CALFED, DWR, and the Cantara Trust.

Cow Creek Watershed Management Group

The Cow Creek Watershed Management Group is a nonprofit organization formed by citizens to manage the resources of the Cow Creek Watershed in a way that "meets the needs of today without infringing on the needs of future generations." The Western Shasta RCD assists the group in an advisory capacity and secured grants from SWRCB and the Packard Foundation to conduct the Cow Creek Watershed Assessment in 2001. Action options considered in the watershed assessment include the following:

- Installing fish screens and/or ladders on diversions
- Installing screening pump intakes in Old Cow Creek and the mainstem of Cow Creek
- Increasing flows in Cow Creek and tributaries through practicing irrigation efficiency and vegetation management, purchasing water rights from willing sellers, developing alternate water sources during important flow periods, and implementing a conjunctive use program
- Obtaining landowner easements along key habitat corridors and conducting riparian habitat restoration
- Restoring and protecting oak woodlands in the lower watershed
- Initiating a prescribed fire/burn program to enhance habitat
- Conducting eradication or control programs for non-native invasive plants
- Considering augmenting streamflows by off-site storage and retention of winter flood flows to improve habitat for fish and wildlife
- Managing vegetation to augment streamflows and improve habitat
- Improving spawning substrate in upper reaches

Cottonwood Creek Watershed Group

The mission of the Cottonwood Creek Watershed Group is to work to preserve the environment, private property and water rights, and economic resources of the Cottonwood Creek watershed through responsible stewardship, coordination, cooperation, and education. Watershed stewardship issues include timber harvesting, fuel management and fire suppression, erosion control, maintenance of riparian zones, sediment supply and floodplain processes, and spawning and rearing habitat for salmon in the lower watershed. Specific recommendations are being developed, and fish passage projects are underway in coordination with USFWS.

Sacramento River Preservation Trust

The Sacramento River Preservation Trust is a private, nonprofit organization active in environmental education and advocacy to preserve the natural environmental values of the Sacramento River. The Trust has participated in various conservation and land acquisition projects, including securing lands for the Sacramento River National Wildlife Refuge. Although the group has had limited activity in the study area, it is pursuing designation of a portion of the Sacramento River between Redding and Red Bluff as a National Conservation Area (see previous discussion on BLM activities).

Shasta Land Trust

The Shasta Land Trust is a regional, nonprofit organization dedicated to conserving open space, wildlife habitat, and agricultural land. The Trust works with public agencies and private landowners and is funded primarily through membership dues and donations. It employs various voluntary programs to protect and conserve valuable lands using conservation easements, land donations, and property acquisitions. Current efforts include work in the Cow Creek and Bear Creek watersheds. The Shasta Land Trust has purchased or negotiated conservation easements in Fenwood Ranch of southern Shasta County and various properties east of Redding. The Trust is a potential local partner for restoration activities in the Shasta Dam to Red Bluff subarea.

The Trust for Public Land

The Trust for Public Land is a national, nonprofit organization involved in preserving lands with natural, historic, cultural, or recreational value, primarily through conservation real estate. The Trust's Western Rivers Program has been involved in conservation efforts along the Sacramento River between Redding and Red Bluff (the BLM's Sacramento River Bend Management Area), Battle Creek, Paynes Creek, Inks Creek, and Fenwood Ranch in Shasta County. The group promotes public ownership of conservation lands to ensure public access and enjoyment.

Cantara Trustee Council

The Cantara Trustee Council was established to administer settlement funds stemming from the 1991 spill of metam sodium into the upper Sacramento River, upstream from Shasta Lake. Over 19,000 gallons of the herbicide were released into the Sacramento River when a Southern Pacific train derailed on the Cantara Loop, a rail line near Dunsmuir. The spill resulted in the destruction of nearly all aquatic life within the upper Sacramento River between the spill and Shasta Lake. The Cantara Trustee Council includes representatives from CDFG, USFWS, the

Central Valley Regional Water Quality Control Board (CVRWQCB), California Sportfishing Protection Alliance, and Shasta Cascade Wonderland Association. The Council monitors fish and wildlife along the affected reach and has concluded that major components of the ecosystem have successfully recovered from the spill. The Council also administers a grant program that has provided funding for numerous environmental restoration projects in the primary study area, including programs in the Fall River watershed, Sulphur Creek, upper Sacramento River, Middle Creek, lower Clear Creek, Battle Creek, Salt Creek, and Olney Creek. The Council is a potential local sponsor for future restoration actions in the primary study area.

The Nature Conservancy

The Nature Conservancy (TNC) is a private, nonprofit organization involved in environmental restoration and conservation throughout the United States and the world. TNC approaches environmental restoration primarily through strategic land acquisition from willing sellers and obtaining conservation easements. Some of the lands are retained by TNC for active restoration, research, or monitoring activities while others are turned over to government agencies such as USFWS or CDFG for long-term management. Lower in the Sacramento River Basin, the TNC has been instrumental in acquiring and restoring lands in the Sacramento River National Wildlife Refuge and manages several properties along the Sacramento River. It has also pursued conservation easements on various properties at tributary confluences, including Cottonwood and Battle creeks. Within the study area, TNC manages the McCloud River Preserve and lands within the Lassen Foothills Project, described below.

McCloud River Preserve

The McCloud River Preserve was initially formed in 1974 when the McCloud River Club, one of the oldest private fishing clubs in the state, donated 2,330 acres of its stream-front land to TNC. The preserve is located just downstream from McCloud Dam and Lake on the lower McCloud River, and hosts the famous McCloud River trout. The public is permitted limited access to maintain the wild nature of the preserve, and prevent fish poaching and other disturbances.

Lassen Foothills Project

Launched in 1997, the Lassen Foothills Project encompasses about 900,000 acres of grasslands, oak woodlands, and stream-side forests in the upper Sacramento Valley, roughly between Red Bluff and Mount Lassen. The project has focused on purchasing and obtaining conservation easements on large, working ranches in the area and preventing urbanization and land development while developing wildlife-friendly ranching practices. Land management practices and research projects have included prescribed burning, rotational grazing, reseeding native grasses, research on blue oak woodlands, and various methods of controlling invasive weeds. Restoration actions have included riparian habitat projects along the lower floodplains and streams.

One of the first management properties in the project was the 37,540-acre Gray Davis Dye Creek Preserve, located in the foothills below Mount Lassen. The Dye Creek Ranch came under TNC management in 1987 as the result of a 25-year lease with the State of California. TNC continues to operate the ranch, and the preserve supports a variety of habitat types and native wildlife.

Also, the preserve hosts education and research activities, land management, and prescribed burn experiments, and various habitat restoration projects, primarily along lower Dye Creek.

The latest addition to the Lassen Foothills Project is the 1,844-acre Wildcat Ranch in the upper Sacramento Valley, also part of the Battle Creek Restoration Project. TNC has assisted the Battle Creek Restoration Project in arranging for removal of several dams and construction of fish ladders to promote anadromous fisheries migration within the ranch. Working with the BCWC, agreements were reached with PG&E and various government agencies to open over 40 miles of migratory fish habitat. The partners in the project received the 1999 Governor's Environmental and Economic Leadership Award for environmental restoration and rehabilitation.

California Trout

California Trout (CalTrout) is a private, nonprofit organization with a mission to protect and restore wild trout and steelhead and their waters throughout California. CalTrout conservation priorities include the Wild Trout Campaign, grazing reform on public lands, hydropower and dam regulation, and the Steelhead Recovery Campaign. In 1999, CalTrout completed the Conservation Plan for the New Millennium, which sets forth restoration policies and details site-specific restoration projects or actions to support steelhead and trout fisheries statewide. CalTrout focuses much of its efforts on flow regulation, including operation of dams and hydropower facilities to benefit native fisheries. CalTrout has been involved in numerous Federal Energy Regulatory Commission (FERC) dam relicensing projects, including current relicensing efforts on the Pit and Hat rivers. Other activities include stream restoration and protection projects. CalTrout is a potential partner in future fisheries restoration programs in the study area.

COMMON ASSUMPTIONS FOR CALFED SURFACE WATER STORAGE PROJECTS

Efforts are underway primarily by DWR and Reclamation to identify a series of Common Assumptions for use in developing each of the CALFED storage projects. Common Assumptions would be used to develop without-project conditions, which is a critical element in the plan formulation process. Common Assumptions is meant to establish recognized baseline conditions including, at minimum, (1) period of analysis; (2) evaluation levels (i.e., 2001 for existing conditions and 2020 for future conditions); (3) water supply demands; (4) water supply system facilities; (5) regulatory standards, including minimum flow and temperature requirements; (6) system operation criteria; and (7) likely foreseeable actions.

The primary planning analytical tool being used for establishing baseline assumptions for water supply budgeting is the California Water Allocation and Reservoir Operations Model (CALSIM-II). This mathematical model is also used for studying water supply impacts of various potential alternate system operations and project modifications. A description of the application of the model as studied for the SLWRI is contained in **Appendix A** (CALSIM II System Operation Simulation).

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CHAPTER III
WITHOUT-PROJECT CONDITIONS

One of the most important elements of any water resource evaluation is defining the scope of problems to be solved and opportunities to be addressed. Significant in this process is defining existing resource conditions and how these conditions may change in the future. The magnitude of change not only influences the scope of the problems, needs, and opportunities, but the extent of related resources that could be influenced by possible actions taken to address them. Accordingly, presented below is a brief assessment of existing conditions, and estimated future without-project baseline conditions, in the primary and extended study areas.

EXISTING CONDITIONS

Existing physical, biological, social and economic, cultural, conditions are described in this section, focusing on the primary study area. Additional information on these conditions and conditions in the extended study area, including the Sacramento-San Joaquin Delta, will be contained in future documents for the SLWRI.

Shasta Dam and Reservoir Project

This section describes existing conditions for Shasta Dam and Reservoir water control facilities, recreation facilities, and other reservoir area infrastructure.

Existing Water Control Facilities

Shasta Dam is a curved, gravity-type, concrete structure that rises 533 feet above the streambed with a total height above the foundation of 602 feet. The dam has a crest width of about 41 feet and a length of 3,460 feet. Shasta Lake has a storage capacity and water surface area at gross pool of 4,550,000 acre-feet and 29,600 acres, respectively. Seasonal flood control storage space in Shasta is 1.3 MAF. The Shasta Powerplant consists of five main generating units and two station service units with a combined capacity of 652,000 kilowatts. **Table III-1** summarizes the pertinent data and features of Shasta Dam and Reservoir. **Plates 4** and **5** show several elevation, section, and plan views of Shasta Dam and Powerplant. These drawings were prepared prior to construction of the existing temperature control facilities on the upstream face of the dam. **Plate 6** shows the relationship between reservoir surface area and storage capacity at various water surface elevations.

Keswick Dam is about 9 miles downstream from Shasta Dam and, in addition to regulating outflow from the dam, controls runoff from 45 square miles of drainage area. Keswick Dam is a concrete, gravity-type structure with a spillway over the center of the dam. The spillway has four 50-foot by 50-foot fixed wheel gates with a combined discharge capacity of 248,000 cfs at full or gross pool elevation (587 feet). Storage capacity below the top of the spillway gates at gross pool is 23,800 acre-feet. The powerplant has a nameplate generating capacity of 75,000 kilowatts and can pass about 15,000 cfs at gross pool.

TABLE III-1
PERTINENT DATA – SHASTA DAM AND RESERVOIR AND KESWICK DAM AND RESERVOIR

GENERAL			
Drainage Areas (excluding Goose Lake Basin)		**Mean Annual Runoff (1908-1974)**	
Sacramento R. at Shasta Dam	6,421 sq-mi	Sacramento R. at Shasta Dam	5,737,000 ac-ft
Sacramento R. at Keswick	6,468 sq-mi	Sacramento R. near Red Bluff	8,421,000 ac-ft
Sacramento R. near Red Bluff	8,900 sq-mi	Sacramento R. at Ord Ferry	9,812,000 ac-ft
Sacramento R. near Ord Ferry	12,250 sq-mi	***Sacramento River Maximum Flows of Record (1903-1976)***	
Pit R. at Big Bend	4,710 sq-mi	at Shasta Lake (16 Jan 1974)	216,000 cfs
McCloud R. above Shasta Lake	604 sq-mi	near Red Bluff (28 Feb 1940)	291,000 cfs
Sacramento R. at Delta	425 sq-mi	at Ord Ferry (28 Feb 1940)	370,000 cfs
SHASTA DAM AND RESERVOIR			
Shasta Dam (concrete gravity)		**Shasta Reservoir**	
Crest elevation	1,077.5 ft	Gross pool elevation (msl)	1,067.0 ft
Freeboard above gross pool	9.5 ft	Minimum operating level	840.0 ft
Height above foundations	602 ft	Taking line	Irregular
Height above streambed	487 ft	Area	
Length of crest	3500 ft	Minimum operating level	6,700 acres
Width of crest	30 ft	Gross pool	29,500 acres
Slope, upstream	Vertical	Taking line	90,000 acres
Slope, downstream	1 on 0.8	Storage capacity	
Volume (cubic yards)	8,430,000	Minimum operating level	587,000 ac-ft
Normal tailwater elevation	585 ft	Gross pool	4,552,000 ac-ft
Spillway (gated ogee)		**Shasta Power Plant**	
Crest Length		***Main Units***	
Gross	360 ft	5 turbines, Francis type Total Capacity	515,000 hp
Net	330 ft		
Crest Gates (drum type)		5 generators, 125,000 kW each Total Capacity	625,000 kW
Number and size	3 @ 110' x 28'		
Top elevation when lowered	1037.0 ft	***Station Units***	
Top elevation when raised	1065.0 ft	2 generators, 2,000 kW each Total Capacity	4,000 kw
Discharge capacity at pool, elevation 1,065	186,000 cfs		
Flashboard Gates	3 @ 110' x 2'	Elevation centerline turbines	586 ft
Top elevation when lowered	1067.0 ft	Maximum tailwater elevation	632.5 ft
Bottom elevation when raised	1069.5 ft	Total discharge capacity at pool, elevation 1,065	14,500 cfs
Outlets			
River outlets (102-inch diameter conduit with 96-inch diameter wheel type gate)		Total discharge capacity at pool, elevation 827.7	16,000 cfs
4 with invert elevation	737.75 ft		
8 with invert elevation	837.75 ft		
6 with invert elevation	937.75 ft		
Capacity at elevation 1,065	81,800 cfs		
Capacity at elevation 827.7	12,200 cfs		
Power outlets (15-ft steel penstocks)			
5 with invert elev. of intake	807.5 ft		
KESWICK DAM and RESERVOIR			
Keswick Dam (concrete gravity)		**Keswick Reservoir**	
Crest elevation	595.5 ft	Elevation msl	
Freeboard above maximum operating level	8.5 ft	Maximum operating level	587.0 ft
Height of dam above foundation	159 ft	Minimum operating level	574.0 ft
Height of dam above streambed	119 ft	Area at max operating level	643 acres
Length of crest	1,046 ft	*Storage capacity*	
Width of crest	20 ft	At maximum operating level	23,800 ac-ft
Volume	197,000 cu-yd	At minimum operating level	16,300 ac-ft
Normal tailwater elevation	487 ft	***Keswick Power Plant***	
Spillway (gated ogee)		Generator capacity, 3 units	75,000 kW
Crest length	200 ft		
Crest gates (fixed wheel)	4 @ 50' x 50'		
Discharge capacity at pool, elevation 587	248,000 cfs		

Key: ac-ft – acre feet; cfs – cubic feet per second; cu-yd – cubic yard; elevation – elevation in feet above msl; ft – feet; hp – horsepower; kW – kilowatt; msl – mean sea level; R. – river; sq-mi – square mile

The existing TCD at Shasta was constructed from 1996 to 1998. It is a multilevel water intake structure located on the upstream face of the dam, as shown in **Figure III-I**. The TCD allows operators to draw water from the top of the reservoir during the winter and spring when surface water temperatures are cool, and from deeper in the reservoir in the summer and fall when surface water is warm. It also improves oxygen and sediment levels in downstream river water. The TCD helps Reclamation fulfill contractual obligations for both water delivery and power generation while benefiting fish, such as salmon, that require cooler water temperatures.

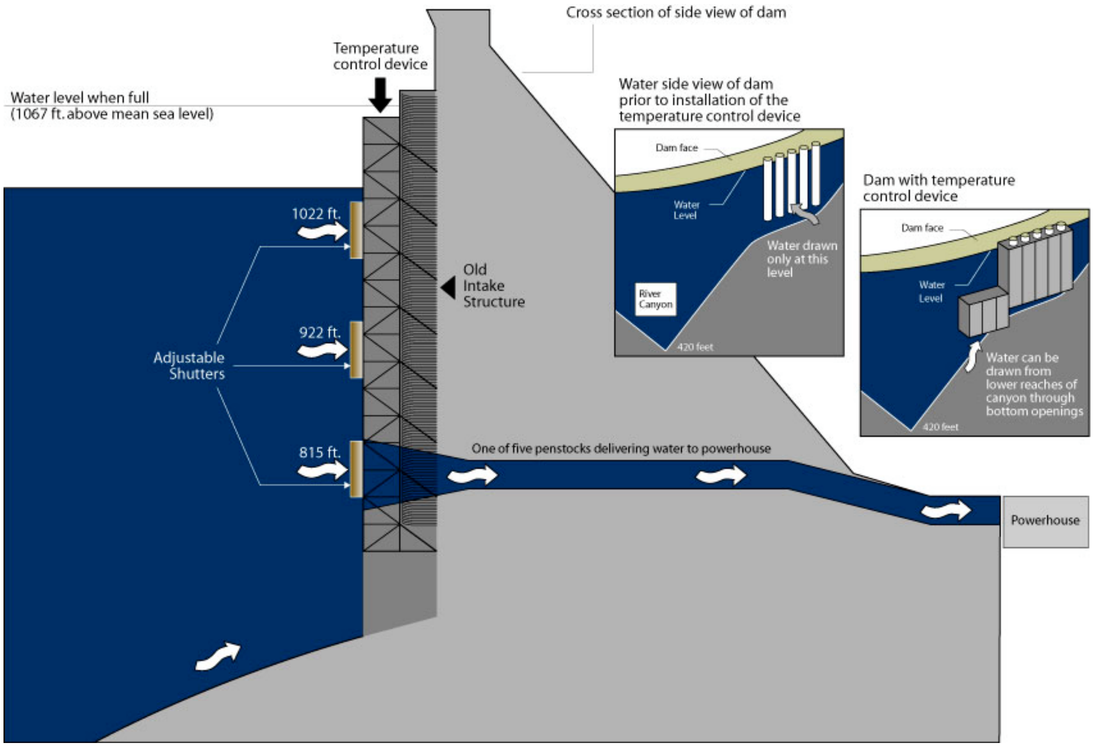


Figure III-1 – Shasta Dam temperature control device.

Recreation Facilities and Other Reservoir Area Infrastructure

The Whiskeytown-Shasta-Trinity National Recreation Area was established by an Act of Congress in November 1965. The area comprises three separate units: Whiskeytown Lake, Shasta Lake, and Clair Engle-Lewiston lakes. The Shasta Unit and the Clair Engle-Lewiston Unit are within the STNF and are administered by USFS. The Whiskeytown Unit is administered by the National Park Service. Facilities provided by USFS at Shasta Lake include 29 campgrounds, 4 boat-launching ramps, and 2 beach and picnic areas. In addition to USFS facilities, about 18 resorts and marinas are operating under permit within the Shasta Lake Unit. Facilities provided by these permit-holders include rental housing, stores, snack bars, restaurants, excursion boats, boat-dock service and rental, camping areas, and boat-launching ramps. A map showing locations of the major recreation facilities in the Shasta Unit of the Whiskeytown-Shasta Trinity National Recreation Area is shown in **Plate 7**.

Various recreation facilities and other infrastructure are located around the reservoir rim. An inventory of structures between the existing gross pool and 1,100 feet above mean sea level (msl) (elevation 1,100), a distance of about 30 feet, was conducted. About one-third of the total number of structures in the Shasta Reservoir vicinity (and nearly all of the recreation-related structures) is located within this 30-foot pool elevation band. At least one-fourth of the buildings within this band are homes or cabins, more than one-third are associated with private resorts or marinas, and an estimated 10 percent are associated with USFS facilities such as campgrounds, boat ramps, and stations. Some businesses and community buildings in the community of Lakeshore also may be located within 30 feet of the existing gross pool. Of the almost 30 campgrounds, half are either shoreline campsites or boat camps with no significant infrastructure. Portions of developed campgrounds, however, are located within 30 feet of the existing gross pool. Other significant infrastructure in the reservoir area includes vehicular and railroad bridges. Of the 22 bridges in the reservoir area, 10 carry the UPRR; 2 of the bridges are on Interstate 5 (I-5); 1 of the bridges (Pit River Bridge) carries both I-5 and UPRR; 3 of the bridges are maintained by Shasta County; and 6 of the bridges are maintained by USFS.

The most significant infrastructure between the existing gross pool and elevation 1,100 (i.e., within 30 feet of the existing gross pool, summarized in **Table III-2**) includes the following:

- Pit River Bridge (I-5 and UPRR)
- UPRR between Tunnels 1 and 2 (0.6 miles south of the Pit River Bridge)
- I-5 Bridge over the Sacramento River in the Lakeshore/Antlers area (and approximately 2,000 feet of I-5 at Lakeshore, just north of the bridge)
- Several homes in the communities of Lakeshore and Sugarloaf
- Pit 7 Dam (owned by PG&E)

TABLE III-2
SUMMARY OF AREA FACILITIES FROM EXISTING GROSS POOL TO ELEVATION 1,100

Facilities	Number
Buildings	197
Bridges	22
Dams	2
Paved road segments	86
Unpaved road segments	53
Parking areas	16
Railroad segments (not including railroad bridges)	1
Power towers	3
Other infrastructure	23
Total Items	**403**

Source: Shasta Reservoir Area Inventory, February 2002.

Plate 8 shows a plan and profile view of the Pit River Bridge. The Pit River Bridge is the most significant structure within the inventory range.

Physical Environment

Elements of the physical environment surrounding Shasta Dam and Reservoir described in this section include topography, geology, soils, geomorphology, sedimentation and erosion, climate and hydrology, flood control, water quality, air quality, and noise.

Topography

Shasta Dam and Reservoir are located on the northern edge of California's Central Valley, which is almost completely enclosed by mountains and has only one outlet, through San Francisco Bay to the Pacific Ocean. The valley is nearly 500 miles long and averages 120 miles in width. The Central Valley is drained by the Sacramento River in the northern portion and the San Joaquin River and Tulare Lake tributaries in the southern portion.

The major tributary drainages above Shasta Dam, the Sacramento, McCloud, and Pit rivers, and several smaller drainages, originate in the east and flow generally westward into Shasta Lake. Downstream from the dam, the Sacramento River travels south to the Delta, picking up additional flows from numerous tributaries, including Cottonwood Creek, Stony Creek, the Feather and American rivers, and others. The Sacramento River basin covers approximately 27,000 square miles and is about 240 miles long and up to 150 miles wide.

Ground surface elevations in the northern portion of the Sacramento Valley range from above 14,000 feet at Mount Shasta in the headwaters of the Sacramento River to approximately 1,070 feet at Shasta Lake. About 65 percent of the mountainous area within this range lies below 4,000 feet in elevation and 97 percent below 7,000 feet in elevation. Other mountain areas bordering the valley reach elevations higher than 10,000 feet. In the southern portion of the Sacrament River basin, the Sacramento Valley floor is relatively flat.

Geology

The geology of the study area is highly complex, containing portions of five geomorphic provinces: the Coast Range, Klamath Mountains, Great Valley, Cascade Range, and Modoc Plateau.

Shasta Lake is located within the Klamath Mountain geomorphic province at the north end of the Sacramento Valley. The Klamath Mountain province is considered to be a northern extension of the Sierra Nevada and consists of rugged topography with prominent peaks and ridges. The drainage of this province is primarily through the Klamath and the upper Sacramento rivers.

Geology of the Klamath Mountains to the north and west of the study area, including Shasta Lake and its tributaries, comprises older bedrock materials, sedimentary basin deposits, and volcanic deposits, and includes the Bully Hill Rhyolite, Pit, Hosselkus Limestone, Balaklala Rhyolite, Kennett, and Bragdon formations. The Balaklala Rhyolite group of rhyolitic flows, pyrite, and other pyroclastic rocks were the primary source of base-metal ore bodies that supported copper, zinc, gold, and silver mining operations in the subarea. Other geologic formations include Mesozoic formations of sedimentary and volcanic fragments that contain mudstone, shale, sandstone, and conglomerate, and pre-Cretaceous metamorphic, abundant serpentine and granitics. Volcanic components typically arise in the east from the Klamath

Mountain Belt and include basalt, andesite, breccia, agglomerate, and tuff. Alluvial deposits overlay a large portion of this area.

The McCloud limestone formation, in the northeastern portion of the area around Shasta Lake and its tributaries, is a unique feature of the study area. This formation is of paleontological significance because it is composed primarily of coral reefs and other marine formations that hold the fossilized remains of a diverse group of fauna. Paleontological findings and information from the McCloud limestone have provided the basis for current scientific knowledge of invertebrate and vertebrate development in California. Today, limestone caves also provide unique habitat for several cave-dwelling species in the subarea, including the Shasta salamander, Shasta eupatorium, Howell’s cliff-maids, and Shasta snow-wreath.

The portion of the study area along the Sacramento River downstream to the RBDD encompasses portions of the Cascade Range, Klamath Mountains, and Great Valley geomorphic provinces. The Cascade Range to the east comprises primarily volcanic formations and volcanic sedimentary deposits, including the Tuscan Formation and Montgomery Creek Formation. The Central Valley province (also referred to as the Great Valley) is a large, asymmetrical, northwestwardly trending, structural trough formed between the uplands of the California Coast Ranges to the west and the Sierra Nevada to the east. This trough has been filled with a tremendously thick sequence of sediments ranging in age from Jurassic to Recent.

Principal formations include the Tehama, Riverbank, Chico, and Red Bluff formations, which contain marine and nonmarine sedimentary rocks eroded from the surrounding Cascade Range and Klamath Mountains. These fluvial formations comprise silt, sand, clay, and gravel.

Soils

Soils in the Sacramento River basin are divided into four physiographic groups: upland soils, terrace soils, valley land soils, and valley basin soils. Upland soils are prevalent in the hills and mountains of the region and are composed mainly of sedimentary sandstones, shales, and conglomerates of igneous rocks. Terrace and upland soils are predominant between Redding and Red Bluff; however, valley land soils border the Sacramento River through this area. Valley land and valley basin land soils occupy most of the Sacramento Valley floor south of Red Bluff. Valley land soils consist of deep alluvial and aeolian soils that make up some of the best agricultural land in the State. The valley floor was once covered by an inland sea and sediments were formed by deposits of marine silt followed by mild uplifting earth movements. After the main body of water disappeared, the Sacramento River began eroding and redepositing silt and sand in new alluvial fans.

Geomorphology

The geomorphology of the Sacramento River is a product of several factors: the geology of the Sacramento Valley, hydrology and climate, vegetation, and human activity. Large flood events drive lateral channel migration and remove large flow impediments. Riparian vegetation stabilizes riverbanks and reduces water velocities, inducing deposition of eroded sediment. In the past, a balance existed between erosion and deposition along the Sacramento River. However, construction of dams, levees, and water projects has altered stream flow and other hydraulic characteristics of the Sacramento River. In some areas, human-induced changes have stabilized and contained the river, while in other reaches the loss of riparian vegetation has reduced sediment deposition and led to increased erosion.

The upper Sacramento River between Shasta Lake and Red Bluff is bounded and underlain by resistant volcanic and sedimentary deposits that confine the river, resulting in a relatively stable river course. This reach of river is characterized by steep vertical banks and the river is primarily confined to its channel with limited overbank floodplain areas. There is limited meander of the river above Red Bluff. Downstream from Red Bluff, the Sacramento River is active and sinuous, meandering across alluvial deposits within a wide meander belt. Geologic outcroppings and man-made structures, such as bridges and levees, act as local hydraulic controls along the river. Bank protection, consisting primarily of rock riprap, has been placed along various sections of the Sacramento River to prevent erosion and river meandering.

Sedimentation and Erosion

Sedimentation and erosion are natural processes throughout the primary and extended study areas. These processes have been affected by a number of factors, including logging, hydraulic mining; construction of dams and roads, reservoirs, and channel modifications; and agricultural and urban activities. Sedimentation and erosion in the basin also have been significantly accelerated at times following large forest fires. It is difficult for forests to recover from severe wildfires, which can cause increased erosion and sediment input into streams. Subsequent changes in stream morphology often have resulted in degraded aquatic habitat and loss of adjacent wetland areas.

The watershed above Shasta Lake is generally well forested and erosion is not excessive. Many of the tributaries of Shasta Lake are well-balanced stream systems, where flows, sediment bedload, and the delivery of large woody debris are in dynamic equilibrium. This equilibrium contributes to the formation and maintenance of favorable fisheries habitat, including pools, riffles, complex woody structures, and desirable spawning areas within the tributaries.

However, as much of the terrain is steep, landslides are relatively common and range from small mudflows and slumps to large debris slides, debris flows, or landslides. Slides and sheet wash typically supply debris and sediments to the tributary streams of Shasta Lake during the rainy season. Volcanic eruptions and mudflows have periodically affected channel morphology, often changing habitat conditions in area streams. The most active volcanic feature in the area around Shasta Lake is Mount Shasta, which is estimated to have erupted 13 times in the last 10,000 years. The last major mudflow, which occurred on Mud Creek in 1924, sent sediment down the McCloud River that was observed as far downstream as San Francisco Bay.

Shasta and Keswick dams affect sediment transport because they block sediments that would normally have been transported from the upper Sacramento River basin. The result has been a net loss of coarse sediment in the Sacramento River below Keswick Dam that has negatively impacted spawning gravels. In alluvial river sections, bank erosion and sediment deposition cause migrations of the river channel that are extremely important in maintaining instream and riparian habitats, but also can cause loss of agricultural lands and damage to roads and other structures. In the Sacramento River, these processes are most important in the major alluvial section of the river, which begins downstream from the RBDD. The river channel in the Keswick to RBDD reach is more constrained by erosion-resistant volcanic and sedimentary formations and therefore is more stable.

The problem of gravel availability in the Sacramento River is exacerbated downstream from Keswick Dam by dams constructed on Sacramento River tributaries, bank protection measures along the mainstem of the Sacramento River, and instream gravel mining. In the recent past, Reclamation, DWR, and CDFG have cooperated in actions to artificially replenish salmon spawning gravel in the reach.

Along the tributaries, human-induced impacts to river morphology include livestock grazing, urbanization and related infrastructure construction, riparian vegetation removal, gravel mining, bank protection, dams, and water diversions. Over time, the major tributary streams developed multiple terraces adjacent to the stream channels. Some also have developed small fan deposits of gravels at their mouths, but large fans are more typical of the tributaries downstream from Red Bluff. Some tributaries, such as Cottonwood Creek, also include deposits of mine tailings, either washed downstream from mining in the mountains or left by floating dredges. Eastside streams tend to produce less gravel because they drain steep, resistant volcanic terrain. Westside streams produce the majority of gravel entering the Sacramento River because they flow through gravelly alluvial deposits subject to tectonic uplift. Sediment and gravel discharge changes from year to year depending on hydrology and conditions in the watersheds, such as fires, mass wasting, timber harvesting, road construction, and changing land uses.

Climate and Hydrology

The Sacramento River basin contains the entire drainage area of the Sacramento River and its tributaries and extends almost 300 miles from Collinsville in the Delta north to the Oregon border. Hot, dry summers, with temperatures that can exceed 100 degrees Fahrenheit, and mild winters characterize the valley floor. Average temperatures range from about 60 degrees Fahrenheit in low valley regions to about 40 degrees in mountain areas.

Total annual precipitation at higher elevations averages between 60 and 70 inches and is as much as 95 inches in the northern Sierra Nevada and the Cascade Range, where snow typically accumulates above 4,000 to 5,000 feet in elevation. Precipitation on the valley floor occurs mostly as rain, and yearly totals range from 20 inches in the northern end of the valley to about 15 inches at the Delta. Average annual precipitation throughout the Sacramento River basin is 36 inches.

Hydrologic features of the study area include perennial, intermittent, and ephemeral stream channels, and natural water bodies and wet meadowlands. Major floods are typically a result of rain-on-snow events that result in a rapid melting of the winter snowpack. Eastside tributaries to the Sacramento River typically originate in the Cascade Range and include Stillwater, Cow, Bear, Battle, and Paynes creeks. Perennial and intermittent westside tributaries originate in the Klamath Mountains or foothills, and include Clear and Cottonwood creeks.

The most intensive runoff occurs in the upper watershed of the Sacramento River above Shasta Lake and on the rivers originating on the west slope of the Sierra Nevada. These watersheds produce an annual average of 1,000 to more than 2,000 acre-feet of runoff per square mile.

The Sacramento River contributes the majority water to Delta inflow. Unimpaired flow from the four major rivers in the Sacramento River basin (Sacramento, Feather, Yuba, and American rivers) averaged 21.2 MAF and ranged from about 5 to 38 MAF during the 1906-1996 period. Of this flow, the Sacramento River (at Red Bluff) averaged 8.4 MAF (including Trinity River imports, described below), the Feather River averaged 4.5 MAF, the Yuba River averaged 2.4 MAF, and the American River averaged 2.6 MAF.

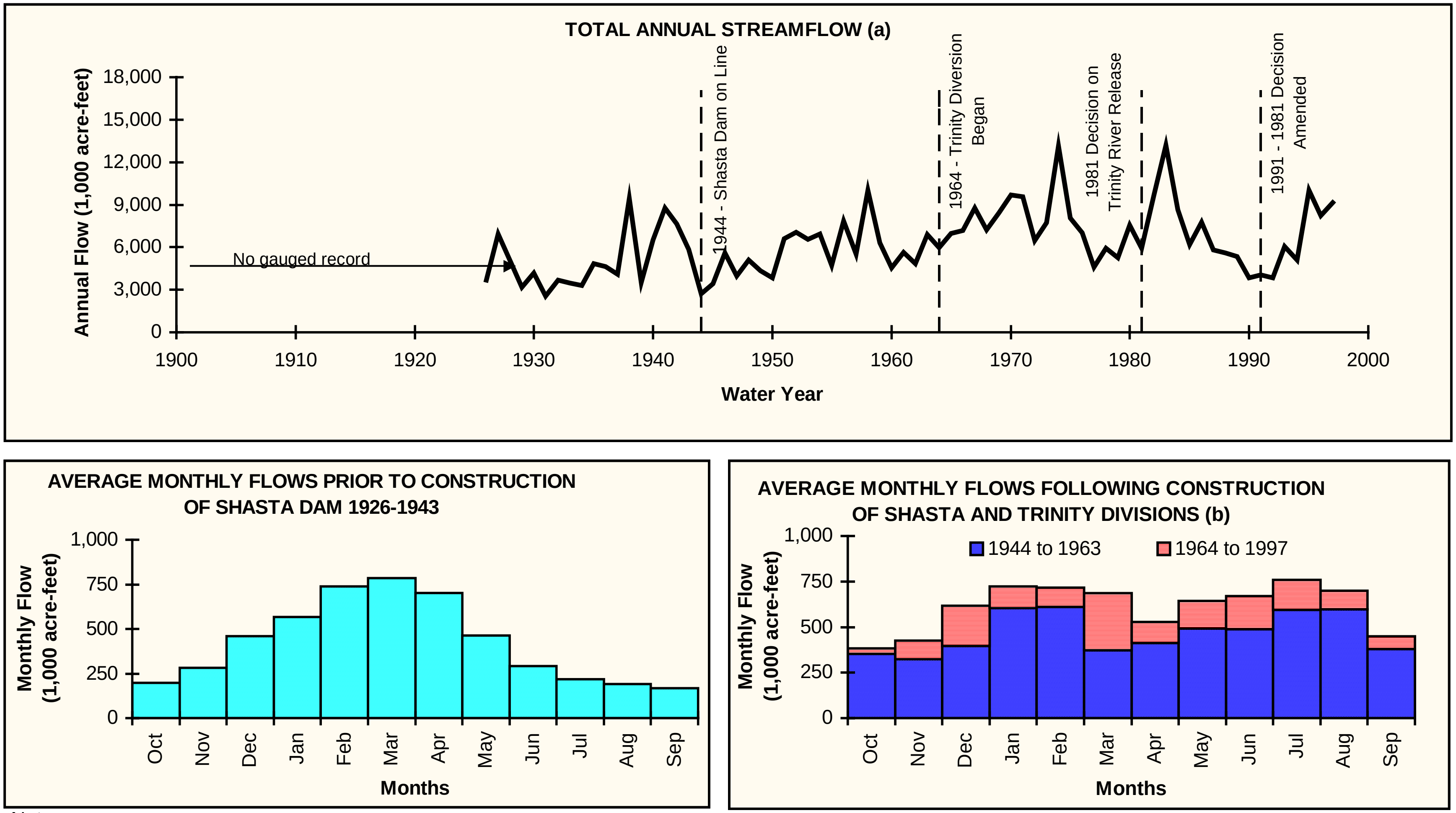
Mean monthly inflow, outflow, and storage at Shasta Reservoir are shown in **Table III-3**. The highest average monthly inflow period for Shasta is January through March. Winter and early spring inflows are stored for later release during the summer irrigation season.

Since 1964, a portion of the flow from the Trinity River basin has been exported to the Sacramento River basin through CVP facilities, as shown in **Figure III-2**. Historically, an average annual quantity of 1.27 MAF of water has been exported. This annual quantity is approximately 17 percent of the flows measured in the Sacramento River at Keswick Dam. However, Trinity River diversions to the Sacramento River are to be reduced as part of the December 2002 ROD to allow more inflows to remain in the Trinity River for fish restoration purposes.

TABLE III-3
MEAN MONTHLY INFLOW TO SHASTA RESERVOIR

Month	Inflow [1] (1,000 acre-feet)	Outflow [2] (1,000 acre-feet)	Shasta Storage [3] (1,000 acre-feet)
January	799	587	3,131
February	836	628	3,355
March	889	511	3,719
April	693	421	3,961
May	537	524	3,948
June	339	536	3,720
July	247	615	3,326
August	223	571	2,966
September	220	377	2,809
October	263	301	2,775
November	365	331	2,801
December	585	465	2,906
Total	**5,991**	**5,868**	**-**
Average	**499**	**489**	**3,285**

Notes:
[1]Computed data based on a period from 1944 to 2002.
[2]Recorded data based on a period from 1944 to 2002.
[3]Shasta storage data computed based on a period from 1953 to 2002.



Notes:
(a) First full year of stream flow data for station 11370500 was 1939. Data for 1926-1963 are from Station 1136950.
(b) Upper portion of bar represents incremental increase in average monthly flows since 1964 water year, due to releases through the Spring Creek Powerplant.

Figure III-2 – Historical streamflow in the Sacramento River below Keswick Dam.

Flood Control

A number of flood management projects along the Sacramento River affect the flow and operation of facilities, including dams and reservoirs, levees, and weirs. Major reservoirs in the Sacramento River watershed and flood control storage space include Folsom Reservoir on the American River, Lake Oroville on the Feather River, Black Butte Reservoir on Stony Creek, and Shasta Reservoir. Other major flood management system facilities include five weirs, located along the Sacramento River, to divert part of flood flows to overflow basins and bypasses (Butte Basin, Sutter Bypass, and Yolo Bypass). The weirs allow high Sacramento River flow to enter the basin and bypass the system. Weirs were designed to begin operation in a certain order: Tisdale Weir, Colusa Weir, Fremont Weir, Moulton Weir, and Sacramento Weir.

The flood management system of the San Joaquin River basin includes levees along the lower portions of Ash and Berenda sloughs; Bear Creek; Fresno and Stanislaus rivers; and levied sections along the San Joaquin River. The Chowchilla Canal Bypass diverts San Joaquin River flow excess and sends it to the Eastside Bypass. In addition to the Chowchilla Canal Bypass, the Eastside Bypass intercepts flows from minor tributaries and rejoins the San Joaquin River between Fremont Ford and Bear Creek. The San Joaquin River levee and diversion system is not designed to contain the objective release from each project reservoir simultaneously.

The primary non-Federal sponsor for flood control projects in both the Sacramento River and San Joaquin River basins is the Reclamation Board of the State of California. The Reclamation Board has signed onto the assurances of operating and maintaining the Federal project under the authority of the Flood Control Act of 1944. The Reclamation Board has local agreements with DWR, levee districts, reclamation districts, and other entities. These local agreements document shared operation and maintenance requirements with the Reclamation Board. Because reclamation districts and other local entities perform the actual maintenance and operation for sections of the flood control project, maintenance practices vary from almost no maintenance to outstanding maintenance. The quality of maintenance normally depends on the funding availability to the maintaining entity; funding availability varies widely.

Maintaining flood management system levees and channels is difficult due to the erosive nature of the flood flows that the current system configuration produces, and due to expensive environmental mitigation when bank protection is required. The system is tightly leveed in many locations and the levees must be continually protected from erosion. The most common material used is rock riprap, which effectively prevents erosion but negatively impacts riparian habitat. Mitigation costs for new flood control projects and improvements have constantly increased over the past decades due to environmental awareness.

Prior to construction of Shasta Dam, the Sacramento River typically experienced large fluctuations in flow driven by winter storms, with late-summer flows averaging 3,000 cfs or less. These fluctuations and periodic floods moved large amounts of sediment and gravel out of the mountainous tributaries and down the Sacramento River. Completion of Shasta Dam in 1945 resulted in a general dampening of historic high and low flows, reducing the magnitude of winter floods while maintaining higher summer flows between 7,000 and 13,000 cfs.

The current regulation of Shasta Dam for flood control requires that releases be restricted to quantities that will not cause downstream flows or stages to exceed, insofar as possible, (1) a flow of 79,000 cfs at the tailwater of Keswick Dam and (2) a stage of 39.2 feet at the Sacramento River at Bend Bridge gaging station near Red Bluff (corresponding roughly to a flow of 100,000 cfs). **Plates 9 and 10** show peak flow-frequency relationships at both Keswick and Bend Bridge. A storage space of up to 1.3 MAF below gross pool elevation of 1,067 is also kept available for flood control purposes in the reservoir in accordance with the Flood Control Diagram (see **Plate 11**), as prescribed by the Corps. Under the diagram, flood control storage space increases from zero on October 1 to 1.3 MAF (elevation 1,018.55) on December 1 and is maintained until December 23. From December 23 to June 15, the required flood control space varies according to parameters based on the accumulation of seasonal inflow. This variable space allows for the storage of water for conservation purposes, unless it is required for flood control based on basin wetness parameters and the level of seasonal inflow. Daily flood control operation consists of determining the required flood storage space reservation and scheduling releases in accordance with flood operating criteria.

Flood control operations of Shasta Dam require forecasting of flood runoff both above and below the dam. Rapidly changing inflows are continually monitored, and the forecasts of the various inflows are adjusted as required. The time of streamflow travel from Shasta Dam to Bend Bridge is about 9 to 10 hours under higher flow conditions. The timing of peak reservoir inflows and peak inflows from tributaries downstream from the dam can complicate release operations. The large size of the flood control pool at Shasta Reservoir can prolong flood release operations for many weeks as operators vacate the pool before the next storm event.

As indicated, a goal of the existing operation is to have an excess of the required flood control space vacant in the flood season and then fill the pool to the maximum extent possible for water supply and other needs in the remainder of the year. **Plate 12** is a plot showing the historical monthly storage in Shasta Reservoir for the period of 1953 through 2002. In most years, Shasta Reservoir has been able to fill following the flood season drawdown.

Releases from Shasta Dam are often made for flood control. **Table III-4** shows the historical annual inflow, storage, and outflow history for Shasta Reservoir from 1945 through 2002. Releases for flood control can either occur in the fall to reach the prescribed vacant flood space beginning in early October, or to evacuate space during or after a storm event to maintain the prescribed vacant flood space in the reservoir. During a storm event, releases for flood control can occur either over the spillway during large events or through river outlets for smaller events. As shown in **Table III-4**, from about 1950 through 2002, flows over the spillway occurred in 12 years, or in 23 percent of post-1950 years. It is estimated that releases for flood control (either for seasonal space evacuation or during a flood event, and including spills over the spillway) occurred in about 37 years, or nearly 70 percent of the years.

The estimated frequency (percent exceedance) of storage in Shasta Reservoir for the end of September, based on the SLWRI CALSIM II benchmark simulation, is shown in **Figure III-3**. The average storage in the reservoir (50 percent exceedance) under existing conditions prior to the beginning of flood control operations is about 2.7 MAF. The frequency distribution graph also shows that in about 80 percent of the years, the end of September stage is greater than about 1.9 MAF, and 3.3 MAF in approximately 20 percent of the years.

TABLE III-4
SHASTA DAM AND RESERVOIR FLOOD CONTROL RELEASES

Water Year	Total Inflow (TAF)	End of Sept. Storage (TAF)	Outflows (TAF)				Water Year	Total Inflow (TAF)	End of Sept. Storage (TAF)	Outflows (TAF)			
			Total	Power-Plant	Spill-way	Outlets				Total	Power Plant	Spill-way	Outlets
1945	4,858		3,462	2,624		839	1974	10,796	3,658	10,364	6,796		3,568
1946	5,906		5,599	3,898		1,700	1975	6,405	3,570	6,384	6,153		231
1947	3,908		3,964	3,571		393	1976	3,611	1,295	5,813	5,813		
1948	5,416		4,958	4,244		714	1977	2,628	631	3,247	3,247		
1949	4,318		4,303	4,303		0	1978	7,837	3,428	4,944	4,538		407
1950	4,133		3,784	3,781	1	2	1979	4,022	3,141	4,203	4,203		
1951	6,316		6,486	5,696		790	1980	6,415	3,321	6,139	4,773		1,366
1952	7,785		6,800	5,625	9	1,166	1981	4,103	2,480	4,845	4,845		
1953	6,540	3,300	6,408	5,067		1,341	1982	9,013	3,486	7,910	6,464	253	1,193
1954	6,541	3,059	6,826	5,941		885	1983	10,794	3,617	10,576	7,123	1	3,452
1955	4,112	2,455	4,612	4,612			1984	6,667	3,240	6,944	6,514		429
1956	8,834	3,569	7,606	4,926	12	2,668	1985	3,971	1,978	5,154	5,152	2	
1957	5,368	3,485	5,341	4,841	17	483	1986	7,546	3,211	6,225	4,383		1,842
1958	9,698	3,473	9,610	6,672	13	2,924	1987	3,944	2,108	4,957	4,800		157
1959	5,086	2,504	5,952	5,631		321	1988	3,931	1,586	4,368	3,973		395
1960	4,733	2,756	4,380	4,380			1989	4,745	2,096	4,154	3,951		203
1961	5,071	2,333	5,402	5,402			1990	3,616	1,637	3,999	3,707		292
1962	5,262	2,908	4,582	4,582			1991	3,051	1,340	3,286	2,666		620
1963	7,003	3,242	6,575	6,077	13	485	1992	3,622	1,683	3,204	1,755		1,449
1964	3,905	2,202	4,849	4,849			1993	6,825	3,102	5,316	3,728		1,588
1965	6,983	3,612	5,475	4,581		894	1994	3,087	2,102	4,002	3,252		750
1966	5,299	3,263	5,544	5,544			1995	9,638	3,136	8,511	5,187		3,324
1967	7,404	3,506	7,066	6,131		935	1996	6,846	3,089	6,781	3,703		3,078
1968	4,772	2,670	5,515	5,138		377	1997	7,424	2,308	8,106	5,808		2,298
1969	7,668	3,528	6,714	5,421		1,293	1998	10,294	3,441	9,072	6,698	2	2,372
1970	7,902	3,440	7,885	5,477	4	2,404	1999	7,196	3,328	7,202	6,379		824
1971	7,328	3,275	7,402	6,824	1	578	2000	6,839	2,985	7,074	5,573		1,501
1972	5,078	3,267	5,000	5,000			2001	4,141	2,200	4,824	4,823		1
1973	6,167	3,317	6,026	5,583		443	2002	5,052	2,558	4,590	4,590		
						Average		**5,991**	**2,818**	**5,868**	**4,949**	**6**	**913**

Key:
TAF – thousand acre-feet

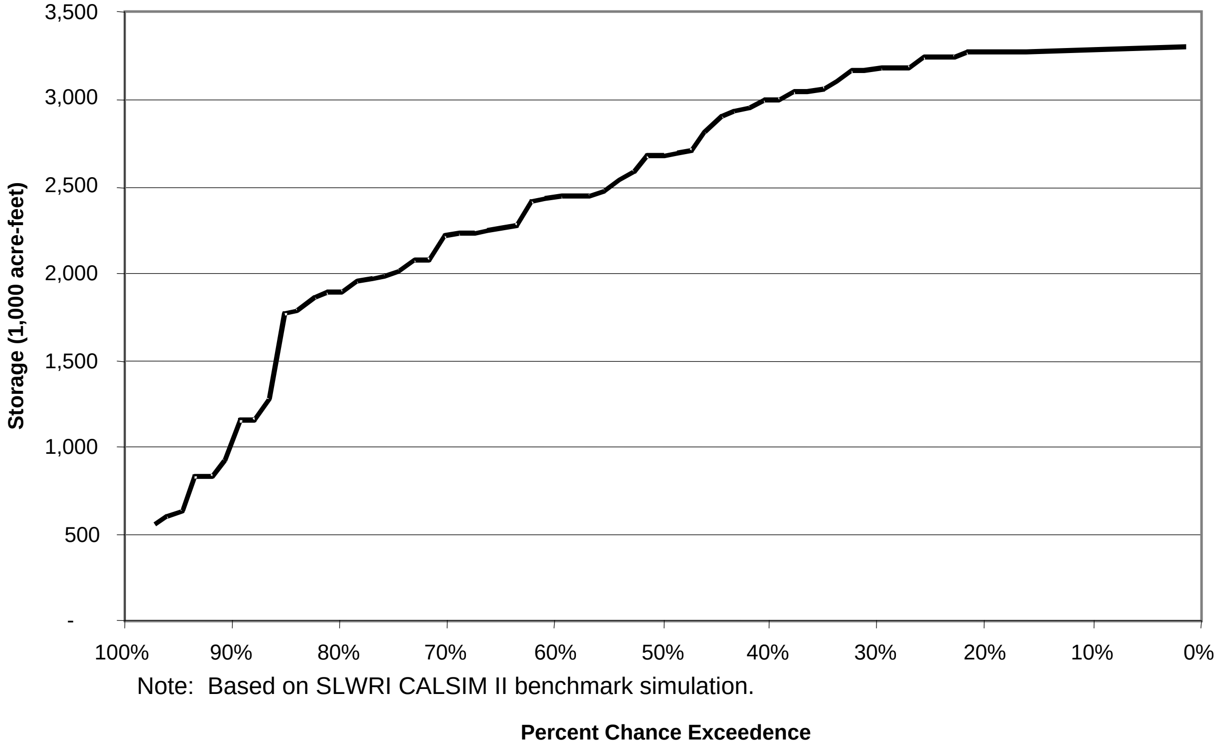


Figure III-3 – Estimated frequency (percent chance exceedence) of storage at the end of September in Shasta Reservoir with 2000 level demands and D-1641 requirements.

The estimated safe channel carrying capacity of the Sacramento River downstream from Keswick through Redding is 79,000 cfs. Shasta Dam and Reservoir can control outflows from Keswick to that value from about a 1.3 chance in 100 to 1.0 chance in 100 in any one year (see **Plate 9**) if it is operated precisely according to the Flood Control Manual. For flood events rarer than about the 1.0 chance in 100 in any one year, inflows to Shasta would exceed the ability of the reservoir to store the inflow volume and maintain the 79,000 cfs channel capacity. Under these circumstances, outflows from the dam would need to be increased to prevent uncontrolled conditions (see **Plate 9**).

Shasta Lake collects flow in the upper Sacramento River watershed, but many uncontrolled tributaries enter the Sacramento River downstream from the dam. Stream gages have been added to major uncontrolled tributaries entering downstream from Shasta Lake (Cow, Battle, Cottonwood, and Thomes creeks). To a limited extent, the operators of Shasta Dam can adjust releases containing these uncontrolled flows to try to reduce downstream peak flows. Accordingly, the influence of Shasta's operation on reducing peak flood flows diminishes downstream on the Sacramento River.

Water Quality

The SWRCB and RWQCBs largely determine objectives for water quality in California's surface waters. The study area lies entirely within the region under jurisdiction of the Central Valley Regional Water Quality Control Board (CVRWQCB). Water quality objectives for a particular reservoir or river reach are affected by its beneficial uses, which are determined by CVRWQCB.

Water quality must adequately protect beneficial uses. Beneficial uses for Shasta Lake and its tributaries, and the reach of the Sacramento River between Shasta Dam and the Colusa Basin Drain (which includes Keswick Reservoir and the river between Keswick Dam and the Colusa Basin Drain), are provided in **Table III-5**.

Water quality in the study area generally supports the beneficial uses of area rivers and reservoirs. However, impaired water quality conditions have been found for specific waters of the study area in the recent past and some of these impaired conditions persist. Principal water quality issues in the study area include water temperatures in the Sacramento River between Keswick Dam and the RBDD, turbidity in Shasta Lake, and acid mine drainage and associated heavy metal contamination from the Spring Creek drainage and other abandoned mining sites. Elevated pesticide levels have been found at some sites in the Sacramento River Valley for a number of years, but these sites are downstream from Red Bluff. Stormwater runoff from Redding and other urban areas likely flushes contaminants into the Sacramento River, but the volume of flow in the river generally provides sufficient dilution to prevent excessive concentrations in the river. The City of Redding is working toward compliance under Phase II of the National Pollution Discharge Elimination System (NPDES).

TABLE III-5
BENEFICIAL USES FOR SURFACE WATERS IN THE STUDY AREA

Beneficial Use	Pit River - Hat Creek to Shasta Lake	McCloud River	Sacramento River – Box Canyon Dam to Shasta Lake	Shasta Lake	Sacramento River - Shasta Dam to Colusa Basin Drain
Municipal & domestic supply (drinking water)	E	E		E	E
Agriculture, irrigation	E		E	E	E
Agriculture, stock watering	E		E		E
Industry, service supply					E
Industry, power	E	E		E	E
Recreation, contact	E	E	E	E	E
Recreation, whitewater	E	P	P		E
Recreation, noncontact	E	E	E	E	E
Freshwater habitat, warm	P			E	P
Freshwater habitat, cold	E	E	E	E	E
Migration, warm					E
Migration, cold					E
Spawning, warm	E			E	E
Spawning, cold	E	E	E	E	E
Wildlife habitat	E	E	E	E	E
Navigation					E

Key:
E – existing beneficial use
P – potential beneficial use

Air Quality

The northern half of the Central Valley is located in the Sacramento Valley Air Basin (SVAB). The Coast Range, Sierra Nevada Range, Cascade Mountains, and San Joaquin Valley basin bound the basin. Marine winds enter the valley at the Carquinez Straits and head eastward until deflected north into the Sacramento Valley and south into the San Joaquin Valley. A combination of air contaminants, meteorological conditions, and the topographic configuration of the valley affect air quality throughout the Sacramento Valley basin. Most of the air pollutants in the study area may be associated with either urban or agricultural land uses.

During the summer, Pacific high-pressure systems can create inversion layers in the lower elevations that prevent the vertical dispersion of air. As a result, air pollutants can become concentrated during the summer, lowering air quality. During the winter, when the Pacific high-pressure system moves south, stormy, rainy weather intermittently dominates the region. Prevailing winter winds from the southeast disperse pollutants, often resulting in clear, sunny weather and better air quality over most of the region. Much of the SVAB is designated as a nonattainment area with respect to the national and State ozone (O_3) and particulate matter (PM_{10}) standards, and the urban Sacramento and Maryville/Yuba City areas are designated as nonattainment for national and State carbon monoxide standards.

The relatively low residential density of Shasta County's rural and suburban areas contributes to an auto-dependent lifestyle that affects air quality. Pollution from mobile sources, such as cars and trucks, represents 43 percent of hydrocarbons emissions, 57 percent of nitrogen oxide (NO) emissions, 59 percent of reactive organic gases, and 82 percent of carbon monoxide emissions in typical urban areas of Shasta County (Shasta County General Plan). Many other sources of air pollution exist in the study area (e.g., residential, agricultural, and forest management burn practices, imported pollutants from lower Sacramento Valley, unpaved roads, etc.).

Noise

Noise levels in densely populated areas of the State are influenced predominantly by the presence of limited-access highways carrying extremely high volumes of traffic, particularly heavy trucks. Noise in rural areas where traffic generally is low to moderate is measured at considerably lower decibels. Noise at Shasta Lake is affected by the presence of boats and personal watercraft.

Biological Environment

Biological resources in the region result from a wealth and diversity of climatic and vegetative associations within and adjacent to the study area. Influences from the coastal mountains, southern Cascades, northern Sierra Nevada, Great Basin, and Central Valley provide for a unique mix of biota.

Much of the area, especially within the Central Valley, has been modified by past and present land uses. Prior to human settlement, this region was dominated by riparian vegetation within the annual floodplains, with stands of valley oak and interior live oak on higher ground. Herbaceous wetland bottoms and upland native grassland communities were common in this vegetation mosaic. The extensive oak forests and riparian/wetland habitats hosted a diverse and abundant wildlife community. Cattle grazing, deforestation of the oak woodlands, and flood protection resulting in expansion of agriculture onto the floodplains in the early to mid-1800s substantially altered both the floodplain and channel vegetation. Agriculture is currently the primary land use in the Central Valley, with riparian vegetation relegated to narrow strips along portions of the Sacramento and San Joaquin Rivers and their tributaries.

Aquatic and Fishery Resources

Table III-6 contains the common and scientific names of fish species found in the study area and their likely locations. Fish species assemblages of the Sacramento River include anadromous and resident salmonids and native warm water river species such as Sacramento sucker and Sacramento pike minnow.

The Shasta Lake and Keswick Reservoir fish species include mostly introduced warm water and cold water species. The Shasta Lake tributary species comprise planted and wild trout and several native species. Major nonfish aquatic animal species assemblages of the study area are the benthic macroinvertebrates of Shasta Lake, the Sacramento River, and tributaries to Shasta Lake, and the zooplankton of the reservoirs.

TABLE III-6
FISH SPECIES KNOWN TO OCCUR IN THE STUDY AREA

Common Name	Scientific Name	Shasta Lake Tributaries	Shasta Lake / Keswick Reservoir	Sacramento River - Keswick to Red Bluff
Chinook salmon	*Oncorhynchus tshawytscha*		X	
winter-run				X
spring-run				X
fall-run				X
late fall-run				X
Kokanee salmon	*Oncorhynchus nerka*	X	X	
Rainbow trout	*Oncorhynchus mykiss*	X	X	X
Steelhead trout	*Oncorhynchus mykiss*			X
Brown trout	*Salmo trutta*	X	X	
Green sturgeon	*Acipenser medirostris*			X
White sturgeon	*Acipenser transmontanus*	X	X	X
Pacific lamprey	*Lampetra tridentata*			X
Western brook lamprey	*Lampetra richardsoni*			X
Sacramento sucker	*Catostomus occidentalis*	X	X	X
Sacramento pikeminnow	*Ptychocheilus grandis*	X	X	X
Hardhead	*Mylopharodon conocephalus*	X	X	X
Sacramento blackfish	*Orthodon microlepidotus*	X	X	
California roach	*Hesperolecus symmetricus*	X		X
Speckled dace	*Rhinichthys osculus*	X	X	
Golden shiner	*Notemigonus crysoleucas*	X	X	
Carp	*Cyprinus carpio*	X	X	X
Channel catfish	*Ictalurus punctatus*	X	X	X
White catfish	*Ameiurus catus*		X	X
Brown bullhead	*Ameiurus nebulosus*		X	X
Black bullhead	*Ameiurus melas*		X	X
Riffle sculpin	*Cottus gulosus*	X	X	
Prickly sculpin	*Cottus asper*			X
Largemouth bass	*Micropterus salmoides*		X	
Smallmouth bass	*Micropterus dolomieui*	X	X	X
Spotted bass	*Micropterus punctulatus*	X	X	
Black crappie	*Pomoxis nigromaculatus*		X	
White crappie	*Pomoxis annulauris*		X	
Bluegill sunfish	*Lepomis macrochirus*		X	
Green sunfish	*Lepomis cyanellus*	X	X	
Threadfin shad	*Dorosoma petenense*		X	

Shasta Lake/Tributaries and Keswick Reservoir

The fisheries resources of Shasta Lake are greatly affected by the reservoir's thermal structure. During summer months, the epilimnion (warm surface layer) is 30 feet deep and up to 80 degrees Fahrenheit. Water temperatures above 68 degrees Fahrenheit favor warm water fishes such as bass and catfish. Deeper water layers, which include the hypolimnion and the metalimnion (transition zone between epilimnion and the hypolimnion), are colder and suitable for cold water species. Shasta Lake is classified as warm monomitic because it has one period of mixing per year.

The warm water fish habitats of Shasta Lake occupy two ecological zones: the littoral (shoreline/vegetated) and the pelagic (open water) zones. The littoral zone lies along the reservoir shoreline down to the maximum depth of light penetration on the reservoir bottom, and supports populations of spotted bass, smallmouth bass, largemouth bass, black crappie, bluegill, channel catfish, and other warm water species.

The upper, warm surface layer of the pelagic (open water) zone is the principal plankton-producing region of the reservoir. Plankton comprises the base of the food web for most of the reservoir's fish populations. Operation of the Shasta Dam TCD, which helps conserve the reservoir's cold water pool by accessing warmer water for storage releases in the spring and early summer, may reduce zooplankton biomass, which resides primarily in the reservoir's warmer surface water layer.

The deeper areas of Shasta Lake, hypolimnion and metalimnion, support cold water species such as rainbow and brown trout and landlocked chinook and kokanee salmon. Native species such as white sturgeon, Sacramento blackfish, hardhead minnow, riffle sculpin, Sacramento sucker, and Sacramento pikeminnow reside in cold water near the reservoir bottom. Trout may congregate near the mouths of the reservoir's tributaries, including the upper Sacramento River, McCloud River, Pit River, and Squaw Creek, when inflow temperatures of these streams are favorable.

The lower reaches of the reservoir's tributaries also provide spawning habitat for reservoir fish populations, and have important resident fisheries of their own (rainbow trout is the principal games species). Most native species found in the reservoir and listed previously also inhabit the lower reaches of the tributaries. One of the species, the hardhead minnow, is classified as a State of California Species of Special Concern. The McCloud River once supported a population of bull trout, which is currently a Federal and State listed species. A few creeks on the western shore of the reservoir are devoid of biological life due to toxic effluent from local mines.

Sacramento River

The Sacramento River flows for about 59 miles between Keswick Dam and the RBDD. The river in this reach has a stable, largely confined channel with little meander. Riffle habitat with gravel substrates and deep pool habitats are abundant in comparison with reaches downstream from RBDD. Immediately below Keswick Dam, the river is deeply incised in bedrock with very limited riparian vegetation and no functioning riparian ecosystems. Water temperatures are generally cool even in late summer due to regulated releases from Shasta Lake and Keswick Reservoir. Near Redding, the river comes into the valley and the floodplain broadens.

Historically, this area appears to have had wide expanses of riparian forests, but much of the river's riparian zone is currently subject to urban encroachment. This encroachment becomes quite extensive in the Anderson/Redding area with homes placed directly within or adjacent to the riparian zone.

The Keswick to Red Bluff reach of the Sacramento River contains a large assemblage of resident and anadromous fish species, including commercially important species and species that are listed as threatened or endangered. Despite net losses of gravel since construction of Shasta Dam, substrates in much of this reach contain gravel needed for spawning by salmonids. This reach provides much of the remaining spawning and rearing habitat of several listed anadromous salmonids. As such, it is one of the most sensitive and important stream reaches in the State.

The upper Sacramento River system is unique in that it supports four separate runs of chinook salmon. Each is recognized by its season of upstream migration: fall-, late-fall-, winter-, and spring-run chinook salmon. As seen in **Figure III-4,** runs of fall- and spring-run salmon also occur on several tributaries of the Sacramento River. The adult population of the four runs of salmon and other important fish species (including steelhead trout), which also spawn upstream from Red Bluff, has significantly declined since the 1950s (see **Figure III-5**). Today, fall-run, late-fall-run and winter-run chinook salmon stocks and steelhead stocks in the Keswick to Red Bluff reach are augmented by production from the Coleman Fish Hatchery on Battle Creek.

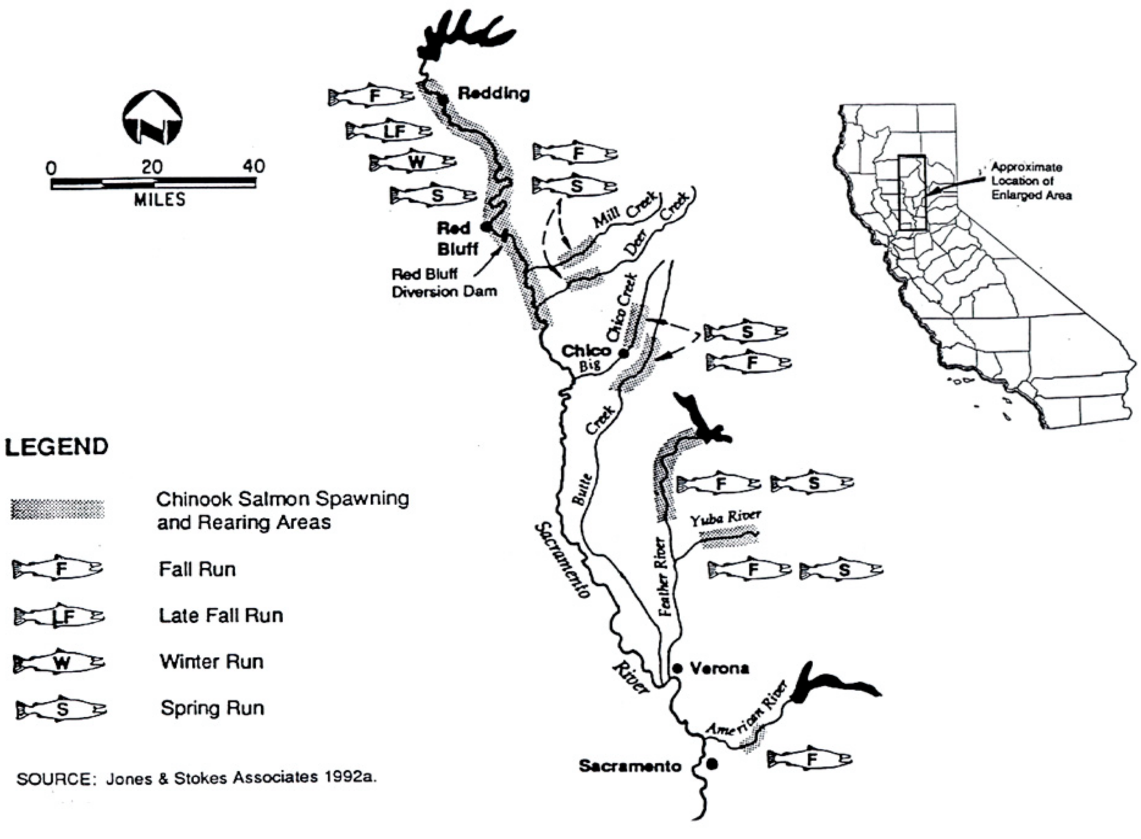


Figure III-4 - Major chinook salmon spawning and rearing areas in the Sacramento River watershed.

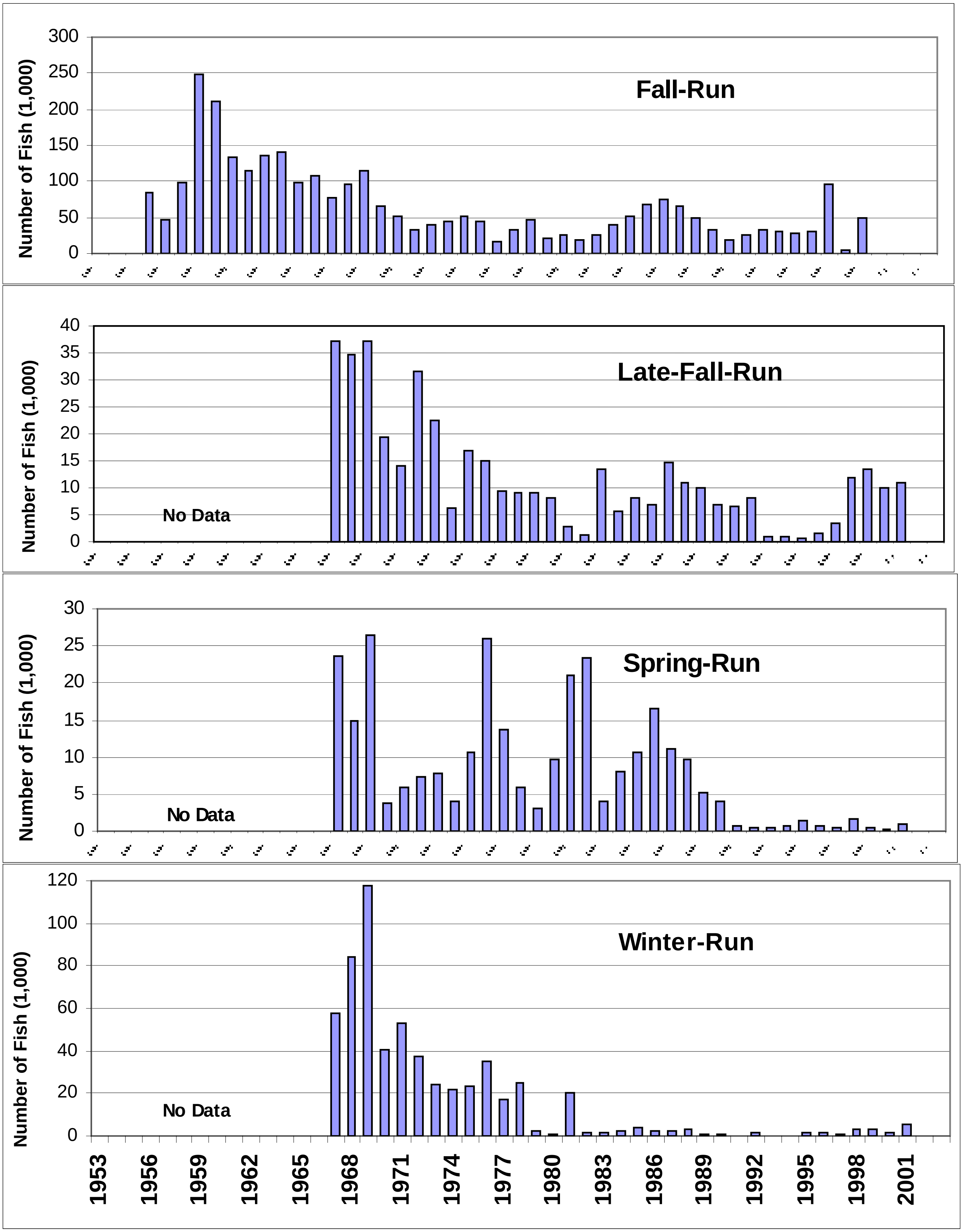


Figure III-5 - Estimated chinook salmon spawning escapement from the mainstem Sacramento River between 1953 and 2002.

- **Fall-run chinook salmon –** Fall-run chinook salmon were historically one of the more abundant salmon races in the Central Valley. Annual estimates of spawning escapement (total number of adult salmon aged 2 years and older that escape the fishery and return to spawn) in the mainstem Sacramento River have declined over the last 50 years. Annual run size declined from an average of about 180,000 adults during the 1950s and1960s to an average of about 77,000 during the 1970s through about 2000. Fall-run salmon are currently a candidate species for Federal listing.
- **Late-fall-run chinook salmon –** The number of late-fall-run chinook salmon passing the RBDD declined from an average of about 35,000 adults in the late 1960s to about 7,000 in recent years. Late-fall-run salmon are also a candidate species for Federal listing.
- **Winter-run chinook salmon –** With the possible exception of Battle Creek, the upper Sacramento River is the only spawning stream of winter-run chinook, which have been in a major decline since the 1960s. The return of only 550 adults in 1989 from an average annual population in the late 1960s of 80,000 adults prompted listing of winter-run chinook salmon as an endangered species by both the Federal Government and State of California.
- **Spring-run salmon –** The number of spring-run adult salmon passing the RBDD has fluctuated between highs of more than 25,000 fish to a low of about 770 in 1991. Because of the decline in spring-run salmon populations, spring-run salmon have been both Federally and State-listed as threatened.

Major factors that contribute to the decline in upper Sacramento River salmon populations include elevated water temperature; passage problems at the RBDD; modification and loss of spawning and rearing habitat due to construction of water resources projects; predation; pollution; and entertainment in water diversions on the Sacramento river and in the Delta. Drought conditions in the late 1980s and early 1990s also significantly contributed to population declines. Of these influencing factors, water temperature is one of the most important. Fortunately, cold water released from Shasta Dam significantly helps support spawning habitat in the reach below Keswick Dam. Without these cold water releases, winter-run salmon would possibly have become extinct, otherwise dispossessed of their historic spawning streams. However, temperatures still rise to levels harmful to salmon and steelhead trout.

Temperature impacts vary according to life cycle. Maximum survival of incubating salmon and steelhead eggs and yolk-sac larvae occurs at water temperatures between 41 and 56 degrees Fahrenheit, with no survival occurring at 62 degrees Fahrenheit or higher. After hatching, sac fry are completely dependent on the yoke sac for nourishment and may tolerate water temperatures up to 58 degrees. After juvenile salmon have emerged from the gravel and become independent of the yoke sac, the young salmon are able to tolerate water temperatures up to 67 degrees. Since winter-run and spring-run chinook salmon spawn during late spring and summer, they are particularly vulnerable to warmer water temperature conditions in the river.

For a period after Shasta Dam was constructed, the reservoir was kept relatively full and the cold water released from the hypolimnion provided cooler summer temperatures in the downstream reaches. The cold water releases created suitable conditions for winter-run and spring-run salmon to spawn in the mainstem Sacramento River below Shasta and Keswick Dams. Since winter-run salmon spawning habitat is almost entirely restricted to the Sacramento River between Keswick Dam and the RBDD, winter-run salmon survival is strongly tied to habitat conditions in this reach. In the late 1980s and early 1990s, because of a series of dry year conditions, storage space in Shasta Lake was decreased to satisfy water demands for agricultural, M&I, and other environmental uses (see **Plate 12**). This decrease in storage resulted in a depletion of the cold water pool, resulting in warmer water in the river and a higher mortality of salmon eggs.

The NMFS (now NOAA Fisheries) BO for winter-run chinook (1993) established water temperature objectives for the river upstream of Jellys Ferry (near RBDD) of 56 degrees Fahrenheit from April 15 through September 30, and 60 degrees for October. Recent changes in reservoir operations, including greater carryover storage, increased imports of cold water from the Trinity River system, and, most importantly, installation of a TCD on Shasta Dam, have substantially improved water temperature conditions in the reach.

In addition to anadromous salmonids, the Sacramento River contains resident rainbow trout and other native fishes. Resident rainbow trout are particularly abundant in the Keswick to Red Bluff reach. Their abundance is attributable to stable, cool summer flows resulting from Keswick Dam releases designed to enhance habitat conditions for winter-run salmon. The cool, nutrient-rich flows from the reservoir provide excellent rearing conditions for the trout. Other native species that reside in the Sacramento River upstream of Red Bluff include Sacramento pike minnow, Sacramento sucker, and hardhead minnow. White sturgeon and green sturgeon are native anadromous species that have been found at the RBDD. Green sturgeon has been proposed for Federal listing as endangered or threatened.

Vegetation

The Central Valley historically contained an estimated 1,400,000 acres of wetlands. Today, approximately 123,000 acres remain. Riparian and wetland habitats provide food and shelter to aquatic fauna, and attenuate high flows as well. The Sacramento River Valley contains a large diversity of both lowland and upland habitats and species. Along most of the Sacramento River and its tributaries, remnants of riparian communities are all that remain of once productive and extensive riparian areas. However, along the upper reaches of the Sacramento River, a higher percentage of the riparian vegetation is still intact. Vegetation in the river corridor varies from oak/gray pine and chaparral communities with very limited riparian vegetation above Redding to broad riparian ecosystems and agricultural lands from Redding to Red Bluff. Wetlands occupy many areas along Sacramento River waterways, but are not as extensive as the wetlands found in the Delta. However, grasslands and wooded upland communities are more abundant in this region. Agricultural lands also occupy a significant portion of the Sacramento River basin. Open-water areas occur mainly on the larger waterways, where waterways converge, and in reservoirs.

Shasta Lake and Vicinity

Shasta Lake is surrounded by mountainous terrain forested primarily by brushy, hardwood stands, chaparral, oak woodlands, mixed conifer forests and ponderosa pine-dominated conifer stands. Vegetation diversity tends to be high in the area, due largely to the favorable climate and varying geology. Elevation and sun exposure create variation in the forest stands around the lake. Vegetation in the Sacramento River watershed upstream from Shasta Lake can be separated into seven basic vegetation types: Douglas fir-mixed conifer forest, mixed conifer, Ponderosa pine, canyon oak woodland, black oak woodland, gray pine woodland, and chaparral. Elevation ranges for these vegetation types are between 1,065 feet (lake shore) and 5,100 feet (Schell Mountain). This elevation gradient travels through two transition zones: (1) valley (<1,500 feet) and lower montane (foothill) vegetation types and (2) lower montane (1,000 to 3,500 feet) and montane (>3,000 feet) vegetation types.

Lower elevation vegetation consists of a mix of chaparral and hardwoods; mid-elevation slopes are within a transitional zone that contains both the chaparral/hardwood mix and a mixed conifer component; and higher elevation sites are dominated by mixed conifer overstory with brush species in the understory primarily in open areas. An exception is in the riparian corridors where conifers can span from lower to upper elevations. Montane riparian vegetation is located in narrow belts along many of the tributaries.

Fire suppression activities during the 1900s have generally increased the amount of vegetation in the watersheds surrounding Shasta Lake, particularly understory brush and other forest floor vegetation. In general, increased vegetation in these areas contributes to lower rainfall runoff (more water retained in the soil) and slower erosion processes. Thick understory brush tends to burn hotter and wildfires become more devastating, with fewer trees and other large vegetation surviving. Wildfires in the area over the last century have resulted in significant loss of mature vegetation and slower forest recovery. Most of the recent logging in this area has occurred on private lands, with the exception of salvage logging on lands affected by forest fires.

Timber harvesting, water resource development, and environmental disasters also have affected riparian vegetation systems in this area. Riparian forests along the lower Sacramento, McCloud, and Pit rivers began diminishing as early as the mid-1800s when trees were harvested and floated downstream to support ore smelters. Water development and hydropower projects, including associated channelization, dam construction, and streamflow regulation, have also altered natural riparian systems and contributed to vegetation loss along major stream corridors. In particular, riparian vegetation succession has been significantly hampered on the lower Pit River due to water diversions and flow fluctuations. On the upper Sacramento River, vegetation along the river corridor was nearly completely destroyed in 1991 when a railroad car overturned and spilled a toxic herbicide into the river. The riparian vegetation has since recovered and associated aquatic and terrestrial wildlife are increasing in numbers. More recently, urbanization and recreation have contributed to the loss of riparian vegetation along the lower tributaries and shoreline of Shasta Lake.

Shoreline vegetation around Shasta Lake provides important cover for aquatic species and shade to maintain cooler water temperatures. Within the drawdown area of the lake, fluctuating water levels, wave action, and erosion have resulted in the loss of all but the heartiest vegetation. The lack of vegetation along the shoreline at certain reservoir levels negatively affects shallow aquatic habitat, which is the primary rearing habitat for juvenile fish in the lake.

Also of concern in the Shasta Lake area are non-native plant species, which were introduced to the region by early settlers. Some of the more invasive exotic species out-compete native vegetation and have required management actions within the subarea to prevent loss of habitat.

However, these management actions have been limited and confined primarily to areas adjacent to campgrounds and USFS facilities. Non-native species include yellow star thistle, Klamath weed (St. John's Wort), hedge parsley, several exotic grasses, and Himalayan blackberry.

Sacramento River

The type and diversity of vegetation from Shasta Dam to Red Bluff has changed significantly over the last 150 years. Primary factors influencing changes in vegetation and habitat are fire suppression and timber harvesting, land conversion, and invasive species. Fire suppression and timber harvesting methods through the mid-1900s created forests that were smaller, younger (less age diversity), and denser than those existing prior to settlement. This resulted in intense and devastating wildfires in the late 1900s, leading to modern fuel reduction and prescribed burn practices. Intensive grazing and conversion of habitat to agriculture also affected some areas, particularly lowland grasslands and riparian areas.

In the mid-1800s, settlers brought cattle and other grazers that imported nonnative grasses and other plants. Many exotic plants flourished and out-competed native vegetation. Today, numerous noxious and invasive plants are known to inhabit the area, including yellow star thistle, arundo (giant reed), pampas grass, cheat grass, hydrilla, Scotch broom, Himalayan blackberry, medusahead, tree of heaven, and edible fig. These nonnative species have significantly altered native habitats, particularly riparian and grassland communities, by changing vegetation density, water demand, and overall ecology.

Riparian Habitat – Vegetation in the river corridor varies from oak/gray pine and chaparral communities with very limited riparian vegetation above Redding to broad riparian ecosystems and agricultural lands from Redding to Red Bluff. Riparian vegetation along the Sacramento River corridor is in the valley foothill riparian association. This habitat has a canopy height of 100 feet with 20 to 80 percent closure. Plant species have specialized adaptations to life in an environment frequently disturbed by flooding and deposition. This vegetative complex provides necessary habitat for many species of native fish and wildlife. Primary native tree species within the riparian forests of the upper Sacramento River include Fremont cottonwood; white alder; California sycamore; black walnut; Oregon ash; red, black and yellow willow; and valley oak. Numerous native shrubs, vines, grasses and sedges are located within the understory of these trees and, in cases where tree cover is absent, provide the sole vegetative riparian cover.

While flooding of the lands adjacent to the river was an annual event lower in the Sacramento River system, the river above Red Bluff is more confined and entrenched. Consequently, riparian habitats are limited to areas immediately adjacent to the Sacramento River and along tributary streams. Historically, these small areas probably did not contain the breadth of habitat necessary to support the complex riparian ecosystem found in the gallery riparian forests south of Red Bluff. Riparian forest communities in the subarea include cottonwood, alder, ash, sycamore, walnut, willow, and valley oak.

Also, since the river immediately below Keswick is deeply incised in bedrock, riparian vegetation is very limited and no functioning riparian ecosystems occur. Near Redding, the river comes into the valley and the floodplain, which historically had wide expanses of riparian forests, broadens. However, the river's riparian zone from Balls Ferry to Keswick is subject to considerable urban encroachment.

A breakdown of riparian habitats within the 100-year floodplain between Keswick Dam and Red Bluff is shown in **Table III-7**. Non-native species, urban development, and water resources development have reduced and fragmented riparian communities, particularly along the Sacramento River, Battle Creek, and Cow Creek. Freshwater marsh, vernal pools, seeps, montane wet meadows, and other wetland communities are also highly fragmented and scattered throughout this area.

TABLE III-7
RIPARIAN AND RELATED HABITATS WITHIN THE 100-YEAR FLOODPLAIN ALONG THE SACRAMENTO RIVER BETWEEN KESWICK AND RED BLUFF

Vegetation Type	Acres	Percent of Land Surface Area
Riparian forests	2,801	15%
Riparian scrub	1,439	8%
Valley oak woodland	315	2%
Marsh	58	<1%
Blackberry scrub	61	<1%
Total Riparian Vegetation	**4,674**	**26%**

Wetland Habitat – While often combined with riparian ecosystems, wetlands within the study area are defined as shallow to moderately deep open water areas having a vegetative component of emergent and aquatic species (specifically cattails, rushes, and sedges). Wetlands are normally the result of annual flooding that breaches natural levees along the river, resulting in shallow pools of semipermanent water. Fairly significant wetland areas exist on tributaries to Shasta Lake and to a limited extent along the Sacramento River downstream to Red Bluff.

Upland Habitat – Upland habitats downstream from Shasta Dam include categories based on elevation and soil conditions, such as valley oak woodland adjacent to the river from Redding to Red Bluff, and blue oak/digger pine (foothill or grey pine) and montane hardwood/conifer associations from Shasta Dam downstream to Redding.

The valley oak woodland association varies from savannah-like to more dense forests with partial canopy-closure. Valley oak woodland is usually associated with conditions where trees can put roots into a permanent water supply, such as along drainages. These woodlands provide abundant food and cover for many species of wildlife.

The blue oak/foothill pine association is diverse structurally, both horizontally and vertically. The understory shrub layer is sparse and may be limited to annual grassland.

The montane hardwood/conifer association consists of Ponderosa pine, sugar pine, Douglas fir, white fir, incense cedar, black oak, Oregon white oak, and canyon live oak, with relatively little understory. Because of its variety of vegetation, and close proximity to other associations, this habitat type provides for a diverse fauna. These mixed conifer forests occur in the higher foothill and mountain elevations in the area, typically above 2,000 feet. Fire suppression has been the major factor affecting the health of mixed conifer habitat within the region, resulting in increasingly dense understory vegetation, including manzanita, poison oak, California redbud, and various non-native species.

Unlike the highly fragmented riparian communities, blue oak/digger pine and montane hardwood/conifer associations are found along nearly continuous elevation bands or belts, both to the east and west of the Sacramento River.

A limited amount of white fir and red fir true conifer forest exists in the mountains to the east of the Sacramento River, primarily above 5,000 feet.

Wildlife

The composition, abundance, and distribution of wildlife resources in the Sacramento Valley are directly related to available habitat. Wildlife resources in the primary study area include habitat conditions suitable for over 200 species of birds and 55 species of mammals, reptiles, and amphibians. Typical species include hummingbird, swallow, owl, ducks, ravens, geese, gray squirrel, black bear, deer, and elk. Lower elevation areas in the McCloud River, Sacramento River, Pit River, and Squaw Creek drainages are also winter ranges for deer. Elk winter range is located on the McCloud River and Pit River peninsulas. Overall, however, fewer wildlife species now inhabit the study area than before agricultural and residential development permanently removed much of the native and natural habitat. Many of the wildlife species are unable to adapt to other habitat types or altered habitat conditions and are, therefore, most susceptible to habitat loss and degradation. Species that depended on riparian woodland, oak woodland, marsh, and grassland habitats have declined.

A variety of wildlife is present in the areas surrounding Shasta Lake, including black-tailed deer, elk, black bear, lion, bobcat, gray squirrel, rabbit, and turkey. Avian species include quail, falcon, eagle, turkey, dove, pigeon, hawk, woodpecker, ash-throated flycatcher, Hutton’s and warbling vireos, and house sparrow. The area provides excellent habitat for deer and elk, and suitable habitat for numerous bat species, although there have been few confirmed bat sightings. Several other wildlife species inhabited this area prior to European settlement but were extirpated by over-hunting or because they were seen as threats, including grizzly bear, wolf, and various species of elk.

Shasta Lake is home to the largest concentration of nesting bald eagles in California. There are three bald eagle territories on the Sacramento River arm alone: Little Squaw, Bass Point, and Frost Gulch. Bald eagles also nest near Lake Britton and along the lower Pit River. The High Complex Fire of 1999, which killed numerous large pines, may have affected potential nesting and roosting areas around Shasta Lake.

Timber harvesting, fire suppression, recreation, and wildfires have affected the population and distribution of wildlife in this area. Fire suppression, which has generally increased understory vegetation, has had mixed effects on wildlife. Bear, deer, and birds that prefer near-ground vegetation for food and cover have generally benefited, while birds requiring aerial foraging, such as the golden eagle, peregrine falcon, and great-horned owl, have declined. Species that have adapted or thrived in the altered human environment include coyote, raccoons, and various late-successional species. Potential bat habitat, found primarily in the limestone formations to the north and east of Shasta Lake, has suffered from increased use by recreational rock climbers and spelunkers. Wildlife may also be impacted by a lack of contiguous travel corridors in certain portions of the area that prevent species from moving between remaining suitable habitat.

The diverse habitats present in the Shasta Dam to Red Bluff portion of the primary study area support a variety of wildlife. Existing native habitat, especially riparian corridors along the Sacramento River and associated sloughs and creeks, provides habitat for many native species. While riparian habitat is limited in this area, it supports the greatest abundance of wildlife, including a variety of avian species such as waterfowl and raptors; rodents such as skunk and opossum; frogs, toads, and other amphibians; bats; coyote and fox; garter snake and other reptiles. Riparian habitat provides shade, cover, and food supply to the immediate shoreline environment of large rivers, benefiting fish and wildlife species such as salmonids, native fish, river otter, beaver, heron, egret, and kingfisher.

Lower elevation grasslands and oak woodlands host a variety of seasonal game species and other wildlife, such as deer, jackrabbit, coyote, hawk and other raptors, gopher snake, pheasant, fox, raccoon, and quail. The grasslands and foothills also support vernal pools and other seasonal wetlands that provide unique habitat for waterfowl and various small aquatic organisms.

More arid chaparral habitat and scrub habitat support a variety of reptiles, weasel, wild pig, skunk, coyote, and larger mammals such as deer, bobcat, and mountain lion. Bird species that forage and nest in brush habitat within the area include wild turkey, pigeon, California thrasher, California towhee, and California quail.

Higher elevation forest habitats support woodpecker, marten, fishers, owls, eagle, forest-floor amphibians such as newt, a variety of reptiles, black bear, gray fox, mountain lion, deer, and feral pig. Due to a sharp decline in deer populations, deer herds are managed within portions of the area, including the Yolla Bolly Deer Herd in the Cottonwood Creek watershed and the Cow Creek Deer Herd.

Exotic wildlife species include the brown-headed cowbird, feral pig, wild turkey, pheasant, chukar, elk, and bullfrog. Some of these exotic species have been detrimental to native vegetation and wildlife, such as the cowbird (which parasitizes the nests of other birds) and feral pigs (which uproot native vegetation and the nests of ground-nesting birds).

Because animals are highly dependent on their choice habitats, changes in the quality and quantity of various habitat types have impacted area wildlife. The wildlife most affected in this area have been those associated with riparian and grassland habitats, which have been highly impacted by land use, water resources development, and land management practices. Wildlife populations are also influenced by the age and density of the vegetation within the various habitat types. The general trend toward more dense underbrush in foothill and mountain habitats, due to fire suppression, has favored species that rely on dense vegetation for cover or foraging while negatively impacting raptors and other wildlife that require open areas for foraging. Land conversion and the introduction of non-native species have had similar positive and negative effects on wildlife in riparian and grassland areas. Although mountainous terrain in this area tends to be less developed, timber harvesting and fire suppression have changed the suitability of some areas for various types of wildlife.

Special-Status Species

The Sacramento River basin is home to numerous special-status plants and animal species as described by Federal and State agencies: 65 special-status plant species, 9 special-status fish species, and 39 special-status wildlife species. Most of the plant species live in grasslands, including vernal pools. The next greatest number of special-status species inhabits chaparral and montane hardwood areas. Most of the special-status fish and wildlife species inhabit grasslands, freshwater emergent wetlands, lakes, and rivers on the valley floor.

Plants

Plants considered by the State and/or USFS to require special attention are designated as "sensitive." Plants potentially within the study area under this designation are shown in **Table III-8**. No known populations of listed plants occur in the study area.

TABLE III-8
POTENTIAL HABITAT FOR SPECIAL-STATUS PLANTS
IN THE SHASTA LAKE WATERSHED

Species	Status	Habitat	Nearest Population to Watershed
Arnica venosa Veiny arnica	Endemic	Hot dry slopes under pine, black oak, and Douglas fir; usually on north-facing aspects or ridgetops. Elevation 1,500-5,000.	Two populations occur in the primary study area.
Cypripedium faciculatum Clustered lady's slipper	Sensitive	Mixed conifer or oak forests on a variety of soil types, often but not always associated with streams; widespread but sporadic. Elevation 1,300-6,000.	No known populations on the Shasta side of the forest. Several populations occur on the Trinity side of the forest.
Cypripedium montanum Mountain lady's slipper	Sensitive	Mixed conifer or oak forests on a variety of soil types, often but not always associated with streams; widespread but sporadic. Elevation 1,300-6,000.	One known population occurs along the Soda Creek Road approximately 18 miles northeast of the watershed.
Lewisia cantelovii Cantelow's lewisia	Sensitive	Moist rock outcrops in broad-leaf and conifer forests. Elevation 500 to 3,000.	Two known populations occur near Lamoine, approximately 2 miles north of the watershed.
Neviusia cliftonii Shasta snow-wreath	Sensitive	North facing slopes on limestone-derived soils, within riparian zones. Elevation 2,400 to 3,000.	One known population, three miles east in Waters Gulch; potential habitat in limestone outcrops on Big Backbone Creek and Little Backbone Creek.

Source: Shasta Lake West Watershed Analysis. USFS, 2001.

Fish and Wildlife

Within the primary study area, there is potential for occupancy by 12 species listed as threatened or endangered under the Federal ESA and/or the California Endangered Species Act (CESA). These species (see **Table III-9**) are provided protection by one or both of these acts and any actions resulting in take must be permitted by USFWS and CDFG. In addition, the study area has the potential to host species of special concern, also shown in **Table III-9**. Species of special concern, while not offered protection under the endangered species acts, require analysis and mitigation under the California Environmental Quality Act (CEQA).

TABLE III-9
ENDANGERED, THREATENED, AND SPECIAL-STATUS FISH AND WILDLIFE POTENTIALLY INHABITING THE SHASTA LAKE WATERSHED

Species	Status	Habitat
Federal and State Threatened and Endangered Species		
Bald eagle	FT, SE	Riparian zones along larger rivers and open water areas w/large trees for nesting and roosting
Bank swallow	ST	Steep river banks and banks near water sources
Bull trout	SE, FT	McCloud River
California red-legged frog	FT	Still or slow-moving water w/shrubby riparian vegetation. Extinct in study area.
Chinook salmon (spring-run)	FT, ST	Sacramento River and tributaries
Chinook salmon (winter-run)	FE, SE	Sacramento River and tributaries
Peregrine falcon	SE	Riparian zones for wintering habitat
Shasta salamander	ST	McCloud River, Pit River, and Squaw Creek in moist limestone fissures and caves
Steelhead	FT	Sacramento River and tributaries
Swainson's hawk	ST	Riparian areas w/ large trees for nesting; adjacent open lands for foraging
Valley elderberry longhorn beetle	FE	Riparian; requires mature elderberry bushes
Yellow-billed cuckoo	SE	Riparian forests greater than 50 acres
Species of Special Concern		
Black tern	SC	Marsh lands w/permanent open water
Burrowing owl	SC	Grasslands
California gull	SC	Wintering populations only; riverine and wetlands
California horned lark	SC	Grasslands
California tiger salamander	SC	Wetland and vernal pools and adjacent uplands
Chinook salmon (fall/late-fall-run)	SC	Sacramento River and tributaries
Cooper's hawk	SC	Riparian zones
Ferruginous hawk	SC	Wintering populations only; grasslands
Foothill yellow-legged frog	SC	Shallow river and streams with gravel bottoms
Hardhead minnow	SC	Shasta Reservoir and tributaries
Tri-colored blackbird	SC	Marsh
Loggerhead shrike	SC	Oak woodland
Long-billed curlew	SC	Grasslands and irrigated pastures
Long-eared owl	SC	Riparian habitat w/dense canopies
Merlin	SC	Riparian zones for wintering habitat
Purple marten	SC	Riparian forests
Sharp-shinned hawk	SC	Riparian zones
Short-eared owl	SC	Open areas, grasslands, irrigated pasture
Osprey	SC	Riparian zones along larger rivers and open water areas w/large trees for nesting and roosting
Vaux's swift	SC	Coniferous (Douglas fir) habitats; snags
Western least bittern	SC	Marshy areas with emergent vegetative cover
Western pond turtle	SC	Moderate to deep slow-moving rivers, ponds, and streams having deep pools.
Western spadefoot toad	SC	Vernal pools and ponds
White-faced ibis	SC	Irrigated pastures, shallow marsh
Yellow-breasted chat	SC	Riparian scrub
Yellow warbler	SC	Riparian scrub/forests

Key:
FE – Federally listed as endangered FT – Federally listed as threatened
SC – Regarded by USFWS and/or CDFG as a species of special concern
SE – State-listed as endangered ST – State-listed as threatened

Survey and Manage Species

Portions of the study area, primarily around Shasta Lake, lie within federal lands managed by BLM and the USFS STNF. The Northwest Forest Plan identifies species that are rare or sensitive and require special management and/or mitigation actions. USFS Sensitive and Northwest Forest Plan Survey and Manage species potentially located within the study area are shown in **Tables III-10** and **III-11**.

TABLE III-10
USFS SENSITIVE AND SURVEY AND MANAGE FLORAL SPECIES POTENTIALLY OCCURRING IN THE SHASTA LAKE WATERSHED

Species	Status	Habitat
Ageratina shastensis Shasta ageratina	USFS Endemic	Limestone outcrops
Bondarzewia montana Bondarzewia fungus	S&M	Mixed conifer and conifer/woodland habitats
Botrychium inc. *B. crenulatum* Moonwort, grape-fern	USFS Sensitive	Mixed conifer and conifer/hardwood habitats
Botrychium minganese Moonwort	S&M	Mixed conifer and conifer/woodland habitats
Botrychium montanum Moonwort	S&M	Mixed conifer and conifer/woodland habitats
Buxbaumia viridis Bryophyte	S&M	Mixed conifer and conifer/woodland habitats
Cypripedium fasciculatum Clustered lady's slipper	S&M	Lower montane coniferous forest
Cypripedium montanum Mountain lady's slipper	S&M	Cismontane woodland and lower montane coniferous forest habitats
Lewisia cantelovii Cantelow's lewisia	USFS Sensitive	Chaparral, cismontane woodland, and lower montane coniferous forest habitats
Neviusia cliftonii Shasta snow-wreath	USFS Sensitive	Cismontane woodland, lower montane coniferous forest, and riparian woodland habitats
Otidea leporina Otidea fungus	S&M	Mixed conifer and conifer/woodland habitats
Polyozellus mulitplex Blue chantrelle	S&M	Mixed conifer and conifer/woodland habitats
Ptilidium californicum Pacific fuzzwort	S&M	Mixed conifer and conifer/woodland habitats
Schistostega pennata Bug on a stick	S&M	Mixed conifer and conifer/woodland habitats
Smilax jamesii English Peak greenbriar	USFS Sensitive	Lower montane coniferous forest, marshes, and swamp habitats
(Aleuria) Snowerbyella rhenana Orange peel fungus	S&M	Mixed conifer and conifer/woodland habitats

Key:
S&M – Survey and Manage Species considered rare or threatened per the Northwest Forest Plan, 2002.
USFS Endemic – Species considered sensitive by the USFS that are endemic to habitat found in specific regions or National Forests.
USFS Sensitive – Species considered sensitive by United States Forest Service (USFS).

TABLE III-11
USFS SENSITIVE AND SURVEY AND MANAGE FAUNAL SPECIES POTENTIALLY OCCURRING IN THE SHASTA LAKE WATERSHED

Species	Status	Habitat
Hydromantes shastae Shasta salamander	S&M	Mixed conifer, woodland, and chaparral habitats, especially limestone outcroppings
Rana boylii Foothill yellow-legged frog	USFS Sensitive	Stream habitats
Clemmys marmorata Northwestern pond turtle	USFS Sensitive	Stream or wetland habitats
Naccipiter gentilis Northern goshawk	USFS Sensitive	Mixed conifer forests
Falco peregrinus Peregrine falcon	USFS Sensitive	Mixed conifer and conifer/woodland habitats
Plecotus townsendii Townsend's big-eared bat	USFS Sensitive	Mixed conifer and conifer/woodland habitats
Antrozous pallidus Pallid bat	USFS Sensitive	Mixed conifer and conifer/woodland habitats
Monadeia troglodytes troglodytes Shasta sideband	S&M	Terrestrial mollusk inhabiting mixed conifer and woodland habitats, especially with limestone outcroppings
Monadenia troglodytes wintu Wintu sideband	S&M	Terrestrial mollusk inhabiting mixed conifer and woodland habitats, especially with limestone outcroppings
Trilobopsis roperi Shasta chaparral	S&M	Terrestrial mollusk inhabiting mixed conifer and conifer/woodland habitats
Vespericola shasta Shasta herperian	S&M	Terrestrial mollusk inhabiting mixed conifer and conifer woodland habitats
Fluminicola seminalis Nugget pebblesnail	S&M	Aquatic mollusk inhabiting mixed conifer and conifer/woodland habitats
Fluminicola sp. 14 Potem pebblesnail	S&M	Aquatic mollusk inhabiting mixed conifer and conifer/woodland habitats
Fluminicola sp. 15 Flat-top pebblesnail	S&M	Aquatic mollusk inhabiting mixed conifer and conifer/woodland habitats
Fluminicola sp. 16 Shasta pebblesnail	S&M	Aquatic mollusk inhabiting mixed conifer and conifer/woodland habitats
Fluminicola sp. 17 Disjunct pebblesnail	S&M	Aquatic mollusk inhabiting mixed conifer and conifer/woodland habitats
Fluminicola sp. 18 Globular pebblesnail	S&M	Aquatic mollusk inhabiting mixed conifer and conifer/woodland habitats
Juga (Orebasis) sp. 3 Cinnamon juga	S&M	Aquatic mollusk inhabiting mixed conifer and conifer/woodland habitats
Lyogyrus sp. 3 Canary duskysnail	S&M	Aquatic mollusk inhabiting mixed conifer and conifer/woodland habitats
Vorticifex sp. 1 Knobby rams-horn	S&M	Aquatic mollusk inhabiting mixed conifer and conifer/woodland habitats

Key:
S&M – Survey and Manage Species considered rare or threatened per the Northwest Forest Plan, 2002.
USFS Sensitive – Species considered sensitive by United States Forest Service.

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Wild and Scenic Rivers

In the Shasta Dam area, the free-flowing stretches of the McCloud River are protected under the California Wild and Scenic River Act of 2002 (Public Resources Code Section 5093.50). Under the act, the State legislature found that "maintaining the McCloud River in its free-flowing condition to protect its fishery is the highest and most beneficial use of water." The act restricts construction of dams, reservoirs, diversions, or other water impoundment facilities on the McCloud River from the location of the present confluence of the McCloud River with Shasta Reservoir (McCloud Bridge). With the exception of participation by DWR in studies involving the feasibility of enlarging Shasta Dam, the act prohibits any State department or agency from assisting or cooperating with any agency of the Federal, State, or local governments in planning or constructing any facility that could have an adverse effect on the free-flowing condition of the McCloud River or on its wild trout fishery.

Social and Economic Resources

Existing social and economic resources described in this section include population, land use, employment and business/industrial activities, local government and finance, public health and safety, traffic and transportation, recreation and public access, utilities and public services, water supply, power and energy, hazardous materials and waste, fire hazards, natural resources, and aesthetics.

Population

The number of persons living in California as of 2000 totaled an estimated 35 million. Approximately 2.7 million and 1.9 million of this population resided in the Sacramento and San Joaquin River basins portion of the Central Valley, respectively. The population in the primary study area in Shasta and Tehama counties totaled over 230,000. About three-fourths of the population in the Sacramento River Basin resides in or near the City of Sacramento. In California, population growth during the 1990-2000 decade totaled approximately 4.6 million persons, or a growth rate of about 15 percent. The growth rate in the Sacramento and San Joaquin River basins was significantly greater, at over 20 and 30 percent for the same period, respectively.

Population growth in the Central Valley and throughout the State has created demands for land and water resources for residential, commercial, and infrastructure uses. As population has increased, urbanization has caused substantial amounts of land to be converted from agriculture, wetland, open space, and other land use categories to roads, parks, housing, retail stores, office space, and other urban uses. Population increases also have included increased demand for a more dependable water supply.

Land Use

Land uses in the Sacramento River Valley are principally agricultural and open space, with urban development focused in the Sacramento metropolitan area. Urban development has occurred along major highway corridors, primarily in Sacramento, Placer, El Dorado, Yolo, Solano, and Sutter counties, and has caused some agricultural land to be taken out of production. Soil conditions in the basin allow a wide variation in crop mix.

The primary private land use in the region is agriculture. As of 1997, California's 74,126 farms included a total of 27.7 million acres. Of that, the Sacramento River Valley area had over 11,000 farms with about 4.3 million acres. Shasta County's 850 farms encompassed a total of almost 317,000 acres. The region has extensive tracts of Federal and State land, including portions of the Shasta-Trinity, Lassen, Plumas, and Mendocino national forests plus several Federally or State-owned wildlife management areas.

Employment and Business/Industrial Activities

It is estimated that in August 2002, California's civilian labor force totaled 17.5 million. During 2001, approximately 1.2 million persons, or half of the people in the Sacramento River Valley area, were in the civilian labor force. The area's rate of unemployment ranged from 4.1 percent in Solano County to 17.6 percent in Colusa County. For 2001, Shasta County had a labor force that averaged 76,487, of whom 71,332 were employed and 5,155 unemployed (this represents an unemployment rate of 6.7 percent).

The State's economy is based on the manufacture of computers and electronic products, transportation equipment (particularly aerospace products), fabricated metal products and machinery, food processing, business services, and farming. The economy of the central and northern counties in the Central Valley is based on lumbering, the manufacture of wood products, farming, and food processing. In 2000, manufacturing establishments employed 74,046 workers in the Central Valley. Shasta County manufacturers accounted for 5,039 of these jobs or 6.8 percent for the area. The manufacturing sector in the Central Valley had sales totaling almost $17.0 billion, and Shasta County's manufacturing establishments earned $635 million.

Shasta County's economy has expanded as the result of the provision of new health service facilities, shopping centers, and recreational services for nonresidents of that county. Tourism, recreation, and related hospitality industries are a major source of economic development in the primary study area. In 1998, travel-related spending alone exceeded $360 million in Shasta County, generating over 4,600 jobs. Shasta Lake and the Sacramento River play a central role in the tourism industry and the appeal of the region to prospective businesses and investors.

Local Government and Finance

Local government services in California are provided by counties, school districts, fire districts, water districts, and other special districts. Based on 1997 census data, it is estimated that local governmental units operating within the 10-county Sacramento River Valley area had combined revenues totaling almost $8.8 billion or about $3,950 per regional resident. Shasta County's governmental units had combined revenue of about $644 million or $3,983 per resident. Forty-one percent of the combined revenue of all the local governmental units operating within the Sacramento River valley area was derived from the transfer of State governmental revenue and about nineteen percent from local taxes.

Public Health and Safety

Data from the 1997 census indicate that local governmental units operating within the region employed about 4,200 full-time workers and spent about $310 million, or $139 per regional resident, to provide health and hospital services. Local governmental units in Shasta County spent about $36 million, or $223 per county resident, on providing public health services. Shasta and Tehama counties are the only jurisdictions in the Sacramento River Valley area in which hospital care is provided by local government.

State police, county sheriffs, fire districts, and county-run detention facilities provide public safety in California's rural areas and smaller incorporated places. Larger cities in the State almost always provide police and fire services within their jurisdictions. In 1997, local governments within the Sacramento Valley employed about 7,500 workers to provide police and fire protection. This number included about 5,000 workers for police protection and about 2,400 for fire protection. Shasta County's local governments employed a total of 467 workers to provide public safety, including 364 for police protection and 103 for fire protection. Annual expenditures for public safety in the Sacramento River Valley area totaled $732 million or $329 per regional resident. The provision of public safety in Shasta County cost $48 million or $297 per county resident.

Traffic and Transportation

Major transportation routes in the study area include I-5, which traverses the valley from north to south; State Route 299, an east-west route, which traverses Trinity, Shasta, Lassen, and Modoc counties in the northern watershed areas; and State Route 99 and State Route 70, portions of which are expressway, and run north-south from Sacramento northward toward Chico. The upper watershed areas west and east of the Sacramento Valley contain a network of State highways. Major routes on the west side of the valley include State Route 29, which runs north-south through Napa and Lake counties, and several east-west freeways, including State Route 20 in Lake County, State Route 162 in Glenn County, and State Route 36 in Tehama and Trinity counties. Excluding Chico, traffic within the central and northern portions of the Central Valley usually is moderate to light. During weekends and holidays from May 1 through Labor Day, however, heavy traffic in the Redding-Shasta Lake area is not unusual.

Recreation and Public Access

Major recreation areas in the Sacramento River Basin include lakes and reservoirs, rivers and streams, Federal wildlife refuges, and State wildlife management areas. Private lands also support considerable waterfowl hunting activity in the region. Shasta Lake, Whiskeytown Lake, Lake Oroville, Folsom Lake, New Bullards Bar Reservoir, and Englebright Lake provide extensive reservoir recreation opportunities, including flat-water recreation.

Information from the 1997 census indicates the importance of outdoor recreation in Shasta County. The county's accommodation and food services establishments had sales totaling $162 million, or almost $1,000 per county resident. This per capita amount is the highest of all the counties in the Sacramento River basin. Outdoor recreation and tourism in Shasta County is the result of Shasta Lake. USFS personnel in Redding report that the lake has attracted the development of 11 marinas with 1,075 houseboats, including 625 that are privately owned and 450 that are owned by a marina and rented on a weekly or weekend basis, and 18 developed public campgrounds with a total of 246 sites. In addition, several of the lake's marinas have developed rental campsites and numerous cabins on land leased from USFS. Access to most of the campgrounds, day-use areas, and marina/resorts around Lake Shasta is provided by I-5 and secondary roads maintained by USFS or Shasta County.

Utilities and Public Services

Various departments within the cities and counties of the Sacramento River Valley provide fire protection, police protection, and emergency services to members of their communities. A vast network of utility generation/transmission systems and service providers exists across all regions of the study area, supplying urban and rural areas with power, water, and emergency services. Other significant infrastructure consists of hydroelectric and natural gas-fired generating facilities, transmission lines, substations, distribution lines, fiber optic and cable lines, and communication towers. Pipelines, storage areas, and compressor stations also are located in the Sacramento Valley.

Water Supply

On the basis of information contained in the 1998 DWR California Water Plan (Bulletin 160-98), it is estimated that water demands (applied water) in the State in 2000 for urban, agricultural, and environmental purposes under average and drought year conditions amounted to about 79.7 and 65 MAF, respectively (see **Table III-12**). To address this demand, available statewide supplies from surface water, groundwater, and recycled and desalted sources also under average and drought year conditions amounted to about 78 and 60 MAF, respectively. During average years, about 83 percent of the available supplies come from surface water sources and 16 percent from groundwater. In dry years, water from surface water sources declines to about 73 percent of the available supplies and nearly all of the remainder (about 26 percent) comes from groundwater.

Similar conditions existed in the Central Valley. As can be seen in **Table III-12**, estimated 2000 water use (demands) during average and drought years in the Sacramento River and San Joaquin River basins were about 26 and 24 MAF, respectively. The total estimated water supply for average and drought year conditions was about 25 and 22 MAF, respectively. The estimated net water demands (or shortages) for drought year conditions amounted to about 1.7 MAF.

The largest water supply provider in the Central Valley is the CVP. The total annual contract water amount in the CVP is about 8.3 MAF. However, the project can only deliver portions of this amount depending on various conditions. As presented in Bulletin 160-98, the CVP has a 7 MAF delivery capability under average year conditions. Of this 7 MAF, 3 MAF are in the Northern (Sacramento) CVP System, 2.7 MAF in the Southern (San Joaquin) CVP System, and 1.3 MAF in the Eastside and Friant divisions. On the basis of more recent system modeling runs, however, it is estimated that system delivery capability under average year conditions, based on 2000 demands, is about 10 percent less, at an estimated 6.3 MAF. In addition, **Figure III-6** shows the expected frequency of the Northern and Southern CVP systems meeting estimated annual deliveries under current conditions. As can be seen, it is estimated that in about 80 percent of the years, the system can deliver at least 4.5 MAF and in 20 percent of the years at least 5.8 MAF. The median annual delivery (50 percent exceedance) is about 5.5 MAF. Accordingly, it is highly likely that the potential shortages in **Table III-12** are significantly underestimated.

TABLE III-12
ESTIMATED WATER DEMANDS, SUPPLIES, AND SHORTAGES FOR 1995

Item	Hydrologic Basin: Sacramento River		San Joaquin River		Two-Basin Total		State of California	
	Average Year	Drought Year	Average Year	Drought Year	Average Year	Drought Year	Average Year	Drought Year
Population	2.7		1.9		4.5		34.9	
Urban Use Rate (GPCPD)	282	306	309	314	293	309	241	247
Acres in Production (mil)	2.1		2		4.1		9.5	
Agricultural Use (AFPA)	3.8	4.2	3.5	3.6	3.6	3.9	3.5	3.6
Applied Water (MAF)								
Urban	.8	.9	.7	.7	1.5	1.6	9.4	9.7
Agricultural	8.0	9.0	6.9	7.1	15.0	16.1	33.3	34.1
Environmental	5.8	4.2	3.4	1.9	9.2	6.1	36.9	21.2
Total	***14.7***	***14.1***	***11.0***	***9.7***	***25.7***	***23.8***	***79.7***	***65.0***
Water Supply (MAF)								
Surface Water	11.9	10.0	8.5	6.0	20.5	16.1	65.1	43.5
Groundwater	2.7	3.2	2.2	2.9	4.9	6.1	12.5	15.8
Recycled/Desalted	0	0	0	0	0	0	.3	.3
Total	***14.6***	***13.3***	***10.8***	***8.9***	***25.4***	***22.2***	***77.9***	***59.7***
Shortage (MAF)	**.1**	**.9**	**.2**	**.8**	**.3**	**1.7**	**1.8**	**5.4**

Key:
AFPA – acre-feet per acre
GPCPD – gallons per capita per day
MAF – million acre-feet
mil – million

Source: California Water Plan, Bulletin 160-98, Appendix 6A, Regional Water Budgets with Existing Facilities and Programs, November 1998.

When deficiencies in the ability of the system to deliver full entitlements occur, as indicated in **Table III-12** and **Figure III-6**, deliveries are reduced by varying percentages based on demand type (e.g., refuges, settlement contracts, and CVP contracts). Priority deliveries include water for wildlife refuges north and south of the Delta and water required by CVP Exchange and Settlement Contractors. Discretionary deliveries, which can be shorted significantly depending on the type of water year, include agricultural and M&I CVP contractors both north and south of the Delta.

Power/Energy

Major energy generators in the study area include the SWP, CVP, and private suppliers. The primary purpose of SWP power generation facilities is to meet energy requirements for SWP pumping plants. To the extent possible, SWP pumping is scheduled during off-peak periods, and energy generation is scheduled during on-peak periods. Although the SWP uses more energy than it generates from its hydroelectric facilities, DWR has exchange agreements with other utility companies and has developed other power resources. When available, surplus power is sold by DWR to minimize the net cost of pumping energy.

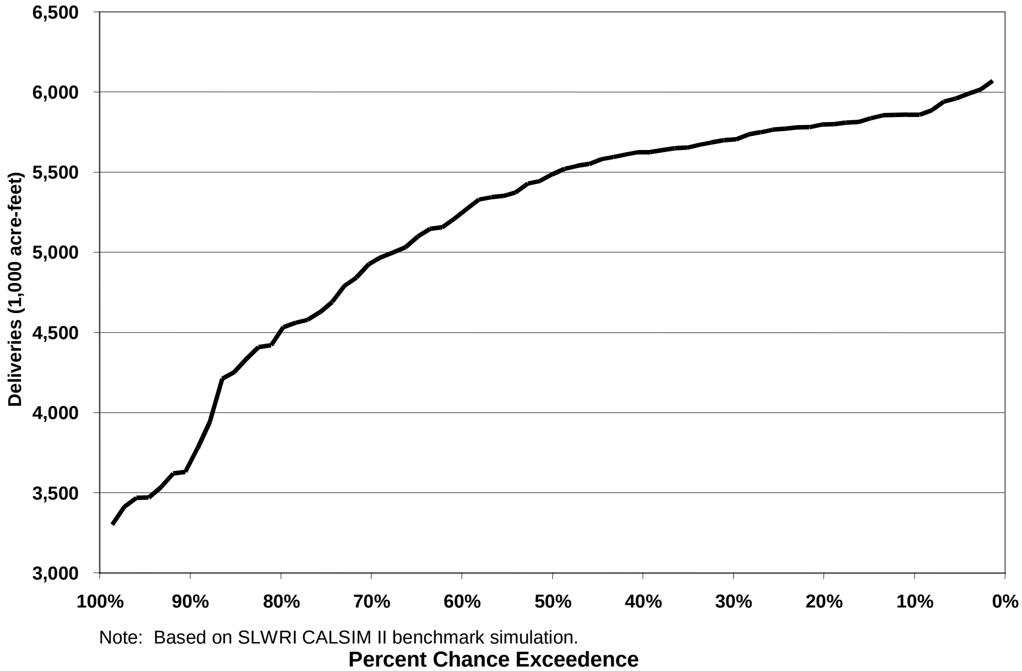

Figure III-6 – Estimated frequency (percent exceedence) of total CVP deliveries in the Northern and Southern CVP systems (excluding Madera and Friant-Kern systems) with 2000 level demands and D-1485 requirements.

CVP power generation facilities initially also were developed based on the premise that power could be generated to meet project use loads. The Reclamation Act of 1939 provided for surplus power to be sold first to preferred customers, including irrigation and reclamation districts, cooperatives, public utility districts, municipalities, and large educational or government facilities. Surplus commercial power may be sold to nonpreferred utility companies.

The California Independent Systems Operator (ISO) synchronizes all major electrical loads and generators within State boundaries to operate as a single cohesive system. In addition to the California ISO, a much broader system of electric generation and transmission exists with the CVP and SWP interact called the Western Systems Coordinating Council (WSCC). These interactions with the WSCC could extend over the entire West Coast and inland to the desert regions of the Southwest.

Other major hydroelectric facilities present in the study area are investor-owned utility companies, such as PG&E and Southern California Edison (SCE); owned by municipal agencies, such as the Sacramento Municipal Utility District (SMUD); and owned by several water and irrigation districts. Some of the larger facilities outside the CVP and SWP systems in the Sacramento Valley area include PG&E’s Pit System (317 megawatt (MW)) and McCloud-Pit System (340 MW) in Shasta County, PG&E’s Upper North Fork Feather River System (340 MW) in Plumas County, SMUD’s Upper American River Project System (640 MW) in El Dorado County, and Yuba County Water Agency’s Yuba River Project (300 MW) in Yuba County.

Hazardous Materials and Waste

Types of hazardous waste sites in the Sacramento River basin include contaminated agricultural ponds; hazardous materials spills; and leaking tanks or pipelines from industrial sites, railroad operations, commercial sites, and mining. Metals such as cadmium, copper, mercury, and zinc are present in inactive and abandoned mines in the Sacramento River drainage. Inactive underground mines and surface waste piles at Iron Mountain, California, in the Clear Creek watershed, have extremely acidic drainage with high concentrations of toxic discharges and metals.

Fire Hazard

Fire suppression policies and large-scale grazing have caused the rate of material decomposition to decline dramatically, and have led to fuel accumulation throughout most of the wild lands of the Sacramento River basin. Fire suppression efforts also have reduced the frequency of wildfires and greatly reduced land areas impacted by fires.

Natural Resources

The State's scenic beaches and mountains, mild climate, extensive rivers with cold water fisheries, fertile soil, and forested areas have been a major factor behind the in-migration of persons from other areas. The soil and climate of the Central Valley have brought about its development as a major agricultural area specializing in fruits, vegetables, rice, and other farm products. Farm production, in turn, has stimulated development of food processing establishments and businesses that provide services for area farms. Similarly, extensive timber resources have been the catalyst behind the growth of the Central Valley's lumber and wood products manufacturing. Development of Shasta Lake has resulted in Shasta County becoming a major outdoor recreational area that attracts significant numbers of recreationalists who reside outside Shasta County.

Aesthetics

Visual resources in the Sacramento River valley are characterized by agricultural uses in the valley, grasslands, and woodlands in the foothills, and forests in the upper watersheds. The Sacramento Valley's upper watershed has retained its oak woodland, grasslands, forests, and small rural communities despite substantial development along Federal and State highways in the foothills and mountain areas. These areas are framed by the forested ridgelines of the Sierra Nevada to the east, the Cascade Range to the north, and the Coast Ranges to the west. Little urbanization in these areas has preserved pristine wildernesses, mountains, and other dramatic landscapes.

Shasta Lake adds visual variety to this region. Viewer sensitivity is high in this area because of high recreation use and easy public access. A scenic highway is a road designated by the State or local agencies as having exceptional scenic qualities or affording panoramic vistas. Highway 151 (from Shasta Dam to near Summit City) is officially designated a State scenic highway.

Cultural Environment

The cultural environment elements described in this section include paleontology, archaeology, history, and ethnography.

Paleontology

California is geologically diverse, with metamorphic and intrusive and extrusive igneous rock formations, and a wide range of fossil-bearing sedimentary rock formations. Within the Shasta Lake area, metasedimentary and metavolcanic formations and more recent volcanic deposits occur. Sedimentary deposits are prominent in the area. The Triassic Hoselkus Limestone contains marine invertebrates such as ammonites, and marine vertebrate remains, including icthyosaurs and thallatosaurs. Solution caves in the Permian McCloud Limestone contain a significant Pleistocene fauna, including remains of horses, bison, giant bears, dire wolves, ground sloths, and mammoths.

Archaeology

California is rich in both prehistoric and historic archaeological remains. The Central Valley is an especially productive region for archaeological remains, with many deeply stratified sites that have produced information of crucial importance in understanding the prehistory of the state. The Shasta Lake area was little known until quite recently, and into the 1950s, it was believed that the area was unoccupied prior to A.D. 900, after which the Shasta area was occupied primarily by ancestors of the Wintu people. Subsequent investigations have revealed repeated occupation of the area as early as 8,000 years ago. Archaeological remains have been found that also represent ancestors of the Yana people. Historic archaeological sites represent remains from various historic era activities in the Shasta Lake region, especially relating to fur trapping, mining, early settlement, and agriculture (farming and ranching).

The Shasta Reservoir area has been surveyed for archaeological remains on numerous occasions. Thirty-seven sites were recorded in the 1940s prior to construction of Shasta Dam, but it is doubtful that this constituted an intensive survey by contemporary standards. During a drought in 1976-1977, USFS revisited previously recorded sites, and surveyed areas usually inundated, but again it is unclear whether this was a complete survey. Areas above gross pool apparently have been surveyed haphazardly and surveys are highly incomplete.

From available information, it is estimated that there are at least 118 archaeological sites believed to be inundated by Shasta Reservoir at gross pool elevation (1,076 feet). Of these, an estimated 76 sites are below gross pool but above the minimum pool elevation (840 feet). Of the 118 sites, the great majority (101) are prehistoric sites. Also, 7 historic sites and 10 multi-component (prehistoric/historic) sites are present. Around the reservoir, to elevation 1,276, are an additional estimated 55 archaeological sites. Of these, 50 are prehistoric sites, 4 historic are sites, and 1 is a multicomponent site.

History

Northern portions of the Central Valley are largely unmentioned in records of the Spanish and Mexican-era activities that occurred in the more southerly coastal portions of the state. The earliest historic records pertaining to the Shasta Lake area are from Hudson's Bay Company fur trappers. Malaria, introduced by fur trappers in the area, had devastating effects on aboriginal populations. Gold, copper, and iron mining were important activities in the Shasta Lake area during the latter half of the nineteenth century, and later activities included settlement by farmers and ranchers. Most known historic archaeological sites are related to mining, transportation, commerce, and recreation.

Historic sites include historic buildings and lodges and historic hiking and fishing trails. On the McCloud River, a private fly-fishing club has been in operation since 1904; its lodges date from the 1860s. Some lodges are likely eligible for inclusion in the registers of national and State historic structures.

Ethnography

California is home to many linguistically and culturally diverse Native American groups. Within the Shasta Lake area, archaeological and ethnographic sites include Indian villages, locations where ceremonies were held, burial grounds, and a number of other types of sites. Large portions of the Sacramento River, McCloud River, and Squaw Creek watersheds were known to have populations of the Wintu Tribe. Sites are known to occur on lands adjacent to Shasta Lake. The Wintu Tribe is a group whose language belongs to the Penutian family. These people are believed to have arrived in California around 1,000 B.C. The Wintu lived primarily in large villages along the rivers in their territory; they fished for chinook salmon in the McCloud and Sacramento rivers, and hunted deer and other animals. They also ate large quantities of acorns and other vegetable foods. Several local groups lived within the Shasta Lake area, including the Nomtipom, the Winnemem, and the Waimuk.

The Okwanuchu were a group, related to the Hokan-speaking Shasta people of southern Oregon, that lived in the McCloud River drainage Another distinct group was the Madesi band of Achumawi, farther east along the Pit River. In addition, the Central Yana people held territory in the Cow Creek drainage.

Numerous sacred sites are located immediately above the existing gross pool of Shasta Reservoir. These include burials and cemeteries, places of spiritual power, named villages, and other sites of special concern. The California Native American Heritage Commission identified a number of locations of particular concern.

FUTURE WITHOUT-PROJECT BASELINES

Identification of the magnitude of potential water resources and related problems and needs in the study area is not only based on the existing conditions described in this chapter, but also on an estimate of how these conditions may change in the future. Two baselines were identified to help define the extent of potential resources problems/needs and for use in identifying the relative effectiveness of alternative plans to be formulated to address these problems/needs:

- **California Environmental Quality Act Baseline** – This baseline is important for developing the EIR to meet requirements of CEQA. Under this baseline, future conditions are assumed to be equal to existing conditions.

- **National Environmental Policy Act (NEPA) Baseline –** Under this without-project future condition, only actions reasonably expected to occur in the future would be included. This would include projects and actions that are currently authorized, funded, permitted, and/or highly likely to be implemented. The NEPA Baseline is important for developing the EIS to meet the requirements of NEPA. The NEPA Baseline includes the CEQA Baseline for existing conditions.

Predicting future changes to the physical, biological, social, and economic environments in the study area, without a potential action to resolve the problems and identified needs in the study, is complicated by ongoing programs and projects primarily related to CALFED and the CVPIA. Accordingly, although not authorized or under construction, ongoing ecosystem restoration efforts are likely to be implemented through various small projects. Collectively these efforts would improve the quantity and value of freshwater emergent marsh, scrub-shrub, riparian, oak woodland, annual grasslands, agricultural habitat, wildlife, fishery and aquatic resources, and special-status species. Much of this improvement would be based on separate opportunities that are not integrated in a single plan.

Several significant projects that are expected to be implemented in the future in and near the primary study area, and to be included in the NEPA Baseline (for consideration in both conditions with or without a modification of Shasta Lake) include the following:

- **Sacramento River National Wildlife Refuge –** This is a land acquisition and habitat restoration program along the Sacramento River between Colusa and Ord Bend.
- **Folsom Modifications –** Modifications consist of enlarging existing outlets and constructing new low-level outlets to increase releases during lower pool stages, and revising the surcharge storage space in the reservoir.
- **Environmental Water Account –**EWA is a cooperative short-term management program to provide protection to fish of the Bay-Delta estuary through changes in SWP/CVP operations with no uncompensated water costs to project water users. The program appears to be very successful and it is believed that in some form of will continue into the long-term future.
- **Water Use Efficiency –** CALFED seeks to accelerate implementation of cost-effective actions of its water use efficiency (WUE) program to conserve and recycle water throughout the State. As with EWA, it is believed that some form of this program will develop and continue into the long-term future.
- **South Delta Improvements –**DWR and Reclamation are responsible for implementing CALFED's South Delta Improvements Program (SDIP). The SDIP includes providing for more reliable long-term export capability by State and Federal water projects, protecting local diversions, and reducing impacts on San Joaquin River salmon. Specifically, the CALFED actions in the SDIP include placing a fish barrier at the head of Old River, constructing up to three hydraulic barriers in south Delta channels, dredging and extending some agricultural diversions, and increasing the diversion capability of the Banks Pumping Plant at the Clifton Court Forebay from 6,680 cfs to 8,500 cfs during certain periods. The potential project is still in the planning phase and not yet approved. Accordingly it will not be included as a without-project condition in the SLWRI. However, because it is an essential

element of the ROD and has broad State and Federal agency support, there is a strong likelihood that it will be implemented in the future. Accordingly, the potential influence on the plan formulation process in this report of increasing the pumping capacity at Banks to 8,500 cfs is included as a sensitivity analysis in Chapter IX (Special Topics).

- **Trinity River Restoration Plan –** It is expected that over time, elements of the December 2000 ROD for the Trinity River Restoration Plan will be implemented. This includes reducing annual exports of Trinity River water to the Sacramento River from 74 percent of Trinity River flow to 52 percent.
- **Phase 8 Short-Term Agreement –** It is highly likely that some of the 45 projects identified in the Phase 8 Short-Term Settlement Agreement will be implemented, including dedication of a portion of 185,000 acre-feet of water for environmental needs. It is likely that the portion of this water not requiring construction of new infrastructure will be made available.
- **Operation Criteria and Plan –** Numerous actions contained in the 2004 revision to the 1992 OCAP will be implemented to address how the CVP and SWP would be operated in the future as several projects come on-line and as water demands increase.
- **Other Projects –** Various other projects and programs are expected to be implemented in the future, including the Battle Creek Restoration Project, CVP Contract Renewals, and further implementation of CVPIA (b)(2) water accounting.

FUTURE WITHOUT-PROJECT CONDITIONS

Summarized below are some of the expected physical, environmental, and socio-economic conditions generally expected to occur in the future in the study area.

Physical Environment

Basic physical conditions in the study area are expected to remain relatively unchanged in the future. No changes to area topography, geology, and soils, are foreseen. From a geomorphic perspective, ongoing restoration efforts along rivers are expected to marginally improve natural riverine processes. Without major physical changes to the river systems, which are unlikely, hydrologic conditions will probably remain unchanged. There is some speculation that the region’s hydrology could be altered should there be significant changes in global climatic conditions. Scientific work in this field of study is continuing.

Much effort has been expended to control the levels and types of herbicides, fungicides, and pesticides that can be used in the environment. Further, efforts are underway to better manage the quality of runoff from urban environments to the major stream systems. However, water quality conditions are expected to generally remain unchanged and similar to existing conditions. Most of the air pollutants in the study area will continue to be influenced by both urban and agricultural land uses. As the population continues to grow, with about 4 million additional people expected in the Central Valley by the year 2020, and agricultural lands converted to urban centers, a general degradation of air quality conditions could occur.

Biological Environment

Significant efforts are underway by numerous agencies and groups to restore various biological conditions throughout the study area. These efforts include elements of the CALFED programs, the Upper Sacramento River Conservation Area program, efforts by TNC and other private conservation groups, and numerous other programs and projects. Accordingly, major areas of wildlife habitat, including wetlands and riparian vegetation areas, are expected to be protected and restored. However, as population and urban growth continues and land uses are converted to urban centers, many wildlife species especially dependent on woodland, oak woodland, and grassland habitats may be impacted.

Efforts are also underway to implement programs and projects to help restore fisheries resources. Although significant increases in anadromous and resident fish populations in the Sacramento River are likely to continue through implementation of projects such as the Battle Creek Restoration Project, some degradation will likely occur through actions such as reduction in Sacramento River flows and resulting elevated water temperatures due to reduced diversions of cooler water from the Trinity River. Accordingly, populations of anadromous fish are expected to remain generally similar to existing conditions.

Through the significant efforts of Federal and State wildlife agencies, populations of special-status species in the riverine and nearby areas will generally remain as under existing conditions.

Social and Economic Environment

The population of the State is estimated to increase from about 35 million in 2000 to about 46 million by 2020, and to nearly 60 million by 2040. The population of the Sacramento and San Joaquin River basins portions of the Central Valley is expected to increase from approximately 4.4 million people in 2000 to about 7 million people by 2020 and 10 million in 2040. In the Sacramento River basin, the population is expected to increase from about 2.6 million to about 3.8 million by 2020 and 5 million by 2040. To support these expected increases in population, some conversion of agricultural and other rural land to urban uses is anticipated. Also to accommodate the increasing population, modification of existing major traffic corridors is anticipated. Increased transportation routes are likely to be constructed to connect the anticipated population increase in the Central Valley to existing transportation infrastructure.

Anticipated increases in population growth in the Central Valley will result in increased demands on water resources systems for additional and reliable water supplies, energy supplies, water-oriented facilities, recreational facilities, and flood damage reduction facilities.

Table III-13 summarizes Bulletin 160-98 estimated water demands (applied water), supplies, and potential shortages for 2020 levels of demand in the Sacramento River and San Joaquin River basins and for the State of California. As shown in the table, estimated future shortages of water supplies in drought years are expected to equal about 1.7 MAF in the Sacramento River and San Joaquin River basins and 6 MAF for the State. However, for many of the reasons mentioned in the existing conditions discussion, it is believed that the potential water shortages under 2020 demands will be significantly greater than shown in **Table III-13**.

Anticipated increases in population growth also will have impacts on visual resources within the Central Valley, as areas of open space on the valley floor are converted to urban uses. These increases also will result in increased demands for electric, natural gas, water, and wastewater utilities; public services such as fire, police protection, and emergency services; water-related infrastructure; and communication infrastructure. Further, the increasing population will increase the potential for hazardous toxic radiologic waste issues in the future. In addition, it will place pressures on preservation of existing historic and prehistoric cultural sites within the study area

TABLE III-13
ESTIMATED WATER DEMANDS, SUPPLIES, AND SHORTAGES FOR 2020

	Hydrologic Basin							
	Sacramento River		San Joaquin River		Two Basin Total		State of California	
Item	**Average Year**	**Drought Year**	**Average Year**	**Drought Year**	**Average Year**	**Drought Year**	**Average Year**	**Drought Year**
Population	3.8		3.0		8.8		45.6	
Urban Use Rate (GPCPD)	267	289	282	286	273	288	235	242
Acres In Production (mil)	2.2		1.9		4.1		9.2	
Agricultural Use (AFPA)	3.7	4.1	3.3	3.5	3.6	3.9	3.4	3.5
Applied Water (MAF)								
Urban	1.1	1.2	1.0	1.0	2.1	2.2	12.0	12.4
Agricultural	7.9	8.8	6.5	6.7	14.4	15.5	31.5	32.3
Environmental	5.8	4.8	3.4	1.9	9.3	6.1	37.0	21.3
Total	***14.9***	***14.3***	***10.8***	***9.6***	***25.7***	***23.9***	***80.5***	***66.0***
Water Supply (MAF)								
Surface Water	12.2	10.0	8.5	6.0	20.7	16.0	65.0	43.3
Groundwater	2.6	3.3	2.3	2.9	4.9	6.2	12.7	16.0
Recycled/Desalted	0	0	0	0	0	0	0.4	0.4
Total	***14.9***	***13.3***	***10.8***	***8.9***	***25.6***	***22.2***	***78.1***	***59.8***
Shortage (MAF)	***85***	***1.0***	***0.1***	***0.7***	***721***	***1.7***	***2.4***	***6.2***

Key: AFPA – acre-feet per acre GPCPD – gallons per capita per day MAF – million acre-feet mil – million

Source: The California Water Plan, Bulletin 160-98, Appendix 6A, Regional Water Budgets with Existing Facilities and Programs, November 1998.

The increase in population and aging “baby boomer” generation will increase the need for health services. During the 2000-2010 decade, many workers will reach 60 years and older. The general migration of retirees and older Americans from colder northeastern regions to warmer southern regions is expected to continue. While many of the region’s high school graduates will leave the area for colleges and jobs located in San Francisco and southern California, the region’s superior outdoor recreational opportunities and moderate housing opportunities are expected to attract increasing numbers of retirees from outside the region. Increasing numbers of residents, in turn, will produce increased employment gains, particularly in the sectors of retail sales, personal services, finance, insurance, and real estate.

Cultural Environment

Any paleontological, historic, archeological, or ethnographic resources currently being affected by erosion due to reservoir fluctuations would continue to be impacted. Fossils and artifacts located around the perimeter of the existing reservoir will continue to be subject to collection by recreationalists. Resources located within the potential inundation zone of an enlarged Shasta Lake will likely be unaffected.

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CHAPTER IV
WATER AND RELATED RESOURCES PROBLEMS AND NEEDS

Based on the overall authority of the SLWRI, and the without-project conditions described in Chapter III, following is a summary of major water resources problems and needs identified in the primary study area.

ANADROMOUS FISH SURVIVAL

The population of chinook salmon in the Sacramento River has significantly declined over the past 30 years. Numerous factors have contributed to the decline, including unstable water temperature; loss of historic spawning areas and suitable rearing habitat; water diversions from the Sacramento River; drought conditions; reduction in suitable spawning gravels; fluctuations in river flows; toxic acid mine drainage; unnatural rates of predation; and fish harvests.

One of the most significant environmental factors is unstable water temperature. Water temperatures that are too high, or in some cases too low, can be detrimental to the various life stages of salmon. Elevated water temperatures, primarily caused by reductions in river flow, can negatively impact spawning adults, egg maturation and viability, and preemergent fry, significantly diminishing the resulting ocean population and next generation of returning spawners. Stress caused by high water temperatures also may reduce the resistance of fish to parasites, disease, and pollutants. Conversely, water that is too cold is detrimental to the rapid growth of some juveniles. Following construction of Shasta Dam, water released in the spring was unusually cold and prevented the characteristic rapid growth of fall- and late-fall-run juvenile salmon. Reduced growth rates are detrimental to juvenile salmon because they must attain a length of about 70 millimeters to migrate downstream, and must out-migrate before temperatures in the lower Sacramento River and the Delta reach about 73 degrees.

Various Federal, State, and local projects are addressing each of the aforementioned contributing factors. Recovery actions range from changing the timing and magnitude of reservoir releases to changing the temperature of released water. In the 1993 NMFS BO for winter-run chinook salmon, SWRCB established certain operating parameters for Shasta Reservoir. This BO set surrogate or minimum flows in the river downstream from Keswick Dam primarily to affect water temperatures during key periods. Implementation of CVPIA (b)(2) fish actions is another important minimum flow assumption used in operational studies for surface water storage projects in the CALFED ROD.

In addition to flow requirements, structural changes at Shasta Dam have been made, such as completing the TCD in 1997, to better manage water temperature in the upper Sacramento River to benefit anadromous fish populations. The TCD can selectively draw water from different depths within the lake, including the deepest, to help maintain river temperatures beneficial to salmon. The TCD is effective in helping to reduce winter-run salmon mortality in some critically dry years, and for fall- and spring-run salmon in below-normal years.

Implementation of requirements contained in the Trinity River December 2000 ROD may conflict with water temperature improvements made by the TCD at Shasta Dam. One of the major elements of the Trinity ROD is reducing the average annual export of Trinity River water from 74 percent to 52 percent of the flow. This would reduce flow from the Trinity River basin into Keswick Reservoir, and then into the Sacramento River. Because water diverted from the Trinity River is generally cooler than flows released from Shasta Dam, implementing Trinity ROD flow reductions would offset some of the benefits derived from the TCD.

Findings in the 2000-2001 Biennial Report of the CDFG Commission on Sacramento River winter-run chinook salmon indicate that the total number of fish is increasing. This is likely due primarily to minimum release requirements at Shasta Dam and to the TCD. However, a residual need still exists for generally cooler water in the Sacramento River, especially in dry and critically dry years. This need for additional temperature management would increase should the Trinity River ROD be implemented.

WATER SUPPLY NEEDS

Demands for water in California exceed available supplies. As indicated previously in **Tables III-12** and **III-13**, the need for additional supplies also exists in the Central Valley and is expected to continue. As the population of the Central Valley continues to grow, along with the need for maintaining a healthy and vibrant industrial and agricultural economy, the demand for adequate and reliable water supplies will become more acute. **Table IV-1** is a summary comparison of existing and expected future water use versus available supplies in the Sacramento River and San Joaquin River basins and in the State under drought year conditions. As shown, it is estimated that the demand for water in the future will significantly exceed available supplies. Based on results of recent system modeling (CALSIM II), it is highly likely that expected shortages would be greater than those shown in the table.

It is believed that competition for available water supplies will intensify as water demands to support M&I and related urban growth increase relative to agricultural uses. **Table IV-1** also shows the expected trend in distribution of water supplies and water sources under drought year conditions (Bulletin 160-98) for 2020. In addition, projections are included based on 2040 population projections and 2020 water use rates. Data illustrate that although current and projected shortages are significant, just as important is understanding that much of the water required for new urban growth is projected to come from redirected agricultural uses.

Various potential options are identified in Bulletin 160-98 to help meet expected future water shortages in the Central Valley. They include constructing new dams and reservoirs on the Yuba and American Rivers and enlarging Friant Dam on the upper San Joaquin River, Pine Flat Dam on the Kings River, and Lake Kaweah on the Kaweah River. Bulletin 160-98 also identified construction of offstream storage at the Waldo Reservoir Site near the Yuba River. As part of the CALFED ROD, various projects were identified to help meet future water needs, including new surface water dams and reservoirs, groundwater storage, WUE, water transfers, conveyance improvements, and more. To date, feasibility scope studies are proceeding on only one project identified in Bulletin 160-98 and four of the of the new surface water storage projects identified in the CALFED ROD: SLWRI, NODOS Project, Upper San Joaquin River Storage Investigation, and Los Vaqueros Reservoir Enlargement Project.

TABLE IV-1
COMPARISON OF EXISTING AND FUTURE WATER USE VERSUS SUPPLIES UNDER DROUGHT YEAR CONDITIONS

Item	Sacramento & San Joaquin River Basins			California		
	2000	2020	2040	2000	2020	2040
Population (million)	5	7	10	35	46	59
Urban Use Rate (GPCPD)	309	288	288	247	242	242
Acres In Production (million)	4.1	4.1	4.1	9.5	9.2	9.1
Agricultural Use (AFPA)	3.9	3.8	3.8	3.6	3.5	3.5
Water Use (MAF)						
Urban	1.6	2.2	3.1	9.7	12.4	15.9
Agriculture	16.1	15.5	15.5	34.1	32.3	32.3
Environmental	6.1	6.1	6.1	21.2	21.3	21.3
Total	23.8	23.9	24.8	65.0	66.0	69.5
Supplies (MAF)						
Surface Water	16.1	16.0	16.0	43.5	43.3	43.3
Groundwater	6.1	6.2	6.2	15.8	16.0	16.0
Recycled & Desalted	0.0	0.0	0.0	0.3	0.4	0.4
Total	22.2	22.2	22.2	59.7	59.8	59.8
Shortage (MAF)	***1.7***	***1.7***	***2.6***	***5.4***	***6.2***	***9.8***

Key:
AFPA - acre-feet per acre GPCPD – gallons per capita per day MAF – million acre-feet

Source: Based primarily on information contained in the California Water Plan, Bulletin 160-98, with extended 2040 estimates using available population projects and 2020 water use rates.

Even with major efforts by multiple agencies to address the complex water resources issues in the State, aggressive water conservation, increased water recycling, and other water management measures, it is expected that demands will significantly exceed supplies. To avoid major impacts to the economy and the overall environment of the State, it is believed that developing additional water sources to increase the reliability of providing adequate supplies of water for M&I, agricultural, and environmental purposes is needed to meet future demands.

OTHER ENVIRONMENTAL OPPORTUNITIES

The health of the Sacramento River ecosystem, as elsewhere in the Central Valley, has been severely impacted in the last century by conflicts over the use of limited natural resources, particularly water resources. Humans have harnessed many of California’s rivers and streams for beneficial uses such as hydropower, flood control, and water supply. One result has been a decline in habitat and native species populations, and a growing number of endangered and threatened species.

Construction of Shasta Dam has had both negative and positive effects on environmental resources in the region. Negative impacts of Shasta Dam include blocking historic fish migration into the upper watersheds of the Sacramento River, modifying seasonal flow patterns and the natural riverine processes that they support, and inundating fish and wildlife habitat. However, water resources within the reservoir also support a variety of environmental values and objectives throughout the Central Valley and Bay-Delta, playing a central role in environmental flow regulation and water quality. While construction of the dam displaced valuable riverine and upland habitat, it also created shoreline and shallow-water habitat for aquatic, terrestrial, and avian species. For example, Shasta Lake is home to the largest concentration of nesting bald eagles in California, with 18 pairs nesting within 0.5 miles of the shoreline in any given year.

Shasta Lake Area

Various activities have impacted natural resources upstream from Shasta Dam, within the lake, on adjacent lands, and in and near tributary streams. The greatest impact in the area has probably come from historic mining, ore processing practices, and resulting acid mine drainage, and fire suppression.

To guide management of STNF, USFS has prepared the STNFLRMP. Primary goals are to integrate a mix of management activities that allows use and protection of forest resources; meets the needs of guiding legislation; and addresses local, regional, and national issues. The STNFLRMP includes actions to implement management practices for increasing the amount of cover available for spawning and nursery habitat for warm water fish in Shasta Lake and its tributary streams. The STNFLRMP also is intended to guide implementation of the Aquatic Conservation Strategy of the Northwest Forest Plan for protection and management of riparian and aquatic habitats adjacent to Shasta Lake. CDFG has stocked Shasta Lake with chinook salmon and rainbow trout to support cold water fisheries.

Opportunities exist to further support ongoing programs of USFS. These opportunities include improving and restoring environmental conditions by developing self-sustaining natural habitat in the area of Shasta Lake and its tributaries to benefit fish and wildlife resources.

Downstream from Shasta Dam

Land and water resources development has caused major resource problems and challenges in the Sacramento River basin, including reductions in anadromous fish populations and riparian, wetland, floodplain, and shaded riverine habitat. In turn, this has resulted in reduced populations of many individual plant and animal species.

The quantity, quality, diversity, and connectivity of riparian, wetland, floodplain, and shaded riverine habitat along the Sacramento River has been severely limited from the confinement of the river system by levees, reclamation of adjacent lands for farming, bank protection, channel stabilization, and land development. Modification of seasonal flow patterns by dams and water diversions also has inhibited the natural channel-forming processes that drive riparian habitat succession. It is estimated that less than 5 percent of the historic acreage of riparian habitat within the Sacramento River basin remains today.

Reduced quality and quantity of habitat has resulted in reduced populations of many fish and wildlife species. The low populations and questionable sustainability of many species has led to an increase in listings under State and Federal ESAs in recent years. Introduction of nonnative species has also contributed to the decline in native animal and plant species. Lack of linear continuity of riparian habitat impacts the movement of wildlife species among habitat patches, adversely affecting dispersal, migration, emigration, and immigration. For many species, this has resulted in reduced wildlife numbers and population viability.

Ecosystem restoration along the Sacramento River has been the focus of several ongoing programs, including the CALFED Bay-Delta Program, SB 1086 Program, CVPIA, and the Central Valley Habitat Joint Venture. These and numerous local programs have been established to address ongoing conflicts over the use of limited resources within the Central Valley. Much effort has been directed in the upper Sacramento River region toward restoring or improving anadromous fisheries, which provide recreational and commercial values in addition to their environmental value. Despite these efforts, a significant need remains to restore and preserve ecosystem resources along the Sacramento River.

FLOOD PROBLEMS

Large and small communities and agricultural lands in the Central Valley are under the threat of flooding along the Sacramento River. The Corps is conducting a comprehensive, basin-wide study of flood management issues and options in the Sacramento River basin, and continues to develop the Sacramento River Bank Protection Project and assist in local flood control projects along the Sacramento River.

Flooding poses risks to human life, health, and safety. Development in flood-prone areas has exposed the public to the risk of flooding. While the existing flood management system has reduced the frequency of flooding, large storms can result in river flows that exceed the capacity of the system or cause failures in the system. The January 1997 flood revealed flood management system problems, including levee instability, insufficient conveyance capacity of many channels, and inefficiencies in flood management and warning programs and procedures. Threats to the public from flooding are caused by many factors, including overtopping or sudden failures of levees, which can cause deep and rapid flooding with little warning, threatening lives and public safety.

Physical impacts from flooding occur to residential, agricultural, commercial, industrial, institutional, and public property. Damages occur to buildings, contents, automobiles, and outside property, including agricultural crops, equipment, and landscaping. Physical damages include cleanup costs and costs to repair roads, bridges, sewers, power lines, and other infrastructure components. Nonphysical flood losses include income losses and cost of emergency services such as flood fighting and disaster relief.

Even though the Shasta Dam project has the potential to significantly control flood flows in the upper Sacramento River, influencing factors exist that can conflict with flood operation. Flood control operations at Shasta Dam, even with explicit rules provided in the flood control manual, are difficult to manage during a flood event. This is primarily due to the extreme inflow volumes to Shasta that can occur over long periods, numerous points of inflow along the river downstream from Shasta, and multiple points of operational interest downstream. The primary downstream control point along the Sacramento River that determines reservoir releases under real-time operation is Bend Bridge. However, other unofficial points of operation are considered, such as peak flows at Hamilton City or other rural communities that are at risk of flooding.

These factors, combined with the uncertainty of storm forecasting, can lead to staff exhaustion and, worse, loss of efficient control at Shasta Dam. Once this occurs, it could cause a cascading effect on flood problems downstream to the Delta. Accordingly, the need is recognized for improved flood protection along the Sacramento River.

HYDROPOWER NEEDS

Were California a nation, it would be the twelfth largest consumer of electricity, using roughly the same amount as South Korea and Italy. Among the 50 states, California is the second largest consumer of electricity. Although California has 12 percent of the nation’s population, it only uses 7 percent of the electricity. This makes California the most-energy efficient state per capita in the nation. Even so, demands for electricity are growing at a rapid pace. As an example, over the next 10 years, California’s peak demand for electricity is expected to increase 30 percent from about 50,000 MW to about 65,000 MW. There are, and will continue to be, increasing demands for new electrical energy supplies, including clean energy sources such as hydropower.

CHAPTER V
PLAN FORMULATION APPROACH

This chapter discusses the process of formulating plans for the SLWRI, and presents the planning objectives, planning constraints and criteria, and mission statement for the study.

PLAN FORMULATION PROCESS

The basic plan formulation process for Federal water resources studies and projects consists of the following steps:

- Identifying existing and projected future resource conditions without implementation of a project.
- Defining water resources problems and needs to be addressed.
- Developing planning objectives, constraints, and criteria, and an overarching Mission Statement.
- Identifying resources management measures and formulating potential alternative plans to meet study objectives.
- Comparing and evaluating alternative plans.
- Selecting a plan for recommended implementation.

For the SLWRI, the above process was separated into four phases, as shown in **Figure V-1** and described below:

- **Mission Statement Phase –** Identify without-project future conditions, define resulting resources problems and opportunities, define a specific set of planning objectives, identify the constraints and criteria in addressing the planning objectives, and develop a concise Mission Statement based on study objectives.
- **Initial Plans Phase –** Identify potential resources management measures to address planning objectives, and formulate, coordinate, and compare a set of concept plans. From these concept plans, a set of initial alternatives will be identified.
- **Alternative Plans Phase –** From the initial alternatives, formulate specific alternative plans to address the planning objectives; evaluate, coordinate, and compare the plans; and identify a plan for tentative recommendation.
- **Recommended Plan Phase –** Complete the development of a tentatively recommended plan and prepare, coordinate, and process supporting decision documentation.

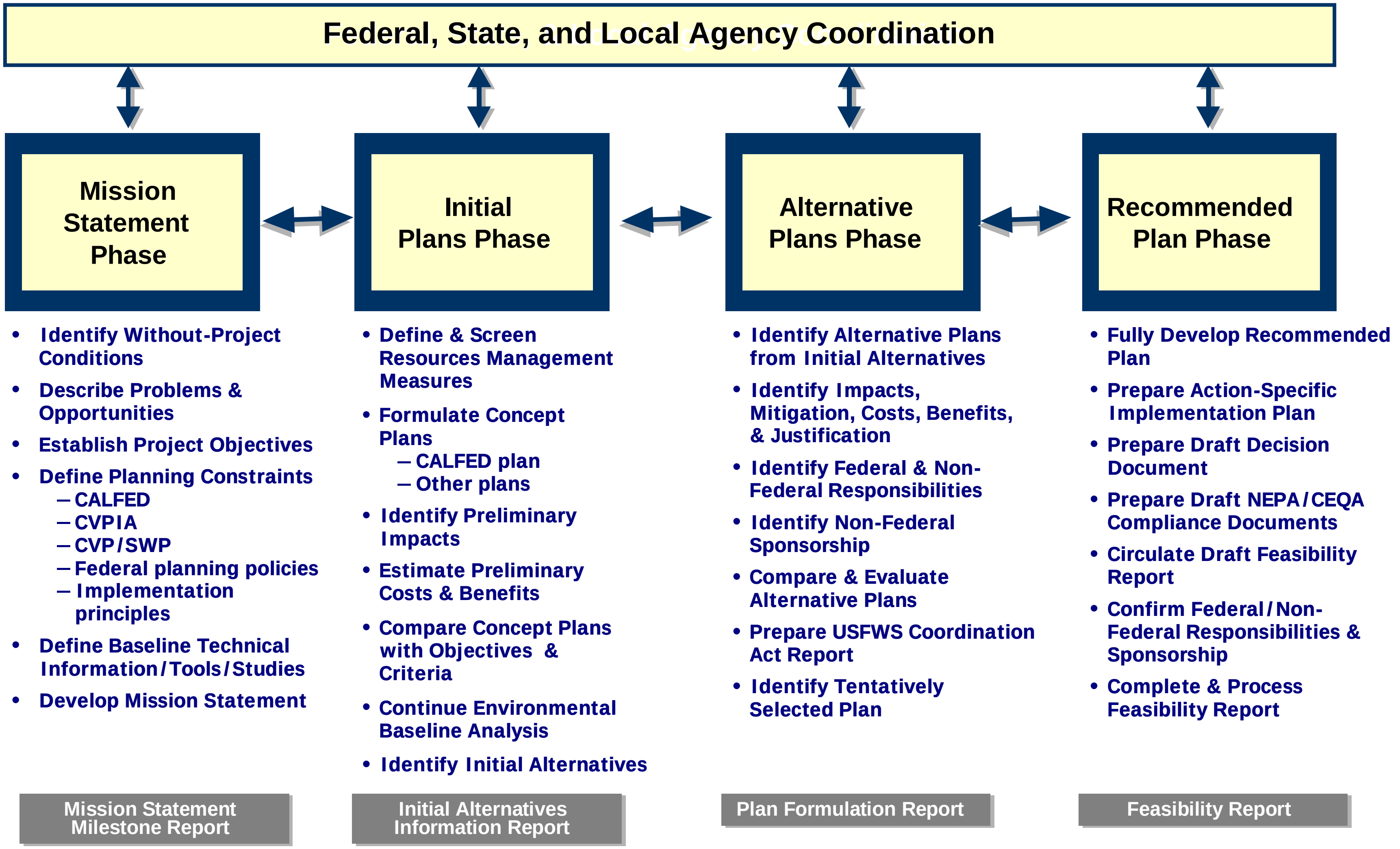

Figure V-1 – Plan formulation process.

The first two phases, Mission Statement and Initial Plans, are nearing completion. A summary of existing and potential future without-project conditions (consistent with the NEPA Baseline) and problems and needs is included in **Chapters III** and **IV**. This chapter presents the identified planning objectives, constraints, and criteria, and resulting Mission Statement to help guide the SLWRI. **Chapters VI**, **VII**, and **VIII** describe the formulation of a set of initial plans. First, **Chapter VI** identifies resources management measures. From these measures, a representative set of concept plans was formulated, which is included in **Chapter VII**. **Chapter VIII** compares the concept plans and identifies initial alternatives for further development in feasibility studies for the SLWRI.

PLANNING OBJECTIVES

On the basis of the previously identified and defined problems and needs in the study area, and in relation to study authorities, the following planning objectives were developed. These objectives are to be used to help guide formulation of alternatives to address the problems and needs, and are separated into primary and secondary objectives. Primary objectives are those for which specific alternatives would be formulated to address. Secondary objectives are opportunities that should be considered in the plan formulation process, but only to the extent possible through pursuit of the primary planning objectives.

- **Primary Objectives –** Formulate alternatives specifically to address the following:
  - Increasing the survival of anadromous fish populations in the Sacramento River primarily upstream from the RBDD.
  - Increasing water supplies and water supply reliability for agricultural, M&I, and environmental purposes to help meet future water demands, with a focus on enlarging Shasta Dam and Reservoir.
- **Secondary Objectives –** To the extent possible, through pursuit of the primary planning objectives, include as opportunities features to help accomplish the following:
  - Preserving and restoring ecosystem resources in the Shasta Lake area and along the upper Sacramento River.
  - Reducing flood damages along the Sacramento River.
  - Developing additional hydropower capabilities at Shasta Dam.

PLANNING CONSTRAINTS AND CRITERIA

Planning constraints and criteria used to help guide the investigation are described in this section.

Constraints

Fundamental to the plan formulation process is identifying and developing basic constraints specific to this investigation. Planning constraints are used to help guide the conduct of the feasibility study. Some planning constraints are more rigid, including Congressional direction;

current applicable laws, regulations, and policies; and physical conditions (topography, hydrology, etc.). Other planning constraints are less stringent for the feasibility study but still influential in guiding the process. Examples include existing water resource projects and programs such as CALFED and the CVPIA. Accordingly, several major constraints in formulating and ultimately implementing a plan to meet study objectives are as follows:

- **Study Authorization –** The authorization provides for an investigation of the potential benefits of enlarging or replacing Shasta Dam and Reservoir.

- **Laws, Regulations, and Policies –** Numerous laws, regulations, executive orders, and policies need to be considered, including NEPA, Fish and Wildlife Coordination Act, Clean Air Act, Clean Water Act, Federal and State ESAs, CEQA, and the CVPIA.

- **CALFED Record of Decision –** The CALFED ROD includes program goals, objectives, and projects primarily to benefit the Bay-Delta system. The ROD has been adopted by various State and Federal agencies for further consideration. In addition to enlarging Shasta Reservoir, the PPA in the ROD includes four other surface water and various groundwater storage projects to help reduce the discrepancy between water supplies and projected demands. The program also includes numerous other projects to help improve the ecosystem functions of the Bay-Delta system. Developed plans should be cognizant of the goals, objectives, and programs/projects of the CALFED ROD.

Principles and Criteria

In addition to the planning constraints, a series of planning principles and guidelines help guide plan formulation and planning criteria for consideration not only in formulating the initial set of alternatives but also to determine which alternatives best address the planning objectives. Many of the planning principles and guidelines are included in the Federal Water Resources Council's Principles and Guidelines or "P&G," and other Federal planning regulations. Planning principles and guidelines relate to economic justification, environmental compliance, technical standards, etc. Also, many of the principles result from local policies, practices, and conditions. Several examples in the SLWRI for use in formulating, evaluating, and comparing concept plans, initial alternatives, and later, detailed alternatives include the following:

- Alternatives and their major elements are to be consistent with the identified planning constraints above.

- A direct and significant geographical, operational, and physical dependency must exist between major components of alternatives.

- Alternatives should address at minimum each of the identified primary planning objectives and, to the extent possible, the secondary planning objectives.

- Measures to address secondary objectives should be either directly or indirectly related to the primary objectives (i.e., plan features should not be independent increments).

- Primary consideration should be given to recommendations in the CALFED ROD.

- Alternatives should avoid any reduction in flood control or other significant hydraulic impacts to areas downstream on the Sacramento River.
- Alternatives should strive to either avoid potential adverse impacts to environmental resources or include features to mitigate unavoidable impacts through enhanced designs, construction methods, and/or facilities operations.
- Alternatives should strive to avoid potential adverse impacts to present or historical cultural resources or include features to mitigate unavoidable impacts.
- Alternatives should not result in a significant adverse impact to existing future water supplies, recreation facilities, hydropower generation, and related water resource conditions.
- Alternatives are to reflect the purposes, operations, and limitations of existing and without-project future projects and programs.
- Alternatives are to be formulated and evaluated based on a 100-year period of analysis.
- First costs for alternatives are to reflect current prices and price levels, and annual costs are to include the current Federal discount rate and an allowance for interest during construction.
- Alternatives are to be formulated to neither preclude nor enhance development and implementation of other elements of the CALFED program or other water resources programs and projects in the Central Valley.
- Alternatives should have a high certainty for achieving the intended benefits and not significantly depend on long-term actions (past the initial construction period) for success.

The Federal planning process included in P&G also includes four specific criteria for consideration in formulating and evaluating alternatives: (1) completeness, (2) effectiveness, (3) efficiency, and (4) acceptability. These criteria and how they include planning principles and apply in helping to compare concept plans are described in **Chapter IX**.

MISSION STATEMENT

On the basis of identified problems and needs, primary and secondary planning objectives, relationship to other programs and projects, and Federal planning guidance, the following draft Mission Statement was developed for the SLWRI:

> *To develop an implementable plan primarily involving the enlargement of Shasta Dam and Reservoir to promote increased survival of anadromous fish populations in the upper Sacramento River and increased water supply reliability, and to the extent possible through meeting these objectives, include features to benefit other identified ecosystem, flood control, and related water resources needs.*

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CHAPTER VI
RESOURCES MANAGEMENT MEASURES

Following development of the planning objectives, constraints, and criteria for the SLWRI, the next major step in formulating initial alternatives is to identify and evaluate potential resource management measures. A resource management measure is any structural or nonstructural action that could address the study objectives. Concept plans are formulated by combining the most applicable resources management measures.

Numerous potential resources management measures have been identified as part of previous studies, programs, and projects to address water resources and related problems and needs in the study area. These measures were reviewed and others developed during study team meetings, field inspections, and outreach for the SLWRI, for their ability to address the primary and secondary planning objectives listed in **Chapter V**. Following is a general description of the measures considered, reasons for retaining or deleting measures from further development in the SLWRI, and information on how retained measures could fit into potential concept plans.

Various reasons exist for retaining a measure for possible inclusion into a concept plan or deleting it from further consideration in the SLWRI. One important factor is the potential for a measure to directly address a planning objective without adversely impacting other objectives. Measures were rated on a scale of low to high based on their relative ability to address the primary and secondary objectives of the SLWRI. In most cases, measures that were rated as moderately addressing a planning objective or less than moderately were deleted from further consideration, while measures rating higher were retained. This is primarily because measures that can only marginally address a study objective of the SLWRI are generally inconsistent with study constraints or other principles and criteria presented in **Chapter V**. Other major factors and rationale in retaining or deleting a measure are included in the following descriptions of the individual resources management measures.

It should be noted that measures dropped from consideration and further development as alternative plan components in the SLWRI may be revisited at a later date. Measures that do not directly address the planning objectives may be reconsidered for inclusion in future alternative plans as mitigation elements or other plan features. These elements will be identified and developed at a later time.

MEASURES TO ADDRESS PRIMARY PLANNING OBJECTIVE – INCREASE ANADROMOUS FISH SURVIVAL

A number of potential measures to address anadromous fish and other ecosystem opportunities were identified. Most are listed in the November 2003 Ecosystem Restoration Office Report included in the reference document section. Of 17 measures identified specifically to address the primary objective of anadromous fish survival on the Sacramento River, 4 were retained for possible inclusion in concept plans, as shown in **Table VI-1**.

Measures Considered

Following is a brief discussion of the array of measures considered, which are separated into three broad categories: (1) improved fish habitat, (2) improved water flows and quality, and (3) improved fish migration. This section summarizes rationale for deleting or retaining measures for further consideration, as presented in **Table VI-1**.

Improved Fish Habitat

- **Restore abandoned gravel mines along the Sacramento River -** Instream gravel mining has degraded aquatic and floodplain habitat, creating large, artificial pits at various locations in the primary study area that disrupt natural geomorphic processes and riparian regeneration. Aquatic conditions at former gravel mining sites are typically unsuitable for spawning and rearing. High fish mortality due to stranding and unnatural predation occurs in many abandoned pits that lose their connections with the river during low-flow periods. The river cannot refill and restore many of these pits naturally due to changes in flow regime and reductions in coarse sediment input. This measure consists of acquiring, restoring, and reclaiming several inactive gravel mining operations along the Sacramento River to create valuable aquatic and floodplain habitat. Gravel pit restoration would involve filling deep depressions and recontouring the stream channel and floodplain to mimic more natural conditions. Side channels and other features could be created to encourage spawning and rearing and prevent stranding. Soil may need to be imported to replenish areas where gravel mining has resulted in a significant loss of fine sediments. Revegetation using native riparian plants would be performed on restored floodplain lands.

  This measure was retained for potential further development because it would have a high likelihood for success in helping to achieve the primary objective. Furthermore, it would combine favorably with other potential measures related to Shasta Dam and Reservoir and its operation. This measure would not be expected to conflict with other known programs or projects on the upper Sacramento River.

- **Construct instream aquatic habitat downstream from Keswick Dam –** Keswick Dam is the uppermost barrier to anadromous fish migration on the Sacramento River. Releases from the dam have scoured the channel, and the dam blocks passage of gravels, bed sediments, and woody debris that were replenished historically by upstream tributaries. As a result, aquatic habitat is poor for spawning and rearing of anadromous fish, and predation can be high due to the lack of instream cover. Despite these unfavorable channel conditions, cold water releases from Keswick Dam attract large numbers of spawners to this reach. This measure consists of constructing aquatic habitat in and adjacent to the Sacramento River downstream from Keswick Dam to encourage use of this reach by anadromous fish for reproduction. Habitat restoration would involve acquiring lands adjacent to the Sacramento River; earthwork along the riverbank to construct side channels for spawning; and strategic placement of instream cover structures within the river channel, including large boulders, anchored root wads, and other natural materials.

TABLE VI-1
RESOURCES MANAGEMENT MEASURES ADDRESSING THE PRIMARY PLANNING OBJECTIVE OF ANADROMOUS FISH SURVIVAL

Resources Management Measure	Potential to Address Planning Objective	Status/Rationale
Improved Fish Habitat		
Restore abandoned gravel mines along the Sacramento River	**High** – Addresses primary planning objective.	**Retained** – High potential to effectively address the primary objective and for likelihood of success. Consistent with other anadromous fish programs and high likelihood for local interest. Consistent with secondary planning objectives and constraints/principles/criteria. Combines well with other measures - provides benefits for both aquatic and floodplain/riparian habitat. Low long-term O&M requirements.
Construct instream aquatic habitat downstream from Keswick Dam	**Moderate** - Addresses primary planning objective.	**Deleted** – High potential for combining with other measures. Relatively low initial cost but high O&M costs. Difficult to construct and maintain. Low certainty for long-term success. Not consistent with Federal project practices.
Replenish spawning gravel in the Sacramento River	**Moderate** - Addresses primary planning objective.	**Deleted** – High potential for combining with other measures. Demonstrated benefits that continue as gravel moves downstream. Low initial cost but very high annual cost relative to initial cost. Concerns over induced downstream impacts to agricultural facilities. Depends on long-term commitment to regular and recurring project replacement for success. Not consistent with Federal project practices.
Construct instream fish habitat on tributaries to the Sacramento River	**Low to Moderate** – Indirectly benefits planning objective.	**Deleted** – Significant benefit to tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not directly contribute to improved ecological conditions along mainstem Sacramento River.
Remove instream sediment along Middle Creek	**Low** – Indirectly benefits planning objective.	**Deleted** – Significant benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not directly contribute to improved ecological conditions along mainstem Sacramento River. High uncertainty due to increased need for long-term remediation.
Rehabilitate inactive instream gravel mines along Stillwater and Cottonwood creeks	**Low** – Indirectly benefits planning objective.	**Deleted** – Significant benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not directly contribute to improved ecological conditions along mainstem Sacramento River.
Restore the streambed near the ACID siphon on Cottonwood Creek	**Low** – Indirectly benefits planning objective.	**Deleted** – Significant benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not directly contribute to improved ecological conditions along mainstem Sacramento River.
Improved Water Flows and Quality		
Make additional modifications to Shasta Dam for temperature control	**Moderate to High** – Potential to contribute to planning objective by improving temperatures for anadromous fish.	**Retained** - High likelihood of combining with measures involving increasing Shasta storage. Although existing TCD at Shasta effectively meets objectives, potential exists to further modify the device to benefit anadromous fish with increased storage at Shasta.
Enlarge Shasta Lake cold water pool	**Moderate to High** – Directly contributes to planning objective by improving water temperature conditions for anadromous fish.	**Retained** – High potential for combining with other measures. Consistent with other primary objective and secondary objectives. Consistent with goals of CALFED.
Modify storage and releases operations at Shasta Dam	**Moderate to High** – Directly contributes to planning objective by improving flow conditions for anadromous fish.	**Retained** - Potential to combine with other measures including Shasta Dam and Reservoir. Potential to conflict with other primary and a secondary objective. Consistent with goals of CALFED and other programs/projects to benefit anadromous fish.
Modify ACID diversions to reduce flow fluctuations	**Moderate** – Reduced flow fluctuations would benefit anadromous fish, directly contributing to the planning objective.	**Deleted** – Conflicts with other primary planning objective of water supply reliability.
Increase instream flows on Clear, Cow and Bear creeks	**Low** – Indirectly benefits planning objective on the Sacramento River.	**Deleted** – Independent of hydraulic/hydrologic conditions in upper Sacramento River.
Construct a storage facility on Cottonwood Creek to augment spring instream flows	**Very Low** – Indirectly benefits planning objective on the Sacramento River.	**Deleted** – Independent of hydraulic/hydrologic conditions in upper Sacramento River. Adverse environmental impacts expected to exceed benefits.
Improved Fish Migration		
Improve fish trap below Keswick Dam	**Low to Moderate** – Directly contributes to planning objective by reducing mortality and supplying more fish to hatcheries.	**Deleted –** Although helps fish populations, does not contribute to favorable conditions for sustained spawning and rearing of anadromous fish.
Screen diversions on Old Cow and Cow creeks	**Moderate** – Indirectly benefits planning objective on the Sacramento River.	**Deleted** – Significant benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not contribute to improved ecological conditions along mainstem Sacramento River.
Remove or screen diversions on Battle Creek	**Moderate** – Indirectly benefits planning objective on the Sacramento River.	**Deleted** – Significant benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not contribute to improved ecological conditions along mainstem Sacramento River.
Construct a fish barrier at Crowley Gulch on Cottonwood Creek	**Moderate** – Indirectly benefits planning objective on the Sacramento River.	**Deleted** – Significant benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not contribute to improved ecological conditions along mainstem Sacramento River.

Key: ACID – Anderson Cottonwood Irrigation District   cfs – cubic feet per second   O&M – operations and maintenance   TCD – temperature control device

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This measure was deleted from further development primarily because it would have a relatively low potential for sustained success without considerable periodic reconstruction, and operation and maintenance (O&M). High peak flood flows are expected from Keswick Dam for fairly frequent events (see **Plate 9**). It is likely that high flood flows would damage restoration sites and reconstruction would be required for flood events with fairly frequent return periods, every 5 to 10 years. High recurrent O&M responsibilities would adversely affect the potential for sustained project success and result in low Federal interest.

- **Replenish spawning gravel in the Sacramento River -** Historically, tributary watersheds upstream from Keswick and Shasta dams provided a continuous source of high-quality gravel and other coarse sediments to the Sacramento River. Today, dams, river diversions, gravel mining, and other obstructions have blocked or reduced natural gravel sources. Gravel suitable for spawning has been identified as a significant influencing factor in the recovery of anadromous fish populations in the Sacramento River. Several programs, including CALFED and the AFRP, are proceeding with gravel replenishment on the Sacramento River in selected locations. With the exception of the CVPIA (b)(13) program, these programs represent single applications at discrete locations. This measure consists of helping to replenish spawning-sized gravel in the Sacramento River between Keswick Dam and Red Bluff on a long-term basis. Gravel would be transported and injected into the Sacramento River downstream from Keswick Dam.

  This measure was deleted from further development primarily due to very high ongoing implementation and O&M requirements required for success.

- **Construct instream fish habitat on tributaries to the Sacramento River –** This measure consists of improving instream aquatic habitat along the lower reaches of tributaries to the Sacramento River. Various structural techniques would be employed to trap spawning gravels in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Both perennial and intermittent streams would be potential candidates for structural habitat improvements. Although this measure would have significant benefits for tributaries, it was deleted from further development primarily because it is a separate and independent action. It would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area.

- **Remove instream sediment along Middle Creek –** This measure consists of implementing a sediment removal and control program along Middle Creek, an intermittent tributary to the Sacramento River between Keswick Dam and Redding. Lower Middle Creek supports spawning runs of rainbow trout, steelhead, and salmon. Spawning gravels have been degraded by fine granitic sediment eroding from streambanks and adjacent land. Sediment from the creek also negatively impacts spawning habitat in the Sacramento River around the Middle Creek confluence. This measure was deleted from further development primarily because it is a separate and independent action. It would not contribute significantly to increasing anadromous fish survival within the primary Sacramento River study area.

- **Rehabilitate inactive instream gravel mines along Stillwater and Cottonwood creeks –** This measure consists of rehabilitating ecological conditions in former instream gravel mining sites along Stillwater Creek. Seven inactive gravel pits on Stillwater and/or Cottonwood creeks historically contributed to depletion of nearly all instream gravel resources along various reaches, leaving the channel scoured to bedrock. Restoring these gravel mines could help Stillwater Creek provide additional seasonal habitat for various anadromous and resident fish. This measure was deleted from further development primarily because it is a separate and independent action. It would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area.

- **Restore the streambed near the ACID siphon on Cottonwood Creek –** This measure consists of restoring the streambed near the ACID siphon on Cottonwood Creek to prevent degradation of this anadromous fish migration corridor. Erosion and channel down-cutting at the siphon have altered the streambed and may prevent migration of fish up Cottonwood Creek during low-flow periods. This measure was deleted from further development primarily because it is a separate and independent action. It would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area.

Improved Water Flows and Quality

- **Make additional modifications to Shasta Dam for temperature control –** The TCD installed at Shasta Dam allows operators to make selective releases from various reservoir depths to regulate water temperatures to benefit anadromous fish in upper Sacramento River. This measure consists of determining if making additional structural modifications to the outlets and existing TCD for temperature control is possible and feasible, and if so, implementing those modifications.

  This measure was retained for further development primarily because it could (1) improve the performance of the existing facility, (2) complement other measures under consideration to raise Shasta Dam, and (3) complement measures to improve aquatic spawning habitat in the Sacramento River. This measure would not conflict with other ecosystem restoration measures preliminarily retained herein or other known programs or projects on the upper Sacramento River.

- **Enlarge Shasta Lake cold water pool -** Cold water released from Shasta Dam significantly influences water temperature conditions on the Sacramento River between Keswick and Red Bluff, and can have an extended influence on river temperatures farther downstream. This measure consists of enlarging the cold water pool by either raising Shasta Dam and enlarging the minimum operating pool, or increasing the seasonal carryover storage in Shasta Lake. Each action would help provide greater flexibility in meeting water temperature targets throughout the year and extending suitable spawning habitat downstream. This measure also would be consistent with the goals of CALFED.

  This measure was retained for further development primarily because it would (1) directly contribute to both primary objectives for the SLWRI, (2) combine favorably with other measures, and (3) have a high certainty of providing the intended benefits once implemented. This measure would not conflict with any other ecosystem restoration measures that were preliminarily retained, nor would it conflict with other known programs or projects on the upper Sacramento River.

- **Modify storage and release operations at Shasta Dam –** In addition to water temperature, flow conditions in the upper Sacramento River are also important in addressing anadromous fish needs. This measure consists of enlarging Shasta Dam and modifying seasonal storage and releases to benefit anadromous fisheries. Although this measure could help provide greater flexibility in meeting water temperature targets, it would be aimed primarily at improving flows and influencing physical channel conditions for anadromous fish. Changes would be made to the timing and magnitude of releases performed to maintain target flows in spawning areas and improve the quality of aquatic habitat by cleaning spawning gravels. This measure would contribute to the goals of the AFRP included as part of the CVPIA. This measure also could include release changes during the flood season to permit “pulse flows” and other releases that could improve aquatic habitat conditions. Further, the measure could provide additional control and dilution of acid mine drainage from Spring Creek.

  This measure was retained for further development primarily because it could directly contribute to both primary objectives of the SLWRI and combine favorably with other measures. This measure would not conflict with any other ecosystem restoration measures that were preliminarily retained, nor would it conflict with other known programs or projects on the upper Sacramento River.

- **Modify ACID diversion to reduce flow fluctuations –** This measure consists of modifying operations at the ACID diversion dam near Anderson to reduce extreme flow fluctuations and their resulting impacts on anadromous fish. Extreme fluctuations in Sacramento River flows result in fish stranding and juvenile fish mortality. This measure was deleted from further development, however, primarily because of potential impacts to water supply reliability. Negative impacts on water deliveries from the ACID diversion dam would conflict with the second primary objective of increasing water supply reliability.

- **Increase instream flows on Clear, Cow, and Bear creeks –** This measure consists of increasing instream flows on Clear, Cow and Bear creeks during critical periods to support anadromous fish that spawn in the creek. Increasing flows would improve the quality of spawning habitat and help reduce water temperatures, thereby increasing the amount of suitable tributary spawning habitat available in the creeks. This measure was deleted from further development primarily because it would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area. In addition, this measure could impact hydropower production.

- **Construct a storage facility on Cottonwood Creek to augment spring instream flows –** This measure consists of constructing a dry dam or offstream storage facility on upper Cottonwood Creek to support flows for spring-run chinook salmon. A storage facility would allow late-spring and summer releases for spring-run chinook salmon, and improve overall seasonal aquatic conditions. This measure was deleted from further development primarily because it is an independent action. It would not significantly contribute directly to increasing anadromous fish survival within the primary Sacramento River study area. In addition, it is highly likely that this measure would have significant and overriding adverse environmental impacts in the Cottonwood Creek watershed.

Improved Fish Migration

- **Improve fish trap below Keswick Dam -** Keswick Dam is an upstream barrier to fish migration on the Sacramento River. As part of mitigation actions associated with the construction of Shasta and Keswick dams, a fish trap facility was constructed at Keswick Dam to capture anadromous fish for transport to the Coleman National Fish Hatchery on Battle Creek. This measure consists of improving the efficiency and performance of the fish trap below Keswick Dam to increase survival of anadromous fish captured at the facility, thereby, providing additional adults and increased egg production for fish hatchery operations. Although this measure has potential to contribute to the primary objective of increasing anadromous fish populations in the upper Sacramento River, it would not necessarily contribute to increasing survival of anadromous fish in the upper Sacramento River. This measure was deleted from further development primarily because it would not improve spawning and rearing conditions necessary for natural and sustainable reproduction of anadromous fish in the upper Sacramento River.

- **Screen diversions on Old Cow and Cow creeks –** This measure consists of screening diversion intakes in the Cow Creek watershed to reduce fish mortality. Over 100 agricultural diversions exist from the Cow Creek watershed; while many are small, larger diversions can entrain juvenile salmonids and other fish that use spawning habitat provided by the watershed. This measure would potentially reduce salmonid mortality at diversions within the Cow Creek watershed. However, this measure was deleted from further development primarily because it is an independent action and would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area.

- **Remove or screen diversions on Battle Creek –** This measure consists of removing or screening diversions and other water control facilities on Battle Creek to allow full use of the watershed's high-quality, cold water spawning habitat. Several projects have been implemented on lower Battle Creek to improve access to habitat and spawning success, but large portions of the upper Battle Creek watershed remain inaccessible to anadromous fish due to diversions. This measure would provide access to high-quality spawning habitat in the upper Battle Creek watershed. However, this measure was deleted from further development primarily because it is an independent action and would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area.

- **Construct a fish barrier at Crowley Gulch on Cottonwood Creek –** This measure consists of constructing a fish barrier at the mouth of Crowley Gulch on Cottonwood Creek to eliminate stranding of adult fall-run chinook. Due to irrigation runoff, intermittent flows in Crowley Gulch, attract spawning salmon to this small waterway where they often are trapped when flows decrease. This measure would help prevent stranding mortality in Crowley Gulch. However, this measure was deleted from further development primarily because it is an independent action and would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area.

Measures Retained for Further Consideration

Each of the four management measures retained to address the primary objective of anadromous fish survival was considered in greater detail to determine how they might become components of potential concept plans. Measures are shown in **Figure VI-1**, and their major components, accomplishments, and costs are described below.

Restore Abandoned Gravel Mines Along the Sacramento River

Protecting and restoring spawning and rearing habitat has been identified by NOAA Fisheries as a primary goal in the recovery of Sacramento River winter-run chinook salmon. It is estimated that over 80 percent of the winter- and spring-run chinook spawning population migrates to the upper Sacramento River when passage at the RBDD is unobstructed. Therefore, restoring suitable spawning habitat in the upstream reach of river has potential to benefit a large portion of the salmonid population.

One method of increasing anadromous fish survival is rehabilitating lands formerly mined for gravel along the Sacramento River. Instream gravel mining degrades aquatic and floodplain habitat by (1) creating large artificial pits along the river that disrupt natural geomorphic processes and riparian regeneration, (2) stranding fish and encouraging predation, and (3) removing valuable gravel sources. Aquatic conditions at former gravel mining sites are typically unsuitable for spawning and rearing. High fish mortality occurs at many abandoned pits that loose their connection with the river during low flow periods, stranding fish and encouraging unnatural predation rates. Due to changes in flow regime and reductions in coarse sediment input, the river is not capable of refilling and restoring many of these pits naturally. In addition, removing fine sediments during the gravel extraction process inhibits establishment of riparian vegetation that provides protective cover and shade for spawning and rearing.

Actions associated with this measure would help restore the natural complexity required for a healthy, self-sustaining river ecosystem. Actions would include filling deep pits (potentially requiring suitable fill material to be imported from local sources), recontouring the stream channel and floodplain to mimic natural conditions, and reconnecting the reclaimed area to the Sacramento River. Side channels and other features could be created to encourage spawning and rearing, and restored floodplain lands could be revegetated using native plants. Soil might need to be imported to replenish areas where gravel mining has resulted in a significant loss of fine sediments. Hydrologic, hydraulic, and sedimentation studies would identify optimal restoration conditions and any actions necessary to offset or minimize undesirable hydraulic conditions caused by restoration.

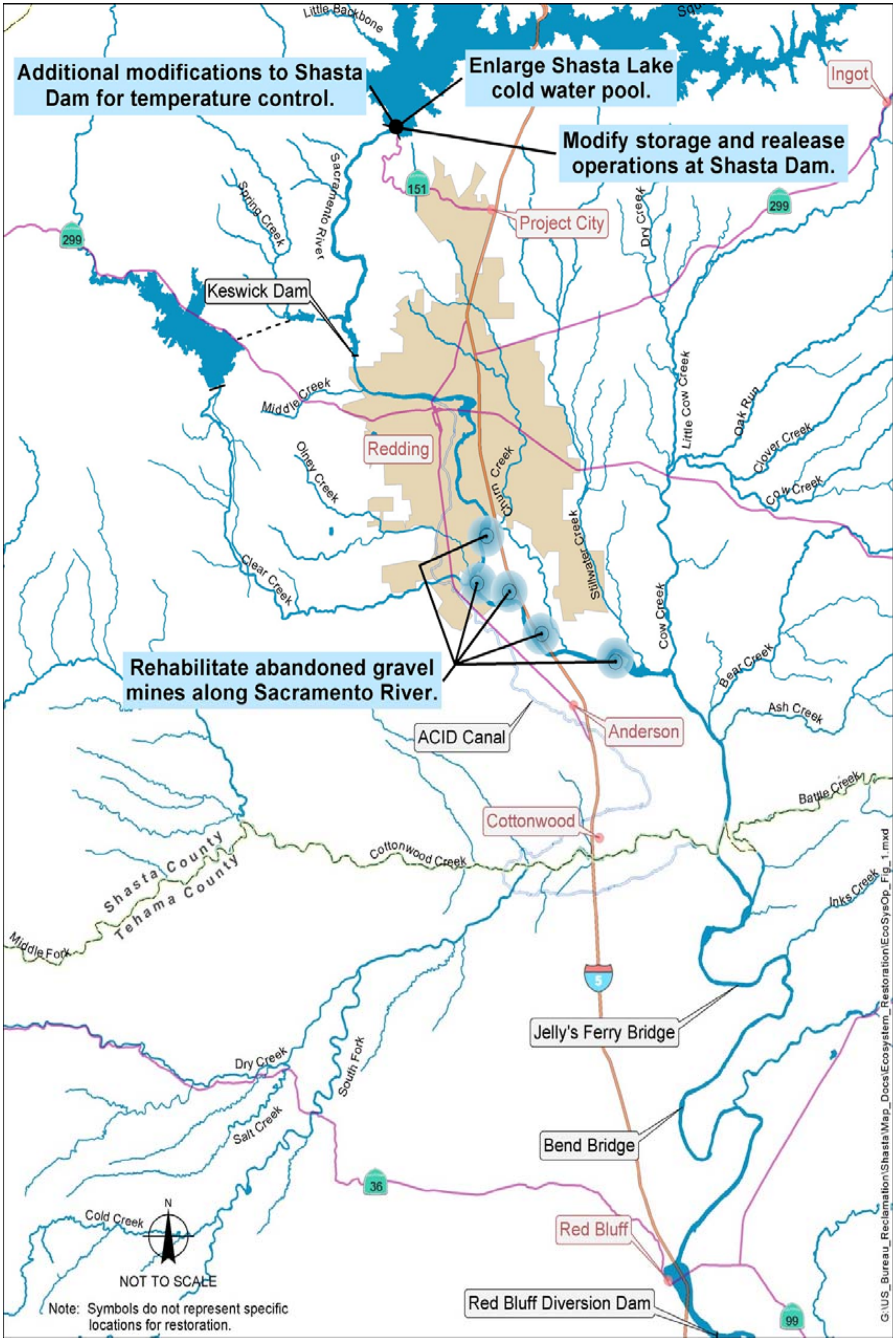

Figure VI-1 - Measures retained to address primary planning objective – anadromous fish survival.

This measure consists of acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the Sacramento River to create valuable aquatic and floodplain habitat. Several potential sites for gravel mine restoration along the Sacramento River between Keswick and Red Bluff are shown in **Figure VI-1** and listed in **Table VI-2**. **Figure VI-2** shows an example area for implementing this measure. Most of these sites consist of one or more deep pits surrounded by partially disturbed land, with the majority of sites consisting of disturbed lands that would require minimal restoration actions. For this assessment, however, a potential restoration area of 150 acres was considered. The exact size and location(s) would be determined in further studies.

Source: M. Kondolf, 1989

Figure VI-2 – Example of abandoned gravel mine with isolated pits (left side of photo).

TABLE VI-2
POTENTIAL GRAVEL MINE RESTORATION SITES
ALONG THE SACRAMENTO RIVER

Location	Approximate River Mile	Bank	Area acres
Red Bluff near Salt Slough	247	Left	140
Upstream of Stillwater Creek	282	Right	320
Redding	287-288	Right	135
Redding	287.5-288	Left	65
Redding	288.5-290.3	Left	305
Redding	292.5-294	Left	230

Primary accomplishments of gravel mine site restoration along the upper Sacramento River would be to (1) improve spawning success by increasing the amount of suitable spawning habitat along the Sacramento River for anadromous fish and (2) improve the health and vitality of self-sustaining riverside riparian ecosystems by restoring their connection with natural geomorphologic processes. This measure would support the primary objective of increasing the survival of anadromous fish populations in the Sacramento River by eliminating stranding and restoring spawning and rearing habitat at one or more abandoned gravel pits. The measure also would support the secondary objective of preserving and restoring ecosystem resources along the upper Sacramento River through restoring riparian and floodplain habitat. This measure would combine favorably with other potential measures to increase fish spawning and rearing along the upper Sacramento River. It would be compatible with plans to modify Shasta Dam because increased cold water releases and other operational changes at the dam would further enhance habitat restored by this measure and increase opportunities for anadromous fish to use the restored habitat. This measure would not conflict with any ecosystem restoration measures that were preliminarily retained. It would also combine favorably with measures involving floodplain restoration along the Sacramento River. This measure would not conflict with other known programs or projects on the upper Sacramento River.

The estimated certainty of this measure achieving its intended accomplishments would be very high. Similar restoration projects in other areas have provided favorable, sustainable results. Further, it is estimated that gravel mine restoration would have lasting benefits for the environment because more natural physical and biological processes would be restored.

Make Additional Modifications to Shasta Dam for Temperature Control

Adverse water temperature conditions in the upper Sacramento River have been identified as a critical factor leading to decline of anadromous fish species. As demand for CVP water has increased over time, the ability to maintain suitable water temperatures downstream from Keswick Dam for salmonids has become increasingly difficult. The NMFS 1993 BO for Central Valley Project Operations established water temperature criteria for the Sacramento River between Keswick Dam and Bend Bridge, or points upstream of Bend Bridge depending on climatic and water storage conditions. The existing TCD at Shasta Dam, shown in **Figure VI-3,** was constructed to help meet requirements of the 1993 BO. The TCD consists of a submersed multilevel intake structure that hangs from the upstream face of the dam. The shuttered structure is 250 feet wide and 300 feet high, with a low-level intake that is 125 feet wide and 170 feet high (**Figure III-1**). The structure allows operators to make selective releases from various reservoir depths to regulate water temperatures in the Sacramento River, adding greatly to the ability to meet temperature objectives. However, concern has been expressed that under certain conditions unintended warmer water can enter the TCD and mix with cooler water, thereby lessening effectiveness of the TCD.

Figure VI-3 – TCD located on upstream face of Shasta Dam.

This measure consists of first assessing if modifications to the TCD are possible and feasible and if so, implementing those modifications. This measure could be highly effective when combined with measures to increase storage space in Shasta Reservoir. For relatively small raises of Shasta Dam, it is believed that the existing TCD structure would be retrofitted to account for additional dam height and to reduce leakage of warm water into the facility, but no new structure would be needed. However, modifications to the existing structure would become more significant for increasingly higher dam raises. For dam raises higher than about 50 feet, it is believed that major modifications to the TCD would be needed to manage the increasing depth and volume of water. Accordingly, modifications under this measure for higher dam raises would include widening the existing structure to increase intake capacity, and extending the device to a greater depth. In addition, this measure would provide for added structural modifications to the outlets at Shasta Dam for the purpose of temperature control.

Accomplishments of this measure would be to increase survival of anadromous fish populations in the Sacramento River by (1) increasing the ability of operators at Shasta Dam to meet downstream temperature requirements for anadromous fish, (2) providing more flexibility in achieving desirable water temperatures during critical spawning, rearing, and out-migration, and (3) extending the area of suitable spawning habitat in the Sacramento River.

This measure would support the primary objective of increasing survival of anadromous fish populations in the Sacramento River. Also, it would complement potential measures to increase storage in Shasta Dam because additional temperature control improvements could be incorporated into the design of a dam raise and further improve cold water releases. This measure would combine well with measures to improve aquatic spawning habitat in the Sacramento River because better water temperature regulation could allow anadromous fish to take greater advantage of these habitat improvements. This measure would not conflict with other environmental restoration measures or other known programs or projects on the upper Sacramento River.

Enlarge Shasta Lake Cold Water Pool

Cold water released from Shasta Dam significantly influences water temperature conditions on the Sacramento River between Keswick and Red Bluff, and can have an extended influence on river temperatures even farther downstream. This measure includes increasing the volume of the cold water pool in Shasta Lake by raising Shasta Dam and enlarging Shasta Reservoir (see **Figure VI-1**) primarily to help maintain colder releases for anadromous fish during certain periods. Increased storage volume could also help increase seasonal flows in the upper Sacramento River that also are important to fish populations.

Dam raises ranging from about 6.5 feet to about 200 feet have been considered in previous studies by Reclamation. A dam raise of about 6.5 feet, as suggested in the CALFED ROD, would increase storage by about 290,000 acre-feet. A dam raise of about 200 feet would increase storage by about 9.3 million acre-feet. The increased cold water pool could be used to meet existing or proposed temperature targets or provide additional cold water discharges during the summer, which could significantly extend the downstream reach of suitable spawning habitat. Increased volume could also help meet minimum flows in late fall in the upper Sacramento River.

Raising Shasta Dam and increasing Shasta Reservoir would result in impacts to natural resources and infrastructure around the reservoir rim, potentially requiring significant mitigation and relocations. Impacts associated with dam raises less than about 18 feet would be significant but likely manageable. Higher dam raises would result in major impacts to reservoir area resources and infrastructure, reducing the likelihood of economic justification. In addition to extreme impacts in the Shasta Lake area, very high dam raises (100 to 200 feet) might also result in major impacts to natural resources along the Sacramento River downstream from the dam. These impacts would likely eliminate serious consideration of high dam raises.

Primary accomplishments of this measure would be (1) improved water temperature control, (2) extension of suitable spawning habitat, and (3) improved in overall physical aquatic habitat conditions in the Sacramento River. This measure would support the primary objective of increasing survival of anadromous fish populations in the Sacramento River. It also would support the primary objective of increasing water supply reliability. The estimated certainty of this measure in achieving its intended accomplishments would be high.

This measure would complement the other primary and secondary planning objectives. Also, it would combine favorably with measures aimed at changing the timing and magnitude of releases from the increased pool, which would improve the quality of spawning and rearing habitat, increase attraction flows that cue in-migration, and improve water temperatures that cue out-migration. This measure would not conflict with other ecosystem restoration measures that were preliminarily retained, nor does it conflict with other known programs or projects on the upper Sacramento River.

Modify Storage and Release Operations at Shasta Dam

In addition to water temperature, maintaining desirable river flows has been identified as an important factor in achieving recovery goals for anadromous fish in the Sacramento River. Timing and magnitude of river flows are important to successful spawning and rearing of anadromous fish populations. This measure would modify seasonal reservoir storage and dam release operations to benefit anadromous fisheries in the Sacramento River by providing greater flexibility in achieving desirable river flows that would improve and expand suitable spawning and rearing habitat (**Figure VI-1**).

Operational changes would be made to the timing and magnitude of releases primarily to improve the quality and quantity of aquatic habitat. Nearly all winter-run, and by far the majority of the spring-run and late-fall-run salmon in the Sacramento River, spawn in the reach upstream from the confluence with Battle and Cottonwood creeks. It is within this reach of river that the measure would be most effective by reducing the frequency and magnitude of habitat dewatering.

Shasta Dam operates for multiple objectives, including water supply, flood control, water temperature, hydropower, and others. Modifying existing storage and release operations could adversely impact water supply reliability to agricultural and M&I uses or other beneficial uses of the water stored in the reservoir, which would be contrary to SLWRI goals and objectives. Therefore, this measure would need to include enlarging the storage space in Shasta Reservoir to mitigate potential adverse impacts to water supply reliability. This measure would not conflict with any ecosystem restoration measures that were preliminarily retained, nor would it conflict with other known programs or projects on the upper Sacramento River.

The estimated certainty of this measure in achieving its intended accomplishments would be moderate. The relationship between minimum river flows and increased survivability of salmon is not clear, as many factors affect anadromous fish populations. Further, successful implementation would be highly dependent on the extent of dam modifications and reoperation that could be implemented while offsetting or minimizing adverse impacts to water supply or hydropower.

MEASURES TO ADDRESS PRIMARY PLANNING OBJECTIVE – INCREASE WATER SUPPLY RELIABILITY

Various potential water resources management measures were identified to address the primary objective of increasing water supply reliability for agricultural, M&I, and environmental purposes to help meet future water demands. Of 18 measures considered to help increase water supply reliability (see **Table VI-3**), 3 were retained for possible inclusion in alternative plans. Rationale is discussed for retaining or deleting measures in this section.

Measures Considered

Following is a brief discussion of the measures in this section considered, which are separated into seven categories: (1) surface water storage, (2) reservoir reoperation, (3) conjunctive use, (4) coordinated operation, (5) demand reduction, (6) water transfers and purchases, and (7) Delta export and conveyance. Also included are additional descriptions of the three measures retained for further consideration.

Surface Water Storage

- **Increase conservation storage space in Shasta Reservoir by raising Shasta Dam –** This measure consists of increasing the amount of available space for conservation storage in Shasta Reservoir through raising Shasta Dam. A range of potential dam raises has been considered in previous studies, including raises of over 200 feet. A raise of 6.5 feet is included in the PPA for the CALFED ROD. Raising Shasta Dam would contribute directly to the primary planning objectives, and previous studies have indicated that raising the dam would be technically feasible. Raising Shasta Dam also could contribute to the secondary planning objectives. In addition, there is likely strong Federal and non-Federal interest in this measure. Therefore, this measure was retained for further development.

- **Construct new conservation storage reservoir(s) upstream from Shasta Reservoir –** This measure consists of constructing dams and reservoirs at one or more locations upstream from Shasta Lake, primarily for increased water conservation storage and operational flexibility. Numerous reservoir storage projects have been considered and many constructed in the watershed upstream from Shasta Lake. A description of these studies and results is contained in **Appendix B** (Surface Water Storage Options). Three of the most promising remaining sites include Allen Camp Reservoir (180,000 acre-feet on the Pit River in Modoc County), Kosk Reservoir (800,000 acre-feet on the Pit River in Shasta County), and Squaw Valley Reservoir (400,000 acre-feet on Squaw Valley Creek in Shasta County). In addition to this measure being inconsistent with the primary study objectives, these three potential project sites were eliminated from further consideration because they would (1) only be capable of marginally improving water supply reliability to the CVP, (2) not be consistent with screening criteria established in the CALFED Integrated Storage Investigations, (3) likely not be supported in the local area because the water would need to be developed for CVP system reliability (not retained for local use), and (4) result in a relatively high unit water cost to implement. This measure was deleted from further consideration in the SLWRI.

- **Construct new conservation storage on tributaries to the Sacramento River downstream from Shasta Dam –** Numerous onstream surface water storage projects along tributaries to the Sacramento River downstream from Shasta Dam have been investigated in past studies (see **Appendix B**). Several projects have potential to significantly contribute to increasing water supply reliability, including the Cottonwood Creek Project (1.6 MAF on Cottonwood Creek north of Red Bluff), the Auburn Dam Project (up to about 2.3 MAF on the Middle Fork American River near Sacramento), and the Marysville Lake Project (920,000 acre-feet on the Yuba River near Marysville). Although each of these potential projects could significantly contribute to increasing the water supply reliability of the CVP and SWP systems, they have been rejected by state and local interests as potential candidates for new water sources. Each was eliminated from further consideration in the SLWRI primarily because they would not contribute to the primary planning objectives or because they have significant overriding environmental issues and opposition. This measure was deleted from further consideration in the SLWRI.

- **Construct new conservation offstream surface storage near the Sacramento River downstream from Shasta Dam -** Various offstream reservoir storage projects have been evaluated in previous studies (see **Appendix B**). All but one of the offstream reservoir storage projects were eliminated from further consideration in the CALFED ROD, primarily due to project cost considerations, potential environmental impacts, and lands and relocation issues. The one project retained for further consideration in the ROD is Sites Reservoir with a storage capacity of up to 1.8 MAF. DWR is studying Sites Reservoir and alternatives under the NODOS Project. Sites Reservoir would be filled primarily by water diverted from the Sacramento River and tributaries during periods of excess flows through the Tehama-Colusa Canal, Glenn-Colusa Irrigation District Canal, and/or a new pipeline near Maxwell. Another potential source of water for filling the reservoir is moving (predelivery) Tehama-Colusa Canal Authority and Glenn-Colusa Irrigation District water from Shasta Reservoir during the spring and storing it at Sites Reservoir for delivery during the irrigation season. Reclamation received Federal feasibility study authority for NODOS in Section 215 of PL 108-7 in September 2003. NODOS has the potential to increase the water supply reliability of Sacramento Valley users, the SWP, and CVP, improve Delta water quality, contribute to ecosystem restoration, and provide water to support EWA. The objectives of the NODOS project are different than those of Shasta enlargement; NODOS would not be a substitute for enlarging Shasta Dam and Reservoir and was eliminated from further consideration in the SLWRI.

- **Construct new conservation surface water storage south of the Sacramento-San Joaquin River Delta –** A relatively large portion of the CVP's future water needs is located in service areas in the San Joaquin River Basin, south of the Delta. In addition, large demands will continue to be made, primarily on the SWP, to provide water for M&I purposes further south via the California Aqueduct and for increased water supply reliability to the South Bay areas. A portion of these demands could be provided by onstream and/or offstream surface water storage within the San Joaquin River Basin. Numerous surface water storage sites have been identified in the past along the east and west sides of the San Joaquin Valley and in areas to the west of the Delta near Stockton (see **Appendix B**).

TABLE VI-3
RESOURCES MANAGEMENT MEASURES ADDRESSING THE PRIMARY PLANNING OBJECTIVE OF WATER SUPPLY RELIABILTIY

Resources Management Measure	Potential to Address Planning Objective	Status/Rationale
Surface Water Storage		
Increase conservation storage space in Shasta Reservoir by raising Shasta Dam	**Very high** – Raising dam directly contributes to increased water supply reliability.	**Retained** – Consistent with primary planning objective and directly contributes to secondary objectives.
Construct new conservation storage reservoir(s) upstream from Shasta Reservoir	**Very low** – Limited potential to effectively contribute to increased system water supply reliability or other planning objectives.	**Deleted** - Upstream storage sites capable of CVP system-wide benefits would be very costly, result in environmental impacts difficult to mitigate and be inconsistent with the CALFED ROD.
Construct new conservation storage on tributaries to the Sacramento River downstream from Shasta Dam	**Low** – Several sites/projects, including Auburn Dam Project, have demonstrated an ability to contribute to system water supply reliability.	**Deleted** - Although potentially feasible sites/projects exist that could increase water supply, significant overriding environmental and socioeconomic issues restrict implementation at this time.
Construct new conservation offstream surface storage near the Sacramento River downstream from Shasta Dam	**Moderate to High** – Although not as effective as additional storage at Shasta, there is significant potential for offstream storage projects (NODOS) to contribute to increasing water supply reliability.	**Deleted** – Not as efficient as developing additional storage in Shasta Dam. NODOS being pursued as added increment to system by CALFED through a separate feasibility scope study initiated under PL 108-7.
Construct new conservation surface water storage south of the Sacramento-San Joaquin River Delta	**Moderate** – Potential for surface water storage projects (Upper San Joaquin River) to contribute to increasing water supply reliability to CVP primarily in the San Joaquin Valley and Tulare Lake Basin area.	**Deleted** - Not an effective alternative to additional storage at Shasta. Does not contribute to other planning objectives. Upper San Joaquin River being pursued as added increment to system by CALFED; feasibility scope study initiated under PL 108-7.
Increase total or seasonal conservation storage at other CVP facilities	**Moderate** – Would require several projects to contribute to water supply reliability (eg., raise Folsom and Berryessa).	**Deleted** – Not an efficient alternative to increasing storage in Shasta Reservoir; significantly higher unit cost for increased water supply. Known efforts to increase space in other northern California CVP (or SWP) reservoirs rejected by CALFED.
Reservoir Reoperation		
Increase effective conservation storage space in Shasta Reservoir by increasing efficiency of reservoir operation for water supply reliability	**Moderate to High** – Potential for increment of increased water supply reliability at Shasta Reservoir.	**Retained** – Although potential for increased water supply reliability is limited, added opportunities exist for increased flood control and other management elements.
Increase the conservation pool in Shasta Reservoir by encroaching on dam freeboard	**Very low** – Very small space increase possible.	**Deleted** - Very limited potential to encroach on existing freeboard above gross pool, which is only 9.5 feet. High relative cost to resolve uncertainty issues related to encroachment.
Increase conservation storage space in Shasta Reservoir by reallocating space from flood control	**Low** – Significant space reallocated to water supply could contribute to increased water supply reliability.	**Deleted** - Very low potential for implementation due to significant adverse impacts on flood control.
Conjunctive Water Management		
Develop conservation offstream surface storage near the Sacramento River downstream from Shasta Dam	**Moderate** – Potential to enhance system yield when combined with new storage and reoperation of Shasta.	**Deleted** – Implementing additional surface water storage project increment for Shasta would not be as efficient as new storage in Shasta Reservoir. Potential for shared storage in NODOS project is being considered in separate feasibility study initiated under PL 108-7.
Develop conservation groundwater storage near the Sacramento River downstream from Shasta Dam	**Moderate to High** – Significant potential to enhance system yield when combined with new storage and reoperation of Shasta.	**Retained** – In-lieu storage may be shown to be physically and economically effective combined with a modification of Shasta Dam. Would not conflict with other planning objectives. Would be consistent with goals of CALFED.
Develop additional conservation groundwater storage south of the Sacramento-San Joaquin River Delta	**Moderate** – Potential to enhance system yield when combined with new storage and reoperation of Shasta.	**Deleted** – Not as effective as storage north of the Delta and would not contribute to other study objectives.
Coordinated Operation		
Improve Delta export and conveyance capability through coordinated CVP and SWP operations	**Moderate** – Potential to enhance system yield when combined with new storage and reoperation of Shasta.	**Deleted** – JPOD is being actively pursued in other programs. A likely without-project condition.
Demand Reduction		
Implement water use efficiency methods	**Very Low** – Very limited potential to increase water supply reliability to the CVP.	**Deleted** – Not an effective alternative to new storage. Does not address other SLWRI planning objectives and constraints/criteria. Conservation being actively pursued by other CALFED programs. Most effective elements are likely a without-project condition.
Retire agricultural lands	**Moderate** – Would reduce water demand rather than increase ability to meet projected future demands.	**Deleted** - Not an alternative to new storage. Does not address planning objectives and constraints/criteria. Land retirement test programs being performed by Reclamation. On a large scale, could have significant negative impacts on agricultural industry.

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TABLE VI-3 CONTINUED
RESOURCES MANAGEMENT MEASURES ADDRESSING THE PRIMARY PLANNING OBJECTIVE OF WATER SUPPLY RELIABILTIY

Resources Management Measure	Potential to Address Planning Objective	Status/Rationale
Water Transfers and Purchases		
Transfer water between users	**Moderate** – Potential to help satisfy increase in future water demands.	**Deleted** - Not an alternative to new storage at Shasta Dam. Does not address planning objectives or constraints/principles/criteria. Will likely be accomplished with or without additional efforts to develop new sources.
Delta Export and Conveyance		
Expand Banks Pumping Plant	**Moderate to High** – Significant potential to help increase water supply reliability south of the Delta.	**Deleted** – Not an alternative to new storage north of the Delta. Does not address planning objectives or constraints/principles/criteria. Will likely be accomplished with or without additional efforts to develop new sources.
Construct DMC/CA intertie	**Moderate -** Significant potential to help increase water supply reliability south of the Delta.	**Deleted** - Not an alternative to new storage north of the Delta. Does not address planning objectives or constraints/principles/criteria. Will likely be accomplished with or without additional efforts to develop new sources.
Key: CVP – Central Valley Project Delta – Sacramento- San Joaquin River Delta DMC/CA – Delta-Mendota Canal/California Aqueduct	JPOD – joint point of diversion NODOS – north-of-delta offstream storage PL – Public Law	ROD – Record of Decision SLWRI – Shasta Lake Water Resources Investigation SWP – State Water Project

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Potential onstream storage sites are exclusively located on the east side of the valley due to the lack of significant annual runoff from the Coast Range. Several potential onstream storage sites could include enlarging Pardee Reservoir on the Mokelumne River, enlarging and modifying Farmington Dam on Littlejohns Creek, and enlarging Friant Dam on the upper San Joaquin River. Numerous potential offstream storage sites also have been considered in the San Joaquin valley. Several potential sites have been identified on the east side of the valley and would receive diverted flows from nearby rivers, but most sites are on the west side of the valley and designed to receive pumped water primarily from the California Aqueduct during periods of excess flows. Potential sites would include Los Vaqueros enlargement, Ingram Canyon Reservoir, Quinto Creek Reservoir, and Panoche Reservoir.

All of the potential onstream or offstream storage projects south of the Delta were dropped from further consideration primarily because they would not (1) contribute to the objectives of the SLWRI or (2) be as efficient or effective as additional storage in an enlarged Shasta Reservoir. In addition, feasibility scope investigations for both the Los Vaqueros and Upper San Joaquin River storage investigations were authorized in Section 215 of PL 108-7. Both studies are addressing specific planning objectives that are unique to their geographic areas, but differ from those of the SLWRI.

- **Increase total or seasonal conservation storage at other CVP facilities -** This measure primarily consists of providing additional conservation storage space in other major CVP (and/or SWP) reservoirs in the Sacramento River watershed through enlarging existing dams and reservoirs. Besides Shasta Dam and Reservoir, projects primarily would include additional storage in facilities such as Lake Berryessa on Putah Creek, Folsom Reservoir on the American River, Trinity Lake on the Trinity River, and Lake Oroville on the Feather River. It is believed that, of the existing reservoirs in the CVP/SWP systems, increasing water supply reliability through modifying Shasta Dam and Reservoir would be the most cost-effective. Further, all known efforts to increase storage space in other northern California CVP (or SWP) reservoirs were rejected by CALFED and local interest groups. For these reasons, and because this measure would not address all SLWRI study objectives, constraints, principles, and criteria, this measure was deleted from further consideration in the SLWRI.

Reservoir Reoperation

- **Increase the effective conservation storage space in Shasta Reservoir by increasing the efficiency of reservoir operations for water supply reliability –** This measure consists of changing the flood control operations of Shasta Dam and Reservoir (without reducing the maximum flood pool) with a goal of increasing water supply reliability. This measure would focus on revising the operation rules for flood control such that the facility could potentially be managed more efficiently for flood control, thereby freeing some seasonal storage space for water supply. A primary constraint would be to ensure no adverse impacts to the existing level of flood protection provided by the Shasta Dam project. It is believed that some degree of operational efficiency could be gained through a critical assessment of reservoir operations using more current analytical and weather forecasting tools. Although the potential for increased water supply reliability through reoperation efficiencies for flood control is believed to be limited, this measure was retained for further detailed consideration for possible inclusion in concept plans.

- **Increase the conservation pool in Shasta Reservoir by encroaching on dam freeboard –** This measure consists of increasing the conservation storage space in Shasta by raising the gross pool elevation without raising Shasta Dam. The current gross pool elevation at Shasta Dam is 1,067 feet and the top-of-dam elevation is approximately 1,076.5 feet. Accordingly, the design freeboard above maximum water surface elevation is 9.5 feet. It is estimated that major modifications would be required to the dam and appurtenances to allow operational encroachments on the design freeboard of the dam, only to gain a small potential increase in reservoir storage. This measure was deleted from further development primarily because it would have low potential to effectively address the planning objective.

- **Increase the conservation storage space in Shasta Reservoir by reallocating space from flood control –** This measure consists of decreasing the maximum seasonal flood control storage space in Shasta Reservoir and dedicating that space to water supply reliability in the CVP. It also includes constructing flood protection features along the Sacramento River to mitigate for potential induced flood damages. The maximum seasonal flood control storage space in Shasta is 1.3 MAF from December 1 through March 20, depending on accumulated seasonal inflow volumes. Reducing seasonal flood control storage space would reduce the ability of the reservoir to control peak flood flow releases. This would result in an increase in the frequency of flooding and flood damages along the Sacramento River downstream from Shasta Dam. This measure was deleted from further consideration in the SLWRI primarily because of its likely adverse impacts on flood controls.

Conjunctive Water Management

- **Develop conservation offstream surface storage near the Sacramento River downstream from Shasta Dam –** This measure consists of developing surface water transfer storage capabilities near the Sacramento River downstream from Shasta Dam to use in conjunction with storage in Shasta Reservoir. This storage would be an extension of storage space in Shasta Reservoir. Water temporarily stored or “parked” in the transfer storage facility would be delivered to local CVP contractors in substitution for their current diversions via either the ACID facilities or Tehama-Colusa Canal water users facilities. Water not diverted from the water users would remain in the Sacramento River to benefit anadromous fish, for delivery to downstream water users, and/or for Delta water quality. One possibility identified would be to consider some of the space in the Sites Reservoir project, or NODOS, that was previously described as conjunctive use storage for Shasta. This possibility is being considered in studies by DWR. However, development of a separate surface water storage project or space in the Sites Project expressly as part of the SLWRI is believed to be inconsistent with the planning objectives and constraints for the SLWRI. Accordingly, this measure was deleted from further consideration in the SLWRI. It continues to be considered, however, as part of the NODOS project.

- **Develop conservation groundwater storage near the Sacramento River downstream from Shasta Dam –** This measure consists of developing groundwater storage near the

Sacramento River. Similar to the surface storage measure described above, releases from Shasta Dam would be diverted from the Sacramento River and used to recharge local groundwater rather than be stored in a surface water facility. During drought periods, stored groundwater would be pumped for local uses. This pumped water would be substituted for surface water that would have otherwise been diverted from the Sacramento River during the irrigation season. Several options have been identified. One option would be similar to surface water conjunctive use storage except diverted water would be stored in groundwater basins adjacent to the Sacramento River. However, this option would be very costly due to the amount of land or land rights required. Another option would be to work with existing water contractors in the Sacramento River Valley to exchange surface water for in-lieu pumped groundwater, depending on the water year.

The in-lieu option of this measure was retained for further development primarily because it would have potential to help address the primary planning objectives and would be consistent with the identified plan formulation constraints and criteria. Also, it would be consistent with CALFED goals for the water storage component of the August 2000 ROD. It would not conflict with other planning objectives.

- **Develop additional conservation groundwater storage south of the Sacramento-San Joaquin River Delta –** This measure consists of either developing new groundwater recharge projects south of the Delta or contributing to existing recharge projects. It would include diverting flows during periods of excess from the San Joaquin River, Delta-Mendota Canal (DMC), or CA and helping recharge depleted groundwater basins. It is believed that this measure would have limited potential to allow storage from modifying Shasta to be temporally stored south of the Delta for later use during critical dry periods. Conjunctively using water in the DMC or CA is being actively pursued in other CALFED programs. These conjunctive use scenarios would not be significantly influenced by added system storage north of the Delta. This measure would not be as effective or efficient as increased storage space in Shasta Reservoir and would not contribute to the other primary planning objective. Accordingly, this measure was deleted from further consideration in the SLWRI because it would not effectively address primary planning objectives of the SLWRI.

Coordinated Operation

- **Improve Delta export and conveyance capability through coordinated CVP and SWP operations –** This measure primarily consists of improving Delta export and conveyance capability through a more effective coordinated management of surplus flows in the Delta. A specific application of the measure would be the joint point of diversion (JPOD). JPOD operations would allow Federal and State water managers to use excess or available capacity in their respective south Delta diversion facilities at the Tracy and Banks pumping plants. Currently, little excess capacity exists in the Federal pumps at Tracy, but some additional capacity is available in the SWP pumps at Banks. The potential added benefit to CVP through JPOD operations during average and critically dry years would be about 61,000 and 32,000 acre-feet, respectively. This measure is being actively pursued by Reclamation and DWR and it is highly likely that some form of the JPOD will be implemented in the future. This measure was deleted from further consideration in the SLWRI because it would not effectively address the primary study objectives and is likely to be implemented, in some form, independent of the SLWRI.

Demand Reduction

- **Implement water use efficiency methods –**WUE methods can make additional water supplies available to help meet expected future demands. It is important to note, however, that water "saved" by conservation practices is often water that, without conservation, would return to the hydrologic system and become a supply for other users. Accordingly, conservation does not simply mean reducing consumptive uses for crops in agricultural areas or for dwelling units in urban areas. However, conservation could apply when it consists of reducing irrecoverable water, or reducing water use that otherwise would be lost to the hydrologic system. For agricultural uses, examples of irrecoverable water would be (1) water used to leach salts from the soil and subsequently lost to the system through collection and evaporation, (2) water lost to excessive evaporation or transpiration, or (3) channel evaporation losses. For urban uses, examples of genuine water conservation would be reducing (1) residential landscape evapotranspiration requirements uses to evaporation or transpiration, (2) commercial, industrial, and institutional losses that are not recoverable, and (3) water distribution system losses or leakage in areas where water would not be recoverable.

  In its July 2000 Water Use Efficiency Program Plan, CALFED estimated that the potential for recovering currently irrecoverable losses in the Sacramento River and San Joaquin River basins was between 10,000 to 60,000 acre-feet per year (up to 40,000 acre-feet for agriculture and between about 10,000 to 20,000 acre-feet for urban conservation). Contained in the CALFED ROD is a program to pursue additional WUEs, including expanding existing water management programs and applying new technology. Specific methods range from installing automated delivery systems and lining canals in the agricultural sector to additional low-flow-device retrofits in the urban sector. Estimated costs to accomplish increased efficiencies in the Sacramento River and San Joaquin River basins range from about $100 to $600 per acre-foot for the agricultural sector, and approximately $200 to $2,000 per acre-foot for the urban sector. The CALFED WUE program is being implemented through a competitive grant/loan program.

  Many actions planned under the CALFED WUE program will be implemented with or without implementation of other projects to address water supply reliability. In addition, it is believed that as various WUE features continue to be implemented, additional opportunities will be significantly less efficient and more costly than other programs to improve water supply reliability. It is believed that additional WUE measures should be vigorously pursued by CALFED and local interests to help offset future shortages in water supplies. However, it is also believed that since this measure would not result in an increment of additional firm dry-period supply, and since it likely would depend on voluntary actions by numerous interests, the relative effectiveness in addressing the primary planning objective of the SLWRI would be highly uncertain. Accordingly, this measure was deleted from further consideration in the SLWRI.

- **Retire agricultural lands –** Recent studies indicate that by retiring 200,000 acres from irrigated croplands in the San Joaquin Valley, the demand for irrigation water could be reduced by about 236,000 acre-feet per year under average conditions. It is estimated that in dry and critically dry years, potential savings could be about 144,000 acre-feet per year. The estimated first cost to acquire land rights to permanently retire lands from irrigated agriculture uses would be over $600 million, resulting in an equivalent dry-period unit water cost likely in excess of $300 per acre-foot. Although the equivalent unit cost of water for this measure would be likely competitive with other potential water sources, this measure was deleted from further consideration because it would not be a substitute for new storage. Further, it would not address the primary planning objectives of the SLWRI. In addition, there would be a high degree of uncertainty regarding the institutional ability to acquire sufficient additional land rights necessary to preclude future irrigated agriculture on lands identified for inclusion in a project/program.

Water Transfers and Purchases

- **Transfer water between users -** This measure primarily consists of transferring water between users depending on water availability, storage capabilities, transmission capacity, and purchase/transfer costs to allow more efficient use of available supplies. This measure is reflected in the CALFED WUE program. Three potential water transfer projects were considered by CALFED: Semitropic Water Storage District’s Groundwater Banking and Exchange Program, Kern Water Bank, and Phase 8. Both Reclamation and DWR also have active water transfer programs and a significant number of water transfers will continue to occur in the future under without-project conditions as available supplies become scarce. Opportunities are available to enhance the existing transfer program with an estimated yield increase to the CVP of about 70,000 acre-feet in average years, and greater increases in critical and dry years. Currently, equivalent water yield costs from the program would likely be competitive with other new water sources. However, as water supply demands continue to grow and exceed developed supplies, especially during dry years, and as market conditions change, the unit water cost is likely to increase significantly. Consequently, this measure was deleted from further consideration in the SLWRI primarily because it would not be a substitute for new system storage at Shasta Reservoir.

Delta Export and Conveyance

The two measures in this category would divert surplus water when safe for fish, then bank, store, transfer, and release the surplus water as needed to protect fish and to compensate water users. This could be accomplished by increasing the capacity of conveyance facilities of the CVP and SWP at several locations, as follows:

- **Expand Banks Pumping Plant –** The current allowable pumping capacity at the SWP Banks Pumping Plant is 6,680 cfs. Efforts are underway by DWR and Reclamation to construct fish protection features under the SDIP to allow increasing the allowable pumping capacity to 8,500 cfs during certain seasonal periods. The maximum installed pumping capacity at Banks is about 10,300 cfs. This measure primarily includes implementing additional physical features and operational improvements aimed at benefiting the overall water quality of the Delta to further increase the allowable pumping capacity at Banks from 8,500 cfs to 10,300 cfs during certain seasonal periods, and splitting the increased pumping capacity equally between the CVP and SWP. This increased capacity would allow more water that otherwise would flow to the Pacific Ocean to be conveyed south of the Delta. It is estimated that the average annual increase in supplies south of the Delta allocated to the CVP could amount to over 100,000 acre-feet. The estimated unit cost for the increase in water supply reliability would be highly efficient when compared with other potential sources of new water supplies. However, because this measure would not contribute to the SLWRI planning objectives or identified plan formulation constraints, principles, and criteria, it was not viewed as a potential alternative to new storage in Shasta Reservoir. Accordingly, it was eliminated from further consideration in the SLWRI.

- **Construct DMC/CA intertie -** The pumping capacity of the CVP Tracy Pumping Plant into the DMC in the south Delta is 4,600 cfs. However, due to land subsidence in the southern reaches of the DMC, the effective capacity is limited to 4,200 cfs. Studies have considered modifying the subsided reach of canal and constructing a new canal parallel to the existing DMC. However, it appears that a more cost-effective measure would be to connect the DMC to the CA. In some locations, the two canals are about 400 feet apart horizontally and 50 feet apart vertically. A potential intertie would consist of constructing pumps and a 400-cfs-capacity conveyance canal between the two facilities several miles south of the Tracy Pumping Plant. It is estimated that this measure would result in an average annual increase in supplies south of the Delta of about 55,000 acre-feet. It is believed that the unit cost for the increase in water supply reliability for this measure would be comparable to other potential sources of new water supplies. However, because this measure would not contribute to the planning objectives of the SLWRI or identified plan formulation constraints, principles, and criteria, it was not viewed as a potential alternative to new storage in Shasta Reservoir. Accordingly, it was eliminated from further consideration in the SLWRI.

Measures Retained for Further Consideration

Three of the above management measures to increase water supply reliability were retained for inclusion into concept plans.

Increase Conservation Storage Space in Shasta Reservoir by Raising Shasta Dam

This measure consists of structural dam raises of Shasta Dam ranging from about 6.5 feet to approximately 200 feet. Included in **Chapter IX** are descriptions of features, accomplishments, major impacts, and costs for various dam raises within this range. Also included in the chapter is a comparison of various dam raise options.

Increase Effective Conservation Storage Space in Shasta Reservoir by Increasing Efficiency of Reservoir Operation for Water Supply Reliability

This measure consists of modifying the operation of Shasta Dam to improve water supply reliability. It can also assist in improving flood control. Potential methods to improve water supply reliability include modifying rainflood parameters in the operation rules for Shasta Lake and modifying the Shasta Dam release schedule. The goal of the operation changes would be to minimize the required evacuation of the reservoir during the period from about late November through March, and to possibly allow the reservoir to be filled more rapidly in the fall. As mentioned, a primary criterion would be to not reduce the existing level of flood control provided by Shasta Dam and possibly improve it. These possible reoperation opportunities are described in the reference report Assessment of Potential of Shasta Dam Reoperation for Flood Control and Water Supply Improvement.

Although the concept of this measure is being retained for inclusion in concept plans, its specific features and their influence on water supply reliability and flood damage reduction will not be developed until detailed operation modeling can be accomplished in further investigations as part of detailed alternative plan formulation in the SLWRI.

Develop Conservation Groundwater Storage near the Sacramento River Downstream from Shasta Dam

This in-lieu conjunctive water management measure primarily consists of using the incremental increase in stored water in Shasta Reservoir to support a shift in the timing of water diversion from the Sacramento River to help increase water supply reliability to other CVP and possibly SWP water users in dry periods. Under this measure, for agricultural interests willing to participate in an in-lieu program, during average and wetter years, more surface water from an increased storage space in Shasta Reservoir would be diverted from the Sacramento River and used in-lieu of groundwater pumping. Accordingly, during drought years less surface water would be delivered to agricultural users, who would depend more on groundwater supplies, allowing more of the normally diverted surface water to be delivered to other users. The in-lieu conjunctive water management program would need to include incentives to agricultural users to warrant their participation. Additional information on this measure is contained in **Appendix C** (Conjunctive Use Assessment).

MEASURES TO ADDRESS SECONDARY PLANNING OBJECTIVE – ECOSYSTEM RESTORATION

Identification of potential ecosystem restoration opportunities includes measures to address the primary objective of anadromous fish survival and the secondary objective of ecosystem restoration in the Shasta Lake vicinity and along the Sacramento River downstream from Shasta Dam. Of the 21 management measures identified to address the secondary restoration objective, 3 were retained for possible inclusion in concept plans (see **Table VI-4**).

It should be mentioned that some of the measures deleted from further consideration in this report for the purpose of ecosystem restoration might be determined in further studies to be suitable for helping mitigate potential adverse impacts of alternative plans. Further, some measures or expansions measures retained for further consideration also could be considered for mitigating adverse environmental and related impacts.

Measures Considered

Following is a brief discussion of the measures considered, which are separated into three categories: (1) cold water and warm water fisheries, (2) riparian and wetland habitat, and (3) other fish and wildlife habitat improvements. Rationale is included in this section for retaining or deleting measures. Also included are additional descriptions of the three measures retained for further consideration.

Cold Water and Warm Water Fisheries

- **Construct shoreline fish habitat around Shasta Lake –** Many of the shallow, warm water areas along the shoreline of Shasta Lake are capable of providing preferred habitat for juvenile fish and other adult resident fish species. The shorelines of most natural lakes and water bodies are lined with trees, rocks, debris, and other structures that provide cover. However, the shoreline of Shasta Lake is comparatively barren, which increases juvenile mortality. The lack of shoreline cover and suitable shallow water fish habitat is due to several factors, including steep topography, soils, wave action, and seasonal water fluctuations in the reservoir. These factors cause erosion and prevent vegetation from becoming established within the reservoir drawdown area. This measure consists of improving shallow, warm water habitat around the shoreline of Shasta Lake by planting resistant vegetation and placing large woody debris, boulders, and other aquatic “cover” structures within the drawdown area of the lake. This measure would support the secondary planning objective of preserving and restoring ecosystem resources in the Shasta Lake area. It would not conflict with any other ecosystem restoration measures that were preliminarily retained, nor would it conflict with other known programs or projects in the vicinity of Shasta Lake. This measure was retained for potential inclusion in concept plans primarily because it would be compatible with potential measures to raise Shasta Dam; habitat treatments could be extended, as needed, into the additional drawdown area.

- **Construct instream fish habitat on tributaries to Shasta Lake -** Tributary streams are an important environmental resource in the primary study area, supporting a variety of native and nonnative fish and other aquatic organisms. However, the quality and quantity of instream aquatic habitat has decreased over the last century due to the construction of dams, modification of stream hydrology, and other human influences. This measure consists of improving and restoring instream aquatic habitat along the lower reaches of major tributaries to Shasta Lake using various structural techniques to trap spawning gravel in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. It would not conflict with other known programs or projects in the vicinity of Shasta Lake. This restoration measure was retained for further consideration primarily because it would be compatible with potential measures to raise Shasta Dam and with other potential ecosystem restoration measures.

TABLE VI-4
RESOURCES MANAGEMENT MEASURES ADDRESSING THE SECONDARY PLANNING OBJECTIVE OF ECOSYSTEM RESTORATION

Resources Management Measure	Potential to Address Planning Objective	Status/Rationale
Cold Water and Warm Water Fisheries		
Construct shoreline fish habitat around Shasta Lake	**Moderate to High** – Contributes to ecosystem restoration goals within watershed.	**Retained** - Would complement measures to increase storage in Shasta Lake.
Construct instream fish habitat on tributaries to Shasta Lake	**Moderate to High** – Contributes to ecosystem restoration goals within watershed.	**Retained** - Would complement measures to increase storage in Shasta Lake. High local interest.
Increase instream flows on the lower McCloud River	**Moderate –** Potential to benefit aquatic resources on lower McCloud River	**Deleted –** Significant impacts to hydropower.
Reduce acid mine drainage entering Shasta Lake	**Moderate** – Significant benefit under certain hydrologic conditions.	**Deleted** – Significant implementation, O&M, and liability issues.
Reduce motorcraft access to upper reservoir arms	**Moderate** – Potential to benefit fisheries in Shasta Lake.	**Deleted** – Motorcraft management is under the purview of USFS.
Increase instream flows on the Pit River	**Moderate** – Potential to benefit aquatic resources in upper Pit River.	**Deleted** – Significant impacts to hydropower.
Construct a migration corridor from the Sacramento River to the Pit River	**Low** – High uncertainty as to the potential to successfully benefit area resources.	**Deleted** - Extremely high cost. High uncertainty of success.
Riparian and Wetland Habitat		
Restore riparian and floodplain habitat along the Sacramento River	**High** – Directly contributes to ecosystem restoration along mainstem Sacramento River.	**Retained** – Would be compatible with other primary study objectives. Consistent with other restoration programs and projects in the primary study area.
Restore wetlands along Fall River and Hat Creek	**Low** – Very low potential to contribute to ecosystem restoration in the Shasta Lake area.	**Deleted** – Significantly removed from primary study area. Independent action with low potential to contribute to other primary or secondary planning objectives.
Preserve upper Pit River riparian areas	**Low** – Very low potential to contribute to planning objective.	**Deleted** –Significantly removed from primary study area. Independent action with low potential to contribute to other primary or secondary planning objectives.
Restore riparian and floodplain habitat on lower Clear Creek	**Moderate** – Indirectly supports planning objective.	**Deleted** – Significant benefit to tributaries. Independent action and would not directly contribute to improved ecological conditions along mainstem Sacramento River.
Promote Great Valley cottonwood regeneration along the Sacramento River	**Moderate –** Potential to contribute to planning objective.	**Deleted** – High uncertainty for Federal participation and low potential to contribute to primary and other secondary planning objectives.
Preserve riparian corridor along Cow Creek	**Moderate** – Indirectly supports planning objective.	**Deleted** – Significant benefit to tributaries. Independent action and would not directly contribute to improved ecological conditions along mainstem Sacramento River.
Remove and control nonnative vegetation in the Cow and Cottonwood Creek watersheds	**Moderate** – Indirectly supports planning objective.	**Deleted** – Significant benefit to tributaries. Independent action and would not contribute to primary or secondary planning objective conditions along mainstem Sacramento River.
Other Fish and Wildlife Habitat Improvements		
Create a parkway along lower Clear Creek	**Moderate** – Indirectly supports planning objective.	**Deleted** – Significant benefit to tributaries. Independent action and would not directly contribute to primary or secondary planning objectives.
Create a parkway along the Sacramento River	**Moderate** – Can contribute to ecosystem restoration in the study area.	**Deleted** – Primarily focuses on land acquisition and conversion to public uses. As a project element, it would be a non-Federal responsibility with little direct Federal interest. Elements are a likely without-project condition.
Enhance forest management to preserve bald eagle nesting habitat	**Low to Moderate** – Can contribute to ecosystem restoration in study area.	**Deleted** – Likely a without-project condition; is an element of forest recovery plans by USFS.
Remove and control nonnative plants around Shasta Lake	**Low to Moderate** – Can contribute to ecosystem restoration in study area.	**Deleted** – Likely a without-project condition; is an element of forest recovery plans by USFS.
Control erosion and restore affected habitat in the Shasta Lake area	**Low to Moderate** – Can contribute to ecosystem restoration in study area.	**Deleted** – Likely a without-project condition; is an element of forest recovery plans by USFS.
Develop geographic information system for Shasta to Red Bluff reach	**Low to Moderate** – Can contribute to ecosystem restoration in study area.	**Deleted –** Would not directly contribute to other primary or secondary planning objectives. GIS mapping likely a without-project condition as part of other ongoing studies and projects.
Implement erosion control in tributary watersheds	**Moderate** – Indirectly supports planning objective.	**Deleted** – Significant benefit to tributaries. Independent action and would not directly contribute to improved ecological conditions near Shasta Lake or along mainstem Sacramento River.

Key:
GIS – geographic information system; O&M – operations and maintenance; USFS – United States Forest Service

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- **Increase Flows on the lower McCloud River –** This measure consists of increasing releases from McCloud Dam for the purpose of increasing flows on the lower McCloud River. This measure would benefit fisheries on the lower McCloud River. Currently, McCloud Dam operations are part of the Pit-McCloud Hydroelectric Project. Water is exported from the McCloud River watershed through a tunnel to Iron Canyon Reservoir and from there to a powerhouse on the Pit River. Dam operations maintain minimum flows between 40 and 50 cfs on the lower McCloud River. This measure was eliminated from further consideration for addressing the objective of ecosystem restoration primarily because of the significant adverse impact on hydropower generation. However, it is a good example of a measure that may be reconsidered in the future to help mitigate adverse impacts.

- **Reduce acid mine drainage entering Shasta Lake –** This measure consists of remediating the residual adverse environmental impacts of abandoned former mining operations on aquatic conditions in Shasta Lake and its tributaries. This measure was eliminated from further consideration due to numerous implementation issues.

- **Reduce motorcraft access to upper reservoir arms –** This measure consists of imposing additional boating and personal watercraft restrictions on portions of Shasta Lake. This measure was eliminated from further consideration primarily because motorcraft activity on Shasta Lake is already regulated by State and Federal boating laws, Shasta County, and the USFS; additional regulations (if applicable) would be more appropriate as part of these existing programs.

- **Increase instream flows on the Pit River –** This measure consists of increasing instream flows on the lower Pit River to benefit native fish and aquatic habitat through performing power buy-outs, altering power generation operations, or removing selected water diversions or diversion facilities. This measure was eliminated from further consideration primarily because of the significant adverse impact on hydropower generation from these existing facilities.

- **Construct a migration corridor from the Sacramento River to the Pit River –** This measure consists of providing passage to spawning areas upstream from Shasta Dam for anadromous fish from the Sacramento River. One concept includes connecting the upper Pit River to the Sacramento River consists of: (1) constructing a fish channel between the Cow Creek basin and the Pit River Arm of Shasta Lake; (2) constructing a fish barrier to prevent fish from entering Shasta Lake; and (3) installing fish screens and flow control structures at various locations along the natural and manmade migration route to prevent straying. This and similar measures were eliminated from further consideration primarily because of the (1) high cost for complex infrastructure, (2) major impacts to other facilities and extensive long-term operation and maintenance requirements, and (3) high uncertainty for the potential to achieve and maintain successful fish passage and spawning.

Riparian and Wetland Habitat

- **Restore riparian and floodplain habitat along the Sacramento River -** Riparian areas provide habitat for a diverse array of plant and animal communities along the Sacramento River, including numerous threatened or endangered species. Riparian areas also provide shade and woody debris that improve the complexity of aquatic habitat and its suitability for spawning and rearing. Lower floodplain areas, river terraces, and gravel bars play an important role in the health and succession of riparian habitat. These areas are seasonally flooded on a frequent basis, interacting with dynamic river processes such as erosion and deposition. Riparian and floodplain terrace habitat along the Sacramento is limited between Keswick Dam and Red Bluff. This is partially due to the natural topography and hydrology of the region; the Sacramento River is naturally more entrenched in this reach, and floodplains are narrow compared with the broad alluvial floodplains found lower in the Sacramento River system. This measure consists of restoring riparian and floodplain habitat along the Sacramento River to promote the health and vitality of the river ecosystem. It would not conflict with other ecosystem restoration measures that were preliminarily retained or with other known programs or projects on the upper Sacramento River. The restoration would support the goals of the Sacramento River Conservation Area (SRCA), CALFED, and other programs associated with riparian restoration along the Sacramento River. This measure was retained for consideration primarily because it would have a high likelihood of success in accomplishing effective restoration and would indirectly benefit aquatic habitat conditions for anadromous fish.

- **Restore wetlands along the Fall River and Hat Creek –** This measure consists of restoring marshlands and wetlands along Fall River and the Hat Creek, in the Pit River watershed. This measure was deleted from further consideration primarily because it is an independent action and would not be directly contribute to accomplishing the primary or other secondary planning objectives.

- **Preserve upper Pit River riparian areas -** This measure primarily consists of preserving high-value existing stands of riparian vegetation along the upper Pit River through acquiring environmental easements, and installing fencing and natural vegetation barriers around riparian corridors affected by grazing animals. This measure was eliminated from further consideration primarily because it is an independent action and would not directly contribute to accomplishing the primary or other secondary planning objectives.

- **Restore riparian and floodplain habitat along lower Clear Creek –** This measure includes restoring floodplain and riparian habitat along lower Clear Creek. This measure was deleted from considered further consideration primarily because it would not directly contribute to accomplishing the primary or other secondary planning objectives.

- **Promote Great Valley cottonwood regeneration on the Sacramento River –** This measure consists of actively supporting the Great Valley cottonwood regeneration concept along the Sacramento River. This concept includes working to replace lost floodplain sediment, recontouring floodplains that have disconnected from the river, and revegetating floodplain areas that could support Great Valley cottonwoods. This measure was eliminated from further consideration primarily because (1) there would be major complexities associated with continuing Federal participation in an ongoing broad-scope program in the Sacramento Valley, and (2) it would not directly contribute to accomplishing the primary or other secondary planning objectives.

- **Preserve riparian corridor along Cow Creek –** This measure consists of protecting and preserving the riparian corridor along Cow Creek. It primarily includes acquiring environmental easements, installing livestock fencing, developing natural vegetation barriers, and replanting streamside grasses, shrubs, and trees. This measure was deleted from considered further consideration primarily because it would not directly contribute to accomplishing the primary or other secondary planning objectives.

- **Remove and control nonnative vegetation in the Cow and Cottonwood Creek watersheds –** This measure consists of abating exotic vegetation in the Cow Creek and Cottonwood Creek watersheds through removing invasive species from riparian corridors. This measure was deleted from considered further consideration primarily because it would not directly contribute to accomplishing the primary or other secondary planning objectives.

Other Fish and Wildlife Habitat Improvements

- **Create a natural parkway along the Sacramento River -** Interest is growing in preserving public access to area rivers, lakes, streams, and other natural resources, and protecting their recreational, environmental, and aesthetic values. For instance, local groups have successfully established public parks and other ecosystem-focused conservation areas within the Redding area. This measure consists of establishing a natural, riverfront parkway along the Sacramento River near the Redding and Anderson urban areas to preserve riparian and floodplain habitat and promote habitat continuity along the river corridor. While this restoration would support the goals of the Sacramento River Conservation Areas (SRCA), CALFED, and other programs, it is primarily focused on acquisition of lands and land rights and converting existing uses to those supporting public uses. Because of the high focus on land acquisition, little known Federal interest would exist and small potential to contribute to the primary or other secondary objectives for the SLWRI. In addition, elements of this measure are being implemented as part of other programs and likely a without-project condition. Accordingly, this measure was deleted from further consideration as an element of the SLWRI.

- **Enhance forest management practices to preserve bald eagle nesting habitat –** This measure consists of enhancing bald eagle nesting habitat at various locations around Shasta Lake through forest management practices, including thinning, applying insecticides to reduce mortality from bark beetles and other pests, control stocking in conifer stands to encourage growth of large trees, and managing underbrush to protect important stands from wildfires. This measure was eliminated from further consideration primarily because it is a likely without-project condition.

- **Remove and control nonnative plants around Shasta Lake -** This measure consists of removing and controlling nonnative species at various locations around Shasta Lake primarily through herbicides, physical removal, or controlled burning. This measure was eliminated from further consideration primarily because it is a likely without-project condition. Also, it is similar to programs being implemented in the study area by USFS.

- **Control erosion and restore affected habitat in the Shasta Lake area –** This measure consists of restoring highly erodible lands in the Sacramento and Pit River watershed near Shasta Lake that have been impacted by timber harvest, historic smelter blight, and other human activities. This measure was eliminated from further consideration primarily because it is a likely without-project condition. Also, it is similar to programs being implemented in the study area by USFS.

- **Develop geographic information system for Shasta to Red Bluff reach –** This measure consists of developing a geographic information system (GIS) for the Sacramento River and tributaries between Shasta Dam and Red Bluff. This measure was deleted from further consideration primarily because (1) it would not directly contribute to accomplishing the primary planning objectives and (2) GIS-based mapping is being developed by numerous regional studies and local entities.

- **Implement erosion control in tributary watersheds –** This measure consists of implementing local erosion control projects in watersheds tributary to the Sacramento River to prevent loss of key floodplain and riparian habitat, and to preserve the quality of aquatic habitat impaired by excessive sediment input. This measure was deleted from further consideration as a potential restoration element primarily because it would not contribute to improved ecological conditions near Shasta Lake or along the upper Sacramento River and would not directly contribute to accomplishing the primary or other secondary planning objectives.

Measures Retained for Further Consideration

Each of the three resources management measures retained to address the secondary objective of ecosystem restoration in the Shasta Lake vicinity and along the Sacramento River downstream from Shasta Dam were considered in greater detail to determine how they might become components of concept plans. The locations of the shown measures are in **Figure VI-4** and described below in terms of their major components, accomplishments, and cost.

Construct Shoreline Fish Habitat Around Shasta Lake

The shorelines of most natural lakes and water bodies are lined with trees, rocks, debris, and other structures that provide aquatic cover. But the shoreline of Shasta Lake and other reservoirs is comparatively barren, increasing juvenile fish mortality. The lack of shoreline cover and suitable shallow water fish habitat is due to several factors, including the steep topography, soils, wave action, and seasonal water fluctuations in the reservoir. These factors cause erosion and prevent vegetation from becoming established within the reservoir drawdown area. In addition, large woody debris entering the lake from its tributaries is removed annually due to boating concerns. Shallow, warm water areas along the shoreline of Shasta Lake provide preferred habitat for juvenile fish and other adult resident fish species. This measure would improve shallow, warm water fish habitat at specific locations around the shoreline of Shasta Lake using resilient vegetation and aquatic “cover” structures within the upper drawdown area of the lake.

The measure would involve (1) installation of artificial fish cover, including anchored complex woody structures (root wads, trunks, and other large woody structures) and boulders, (2) planting of water-tolerant and/or erosion-resistant vegetation at prescribed locations within the reservoir drawdown area, and (3) selective reservoir rim clearing. Specific applications would be chosen as appropriate to site-specific shoreline conditions, taking into consideration bank slope, rate of erosion, proximity to tributaries, soils, and the presence of existing cover or vegetation. It is estimated that about 20 structures and approximately 400 selective plantings would be required for each acre of shoreline restored. The estimated life of the artificial cover structures could depend on the type of structure.

It is estimated that locations near the mouths of tributaries would be targeted for restoration because their lower reaches provide favorable spawning conditions and juvenile fish leaving the tributaries would benefit from improved adjacent shoreline habitat. Further, fishermen and other recreational users favor the mouths of tributaries. Shoreline areas with gradual slopes provide a wider, shallow-habitat area and would be more appropriate than steep banks that are prone to accelerated erosion. In addition, the sites would need to be undeveloped, provide reasonable construction access, and not be subject to significant recreational disturbances (i.e., adjacent to marinas, picnic areas, campgrounds, or other areas that attract large numbers of people). Several major and minor tributaries to Shasta Lake appear to have a high potential for application of this measure. For the purpose of this initial evaluation, it is estimated that sites at the mouths of eight perennial tributaries would be selected with approximately 5 acres of shoreline suitable for restoration at each site. Other areas also may have a high potential and would be evaluated in future studies.

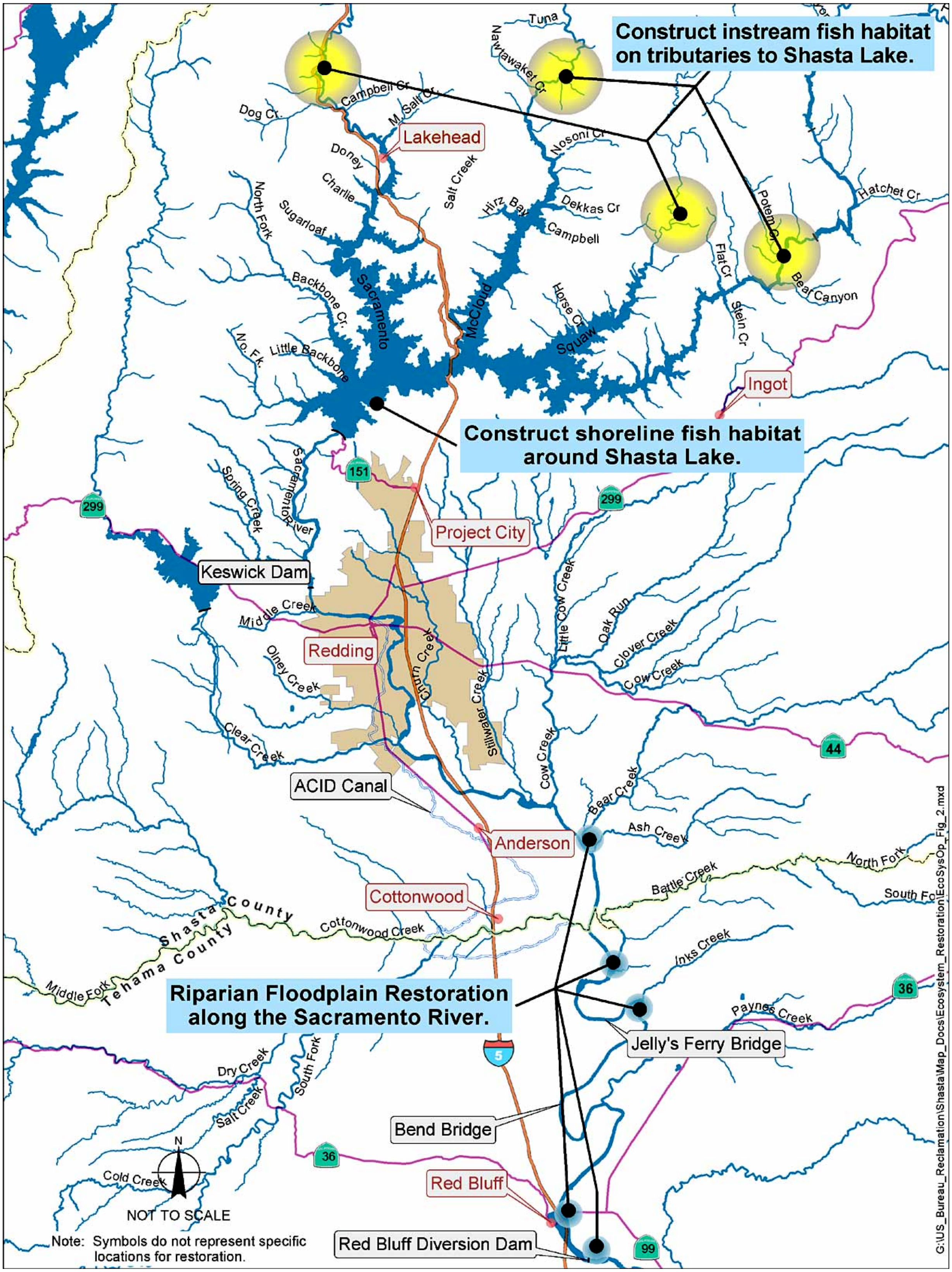

Figure VI-4 - Measures retained to address secondary planning objective – ecosystem restoration.

Major accomplishments of this measure would be to (1) increase the survival of juvenile fish by improving the quantity of available cover and overall quality of shallow water habitat, and (2) benefit land-based species that inhabit the shoreline of Shasta Lake through establishing resilient vegetation. This measure would support the secondary objective of preserving and restoring ecosystem resources in the Shasta Lake area. Increased shallow water fish survival also would enhance recreational sport-fishing opportunities in the lake.

Potential measures to raise Shasta Dam would increase the reservoir drawdown area that is subject to erosion and other factors that diminish shoreline habitat. This measure would complement measures to raise Shasta Dam because shoreline habitat treatments could be extended, as needed, into the additional drawdown area. This measure does not conflict with any other ecosystem restoration measures that were preliminarily retained, nor does it conflict with other known programs or projects in the vicinity of Shasta Lake.

The estimated certainty of the measure in achieving its intended accomplishments is moderate, primarily because numerous factors affect the sustainability of habitat within the drawdown area of the lake. An adaptive management approach that would monitor and modify restoration elements would improve the likelihood of success.

Construct Instream Fish Habitat on Tributaries to Shasta Lake

Tributary streams are an important environmental resource in the primary study area, supporting a variety of native and nonnative fish and other aquatic organisms. However, the quality and quantity of instream aquatic habitat has decreased over the last century due to construction of dams, modification of stream hydrology, and other human influences. This measure would improve and restore instream aquatic habitat along the lower reaches of major tributaries to Shasta Lake (see **Figure VI-4**).

This measure would primarily include various structural techniques to trap spawning gravels in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Structural treatments would vary depending on stream conditions but would generally include installing gabions, log weirs, boulder weirs, and other anchored structures. Spawning and rearing habitat would be created by providing instream cover with large root wads and by the use of drop structures, boulders, gravel traps, and/or logs that cause scouring and help clean gravels.

Although both perennial and intermittent streams would benefit from structural habitat improvements, the lower reaches of perennial tributaries to Shasta Lake would be targeted for aquatic restoration under this measure because they provide year-round fish habitat. Although up to nearly 20 miles of stream could be considered for this measure, initial implementation would likely be restricted to larger tributaries, after which the potential to expand to smaller tributaries could be assessed. For this measure, it is estimated that instream aquatic restoration would be performed along a total of 8 miles of stream, or about 2 miles along the lower reaches of each of the four major tributaries to Shasta Lake. The measure would involve construction of about 40 complex boulder/log structures per mile of stream to create gravel traps, pools, and riffles. The life of structural aquatic restoration measures would be highly dependent on localized streamflow hydrology and the occurrence of large flood events. It is estimated that many of the restoration activities would be conducted on Federal lands.

Major accomplishment of this measure would be to improve the quality and availability of aquatic habitat on tributary streams. This measure would support the secondary objective of preserving and restoring ecosystem resources in Shasta Lake. Both native and nonnative fish would benefit, including some lake fish that spawn on the lower reaches of the tributaries. It could also benefit steelhead, a native species that must be planted in the lake annually, as some natural reproduction occurs on the lower reaches of the tributaries to Shasta Lake. Improving aquatic habitat also would enhance recreational sport-fishing opportunities in the area.

This restoration measure would complement potential efforts to restore shoreline fish habitat in Shasta Lake because many juveniles that use shoreline habitat hatch on the lower reaches of the tributaries. Thus, improving and restoring aquatic habitat on the tributaries would increase the number of juveniles entering Shasta Lake. This measure would be compatible with potential measures to raise Shasta Dam and does not conflict with any other ecosystem restoration measures that were preliminarily retained. This measure does not conflict with other known programs or projects in the vicinity of Shasta Lake.

The estimated certainty of this measure in achieving its intended accomplishments is high. Most of the major tributaries to Shasta Lake are highly regulated, reducing the potential for improvements to be damaged or destroyed during extreme flow events. Similar activities have been accomplished with success on other, similar stream systems. CDFG, the Cantara Trust, and the CRMP group have participated in similar restoration activities in Shasta County. Restoration actions should be coordinated with local restoration groups, tribes, landowners, and the CDFG, as appropriate.

Riparian and Floodplain Restoration Along the Sacramento River

Riparian areas provide habitat for a diverse array of plant and animal communities along the Sacramento River, including numerous threatened or endangered species. Riparian areas also provide shade and woody debris that improve the complexity of aquatic habitat and its suitability for spawning and rearing. Lower floodplain areas, river terraces, and gravel bars play an important role in the health and succession of riparian habitat. These areas are seasonally flooded on a frequent basis, interacting with dynamic river processes such as erosion and deposition. Riparian and floodplain terrace habitat along the Sacramento is limited between Keswick Dam and Red Bluff. This measure consists of restoring riparian and floodplain habitat at specific locations along the Sacramento River to promote the health and vitality of the river ecosystem (see **Figure VI-4**).

This measure would involve acquiring and revegetating floodplain terraces and adjacent riparian areas with native plants. Suitable locations for restoration would be in areas with a 20 percent to 50 percent chance of flooding in any year (commonly referred to as 2-year to 5-year floodplains). Locations near the confluences of perennial tributary creeks and streams to the Sacramento River would have potential to provide maximum benefits. Continuity is also important to the health and vitality of riparian areas; small, isolated patches of riparian habitat tend to be less productive than larger, continuous stretches of habitat. It is estimated that a limited amount of land contouring and imported fill material would be required at several locations where the historic floodplain has been disconnected from the river or disturbed by human activity.

For the purpose of this preliminary evaluation, it is estimated that a total of 500 acres would be restored at one or more sites. Planting mix, composition, and density would be determined by a more detailed site analysis, but could include native cottonwood, willow, boxelder, valley oak, western sycamore, elderberry, and a variety of understory brush species. Temporary irrigation would be provided on an as-needed basis. The revegetated areas are expected to develop into self-sustaining riparian habitats within 1 to 4 years of initial planting, based on results of previous riparian restoration projects along the Sacramento River. Regraded floodplain areas are expected to change over time depending on hydrologic conditions, but it is anticipated that no elements of this measure would need to be replaced or reapplied during the 50-year project life. The site would be fenced to reduce the potential for access by livestock.

The measure would involve land acquisition, floodplain contouring and other earthwork, and revegetation. There appears to be local support for this type of restoration project along the Sacramento River. The primary accomplishment of this measure would be to restore native riparian habitat and associated floodplain lands. This measure would support the secondary objective of preserving and restoring ecosystem resources along the upper Sacramento River. Riparian habitat contributes to species diversity, water quality, and the quality of instream aquatic habitat, providing shade and a source of woody debris. In this manner, this measure indirectly supports the primary study objective to increase the survival of anadromous fish on the Sacramento River. The estimated certainty of this measure achieving the intended accomplishments is very high. Similar restoration projects along the Sacramento River have provided favorable, sustainable results.

This measure would combine favorably with potential measures to modify Shasta Dam because operational changes could benefit the natural riverine processes that drive sustainable riparian habitat regeneration. This measure would not conflict with other ecosystem restoration measures preliminarily retained or other known programs or projects on the upper Sacramento River. Restoration would support the goals of the SRCA, CALFED, and other restoration programs.

MEASURES TO ADDRESS SECONDARY PLANNING OBJECTIVE – FLOOD DAMAGE REDUCTION

Of four management measures identified to help reduce flood damages along the Sacramento River, one was retained for further development and possible inclusion in concept plans (**Table VI-5**). Following is a brief description of the measures and rationale for retaining or deleting measures.

- **Update Shasta Dam and Reservoir the flood management operations –** This measure consists of revising the established rules for operating Shasta Dam and Reservoir for flood management. This measure would include reassessing existing seasonal flood control storage space needs at Shasta using updated information on regional hydrologic and meteorological conditions and rainfall/runoff characteristics in the drainage basin. Potential methods to improve flood control would include improved long-range weather forecasting, implementing a forecast-based reservoir drawdown for flood control, changing the rate of outflows from Shasta Dam for flood control, and modifying target peak flows at Bend Bridge. These possible reoperation opportunities are described in the reference document Assessment of Potential Shasta Dam Reoperation for Flood Control and Water Supply Improvement. This measure was retained for further development primarily because it would be compatible with any potential modification of Shasta Dam and Reservoir. It would not conflict with other secondary planning objectives or planning constraints/criteria. As with reoperation for water supply reliability, although the concept of this measure is being retained for inclusion in initial alternatives, its specific features and their influence on water supply reliability and flood damage reduction will not be developed until detailed operational modeling can be accomplished in further investigations as part of detailed alternative plan formulation in the SLWRI.

- **Increase flood control storage space in Shasta –** This measure consists of increasing the flood control storage space in Shasta Reservoir primarily through raising the dam or reducing water conservation storage space. A variation would be to substitute water conservation storage space in Shasta with storage in another reservoir, such as the NODOS project, and use vacant seasonal space in Shasta for increased flood control. However, it is estimated that potential flood damage reduction benefits to be gained from either action would be far less than the costs to create increased storage space either in Shasta Reservoir or other facilities. For increased space resulting from raising Shasta Dam, it is estimated that the cost to raise the dam would significantly exceed potential flood control benefits. For space increase through reoperation, the expected costs to replace reduction in water reliability would also significantly exceed flood control benefits. This measure was not considered further primarily because it would likely conflict with the primary planning objectives. In addition, it would not be economically feasible (costs are expected to exceed benefits).

TABLE VI-5
RESOURCES MANAGEMENT MEASURES ADDRESSING THE SECONDARY PLANNING OBJECTIVES OF FLOOD DAMAGE REDUCTION AND INCREASING HYDROPOWER

Resources Management Measure	Potential to Address Planning Objective	Status/Rationale
Planning Objective of Flood Damage Reduction		
Update Shasta Dam and Reservoir flood management operations	**Moderate to High** – Directly contributes to planning objective.	**Retained –** Compatible with any potential modification of Shasta Dam and Reservoir. Potential to realize an increase in flood control with increasing size of Shasta Reservoir for primary planning objectives. Would not conflict with other secondary planning objectives and planning constraints/criteria.
Increase flood control storage space in Shasta	**Moderate** – Significant potential to further reduce peak flows on upper Sacramento River; however, low potential to reduce flood damages due to the relatively high level of protection from existing facilities.	**Deleted** – Would conflict with the primary planning objectives. Estimated low potential for economic justification (costs are expected to exceed benefits). For increased space via raising Shasta Dam, it is expected that dam raise construction costs would significantly exceed flood control benefits. For space increase through reoperation, expected costs to replace reduction in water reliability would also significantly exceed flood control benefits.
Implement nonstructural flood damage reduction measures	**Moderate** – Partially contributes to planning objective.	**Deleted –** Independent action and not directly related to accomplishing the primary or other secondary planning objectives.
Implement traditional flood damage reduction measures	**Moderate** – Partially contributes to planning objective.	**Deleted –** Independent action and not directly related to accomplishing the primary or other secondary planning objectives.
Planning Objective of Increased Hydropower		
Modify existing/construct new generation facilities at Shasta Dam to take advantage of increased hydraulic head	**Moderate to High** – Directly contributes to planning objective.	**Retained** - Potential to realize an increase in hydropower output from Shasta with increasing size of Shasta Reservoir for primary planning objectives. Would not conflict with other secondary planning objectives or planning constraints/criteria.
Construct new hydropower generation facilities	**Moderate** – Directly contributes to planning objective.	**Deleted** – This measure would directly contribute to the secondary planning objective but it is an independent action and not directly related to accomplishing the primary planning objectives. Although potential to realize additional hydropower benefits with increased/replaced hydropower facilities, could be pursued regardless of primary planning objectives.

- **Implement nonstructural flood damage reduction measures –** Typical nonstructural (or nontraditional) flood damage reduction measures can include (1) flood-proofing(temporary or permanently closing structures, raising existing structures, and constructing small walls or levees around structures), (2) floodplain evacuation (moving the structure and its contents to a safer site), (3) development of restrictions (restricting future building in flood-prone areas), and (4) flood warning (flood forecasting, warning, evacuation, and post-flood reoccupation and recovery). This measure was deleted from further consideration primarily because it is an independent action and would not be directly related to accomplishing the primary or other secondary planning objectives. Programs are already in place through State and Federal agencies to address flood hazard mitigation.

- **Implement traditional flood damage reduction measures –** Various structural methods to reduce flood damages include constructing levees or modifying the flood-carrying capacity of a river system. This measure was deleted from further consideration primarily because it is an independent action and would not be directly related to accomplishing the primary or other secondary planning objectives. Programs are already in place through State and Federal agencies to address flood hazard mitigation.

MEASURES TO ADDRESS SECONDARY PLANNING OBJECTIVE - HYDROPOWER

Two measures were considered to increase hydropower potential in the study area (see **Table VI-5**). Following is a brief description of each measure:

- **Modify existing/construct new generation facilities at Shasta Dam to take advantage of increased hydraulic head –** This measure consists of modifying the hydropower generation facilities at Shasta Dam to take advantage of any increases in water surface elevations resulting from enlarging the dam, if applicable. Nearly all releases from Shasta and Keswick dams are made through their generating facilities. On occasion, however, outflows during flood operations are made through the flood control outlets and occasionally over the spillway. During these instances, the existing powerplant is bypassed for much of the flood control (space evacuation) release. Power generated during these brief and infrequent periods generally has a lower value due to usually abundant supplies during winter periods. Raising Shasta Dam would allow the potential to reduce these flood releases in winter and allow water to pass through the generators later in the year when the water is usually more valuable. Further, with higher water surface elevation, greater energy levels (head) would be available for operating the turbines. With the greater total head, a need may exist to replace the existing power facilities, including turbines and penstocks, especially with large dam raises (e.g. 100 or 200 foot raises). This measure was retained for consideration as part of concept plans that include modifying Shasta Dam.

- **Construct new hydropower generation facilities –** This measure consists of constructing new hydropower facilities at Shasta Dam to increase the electrical generation capabilities from the project. This measure was not retained for further consideration primarily because it would not contribute either directly or indirectly to addressing the primary objectives and because it can be accomplished independent of modifying Shasta Dam and Reservoir.

MEASURES SUMMARY

Tables VI-6 and **VI-7** summarize the water resources management measures carried forward for potential inclusion in concept plans to address the primary and secondary planning objectives, respectively. Those being carried forward are believed to best address the objectives of the SLWRI, with consideration of planning constraints and criteria. It should be noted that measures that have been dropped from consideration at this stage might be reconsidered in the future as mitigation measures or other plan features. Similarly, additional measures not considered herein may be added to alternative plans as they are formulated.

TABLE VI-6
MEASURES RETAINED TO ADDRESS THE PRIMARY PLANNING OBJECTIVES

Primary Planning Objectives	Resources Management Measure	
Anadromous Fish Survival	Restore Spawning Habitat	Restore abandoned gravel mines along the Sacramento River.
	Modify TCD	Make additional modifications to Shasta Dam for temperature control.
	Enlarge Shasta Lake Cold Water Pool	Enlarge Shasta Dam and Reservoir to increase the cold water pool in the lake to benefit anadromous fish.
	Increase Minimum Flows	Modify the storage and/or releases operations of Shasta Dam and Reservoir to benefit anadromous fish.
Water Supply Reliability	Increase Conservation Storage	Increase conservation storage space in Shasta Reservoir by raising Shasta Dam.
	Reoperate Shasta Dam	Increase the effective conservation storage space in Shasta Reservoir by increasing the efficiency of reservoir operation for water supply reliability.
	Perform Conjunctive Water Management	Develop conservation groundwater storage near the Sacramento River downstream from Shasta Dam.
Key: TCD – temperature control device		

TABLE VI-7
MEASURES RETAINED TO ADDRESS THE SECONDARY PLANNING OBJECTIVES

Secondary Planning Objectives	Resources Management Measure	
Ecosystem Restoration	Restore Shoreline Aquatic Habitat	Construct shoreline fish habitat around Shasta Lake.
	Restore Tributary Aquatic Habitat	Construct instream fish habitat on tributaries to Shasta Lake.
	Restore Riparian Habitat	Restore riparian and floodplain habitat along the upper Sacramento River.
Flood Damage Reduction	Modify Flood Control Operations	Update Shasta Dam & Reservoir flood management operations.
Hydropower	Modify Hydropower Facilities	Modify existing/construct new generation facilities at Shasta Dam to take advantage of increased head.

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CHAPTER VII
CONCEPT PLANS

A set of concept plans was formulated from the retained resources management measures presented in **Chapter VI**. Because there is a vast array of potential measure combinations and sizes, the strategy was not to develop an exhaustive list of concepts or to optimize concept outputs. Rather, the purpose of this phase of the formulation process was (1) to explore an array of different strategies to address the primary planning objectives, constraints, and criteria, and (2) to identify concepts that may warrant further development into initial alternatives and then detailed alternative plans. These concepts are intended to promote discussion and provide a background for the formulation of initial alternatives and alternative plans in the remainder of the feasibility study, with input from participating agencies, stakeholders, and the public.

The formulation strategy for the concepts was to develop an array of plans representative of the range of potential actions to address objectives of the SLWRI. First, two sets of concepts were developed that focus on a single primary planning objective: either anadromous fish survival (AFS) or water supply reliability (WSR). Although the AFS and WSR concepts focus on single planning objectives, each contributes somewhat to both primary planning objectives. In the three AFS concepts, for example, emphasis was placed on the combinations of measures that could best address the fish survival goals while also considering WSR. Second, a set of concepts was developed that includes a mixture of measures to address both primary and secondary objectives, termed combined objective (CO) concepts.

This chapter is organized into five sections, beginning with a discussion of the Federal No-Action plan followed by a section with overview of the measures contained in the concepts, including a discussion of features that are common to some or all of the concepts. The AFS, WSR, and CO concepts then are discussed individually in the remaining three sections.

NO-ACTION (NO FEDERAL ACTION)

Under the No-Action plan, the Federal Government would take no action toward implementing a specific plan to help increase anadromous fish survival in the upper Sacramento River, nor help address the growing water reliability issues in California. The following discussions highlight the consequences of implementing the No-Action plan, as they relate to the objectives of the SLWRI.

Anadromous Fish Survival

Much has been done, especially over the last decade, to address anadromous fish survival problems in the upper Sacramento River. Solutions have ranged from changes in the timing and magnitude of releases from Shasta Dam to constructing and operating the TCD at the dam. Actions also include site-specific projects, such as introducing spawning gravels to the Sacramento River and work to improve or restore spawning habitat on tributary streams. However, some of these actions have been conflicting. These include implementing requirements of the Trinity River December 2000 ROD, which will reduce flows from the Trinity River basin into Keswick Reservoir and then into the Sacramento River. Water diverted from the Trinity River is generally cooler than flows released from Shasta Dam. Accordingly, when elements of the Trinity ROD are fully implemented, some of the benefits derived from flow changes and the Shasta TCD will be offset by the reduction in the cooler water from the Trinity River. Over time, especially with increasing needs for additional water supplies, the need will continue for helping to ensure long-term and sustained improvements in anadromous fish populations in the upper Sacramento River.

Water Supply Reliability

Demands for water in the Central Valley and throughout California exceed available supplies and the need for additional supplies is expected to grow. As the population of the Central Valley increases, along with the need to maintain a healthy and vibrant industrial and agricultural economy, the demand for adequate and reliable water supplies will become more acute. Competition for available water supplies will intensify as water demands increase to support M&I, and associated urban growth relative to agricultural uses. It is estimated that the demand for water in the future will significantly exceed available supplies. In drought years in the Sacramento River and San Joaquin River basins, estimated shortages would be about 1.7 MAF by 2020 and 2.6 MAF by 2040. Statewide, during drought years, shortages in reliable supplies could reach about 10 MAF by 2040. Water conservation and reuse efforts are increasing and forced conservation resulting from increasing shortages will continue. Without developing cost-efficient new sources, however, more reliance will be placed on shifting uses from such areas as agricultural production to urban uses. It is likely that with continued and deepening shortages in available water supplies, increasing adverse economic impacts will occur over time in the Central Valley and elsewhere in California.

Environmental Restoration, Flood Control, and Hydropower

Numerous opportunities exist to contribute to restoring ecosystem values in and around Shasta Lake and along the upper Sacramento River that would not be pursued under the No-Action plan. Opportunities exist in Shasta Lake and along the major tributary waterways to benefit resident warm and cold water fisheries. Downstream from Keswick Dam, numerous needs exist to help restore riparian, wetland, and riverine habitats, which support many individual plant and animal species. The quantity, quality, diversity, and connectivity of these habitats along the Sacramento River have been limited by the confinement of the river system by levees, reclamation of adjacent lands for farming, bank protection, channel stabilization, and land development. Conservation efforts, primarily through various State of California and local programs, will continue. However, many of these unmet opportunities and needs will continue in the future.

Shasta Dam and Reservoir have greatly reduced flooding along the Sacramento River. Shasta has paid for itself many times over compared to the amount of flood damages it has prevented. However, residual risks to human life, health, and safety remain. Development in flood-prone areas has exposed the public to the risk of flooding. Storms producing peak flows and volumes greater than the existing system was designed for can occur and result in extensive flooding along the upper Sacramento River. Any increase of storage space in Shasta Reservoir can help reduce downstream flood flows. Opportunities exist to better manage the flood control system especially with nonstructural actions on tributaries to the Sacramento River between Keswick and Bend Bridge. Under the No-Action plan, these problems would continue. Also, over the next 10 years, California's peak demand for electricity is expected to increase by over 30 percent. Under the No-Action plan, no new hydropower facilities would be constructed to help meet this growing demand.

OVERVIEW OF CONCEPT FEATURES

This section describes various measures or features that are common to all or many of the concepts. Specifically, it summarizes physical features common to the three dam raise scenarios, measures that are common to all of the concepts, and reservoir operation assumptions. The concepts and their unique features are discussed individually in the remaining sections of this chapter. **Table VII-1** summarizes how the retained measures were combined to form concepts that focus on anadromous fish, water supply reliability, or combined objectives.

TABLE VII-1
SUMMARY OF CONCEPT PLAN FEATURES

	Features (Measures Retained)												
		Primary Objective Focus							Secondary Objectives Addressed				
		Water Supply Reliability		Anadromous Fish Survival					Environmental Restoration			Flood Control & Hydropower	
	Raise Shasta Dam (feet)	Increase Conservation Space	Perform Conjunctive Water Management	Reoperate Shasta Dam	Modify TCD	Restore Spawning Habitat	Enlarge Shasta Lake Cold Water Pool	Increase Minimum Flows	Restore Shoreline Aquatic Habitat	Restore Tributary Aquatic Habitat	Restore Riparian Habitat	Modify Flood Control Operations	Modify Hydropower Facilities
AFS-1	6.5	*		Changes to water supply operations and modification of the TCD would likely be included, to some extent, in any alternative that includes raising Shasta Dam.			X					Changes to flood control operations and hydropower facilities would likely be part of any alternative that includes physically modifying Shasta Dam; the degree and details of these changes will be evaluated in future studies.	
AFS-2	6.5	*					*	X					
AFS-3	6.5	*				X	*	X					
WSR-1	6.5	X					*						
WSR-2	18.5	X					*						
WSR-3	200	X					*						
WSR-4	18.5	X	X				*						
CO-1	6.5	X				X	X						
CO-2	18.5	X				X	X						
CO-3	18.5	X				X	X	X					
CO-4	6.5	X	X			X	X		X	X	X		
CO-5	18.5	X	X			X	X		X	X	X		

Key:
AFS – anadromous fish survival CO – combined objectives TCD – temperature control device WSR – water supply reliability
X – Primary focus of concept * Coincidental benefit, although not a primary focus of the concept[1]

Note:
[1]Raising Shasta Dam provides both water supply and temperature benefits, regardless of the how the additional storage is exercised. While the AFS measures focus use of the additional space for anadromous fish survival, they also provide significant water supply benefits. Similarly, the WSR measures focus on water supply reliability but the reservoir enlargements also provide coincidental benefits to anadromous fish.

Common Physical Features

Many of the concepts share common physical features related to raising Shasta Dam. These include the physical or construction features of dam enlargement, and reservoir area relocations and other impacts.

Construction Features of Shasta Dam Enlargement

Each of the concepts includes enlarging Shasta Dam and Reservoir by 6.5 feet, 18.5 feet, or 200 feet. **Table VII-2** summarizes the various physical features, construction components, and modifications associated with the three dam raises.

TABLE VII-2
PHYSICAL FEATURES OF DAM RAISE SCENARIOS

Item	*Existing*	6.5-Foot Raise	18.5-Foot Raise	200-Foot Raise
Shasta Dam				
Type	*Concrete Gravity*	Concrete Gravity	Concrete Gravity	Concrete Gravity
Construction Means	-	Block Raise (crest)	Block Raise (crest)	Mass Raise (overlay)
Crest Elevation (ft)	*1,077.5*	1,084.0	1,096.0	1,280.0
Height Above Stream Bed (ft)	*487*	493.5	505.5	689.5
Dam Crest Length (ft)	*3,460*	3,660	3,770	4,930
Dam Crest Width (ft)	*30*	30	30	30
Shasta Lake				
Elevation Change				
Increase in Gross Pool (ft)	-	8.5	20.5	204.5
Elevation of Gross Pool (ft)	*1,067.0*	1,075.5	1,087.5	1,271.5
Elevation Min Operating Pool (ft)	*840*	840	840	840
Capacity (1,000 acre-feet)				
Capacity Increase	-	290	636	9,338
Total at Gross Pool[1]	*4,552*	4,842	5,188	13,890
Min Operating Pool	*590*	590 / 880[2]	590	590
Surface Area Increase (acres)	-	1,060	2,500	31,200
Shoreline Length (miles)	*408*	395	398	540
Reservoir Dikes	*None*	2 Minor Dikes	3 Minor Dikes	4 Major Dikes
Spillway & Outlet Works				
Spillway Crest Elevation (ft)	*1,037*	1,048	1,060	1,244
Top of Gates Elevation (ft)	*1,065*	1,075.5	1,087.5	1,271.5
Number & Type of Gates	*3 Drum Gates 28-ft x 110-ft*	6 Radial Gates 27.5-ft x 55-ft	6 Radial Gates 27.5-ft x 55-ft	6 Radial Gates 27.5-ft x 55-ft
Total Outlet Capacity (cfs)	*81,800*	88,000	92,100	133,600
Hydropower Features				
Penstocks	*5- to 15-ft diameter*	Strengthen Supports	Strengthen Supports	Replace Gates & Structural Supports
Powerplant	*578 MW*	No Major Modification	No Major Modification	Add Units
Switchyard	-	No Change	No Change	Replace
Keswick Dam and Powerplant	-	No Change	No Change	Modification Required
Temperature Control Device	*Shutter Structure*	Raise/Modify Controls	Raise/Modify Controls	Replace Structure

Key:
cfs – cubic feet per second; ft – feet; min – minimum; MW – megawatt; UPRR – Union Pacific Railroad
All elevations in feet above mean sea level

Notes:
[1]Increase in gross pool elevation is greater than the magnitude of the dam raise, largely due to the increased efficiency of the steel radial spillway gates that would replace the existing drum gates.
[2]Concept AFS-1 includes increasing the minimum operating pool to 880,000 acre-feet. All other plans assume existing minimum operating pool of 590,000 acre-feet.

Reservoir Area Relocations and Other Impacts

Table VII-3 summarizes relocations and other reservoir area impacts associated with the three dam raises included in the concepts. These impacts would generally be the same for any alternative that included one of the three raises listed.

TABLE VII-3
RESERVOIR AREA IMPACTS ASSOCIATED WITH DAM RAISE OPTIONS

Item	6.5-Foot Raise	18.5-Foot Raise	200-Foot Raise
Pit River Bridge	Minor skirting around Piers 3 and 4	Skirting around Piers 3 and 4	Relocate
Other Bridges[1]	Replace 7 bridges	Replace 7 bridges	Replace 20 bridges
Recreation Facilities	Minor	Moderate	Impact all
Structures	45	130	630
Roads	About 75 small segments (45 paved and 30 unpaved) of existing roads impacted, including portions of Lakeshore Drive, Gilman and Ferder Ferry Roads, Bully Hill Road, and Silverton Road	About 115 segments of existing paved / nonpaved roads impacted; embankments would be constructed for protection of I-5 at Lakeshore and the UPRR at Bridge Bay	About 35 miles of the UPRR, 19 miles of I-5, and numerous associated tunnels, embankments, and other facilities would be relocated; many miles of local roads also would be impacted
Vegetation and Habitat Around Reservoir Rim	Maximum inundation area would increase by about 1,060 acres (3 percent)	Maximum inundation area would increase by about 2,500 acres (8 percent)	Maximum inundation area would increase by about 31,200 acres (roughly double that of existing conditions)
Habitat Along Shasta Lake Tributaries	Infrequent increased inundation along lower tributaries: Sacramento River – 1,100 lf Squaw Creek – 500 lf North Fk Squaw Ck – 500 lf McCloud River – 1,420 lf	Infrequent increased inundation along lower tributaries: Sacramento River – 3,100 lf Squaw Creek – 1,700 lf North Fk Squaw Ck – 1,700 lf McCloud River – 3,480 lf	Periodic increased inundation along lower tributaries: Sacramento River – 6 miles Squaw Creek – 4 miles North Fk Squaw Ck – 2 miles McCloud River – 5 miles
Other	-	-	Removal of Pit 7 Dam
Key: I-5 – Interstate 5	lf – linear feet	UPRR – Union Pacific Railroad	

Note:
[1]Most bridges impacted would be replaced with higher elevation structures at the same location, but some could be modified or retired. Replacement of the I-5 Antlers Bridge is included in the without-project condition.

Raising the gross pool of the lake would cause direct impacts due to higher water levels, and/or indirect impacts related to facility access, operation, and maintenance. General types of impacts include potential inundation and resulting relocation of buildings, sections of paved and nonpaved roads, campground facilities such as parking areas and restrooms, and low-lying bridges. Use of and access to recreation facilities also may be impacted, including trails, day-use picnic areas, boat ramps, marinas, campgrounds, resorts, and beaches. Several of the main buildings associated with Bridge Bay Resort and Marina, the largest resort and marina complex on Lake Shasta, are located within a few feet of the existing gross pool elevation.

Illustration of the extent of inundation for the 6.5-foot and 18.5-foot dam raise is provided in **Plate 13**. The plate shows increased inundation on the Sacramento River arm at the community of Lakeshore, the most populated area around the lake. Due to the gently sloping shoreline adjacent to Lakeshore, this area is representative of the maximum lateral increase in inundation that could be expected with dam raises up to 18.5 feet. The community of Sugarloaf also would be impacted. Additional information on the potential extent of inundation and impacted structures can be found in the reference document Shasta Reservoir Area Inventory, Shasta Dam and Reservoir, California (February 2003).

The McCloud River is an area of specific interest. California Public Resources Code 5093.542(c) restricts state involvement in studies to enlarge Shasta Dam and Reservoir if that action could have an adverse effect on the free-flowing conditions of the McCloud River or its wild trout fishery. **Plate 14** illustrates the estimated increase in area of inundation on the McCloud River upstream from the McCloud Bridge for the 6.5- and 18.5-food dam raises. As shown in **Table VII-3** and on the plate, raising Shasta Dam 6.5 feet would result in inundating an additional 1,420 lineal feet (about 9 acres) of the lower McCloud River. This represents about 1 percent of the 24-mile reach of river between the McCloud Bridge and the McCloud Dam, which controls flows on the river. For a dam raise of 18.5 feet, an estimated additional 3,480 feet (27 acres) of the lower McCloud River would be impacted. This represents about 2.7 percent of the designated reach. **Plate 15** shows the maximum area of inundation for dam raises of up to 200 feet.

Inventories are underway to help define the precise character of the habitat likely impacted by enlarging Shasta Dam and Reservoir. A major emphasis of the next phase of the SLWRI will be to define specific impacts and features to mitigate those impacts. This will influence the type and magnitude of additional features to be included in alternative plans to compensate for potential impacts. The concepts presented herein do not include specific mitigation measures, but it is estimated that these features could include the following:

- More aggressive management of reservoir area lands and/or restoring significantly degraded habitat in the reservoir area
- Physical means of improving aquatic habitat in the reservoir drawdown area and along the lower reaches of tributaries to Shasta Lake (similar to the artificial fish cover and instream habitat improvements proposed in the retained ecosystem restoration measures)
- Initiating land acquisition and management efforts with a focus on improving the quality or quantity of wildlife habitat.

Measures Common to All Concepts

Three of the measures retained in **Chapter VI** are included, to some degree, in all of the concepts: modification of the TCD, reoperation for flood control, and modification of hydropower facilities. These measures would be included, to some extent, with any enlargement of Shasta Dam, as described below.

- **Modification of the TCD -** The minimum modifications to the TCD that would be required if Shasta Dam were raised 6.5 feet, 18.5 feet, or 200 feet are summarized in **Table VII-2**. However, additional modifications to increase the operating range or effectiveness of the TCD might also be included in future alternatives. More understanding about the operation of the existing TCD is needed to identify possible improvements. Future studies will determine what modifications to the TCD are possible and practical, and how they could be included in alternative plans. For the purpose of this analysis, the existing shutter configuration was used for all simulations.

- **Reoperation of Shasta Dam for flood control -** Physical enlargement of Shasta reservoir would require alterations to the existing flood control operational guidelines or rule curves. The guidelines could be simply adjusted to reflect the physical increase in dam/spillway elevation, or the guidelines could be reformulated to optimize use of the additional storage for flood control and/or increase the flood protection currently provided by the dam. Additional information on potential modifications to the operation rules at Shasta Dam is contained in the reference document Assessment of Potential Shasta Dam Reoperation for Flood Control and Water Supply Improvement.
- **Modification of hydropower facilities at Shasta Dam –** Physical enlargement of Shasta Dam would require various minimum modifications to the existing hydropower facilities at the dam, as summarized in **Table VII-2**, to enable their continued use. However, future alternatives could include additional modifications to increase the power production capabilities of the reservoir (e.g., additional penstocks and generators), commensurate with the magnitude of the enlargement. These opportunities will be evaluated in future studies.

These measures were included in each of the concepts because they would accompany any enlargement, but the extent of modification and/or reoperation was not considered at this time. Future studies will evaluate these measures in greater detail and determine how they could best be combined with the various dam raise and operation scenarios. Hydropower enhancements and increases in flood protection are believed to be separable and independent, and not necessary to identify plans warranting further evaluation in the SLWRI.

Reservoir Operation

The concept plans provide a basis for relative comparison of a range of potential actions to address the SLWRI objectives. To maintain a common baseline among the concepts, it was estimated that the reservoir, and any additional storage created by raising the dam, would be operated as under existing conditions and according to existing institutional agreements. **Plate 16** illustrates simulated reservoir storage fluctuations under existing operating rules for the baseline and three dam raise scenarios. Additional information on potential modifications to the operation of Shasta Dam is contained in the reference document Assessment of Potential Shasta Dam Reoperation for Flood Control and Water supply Improvement. Future studies will explore the potential to reoperate the reservoir and optimize the use of additional storage space for water supply reliability, anadromous fish survival, and other beneficial uses.

Water Rights

The current applications held by Reclamation for the appropriation and use of water in Shasta Lake was issued by the State Water Right Board (now the SWRCB) in 1961 under Decision 990. Any plan to enlarge Shasta Lake would require filing a new application with the SWRCB, or a petition to change an existing state-filed application, for appropriation of new yield created by the enlargement. Such a petition would be published in public venues and interested parties would be given time to file any protests or objections. Protests could be based on numerous issues, such as injury to prior rights, proposed allocation of new yield to the CVP/SWP, or Delta water quality, and could result in a formal hearing by the SWRCB. Potential water rights issues related to enlarging Shasta Dam will be investigated in greater depth when detailed alternative plans provide a clear picture of the amount of, and potential uses for, any additional yield.

CONCEPTS FOCUSED ON ANADROMOUS FISH SURVIVAL

Three concept plans were formulated from the resource management measures retained to address the primary objective of anadromous fish survival (see **Chapter VI**). The main focus of these concepts is on anadromous fish survival in the upper Sacramento River, but each contributes somewhat to water supply reliability. While numerous possible combinations of the type and size of the measures make up these concepts, those shown in **Table VII-1** and described below are believed to be reasonably representative of the range of potential actions.

Each of the three AFS concepts includes raising Shasta Dam 6.5 feet, which would raise the gross pool level by 8.5 feet and enlarge the reservoir by 290,000 acre-feet. Although larger dam raises could produce greater benefits to fisheries, the goal at this stage in plan formulation was to provide a common baseline from which the relative performance of the three AFS concepts could be compared. The primary difference between the three AFS concepts is in how the additional storage gained by the raise would be used to benefit anadromous fish. AFS-1 focuses the additional storage on regulating water temperature on the upper Sacramento River, while AFS-2 and AFS-3 focus the additional storage on regulating flows on the upper Sacramento River. AFS-3 also adds an additional increment, fish habitat restoration on the upper Sacramento River.

Concept AFS-1 - Increase Cold Water Assets with Shasta Operating Pool Raise (6.5 Feet)

Concept AFS-1 focuses on the primary planning objective of anadromous fish survival by raising Shasta Dam 6.5 feet to enlarge the pool of cold water in Shasta Lake for the primary purpose of maintaining cooler water temperatures in the upper Sacramento River.

Major Components

Concept AFS-1 includes the following major components:

- Raising Shasta Dam by 6.5 feet for the primary purpose of enlarging the cold water pool and regulating water temperature in the upper Sacramento River.
- Increasing the size of the minimum operating pool to 880,000 acre-feet.

Both of these components focus on increasing the volume of cold water in Shasta Lake available for regulating water temperature on the upper Sacramento River. AFS-1 would increase the capacity of the reservoir by 290,000 acre-feet to a total of 4.84 million acre-feet. The existing TCD would be extended and potentially modified to achieve efficient use of the expanded cold water pool. In addition, the minimum end-of-October carryover storage target would be increased from 1.9 MAF to about 2.2 MAF, increasing the minimum operating pool to 880,000 acre-feet. This would allow additional cold water to be stored for use the following year. No changes would be made to the existing seasonal temperature targets for anadromous fish on the upper Sacramento River, but the ability to meet these targets would be improved.

Accomplishments

The accomplishments of concept AFS-1 are described below in relation to their contribution to the objectives of the SLWRI.

- **Anadromous Fish Survival -** Water temperature is one of the most important factors in achieving recovery goals for anadromous fish in the Sacramento River. Concept AFS-1 would increase the ability of Shasta Dam to make cold water releases and regulate water temperature in the upper Sacramento River, primarily in dry and critically dry years. This would be accomplished by raising Shasta Dam by 6.5 feet, thus increasing the depth of the cold water pool in Shasta Reservoir and resulting in an increase in seasonal cold water volume below the thermocline (layer of greatest water temperature and density change). Cold water released from Shasta Dam significantly influences water temperature conditions in the Sacramento River between Keswick and Red Bluff, and can have an extended influence on river temperatures farther downstream. Hence, the most significant benefits to anadromous fish would occur upstream from Red Bluff, but some degree of benefit could be realized as far downstream as the Delta.

- The relationship between anadromous fish mortality and environmental conditions (including water temperature) is very complex. Consequently, additional studies are required to ascertain specific benefits to the anadromous fishery in the Sacramento River (reduced mortality or increase in population) resulting from increasing the cold water pool in Shasta Lake. However, a preliminary assessment was conducted using analytical approaches similar to those used previously in evaluating the benefits of the TCD. Although the preliminary assessment has notable limitations (see summary in **Chapter IX** or description in **Appendix D**), it provides a means for comparing the relative performance of the concepts. On the basis of this assessment, it is estimated that AFS-1 could contribute to an average annual increase (reduction in mortality) of salmon amounting to about 860 fish (see **Table VII-4**). For higher dam raise scenarios with corresponding increases in the minimum operating pool, the benefit to salmon would be proportionally greater.

- **Water Supply Reliability -** Concept AFS-1 would only incidentally contribute to increasing the water supply reliability of the CVP and SWP systems.

- **Environmental Restoration, Flood Control, and Hydropower -** Although the focus of this concept was on benefiting anadromous fish in the upper Sacramento River by increasing the cold water pool in Shasta Lake, minor secondary benefits would occur. The higher water surface in the reservoir would result in a net increase in power generation of about 51 gigawatt-hours (GWh) per year (see **Chapter IX**). The ability to manage floods would not increase significantly. AFS-1 does not include any specific measures to address the secondary objective of environmental restoration.

- **Other Accomplishments -** Water-oriented recreation at Shasta Lake, and the services it supports, are very important to the economic health and well-being of the community of Redding and surrounding area. AFS-1 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area. The maximum surface area of the lake would increase by about 1,060 acres (3 percent), from 29,600 to about 30,700 acres.

TABLE VII-4
SUMMARY OF BENEFITS AND COSTS FOR CONCEPTS

Name	Primary Objectives			Secondary Objectives			Cost ($ millions)	
	Increase in Water Supply Reliability (1,000 acre-feet/yr)[1]	Average Annual Salmon Increase[2]	Increase in Spawning Habitat (acres)[3]	Ecosystem Restoration Benefits[4]	Flood Control Benefits[5]	Hydropower Generation (GWh/year)	First Cost[6]	Annual Cost[7]
AFS-1	Incidental	860	-	-	-	51	282	19
AFS-2	20	370	170	-	-	32	282	19
AFS-3	20	370	320	-	-	32	292	20
WSR-1	72	410	-	-	-	15	282	19
WSR-2	125	1,110	-	-	-	44	408	28
WSR-3	703	10,620	-	-	Major	2,254[8]	5,250	383
WSR-4	146	1,020	-	-	-	44	459	32
CO-1	72	410	150	-	Minor	15	292	20
CO-2	125	1,110	150	-	Minor	44	418	29
CO-3	90	980	320	-	Minor	61	418	29
CO-4	89	410	150	500+ acres	Minor	12	356	25
CO-5	146	1,020	150	500+ acres	Minor	44	483	34

Key:
AFS – anadromous fish survival CO – combined objective GWh – gigawatt-hour WSR – water supply reliability

Notes:
[1]Increase in water supply reliability during drought year conditions with Banks Pumping Plant capacity at 6,680 cfs.
[2]Initial estimates for comparison purposes only; to be refined in future investigations.
[3]Includes habitat increase from restoring spawning areas and/or increasing minimum flows, consistent with the objectives of the AFRP. Acres of aquatic habitat associated with increasing minimum flows are preliminary.
[4]Includes restoring riparian and wetland floodplain habitat along the upper Sacramento River and resident fish habitat around Shasta Lake and the lower reaches of its tributaries. Total area and location(s) to be determined.
[5]All concepts provide incidental flood control and hydropower benefits because they all include enlarging Shasta reservoir. The potential range of flood control and hydropower benefits will be evaluated in future studies.
[6]Costs are based on October 2003 price levels.
[7]Costs are annualized using 5-5/8 percent interest over a 100-year period of analysis.
[8]Does not include reduction in generation from the loss of the Pit 7 Dam.

Primary Impacts and Mitigation

Reservoir area relocations and other impacts related to raising Shasta Dam by 6.5 feet are summarized in **Table VII-3**. They include modifying the Pit River Bridge, replacing 7 other bridges, relocating 45 structures, and inundating numerous small segments of existing paved and nonpaved roads. About 20 buildings associated with marinas or resorts would be affected directly, and about 25 other buildings associated with ancillary facilities could be affected indirectly due to their proximity to the new water surface at gross pool.

In most years, fluctuation in the lake surface would be similar to without-project conditions because the operation of Shasta Lake would not change significantly for AFS-1. However, water in the reservoir would be drawn down about 8.5 feet below existing conditions during the late fall and winter of some dry years, corresponding to an increase in the drawdown zone of roughly 21 linear feet. It is believed that the potential adverse impacts to recreation of this additional drawdown would be minimal and outweighed by the recreational benefits resulting from the average annual increase in lake surface area.

The expanded drawdown zone would be inundated about once every 3 years, for periods ranging from several days to 10 months. Vegetation in the expanded drawdown zone would eventually be lost over time, but significant amounts would remain on the lower slopes due to the infrequent inundation. As summarized in **Table VII-3**, the lower reaches of tributaries to Shasta Lake also would experience increased inundation.

AFS-1 includes increasing the carryover storage target from 1.9 MAF to about 2.2 MAF, which would have a minor impact on seasonal flows in the upper Sacramento River. There would be an average maximum reduction in winter flows of about 300 cfs (3 percent of without-project flows), and an average maximum increase in summer flows of about 200 cfs (2 percent). It is believed that these relatively small changes in flows would not result in any significant impacts to fish and/or wildlife resources downstream from Shasta Dam.

Economics

Economic analysis provides a framework for quantifying estimated costs and benefits and for assessing the relationships between costs and benefits. For potential Federal projects to be implemented, national economic benefits must exceed project costs. Further, the amount of benefits in excess of costs (net benefits) helps in identifying the potential Federal and non-Federal shares of a project. National Economic Development (NED) and National Environmental Restoration (NER) benefits will be developed in the next phase of the investigation.

A summary of estimated first and annual costs and summary of anticipated benefits is provided for each concept. A breakdown of costs by major plan feature, and the estimated first and annual costs for each of the concepts is contained in **Chapter IX**. The estimated first costs are based largely on information contained in the Reclamation 1999 Appraisal Report and recent information on relocations. The annual cost is based on a project life of 100 years and a Federal discount rate of 5-⅝ percent. A comparison of the concepts based on these and other factors is contained in **Chapter VIII**.

- **Costs -** The estimated first cost for this plan is $282 million (see **Table VII-4**). The estimated annual costs amount to about $19 million.
- **Benefits -** The most significant benefit of AFS-1 is the increase in anadromous fish population, estimated as 860 fish per year on average. The plan would not provide significant benefits to water supply reliability, although it would provide incidental increases in hydropower. Consequently, all initial costs for this plan would be allocated to anadromous fish survival. The primary benefits of the concepts are summarized in **Table VII-4**.

Concept AFS-2 – Increase Minimum Anadromous Fish Flow with Shasta Enlargement (6.5 Feet)

AFS-2 focuses on the primary planning objective of anadromous fish survival by increasing minimum seasonal flows in the upper Sacramento River from the current 3,250 cfs to about 4,200 cfs.

Major Components

The primary component of concept AFS-2 includes the following major component:

- Raising Shasta Dam by 6.5 feet for the primary purpose of enlarging the volume of water available to meet minimum flows for winter-run salmon on the upper Sacramento River.

Additional storage created by raising the dam is focused on increasing the minimum flow target for winter-run salmon on the upper Sacramento River, consistent with the goals of the January 2001 Final Restoration Plan for the AFRP. Similar to AFS-1, this concept would increase the capacity of the reservoir by 290,000 acre-feet to a total of 4.84 million acre-feet, and extend the existing TCD to achieve efficient use of the expanded reservoir. AFS-2 differs from AFS-1 in that the additional storage would be used to increase minimum flows, rather than temperature, and no changes would be made to the carryover target volume or minimum operating pool.

For this concept, the 290,000 acre-feet of additional storage would allow the minimum flow target in the upper Sacramento River to be increased from 3,250 cfs to 4,200 cfs, without adversely impacting water supply deliveries to the CVP. Although 4,200 cfs does not represent flows that produce optimal spawning conditions in the river (closer to 5,000 cfs), it is believed to represent a possible balance between the various beneficial uses of the reservoir. Future alternatives could consider higher flow targets if negative water supply and hydropower impacts could be offset by larger storage increases in Shasta Dam (e.g., dam raises higher than 6.5 feet).

Accomplishments

The accomplishments of concept AFS-2 are described below in relation to the objectives of the SLWRI.

- **Anadromous Fish Survival -** In addition to temperature, river flow is an important factor influencing anadromous fish survival. Flows in the upper Sacramento River are highly influenced by releases from Shasta Dam, particularly during dry years. Higher instream flows would provide access to additional spawning and rearing habitat sites, extend the area of suitable habitat farther downstream, and generally improve aquatic and riparian habitat conditions along the river. Further, over 80 percent of spring-run, late-fall-run, and endangered winter-run salmon spawn between Keswick Dam and Battle Creek. AFS-2 would use the additional 290,000 acre-feet of storage in Shasta to increase minimum flows in this reach of the upper Sacramento River between October 1 and April 30. Benefits would occur primarily during dryer years, when flows often fall to the current minimum flow of 3,250 cfs. For example, the average daily outflow from Keswick fell below 4,200 cfs on about 175 days between 1998 and 2004 (period of current operating rules). It should be noted that this figure represents flows averaged over 24-hour periods, and does not reflect hourly fluctuations or every day that flows fell below 4,200 cfs (or the duration of these occurrences).

  The relationship between anadromous fish mortality and environmental conditions (including river flow) is very complex. Consequently, additional studies are required to determine the benefits of increasing minimum flows to the anadromous fishery in the Sacramento River in terms of decreased mortality or increased population. However, a preliminary assessment was conducted, using an existing hydraulic model of the upper Sacramento River, to estimate the increase in available spawning habitat that would occur if flows were increased from 3,250 cfs to 4,200 cfs. Although the preliminary assessment has limitations (see summary in **Chapter IX** and description in **Appendix D**), it provides a means for comparing the relative performance of the concepts. On the basis of this assessment, it is estimated that AFS-2 could decrease the amount of spawning area between Keswick and Battle Creek that normally becomes dewatered during low flow years by about 170 acres (see **Table VII-4**).

Although the focus of AFS-2 is on increasing minimum flows, raising Shasta Dam also increases the available cold water pool and allows operators greater flexibility in regulating water temperature in the upper Sacramento River. Based on preliminary analyses, improved temperature conditions under AFS-2 would result in an estimated average annual increase of about 370 salmon.

- **Water Supply Reliability –** As mentioned previously, using the additional storage to increase minimum flows would result in little or no increase in water supply reliability to the CVP. However, AFS-2 would incidentally contribute to increasing average and dry period water supply reliability to the SWP system. This increase corresponds to about 20,000 acre-feet during critical years.
- **Environmental Restoration, Flood Control, and Hydropower -** The higher water surface in the reservoir would result in a net increase in power generation of about 32 GWh per year. Flood control operations at Shasta Dam and Reservoir would continue as under existing conditions. AFS-2 does not include any specific measures to address the secondary objective of environmental restoration. However, increasing minimum flows would provide incidental benefits to riparian habitat along the upper Sacramento River.
- **Other Accomplishments -** AFS-2 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described for AFS-1. The maximum surface area of the lake would increase by about 1,060 acres (3 percent), from 29,600 to about 30,700 acres.

Primary Impacts and Mitigation

Primary impacts associated with AFS-2 are related to raising Shasta Dam 6.5 feet, as summarized in **Table VII-3** and described previously for AFS-1. Increasing minimum flow on the upper Sacramento River to about 4,200 cfs would not significantly impact other project operations at Shasta Dam.

Economics

- **Costs -** The estimated first cost for this plan is $282 million (see **Table VII-4**). Estimated annual costs amount to about $19 million.
- **Benefits -** Primary benefits of AFS-2 include (1) increased spawning habitat for anadromous fish resulting from increasing minimum flows, (2) increases in anadromous fish populations through increasing the cold water pool in Shasta Lake, and (3) a small increase in water supply reliability. AFS-2 also would provide incidental increases in flood control and

hydropower. Benefits of AFS-2 include about 170 acres of additional potential spawning habitat along the upper Sacramento River attributed to increased minimum flows, and an average annual increase of about 370 salmon attributed to the enlarged cold water pool. The water supply reliability benefits are somewhat small: about 20,000 acre-feet increased yield during critical years. Consequently, the majority of the costs for AFS-2 would likely be allocated to anadromous fish survival. This concept would contribute to both NED and NER objectives.

Concept AFS-3 – Increase Minimum Anadromous Fish Flow and Restore Aquatic Habitat with Shasta Enlargement (6.5 Feet)

AFS-3 addresses the primary planning objective of anadromous fish survival through a dual focus on (1) instream habitat restoration, and (2) increasing minimum seasonal flows on the upper Sacramento River by enlarging Shasta Dam and Reservoir.

Major Components

Concept AFS-3 includes the following major components:

- Raising Shasta Dam by 6.5 feet for the primary purpose of enlarging the volume of water available to meet minimum flows for winter-run salmon on the upper Sacramento River.
- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to restore about 150 acres of aquatic and floodplain habitat.

These components are focused on increasing the quality and quantity of spawning habitat on the upper Sacramento River. Similar to AFS-2, minimum spring flows for winter-run salmon would increase from 3,250 cfs to 4,200 cfs; the capacity of the reservoir would increase by 290,000 acre-feet to a total of 4.84 million acre-feet; and the existing TCD would be extended to achieve efficient use of the expanded reservoir.

AFS-3 differs from AFS-2 in that an additional increment of instream habitat would be provided by gravel mine restoration along the upper Sacramento River. For the purpose of this initial evaluation, suitable areas totaling 150 acres would be chosen from one or more abandoned gravel mines (see potential sites in **Figure VII-1**). Restoration would involve filling deep pits, recontouring the stream channel and floodplain to mimic more natural topography, and reconnecting the reclaimed area to the Sacramento River.

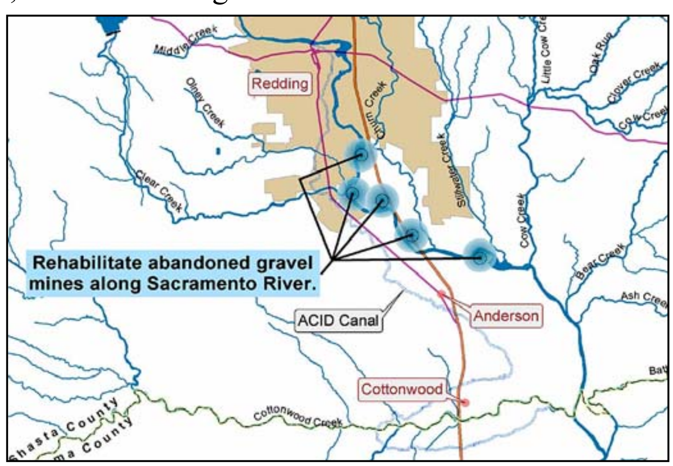

Figure VII-1 – Potential locations along Sacramento River where abandoned gravel mines could be considered for restoration.

Side channels and other features would be created to encourage spawning and rearing, and restored floodplain lands would be revegetated using native riparian plants.

Accomplishments

The accomplishments of concept AFS-3 are described below in relation to the objectives of the SLWRI.

- **Anadromous Fish Survival -** As described previously, instream flows and the availability of suitable aquatic habitat in the reach between Keswick Dam and Battle Creek are particularly influential on the survival of anadromous fish. AFS-3 would support the primary objective of anadromous fish survival by increasing minimum flows from October 1 through April 30 and restoring 150 acres of aquatic and floodplain habitat at one or more inactive gravel mines on the upper Sacramento River. Together, it is estimated that the minimum flow increase and habitat restoration would add approximately 320 acres of potential spawning habitat to the upper Sacramento River between Keswick and Battle Creek. As described for AFS-2, raising Shasta Dam also would increase the cold water pool, and preliminary analyses estimate that improved temperature conditions could result in an average annual increase of 370 salmon.
- **Water Supply Reliability -** AFS-3 would incidentally contribute to increasing average and dry period water supply reliability to the SWP system. This increase corresponds to about 20,000 acre-feet during critical years.
- **Environmental Restoration, Flood Control, and Hydropower -** The higher water surface elevations in the reservoir would result in a net increase in power generation of about 32 GWh per year. Flood control operations at Shasta Dam and Reservoir would continue as under existing conditions.
- **Other Accomplishments -** AFS-3 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that of AFS-1 and AFS-2. The maximum surface area of the lake would increase by about 1,060 acres (3 percent), from 29,600 to about 30,700 acres.

Primary Impacts and Mitigation

Primary impacts associated with AFS-3 are related to raising Shasta Dam 6.5 feet, as summarized in **Table VII-3** and described previously for AFS-1. Increasing minimum flow on the upper Sacramento River to about 4,200 cfs would not significantly impact other project operations at Shasta Dam. Some potential exists for impacting existing habitat at gravel mine restoration sites, but these impacts would likely result from a conversion of present land use back to a more typical riverine environment; consequently, these impacts are not likely to require mitigation.

Economics

- **Costs -** The estimated first cost for this plan is $292 million (see **Table VII-4**). Estimated annual costs amount to about $20 million. Of the total annual cost of this plan, the cost attributed to restoring 150 acres of abandoned gravel mines is about $1 million. In contrast, the cost for the relatively small increment of restored habitat attributed to increasing flows is very high.

- **Benefits -** Primary benefits of AFS-3 include (1) increases in spawning habitat resulting from increasing minimum flows and restoring abandoned gravel mines, (2) increases in anadromous fish populations through increasing the cold water pool in Shasta Lake, and (3) a small increase in water supply reliability. AFS-3 also would provide incidental increases in flood control and hydropower. Benefits include 320 acres of additional spawning habitat along the upper Sacramento River attributed to increased minimum flows and restoration, and an average annual increase of about 370 salmon attributed to the enlarged cold water pool. Water supply reliability benefits are somewhat small, about 20,000 acre-feet increased yield during drought years. Consequently, the majority of the costs for AFS-3 would be allocated to anadromous fish survival. This concept would contribute to both NED and NER objectives.

CONCEPTS FOCUSED ON WATER SUPPLY RELIABILITY

Four concepts were formulated from the management measures retained to address the primary objective of increasing water supply reliability. Although each WSR concept contributes somewhat to both primary planning objectives, these four plans focus on the objective of increased water supply reliability. As with the previous set of plans that focus on anadromous fish survival, numerous potential measure combinations and sizes exist. The magnitude of the enlargement of Shasta Dam was important when developing the WSR concepts because storage size is the most influential factor in determining benefits to water supply reliability. Hence, three dam raises were considered in the WSR concepts: 6.5 feet, 18.5 feet, and 200 feet. The concepts summarized in **Table VII-1** and described below are believed to be reasonably representative of the range of potential actions to address the primary study objective of water supply reliability.

Concept WSR-1 – Increase Water Supply Reliability with Shasta Enlargement (6.5 feet)

Concept WSR-1 focuses on the primary planning objective of water supply reliability by increasing the volume of water stored in Shasta Lake with a 6.5-foot dam raise.

Major Components

Concept WSR-1 includes the following major components:

- Raising Shasta Dam by 6.5 feet for the primary purpose of creating 290,000 acre-feet of additional storage available for water supply.
- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.

Each of these components is focused on increasing water supply reliability to the CVP and SWP. This plan is similar to AFS-1, but the additional storage would be operated for water supply reliability as under existing operational guidelines. Similar to AFS-1, this concept would increase the capacity of the reservoir by 290,000 acre-feet to a total of 4.84 million acre-feet and extend the existing TCD for efficient use of the expanded cold water pool.

In addition, WSR-1 includes revisions to the operational rules for flood control such that the facility could potentially be managed more efficiently for flood control, thereby freeing some additional seasonal storage space for water supply. This would be accomplished using advanced weather forecasting tools. A primary constraint of this component of WSR-1 is that the existing level of flood protection provided by Shasta Dam would not be adversely impacted. A description of the conceptual modifications of the operation rules is included in the reference document Assessment of Potential of Shasta Dam Reoperation for Flood Control and Water Supply Improvement.

Accomplishments

The accomplishments of concept WSR-1 are described below in relation to their contributions to the objectives of the SLWRI.

- **Anadromous Fish Survival –** Although the focus of WSR-1 is on improving water supply reliability, raising Shasta Dam also would increase the cold water pool and benefit seasonal water temperatures along the upper Sacramento River. It is estimated that improved water temperature conditions could result in an average increase in the salmon population of about 410 fish per year.
- **Water Supply Reliability –** WSR-1 would increase water supply reliability by increasing critical and dry year yield of the CVP and SWP. This would help reduce estimated future shortages by increasing critical and dry period supplies by at least 72,000 acre-feet per year. This increase in reliability also could also help reduce CVPIA redirected supplies during drought years by about 13 percent.
- **Environmental Restoration, Flood Control, and Hydropower -** The higher water surface elevation in the reservoir would result in a net increase in power generation of about 15 GWh per year. A potential also exists to slightly increase the ability to control large flood events. WSR-1 does not include any specific measures to address the secondary objective of environmental restoration.
- **Other Accomplishments –** Similar to the AFS plans, WSR-1 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area. The maximum surface area of the lake would increase by about 1,060 acres (3 percent), from 29,600 to about 30,700 acres.

Primary Impacts and Mitigation

Primary impacts associated with WSR-1 are related to raising Shasta Dam by 6.5 feet, as summarized in **Table VII-3** and described previously for AFS-1. Although the reservoir would be operated somewhat differently than for AFS-1, water surface elevation fluctuations in the lake would have similar impacts on recreation.

Economics

- **Costs -** The estimated first cost for this plan is $282 million and estimated annual costs amount to about $19 million, similar to those described previously for AFS-1.
- **Benefits -** The most significant benefits of WSR- 1 are (1) increased dry year water supply reliability, and (2) increased anadromous fish populations resulting from the enlarged cold

water pool. Although the physical components and costs of this concept are similar to AFS-1, this concept operates the reservoir in a manner that creates greater water supply reliability improvements. Benefits include an increase in drought year water supply of 72,000 acre-feet and an average increase of about 410 salmon per year. The plan also would provide incidental increases in hydropower and flood control. This concept would contribute to both NED and NER objectives.

Concept WSR-2 – Increase Water Supply Reliability with Shasta Enlargement (18.5 feet)

WSR-2 focuses on the primary objective of water supply reliability by raising Shasta Dam 18.5 feet.

Major Components

Concept WSR-2 includes the following major components:

- Raising Shasta Dam by 18.5 feet for the primary purpose of creating 636,000 acre-feet of additional storage available for water supply.
- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.

Each of these components focuses on increasing water supply reliability to the CVP and SWP. Although higher dam raises are technically and physically feasible, 18.5 feet is the largest practical dam raise that does not require relocating the Pit River Bridge. The 18.5-foot raise would increase the capacity of the reservoir by 636,000 acre-feet to a total of 5.19 million acre-feet (see **Table VII-2**). Operations for the added storage in the reservoir would be similar to existing operations. The existing TCD would be extended for efficient use of the expanded cold water pool. As described for WSR-1, this concept would include modifying flood control operation rules to manage the reservoir more efficiently for flood control, thereby freeing some additional seasonal storage space for water supply.

Accomplishments

Accomplishments of concept WSR-2 are described below in relation to their contributions to the objectives of the SLWRI.

- **Anadromous Fish Survival –** Although the focus of WSR-2 is on improving water supply reliability, raising Shasta Dam by 18.5 feet would increase the cold water pool and benefit seasonal water temperatures along the upper Sacramento River. It is estimated that improved water temperature conditions could result in an average increase in the salmon population of about 1,110 fish per year.
- **Water Supply Reliability –** WSR-2 would increase water supply reliability by increasing the critical and dry year yield of the CVP and SWP. This would help reduce estimated future shortages by increasing critical and dry period supplies by at least 125,000 acre-feet per year. This increase in reliability could also help reduce CVPIA redirected supplies during drought years by about 20 percent.

- **Environmental Restoration, Flood Control, and Hydropower -** The higher water surface elevation in the reservoir would result in a net increase in power generation of about 44 GWh per year. A potential also exists to slightly increase the ability to control large flood events. WSR-2 does not include any specific measures to address the secondary objective of environmental restoration.

- **Other Accomplishments –** The water-oriented recreation experience at Shasta Lake would generally increase due to the increase in lake surface area. The maximum surface area of the lake would increase by about 2,500 acres (8 percent), from 29,600 to about 32,100 acres.

Primary Impacts and Mitigation

Primary impacts associated with WSR-2 are related to raising Shasta Dam by 18.5 feet, as summarized in **Table VII-3**. Impacts include modifying the Pit River Bridge, replacing 7 other bridges, relocating 130 structures, and inundating numerous small segments of existing paved and nonpaved roads. Two power transmission lines, several water storage tanks, and three USFS fire stations also would be impacted. Of the structures impacted, 40 are private dwellings and about 60 are resort/marina or other commercial buildings. Portions of Lakeshore Drive, Fenders Ferry Road, Gilman Road, and Silverthorn Road would be relocated. Embankments would be constructed to protect I-5 at Lakeshore and the UPRR at Bridge Bay.

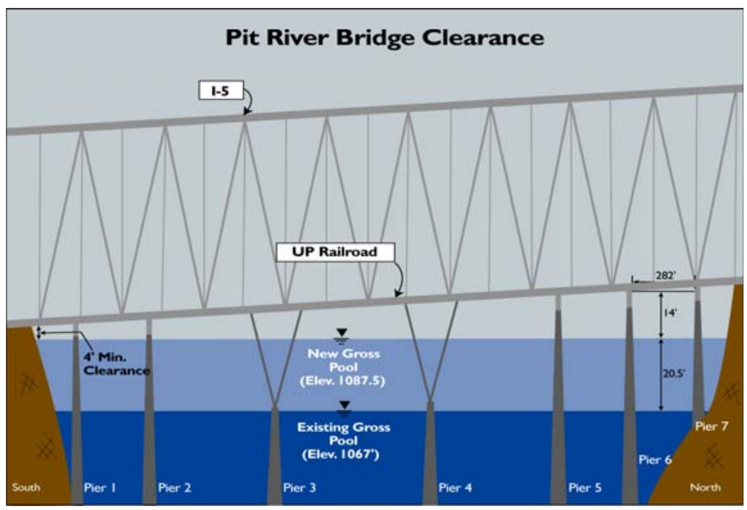

Figure VII-2 – Minimum clearances for boat traffic at Pit River Bridge, gross pool with 18.5-foot dam.

Although recreation would generally improve under WSR-2, water in the lake would be drawn down to existing conditions during the late fall and winter periods of some dry years, representing a drawdown 20.5 feet greater than under existing conditions. During those periods, the drawdown zone could increase by about 50 linear feet. In addition, clearances for boat traffic under the Pit River Bridge would be restricted to the north end of the bridge during periods of high reservoir levels (at or near gross pool). This condition would typically occur in the late spring (May to June) in about 1 out of 4 years, and could last several days to a week. **Figure VII-2** illustrates that the minimum clearance at the new gross pool would be about 14 feet between Piers 6 and 7. This could impact boating on the lake, as some houseboats are up to16 feet high. Since houseboating is a major recreational experience on Shasta Lake, especially around Memorial Day, restrictions on large boat traffic under the Pit River Bridge during maximum pool levels could adversely impact lake area boat rentals, marinas, and other recreation-dependent businesses. Accordingly, WSR-2 would likely need to include features to help offset these impacts. Possible actions for further consideration could include reservoir operation modifications, boat scheduling assistance, or financial compensation.

As described previously, reservoir area habitat inventories are underway to quantify potential habitats impacted by raising Shasta Dam. The maximum inundation area would increase by about 2,500 acres over existing conditions. The expanded drawdown zone would be inundated about once every 3 to 4 years, for periods ranging from several days to several months. Vegetation in the expanded drawdown zone would eventually be lost over time, but significant amounts would remain on the lower slopes due to the infrequent inundation. As shown in **Table VII-3**, the lower reaches of the tributaries to Shasta Lake also would experience increased inundation.

Economics

- **Costs -** The estimated first cost for this plan is $408 million and the estimated annual costs are about $28 million.
- **Benefits -** The most significant benefits of WSR- 2 are (1) increased dry year water supply reliability, and (2) increased anadromous fish populations resulting from the enlarged cold water pool. Specifically, the drought year water supply would increase 125,000 acre-feet and an average increase of about 1,110 salmon per year. The plan also would provide an additional 44 GWh in hydropower capacity. This concept would contribute to NED and NER objectives.

Concept WSR-3 – Increase Water Supply Reliability with Shasta Enlargement (High Level)

WSR-3 focuses on the primary objective of water supply reliability by raising Shasta Dam by 200 feet.

Major Components

Concept WSR-3 includes the following major components:

- Raising Shasta Dam by about 200 feet for the primary purpose of creating 9.3 million acre-feet of additional storage available for water supply.
- Making major modifications to or replacing dam appurtenances, including hydropower facilities and the TCD.

Raising Shasta Dam by about 200 feet is considered to be the largest technically feasible raise without completely reconstructing the existing dam. The 200-foot raise would increase the capacity of the reservoir by 9.3 million acre-feet to a total of 13.9 million acre-feet. The magnitude of this raise would require significant modifications or replacement of most facilities associated with the dam (see **Table VII-2**). The existing TCD would be replaced, and modifications to hydropower facilities would include replacing gates and structural supports for the penstocks, adding generator units to the powerplant, replacing the switchyard, and modifying Keswick Dam and its powerplant. The additional storage in the reservoir would be operated primarily for water supply, but the magnitude of the raise also would significantly increase the cold water pool and the ability for dam operators to meet both temperature and minimum flow requirements on the upper Sacramento River.

Accomplishments

The accomplishments of concept WSR-3 are described below in relation to their contributions to the objectives of the SLWRI.

- **Anadromous Fish Survival –** Raising Shasta Dam by 200 feet would substantially increase the cold water pool and benefit seasonal water temperatures along the upper Sacramento River. Preliminary analyses indicate that improved water temperature conditions could result in an average increase in the salmon population of over 10,000 fish per year over the life of the project. The additional storage also would provide operators with greater flexibility in meeting minimum flow requirements on the upper Sacramento River. Detailed studies are required to more accurately quantify the increase in anadromous fish populations resulting from such a large increase in the capacity of Shasta Dam and Reservoir.
- **Water Supply Reliability –** WSR-3 would significantly increase water supply reliability for the CVP and SWP systems. This would help reduce estimated future shortages, increasing critical and dry period supplies by over 700,000 acre-feet per year. This increase in reliability would likely offset CVPIA redirected supplies during drought years.
- **Environmental Restoration, Flood Control, and Hydropower -** The higher water surface elevation in the reservoir would result in a significant net increase in power generation, amounting to about 2.3 million GWh per year. Much of this increase would be offset, however, by the loss of generation from the Pit 7 Dam, which would be removed. A potential also exists to significantly increase the ability to control large flood events. WSR-3 does not include any specific measures to address the secondary objective of environmental restoration.
- **Other Accomplishments –** The water-oriented recreation experience at Shasta Lake would generally increase due to the increase in lake surface area. The maximum surface area of the lake would increase by about 31,200 acres (roughly twice that of existing conditions), from 29,600 to about 60,700 acres.

Primary Impacts and Mitigation

The primary impacts associated with WSR-3 are related to raising Shasta Dam by 200 feet, as summarized in **Table VII-3**. They include relocating the Pit River Bridge, replacing 20 other bridges, removing Pit 7 Dam, relocating about 630 structures, and inundating numerous large segments of existing paved and nonpaved roads. Significant impacts would occur to all recreational facilities surrounding the lake. About 35 miles of the UPRR, 19 miles of I-5, and numerous associated tunnels, embankments, and other facilities would be relocated.

Although recreation would generally improve under WSR-3, the maximum drawdown zone would increase significantly. While drawdown to minimum pool would occur infrequently, this area would be largely devoid of vegetation, impacting the natural aesthetic value of the shoreline for recreational users. Further, recreational access to natural features (such as the Shasta Caves) and various historic sites would be limited.

The Pit 7 Dam is located at the existing headwater of Shasta Lake (see **Figure VII-3**). The dam is 200 feet high and was constructed for hydropower purposes in the mid-1960s by PG&E. The gross pool elevation for WSR-3 would be similar to the existing top of the Pit 7 Dam, inundating all facilities at the dam. Electric generation lost at Pit 7 would be replaced from the facilities added at the enlarged Shasta Dam.

Figure VII-3 - The Pit 7 Dam, located on the Pit River upstream from Shasta Lake, is 200 feet high.

As described previously, reservoir area habitat inventories are underway to quantify potential habitats impacted by raising Shasta Dam. The maximum inundation area would increase by about 31,000 acres over existing conditions, and environmental impacts could be significant. The expanded drawdown zone would be inundated about once every 3 years, for periods ranging from several days to several months. Vegetation over most of the expanded drawdown zone would be lost over time. As shown in **Table VII-3**, increased inundation would be experienced along several miles of the lower reaches of the tributaries to Shasta Lake. There is also a potential to impact historic sites and cultural resources around the reservoir.

Economics

- **Costs -** The estimated first cost for this plan is $5.3 billion and estimated annual costs are about $383 million.
- **Benefits -** Primary benefits of WSR-3 are (1) increased water supply reliability, (2) increased anadromous fish populations resulting from the enlarged cold water pool, and (3) increased hydropower production. Increased water supply reliability, which would amount to about 703,000 acre-feet per year (drought year), would be accompanied by significant increases in the anadromous fish population (possibly as high as 10,000 fish per year). The concept also would provide substantial increases in net hydropower generation to the CVP, about 2.3 million GWh per year (not including generation reduction from loss of the Pit 7 Dam), which could increase revenues by over $100 million per year. This concept would contribute to NED and NER objectives.

Concept WSR-4 – Increase Water Supply Reliability with Shasta Enlargement (18.5 feet) and Conjunctive Water Management

WSR-4 focuses on the primary objective of water supply reliability by raising Shasta Dam 18.5 feet in combination with a conjunctive water management program.

Major Components

Concept WSR-4 includes the following major components:

- Raising Shasta Dam by 18.5 feet for the primary purpose of creating 636,000 acre-feet of additional storage available for water supply.
- Implementing a conjunctive water management program.

Each of these components focuses on increasing water supply reliability to the CVP and SWP. The 18.5-foot raise would increase the capacity of the reservoir by 636,000 acre-feet to a total of 5.19 million acre-feet (see **Table VII-2**). Operations for the added storage in the reservoir would be similar to existing operations. The existing TCD would be extended for efficient use of the expanded cold water pool. As described for WSR-1, this concept would include modifying flood control operation rules to manage the reservoir more efficiently for flood control, thereby freeing some additional seasonal storage space for water supply.

The conjunctive water management component would consist largely of contract agreements between Reclamation and certain Sacramento River Basin water users. It also would include any additional river diversions, increase in current diversion capacity, and/or transmission facilities to facilitate the exchange. Contract agreements would focus on exchanging additional surface supplies in normal water years with participating CVP users for reducing deliveries (reliance on groundwater supplies) in dry and critically dry years (see **Figure VII-4**). Surface water supplies for dry and critically dry years would be used to increase the reliability of CVP and SWP supplies south of the Delta in dryer years.

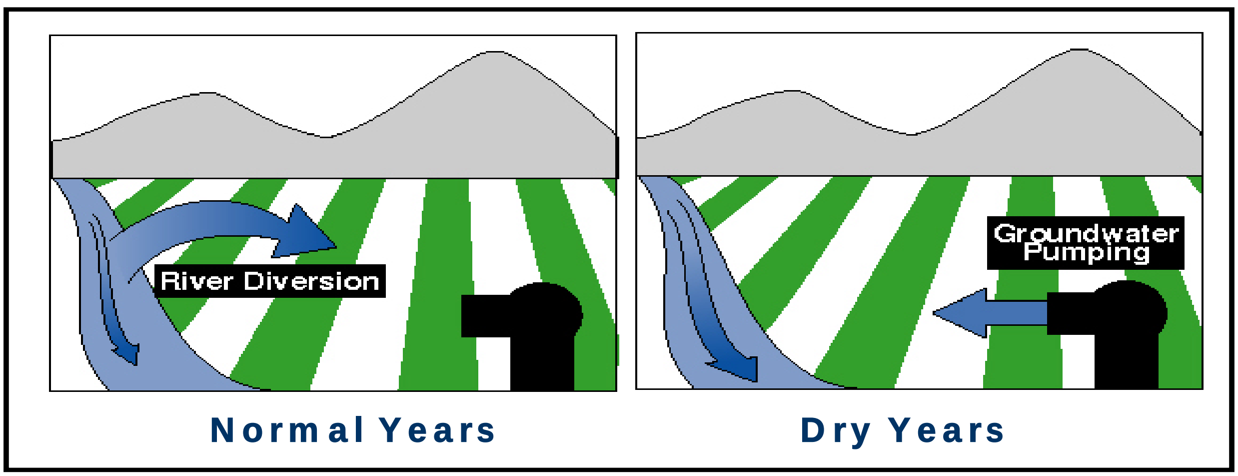

Figure VII-4 – Conjunctive water management concept– participating Sacramento River CVP water users would take more water during normal years and defer deliveries during dry years.

Accomplishments

Accomplishments of concept WSR-4 are described below in relation to their contribution to the primary and secondary planning objectives.

- **Anadromous Fish Survival –** Raising Shasta Dam by 18.5 feet would increase the cold water pool and benefit seasonal water temperatures along the upper Sacramento River. It is estimated that improved water temperature conditions could result in an average increase in the salmon population of about 1,020 fish per year.
- **Water Supply Reliability –** WSR-4 would increase water supply reliability by increasing the critical and dry year yield of the CVP and SWP. The combination of increased storage space in Shasta Reservoir and exchanged surface water for participating Sacramento River water users would result in an increase in water supply reliability of about 146,000 acre-feet per year. This increase in reliability could also help reduce CVPIA redirected supplies during drought years.
- **Environmental Restoration, Flood Control, and Hydropower -** The higher water surface elevation in the reservoir would result in a net increase in power generation of about 44 GWh per year. A potential also exists to slightly increase the ability to control large flood events. WSR-4 does not include any specific measures to address the secondary objective of environmental restoration.
- **Other Accomplishments –** The water-oriented recreation experience at Shasta Lake would generally increase due to the increase in lake surface area. The maximum surface area of the lake would increase by about 2,500 acres (8 percent), from 29,600 to about 32,100 acres.

Primary Impacts and Mitigation

Primary impacts associated with WSR-4 are related to raising Shasta Dam by 18.5 feet, as summarized in **Table VII-3** and described previously for WSR-2.

Economics

- **Costs -** The estimated first cost for this plan is $459 million and estimated annual costs are about $32 million.
- **Benefits -** The most significant benefits of WSR- 4 are (1) increased dry year water supply reliability, and (2) increased anadromous fish populations resulting from the enlarged cold water pool. Specifically, benefits include an increase in drought year water supply of 146,000 acre-feet and an average increase of about 1,020 salmon per year. The plan also would provide incidental increases in hydropower. This concept would contribute to NED and NER objectives.

CONCEPTS FOCUSED ON COMBINED OBJECTIVES

Five concepts were formulated from the retained management measures to represent a reasonable balance between the two primary objectives, as shown in **Table VII-1**. The combined objective concepts also include measures to actively address the secondary objectives, as appropriate. As with previous concepts, numerous potential sizes and combinations of components are possible. The combined objective concepts identified below are believed to be reasonably representative, although not exhaustively, of the range of potential and applicable actions.

Concept CO-1 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (6.5 feet)

Concept CO-1 addresses both primary planning objectives by restoring anadromous fish habitat and raising Shasta Dam by 6.5 feet.

Major Components

Concept CO-1 includes the following major components:

- Raising Shasta Dam by 6.5 feet for the purposes of expanding the cold water pool and creating 290,000 acre-feet of additional storage available for water supply.
- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create about 150 acres of aquatic and floodplain habitat.
- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.

CO-1 would use the additional storage created by the 6.5-foot raise to increase water supply reliability, while also improving the ability to meet temperature objectives for winter-run salmon. The capacity of the reservoir would increase by 290,000 acre-feet to a total of 4.84 million acre-feet and the existing TCD would be extended to achieve efficient use of the expanded reservoir. This concept also would include revisions to the operational rules for flood control such that Shasta Dam and Reservoir could be managed more efficiently for water supply reliability (see previous discussion of WSR-1). Suitable areas totaling 150 acres would be chosen for aquatic and floodplain restoration from one or more abandoned gravel mines on the upper Sacramento River (see previous discussion of AFS-3).

Accomplishments

Accomplishments of concept CO-1 are described below in relation to the objectives of the SLWRI.

- **Anadromous Fish Survival –** CO-1 would increase the ability of Shasta Dam to make cold water releases to regulate water temperature in the upper Sacramento River, primarily in dry and critically dry years. Preliminary analyses estimate that improved temperature conditions could result in an average annual increase of 410 salmon. Habitat restoration would add an additional 150 acres of aquatic and floodplain habitat to the Sacramento River between Keswick and Battle Creek, a critical spawning reach.

- **Water Supply Reliability –** CO-1 would increase average and dry period water supply reliability to the CVP and SWP systems. This increase corresponds to about 72,000 acre-feet during critical years.
- **Environmental Restoration, Flood Control, and Hydropower -** Higher water surface elevations in the reservoir would result in a small net increase in power generation of about 15 GWh per year.
- **Other Accomplishments –** CO-1 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described previously for concepts incorporating a 6.5-foot raise. The maximum surface area of the lake would increase by about 1,060 acres (3 percent), from 29,600 to about 30,700 acres.

Primary Impacts and Mitigation

Primary impacts associated with CO-1 are related to raising Shasta Dam 6.5 feet, as summarized in **Table VII-3** and described previously for AFS-1. Some potential exists for impacting existing habitat at gravel mine restoration sites, but these impacts would likely result from a conversion of present land use back to a more typical riverine environment; consequently, these impacts are not likely to require mitigation.

Economics

- **Costs -** The estimated first cost for this concept is $292 million, and the estimated annual costs are about $20 million.
- **Benefits -** Primary benefits of CO-1 are improved anadromous fish survival from increasing the cold water pool in Shasta Reservoir and restoring aquatic and floodplain habitat, and increased water supply reliability. CO-1 also would provide incidental increases in flood control and hydropower. Specifically, benefits include 150 acres of additional spawning habitat along the upper Sacramento River, and an average annual increase of about 410 salmon attributed to the enlarged cold water pool. Water supply reliability benefits include a 72,000 acre-feet increase in yield during drought years. This concept would contribute to NED and NER objectives.

Concept CO-2 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)

Concept CO-2 addresses both primary planning objectives by raising Shasta Dam by 18.5 feet in combination with anadromous fish habitat restoration.

Major Components

Concept CO-2 includes the following major components:

- Raising Shasta Dam by 18.5 feet for the purposes of expanding the cold water pool and creating 636,000 acre-feet of additional storage available for water supply.
- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create about 150 acres of aquatic and floodplain habitat.
- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.

CO-2 is similar to CO-1, except Shasta Dam would be raised 18.5 feet instead of 6.5 feet. The additional storage created by the 18.5-foot dam raise would be used to increase water supply reliability, while also improving the ability to meet temperature objectives for winter-run salmon. The capacity of the reservoir would increase by 636,000 acre-feet to a total of 5.19 million acre-feet, and the existing TCD would be extended to achieve efficient use of the expanded reservoir. This concept also would include revisions to the operational rules for flood control such that Shasta Dam and Reservoir could be managed more efficiently for water supply reliability (see previous discussion of WSR-1). Suitable areas totaling 150 acres would be chosen for aquatic and floodplain restoration from one or more abandoned gravel mines (see previous discussion of AFS-3).

Accomplishments

Accomplishments of concept CO-2 are described below in relation to the objectives of the SLWRI.

- **Anadromous Fish Survival –** CO-2 would increase the ability of Shasta Dam to make cold water releases to regulate water temperature in the upper Sacramento River, primarily in dry and critically dry years. Preliminary analyses estimate that improved temperature conditions could result in an average annual increase of 1,110 salmon. Habitat restoration would add an additional 150 acres of aquatic and floodplain habitat to the Sacramento River between Keswick and Battle Creek, a critical spawning reach.
- **Water Supply Reliability –** CO-2 would increase average and dry period water supply reliability to the CVP and SWP systems. This increase corresponds to about 125,000 acre-feet during critical years.
- **Environmental Restoration, Flood Control, and Hydropower -** The higher water surface elevations in the reservoir would result in a net increase in power generation of about 44 GWh per year. The ability to control floods may increase to a small degree.
- **Other Accomplishments –** CO-2 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described previously for concepts incorporating an 18.5-foot raise. The maximum surface area of the lake would increase by about 2,500 acres (8 percent), from 29,600 to about 32,100 acres.

Primary Impacts and Mitigation

Primary impacts associated with CO-2 are related to raising Shasta Dam 18.5 feet, as summarized in **Table VII-3** and described previously for WSR-2. Some potential exists for impacting existing habitat at gravel mine restoration sites, but these impacts would likely result from a conversion of present land use back to a more typical riverine environment; consequently, these impacts are not likely to require mitigation.

Economics

- **Costs -** The estimated first cost for this concept is $418 million, and estimated annual costs are about $29 million.
- **Benefits -** Primary benefits of CO-2 are improved anadromous fish survival from increasing the cold water pool in Shasta Reservoir and restoring aquatic and floodplain habitat, and increased water supply reliability. CO-2 also would provide a small increase in hydropower. Specifically, benefits include 150 acres of additional spawning habitat along the upper Sacramento River, and an average annual increase of about 1,110 salmon attributed to the enlarged cold water pool. Water supply reliability benefits include a 125,000 acre-feet increase in yield during drought years. This concept would contribute to NED and NER objectives.

Concept CO-3 – Increase Anadromous Fish Flow/Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)

Concept CO-3 addresses both primary planning objectives by raising Shasta Dam by 18.5 feet in combination with restoring anadromous fish habitat and improving flow conditions on the upper Sacramento River.

Major Components

Concept CO-3 includes the following major components:

- Raising Shasta Dam by 18.5 feet, expanding the cold water pool, and creating 636,000 acre-feet of additional storage available for both water supply and flow regulation.
- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create about 150 acres of aquatic and floodplain habitat.
- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.

CO-3 is similar to CO-2, except a portion of the additional storage created by the 18.5-foot dam raise would be dedicated to managing flows for winter-run salmon on the upper Sacramento River. The additional storage space could be allocated to fisheries and water supply reliability in many different ways; additional investigation would be needed to assess combinations that could best address the two major objectives. For the purpose of this initial analysis, dedicating approximately 320,000 acre-feet to increasing minimum flows is believed to be a good estimation of the potential benefits of this concept.

Minimum flows on the upper Sacramento River would be increased from 3,250 cfs to about 4,200 cfs between October 1 and April 30 (see previous discussion of AFS-2), consistent with the AFRP. Suitable areas totaling 150 acres would be chosen for restoration from one or more abandoned gravel mines (see previous discussion of AFS-3). Temperature benefits also would be gained by increasing the size of the cold water pool.

The existing TCD would be extended to achieve efficient use of the expanded reservoir. This concept also would include revisions to the operational rules for flood control such that Shasta Dam and Reservoir could be managed more efficiently for water supply reliability (see previous discussion of WSR-1).

Accomplishments

Accomplishments of concept CO-3 are described below in relation to the objectives of the SLWRI.

- **Anadromous Fish Survival –** CO-3 would benefit anadromous fish by increasing seasonal minimum flows and improving temperature conditions in the upper Sacramento River, primarily in dry and critically dry years. Significant additional effort is needed to reliably quantify potential benefits to the anadromous fish population from this concept. However, preliminary analyses estimate that improved temperature conditions could result in an average annual increase of 980 salmon. Habitat restoration and minimum flow increases would add an additional 320 acres of aquatic and floodplain habitat to the Sacramento River between Keswick and Battle Creek, a critical spawning reach.
- **Water Supply Reliability –** CO-3 would increase average and dry period water supply reliability to the CVP and SWP systems. This increase corresponds to about 90,000 acre-feet during critical years.
- **Environmental Restoration, Flood Control, and Hydropower -** Higher water surface elevations in the reservoir would result in a net increase in power generation of about 61 GWh per year. The ability to control floods may increase to a small degree.
- **Other Accomplishments –** CO-3 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described previously for concepts incorporating an 18.5-foot raise.

Primary Impacts and Mitigation

Primary impacts associated with CO-3 are related to raising Shasta Dam 18.5 feet, as summarized in **Table VII-3** and described previously for WSR-2. Some potential exists for impacting existing habitat at gravel mine restoration sites, but these impacts would likely result from a conversion of present land use back to a more typical riverine environment; consequently, these impacts are not likely to require mitigation.

Economics

- **Costs** - The estimated first cost for this concept is $418 million, and estimated annual costs are about $29 million.
- **Benefits** - Primary benefits of CO-3 are improved anadromous fish survival from improving flow conditions, restoring aquatic and floodplain habitat, and increasing the cold water pool in Shasta Reservoir, and increased water supply reliability. Specifically, benefits include 320 acres of additional spawning habitat along the upper Sacramento River, and an average annual increase of about 980 salmon attributed to flow increases and the enlarged cold water pool. Water supply reliability benefits include a 90,000 acre-feet increase in yield during drought years. CO-3 also would provide an increase of 61 GWh per year in hydropower generation. This concept would contribute to NED and NER objectives.

Concept CO-4 – Multipurpose with Shasta Enlargement (6.5 feet)

Concept CO-4 addresses the primary and secondary planning objectives through raising Shasta Dam 6.5 feet in combination with conjunctive use, habitat restoration, and environmental restoration in the Shasta Lake area and upper Sacramento River.

Major Components

Concept CO-4 includes the following major components:

- Raising Shasta Dam by 6.5 feet, expanding the cold water pool, and creating 290,000 acre-feet of additional storage available for water supply reliability.
- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create about 150 acres of aquatic and floodplain habitat.
- Implementing a conjunctive water management program.
- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.
- Constructing additional resident fish habitat in Shasta Lake and along the lower reaches of the Sacramento River, McCloud River, and Squaw Creek.
- Restoring 500 acres of wetland and riparian habitat along the Sacramento River at one or more sites between Redding and Red Bluff.

CO-4 addresses both primary and secondary objectives of the SLWRI through a combination of measures. It would improve anadromous fish survival by increasing the cold water pool in Shasta Reservoir and restoring 150 acres of valuable aquatic and floodplain habitat on the upper Sacramento River. The concept would improve water supply reliability through increasing the storage space in Shasta Reservoir by 290,000 acre-feet, implementing conjunctive water management, and reoperating the reservoir more efficiently for flood control. The secondary objective of environmental restoration also would be addressed through shoreline and tributary habitat improvements around Shasta Lake, and riparian restoration along the upper Sacramento River.

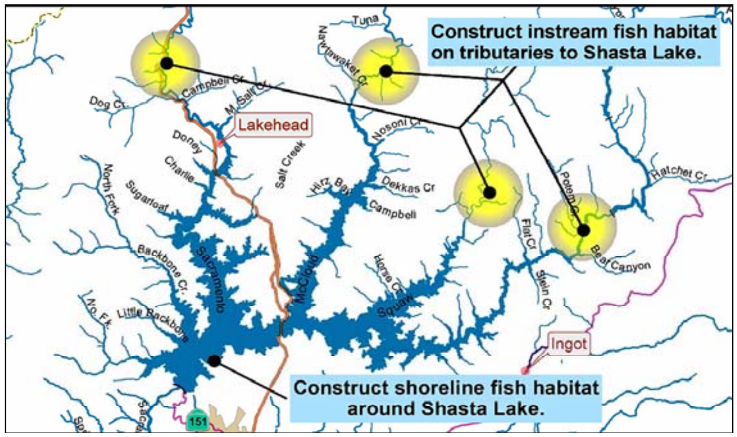

Figure VII-5 – Potential ecosystem restoration features in the Shasta Lake area.

CO-4 includes restoring (1) resident fish habitat in Shasta Lake and (2) riparian habitat at four locations along the lower arms of the Sacramento River, McCloud River, and Squaw Creek (see **Figure VII-5**). This component includes improving shallow, warm water habitat by installing artificial fish cover, such as anchored complex woody structures and boulders, and planting water-tolerant and/or erosion-resistant vegetation near the mouths of tributaries. These improvements would help provide favorable spawning conditions, and juvenile fish leaving the tributaries would benefit from improved adjacent shoreline habitat. Establishing vegetation also could benefit terrestrial species that inhabit the shoreline of Shasta Lake.

This concept also includes improving and restoring instream aquatic habitat along the lower reaches of major tributaries to Shasta Lake using various structural techniques to trap spawning gravel in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Treatments could include installing gabions, log weirs, boulder weirs, and other anchored structures. Spawning and rearing habitat would be created by installing instream cover such as large root wads, and drop structures, boulders, gravel traps, and/or logs that cause scouring and help clean gravel. The lower reaches of perennial tributaries to Shasta Lake would be targeted for aquatic restoration because they provide year-round fish habitat.

Also included in Concept CO-4 is acquisition and restoration of wetland and riparian areas along the upper Sacramento River. The location and area of potential restoration will be the subject of future studies. However, for initial planning purposes, restoration of 500 acres along the Sacramento River between Keswick and Red Bluff is included in this concept.

Accomplishments

The accomplishments of concept CO-4 are described below in relation to the objectives of the SLWRI.

- **Anadromous Fish Survival –** CO-4 would benefit anadromous fish by improving temperature conditions in the upper Sacramento River, primarily in dry and critically dry years, and increasing the quality and quantity of aquatic habitat. Significant additional effort is needed to reliably quantify potential benefits to the anadromous fish population from this concept. However, preliminary analyses estimate that improved temperature conditions could result in an average annual increase of 410 salmon. Habitat restoration would add an additional 150 acres of aquatic and floodplain habitat to the Sacramento River between Keswick and Battle Creek, a critical spawning reach.

- **Water Supply Reliability –** CO-4 would increase average and dry period water supply reliability to the CVP and SWP systems through reservoir expansion and conjunctive water management. This increase corresponds to about 89,000 acre-feet during critical years.
- **Environmental Restoration, Flood Control, and Hydropower –** CO-4 includes restoring resident fish habitat in Shasta Lake and riparian habitat at four locations along the lower arms of the Sacramento River, McCloud River, and Squaw Creek. An additional 500 acres of riparian and wetland habitat would be acquired and restored along the upper Sacramento River. The location and total area of restoration in the Shasta Lake and upper Sacramento River areas will be the subject of future studies. Minor increases in hydropower production and flood protection would occur.
- **Other Accomplishments –** CO-4 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described previously for concepts incorporating a 6.5-foot raise.

Primary Impacts and Mitigation

The primary impacts associated with CO-4 are related to raising Shasta Dam 6.5 feet, as summarized in **Table VII-3** and described previously for AFS-1. Some potential exists for impacting existing habitat at environmental restoration sites, but these impacts would likely result from converting present land use back to a more native environment; consequently, these impacts are not likely to require mitigation.

Economics

- **Costs -** The estimated first cost for this concept is $356 million, and estimated annual costs are about $25 million.
- **Benefits -** Primary benefits of CO-4 are (1) improved anadromous fish survival from restoring aquatic and floodplain habitat, and an increase in the cold water pool in Shasta Reservoir; and (2) increased water supply reliability. These benefits include 150 acres of additional spawning habitat along the upper Sacramento River; an average annual increase of about 410 salmon attributed to the enlarged cold water pool; and over 500 acres of additional habitat restoration in the Shasta Lake area and along the upper Sacramento River. Water supply reliability benefits include an increase in yield of 89,000 acre-feet during drought years. This concept would contribute to NED and NER objectives.

Concept CO-5 – Multipurpose with Shasta Enlargement (18.5 feet)

Concept CO-5 addresses both primary planning objectives by raising Shasta Dam 18.5 feet in combination with conjunctive water management and anadromous fish habitat restoration.

Major Components

Concept CO-5 includes the following major components:

- Raising Shasta Dam by 18.5 feet, expanding the cold water pool, and creating 636,000 acre-feet of additional storage available for water supply.
- Implementing a conjunctive water management program.
- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create about 150 acres of aquatic and floodplain habitat.
- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.
- Constructing additional resident fish habitat in Shasta Lake and along the lower reaches of the Sacramento River, McCloud River, and Squaw Creek.
- Restoring 500 acres of wetland and riparian habitat at one or more sites between Redding and Red Bluff on the Sacramento River.

CO-5 is similar to CO-4, except Shasta Dam would be raised 18.5 feet instead of 6.5 feet. The additional storage created by the 18.5-foot dam raise would be used primarily to increase water supply reliability, while also improving the ability to meet temperature objectives for winter-run salmon during drought years. The capacity of the reservoir would increase by 636,000 acre-feet to a total of 5.19 million acre-feet and the existing TCD would be extended to achieve efficient use of the expanded reservoir. This concept also would include revising the operational rules for flood control such that Shasta Dam and Reservoir could be managed more efficiently for water supply reliability (see previous discussion of WSR-1). Suitable areas totaling 150 acres would be chosen for restoration from one or more abandoned gravel mines (see previous discussion of AFS-3). As with CO-4, the secondary objectives of environmental restoration would be addressed through shoreline and tributary habitat improvements around Shasta Lake, and 500 acres of riparian restoration along the upper Sacramento River.

Accomplishments

The accomplishments of concept CO-5 are described below in relation to the objectives of the SLWRI.

- **Anadromous Fish Survival –** CO-5 would increase the ability of Shasta Dam to make cold water releases to regulate water temperature in the upper Sacramento River, primarily in dry and critically dry years. Preliminary analyses estimate that improved temperature conditions could result in an average annual increase of 1,110 salmon. Habitat restoration would add an additional 150 acres of aquatic and floodplain habitat to the Sacramento River between Keswick and Battle Creek, a critical spawning reach.
- **Water Supply Reliability –** CO-5 would increase average and dry period water supply reliability to the CVP and SWP systems through increasing the capacity of Shasta Lake in combination with conjunctive water management. This increase corresponds to about 146,000 acre-feet during critical years.

- **Environmental Restoration, Flood Control, and Hydropower -** Higher water surface elevations in the reservoir would result in a net increase in power generation of about 44 GWh per year. The ability to control floods may increase to a small degree. An additional 500 acres of riparian and wetland habitat would be acquired and restored along the upper Sacramento River between Red Bluff and Redding. The location and total area of restoration in the Shasta Lake and upper Sacramento River areas will be the subject of future studies.

- **Other Accomplishments –** CO-5 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described previously for concepts incorporating an 18.5-foot raise. The maximum surface area of the lake would increase by about 2,500 acres (8 percent), from 29,600 to about 32,100 acres.

Primary Impacts and Mitigation

Primary impacts associated with CO-5 are related to raising Shasta Dam 18.5 feet, as summarized in **Table VII-3** and described previously for WSR-2. Some potential exists for impacting existing habitat at environmental restoration sites, but these impacts would likely result from converting present land use back to a more typical riverine environment; consequently, these impacts are not likely to require mitigation.

Economics

- **Costs -** The estimated first cost for this concept is $483 million, and estimated annual costs are about $34 million.

- **Benefits -** Primary benefits of CO-5 are (1) improved anadromous fish survival from the restoration of aquatic and floodplain habitat, and an increase in the cold water pool in Shasta Reservoir, and (2) increased water supply reliability. These benefits include 150 acres of additional spawning habitat along the upper Sacramento River; an average annual increase of about 1,110 salmon attributed to the enlarged cold water pool; and over 500 acres of additional habitat restoration in the Shasta Lake area and along the upper Sacramento River. Water supply reliability benefits include an increase in yield of 146,000 acre-feet during drought years. This concept would contribute to NED and NER objectives.

CHAPTER VIII
COMPARISON OF CONCEPT PLANS

This chapter compares the concept plans described in **Chapter VII** and identifies initial alternatives that should be further developed into alternative plans in the SLWRI.

CRITERIA AND COMPARISON

To help focus the plan formulation process and ensure that the most appropriate project is ultimately selected for implementation, the concept plans in **Chapter VII** were compared to each other using four general criteria. The four criteria are based on the Federal P&G for water resources planning and include: (1) completeness, (2) effectiveness, (3) efficiency, and (4) acceptability. Below is a description of each criterion and its application. **Table VIII-1** shows the comparison of the concept plans based on their relative ability to address each of the four criteria. As can be seen in the table and described below, each plan was assigned a relative ranking ranging from very low to very high for each criterion. Each comparison criterion for the concept plans in the table received the same weighting and resulted in an overall relative ranking. This overall ranking was used, along with other information, to determine if a concept plan should be considered further in the plan formulation process in the SLWRI.

It is important to reiterate that numerous combinations of sizes and applications of each of the measures in **Chapter VI** make up the concept plans in **Chapter VII**. Accordingly, recommendations for further plan development in **Table VIII-1** are more for the application and combination of measures than for specific concept plans.

Completeness Criterion

Completeness is a determination of whether a plan includes all elements necessary to realize planned effects. It is also an indication of the degree that the intended benefits of the plan depend on the actions of others. For the SLWRI, the subcriteria described below are believed only to become important in estimating the relative completeness of the concept plan. Each concept plan is considered complete, with its relative completeness ranking ranging from low to high, primarily depending on the degree of uncertainty (or reliability) of achieving the intended objectives and adequately mitigating significant adverse impacts. Concepts that received the highest relative ranking for this criterion are WSR-1, WSR-2, WSR-4 and, with the exception of CO-3, all of the CO plans. Concepts that received the lowest relative ranking are AFS-1 and WSR-3. Concept plan AFS-1 ranks low because it would provide very little benefit to either planning objective. Concept plan WSR-3 ranks low primarily because it would result in very large environmental and socioeconomic impacts, which would be difficult to adequately mitigate.

TABLE VIII-1
SUMMARY COMPARISON OF CONCEPT PLANS

Concept Plans	Comparison Criteria				Recommendation Status and Relative Ranking
	Completeness	**Effectiveness**	**Efficiency**	**Acceptability**	
AFS-1 – Increase Cold Water Assets with Shasta Operating Pool Raise (6.5 feet)	Can be implemented with minimum social and environmental impact. Only addresses one of the primary objectives – anadromous fish survival. Contributes to flood control and hydropower secondary objectives. Physically and environmentally implementable.	Moderately effective in helping benefit anadromous fish survival. Does not significantly contribute to water supply reliability. Incidental contribution to flood control and hydropower objectives.	Because contributes to only one primary objective (anadromous fish survival), results in greatest cost for that purpose.	Low potential for Federal interest – less costly ways of achieving similar benefits to fishery.	Enlarging Shasta only for increasing the cold water pool is **not recommended** for further consideration as a stand-alone plan. Only addressed one primary objective. Very high cost for meeting single objective. Same conclusion for any sized project with similar component measures.
Relative Rank	*Low*	*Very Low*	*Very Low*	*Very Low*	*Very Low*
AFS-2 – Increase Minimum Anadromous Fish Flow with Shasta Enlargement (6.5 feet)	Can be implemented with minimum social and environmental impact. Does not preclude future actions at Shasta or elsewhere in CVP/SWP. Contributes to flood control and hydropower secondary objectives. High uncertainty in ability to effectively improve fish habitat through storage space dedication to increased minimum flows.	Relatively low increase in fish habitat with uncertain benefit to increased survival. Major trade-off in water supply reliability for relatively minor increased minimum flows. Incidental contribution to flood control and hydropower objectives.	Very high unit costs for increased fish habitat. Also, very high unit cost for water supply reliability. High costs due to dedicating storage space to increasing minimum winter/spring flows with little contribution to water supply.	Generally consistent with the goals of CALFED. However, low potential for Federal interest – less costly ways to achieve similar benefits to fishery.	Enlarging Shasta primarily to increase winter/spring river flows for anadromous fish is **not recommended** for further consideration as a stand-alone plan. Very high costs for marginal increases in meeting objectives. Same conclusion for any sized project with similar component measures. However, potential operational changes to increase fish survival are recommended for further study as part of any plan considered.
Relative Rank	*Moderate*	*Low*	*Low*	*Low*	*Low*

TABLE VIII-1
SUMMARY COMPARISON OF CONCEPT PLANS (CONT.)

Concept Plans	Comparison Criteria				Recommendation Status and Relative Ranking
	Completeness	**Effectiveness**	**Efficiency**	**Acceptability**	
AFS-3 – Increase Anadromous Fish Flow and Restore Aquatic Habitat with Shasta Enlargement (6.5 feet)	Similar to AFS-2. However, increased certainty in ability to improve fish habitat through physical fish spawning area improvements.	Similar to AFS-2. Increased effectiveness in anadromous fish habitat through gravel mine restoration.	Similar to AFS-2. Very high unit costs t0 meet primary objective.	Similar to AFS-2.	Similar to AFS-2, **not recommended** for further consideration as a stand-alone plan. High costs for marginal increases in meeting objectives. However, potential for increased fish habitat downstream from Keswick Dam recommended for further assessment and possible inclusion in future plans.
Relative Rank	*Moderate*	*Low*	*Low*	*Low*	*Low*
WSR-1 – Increase Water Supply Reliability with Shasta Enlargement (6.5 feet)	Can be implemented with minimum impact and would not require future elements. Does not preclude future action at Shasta or elsewhere in CVP. Addresses primary objectives.	Relatively low potential to effectively increase water supply reliability and improve fish survival. Incidental contribution to flood control and hydropower objectives.	High cost-efficiency. Unit cost for water supply reliability highly competitive with other new sources, including potential surface water storage projects.	Meets goals of CALFED and consistent with plan in CALFED ROD. High potential for avoiding perceived impacts.	Enlarging Shasta primarily for water supply reliability from sizes 6.5 feet to about 18.5 feet is **recommended** for further development primarily because (1) consistent with goals of the CALFED ROD, (2) high-cost-efficiency compared to other new sources, and (3) provides significant incidental benefits to anadromous fish and secondary study objectives.
Relative Rank	*Very High*	*Low*	*Moderate*	*High*	*Moderate to High*
WSR-2 – Increase Water Supply Reliability with Shasta Enlargement (18.5 feet)	Similar to WSR-1. Significant potential for avoiding/mitigating potential increased impacts.	Moderate potential to effectively address primary objectives. Significant contribution to water supply reliability. Incidental contribution to flood control and hydropower objectives.	Very high cost-efficiency. Superior to all other known new sources, including potential surface water storage projects.	Consistent with goals of CALFED. Significant potential for avoiding perceived impacts.	**Recommended** for further development for reasons similar to WSR-1. Also, enlarging Shasta to maximum extent possible without major relocations can maximize cost-efficiency.
Relative Rank	*Very High*	*Moderate*	*Very High*	*High*	*High to Very High*

TABLE VIII-1
SUMMARY COMPARISON OF CONCEPT PLANS (CONT.)

Concept Plans	Comparison Criteria				Recommendation Status and Relative Ranking
	Completeness	Effectiveness	Efficiency	Acceptability	
WSR-3 – Increase Water Supply Reliability with Shasta Enlargement (High Level)	Can be physically implemented with high confidence. However, numerous impacts would occur, primarily in reservoir area with reduced certainty for successful mitigation.	High potential to significantly address primary planning objectives. Significantly addresses water supply reliability. Can contribute significantly to cold water salmon resources. Provides major opportunities to address secondary objectives.	Very high implementation cost. Relatively high unit cost for new water supplies.	Low potential for Federal interest – likely less costly ways of achieving similar benefits to water supply reliability.	**Not recommended** for further consideration. High social and environmental impacts in Shasta Lake area. Very high implementation cost.
Relative Rank	*Low*	*High*	*Low*	*Low*	*Low*
WSR-4 – Increase Water Supply Reliability with Shasta Enlargement (18.5 feet) and Conjunctive Water Management	Significant potential for avoiding/mitigating potential increased impacts. Some degree of uncertainty about implementing conjunctive water management plan element due to likely contract modifications.	Similar to WSR-2 with increased contribution to water supply reliability through conjunctive use management.	Very high cost-efficiency for water supply reliability. Results in the lowest unit cost of all plans considered and of all other known potential water supply reliability projects.	Similar to WSR-2.	Enlarging Shasta to maximum extent possible without major relocations and including conjunctive water management component is **recommended** for further development. Recommended primarily due to consistency with goals of the CALFED ROD. WSR-4 is also believed highly cost efficient.
Relative Rank	*High*	*Moderate*	*Very High*	*High*	*High*
CO-1 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (6.5 feet)	Can be implemented with minimum impact and would not require future elements. Does not preclude future action at Shasta or elsewhere in CVP. Addresses all planning objectives.	Potential to address primary planning objectives with emphasis on spawning habitat restoration. Contributes to cold water salmon resources and reduced mortality. Includes features to increase reservoir reoperation for flood control and water supply.	Unit cost for water supply reliability competitive with other new sources, including potential surface water storage projects. High potential for efficient salmon habitat restoration along upper river.	Similar to WSR-1. Consistent with goals of CALFED and other local area restoration goals.	**Not recommended** for further consideration as a stand-alone plan. Major components are redundant with WSR-1 and CO-2, which are recommended for further development.
Relative Rank	*High*	*Moderate*	*Moderate*	*High*	*Moderate to High*

TABLE VIII-1
SUMMARY COMPARISON OF CONCEPT PLANS (CONT.)

Concept Plans	Comparison Criteria				Recommendation Status and Relative Ranking
	Completeness	**Effectiveness**	**Efficiency**	**Acceptability**	
CO-2 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)	Similar to CO-1.	Similar to CO-1 but with increased potential to address primary and several secondary planning objectives due to increased storage space.	High cost-efficiency. Unit cost for water supply reliability highly competitive with other new sources, including potential surface water storage projects. High potential for efficient salmon habitat restoration along upper river.	Similar to CO-1.	Enlarging Shasta to maximum extent possible without major relocations and including features to increase anadromous fish habitat is **recommended** for further development. Recommended primarily because this plan is (1) consistent with goals of the CALFED ROD, (2) highly cost efficient, and (3) addresses most of the planning objectives.
Relative Rank	*High*	*High*	*High*	*High*	*High*
CO-3 – Increase Anadromous Fish Flow/Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)	Similar to AFS-2 and AFS-3.	Low to moderate potential to effectively address primary objectives. Potential to significantly benefit salmon resources through restoring fish habitat. Provides major opportunities to address secondary objectives.	Reduced cost-efficiency for water supply reliability due to dedicated increased minimum flows.	Generally consistent with the goals of CALFED. However, high cost with marginal benefits for dedicated storage to anadromous fish minimum flows.	For reasons similar to AFS-2 and AFS-3, enlarging Shasta with significant storage space dedicated to increased winter/spring flows for anadromous fish is **not recommended** for further consideration as a stand-alone plan at this time. Very high costs for marginal increases in meeting objectives. However, potential operational changes to increase fish survival are recommended further study as part of any plan considered.
Relative Rank	*Moderate*	*Moderate*	*Moderate*	*Low to Moderate*	*Moderate*

TABLE VIII-1
SUMMARY COMPARISON OF CONCEPT PLANS (CONT.)

Concept Plans	Comparison Criteria				Recommendation Status and Relative Ranking
	Completeness	**Effectiveness**	**Efficiency**	**Acceptability**	
CO-4 – Multipurpose with Shasta Enlargement (6.5 feet)	Similar to CO-1. Some degree of uncertainty about implementing conjunctive water management plan element due to likely contract modifications.	Moderate potential to address primary planning objectives with emphasis on spawning habitat restoration. Contributes to cold water salmon resources and reduced mortality. Includes features to increase reservoir reoperation for flood control and water supply. Includes features to help restore ecosystem resources along upper Sacramento River and near Shasta Lake.	Most cost-efficient plan for a 6.5-foot dam raise. Moderate potential for efficient salmon habitat restoration along upper river. High potential for helping restore ecosystem resources along upper Sacramento River and near Shasta Lake.	Similar to WSR-1 and CO-1.	**Not recommended** for further consideration as a stand-alone plan with a 6.5-foot raise primarily due to reduced effectiveness and efficiency. Major components are redundant with WSR-1 and CO-5, which are recommended for further development.
Relative Rank	*High*	*Moderate*	*Moderate*	*High*	*Moderate to High*
CO-5 – Multipurpose with Shasta Enlargement (18. 5 feet)	Similar to CO-1. Some degree of uncertainty about implementing conjunctive water management plan element due to likely contract modifications.	High potential to address primary planning objectives with emphasis on spawning habitat restoration. Significantly contributes to cold water salmon resources and reduced mortality. Includes features to increase reservoir reoperation for flood control and water supply. Includes features to help restore ecosystem resources along upper Sacramento River and near Shasta Lake.	High cost-efficiency for water supply reliability. High potential for efficient salmon habitat restoration along upper river. High potential for helping restore ecosystem resources along upper Sacramento River and near Shasta Lake.	Consistent with the goals of the CALFED for various programs, including water supply reliability and ecosystem restoration.	Enlarging Shasta to maximum extent possible (without major relocations), including features for conjunctive water management, anadromous fish habitat, and ecosystem restoration is **recommended** for further development. Recommended primarily because this plan is (1) consistent with goals of the CALFED ROD, (2) highly cost-efficient, and (3) addresses all planning objectives.
Relative Rank	*High*	*High*	*High*	*High*	*High*

Authorization/Objectives

This subcriterion is an estimate of a plan's consistency with the basic study authorization and whether it addresses each of the primary planning objectives and provides opportunities to address the secondary objectives. For example, AFS-1 specifically addresses only one primary planning objective – anadromous fish survival – and therefore receives a low ranking for completeness.

Reliability

Reliability is a measure of a plan's capability to provide, over the life of a project, the specific and sustained benefits for which the plan was intended. It also includes a determination of whether other projects, programs, or actions are necessary to implement the project and develop the full level of benefit for which the plan was intended. It includes determining whether future actions, other than normal and identified O&M, are required for full and successful implementation of the plan. Concept plans that include increasing minimum flows for anadromous fish purposes (AFS-2, AFS-3, and CO-3) have a higher uncertainty than other plans. This is primarily because few definitive links exist between increased minimum flows, in the range being considered with the concepts, and increased fish survival. Concept plans including conjunctive water management also have a higher uncertainty than other plans primarily due to of the peripheral actions likely required for their implementation, such as existing contract modifications and service area structural modifications.

Physical Implementability

Physical implementability is the potential for a plan to be constructed or implemented within the study area, with disclosure of any unusual construction challenges potentially impacting project construction. All of the concept plans have a high potential for physical implementability.

Environmental Resources

This subcriterion estimates the relative ability of a plan to either avoid potential adverse environmental impacts or successfully mitigate for unavoidable adverse impacts. All concept plans, with the exception of WSR-3, are believed to have a high potential to either avoid or successfully mitigate environmental impacts (see also Hydraulic Conditions, below).

Water and Related Resources

This subcriterion is a determination of whether or not a plan can be implemented to mitigate any unavoidable impacts to water, power, recreation, flood control, and/or related resources. All concept plans, with the exception of WSR-3, are believed to have a high potential for implementation with minimum impacts to water and related resources. WSR-3 could provide significant net increases in hydropower resources. However, WSR-3 would also adversely impact existing generating facilities. All plans could indirectly benefit flood control and hydropower generation. Plans with dam raises greater than 6.5 feet would negatively impact near-lake recreation facilities.

Hydraulic Conditions

This subcriterion measures the ability of a plan to avoid potentially adverse hydraulic impacts to other areas or to mitigate any unavoidable impacts. Since all concept plans include increasing the water surface of Shasta Reservoir, each would inundate greater areas than under without-project conditions – 1,100, 2,600, and 31,000 acres for the 6.5-, 18.5-, and 200- foot dam raises, respectively. Once full, the range for the reservoir in annual inundation would be similar to without-project conditions for all alternatives considered, except during dry and critically dry years. Little can be done to avoid impacts associated with increased areas of inundation. Mitigation would include working to reduce the effects of the inundation with soil erosion control measures and introducing water-tolerant vegetation plantings. Acquisition and management of other areas to mitigate impacts also would be considered. The ability to successfully mitigate impacts from low-level dam raises (6.5 and 18.5 feet) would be high.

All concept plans would result in relatively minor changes in flow conditions downstream from Keswick Dam. Each would tend to reduce flows in the river from about December through March annually, and increase flows in spring and summer from about May through August. Average annual peak winter and spring/summer releases from Keswick Dam are about 10,000 and 14,000 cfs, respectively. Estimated maximum decreases in winter flows would range from about 300 and 600 cfs for the 6.5- and 18.5-foot dam raises (3 to 6 percent of without-project flows), respectively, to about 2,000 cfs (21 percent) for the 200-foot dam raise. Average maximum spring and summer increases in flows would range from about 200 and 300 cfs for the 6.5- and 18.5-foot dam raises (2 to 3 percent of the without project flows), respectively, to about 840 cfs (8 percent) for the 200-foot dam raise. These changes in flows become less significant further downstream from Keswick Dam due to the influence of tributaries to the Sacramento River.

Cultural Resources

This subcriterion measures the ability of a plan to avoid potential adverse impacts to present or historic cultural resources or to successfully mitigate for adverse unavoidable impacts. Each of the concept plans, with the exception of WSR-3, would have relatively minimal impact on reservoir area cultural resources. This is primarily due to the relatively small increased inundation area at full pool for all concepts except WSR-3.

Effectiveness Criterion

Effectiveness is the extent to which a plan alleviates problems and achieves objectives. For the primary planning objective of anadromous fish survival, two major relative ranking factors were considered: (1) increasing salmon survival (decreased salmon mortality) and (2) increasing habitat for spawning. For water supply reliability, ranking was based on the relative amount of new drought period yield that could be derived from each concept plan. For the secondary objectives, three relative ranking factors were considered: (1) whether a plan included ecosystem restoration, (2) potential to affect flood peaks downstream from Keswick Dam, and (3) potential to increase net electric energy. Primary planning objectives received 80 percent of the weight and secondary objectives received 20 percent of the weight for this criterion.

As indicated in **Table VIII-1**, concept plans with the greatest effectiveness in meeting planning objectives are WSR-3, CO-2, and CO-5. This is primarily because, of the 12 concept plans, these 3 would result in the greatest combined contribution to both primary planning objectives. Each AFS-focused plan, when compared to other concept plans, ranks low primarily because they would provide limited benefits to other study objectives. The same conclusions apply to the larger sizes of raising Shasta Dam.

Anadromous Fish Survival

This subcriterion is the relative ability of a plan to help increase the survival of anadromous fish populations in the Sacramento River primarily upstream from the RBDD. Included in **Table VIII-2** is a preliminary estimate of the average annual increase in salmon populations resulting from the increase in the cold water pool in Shasta Reservoir for three dam enlargements and reservoir operations. Also included in the table is a ratio of the increase in storage space in Shasta Reservoir to the estimated average annual increase in salmon population for each of the concept plans. This ratio is an attempt to help estimate the relative effectiveness of each plan for anadromous fish survival. For dam raises of 6.5 feet, the greatest benefit to fish survival and the greatest storage-to-increased-fish-survival ratio would occur with AFS-1 because all additional space would be dedicated to the goal of increasing the cold water pool. However, AFS-1 would not significantly contribute to the other planning objectives. The next greatest increase in fish survival with a dam raise of 6.5 feet would occur with WSR-1 and similarly with CO-1. Each plan also could provide significant benefits to the other objectives. The least apparent benefit in increased salmon survival would occur with AFS-2 and AFS-3. This is because increasing minimum flows on the upper Sacramento River would deplete the cold water pool, which may be needed later in the year for temperature regulation during the warm summer months. Also for these two concept plans, the potential to benefit other objectives would be low. It is expected that similar relationships would occur for larger dam raises but with effectiveness increasing for anadromous fish survival.

The estimated difference in increased fish survival benefits between WSR-1 or CO-1 and CO-4 (dam raises of 6.5 feet) or WSR-2 and WSR-4 or CO-5 (dam raises of 18.5 feet) is because operating to include a conjunctive management component in the concept plans lessens the amount of cold water available during critical periods compared to operations without the conjunctive management component. The greatest benefit to anadromous fish from an increase in the cold water pool would be with WSR-3 (dam raise of 200 feet). It is believed, however, that this plan could have adverse impacts not yet defined that would discount the apparent increase in salmon survival.

Also included in **Table VIII-2** is an estimate of the increase in spawning habitat resulting from both restoring several abandoned gravel mines and increasing minimum winter-spring flows for the anadromous fish consistent with the goals of the AFRP. It is estimated that dedicating the increased storage space in Shasta Reservoir to increasing minimum winter and spring flows for AFS-2 and AFS-3 would increase the area of potential successful fish spawning by nearly 150 acres (riverine area that would be dewatered without the increase in increased flows). It is expected that for higher dam raise scenarios, the increases in spawning habitat would be generally proportionally greater. However, it is believed also that based on increase in spawning area only, greater amounts of increased habitat could be obtained by restoring historical spawning areas such as abandoned gravel mining areas.

TABLE VIII-2
COSTS AND ACCOMPLISHMENTS SUMMARY

Item	CONCEPT PLANS											
	Anadromous Fish Survival Focus			Water Supply Reliability Focus				Combined Objective Focus				
	AFS-1	**AFS-2**	**AFS-3**	**WSR-1**	**WSR-2**	**WSR-3**	**WSR-4**	**CO-1**	**CO-2**	**CO-3**	**CO-4**	**CO-5**
Raise Shasta Dam (ft)	**6.5**	**6.5**	**6.5**	**6.5**	**18.5**	**200**	**18.5**	**6.5**	**18.5**	**18.5**	**6.5**	**18.5**
Total Increased Storage (1,000 AF)	290	290	290	290	636	9340	636	290	636	636	290	636
Accomplishments												
Anadromous Fish												
- Spawning Habitat - Restore Gravel Mines (acres)	-	-	150	-	-	-	-	150	150	150	150	150
- Minimum Flows (acres)	-	170	170	-	-	-	-	-	-	170	-	-
- Summer/Fall Mortality Reduction (no. fish)[1]	862	373	373	406	1107	10624	1024	406	1107	975	406	1024
Water Supply Reliability (1,000 AF/year)[2]	0	20	20	72	125	703	146	72	125	90	89	146
Ecosystem Restoration (acres)	-	-	-	-	-	-	-	-	-	-	548	548
Hydropower Generation (GWh/yr)	51	32	32	15	44	2,254	44	15	44	61	12	44
Annual Cost												
Total for Alternative ($millions)	19.4	19.4	20.1	19.4	28.1	383.0	32.3	20.1	28.8	28.8	25.4	34.0
Independent Increments ($millions)[3]												
- Gravel Mine Restoration	-	-	1.0	-	-	-	-	1.0	1.0	1.0	1.0	1.0
- Ecosystem Restoration	-	-	-	-	-	-	-	-	-	-	1.2	1.2
- Subtotal	-	-	1.0	-	-	-	-	1.0	1.0	1.0	2.2	2.2
Creditable to Water Supply Reliability ($millions)[4]	0	5.4	5.4	19.4	28.1	383.0	32.3	19.1	27.8	20.2	23.2	31.8
Creditable to Anadromous Fish ($millions)[5]												
- Spawning Habitat	-	14.0	13.7	-	-	-	-	-	-	7.6	-	-
- Mortality Reduction	19.4	-	-	-	-	-	-	-	-	-	-	-
Relative Anadromous Fish Benefit												
Relative Mortality Reduction Ratio (fish/1,000 AF)[6]	3.0	1.3	1.3	1.4	1.7	1.1	1.6	1.4	1.7	0.6	1.4	1.6
Spawning Habitat ($1,000/acre)[7]												
- Minimum Flow Improvement	-	82	81	-	-	-	-	-	-	34	-	-
- Gravel Mine Restoration	-	-	7	-	-	-	-	7	7	7	7	7
Unit Cost for Water Supply ($millions/AF)[8]	-	270	270	270	225	550	220	265	220	230	260	220
Key: AF – acre-feet AFS – anadromous fish survival CO – combined objective GWh/yr – gigawatt hours per year WSR – water supply reliability												

Notes:
[1]Average annual increase in chinook salmon population.
[2]Increased water supply yield based on drought year conditions with Banks Pumping capacity at 6,680 cfs. At 8,500 cfs pumping capacity, yield about 18 percent greater.
[3]Average annual cost of plan elements that can be implemented independent of other features.
[4]Portion of average annual cost to develop water supply yield based on expected yield multiplied by unit cost for similar-sized WSR alternatives.
[5]Annual cost creditable to anadromous fish = (total average annual cost) – (annual costs for independent features) – (annual costs creditable to water supply reliability).
[6]Average annual increase in salmon population divided by total increase in storage.
[7]Average annual cost of each acre of increased spawning habitat.
[8]Unit water cost based on portion of annual cost creditable to water supply reliability divided by estimated increase in water supply reliability (drought period yield).

Water Supply Reliability

This subcriterion is the relative potential of a plan to help increase water supplies and water supply reliability to the CVP and SWP to help meet future water demands, with a primary focus on modifying Shasta Dam and Reservoir. Included in **Table VIII-2** is an estimate of the increase in drought period water supply reliability for the concept plans. As can be seen, the increase in water supply reliability ranges from about 20,000 acre-feet per year for dam raises of 6.5 feet (including dedication of increased storage to increasing spring fish flows) to over 700,000 acre-feet per year for a dam raise of 200 feet. The exception is concept plan AFS-1, which would only provide an incidental amount of water supply yield.

Ecosystem Restoration

This subcriterion is a measure of the ability of a plan to address the secondary objective of ecosystem restoration. Through pursuit of the primary planning objectives, significant potential is created to implement features to help preserve and restore ecosystem resources in the Shasta Lake area and along the upper Sacramento River. Concept plans CO-4 and CO-5 include ecosystem restoration features in the Shasta Lake area and along the upper Sacramento River.

Flood Damage Reduction

This subcriterion is a measure of the ability of a plan to reduce flood damages along the upper Sacramento River. Each of the concept plans incidentally provides increased flood control opportunities, especially in the reach of the Sacramento River upstream from Cottonwood Creek. Concepts CO-1 through CO-5 also include opportunities to reoperate Shasta Dam and Reservoir to increase its efficiency for flood control. Further evaluations are needed to identify specific operation changes and the relative magnitude of potential flood control benefits.

Hydropower

This subcriterion is a measure of the ability of a plan, through pursuit of the primary planning objectives, to help increase hydropower capabilities at Shasta Dam. Each of the plans incidentally provides increased opportunities for hydropower generation (see **Chapter IX**). From **Table VIII-2**, increases in hydropower generation range from about 12 GWh/year for CO-4 to over 2,200 GWh/year for WSR-3 (not including loss of generation at the Pit 7 Dam).

Efficiency Criterion Description

Efficiency is the measure of how efficiently a plan alleviates identified problems while realizing specified objectives consistent with protecting the Nation's environment. Concept plans ranking highest for this criterion are WSR-2, WSR-4, CO-2, and CO-5. This is primarily because each of these plans provides a significant increase in water supply reliability at a relatively low unit cost while significantly contributing to other planning objectives. Each of the AFS-focused concept plans and WSR-3 rank low. For the AFS-focused plans, this is primarily because the increased storage space would be dedicated to either increasing the cold water pool or instream flows. These plans would provide very little economic benefit to the other planning objectives. The same conclusion applies to larger sizes of raising Shasta Dam. Also, concept plan WSR-3 ranks low because of its very high implementation cost.

Anadromous Fish Survival

This is a measure of the potential for a plan to increase the long-term survivability of anadromous fish in the upper Sacramento River at the lowest incremental cost. As shown in **Table VIII-2**, the estimated annual unit cost for each acre of increased habitat resulting from an increase in the winter/spring minimum flows for concept plans AFS-2, AFS-3 and CO-3 is many times more costly than for habitat increases resulting from physically restoring historical spawning areas.

Water Reliability Unit Cost

This is a measure of the potential for a plan to increase the reliability of the CVP and SWP by developing a reliable additional increment of water at the lowest unit cost (dollars per acre-foot of drought period yield). As shown in **Table VIII-2**, it is estimated that concept plans WSR-2, WSR-4, CO-2, and CO-5 would result in the lowest unit water costs compared to the other plans. Costs would range from a low of about $220 per acre foot to about $550 per acre-foot, which is the total cost creditable to water supply reliability divided by the estimated average annual yield. Excluding AFS-1, concept plans that would result in the highest unit cost for increased water supply reliability are AFS-2, AFS-3, WSR-1, and WSR-3.

Secondary Planning Objective Costs

This is a measure of the potential for a plan to also include benefits for ecosystem restoration, flood damage reduction, and hydropower with the lowest incidental and economically justified additional cost. All dam raise scenarios provide some amount of increased seasonal storage space that can contribute to increased efficiency in flood operations and a higher head for power generation. The relative efficiency to provide flood control and hydropower increases with larger reservoirs and higher dam raises. The efficiency of a plan in providing ecosystem restoration relative to enlarging Shasta Dam and Reservoir will require additional evaluation.

Acceptability Criterion

Acceptability is the workability and viability of a plan with respect to its potential acceptance by other Federal agencies, State and local governments, and public interest groups and individuals. At the current stage of plan formulation for the SLWRI, little is known about the ultimate likelihood for Federal agency acceptance or non-Federal sponsorship. Accordingly, the likelihood of Federal interest and consistency with the CALFED ROD are the primary factors used to assess acceptability at this current stage in the planning process. Other factors important to acceptability that will be focused on in future studies to further develop and evaluate alternative plans include (1) non-Federal sponsorship, (2) potential for broad spectrum acceptance, and (3) likely compliance with existing laws, regulations, and policies.

Concept plans that are estimated to rank highest for this criterion are WSR-1, WSR-2, WSR-4, CO-1, CO-2, CO-4, and CO-5. This is primarily because these plans generally address the primary planning objectives and some or all of the secondary objectives, and are generally consistent with the goals and objectives of CALFED. Concept plans that rank lowest are AFS-1 and WSR-3, primarily because they address only one primary objective, as for AFS-1, or would likely lack Federal interest due to their very high cost and high and difficult-to-mitigate socioeconomic and environmental impacts.

Likelihood for Federal Interest

Potential for Federal interest exists for each of the concept plans providing the plans are economically feasible and a non-Federal sponsor(s) is capable and willing to share in implementing the cost for a potential project. For those plans with high costs for a specific unit of benefit to the anadromous fishery, ecosystem, or water supply reliability, potential for Federal interest is greatly diminished because of the likely lack of economic feasibility. This is believed to especially true for concept plans similar to AFS-1, AFS-2, AFS-3, WSR-3, and CO-3 (see **Table VIII-2**).

CALFED Consistency

This is a measure of the relationship of the plan to the overall goals and objectives of the CALFED ROD or other ongoing projects and programs. To rank high, a plan must neither preclude nor enhance the potential for development of other projects and programs. All of the concept plans, with the exception of AFS-1 and WSR-3, are believed to be fundamentally consistent with the CALFED ROD.

INITIAL ALTERNATIVES

After comparing each concept plan to the planning criteria above, five plans appeared superior in **Table VII-1** and in supporting analyses. Accordingly, these five plans and the required No-Action plan are recommended for further development as full initial alternatives in the SLWRI. Features and combinations of feature sizes in the initial alternatives will likely change in future studies. Some of the initial alternatives may be combined with others or dropped from further development. Further, other measures and combinations of measures may emerge and warrant development into full initial alternatives. Concept plans recommended as initial alternatives include the following:

- No-Action
- WSR-1 –Increase Water Supply Reliability with Shasta Enlargement (6.5 feet)
- WSR-2 – Increase Water Supply Reliability with Shasta Enlargement (18.5 feet)
- WSR-4 – Increase Water Supply Reliability with Shasta Enlargement (18.5 feet) and Conjunctive Water Management
- CO-2 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)
- CO-5 – Multipurpose with Shasta Enlargement (18.5 feet)

No-Action (No Federal Action)

Under this No-Action plan, the Federal Government would take no action toward implementing a specific plan to help increase anadromous fish survival opportunities in the upper Sacramento

River nor help address the growing water reliability issues in the Central Valley of California through the assistance of Shasta Dam and Reservoir.

WSR-1 – Increase Water Supply Reliability with Shasta Enlargement (6.5 feet)

The primary purpose of this plan is to be consistent with the CALFED ROD, with a focus on increasing water supply reliability while contributing to increased anadromous fish survival. It includes raising Shasta Dam 6.5 feet, raising the Shasta Reservoir gross pool by 8.5 feet, and enlarging the total storage space in Shasta Reservoir by 290,000 acre-feet to 484 MAF (see **Plate 17**). This plan would help reduce estimated future water shortages through increasing drought year supplies by about 72,000 acre-feet per year. Increased pool depth and volume also could contribute to seasonal water temperature benefits to spring-run salmon. In addition, incidental benefits to flood control and hydropower would be achieved.

WSR-2 – Increased Water Supply Reliability with Shasta Enlargement (18.5 feet)

This plan focuses on increasing water supply reliability through the likely greatest practical enlargement of Shasta Dam and Reservoir consistent with the goals of the CALFED ROD. It includes raising Shasta Dam 18.5 feet, raising the Shasta Reservoir gross pool by 20.5 feet, and enlarging total storage space in Shasta Reservoir by 636,000 acre-feet to 5.19 MAF (see **Plate 18**). This plan would help reduce estimated future shortages through increasing drought year water supply reliability by about 125,000 acre-feet per year. The increased pool depth and volume also could contribute to seasonal water temperature benefits to anadromous fish.

WSR-4 – Enhanced Water Supply Reliability with Shasta Enlargement (18.5 feet) and Conjunctive Water Management

The goal of this plan is to increase water supply reliability of the CVP and SWP through a combination of conjunctive water management and enlargement of Shasta Dam and Reservoir consistent with the goals of the CALFED ROD. This plan is similar to Plan WSR-2. However, it also includes implementing a conjunctive water management component consisting primarily of contract agreements between Reclamation and certain Sacramento River basin water users. These agreements would focus on exchanging additional surface water supplies in normal water years for reduced deliveries in dry and critically dry years, at which time participants would rely more heavily on groundwater supplies to meet demands (see **Plate 18**). This plan would help reduce estimated future shortages through increasing drought year water supply reliability by about 146,000 acre-feet per year. Increased pool depth and volume also could contribute to seasonal water temperature benefits to anadromous fish.

CO-2 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)

The primary purpose of this plan is to address both primary planning objectives with a focus on increasing anadromous fish habitat and enlarging Shasta Reservoir by 18.5 feet. This plan includes enlarging Shasta Dam and Reservoir as WSR-2. In addition to increasing cold water pool depth and volume in Shasta Lake to help benefit anadromous fish, the plan includes restoring inactive gravel mines along the Sacramento River (see **Plate 19**). Also, the plan includes further investigation of and potential modifications to the existing TCD at Shasta Dam for enhanced temperature management, and increasing the operational efficiencies of Shasta Dam and Reservoir for water supply reliability and flood control.

CO-5 – Multipurpose with Shasta Enlargement (18.5 feet)

This plan addresses both primary planning objectives through enlarging Shasta Dam and Reservoir consistent with the goals of the CALFED ROD, including increased water supply reliability and increased fish spawning habitat in the upper Sacramento River. The plan also contains features to address the secondary objectives. For water supply reliability, this plan includes enlarging Shasta Dam and Reservoir as in WSR-2. For anadromous fish survival, this plan includes an increased cold water pool depth and volume in Shasta Reservoir and restoring inactive gravel mines and floodplain habitat along the Sacramento River (see **Plate 20**). In addition, the plan includes further investigation of and potential modifications to the existing TCD at Shasta Dam for enhanced temperature management, and increasing the operational efficiencies of Shasta Dam and Reservoir for water supply reliability and flood control. Finally, the plan includes (1) implementing conjunctive water management as in Plan WSR-4, (2) constructing warm water fish habitat in the Shasta Lake area, and (3) restoring one or more riparian habitat areas between Redding and Red Bluff on the Sacramento River.

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CHAPTER IX
SPECIAL TOPICS

This chapter summarizes various topics and analyses that, in addition to information in the appendices and reference documents, supported development of the concept plans and initial alternatives. Special topics included in this chapter are (1) scenarios for enlarging Shasta Dam and Reservoir, (2) designs and costs, (3) CALSIM II modeling, (4) fish survival assessment, (5) hydropower benefits and (6) sensitivity of Banks Pumping Plant expansion.

SHASTA DAM AND RESERVOIR ENLARGEMENT SCENARIOS

In the 1999 Reclamation report titled Appraisal Assessment of the Potential for Enlarging Shasta Dam and Reservoir, an evaluation was made of the major features, issues, and costs associated with three potential raise scenarios for Shasta Dam and Reservoir: Low-Raise Option (6.5-foot raise), Intermediate-Raise Option (102.5-foot raise), and High-Raise Option (202.5-foot raise). Information from the report was reviewed and is summarized in this appraisal-level assessment.

A breakpoint analysis was conducted in early 2003 to identify the elevations of Shasta Dam raises for which implementation costs would significantly change due to the need for relocations or modifications of major project features. The analysis identified two fundamental cost components associated with raising Shasta Dam and enlarging Shasta Reservoir: (1) modifying the main dam and appurtenances and (2) modifying reservoir infrastructure and facilities. It was concluded in the analysis that the first major breakpoint in costs for increasing the size of Shasta Reservoir would occur with a top-of-gross-pool raise from elevation 1,067 to about elevation 1,087.5 (20.5-foot raise), which would correspond to a dam raise of about 18.5 feet. This is primarily due to the need to relocate the Pit River Bridge with dam raises greater than about 18.5 feet. The second major breakpoint would occur with a top-of-gross-pool raise to about elevation 1,100, which would correspond to a dam raise of about 30 feet. Raises of up to about 30 feet could likely be accomplished by raising the existing dam crest while higher dam raises would require increasing the dam mass, and constructing coffer dams and other facilities. Accordingly, two additional dam raise scenarios (approximately 18.5 and 30 feet) were developed in an effort to assess the relationship between the height of a dam raise and resulting cost of new water supplies, and also to help focus the number of concept plans.

Information is presented below on the three scenarios included in the 1999 report and two expanded low-level dam raise scenarios. Also included is a comparison of the various dam raise scenarios to identify potential sizes recommended for further development into concept plans.

Low-Level Raise - 6.5 Feet

Major components, accomplishments and costs, system yield, implementation costs and unit costs for the low-level raise (6.5 feet) are described in this section.

Major Components

The 6.5-foot Low-Level Raise scenario consists of a structural dam raise of 6.5 feet with a new enlarged crest elevation at 1,084 feet. This scenario would have a new top of joint-use storage space at elevation 1,075.5, and result in an additional 8.5 feet of water in the reservoir. The total capacity of this new reservoir would be 4.84 million acre-feet, which is an increase of 290,000 acre-feet above the existing available storage. At gross pool storage, the reservoir would cover about 30,700 acres, which is an increase of about 1,100 acres over existing conditions (4 percent increase). **Table IX-1** lists major features associated with this dam raise scenario.

TABLE IX-1
SHASTA DAM AND RESERVOIR ENLARGEMENT FEATURES

Item	Baseline	Low-Level Raise – 6.5 Feet	Expanded Low-Level Raise – 18.5 Feet	Expanded Low-Level Raise – 30 Feet	Inter-mediate-Level Raise – 102.5 Feet	High-Level Raise – 202.5 Feet
Dam Crest Raise (ft)	NA	6.50	18.50	30.00	102.50	202.50
Dam Crest Elevation (ft)	1,077.50	1,084.00	1,096.00	1,107.50	1,180.00	1,280.00
Gross Pool Raise (ft)	NA	8.50	20.50	32.00	104.50	204.50
Gross Pool Elevation (ft)	1,067.00	1,075.50	1,087.50	1,099.00	1,171.50	1,271.50
Reservoir Capacity (MAF)	4.55	4.84	5.19	5.57	8.47	13.89
Surface Area @ Gross Pool Elevation (acres)	29,600	30,700	32,100	33,700	44,200	60,800
Capacity Increase (MAF)	NA	0.29	0.64	1.02	3.92	9.34

Key:
ft – feet MAF - million acre-feet NA - not applicable

The dam raise would be limited to the existing dam crest only, with mass concrete placed in blocks on the existing concrete gravity section and precast concrete panels used to retain compacted earthfill placed on wingdam embankment sections. A new spillway crest section would be developed within the raised structure. Control features of the existing TCD would be extended up to the new crest elevation and the main TCD enclosure would be extended to the new gross pool elevation.

Although the raised dam crest construction would remain above the new top of joint-use storage, and provide for flood surcharge only, waterstops and other seepage control measures would be provided. However, with a new gross pool elevation of 1,075.5, about 7 existing bridges would need to be either significantly modified or relocated. **Table IX-2** lists estimated infrastructure impacts associated with various increases in gross pool. Minor modifications to the Pit River Bridge, which carries I-5 and the UPRR near Bridge Bay, would be required with this scenario.

The expanded gross pool would impact about 45 structures that would need to be removed or relocated (see **Figure IX-1**). However, few impacts would occur to reservoir rim ecosystem resources or reservoir-area developed properties.

TABLE IX-2
RESERVOIR INFRASTRUCTURE IMPACTS AND ACTIONS FOR ELEVATIONS 1,070 - 1,280[1]

New Top of Joint-Use	Impact Remediation Actions
1,071	Relocate Charlie Creek Bridge, Doney Creek Bridge, and Antlers Bridge, relocate impacted portion of Lakeshore Drive north of Sugarloaf
1,072	Relocate UPRR Doney Creek Bridge, UPRR Sacramento River Bridge (2nd Crossing), relocate segment of Bully Hill Rd impacted on Squaw Creek Arm
1,073	Relocate portion of Lakeshore Drive impacted by Charlie Creek Bridge
1,074	Relocate McCloud River Bridge and Didallas Creek Bridge, relocate portion of Silverthorn Road impacted on Pit River Arm
1,075	Relocate Second Creek Bridge
1,076	Relocate portion of Lakeshore Drive impacted by Doney Creek Bridge
1,077	Relocate portion of impacted Conflict Point Road (on north side of Salt Creek)
1,078	Build embankment for UPRR at Bridge Bay
1,080	Build embankment for I-5 at Lakeshore, relocate portion of Gilman Road impacted near McCloud Bridge, and portion of Fender Ferry Road impacted near McCloud Bridge
1,090	Relocate UPRR Lakeshore Drive Overcrossing by Charlie Creek
1,091	Relocate Pit River Bridge, Relocate UPRR Sacramento River Bridge (2nd Crossing), relocate portion of I-5 impacted by Lakeshore (not necessary with protective dike)
1,094	Relocate UPRR Lakeshore Drive Overcrossing by Doney Creek
1,096	Relocate Wittawaket Creek Bridge and UPRR Sacramento River Bridge, 3rd Crossing
1,097	Relocate UPRR I-5 overpass
1,099	Relocate Squaw Creek Bridge
1,100	Begin to remediate impacts to Silverthorn community (population 1,100 to 1,250)
1,105	Relocate portion of West Side Road impacted at Squaw Creek Bridge
1,106	Reservoir gross pool at top of powerhouse at Pit 7 Dam[2]
1,109	Relocate UPRR Sacramento River Bridge, 4th Crossing
1,110	Relocate UPRR Dog Creek Bridge
1,111	Relocate UPRR Salt Creek Bridge
1,114	Relocate Fender Ferry Bridge (Sacramento River near Delta)
1,134	Jones Valley Dike becomes necessary
1,135	Relocate Fender Ferry Bridge (upper Pit River)
1,143	Relocate Tunnel Gulch Viaduct on I-5, relocate UPRR O'Brien Creek Bridge
1,150	Begin to remediate impacts to town of Delta (population 1,150 to 1,190)
1,165	Begin to remediate impacts town of Pollock (population 1,165 to ~1,220)
1,170	Begin to remediate impacts town of Lakehead (population 1,170 to ~1,220)
1,172	Relocate UPRR O'Brien Creek Bridge
1,180	Clickapudi Cove Dike becomes necessary
1,230	Bridge Bay and Centimundi dikes become necessary
1,278	Reservoir gross pool at crest of Pit 7 Dam[2]

Key: I-5 - Interstate 5 UPRR - Union Pacific Railroad

Notes:
[1]This table does not include impacts to specific buildings. Impacted portions of roads, communities, and other infrastructure will be relocated where possible. In cases where relocation is not feasible, facilities may need to be abandoned.
[2]Specific remediation actions at the Pit 7 Dam have not yet been determined. The elevation at which the dam would likely need to be abandoned is between elevation 1,106 feet (powerhouse yard floor) and elevation 1,278 feet (crest of dam).

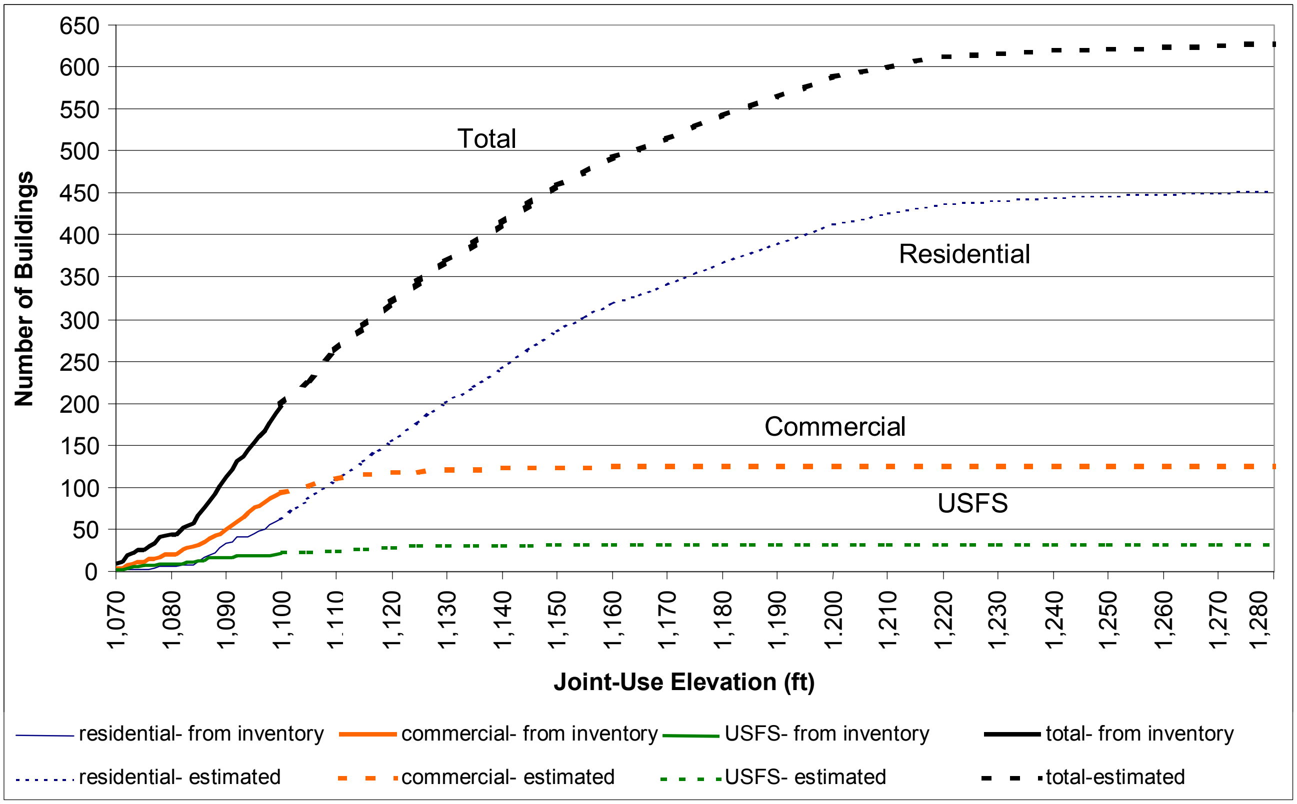

Figure IX-1 – Estimated number of structures affected by increasing the height of Shasta Dam and Reservoir.

Accomplishments and Costs

Although not to the extent of higher-larger reservoir sizes, this scenario would have the potential to contribute to both primary study objectives if also consistent with the CALFED ROD. It could support each of the secondary study objectives, and help increase anadromous fish survival by creation of a small increased cold water pool. In addition, it could help reduce flood damage along the upper Sacramento River, and increase hydropower generation, and slightly increase potential reservoir area recreation opportunities. Also, it would have minor impacts on the McCloud River and associated issues relating to the State of California special designation of that waterway.

System Yield

As mentioned previously and described in **Appendix A**, water system operation studies for the CVP and SWP were made using the CALSIM II mathematical model for the five dam raise scenarios described in this section. **Table IX-3** shows a comparison of the annual yield for simulated CVP and SWP deliveries for average year and drought year conditions with Banks Pumping Plant capacity at 6,680 cfs, and for various Shasta Dam raise scenarios. The table shows the relative increase in reliability of each dam raise scenario to meet future demands. As expected, higher dam raise scenarios have a significantly higher potential to meet future demands.

TABLE IX-3
CVP/SWP SYSTEM YIELD INCREASE
(1,000 acre-feet per year)

Dam Raise	Average Year Conditions	Drought Year Conditions
Low-Level Raise - 6.5 Feet	48	72
Expanded Low-Level Raise – 18 Feet	71	125
Expanded Low-Level Raise – 30 Feet	110	185
Intermediate-Level Raise - 102.5 Feet	214	425
High-Level Raise - 202.5 Feet	331	703
Key: CVP – Central Valley Project	SWP – State Water Project	

Implementation Costs

Preliminary estimates of total first and annual costs for Shasta Dam raise scenarios were developed for relative comparison purposes. Costs were based primarily on updating information contained in Reclamation's 1999 Appraisal report to October 2003 price levels, a 5-5/8 percent interest rate, and a 100-year analysis period. Estimated costs are summarized in **Table IX-4**. **Figure IX-2** shows the estimated first cost for each scenario; two cost estimates were developed for each Expanded Low-Level Raise scenario. The intent of the two estimates was to estimate the influence of major cost breaks or jumps resulting from implementing major relocations for the 18.5-foot raise scenario, and additional dam construction costs for the 30-foot raise scenario. Cost estimates for each Expanded Low-Level Raise scenario in the table are based primarily on interpolating costs between the Low-Level and Intermediate-Level raises. As shown in **Table IX-4,** the estimated first cost for the Low-Level Raise Scenario is $282 million; the resulting estimated average annual cost is $19 million.

TABLE IX-4
FIRST AND ANNUAL COSTS FOR DAM RAISE OPTIONS

Dam Raise Options	First Cost ($millions)[1]	Annual Costs ($millions)[2]
Low-Level Raise	282	19
Expanded Low-Level Raise – 18.5 Feet (without major relocations)	408	28
Expanded Low-Level Raise – 18.5 Feet (with major relocations)	1,060	75
Expanded Low-Level Raise – 30 Feet (block raise)	1,250	89
Expanded Low-Level Raise – 30 Feet (mass raise)	1,330	94
Intermediate-Level Raise – 102.5 Feet	3,890	283
High-Level Raise – 202.5 Feet	5,250	383

Notes:
[1] Most information updated by price levels and interest rates from May 1999 Shasta Dam and Reservoir Enlargement, Appraisal Assessment, by Bureau of Reclamation. October 2003 price levels.
[2] Construction period of 6 years for lower raise scenarios, and 8 to 10 years for higher raise scenarios. Average annual costs based on 5-5/8 percent over a 100-year project life.

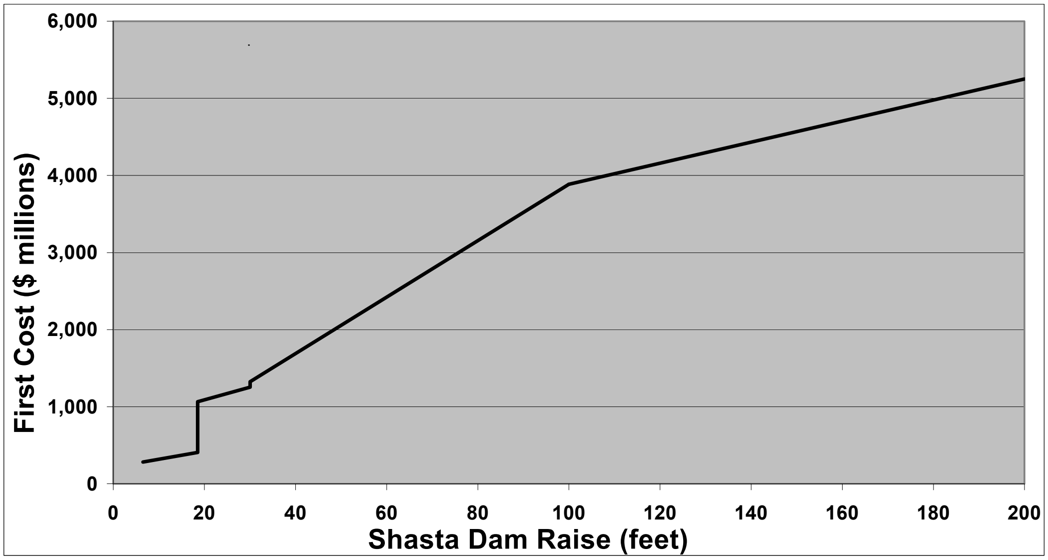

Figure IX-2 – Estimated first cost for various Shasta Dam raises.

Unit Costs

Table IX-5 summarizes the estimated total storage, water supply yield, and first and annual costs for each scenario considered. The table also shows the estimated unit cost of water for the various dam raise scenarios, and estimates of unit costs for the two Expanded Low-Level scenarios, including major relocations and dam construction costs at estimated major breakpoints. The total storage unit cost in the table is the estimated cost to develop an acre-foot of new storage. Total storage unit cost is the total first cost divided by the additional storage created by the scenario. The unit cost for new water supply yield is computed using estimates of both average annual and drought yield. Unit cost information from **Table IX-5** as a function of new dam crest elevation was used to create the plot in **Figure IX-3**. The need for major relocations (primarily for I-5 and UPRR facilities) for a dam raise of about 18.5 feet (elevation 1,095) has a dramatic effect on the estimated unit cost for new storage and new water supplies at Shasta. The need to change construction methods for a dam raise of about 30 feet (elevation 1,107.5) has a significantly smaller influence. As shown in **Table IX-5** and **Figure IX-3**, the estimated total unit storage cost for the Low-Level Raise scenario is about $970 per acre-foot. The estimated unit cost for average annual and drought year yield would be about $410 and $270 per acre-foot, respectively.

TABLE IX-5
WATER SUPPLY UNIT COST SUMMARY

Description	Low-Level Raise – 6.5 Feet	Expanded Low-Level Raise – 18.5 Feet		Expanded Low-Level Raise – 30 Feet		Inter-mediate-Level Raise	High-Level Raise
		Without Bridges	With Bridges	Block Raise	Mass Raise		
Added Storage (1,000 acre-feet)	290	636	636	1,020	1,020	3,920	9,340
Yield (1,000 acre-feet per year)							
- Average Annual	48	71	71	110	110	214	331
- Drought Year	72	125	125	185	185	425	703
Unit Cost ($/acre-foot)							
- Total Storage[1]	970	640	1,670	1,230	1,300	990	560
- Yield – Avg Annual[2]	410	400	1,050	810	850	1,320	1,160
- Yield – Drought Year[3]	270	225	600	480	510	670	550

Notes:
[1]First cost divided by increase in total storage.
[2]Annual cost divided by average annual yield.
[3]Annual cost divided by drought year yield.

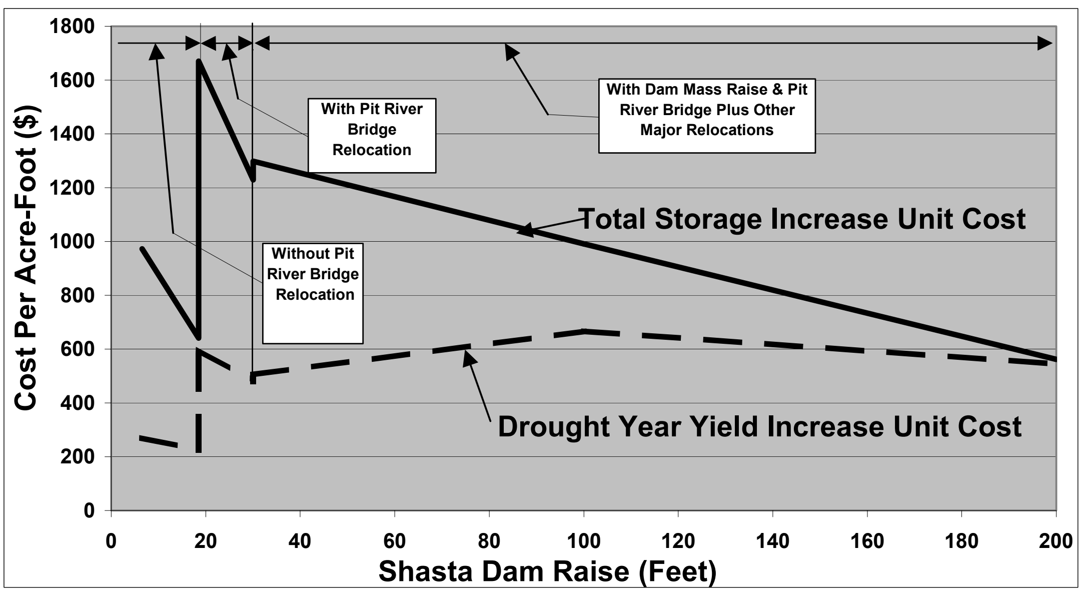

Figure IX-3– Plot of total storage and water supply reliability yield unit cost for various increases of Shasta Dam Raise.

Expanded Low-Level Raise – 18.5 Feet

Major components, accomplishments and costs for the Expanded Low-Level Raise (18.5 feet) are described in this section.

Major Components

This scenario consists of a structural dam raise of 18.5 feet with a new crest at elevation 1,096. The total capacity of this new reservoir would be 5.19 MAF, which is an increase of 636,000 acre-feet above the existing available storage. At gross pool storage, the reservoir would cover about 32,100 acres, which is an increase of about 2,500 acres over existing conditions (9 percent).

The dam raise would be limited to the existing dam crest only, with mass concrete placed in blocks on the existing concrete gravity section and concrete wing dams constructed on both abutments. A new spillway crest section would be developed within the raised structure. Control features of the existing TCD would be raised up to the new crest elevation and the main TCD enclosure would be extended to the new gross pool elevation.

The 18.5-foot Expanded Low-Level Raise scenario would require a new crest roadway, spillway bridge, elevators, gantry crane, and associated mechanical equipment required for operating the various outlet gates, TCD, and other features. Although the raised dam crest construction would remain above the new top of joint-use storage, and provide for flood surcharge only, waterstops and other seepage control measures would be provided.

As can be determined from **Table IX-2**, with the increased gross pool at elevation 1,087.5, an estimated 7 bridges in the reservoir area would need to be modified and/or relocated. Pending the results of additional analysis, it appears that this scenario represents the likely greatest dam raise without full relocation of I-5 and the UPRR Pit River Bridge at Bridge Bay. Even at a gross pool elevation increase of 20.5 feet, the water surface would encroach to within 4 feet of the low cord of the bridge, which is believed to be the minimum freeboard allowable before full relocation for railroad bridges. To prevent adverse impacts to two bridge piers (Piers 3 and 4) resulting from periodic inundation, the project would include constructing a skirting system around the upper portions of the piers. For clearance for houseboats, a maximum gross pool raise would be limited to about 14 feet. However, it is believed that because of the infrequent occurrences of the water surface reaching gross pool during high recreation periods, appropriate mitigation features can be included for this scenario.

The expanded gross pool area requires about 130 structures to be removed or relocated (see **Figure IX-1)**. Relatively minor impacts would occur to reservoir rim ecosystem resources. However, this scenario also includes relocating many reservoir area recreation facilities.

Accomplishments and Costs

This scenario would significantly contribute to both primary study objectives. It also could support each secondary study objective. Increasing the gross pool storage at Shasta Reservoir by about 636,000 acre-feet by raising the dam 18.5 feet would increase the average annual and annual drought year yield by about 71,000 and 125,000 acre-feet, respectively (see **Table IX-5**).

It also could help increase anadromous fish survival by creating a small increased cold water pool. In addition, it could help reduce flood damages along the upper Sacramento River, and increase hydropower generation. It would slightly increase potential reservoir area recreation opportunities. This scenario is generally consistent with the goals and objectives in the CALFED ROD. It would have minor and manageable impacts on the McCloud River and issues relating to the State of California special designation of that waterway.

As shown in **Table IX-4**, to accomplish this magnitude of dam raise without major reservoir area relocations, the estimated first cost for this scenario would be about $410 million. The estimated average annual cost would be about $28 million. This would result in a unit cost for the new storage space in Shasta of about $640 per acre-foot (**Table IX-5**). The resulting estimated unit costs for average annual and drought year yield would be about $400 and $225 per acre-foot, respectively (see **Figure IX-3**).

Tables IX-4 and **IX-5** and **Figures IX- 2** and **IX-3** also show the estimated impact on the first, annual, and unit costs for an 18.5-foot dam raise, including relocating I-5 and the UPRR Pit River Bridge at Bridge Bay. (It is believed for a dam raise greater than about 18.5 feet, this relocation would be needed.) The first cost would increase to an estimated $1.06 billion. The estimated total unit storage cost would increase to about $1,670 per acre-foot. The estimated unit cost for average annual and drought year yield would be about $1,050 and $600 per acre-foot, respectively.

Expanded Low-Level Raise – 30 Feet

Major components and accomplishments and costs for the Expanded Low-Level Raise (30 feet) are described in this section.

Major Components

This scenario consists of a structural dam raise of 30 feet with a new crest at elevation 1,107.5 (see **Table IX-1**). This scenario would have a new top of joint-use (gross pool) storage space at elevation 1,099, resulting in an additional 32 feet of water in the reservoir. The total capacity of this new reservoir would be 5.57 MAF, an increase of 1.02 MAF above the existing available storage. At gross pool storage, the reservoir would cover about 33,700 acres, which is an increase of about 4,100 acres over existing conditions (14 percent).

This scenario represents the likely greatest dam raise without major modification of the dam mass (concrete overlay on downstream face) and replacement of wing dams, river outlets, and penstocks. The dam raise would be limited to the existing dam crest only, with mass concrete placed in blocks on the existing concrete gravity section and concrete wing dams constructed on both abutments. A new spillway crest section would be developed within the raised structure. Control features of the existing TCD would be raised up to the new crest elevation and the main TCD enclosure would be extended to the new gross pool elevation.

The 30-foot Expanded Low-Level Raise 30 foot scenario would require a new crest roadway, spillway bridge, elevators and gantry crane, and associated mechanical equipment required for operating the various outlet gates, TCD, and other features. Although the raised dam crest construction would remain above the new top of joint-use storage, and provide for flood surcharge only, waterstops and other seepage control measures would be provided.

The expanded gross pool area would require about 200 structures to be removed or relocated (see **Figure IX-1**). This scenario also would result in impacts to various major and minor transportation, recreation, hydropower, and other reservoir area facilities. In addition, it would require replacement of the Pit River Bridge at Bridge Bay and 12 other major and minor reservoir area bridges and roadway segments. Also, most recreational facilities would require relocation. Significant impacts to reservoir rim and tributary stream ecosystem resources would occur.

Accomplishments and Costs

This scenario also would significantly contribute to both primary study objectives and also support each of the secondary study objectives. Increasing the gross pool storage at Shasta Reservoir by over 1 MAF through raising the dam 30 feet would increase the average annual and annual drought year yield to the CVP by an estimated 110,000 and 185,000 acre-feet, respectively (see **Table IX-5**). It could help increase anadromous fish survival by creating an increased cold water pool. In addition, it could help reduce flood damages along the upper Sacramento River, and increase hydropower generation. It would increase potential reservoir area recreation opportunities. This scenario is generally consistent with the goals and objectives in the CALFED ROD. It would, however, have impacts on the lower McCloud River and issues relating to the State of California Species of Special Concern designation in that watershed.

As shown in **Table IX-4** and **Figure IX-2**, the estimated first cost for this scenario would be about $1.25 billion. The estimated average annual cost is $89 million. This would result in a unit cost for the new storage space in Shasta of about $1,230 per acre-foot **(Table IX-5).** Estimated unit costs for average annual and drought year yield would be about $810 and $480 per acre-foot, respectively.

It is believed that for dam raises greater than about 30 to 50 feet, the existing concrete gravity dam section would need to be raised using a mass concrete overlay as opposed to raising the dam using concrete blocks. **Tables IX-4** and **IX-5** and **Figures IX- 2** and **IX-3** also show the estimated impact on first, annual, and unit costs for a 30-foot dam raise, including this change in construction method. The first cost would increase to an estimated $1.33 billion and the estimated total unit storage cost would increase to about $1,300 per acre-foot. The estimated unit cost for average annual and drought year yield would be about $850 and $510 per acre-foot, respectively.

Intermediate-Level Raise – 102.5 Feet

Major components and accomplishments and costs for the Intermediate-Level Raise (102.5 feet) are described in this section.

Major Components

The Intermediate-Level Raise scenario consists of a structural dam raise of 102.5 feet to a new crest at elevation 1,180 (see **Table IX-1**). The new top of joint-use storage space would be at elevation 1,171.5. This would allow for storage of an additional 104.5 feet of water in the reservoir above the existing joint-use storage pool elevation. Total capacity of this new reservoir would be 8.47 MAF or an increase of 3.92 MAF above the existing available storage. At gross pool storage, the reservoir would cover about 44,200 acres, which is an increase of about 14,600 acres over existing conditions (49 percent). **Plate 15** includes the aerial extent of the Intermediate-Level Raise scenario in relationship to other dam raise scenarios being considered.

The existing concrete gravity dam section would be raised using a mass concrete overlay on the main section of the dam with roller-compacted concrete (RCC) wing dams constructed on both abutments. The left wing dam would extend approximately 1,380 feet, and the right wing dam would extend approximately 420 feet. The mass concrete overlay on the downstream face of the existing dam in the main section would extend from elevation 1,180 down to the foundation contact at the downstream toe on a 0.7:1 slope. The spillway section would be made thicker to accommodate the gated spillway crest.

This dam raise scenario would require a new crest roadway, spillway bridge, elevators, and a gantry crane, and associated mechanical equipment required for operating the various outlet gates, TCD, and other features. It would also involve constructing two new saddle dikes at Jones Valley and Clickapudi Creek.

The expanded gross pool area would require about 520 structures to be removed or relocated (see **Figure IX-1**). This scenario also would result in impacts to numerous major and minor transportation, recreation, hydropower, and other reservoir area facilities. New power facilities would likely be needed at Shasta, primarily including improvements to the existing penstocks. In addition, most recreational facilities would require relocation. Significant impacts would occur to historical and cultural resources in the Shasta Lake area. Major impacts would occur to reservoir area and tributary stream ecosystem resources. The Intermediate-Level raise would also require relocation or abandonment of the PG&E Pit 7 Dam and Powerhouse on the upper Pit River just upstream of Lake Shasta.

It is important to note that in addition to the Pit River Bridge, which would be the single most costly relocation item associated with a dam raise, 20 other bridges cross Shasta Reservoir or one of its tributaries. A significant number of bridge relocations would be required with minor increases in the top of joint-use elevation, and all of the main reservoir bridges would need to be relocated with a top of joint-use raise of about 73 feet. However, with greater increases in top of joint-use elevations, major railroad and/or roadway system relocation (UPRR and I-5) also would be required.

Accomplishments and Costs

This scenario would significantly contribute to both primary study objectives and also support each of the secondary study objectives. Increasing the gross pool storage at Shasta Reservoir by 3.9 MAF by raising Shasta Dam 102.5 feet would increase the estimated average annual and critical dry period yield to the CVP by an estimated 214,000 and 425,000 acre-feet, respectively (see **Table IX-5**). It could help increase anadromous fish survival by creating a small increased cold water pool. In addition, it could help reduce flood damages along the upper Sacramento River, and increase hydropower generation. It would result in a significant increase in potential reservoir area recreation opportunities. However, it would have major impacts on the McCloud River and issues relating to the State of California special designation of that waterway.

Because of the significant increase in storage in Shasta Reservoir for this scenario, and resulting influence on residual available water resources in the upper watershed, planning for other potential water resources projects would be likely influenced measurably. Also, because this scenario requires most of the infrastructure within the reservoir area to be relocated, significant disruption would occur to local and interstate roadway and railroad transportation, recreation, and related facilities in the Shasta Lake region.

As shown in **Table IX-4** and **Figure IX-2**, the estimated first cost for this scenario is about $3.9 billion with an estimated average annual cost of about $283 million. The estimated unit cost for the new storage space in Shasta Lake would be about $990 per acre-foot. The resulting unit cost for the average annual and drought year water supply yield would be about $1,320 and $670 per acre-foot, respectively **(Table IX-5).**

High-Level Raise – 202.5 Feet

Major components and accomplishments and costs for the High-Level Raise (202.5 feet) are described in this section.

Major Components

The High-Level Raise scenario consists of a structural dam raise of 202.5 feet to a new crest at elevation 1,280 (see **Table IX-1**). The new top of joint-use storage space would be elevation 1,271.5. This would allow storage of an additional 204.5 feet of water in the reservoir. The total capacity of this new reservoir would be 13.89 million acre-feet, an increase of 9.34 million acre-feet above the existing available storage. This dam raises represents the highest practical raise of Shasta Dam. Enlargements beyond this point would begin to experience significant geological foundation problems. At least one upstream PG&E dam and Powerhouse would be relocated with the high level raise - Pit 7 Dam and Powerhouse on the upper Pit River. At gross pool storage, the reservoir would cover about 60,800 acres, which is an increase of about 31,200 acres over existing conditions (105 percent). **Plate 15** shows the aerial extent of the High-Level Raise scenario in relationship to other dam raise scenarios being considered.

The existing concrete gravity dam section would be raised using a mass concrete overlay on the existing dam crest and downstream face. The upstream face within the curved nonoverflow sections would extend vertically to the new dam crest at elevation 1,280, and the downstream face would have a 0.7:1 slope to the downstream toe. The dam crest would be completed with a crest cantilever for the roadway surface, sidewalks, and parapet walls. Existing elevator shafts would be extended to the new dam crest, and new elevator towers would be provided. The spillway section would require a thicker section to accommodate the gated spillway crest.

The new dam crest would include a crest roadway and spillway bridge, passenger and freight elevators, and three gantry cranes. This option would require constructing four saddle dikes to close off the gaps between mountain peaks in the upper watershed. A new powerplant and associated switchyard facilities would be included on the left abutment. The existing powerplant would continue to be operated within its operation range. The existing penstocks on the right abutment would be upgraded.

The expanded gross pool area would require nearly 630 structures to be removed or relocated. As with the Intermediate-Level Raise scenario, this scenario would require replacement of major infrastructure associated with Shasta Dam and Reservoir.

Significant impacts would occur to historical and cultural resources in the Shasta Lake area. Major impacts would occur to reservoir area and tributary stream ecosystem resources. This scenario would have major and likely irreversible impacts to the McCloud River and issues relating to the State of California special designation of that waterway.

Accomplishments and Costs

This High-Level Raise scenario would significantly contribute to both primary study objectives and support each of the secondary study objectives. Increasing the gross pool storage at Shasta Reservoir by 9.1 MAF by raising Shasta Dam 202.5 feet would increase the estimated average annual and critical dry period yield to the CVP by an estimated 330,000 and over 700,000 acre-feet, respectively (see **Table IX-5**). It would significantly increase anadromous fish survival by creating a very large increased cold water pool. In addition, because of the significant increase in total space in Shasta Reservoir capable of capturing significantly more peak flood flows, this scenario could help resolve many existing flood problems along the upper Sacramento River. It would result in major increases in hydropower generation. It also would result in a substantial increase in water-oriented recreation in Shasta Lake by more than doubling the lake surface area at gross pool elevation.

Because of the significant increase in storage in Shasta Reservoir for this scenario, and resulting influence on residual available water runoff from the upper Sacramento River watershed, planning for other potential water resources projects in the Central Valley very likely would be influenced measurably. Also, because the scenario would require most of the infrastructure within the reservoir area to be relocated, significant disruption would occur to local and interstate roadway and railroad transportation, recreation, and related actions in the Shasta Lake region.

The estimated first cost for this scenario is about $5.2 billion with the estimated average annual cost of about $383 million (see **Table IX-4**). The estimated unit cost for new storage space in Shasta Lake would be about $560 per acre-foot **(Table IX-5)**. The resulting unit cost for the average annual and drought year water supply yield would be about $1,160 and $550 per acre-foot, respectively **(Table IX-5)**.

Screening

The five dam raise scenarios were compared to identify the scenarios that should be considered in more detail and included in concept plans. **Table IX-6** is a summary comparison and screening of each scenario. As shown in the table, three Shasta Dam enlargement scenarios were identified for development into concept plans: the Low-Raise scenario, Expanded Low Level Raise – 18.5-Foot scenario, and High-Raise scenario. The Expanded Low-Level Raise – 30-Foot, Intermediate-Raise, and all other Shasta Dam and Reservoir enlargement scenarios were eliminated from further consideration. Following is a summary of each scenario.

TABLE IX-6
SUMMARY COMPARISON OF SHASTA DAM RAISE SCENARIOS

Description	Low-Level Raise (6.5 feet)	Expanded Low-Level Raise (18.5 feet)	Expanded Low-Level Raise (30 feet)	Intermediate-Level Raise (102.5 feet)	High-Level Raise (202.5 feet)
Major Features					
Dam Crest Raise (feet)	6.5	18.5	30	102.5	202.5
Gross Pool Raise (feet)	8.5	20.5	32	104.5	204.5
Capacity Increase (million AF)	0.29	0.64	1.02	3.92	9.34
Surface Area Increase (%)	4	8	14	49	105
Water Reliability Accomplishments					
Drought Year Yield (AF/year)	72	125	185	425	703
CVP Yield Replacement (%)[1]	13	20	31	77	100
Cost					
First Cost ($ millions)	282	408	1,250	3,890	5,250
Annual Cost ($ millions)	19	28	89	283	383
Unit Cost ($/AF)[2]	270	225	480	670	550
Major Advantages	• Low unit cost. • No major relocations. • Consistent with CALFED ROD. • Can contribute to both primary objectives. • Potential to provide about 5 and 14 percent of projected 2020 drought and average year shortages, respectively, in the Sacramento and San Joaquin River basins. • Low impacts in reservoir rim area.	• Low unit cost. • No major relocations. • Consistent with goals of CALFED ROD. • Can contribute to both primary objectives. • Potential to provide up to about 7 and 20 percent of projected 2020 drought and average year shortages, respectively, in the Sacramento and San Joaquin River basins.	• Can contribute to both primary objectives. • Potential to provide up to about 11 and 31 percent of projected 2020 drought and average year shortages, respectively, in the Sacramento and San Joaquin River basins.	• Can contribute to both primary objectives. • Can contribute significantly to increased recreation, hydropower, and flood control secondary objectives. • Potential to provide about 27 and 77 percent of projected 2020 drought and average year shortages, respectively, in the Sacramento and San Joaquin River basins.	• Can significantly contribute to both primary objectives. • Can contribute significantly to increased recreation, hydropower, and flood control secondary objectives. • Potential to provide about 45 and 100 percent of projected 2020 drought and average year shortages, respectively, in the Sacramento and San Joaquin River basins. • Likely lowest-cost project capable of resolving future water supply shortages.
Major Disadvantages	• Relatively low potential to meet primary objectives.	• Marginal potential to meet primary objectives. • Moderate reservoir rim impacts.	• Very high unit cost. • Requires major reservoir area relocations.	• High unit water cost. • Requires major reservoir area relocations. • High reservoir area impacts.	• High unit water cost. • Requires major reservoir area relocations. • Very high reservoir area impacts.
Status	• **Retained** for further development – low unit water cost.	• **Retained** for further development – significant accomplishments for planning objectives and low unit water cost.	• **Deleted** from further consideration – major relocations and high unit water cost.	• **Deleted** from further consideration – major reservoir impacts and high unit water cost.	• **Retained** for further consideration – high potential to meet future water shortages.

Key: AF – acre-feet CVP – Central Valley Project ROD – Record of Decision

Notes:
[1]Percent replacement of CVPIA water reallocation.
[2]Unit cost for drought year yield.

Low-Level Raise – 6.5 Feet - On the basis of an estimated unit cost per an increase in drought year yield of $270 per acre-foot, this scenario would be one of the most efficient of the five considered. Primarily due to (1) the relatively low cost for additional dry period yield, (2) high reliability of accomplishing its identified benefits, (3) low overall impact to ecosystem and related resources, (4) ability to combine with other measures, and (5) consistency with the CALFED program, this scenario was retained for more detailed analysis as part of the concept plans.

Expanded Low-Level Raise – 18.5 Feet - On the basis of an estimated unit cost per increase in drought year yield as low as $225 per acre-foot, this scenario also would be one of the most efficient of the five considered. This option was retained for more detailed analysis. Primarily due to (1) the potential for additional dry period yield and high potential to influence average year water supply reliability, (2) low implementation cost and water supply reliability cost, (3) relatively low overall impact to ecosystem and related resources, and (4) consistency with the goals of the CALFED program,

Expanded Low-Level Raise – 30 Feet - On the basis of an estimated high unit cost per new system yield, this scenario would result in relatively low economic efficiency compared with the 6.5-foot and 18.5 foot scenarios. Primarily due to significantly high implementation costs relative to accomplishments, this scenario was deleted from further consideration.

Intermediate-Level Raise – 102.5 Feet - On the basis of an estimated high unit cost per new system yield, this scenario also would result in low economic efficiency compared with the other dam raise scenarios. Primarily due to significantly high implementation costs and unit costs for water supply reliability relative to overall accomplishments, this scenario was deleted from further consideration.

High-Level Raise – 202.5 Feet - On the basis of an estimated high unit cost per new system yield, this scenario would result in relatively low economic efficiency. However, no other known single surface water storage project or combination of surface water projects in the Central Valley of California is as capable of significantly addressing the projected future water shortages with comparable unit water costs as the High-Level Raise scenario. This scenario could provide nearly half the total expected 2020 water shortages of the CVP and SWP. Also, it could almost completely fulfill the water supply replacement objectives of the CVPIA. It would, however, result in major resources impacts in the reservoir area. Primarily because unit costs for new water storage and for average annual yield reliability would be highly competitive at the magnitude of potential developed supplies compared to other surface water storage projects being considered by CALFED, this scenario was carried forward for inclusion in a concept plan.

DESIGNS AND COSTS

Appraisal-level designs and cost estimates were developed for the concept plans described in **Chapter VII**. A description of these designs and costs are contained in **Appendix E (Basis of Design)** and referenced in the Shasta Dam and Reservoir Enlargement Initial Assessment Study. Following is a summary of these efforts.

Designs

Most of the design information for various dam raise elements and options in the SLWRI is based on previous evaluations preformed as part of the initial feasibility study and for the 1999 Appraisal Report, and contained in reference documents provided with this report. For the 202.5-foot raise, no additional designs were developed beyond the 1999 Appraisal Report. Additional work was conducted on designs for the 6.5-foot and 18.5-foot dam raise scenarios primarily related to main dam features, spillways, wing dams, major relocations, and appurtenant features.

Dam and Appurtenances

Following is a highlight of main dam and appurtenances features for the 6.5-foot and 18.5-foot dam raises.

Main Dam

Raises for Shasta Dam of 6.5 or 18.5 feet could be accomplished by adding blocks of mass concrete to the existing dam crest (concrete gravity section and spillway crest section). It is estimated that the mass concrete block method of raising the dam would be adequate for a raise in height about equal to its crest width (approximately 30 feet).

Wing Dams

As the height of Shasta Dam increases, wing dams would be required to extend the dam crest beyond its existing length. For a 6.5-foot dam raise, wing dams would be composed of reinforced earth embankments. For an 18.5-foot dam raise, the wing dams are estimated to be concrete to elevation 1089.5 with a similar reinforced earth panel construction on top of the concrete.

Spillway

For any raise of Shasta Dam, the three existing drum gates would be removed due to a seismic loading deficiency and their inability to handle increased reservoir loads. The drum gates would be replaced with six radial gates, each of which would be operated using a gate hoist located on an operating deck above the gate. The new top of joint-use storage (gross pool) would be at the top of the radial gates when lowered. The spillway crest and dam crest would be raised, and the training walls would be extended. The existing spillway crest length of 330 feet would be retained and the proper ogee spillway shape would be maintained.

River Outlets

Shasta Dam has 18 river outlets in 3 tiers. A dam raise of 6.5 or 18.5 feet would require replacement of the lower tier tube valves on the 102-inch outlet valves due to problems with vibration during certain operating conditions. New gates on the lower tier outlets would also provide increased operating reliability and improved discharge capacity. Current estimates indicate that the middle tier of gates is adequate for the Low-Level and Expanded Low-Level raises. River outlet modification work is estimated to be the same for the 6.5-foot and 18.5-foot dam raises.

Power Outlets

Facilities associated with the power outlets at Shasta Dam include the TCD and penstocks.

Temperature Control Device

Modifications to the TCD would be needed for dam and top of joint-use elevation raises above about 2 to 3 feet. For both 6.5-foot and 18.5-foot dam raises, modifications would primarily include extending the main steel structure to the new gross pool elevation; raising the TCD operating equipment, including gate hoists, electrical equipment, miscellaneous metalwork, and hoist platform above the new top of joint-use elevation; and lengthening the shutter operating cables.

Penstock Intake and Penstock Modifications

It is estimated that the centerline of the existing penstock intakes would remain at the current level, but the gate hoists would require relocation with a higher dam crest. The existing penstocks are estimated to be adequate for increased hydrostatic pressures resulting from a dam raise of 6.5 or 18.5 feet. Additional penstock foundations (earthquake supports) would be provided on the exposed portion of the penstocks downstream of the dam.

Reservoir Area Dikes

Small reservoir dikes would be required in the areas of Antlers/Lakeshore (for a dam raise of 18.5 feet) and the UPRR between Tunnels 1 and 2 at the south end of Bridge Bay (for dam raises of 6.5 and 18.5 feet) for protection of major existing infrastructure from increased gross pool elevations. A typical section, estimated for both of these dike locations, would have a top width of 15 feet and side slopes of 3:1, with the crest elevation estimated to be the same as the dam crest.

Major Relocations

Major structures that would need to be modified or relocated include the Pit River Bridge, railroad bridges, vehicle bridges, major roads and road segments and buildings.

Pit River Bridge

The Pit River Bridge carries the UPRR on the lower deck and I-5 on the upper deck. With either of the two low-level raises being considered, some type of protection for the bearings and steel members on the piers in the deepest part of the old Pit River channel (Piers 3 and 4) would be necessary. A scenario to protect the bearings and the steel members at Piers 3 and 4 was developed that considers using reinforced concrete box type structures to keep reservoir water off the bearings and the structure. The reinforced concrete structures would be attached to the existing piers and extend out as cantilevers parallel to the tracks with a closure wall around the perimeter. The length of the box is defined to protect the bridge lower chord steel for a distance of 4 feet above the gross pool. The top of the box would have a roof-type structure, which would provide access for inspection and maintenance activities.

Railroad Bridges

Two UPRR bridges would need to be relocated due to the increased reservoir levels with a 6.5-foot or 18.5-foot dam raise: Doney Creek Bridge and Sacramento River Bridge, Second Crossing.

It is estimated that these bridges, which were designed in the late 1930s, could be replaced with structures that would allow the current railroad elevations and grades to remain unchanged. The grades would be maintained so as not to affect railroad operations expenses, which, if changed could result in a substantial perpetual cost. Elevations would remain unchanged to minimize the amount of railroad that would need to be relocated. The railroad has a maximum allowable grade of 1 percent, so if bridge elevations were changed, the corresponding distance of railroad line modifications would be significant.

The scenario for replacing both bridges includes constructing a new replacement bridge immediately adjacent to the existing bridge on top of existing piers that would need to be completed. This would permit the new bridges to be constructed without impact to the railroad except for the short period of time needed to rework tracks on either end to connect new track to existing track. Replacement of railroad bridges is based on potential use of existing pier construction to eliminate the need for deep water construction of new piers. This consideration would result in a significant cost savings for bridge relocations if existing piers are found to be adequate for current design standards.

Vehicle Bridges

Five vehicle bridges would need to be relocated due to the increased reservoir levels with a 6.5-foot or 18.5-foot dam raise. The bridges to be relocated would include Charlie Creek, Doney Creek, McCloud River, Didallas Creek, and Second Creek bridges. No detailed designs, cost estimates, or alternative alignment analyses have been performed for these bridges, except when previous design work was performed by other agencies. Appraisal-level costs have been developed on a per square foot basis. Future study would be needed to address detailed design and cost estimates for these bridges.

Major Roads and Road Segments

Main roads that would be impacted for dam raises of 6.5 or 18.5 feet include Lakeshore Drive, Fenders Ferry, Gilman, and Silverthorn roads. Lakeshore Drive connects residences, resorts, and recreation facilities in the Lakeshore and Sugarloaf areas. Fenders Ferry Road is one of the main forest roads in the northern area of Shasta Reservoir. Gilman Road provides access to recreation facilities along the McCloud River Arm from I-5. The low segments of these roads would either need to be relocated outside of a raised gross pool or abandoned.

Buildings – Resort/Marina, Residential, USFS Facilities

On the basis of the 2003 infrastructure inventory of Shasta Reservoir, it is estimated that raising Shasta Dam by 6.5 or 18.5 feet would result in about 45 or 130 structures (see **Figure IX-1**) requiring disposition, respectively. The estimated average square feet per structure in the inventory is about 1,800. Some of the structures are located around Shasta Lake by permit and may not require acquisition/relocation. However, for this cost estimate assessment, it was estimated that all structures would be acquired. Communities located in close proximity to Shasta Lake include Sugarloaf, Lakeshore, Silverthorn, Delta, Pollock, Lakehead, and Riverview. Bridge Bay Resort and Marina also is located on Shasta Lake. This resort and marina complex is the largest on Shasta Lake and one of the largest inland marinas in the western United States.

Environmental Restoration

Environmental restoration components include restoring abandoned gravel mines, riparian habitat, floodplain terraces and instream and shoreline fish habitat.

Abandoned Mine Restoration Along the Sacramento River

This component of some of the concept plans consists of acquiring, restoring, and reclaiming several inactive gravel-mining operations along the Sacramento River to create valuable aquatic and floodplain habitat. Gravel pit restoration would involve filling deep depressions and recontouring the stream channel and floodplain to mimic more natural conditions.

For cost-estimating purposes, a total of 150 acres is estimated for restoration. Cost estimates include a per-acre cost for restoration and for land acquisition. Estimated per-acre costs were developed from available information from other recently completed upper Sacramento River and various tributary restoration projects.

Riparian and Floodplain Restoration Along the Sacramento River

This component of some of the concept plans would involve acquiring, recontouring, and revegetating floodplain terraces and adjacent riparian areas with native plants, and performing other earth work. Suitable locations for restoration would be in areas with a 20 percent to 50 percent chance of flooding in any year (commonly referred to as 2-year to 5-year floodplains). For the purpose of this preliminary evaluation, it is estimated that a total of 500 acres would be restored at one or more sites. Planting mix, composition, and density would be determined by a more detailed site analysis, but could include native cottonwood, willow, boxelder , valley oak, western sycamore, elderberry, and a variety of understory brush species. Temporary irrigation would be provided on an as-needed basis.

Cost estimates assume a per-acre cost for restoration. Estimated per-acre costs were developed from available information from other recently completed upper Sacramento River and various tributary restoration projects.

Instream Fish Habitat on Tributaries to Shasta Lake

This component of some of the concept plans primarily would include various structural techniques to trap spawning gravels in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Structural treatments would vary depending on stream conditions but generally would include installing gabions, log weirs, boulder weirs, and other anchored structures. Spawning and rearing habitat would be created by providing instream cover with large root wads and by using drop structures, boulders, gravel traps, and/or logs that cause scouring and help clean gravels. This component also would involve construction of about 40 complex boulder/log structures per mile of stream to create gravel traps, pools, and riffles. For cost-estimating purposes, it is estimated that instream aquatic restoration would be performed along a total of 8 miles of stream, or about 2 miles along the lower reaches of each of the four major tributaries to Shasta Lake. A 100-foot wide corridor for the 8 miles of restoration was estimated for land acquisition.

Shoreline Fish Habitat Around Shasta Lake

This component of some of the concept plans would involve installing artificial fish cover, including anchored complex woody structures (root wads, trunks, and other large woody structures) and boulders; planting water-tolerant and/or erosion-resistant vegetation at prescribed locations within the reservoir drawdown area; and selective reservoir rim clearing. Specific applications would be chosen as appropriate to site-specific shoreline conditions, taking into consideration bank slope, rate of erosion, proximity to tributaries, soils, and the presence of existing cover or vegetation. For cost-estimating purposes, a total of 40 acres is estimated for shoreline restoration. Cost estimates include a cost-per-complex-structure plus per-acre costs for plantings. It is estimated that about 20 structures and approximately 400 selective plantings would be required for each acre of shoreline restored.

Conjunctive Water Management

This component consists largely of contract agreements between Reclamation and certain Sacramento River Basin water users. Contract agreements would focus on exchanging additional surface supplies in normal water years with participating CVP users for reducing deliveries (reliance on groundwater supplies) in dry and critically dry years. Possible additional infrastructure needs may include any additional river diversions, increase in current diversion capacity, increase in additional pumping capacity and/or transmission facilities to facilitate the exchange. For cost-estimating purposes, it was assumed that existing river diversion and conveyance facilities would be in place to receive surface water during normal years. However, increased groundwater pumping capacity was estimated to be required during dry and critically dry years. Based on modeling simulations for preliminary work, the peak increase in peak monthly groundwater requirement is approximately 7,700 acre-feet. To pump this additional amount of groundwater, new wells and conveyance facilities likely would be required. For cost-estimating purposes, sixty 1,500-gallon-per-minute wells would be needed. In addition, 1 acre of land for each well and allowance for conveyance facilities were included in the cost estimates.

Costs

Table IX-7 shows a breakdown of costs for items in the concept plans, total estimated first costs, and average annual costs for each of the concept plans considered. First costs in the table are based primarily on information contained in the Reclamation 1999 Appraisal Report. Adjustments, and additions were made for feature additions and deletions from the Appraisal Report. Annual costs in the table are based on a project life of 100 years and a Federal discount rate of 5-5/8 percent.

TABLE IX-7
ESTIMATED FIRST AND ANNUAL COSTS FOR CONCEPT PLANS
($millions)[1]

DESCRIPTION	AFS-1	AFS-2	AFS-3	WSR-1	WSR-2	WSR-3	WSR-4	CO-1	CO-2	CO-3	CO-4	CO-5
Lands and Damages	3.8	3.8	5.6	3.8	9.4	117.0	9.8	5.6	11.3	11.3	13.0	18.7
Relocations	126.0	126.0	126.0	126.0	173.6	1,809.0	173.6	126.0	173.6	173.6	126.0	173.6
Dams and Reservoirs[2]	82.9	82.9	82.9	82.9	125.8	2,046.0	125.8	82.9	125.8	125.8	82.9	125.8
Environmental Restoration	-	-	6.6	-	-	-	-	6.6	6.6	6.6	12.5	12.5
Conjunctive Water Management	-	-	-	-	-	-	37.5	-	-	-	37.5	37.5
Cultural Resources Preservation and Environmental Mitigation[3]	23.0	23.0	23.0	23.0	32.9	424.0	37.1	23.0	33.0	33.0	27.2	37.2
TOTAL FIELD COST	235.7	235.7	244.2	235.7	341.7	4,395.9	383.7	244.2	350.2	350.2	299.2	405.2
Planning, Engineering, and Design[4]	27.8	27.8	28.6	27.8	39.9	513.5	44.9	28.6	40.7	40.7	34.3	46.4
Construction Management[5]	18.6	18.6	19.1	18.6	26.6	347.3	29.9	19.1	27.1	27.1	22.9	30.9
TOTAL FIRST COST	282.0	282.0	291.9	282.0	408.2	5,251.7	458.5	291.9	418.0	418.0	356.4	482.5
Investment Cost												
Interest During Construction	51.7	51.7	53.8	51.7	75.0	1,339.0	84.4	53.8	76.9	76.9	65.6	88.8
TOTAL INVESTMENT COST	333.7	333.7	345.7	333.7	483.2	6,590.7	542.9	345.7	494.9	494.9	422.0	571.3
Annual Cost[6]												
Interest & Amortization	18.8	18.8	19.5	18.8	27.3	372.5	30.7	19.5	28.0	28.0	23.8	32.2
Major Replacement[7]	-	-	-	-	-	-	-	-	-	-	0.2	0.2
O&M	0.6	0.6	0.6	0.6	0.8	10.5	1.6	0.6	0.8	0.8	1.4	1.6
TOTAL ANNUAL COST	**19.4**	**19.4**	**20.1**	**19.4**	**28.1**	**383.0**	**32.3**	**20.1**	**28.8**	**28.8**	**25.4**	**34.0**
Key: AFS - anadromous fish survival; CO – combined objective; O&M – operations and maintenance; WSR – water supply reliability												

Notes:
[1]October 2003 price levels.
[2]Includes pertinent dam crest structure removal, concrete dam, wing dams, spillway, outlet works, and reservoir dikes.
[3]Includes 1 percent of relocations, dams and reservoirs, environmental restoration, and conjunctive water management for cultural resources preservation and 10 percent of relocations, dams and reservoirs, and conjunctive water management for environmental mitigation.
[4]Includes 12 percent of relocations, dams and reservoirs, environmental restoration, and conjunctive water management.
[5]Includes 8 percent of relocations, dams and reservoirs, environmental restoration, environmental mitigation, and conjunctive water management.
[6]Based on 5-5/8 interest rate and 100-year period of analysis.
[7]Includes replacement of habitat features on a 16-year recurrence interval.

First costs in **Table IX-7** include eight major categories: (1) lands and damages; (2) relocations; (3) dams and reservoirs; (4) environmental restoration; (5) conjunctive water management; (6) cultural resources preservation and environmental mitigation; (7) planning, engineering, design, supervision, and administration; and (8) construction management. Estimated annual costs also are included in **Table IX-7**. Annual costs include amortizing the total investment cost over the life of the proposed plan, estimated O&M costs, and any major replacements. The investment cost includes the first cost and interest during construction (IDC). IDC was based primarily on uniform distribution of the first cost over the construction period, which would range from 6 to 8 years.

Lands and Damages

This cost item is intended to cover the estimated value of lands required for the concept plans. It includes land categories for four primary features – Shasta Lake area land rights, anadromous fish restoration, ecosystem restoration, and conjunctive water management.

For the 6.5-and 18.5-foot dam raise scenarios, other than in the vicinity of Lakeshore, few additional lands would need to be acquired through easement or purchase. However, additional lands (mostly Federal) would be inundated by the higher water surface elevation, and these lands have value.

Environmental restoration land requirements include lands for both anadromous fish restoration and ecosystem restoration. Lands required for anadromous fish restoration features include an estimated 150 acres for abandoned gravel mine restoration along the Sacramento River. Lands for ecosystem restoration include 100 acres for instream habitat restoration on tributaries to Shasta Lake, 40 acres for shoreline habitat restoration around Shasta Lake, and 500 acres for riparian and floodplain restoration along the Sacramento River. Land requirements for conjunctive water management facilities were estimated at 60 acres.

Relocations

Cost estimates include relocations and/or modifications to existing infrastructure within the Shasta Reservoir area that would be impacted by raising Shasta Dam. Likely significant relocations related to raising Shasta Dam include major roadways and bridges, UPRR tracks, bridges and appurtenances, area recreation facilities, minor roads, and related surface facilities. Potential modifications to the Pit River Bridge and railroad bridges for the 6.5- and 18.5-foot dam raises are described above. Cost estimates for impacts to I-5, railroad facilities, and other facilities for the high dam raise scenario were obtained from the 1999 Appraisal Report. Potential removal of the Pit 7 Dam for the high dam raise scenario is not included in the cost estimate.

Dams and Reservoirs

Costs for dams and reservoirs include estimated costs for modifications to the main dam at Shasta, wing dams, reservoir dikes, spillway modifications, outlet works, powerplant modifications (for the higher dam raise), and potential changes to or replacements of the TCD.

Environmental Restoration

Environmental restoration costs were developed for abandoned gravel mine restoration along the Sacramento River, riparian and floodplain restoration along the Sacramento River, instream habitat restoration on tributaries to Shasta Lake, and Shasta Lake shoreline habitat restoration.

Conjunctive Water Management

Conjunctive water management includes estimated costs for groundwater pumping facilities and associated infrastructure.

Cultural Resources

A value equal to 1 percent of the first cost for each of the concept plans (less lands) was developed to account for future cultural surveys and limited recovery and restoration. Additional recovery and restoration efforts could be required depending on results of the surveys and future project definition.

Environmental Mitigation

One of the plan formulation criteria is to minimize the need for environmental mitigation. However, at this level of study, to ensure that estimated total project costs are sufficient to cover costs of possible environmental mitigation, or changes in project designs to avoid mitigation, a value of 10 percent of the first cost for each of the concept plans (less lands) was developed. Resources baseline inventories and studies are underway in the primary study area. These inventories and studies will be used in the development of each of the alternative plans to better define the mitigation features, if required, and develop consistent scope cost estimates.

CALSIM II MODELING

As described in **Chapter VII**, three categories of concept plans were developed that focus on (1) increasing anadromous fish survival, (2) increasing water supply reliability or (3) combined objectives. CALSIM II, a statewide water resources planning model, was used in the SLWRI to evaluate hydrologic impacts from Shasta Lake enlargement and/or changes in system operation in the California water supply system. In the hydrologic analyses, a benchmark was established and concept plans were simulated by modifying benchmark facilities or operational rules. Hydrologic impacts are defined as CALSIM II result differences between the concept plans and benchmark conditions. CALSIM II hydrologic features of each SLWRI initial concept plan are summarized in **Table IX-8**. (See **Appendix A** for more detail.)

Concept Plans Focused on Anadromous Fish Survival

The primary objective of the AFS concept plans is to increase anadromous fish survival through a Shasta Lake enlargement of 290,000 acre-feet. Although there were three AFS concept plans, only AFS-2 was simulated in CALSIM II. A primary purpose of AFS-1 would be to increase the cool water pool in Shasta Lake and maintain cooler releases to the Sacramento River. This would be achieved through increasing the Shasta Lake minimum pool from 550,000 to 840,000 acre-feet with no change in Shasta active storage, and no hydrologic impacts (such as downstream operations and downstream flow rate) from a larger Shasta inactive storage. Therefore, a CALSIM II simulation was not necessary for AFS-1. The CALSIM II hydrologic features for AFS-3 are the same as for AFS-2, except spawning habitat restoration cannot be modeled in CALSIM II.

With a 290,000 acre-feet enlargement of Shasta Reservoir, a new minimum Keswick Dam release schedule for October through April (**Table IX-9**) was used to increase minimum Sacramento River flow from 3,250 cfs. The new monthly flow target, developed from the Final Restoration Plan of the Anadromous Fish Restoration Program (January 2001), varies with the previous end-of-September storage in the enlarged Shasta Lake; also, the flow increment is subject to a release increase ceiling of up to 500 cfs.

TABLE IX-8
CALSIM II HYDROLOGIC FEATURES OF SLWRI CONCEPT PLANS

	Shasta Dam Raise / Enlarged Active Storage			Operational Change		
	6.5 feet / 290,000 AF	18.5 feet / 636,000 AF	200 feet / 9,338,000 AF	Increase Fishery Flow Below Keswick Dam	Conjunctive Water Management	Remarks
Concepts Focused on Anadromous Fish Survival						
AFS-1						Not modeled in CALSIM II
AFS-2	X			X		
AFS-3	X			X		Same as AFS-2
Concepts Focused on Water Supply Reliability						
WSR-1	X					
WSR-2		X				
WSR-3			X			
WSR-4		X			X	
Concepts Focused on Combined Objectives						
CO-1	X					Same as WSR-1
CO-2		X				Same as WSR-2
CO-3		X		X		
CO-4	X				X	
CO-5		X			X	Same as WSR-4
Key: AFS – anadromous fish survival WSR – water supply reliability CO – combined objective AF – acre-feet						

Notes:
1. CVP agricultural contractors along Tehama-Colusa Canal (CALSIM II delivery is D112a) are a surrogate for north-of-Delta conjunctive water management. D112a cutback schedule for Tier 1/Tier 2/Tier 3/Tier 4 is 0.0/0.25/0.25/0.5.
2. New Keswick Dam release schedule for higher fishery flows from October through April is shown in Table IX-9.

Concept Plans Focused on Water Supply Reliability

The primary objective of the WRS concept plans is to increase water supply and water supply reliability through enlarging Shasta Lake. Of the four WRS plans, the first three simulated Shasta Dam raises of 6.5, 18.5, and 202.5 feet, and the fourth, WSR-4, modeled a Shasta Dam raise of 18.5 feet with conjunctive water management among CVP north-of-Delta agricultural contractors. The purpose of conjunctive water management is to exchange additional surface water supplies in normal water years for reducing deliveries (reliance on groundwater supplies) during dry years. In the CALSIM II modeling, the delivery schedule to the CVP agricultural contractors along Tehama-Colusa Canal was used as a surrogate for conjunctive water management participants. Various delivery schedules were modeled to assess the viability of adding conjunctive water management as a potential component to the concept plans.

Concept Plans Focused on Combined Objectives

The primary objectives of CO concept plans are to increase anadromous fish survival and water supply reliability. Of five concepts, only two were simulated in CALSIM II: CO-3 and CO-4. For CO-1, CO-2, and CO-5, because their CALSIM II hydrologic features are the same as for WSR-1, WSR-2, and WSR-4, respectively, their hydrologic impacts are assumed to be equivalent. CO concept simulation combines modeling methodology for the AFS and WSR concepts.

TABLE IX-9
SLWRI MINIMUM KESWICK DAM RELEASE TARGETS AND FLOW INCREASE CEILING FOR OCTOBER THROUGH APRIL

Carryover Storage[1] (MAF)	Minimum Keswick Dam Release (cfs)	Keswick Dam Release Increase Ceiling[2] (cfs)
1.9 to 2.1	3,250	0
2.2	3,500	250
2.3	3,750	500
2.4	4,000	500
2.5	4,250	500
2.6	4,500	500
2.7	4,750	500
2.8	5,000	500
2.9	5,250	500
3.0	5,500	500
Key:	cfs – cubic feet per second	MAF – million acre-feet

Notes:
[1]Carryover storage is the end-of-September storage for Shasta Lake.
[2]"Keswick Dam release increase ceiling" limits the differences between the "minimum Keswick Dam release target" under the new release schedule and the benchmark.

CALSIM II Results

CALSIM II modeling results for the SLWRI concept plans are summarized in **Table IX-10** and **Figures IX-4** and **IX-5**.

Table IX-10 shows the annual average increase in project deliveries compared to the SLWRI Benchmark; **Figure IX-5** shows a breakdown of the increase in CVP deliveries. Most of increase in the CVP total deliveries went to south-of-Delta agricultural deliveries, followed by north-of-Delta agricultural deliveries and Cross Valley Canal deliveries. All concept plans had higher CVP total deliveries but some SWP total deliveries were reduced by a small degree. The greater the enlargement, the more CVP total increase deliveries. For the same enlargement, the concept plan with conjunctive water management had a greater increase. During wet years, conjunctive water management created additional underground storage for floodwater through in-lieu banking; in dry years, groundwater was pumped to provide extra water supply. However, for the same enlargement, the concept plan with a new Keswick Dam release target had a smaller increase; higher release requirements for Shasta Dam from October through April reduced storage for summer water consumption.

TABLE IX-10
SUMMARY OF MODELING RESULTS FOR CONCEPT PLANS

Concept Plan	Increase in Annual Average Delivery Compared to the Benchmark (1,000 acre-feet)			
	CVP		SWP	
	All Year Types	Dry and Critical Years	All Year Types	Dry and Critical Years
AFS-1	0	0	0	0
AFS-2	-16	0	18	20
AFS-3	-16	0	18	20
WSR-1	51	83	-3	-11
WSR-2	79	138	-8	-13
WSR-3	348	768	-17	-65
WSR-4	89	162	-9	-16
CO-1	51	83	-3	-11
CO-2	79	138	-8	-13
CO-3	25	70	12	20
CO-4	57	107	-7	-18
CO-5	89	162	-9	-16

Key:
AFS – anadromous fish survival; CO – combined objective; CVP – Central Valley Project
SWP – State Water Project; WSR – water supply reliability

Notes:
1. Year-types are based on the Sacramento Valley Water Year Hydrologic Classification Index.
2. Banks Pumping Plant capacity is 6,680 cfs for the benchmark.

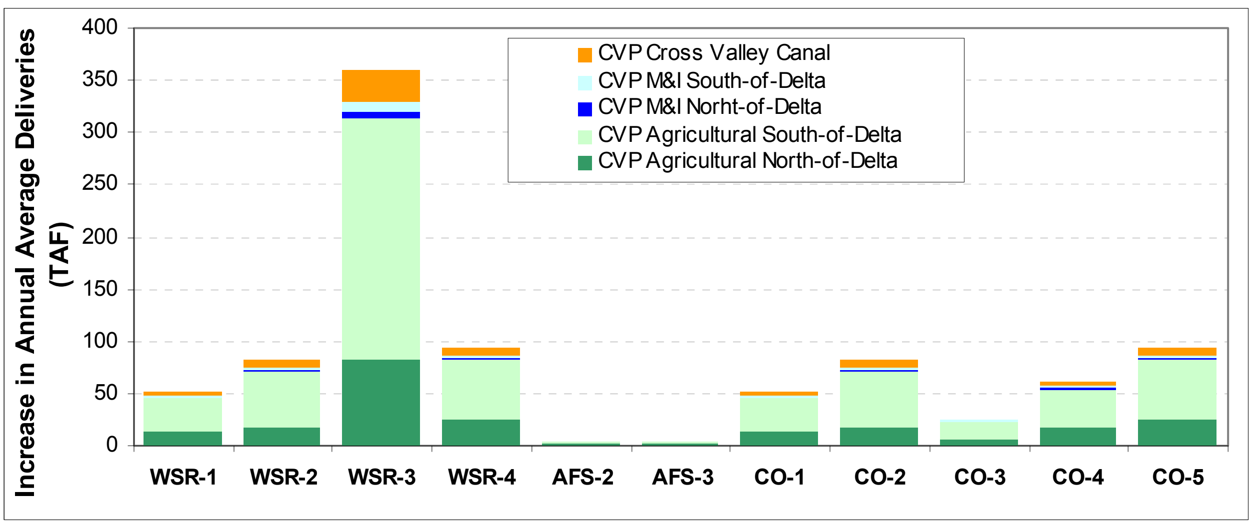

Figure IX-4. Simulated annual average increase in CVP deliveries compared to the benchmark (agricultural, M&I, and Cross Valley Canal).

Figure IX-5 shows the monthly average increase in Keswick Dam releases from the benchmark. For the concept plans, except WSR-3, patterns are similar; for concept with the same enlargement, patterns are even more alike. A larger Shasta Lake captured more flood flow during December through February, and increased releases for high summer consumption from June through September. As noted previously, AFS-1 was not simulated because active storage in Shasta would not change (all additional storage would be dedicated to increasing flows) and there would be no resulting hydrologic impacts.

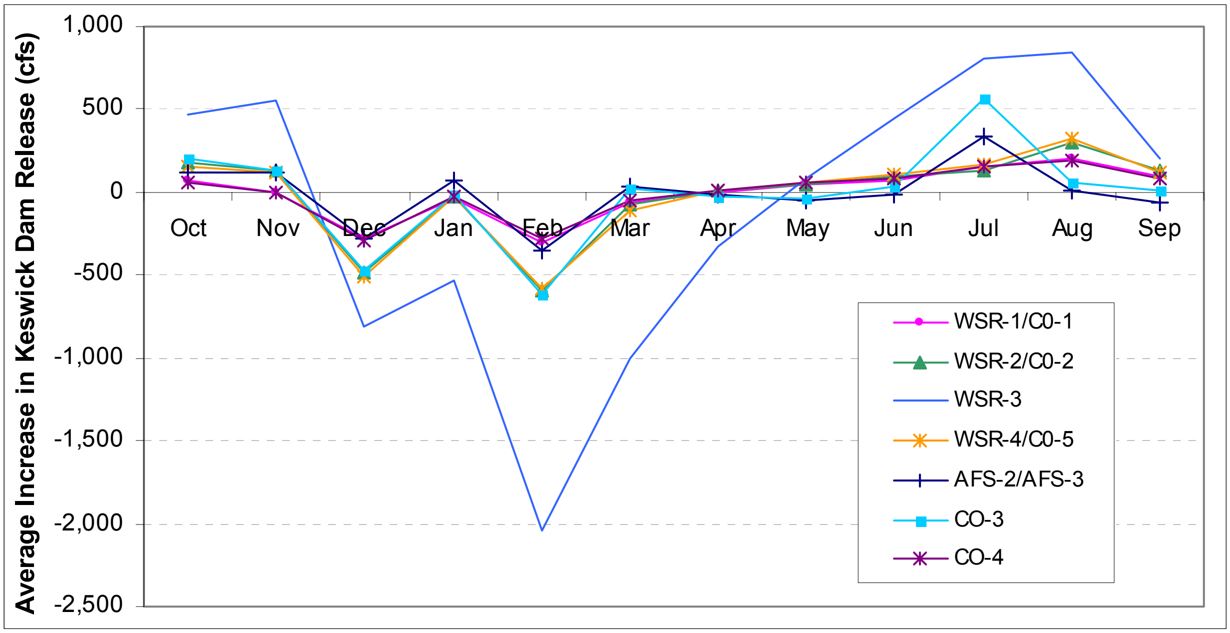

Figure IX-5. Simulated monthly average increase in Keswick Dam releases compared to the benchmark.

FISH SURVIVAL ASSESSMENT

The health and survival of anadromous fish depend on numerous environmental factors, including water temperature, available habitat, river flows, seasonal hydrologic conditions, spawning substrate, ocean conditions, and many more. This complex interaction makes it difficult to predict how changes to one or more environmental conditions will affect the survival of anadromous fish. This section discusses preliminary analyses conducted to assess the potential effects on anadromous fish survival of two important factors: cold water storage in Shasta Lake and minimum flows on the upper Sacramento River.

Currently, no tools exist that take into account all of the major influences on anadromous fish survival in the upper Sacramento River. Consequently, preliminary analyses were performed that evaluated cold water storage and minimum stream flows separately. The effects of additional cold water storage were assessed using procedures and models developed previously by Reclamation and USFWS to evaluate fish mortality related to the TCD. Potential benefits of increases in minimum stream flows were assessed using a hydraulic model of the upper Sacramento River developed previously by DWR. While these preliminary assessments do not take into consideration every factor affecting anadromous fish survival, they provide a means of comparing potential actions to address this primary objective of the SLWRI.

Effect of Additional Cold Water Storage in Shasta Reservoir on Anadromous Fish Survival

An assessment was performed of estimated relative impacts to the chinook salmon population along the upper Sacramento River associated with enlarging the cold water pool in Shasta Reservoir. The assessment followed a process used by Reclamation and USFWS to examine the impacts on water temperature and fish mortality related to the TCD.

Modeling

Three basic modeling tools were used to derive the estimated impacts of various increases and operations of Shasta Dam on the salmon fish populations primarily in the Sacramento River. Modeling tools included CALSIM II, the Sacramento River Water Temperature Model, and the Salmon Mortality Model. The CALSIM II model was described previously in this chapter; the temperature and salmon mortality models are described briefly below.

Sacramento River Water Temperature Model - The Reclamation temperature model consists of reservoir and river modeling components. The reservoir component was developed by the Corps. It simulates one-dimensional, vertical distribution of reservoir water temperature using monthly input data on initial storage and temperature conditions, inflow, outflow, evaporation, radiation, and average air temperature. The river temperature component receives output from the reservoir component and calculates temperature changes in the four reregulating reservoirs (Lewiston, Keswick, Thermalito, and Natoma). The river model also computes temperatures at various selected locations in each river. It is a one-dimensional model, in the longitudinal direction, and assumes fully mixed river cross sections. The effect of tributary inflow on river temperature is computed by mass balance. The models simulate TCD operations by making upper-level releases in the winter and spring, mid-level releases in the late spring and summer, and low-level releases in the late summer and fall. River temperature calculations are based on regulating reservoir release temperatures, river flows, and climatic data. Monthly mean historical air temperatures for the 73-year period and other long-term average climatic data were obtained from Weather Bureau records.

Salmon Mortality Model - The Reclamation Salmon Mortality Model evaluates temperature-exposure mortality criteria for three salmon life stages (pre-spawned eggs, fertilized eggs, and pre-emergent fry), spawning distribution data, and output from the river temperature models to compute salmon spawning losses. Temperature units (TU), defined as the difference between river temperatures and 32° F, are calculated daily by the mortality model and used to track early life-stage development.

The Salmon Mortality Model was run for seven different reservoir raise scenarios using information from the CALSIM and temperature model, and 2020-level hydrologic conditions. Primary output of the mortality model is the estimated percent mortality for each of the four runs of salmon in the upper Sacramento River as a function of water-year conditions. These conditions are defined as wet, above normal, below normal, dry, and critically dry conditions. The increase in salmon populations was estimated for the various dam raise scenarios over baseline conditions, as shown in **Table IX-11**.

TABLE IX-11
PREDICTED UPPER SACRAMENTO RIVER CHINOOK SALMON POPULATION OVER 50-YEAR PERIOD

Concept Plan	Population Over 50 Years[1]				
	Fall-Run	**Late Fall-Run**	**Winter-Run**	**Spring-Run**	**Total**
Initial Returning Population [2]	49,000	10,000	2,800	800	62,600
6.5-ft Raise - Minimum Pool (AFS-1)					
Incremental Population In 50 Years [3]	88,176	10,246	3,802	3,481	105,706
Increase over Without-Project[4]	39,176	246	1,002	2,681	43,106
Percent Increase	80	2	36	335	69
Average Annual Increase	784	5	20	54	862
6.5-ft Raise - AFRP Flows (AFS-2)					
Incremental Population In 50 Years [3]	66,832	10,200	2,733	1,499	81,265
Increase over Without-Project[4]	17,832	200	-67	699	18,665
Percent Increase	36	2	-2	87	30
Average Annual Increase	357	4	-1	14	373
6.5-ft Raise (WSR-1)					
Incremental Population In 50 Years [3]	68,522	10,199	2,595	1,575	82,891
Increase over Without-Project [4]	19,522	199	-205	775	20,291
Percent Increase	40	2	-7	97	32
Average Annual Increase	390	4	-4	16	406
18.5-ft Raise (WSR-2)					
Incremental Population In 50 Years [3]	101,526	10,427	2,912	3,085	117,949
Increase over Without-Project [4]	52,526	427	112	2,285	55,349
Percent Increase	107	4	4	286	88
Average Annual Increase	1,051	9	2	46	1,107
200-ft Raise (WSR-3)					
Incremental Population In 50 Years [3]	537,760	12,017	9,177	34,870	593,824
Increase over Without-Project [4]	488,760	2,017	6,377	34,070	531,224
Percent Increase	997	20	228	4,259	849
Average Annual Increase	9,775	40	128	681	10,624
18.5-ft Raise with Conjunctive Water Management (WSR-4)					
Incremental Population in 50 Years	97,939	10,408	2,825	2,622	113,795
Increase over Without-Project [4]	48,939	408	25	1,822	51,195
Percent Increase	100	4	1	228	82
Average Annual Increase	979	8	1	36	1,024

Key: AFRP – Anadromous Fish Restoration Program; TCD – temperature control device; WSR – water supply reliability

Notes:
[1]Population increases over baseline conditions.
[2]Based on average annual returning population for years 1996 through 2001.
[3]Based on population increase for each return cycle over 50 years (17 occurrences).
[4]Net increase over conditions including increases due to TCD.

Findings

Evaluation indicates a general correspondence between increases in storage space in Shasta Reservoir and increases in the population of chinook salmon in the upper Sacramento River. Raising Shasta Dam 200 feet provides the greatest quantity of cold water and, therefore, has the greatest potential to benefit the salmon population throughout the primary and secondary study areas. For each dam raise scenario evaluated, the largest increase in salmon population is projected to occur to the fall-run salmon, with the smallest increases to the late-fall- and winter-runs. Further, increasing storage in Shasta Reservoir also tends to reduce salmon mortality in other tributaries to the Sacramento River, including the Trinity, Feather, and American rivers.

It should be noted that limitations exist in the use of the CALSIM, temperature, and mortality models. The main limitation is the monthly simulation time-step, which does not distinguish daily variations that could occur in the rivers. The temperature models also are unable to accurately simulate certain aspects of the actual operations strategies used when attempting to meet temperature objectives. Similarly, uncertainty exists regarding actual performance characteristics of the Shasta Dam TCD (due to leakage, overflow, and performance of the side intakes); a more conservative approach is taken in real-time operations that are not fully represented by the models. The Salmon Mortality Model is limited to temperature effects on early life stages of chinook salmon, and does not evaluate potential impacts on later life stages (emergent fry, smolts, juvenile out-migrants, or adults). Also, it does not consider other factors that may affect salmon mortality, such as instream flows, gravel sedimentation, diversion structures, predation, ocean harvest, etc. Furthermore, the salmon model requires daily temperatures, which it computes based on linear interpolation between the monthly output from the temperature models. Despite these limitations, it is believed the above tools and approach provide a valid approximation of the relative influences that increasing the storage space in Shasta Reservoir will have on the salmon population in the upper Sacramento River.

Effect of Minimum Flow Increases on Anadromous Fish Habitat and Survival

A preliminary assessment was performed to evaluate potential aquatic habitat improvements resulting from increasing minimum instream flows on the upper Sacramento River. Water storage to support these instream flow increases would be derived from the various dam raises under consideration by the SLWRI.

Existing Flow Requirements

The 1993 winter-run chinook salmon BO issued by NMFS (now NOAA Fisheries) requires minimum releases from Keswick Dam of 3,250 cfs between October 1 and March 31. These minimum flows are intended to promote successful rearing and safe downstream passage for winter-run chinook salmon. However, flows between 5,000 cfs and 5,500 cfs during this same period produce conditions that are more ideal for anadromous fish. Higher instream flows would provide access to additional spawning and rearing habitat sites, extend the area of suitable habitat farther downstream, avoid dewatering higher spawning beds, and generally improve aquatic and riparian habitat conditions along the river.

Average daily outflow from Keswick Dam between 1998 and the present is illustrated in **Figure IX-6**. The figure provides insight into the success of operators in maintaining healthy flows for anadromous fish in the upper Sacramento River.

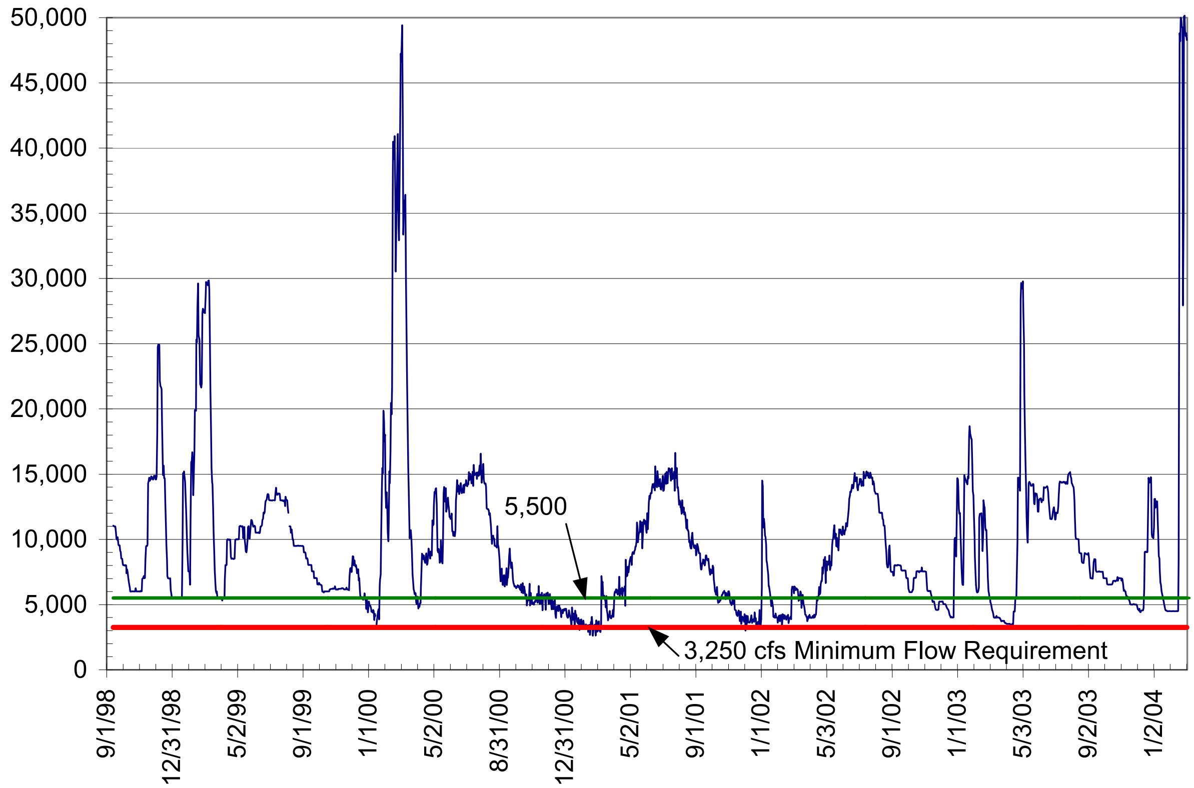

Figure IX-6 – Historic outflow from Keswick, 1998 to the present.

Existing Distribution of Spawning Within the Study Reach

Table IX-12 presents the estimated redd (underwater gravel nest where eggs are deposited) distribution for winter-run salmon within the study reach for 2000 through 2003, as reported by CDFG. This survey confirms that the majority of winter-run salmon are spawning in the uppermost portion of the study reach, with the greatest numbers of redds reported in the subreach between the Highway 44 Bridge and Airport Road Bridge. The distribution of redds within the study reach varies with each salmon run. With the exception of the fall run, the majority of spawning for each of the other runs occurs in the uppermost reaches of the river.

The HEC-RAS model calculates various types of information about hydraulic conditions in the channel at each cross section. Wetted perimeter at each cross section was multiplied by the distance between cross-sections to develop an approximation of the area of aquatic habitat for each simulated flow. These areas were summed for various reaches of the river to estimate the number of acres of aquatic habitat available. Similarly, hydraulic depth is calculated by dividing the cross sectional flow area by the width of flow at each cross section. These values do not represent the maximum or minimum depth of flow, but indicate the geometry of the channel within the reach. It should be noted that this method only provides a rough estimate of aquatic habitat, and is highly dependent on the (1) detail of the channel geometry, (2) spacing between the cross sections, and (3) uniformity of the channel between cross sections.

TABLE IX-12
ESTIMATED REDD DISTRIBUTION, WINTER-RUN CHINOOK SALMON

Reach	2000 Count	2000 % Total	2001 Count	2001 % Total	2002 Count	2002 % Total	2003 Count	2003 % Total
Keswick to ACID Dam	34	6	484	35	297	49	578	66
ACID Dam to Hwy 44 Bridge	157	27	215	15	134	22	151	17
Hwy 44 Bridge to Airport Road Bridge	274	47	624	45	168	28	143	16
Airport Rd Bridge to Balls Ferry Bridge	32	5	55	4	7	1	3	0
Balls Ferry Bridge to Battle Creek	35	6	2	0	3	0	0	0
Battle Creek to Jelly's Ferry	10	2	2	0	0	0	0	0
Jelly's Ferry to Bend Bridge	46	8	8	1	0	0	0	0
Bend Bridge to RBDD	0	0	0	0	0	0	0	0
TOTAL Upstream From RBDD	**588**		**1,390**		**609**		**875**	

Key: ACID – Anderson Cottonwood Irrigation District Hwy – Highway RBDD – Red Bluff Diversion Dam

Source: California Department of Fish and Game aerial surveys.
Note:
Percent of total represents the percentage of all redds surveyed upstream from the RBDD occurring within a given reach. Does not include redds surveyed downstream from the RBDD

Further, this initial assessment does not provide a means of evaluating the quality of the new aquatic habitat, or whether the new habitat was suitable for spawning, rearing, or other life stages of anadromous fish. While this assessment can not quantify the benefits to anadromous fish in terms of fish mortality or long-term survival, the assessment does provide an initial means of comparing the relative benefits of potential flow increases on the upper Sacramento River. Future studies will be required to better quantify the benefits of flow increases to chinook salmon and other anadromous fish on the upper Sacramento River.

Findings

Modeling results indicate that increasing the minimum flow target from 3,250 cfs to 5,500 cfs (identified as the ideal flow for winter-run) could potentially increase aquatic habitat in the study area by between 14 percent and 19 percent, corresponding to a potential increase of about 3,000 acres of aquatic habitat. As shown in **Table IX-13**, the area that showed the greatest potential increases in aquatic habitat was the subreach from Airport Road Bridge to Balls Ferry Bridge. Subreaches between Battle Creek and Bend Bridge also showed notable increases. The subreach between Balls Ferry and Battle Creek showed the greatest increase in hydraulic depth; this could be significant because this subreach is comparatively shallow and has fewer deep pools. Hence, increases in depth could potentially improve aquatic habitat conditions within the subreach.

TABLE IX-13
HEC-RAS MINIMUM FLOW SIMULATION RESULTS BY SUBREACH

Flow (cfs)	Hydraulic Depth (feet) (Avg /	Max /	Min)[1]	Average Wetted Perimeter (feet)	Total Wetted Area[2] (acres)	% Change in Aquatic Habitat over 3,250 cfs
Keswick to ACID Dam (RM 295.92-292.428) 3.5 miles						
3,250	5.22	15.66	1.52	347	123	-
4,000	5.58	16.23	1.65	360	128	4
5,000	6.01	16.91	1.78	373	133	8
6,000	6.38	17.52	1.97	383	138	13
ACID Dam to Hwy 44 Bridge (RM 292.428-290.45) 2.0 miles						
3,250	3.80	8.21	1.75	367	77	-
4,000	3.99	8.60	1.73	398	80	5
5,000	4.14	8.66	2.08	442	85	11
6,000	4.32	8.70	2.41	476	93	21
Hwy 44 Bridge to Airport Road Bridge (RM 290.45-278.49) 12.0 miles						
3,250	4.04	12.03	1.17	423	697	-
4,000	4.33	12.23	1.33	442	725	4
5,000	4.70	12.66	1.53	459	757	9
6,000	5.03	13.09	1.71	478	790	13
Airport Road Bridge to Balls Ferry Bridge (RM 278.49-270.64) 7.8 miles						
3,250	4.38	15.22	1.31	361	352	-
4,000	4.64	15.39	1.29	390	385	9
5,000	4.78	15.60	1.32	481	466	32
6,000	5.09	15.81	1.38	505	488	39
Balls Ferry Bridge to Battle Creek (RM 270.64-268.6) 2.0 miles						
3,250	3.19	4.09	1.98	381	138	-
4,000	3.59	4.49	2.22	390	141	2
5,000	4.06	4.97	2.47	402	146	5
6,000	4.47	5.26	2.83	413	151	9
Battle Creek to Jelly's Ferry (RM 268.6-261.5) 7.1 miles						
3,250	3.81	5.42	1.72	355	266	-
4,000	4.14	5.85	1.82	378	285	7
5,000	4.49	6.38	1.96	405	305	15
6,000	4.83	6.82	2.09	423	320	20
Jelly's Ferry to Bend Bridge (RM 261.54-252.24) 9.3 miles						
3,250	5.75	11.45	1.95	246	257	-
4,000	6.00	11.60	2.12	262	276	7
5,000	6.27	11.52	2.29	284	302	18
6,000	6.51	11.85	2.48	305	326	27
Bend Bridge to RBDD (RM 252.24-237.54) 14.7 miles						
3,250	5.19	13.65	1.88	367	694	-
4,000	5.57	14.05	2.12	381	717	3
5,000	5.94	14.54	2.39	398	749	8
6,000	6.28	15.01	3.02	415	781	13
Key: ACID – Anderson Cottonwood Irrigation District cfs – cubic feet per second RM – river mile Hwy – Highway						

Notes:

[1]Hydraulic depth is calculated by dividing the cross-sectional flow area by the width of flow. Average hydraulic depth is calculated by averaging the hydraulic depth at each cross section within the reach.

[2]Wetted area is estimated by multiplying the wetted perimeter by the reach length (distance between cross sections) at each cross section.

Various potential dam raises are under consideration in the SLWRI. All or a portion of the additional water storage afforded by these raises could be used to increase minimum flow requirements on the upper Sacramento River. **Table IX-14** provides estimates of potential increases in aquatic habitat area under two scenarios being considered: a 6.5-foot raise with an increase in minimum flow to 3,575 cfs, and an 18.5-foot raise with an increase in minimum flow to 5,194 cfs.

TABLE IX-14
POTENTIAL INCREASES IN AQUATIC HABITAT WITH
6.5-FOOT AND 18.5-FOOT DAM RAISE SCENARIOS

		Estimated Increase in Aquatic Area (acres)	
Reach	**Reach Length (miles)**	**6.5-Foot Raise Flow Target: 3,575 cfs**	**18.5-Foot Raise Flow Target: 5,194 cfs**
Keswick to ACID Dam	3.5	2.1	11.2
ACID Dam to Hwy 44 Bridge	2.0	1.8	16.1
Hwy 44 Bridge to Airport Road Bridge	12.0	11.7	62.9
Airport Rd Bridge to Balls Ferry Bridge	7.9	13.4	129.3
Balls Ferry Bridge to Battle Creek	2.0	1.3	8.0
Battle Creek to Jelly's Ferry	7.1	7.9	42.3
Jelly's Ferry to Bend Bridge	9.3	8.1	50.2
Bend Bridge to RBDD	14.7	11.3	62.0
Total	**52.9**	**57.8 acres**	**382.0 acres**

Key:
ACID – Anderson Cottonwood Irrigation District cfs – cubic feet per second Hwy – Highway
RBDD – Red Bluff Diversion Dam

Note:
Estimated increases in aquatic area are interpolated based on the target flow of the scenario and the flows simulated in the HEC-RAS analysis.

Based on HEC-RAS simulation results, aquatic habitat within the study area could potentially be increased by about 56 acres if the minimum flow were increased to 3,575 cfs in conjunction with a 6.5-foot dam raise. Similarly, 382 acres of additional aquatic habitat could potentially be created if the minimum flow were increased to 5,194 cfs in conjunction with an 18.5-foot raise. However, equating the estimated increases in aquatic habitat to increases in anadromous fish survival is not possible at this time. This is largely because anadromous fish survival depends on numerous factors in addition to flow: water temperature, climatic variability, the number of fish migrating upstream, age of the returning fish, etc.

HYDROPOWER BENEFITS

Benefits of additional storage in Shasta Reservoir for hydropower can occur when more electricity is generated as a result of both higher hydrologic head and more water available for release through the powerhouse during high demand periods when energy is more valuable. For each initial concept plan considered, an estimate was made of the average annual increase, or change from the without-project condition, in power generation and revenues to the CVP system.

Table IX-15 shows the estimated changes in power generation in GWh per year for Shasta Dam and for the CVP system as a whole. The estimate was made using results first from CALSIM II modeling runs (level-2020 hydrology) for each concept and then a separate power model designed to identify energy generation changes at system facilities. Also shown is a system adjustment, which is the difference between the energy generated at Shasta and for the CVP system for each concept plan. This difference is due primarily to increased pumping in the Delta because of the increase in water supply reliability. It also accounts for the summation of other system-wide operational changes.

TABLE IX-15
ESTIMATED INCREASE IN HYDROPPOWER GENERATION AND REVENUE FOR CONCEPT PLANS

Concept Plan	Net Generation (GWh/year)			Net System Revenue ($Millions)
	At Shasta Dam	System Adjustments[1]	CVP System	
AFS-1	50.9	0	50.9	2.4
AFS-2	30.0	2.3	32.3	1.5
AFS-3	30.0	2.3	32.3	1.5
WSR-1	32.1	-17.4	14.7	0.6
WSR-2	71.8	-27.8	44.0	2.0
WSR-3[2]	2,383.7	-129.8	2,253.9	107.8
WSR-4	71.8	-27.8	44.0	2.0
CO-1	32.1	-17.4	14.7	0.6
CO-2	71.8	-27.8	44.0	2.0
CO-3	66.5	-5.3	61.2	2.9
CO-4	30.0	-18.3	11.7	0.5
CO-5	71.8	-27.8	44.0	2.0

Key:
AFS – anadromous fish survival
CO – combined objective
CVP – Central Valley Project
GWh – gigawatt-hour
WSR – water supply reliability

Notes:
[1]Accounts for increased pumping.
[2]Does not include loss in energy and revenue due to removal of the Pit 7 Dam.

Table IX-15 also shows the estimated average annual net revenue for each concept plan. Revenue estimates were derived using projected monthly power generation over the period of analysis in the CALSIM model multiplied by the California Independent System Operators 2003 monthly rates. As can be seen in **Table IX-15**, potential net revenues range from about $0.5 million a year for WSR-1, CO-1, and CO-4 to over $100 million for WSR-3. The estimated increase in generation and revenue for WSR-3 does not include the reduction in energy due to the removal of the Pit 7 Dam.

SENSITIVITY OF BANKS PUMPING PLANT EXPANSION

The current allowable pumping capacity at the Banks Pumping Plant is 6,680 cfs, and actions are underway by DWR and Reclamation to increase the allowable pumping capacity to 8,500 cfs during certain seasonal periods. This increase in pumping capacity at Banks is critical to the SDIP and helping improve the reliability of future water supplies in California. Because this potential CALFED action is still in the planning phase and not yet approved, significant uncertainty exists about whether it will be implemented and therefore it is not included as a without-project condition in the SLWRI. However, expanding pumping capacity at Banks and other planned improvements of the SDIP possess broad State and Federal agency support. In addition, efforts are ongoing by DWR and Reclamation to develop a set of common assumptions (see **Chapter II**) for use in planning CALFED storage projects. A Common Assumptions work group has been formed that is developing recommendations relative to without-project conditions, common analytical tools, and other study procedures and processes. A major assumption related to defining a common without-project condition for the studies includes expansion of the Banks Pumping Plant. Following is a brief description of the estimated differences in the without-project condition assumption regarding expanding the pumping capacity at Banks and potential impacts of that assumption on conclusions in this report.

Included in **Appendix A** (CALSIM II System Operation Simulation) is information on the sensitivity of storage and delivery changes for concept plans WSR-1 (6.5-foot Shasta Dam raise and 290,000 acre-feet of additional storage) and WSR-2 (18.5-foot Shasta Dam raise and 640,000 acre-feet of additional storage) under a Banks pumping capacity of 6,680 and 8,500 cfs. Pertinent information from **Appendix A** regarding the changes in storages and deliveries is included in **Table IX-16**. Also included in the table is information on the first, annual, and unit cost differences between the two plans under the two pumping capacities.

As shown in **Table IX-16** and based on current assumptions within the CALSIM model, it is estimated that increasing the pumping capacity at Banks, without any modification at Shasta Dam and Reservoir, would result in an average decrease in end-of-September storage in Shasta and on average the other north-of-Delta reservoirs. It would also result in an increase in storage at San Luis Reservoir. Most important, however, is that increasing Banks pumping would result in an increase in SWP and CVP water supply deliveries. As in the table, it is estimated that in drought and average years, without any modification of Shasta Dam and Reservoir, this increase could be on the order of 109,000 and 162,000 acre-feet, respectively. This increase in water supply reliability is the primary reason for increasing the pumping capacity at Banks.

At a Banks pumping capacity of 6,680 cfs, adding an increment of storage to the CVP under concept plan WSR-1 would result in an increase in drought and average annual deliveries of 72,000 and 48,000 acre-feet, respectively. Increasing the pumping capacity to 8,500 cfs would result in WSR-1 yielding an estimated 84,000 and 59,000 acre-feet during drought and average annual deliveries, respectively. Accordingly, increasing the pumping capacity would improve the effectiveness of WSR-1 during drought years by about 12,000 acre-feet, or 17 percent, and in average years of about 11,000 acre-feet, or 23 percent. As shown in the table, a similar increase in yield would occur with WSR-2 when drought and average year yields between the two pumping capacities were 22,000 acre feet (18 percent) and 30,000 acre-feet (42 percent), respectively.

Table IX-16 also shows that for WSR-1, the estimated cost for each additional acre-foot of drought period yield would be reduced by almost $40 from about $270 to $230. Similarly, for WSR-2, the estimated cost for each additional acre-foot of drought period yield would be reduced by $32 from $225 to $193 per acre-foot.

It is expected that similar results in estimated increases in water supply yields and unit cost reductions would occur for all the concept plans described in **Chapter VII**. Therefore, it is believed that changes in the without-project conditions from a Banks pumping capacity of 6,680 to 8,500 cfs would result in slight increases in the estimated water supply reliability shown in **Table VIII-2** and reductions in the relative unit cost for water for all the concept plans in the table (except AFS-1). However, it is also believed that none of these differences would result in changing how the concept plans would rank against each other (**Table VIII-1)**. Accordingly, the without-project assumption regarding pumping capacity at Banks would make no difference in the concept plans identified in **Chapter VIII** for further development in the SLWRI.

TABLE IX-16
DIFFERENCE BETWEEN WITHOUT AND WITH-PROJECT CONDITIONS FOR BANKS PUMPING CAPACITY OF 6,680 AND 8,500 CFS

Metric	Difference Between Without & With-Project Conditions				Difference Between Banks at 8,500 & 6,680 cfs		
	Banks @ 6,680 cfs		Banks @ 8,500 cfs		Without-Project Conditions	6.5 Feet (WSR-1)	18.5 Feet (WSR-2)
	6.5 Feet (WSR-1)	18.5 Feet (WSR-2)	6.5 Feet (WSR-1)	18.5 Feet (WSR-2)			
Storage – End-of-September (1,000 AF)							
Shasta	315	370	157	369	-63	12	-1
Trinity	15	25	-19	-15	54	-34	-40
Folsom	3	7	-9	-5	-29	-12	-12
Oroville	-6	-12	-20	-12	-46	-14	0
San Luis	-5	-3	-3	-18	142	2	-15
Deliveries (AF/year)							
CVP							
Total Drought Years	83	138	92	146	48	9	8
Total Average	53	79	57	96	67	4	17
SWP							
Total Drought Years	-11	-13	-8	1	51	3	14
Total Average	-5	-8	2	5	95	7	13
Total CVP & SWP							
Drought Years	72	125	84	147	109	12	22
Average	48	71	59	101	162	11	30
Economics							
First Cost ($ millions)	282	408	282	408	NA	0	0
Annual Cost ($ millions/year)	19.4	28.1	19.4	28.1	NA	0	0
Unit Cost (drought years) $/AF	269	225	231	193	NA	-38	-32

Key:
AF – acre-feet cfs – cubic-feet per second NA – not applicable WSR – water supply reliability

CHAPTER X
STUDY MANAGEMENT AND PUBLIC INVOLVEMENT

This chapter describes the management structure being used for the SLWRI. Also included is a description of the public involvement and stakeholder outreach strategy being followed for the study.

STUDY MANAGEMENT

Reclamation has established a study management structure consisting of a Study Management Team (SMT) and Project Coordination Team (PCT). Following is a summary of the responsibilities for each team:

- **Study Management Team –** The SMT consists of participating agency individuals at the management and/or policy level. Each team member is responsible for ensuring that all PCT members are provided sufficient resources and direction to complete the various tasks assigned. The SMT provides overall guidance for the study, and ensures participating agency views are addressed. The Project Manager participates in the SMT by providing administrative and technical focus information and adequate communication between the two teams.
- **Project Coordination Team –** The PCT consists at minimum, of the Project Manager, an environmental specialist, an archaeologist, public affairs specialist, design engineer, hydrologist, and economist. Representatives on the team from USFWS and NOAA Fisheries are to assist in study coordination. At the PCT meetings, each study component is to be adequately represented by the varied backgrounds of team members. Participation in team meetings is subject to the topic discussed, and additional expertise is included as necessary. The PCT directs work performed by other work groups, coordinates results into the overall study, directs public involvement activities, and coordinates general public input into the study.

Other work groups have been and are being established to assist in accomplishing the study. Technical work groups consist of groups focusing on specific study areas such as designs and costs, environmental studies, plan formulation, and hydrologic and hydraulic modeling. Various stakeholder groups include (1) Area Impact and Restoration Communication (AIR Com), (2) Water Supply and Reliability Communication (WSR Com), and (3) Tribal Communication (Tribal Com). These work groups comprise an appropriate combination of Reclamation and DWR employees and their contractors.

PUBLIC INVOLVEMENT PLAN

The Strategic Agency and Public Involvement Plan (Plan) for the SLWRI has been designed to act as a manual to assist the PCT in effectively communicating with individuals, groups, and agencies that are affected by or could benefit from enlarging or modifying Shasta Dam. It is anticipated that the Plan will be amended as the project evolves.

The Plan provides a system by which the following five objectives are met:

- **Stakeholder Identification –** This effort is ongoing and consists of identifying and qualifying individuals, groups, and other entities that have an expressed or implied interest in enlargement and/or operation modification of Shasta Dam. No individual, group, or entity is to be excluded from the process, which includes complying with Executive Order 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.
- **Project Transparency –** Success of the investigation will rely on project transparency, a practice of providing activities and study results to stakeholders in a timely, unbiased fashion. Distributing study information will occur through the media, Web, public meetings, stakeholder meetings, and public presentations, and other means.
- **Issues and Concerns Resolution –** Equally important as project transparency is gaining awareness of the issues and concerns of stakeholders, and establishing a mechanism for the PCT to learn of problems early. Using various public involvement processes, the PCT will address issues and concerns in an effective and timely manner. Priority will be given to finding solutions through consensus with stakeholders.
- **Sponsor Identification –** As a collective effort, the agency and public involvement program builds synergies that contribute to successful completion of the investigation. Through these synergies, potential non-Federal sponsor(s) for implementing enlargement and/or operational modifications of Shasta Dam will emerge. Sponsors may either rise from the stakeholder group, or come by referral within the stakeholder community.
- **Project Implementation –** An implementable project will need to meet primary planning objectives and secondary objectives to the extent possible. The project will also need to address other issues, especially in the Shasta Lake area, and not harm the environment, people, or their property. Accordingly, one goal of the Plan is to build a communication network in which policy-makers understand the project purpose and benefits of the project, and conclude for themselves that the project has met all requirements necessary to be implemented. This will be accomplished through distribution of key information to policy-makers.

The Plan maintains two primary themes: outreach and information. Within these themes will be procedures that enable the overall investigation to satisfy the public involvement requirements of NEPA and CEQA for development of an EIS/EIR. The Plan will also integrate those guidelines and/or requirements outlined under Executive Order 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations; and the President's April 29, 1994, Memorandum regarding the engagement of Federally recognized tribal governments in the planning and development of projects.

Outreach

Within the Plan are four main outreach elements to assist in coordinating the study efforts. Outreach efforts include (1) public meetings, (2) technical work group communication, (3) tribal communication, and (4) SMT and PCT activities.

- **Public Meetings –** A series of focus group briefings and a public workshop were held in fall of 2003. The purpose of the public meetings was to discuss the study, its objectives, and resources management measures being considered to address the study objectives. A second public workshop is scheduled for summer 2004 to update stakeholders about the study and review the concept plans and initial alternatives described in this report. Future public meetings will be held at important points in the investigation, including (1) initiation of the environmental scoping process, (2) after development of a detailed set of alternative plans, and (3) after completion of the draft integrated feasibility report.

- **Technical Work Group Communication –** Members for the Air Com and the WSR Com Work Groups will be recruited to include people with expertise in water supply and distribution, water marketing and exchange, ecosystem restoration, water policy and legislation, local interests, regional economic impacts, environmental justice, and others to be identified through the public involvement process.

- **Tribal Communication –** Consistent with the President's April 29, 1994, Memorandum, Reclamation will actively engage Federally recognized tribal governments in planning and development of the Shasta Dam project, and will consult with each tribe on a government-to-government basis, to the greatest extent practicable and to the extent permitted by law, prior to taking actions that would affect such tribal governments. Under Federal Trust responsibility, Reclamation will provide full disclosure (benefits and negative impacts) of the project, allow time for tribal review/consultation, and receive comments and/or alternatives. Public involvement activities for this component will mirror all other activities. Consultation with these tribal interests, however, is the responsibility of Reclamation. Several tribal meetings have been held to date.

- **SMT and PCT Activities –** The SMT is comprised of key policy and decision-makers with direct influence over strategic guidance and Congressional authorization of the study. The SMT is expected to meet at important junctures in the study. The PCT includes the Project Manager and technical experts from various disciplines and organizations. The PCT meets monthly.

Information Dissemination

Study-related information is planned to be disseminated in a number of ways. Following is a summary of each:

- **Project Updates –** A series of project update notices are planned. The timing of each update will be based on key milestones of the investigation and will provide an opportunity for stakeholders to respond to the project team.

- **Project Information Papers –** At least two project information papers are planned, one for summer of 2004 and one for late 2006. The 2004 information paper is designed to report, in part, on initial alternatives being developed. The second information paper will report on details leading up to release of the final feasibility report.

- **Web Site –** A comprehensive project Web site has been created to provide information about stakeholder functions, project information, a project photo tour, project calendar, project contact database, and stakeholder response forms. The address of the Web site is "www.usbr.gov/mp/slwri."

- **Media Relations –** Media relations tactics for the study will include news releases, media advisories, calendar advisories, editorial board visits, letters to the editor, and opinions/editorials. The media relations effort will be flexible to ensure prompt responses to comments, questions, or information regarding the program.
- **Speakers Bureau –** Outreach for the study will employ a comprehensive speakers bureau program to present information to affected constituents. Members of the speakers bureau program primarily will include the Project Manager and various PCT members. The program also will serve as an outreach mechanism for gathering comments and responses while communicating information to affected constituents.
- **Information Resources –** Information resources include visual aids (PowerPoint slideshow templates, display boards, maps, charts, etc.), information papers, and related templates. Document templates will outline the specific format for all public documents to be distributed. By using an established template, the Plan will look and feel consistent to the public and have a format that is recognizable at a glance.

CHAPTER XI
FUTURE ACTIONS

Following is a summary of (1) the next major steps in alternatives formulation for the SLWRI, (2) study and project schedule, and (3) related issues.

ALTERNATIVES FORMULATION

The next major steps in the SLWRI will be to better define the initial alternatives and formulate a set of alternative plans for detailed development in the remainder of the feasibility study. From the alternative plans, one plan will be selected for display in the draft and final feasibility reports as the Selected Plan. Other important future actions include the following:

- Completing environmental baseline studies.
- Completing hydrologic, hydraulic, temperature, and related modeling studies, and economic evaluations.
- Identifying potential impacts and mitigation features of the alternative plans.
- Preparing a Plan Formulation Report describing the alternative plans.

Developing a tentatively selected plan from the alternative plans.

- Completing designs and cost estimates, cost allocation studies, and defining the requirements for non-Federal participation in the plan.
- Completing environmental compliance investigations.
- Preparing and completing an Integrated Feasibility Report (Federal decision document and NEPA/CEQA compliance).

SCHEDULE

Schedules showing estimated major actions to complete the feasibility study and future milestones leading to project implementation are shown in **Figures XI-1 and XI-2** (end of chapter), respectively. A Plan Formulation Report focusing on alternative plans and environmental compliance issues is scheduled for mid-2005. A draft Integrated Feasibility Report, including a Federal Decision Document and an EIS/EIR, is scheduled for release to the public and other Federal agencies for review in early 2007. The final report is scheduled to be provided for Washington-level review through Reclamation in mid- to late 2007. Assuming authorization by Congress in 2008, followed by detailed project designs beginning in 2008, construction could be initiated in 2009 or more likely 2010. The initial phase of construction would include acquiring real estate, continuing detailed design work, acquiring necessary permits, and performing minor relocations. The construction period would likely range from 4 to 6 years, depending on the selected plan.

INVESTIGATION PROCESS FACTORS

As the SLWRI progresses toward project implementation, issues will evolve that need to be addressed and resolved. Many of these issues or concerns will become better defined and more appropriate for resolution once the alternative plans, and later the tentatively selected plan, are defined. Currently, however, at least three areas will need to be addressed early in the next phase of the SLWRI: State of California active study involvement, relationship to CALFED and other programs and projects, and other requirements of local cooperation.

State of California Active Study Involvement

California DWR is the non-Federal sponsor for the SLWRI. However, as mentioned in **Chapter III**, California Public Resources Code 5093.542(c) restricts State involvement in the study. The code is as follows:

> Except for participation by the Department of Water Resources in studies involving the technical and economic feasibility of enlargement of Shasta Dam, no department or agency of the state shall assist or cooperate with, whether by loan, grant, license, or otherwise, any agency of the federal, state or local government in the planning or construction of any dam, reservoir, diversion, or impoundment facility that could have an adverse effect on the free-flowing condition of the McCloud River, or on its wild trout fishery.

Because of this code, DWR's involvement in the SLWRI has been limited primarily to coordination and participation in study management team activities. However, for the SLWRI to effectively move forward, DWR and other constituents within the State need to take a more active role in future studies. This is especially the case for accomplishing required studies associated with compliance with CEQA. Also, DWR or other State entities will likely need to assume the role of non-Federal sponsor (see below) in implementing potential project purposes, such as anadromous fish restoration, water supply reliability to possible increments allocated to the SWP, or ecosystem restoration.

It is believed that none of the five initial alternatives recommended for further consideration as candidate plans in **Chapter VIII** would have significant adverse effects on the free-flowing conditions of the McCloud River or on its wild trout fishery. Active State support in the SLWRI is needed not only to confirm this finding and help better define the limited impacts to the McCloud River, but to identify and resolve possible effects on other State resources as well.

Relationship to CALFED and Other Programs and Projects

As mentioned, the SLWRI is being conducted following direction contained in Public Law 96-375, which was specific to Shasta Dam and Reservoir. The study is following established Federal planning principles and practices, which require defining water resources and related problems and needs to be addressed, establishing planning objectives and criteria, defining alternatives to address the objectives consistent with the study criteria, and selecting, if appropriate, a plan for implementation when there is a Federal interest. For the SLWRI, a specific set of planning objectives has been developed (see **Chapter V**) to address identified water resources problems and needs (see **Chapter IV**). The ability of potential CALFED or other project or program elements to address these study objectives is a part of the planning process and contained in **Chapter VI**. The influence of detailed alternative plans, which will be developed in the next phase of the planning process for the SLWRI, on the goals and objectives of the CALFED program defined in the 2000 CALFED ROD will be included in the draft and final feasibility report. A summary of these potential influences resulting from enlarging Shasta Dam and Reservoir is contained in **Chapter IX.**

Other Requirements of Local Cooperation

Currently, two likely purposes exist for a project resulting from the SLWRI: ecosystem restoration, which includes anadromous fish survival, and water supply reliability. However, incidental benefits would occur to flood control and hydropower; without specifically added features to enhance these resource opportunities, they would not warrant separate purposes or modification of existing Federal responsibilities. For each of the potential purposes, a non-Federal sponsor must be identified that is willing to share in the cost for the purpose and, in the case of any ecosystem restoration features upstream from Shasta Lake or downstream from Keswick Dam, willing to operate and maintain the completed project elements. Strong support has been expressed for the SLWRI by representatives from contractors to the CVP, SWP, and other water supply interests. In addition, much interest has been identified for implementing ecosystem restoration features consistent with those included in concept plan CO-5. Identifying specific non-Federal sponsoring interests for these purposes will be an important factor in future study efforts.

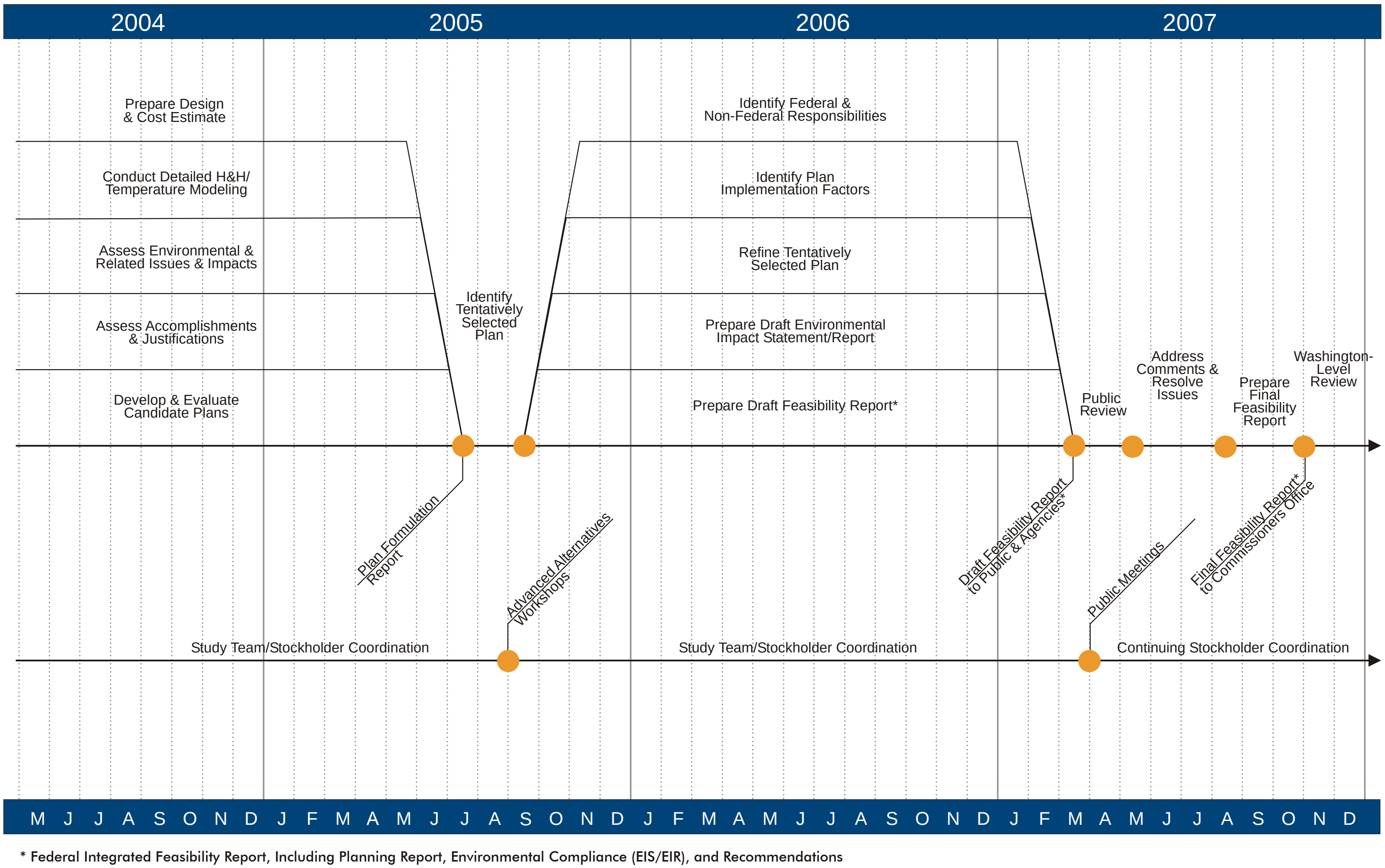

Figure XI-1 – Shasta Lake Water Resources Investigation schedule.

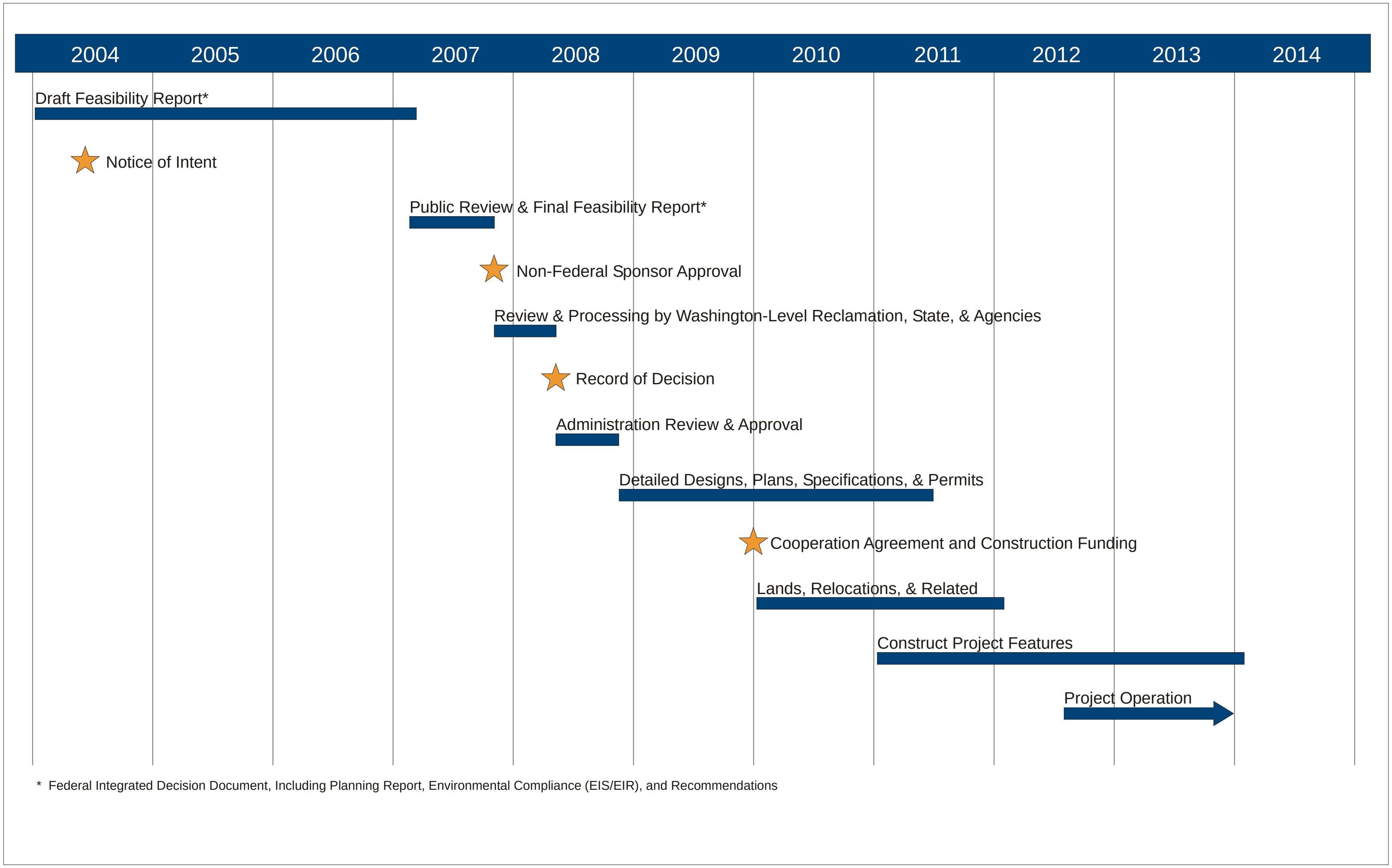

Figure XI-2 – Shasta Lake Water Resources Investigation project schedule.

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CHAPTER XII
SUMMARY OF FINDINGS

Major findings of this report include the following:

- Potential to raise Shasta Dam and enlarge Shasta Reservoir has been found technically and economically feasible in past studies. It is one of five surface water projects recommended for further consideration in the CALFED Bay-Delta Program.
- A continuing significant need exists to implement actions to help increase survival of anadromous fish populations in the upper Sacramento River.
- Demands for water in the Central Valley and elsewhere in the State of California exceed available supplies; this condition is expected to become more pronounced in the future.
- To avoid major impacts to the economy and overall environment of the State, developing, water sources to increase the reliability of providing adequate supplies of water for urban, agricultural, and environmental purposes is necessary to meet future demands.
- A significant need exists to restore ecosystem resources in the upper Sacramento River area, including wetlands, riparian, and aquatic habitat, and water quality conditions in the study area.
- Other identified problems and needs include the threat of flooding and related flood damages along the Sacramento River downstream from Keswick Dam, and a need for increases in renewable energy supplies in the State.
- Primary and secondary planning objectives were developed to address identified problems and needs, including the following:

  Primary Objectives – Formulate alternatives specifically to address the following:

  - Increase the survival of anadromous fish populations in the Sacramento River primarily upstream from the RBDD.
  - Increase water supplies and water supply reliability for agricultural, M&I, and environmental purposes to help meet future water demands, with a primary focus on enlarging Shasta Dam and Reservoir.

  Secondary Objectives – To the extent possible, through pursuit of the primary planning objectives, include as opportunities features to help accomplish the following:

  - Preserve and restore ecosystem resources in the Shasta Lake area and along the upper Sacramento River.
  - Reduce flood damages along the Sacramento River.
  - Develop additional hydropower capabilities at Shasta Dam.

- On the basis of identified problems and needs, relationships to other programs and projects, and Federal planning guidance, the following Mission Statement was developed:

  To develop an implementable plan primarily involving the enlargement of Shasta Dam and Reservoir to promote increased survival of anadromous fish populations in the upper Sacramento River and increased water supply reliability, and to the extent possible through meeting these objectives, include features to benefit other identified ecosystem, flood control, and related water resources needs.

- Of the numerous water resources management measures identified and evaluated, seven were retained for potential inclusion into concept plans to address the two primary planning objectives, and five measures were identified to address the three secondary objectives.

- The No-Action plan and twelve concept plans were formulated from the retained resources management measures. Three concept plans focused on anadromous fish survival, four concept plans focused on water supply reliability, and five concept plans combined various measures to address the two primary and one or more of the secondary objectives.

- Six concept plans were identified for recommended further development as alternative plans in the remainder of the feasibility study, including the following:

  No-Action (No Federal Action) – No change in estimated future water supplies to address reliability problems in California, opportunities to help increase anadromous fish survival, or opportunities to help restore ecosystem values, flood control, or hydropower needs in the upper Sacramento River watershed.

  WSR-1 – Increased water supply reliability with a 6.5-foot raise of Shasta Dam and 290,000 acre-foot enlargement of Shasta Reservoir.

  WSR-2 – Increased water supply reliability with an 18.5-foot raise of Shasta Dam and 636,000 acre-foot enlargement of Shasta Reservoir.

  WSR-4 – Enhance water supply reliability with an 18.5-foot raise of Shasta Dam, 636,000 acre-foot enlargement of Shasta Reservoir, and increased conjunctive water management in the Sacramento River watershed.

  CO-2 – Increase anadromous fish habitat and water supply reliability with an 18.5-foot Shasta enlargement similar to WSR-4 that also includes features to increase anadromous fish survival through restoring inactive gravel mines along the upper Sacramento River.

  CO-5 – Multipurpose plan similar to CO-2 that includes features for ecosystem restoration around Shasta Reservoir and along the upper Sacramento River.

- Enlarging Shasta Dam and Reservoir and related actions for the purpose of increasing AFRP flows were eliminated as a viable component of the alternative plans because the increased minimum flow would not result in significant increases in spawning habitat for anadromous fish. However, because of a strong interest in this measure, further study is believed warranted. Should the study demonstrate a significant beneficial relationship between increasing minimum flows and increased fish survival, this component could be included in future alternative plans.

- Each of the initial alternatives recommended for further development addresses the primary objectives and to varying degrees the secondary objectives. Each also would contribute directly and indirectly to the four CALFED objectives of water quality, water supply reliability, ecosystem restoration, and delta levee system integrity. In addition, each would support implementation of other important resources programs such as EWA.
- One of the without-project condition assumptions is that Banks Pumping Plant capacity remains at 6,680 cfs. Increasing the projected pumping capacity to 8,500 cfs would result in proportionally greater water supply reliability accomplishments from each of the plans evaluated. This would not change the relative findings of this report.
- Next steps in the plan formulation process include detailed development of full alternative plans, completing environmental baseline studies, identifying potential impacts and mitigation features, developing a tentatively selected plan, completing environmental compliance investigations; and, supporting technical analyses. These tasks will lead to completion of the Integrated Feasibility Report, which will serve both Federal decision-making and NEPA/CEQA compliance purposes.
- Public involvement and participation will play a key role in the development of detailed alternative plans and selection of a recommended plan.
- Important factors in future study efforts include State of California participation in the SLWRI to address concerns raised in California Resource Code 5093.342(c), and identification of non-Federal sponsor(s) for the two primary project purposes.

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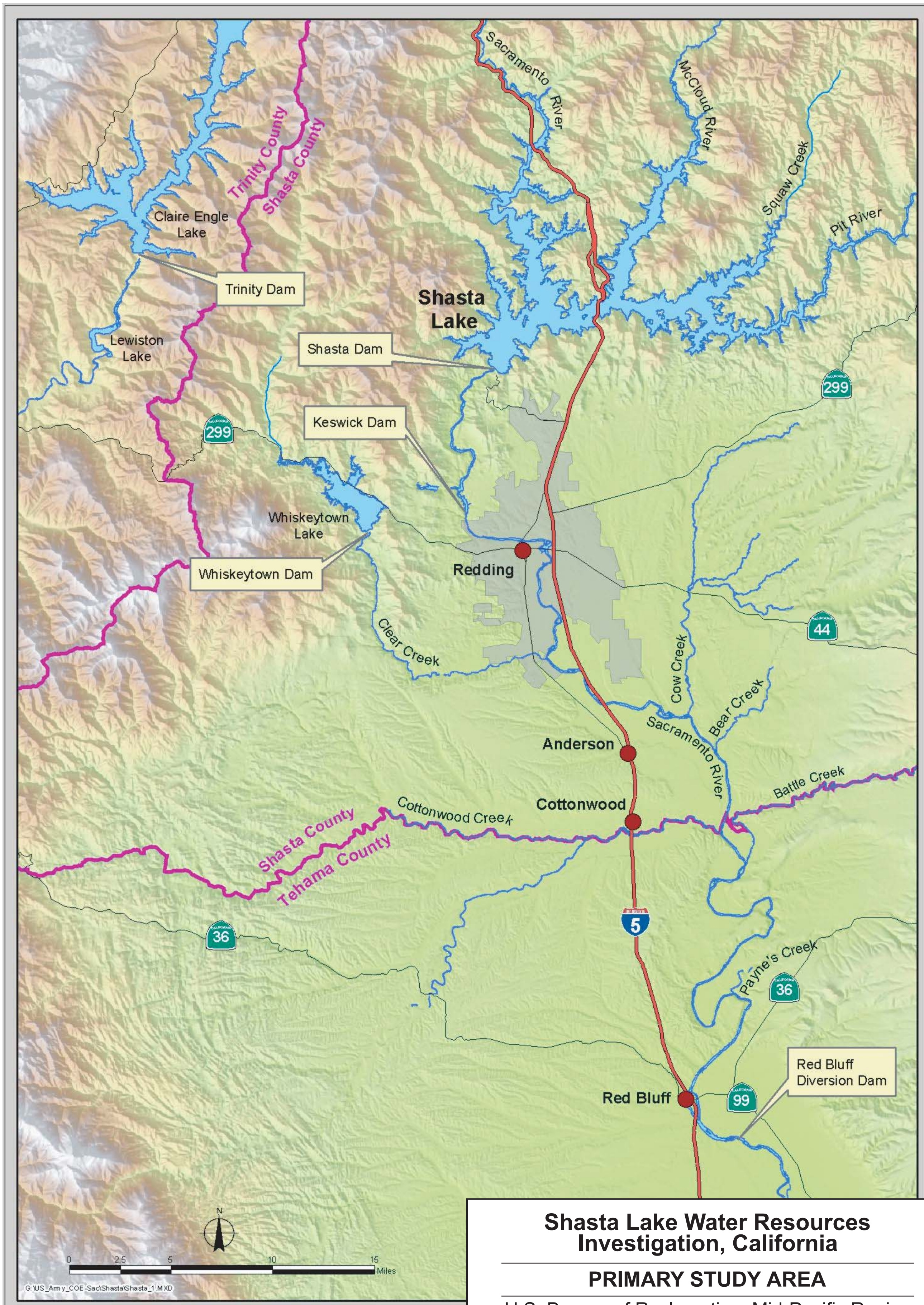
Plates

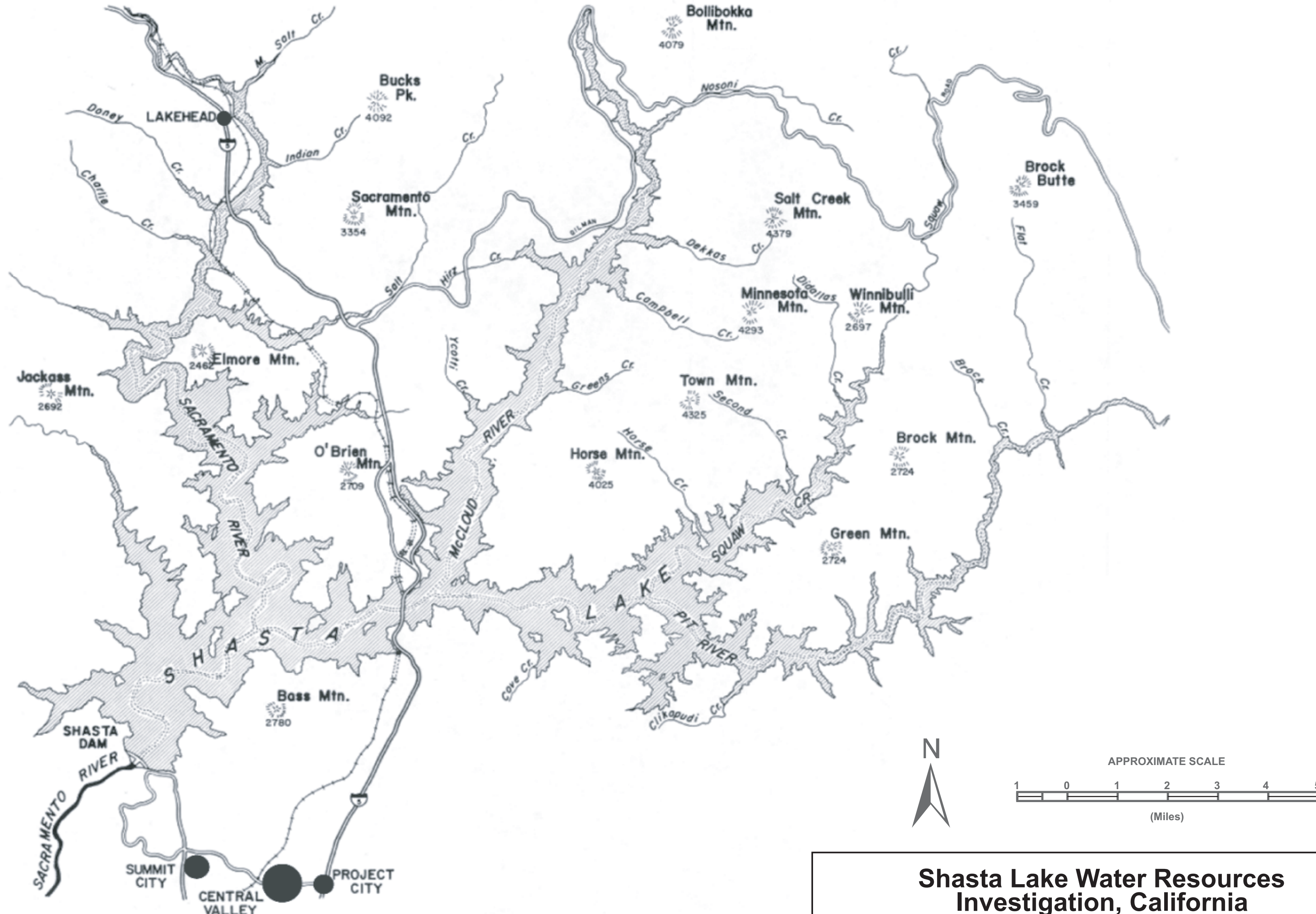


Shasta Lake Water Resources Investigation, California

PRIMARY STUDY AREA

U.S. Bureau of Reclamation, Mid-Pacific Region
June 2004

PLATE 1



Shasta Lake Water Resources Investigation, California

SHASTA RESERVOIR AREA

U.S. Bureau of Reclamation, Mid-Pacific Region
June 2004

Source: U.S. Army Corps of Engineers, Shasta Dam and Lake, Sacramento River, California, Report on Reservoir Regulation for Flood Control, Rev. January 1977

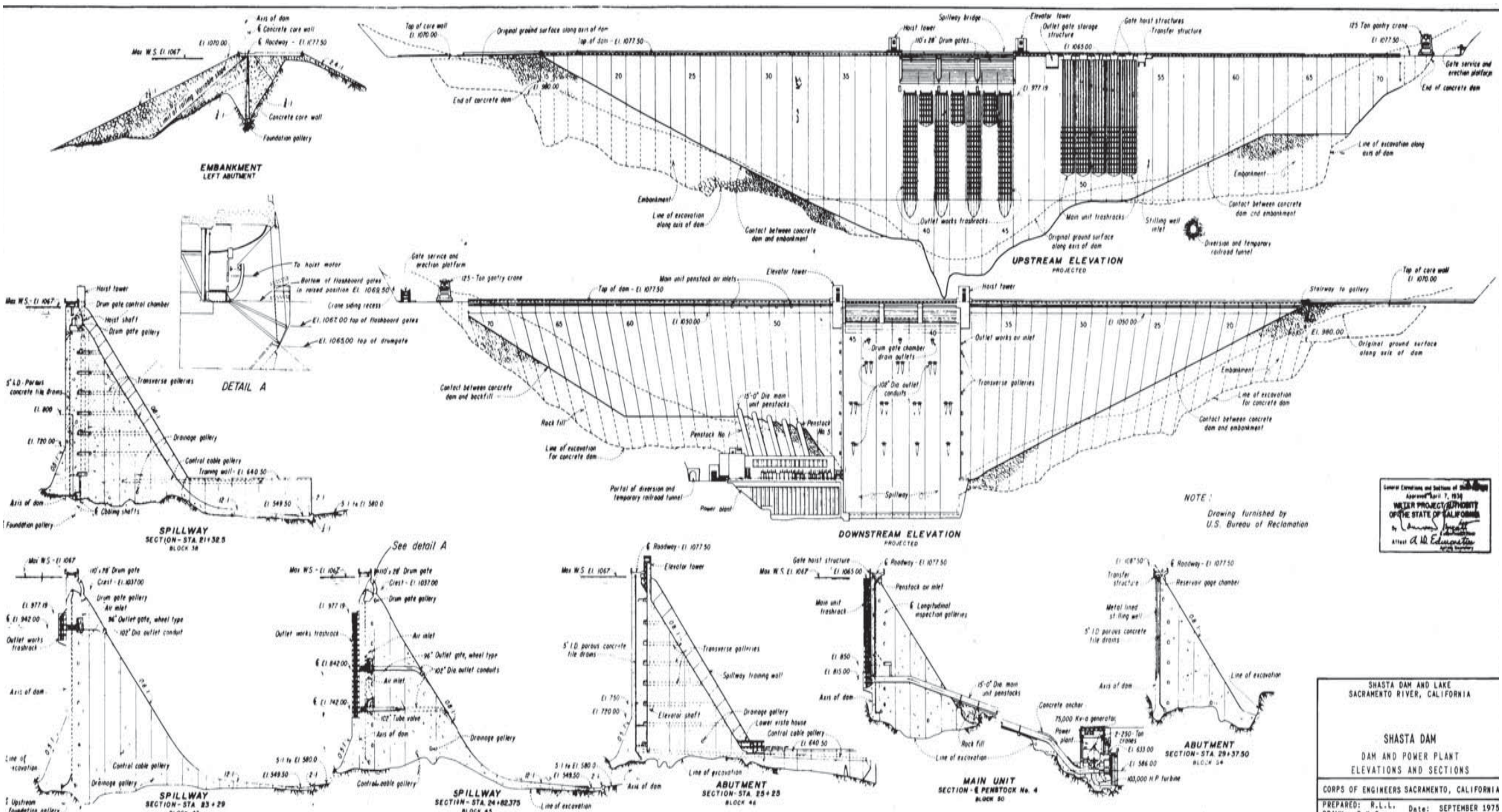
PLATE 2

Shasta Lake Water Resources Investigation, California

MAJOR CVP AND SWP FACILITIES

U.S. Bureau of Reclamation, Mid-Pacific Region
June 2004

PLATE 3



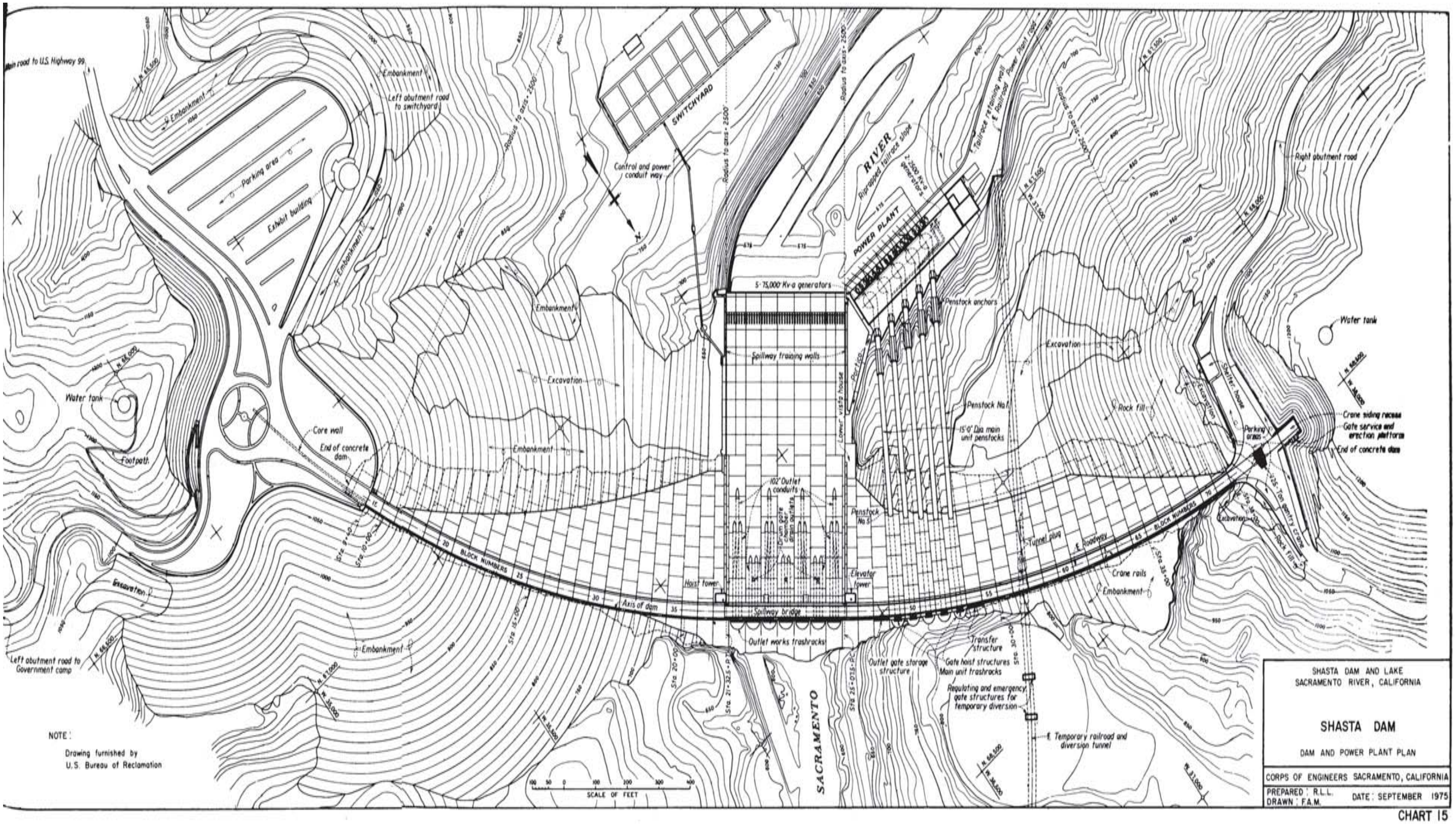
Shasta Lake Water Resources Investigation, California

SHASTA DAM AND POWERPLANT ELEVATIONS AND SECTIONS

U.S. Bureau of Reclamation, Mid-Pacific Region
June 2004

Source: U.S. Army Corps of Engineers, Shasta Dam and Lake, Sacramento River, California, Report on Reservoir Regulation for Flood Control, Rev. January 1977

PLATE 4



Source: U.S. Army Corps of Engineers, Shasta Dam and Lake, Sacramento River, California, Report on Reservoir Regulation for Flood Control, Rev. January 1977

Shasta Lake Water Resources Investigation, California

SHASTA DAM AND POWERPLANT PLAN

U.S. Bureau of Reclamation, Mid-Pacific Region
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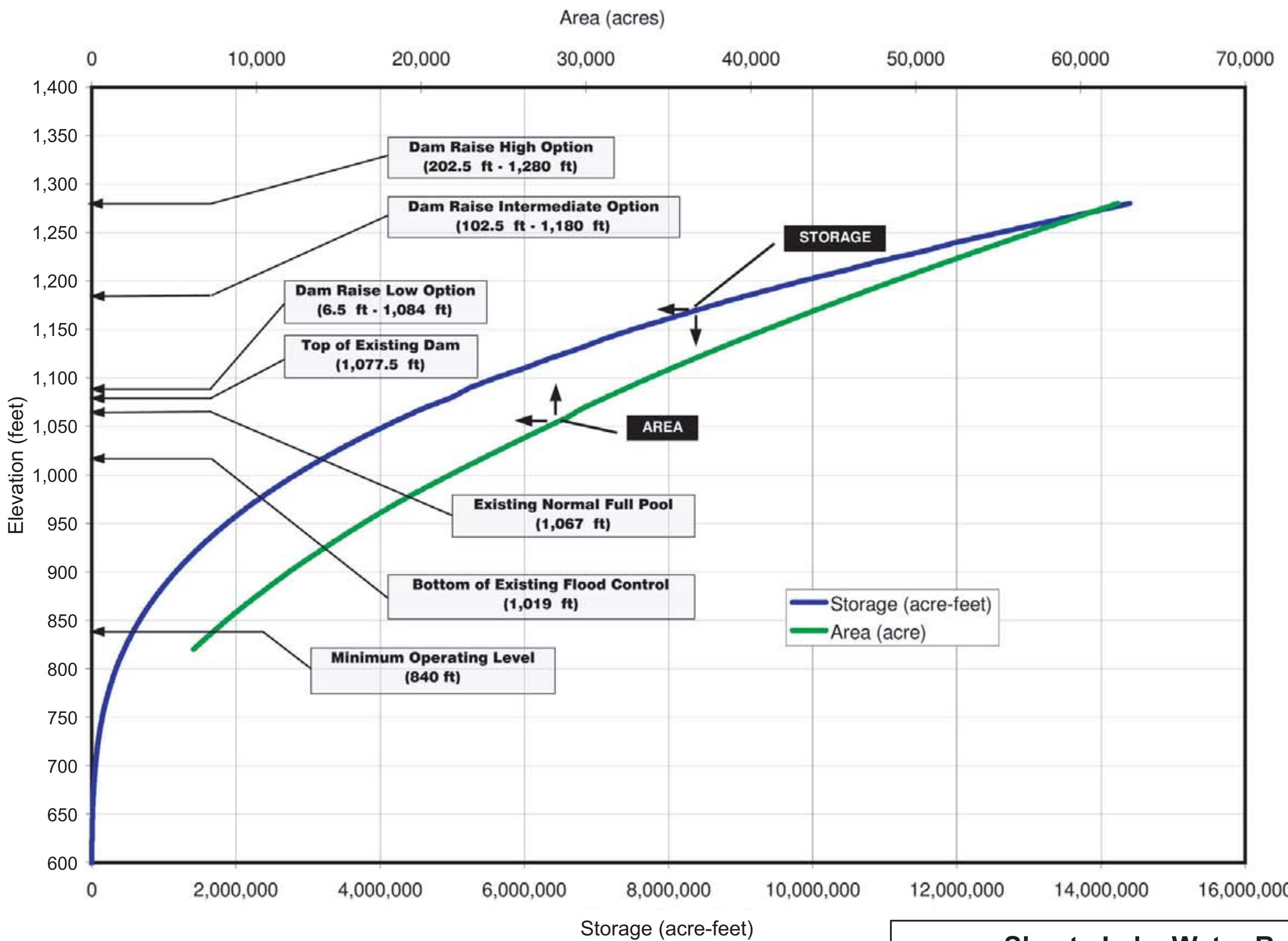
PLATE 5



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ENLARGED SHASTA RESERVOIR AREA - CAPACITY RELATIONSHIPS

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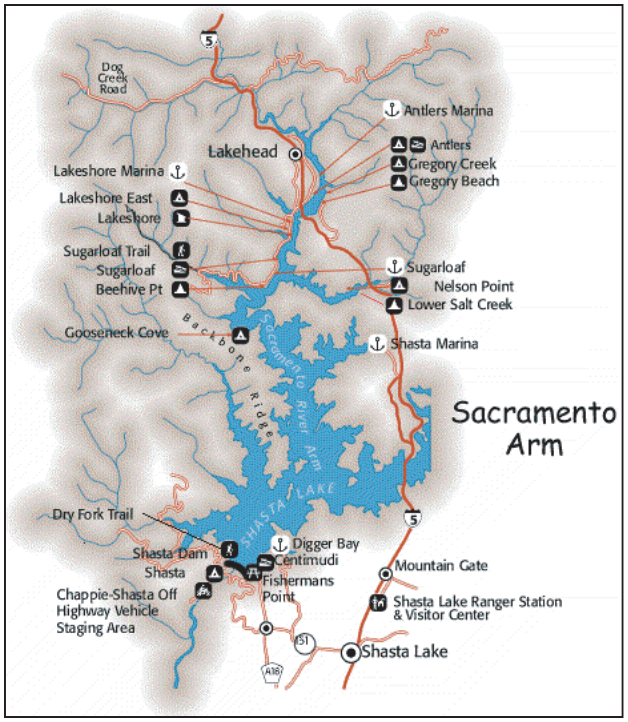
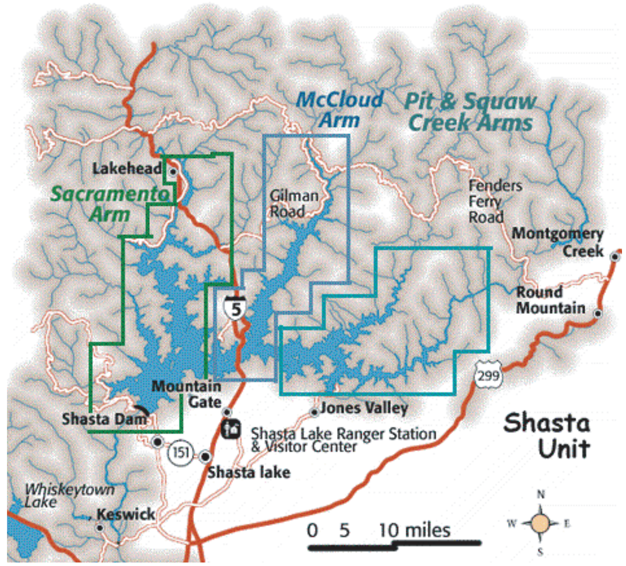
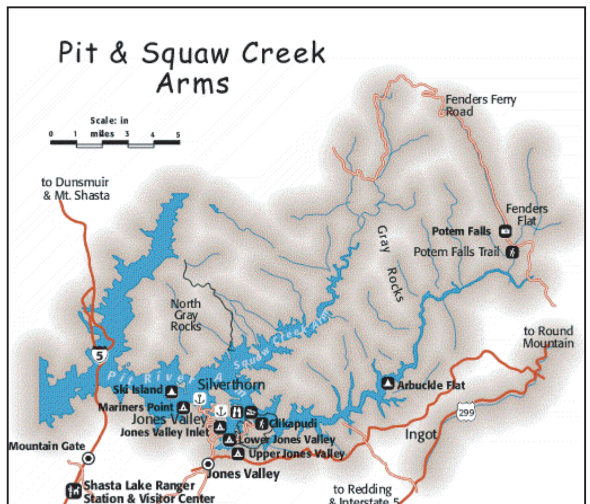
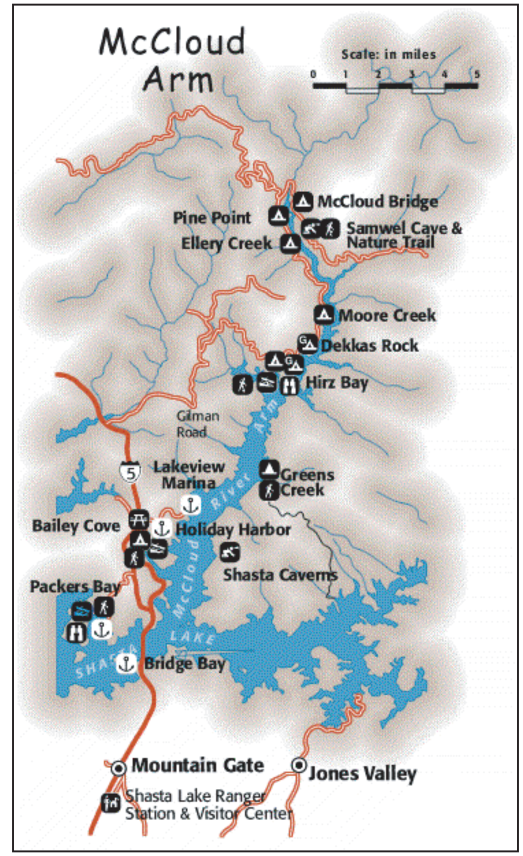
PLATE 6









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SHASTA RECREATION FACILITIES

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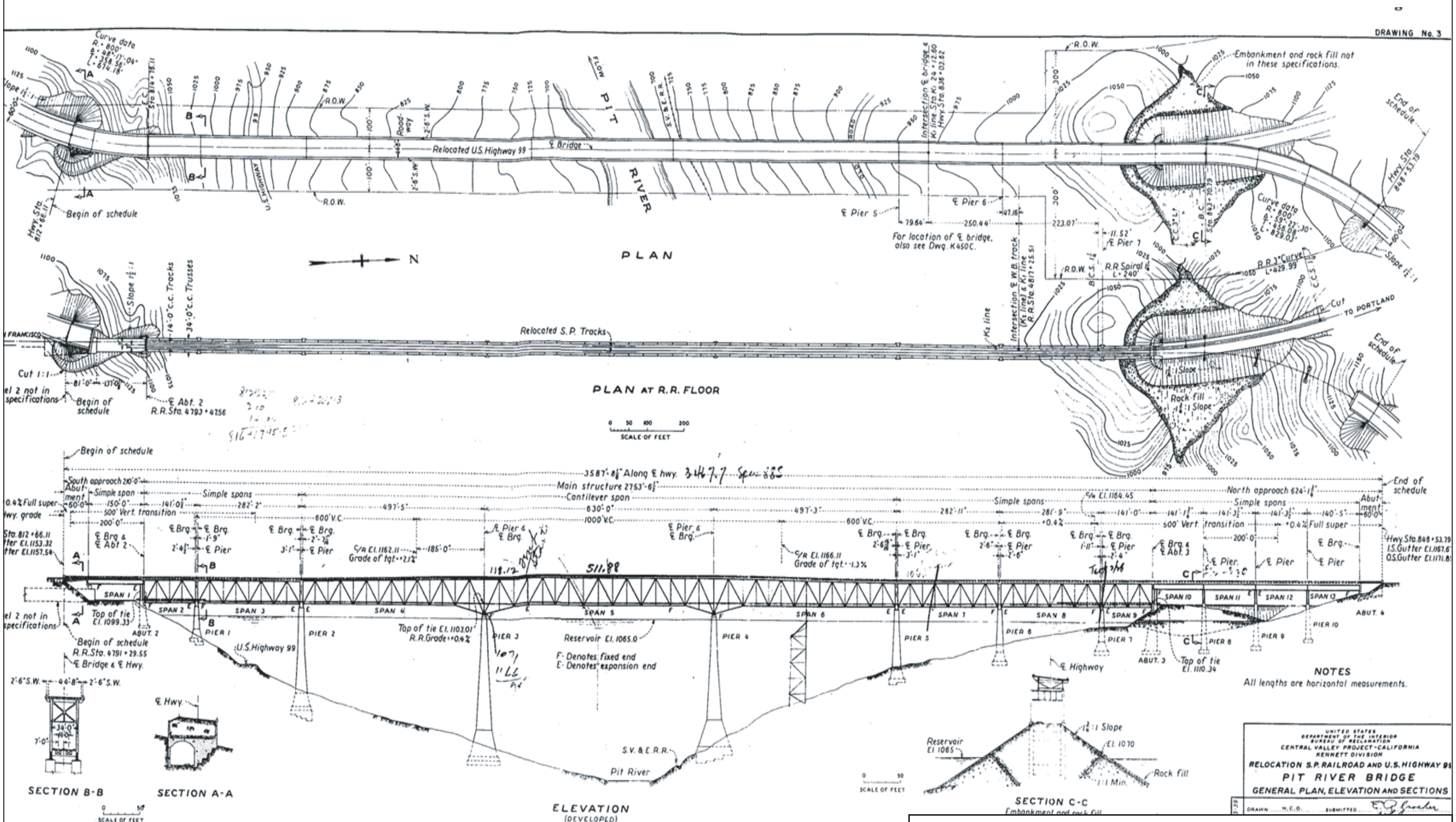
PLATE 7



Source: U.S. Bureau of Reclamation, Abutments and Piers, Pit River Bridge, Relocation of Southern Pacific Railroad and U.S. HIghway 99, 1939

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PIT RIVER BRIDGE

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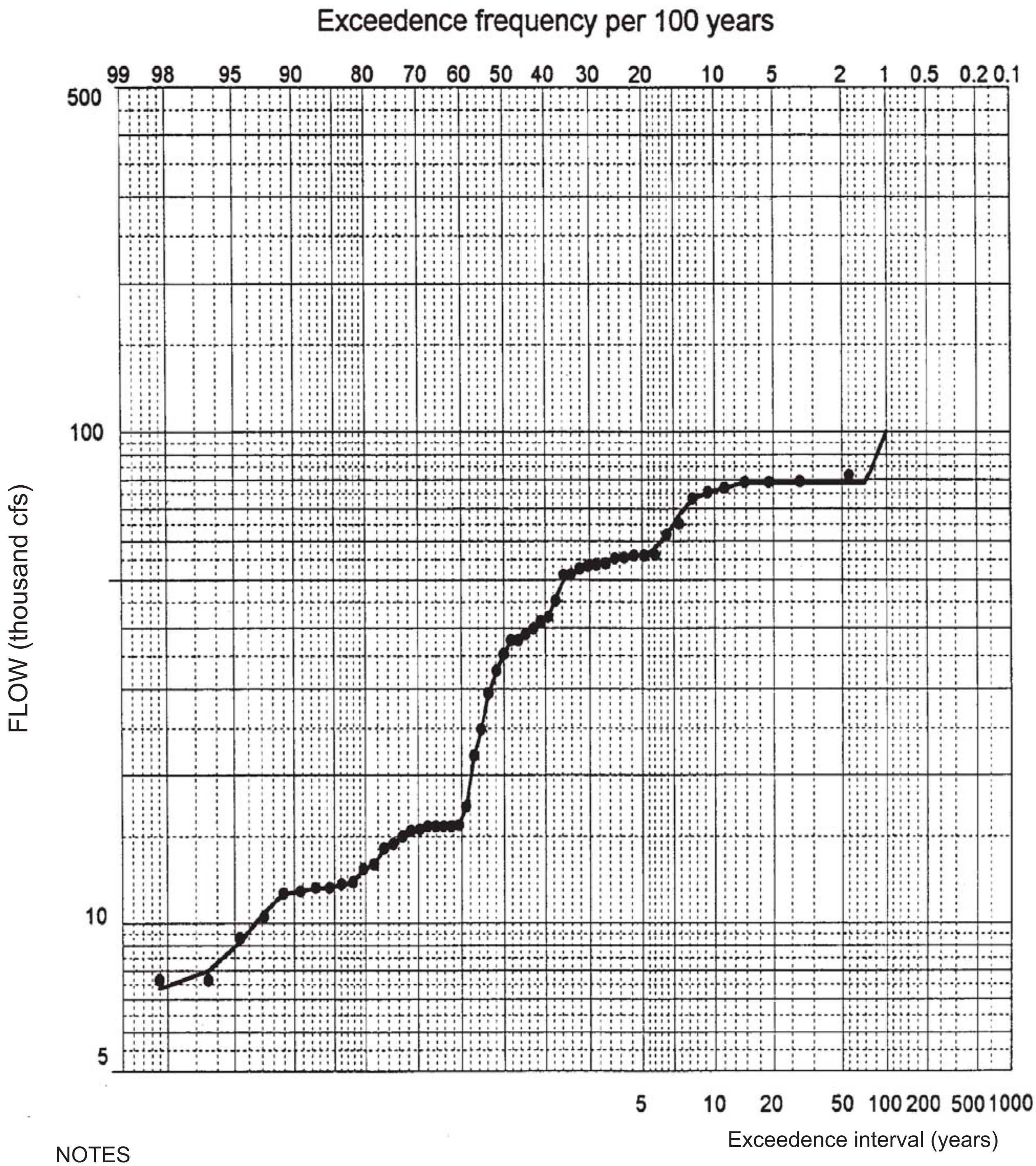
PLATE 8



NOTES
1. Drainage area 6,468 sq. mi.
2. Median plotting positions
3. Period of record: 1944-1998

Source: U.S. Army Corps of Engineers,Sacramento and San Joaquin River Basins, California. Post-Flood Assessment, 1999.

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PEAK RAIN FLOOD FREQUENCY SACRAMENTO RIVER AT KESWICK REGULATED CONDITION

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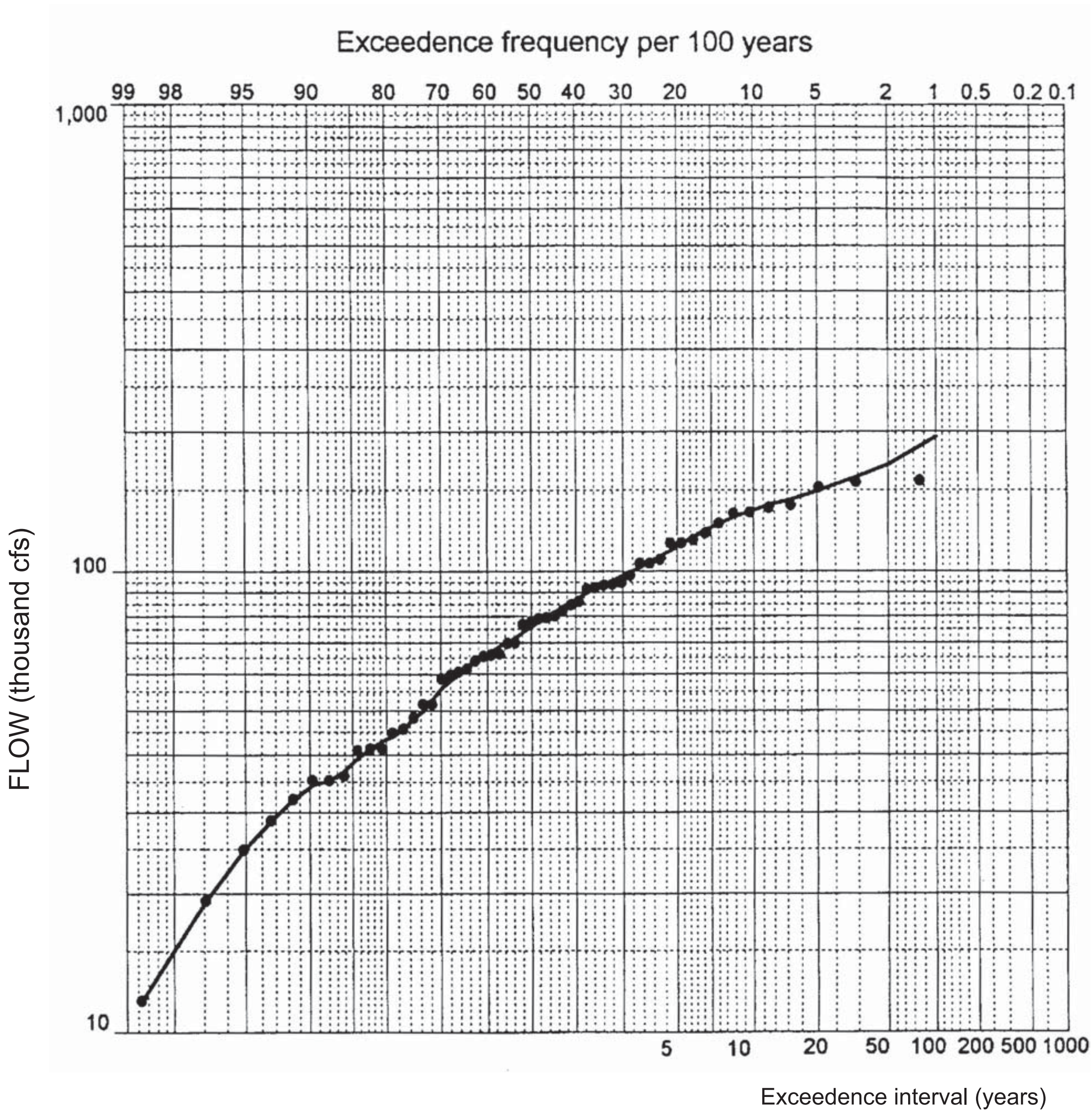
PLATE 9



NOTES
1. Drainage Area 6,468 sq. mi.
2. Median plotting positions
3. Period of Record: 1944-1998

Source: U.S. Army Corps of Engineers,Sacramento and San Joaquin River Basins, California. Post-Flood Assessment, 1999.

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PEAK RAIN FLOOD FREQUENCY SACRAMENTO RIVER ABOVE BEND BRIDGE REGULATED CONDITION

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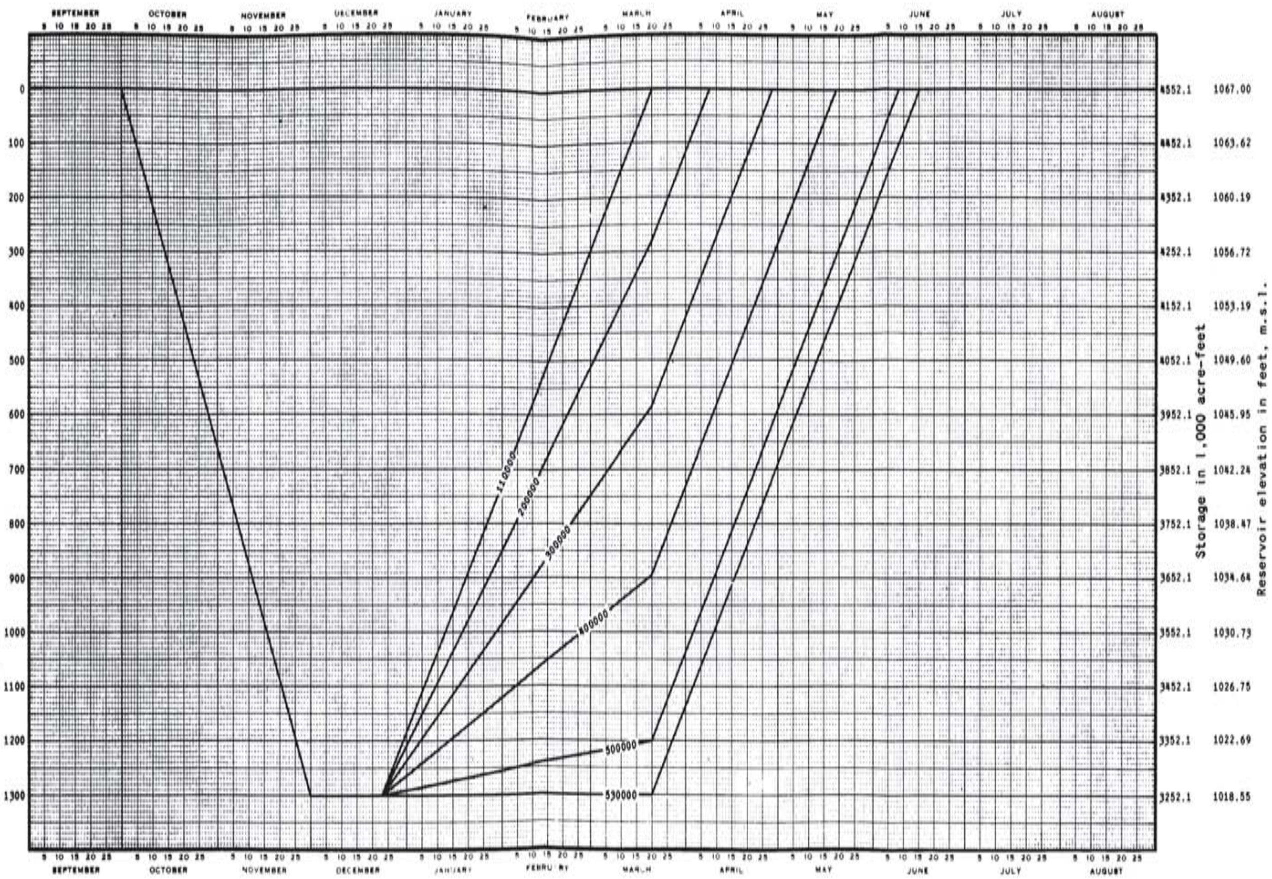
PLATE 10

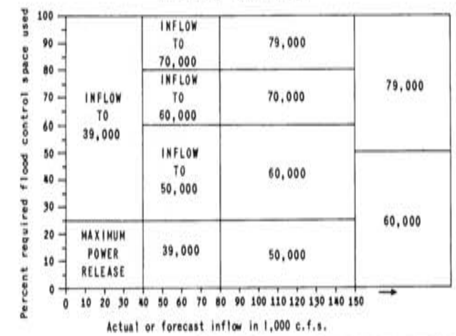


USE OF DIAGRAM

1. Rainflood parameters relate the accumulation of seasonal inflow to the required flood control space reservation on any given day. Parameter values are computed daily, from the accumulation of seasonal inflow by adding the current day's inflow in cubic feet per second (cfs) to 95% of the parameter value computed through the preceding day.*
2. Except when releases are governed by the emergency spillway release diagram currently in force (File No. SA-26-92), water stored in the flood control reservation, defined hereon, shall be released as rapidly as possible, subject to the following conditions:
   a. That releases are made according to the Release Schedule hereon.
   b. That flows in Sacramento River below Keswick Dam do not exceed 79,000 cfs.
   c. That flows in Sacramento River at Bend Bridge gage do not exceed 100,000 cfs.
   d. That releases are not increased more than 15,000 cfs or decreased more than 4,000 cfs in any 2-hour period.

*Flood Control Diagram is initialized each flood season by assuming a parameter value of 100,000 c.f.s. day on 1 October.

RELEASE SCHEDULE



SHASTA DAM AND LAKE
SACRAMENTO RIVER, CALIFORNIA

FLOOD CONTROL DIAGRAM

Prepared Pursuant to Flood Control Regulations for Shasta Dam and Lake

APPROVED: Richard M. Connell
Brigadier General, USA, Division Engineer
South Pacific Division

APPROVED: B.E. Martin
Regional Director Mid Pacific Region
U.S.B.R.

Effective Date: 5 JUL 1977 File No. SA-17-26-13

Source: U.S. Army Corps of Engineers, Shasta Dam and Lake, Sacramento River, California, Report on Reservoir Regulation for Flood Control, Rev. January 1977

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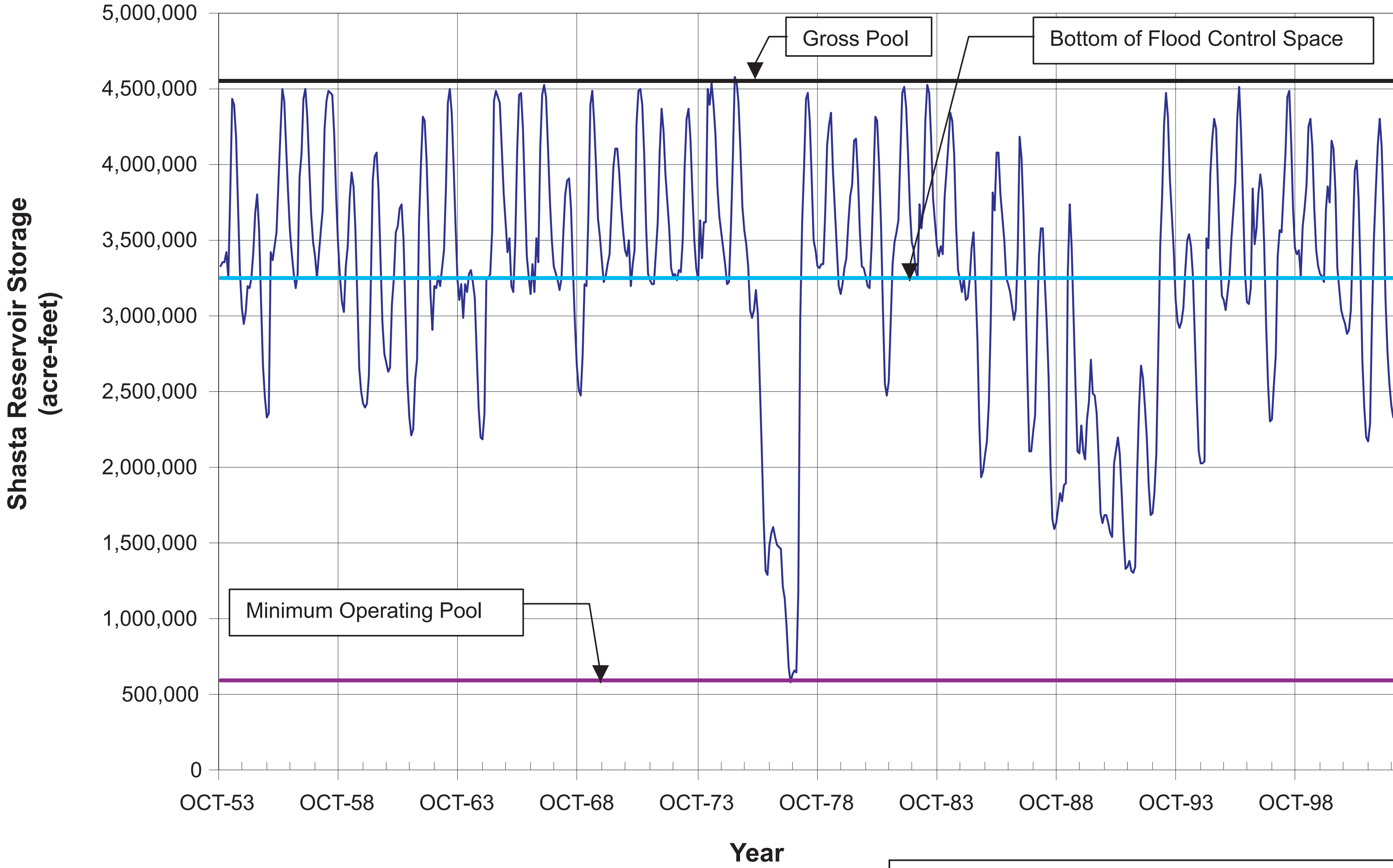
SHASTA DAM FLOOD CONTROL DIAGRAM

U.S. Bureau of Reclamation, Mid-Pacific Region
June 2004

PLATE 11



Shasta Lake Water Resources Investigation, California

SHASTA RESERVOIR STORAGE MONTHLY AVERAGE

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June 2004

PLATE 12

Existing Gross Pool

Approximate Gross Pool with 6.5-Foot Dam Raise

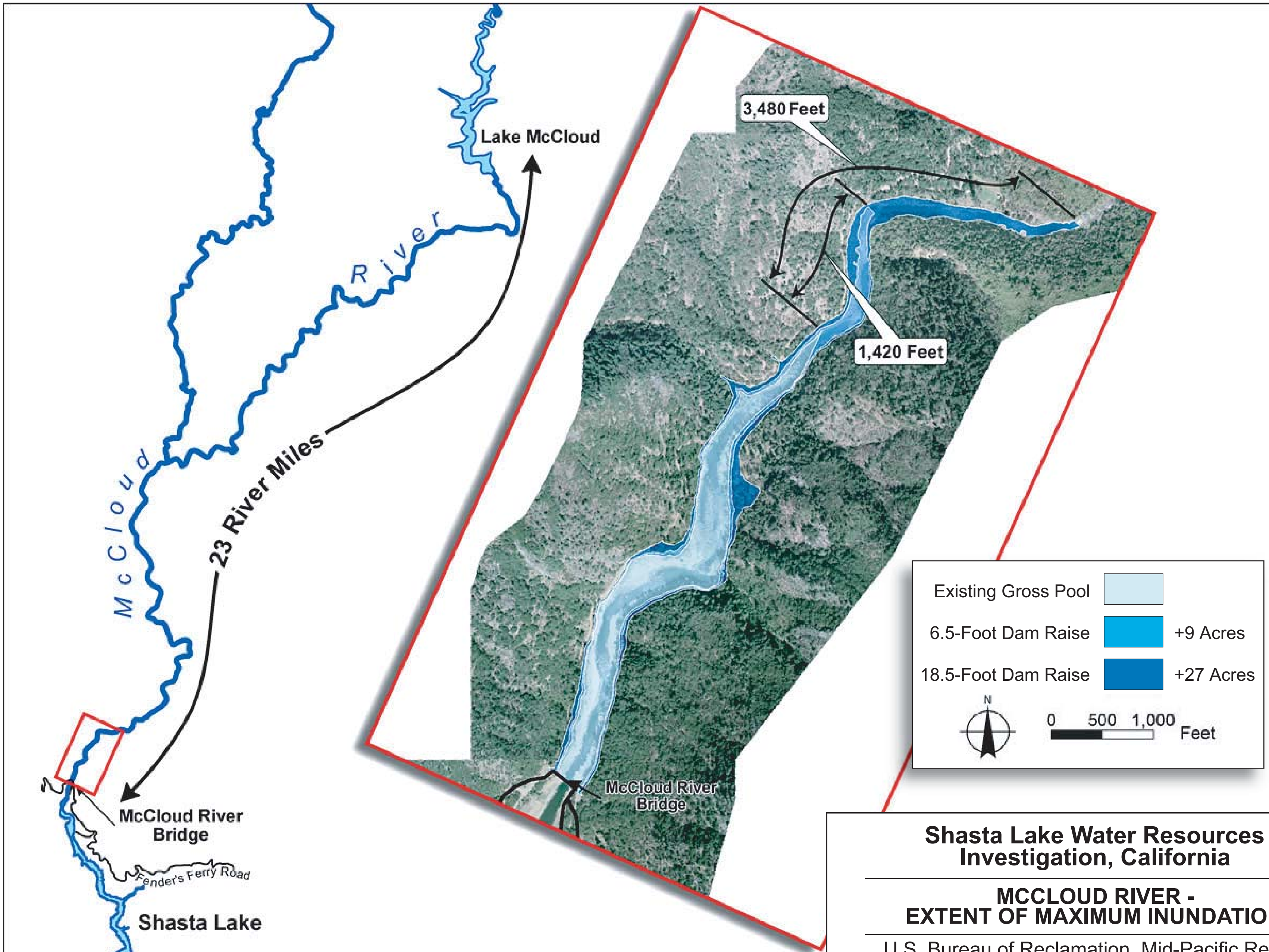
Approximate Gross Pool with 18.5-Foot Dam Raise

Shasta Lake Water Resources Investigation, California

MAXIMUM INUNDATION LIMITS LAKESHORE AREA WITHOUT INFRASTRUCTURE PROTECTION

U.S. Bureau of Reclamation, Mid-Pacific Region
June 2004

PLATE 13



Shasta Lake Water Resources Investigation, California

MCCLOUD RIVER - EXTENT OF MAXIMUM INUNDATION

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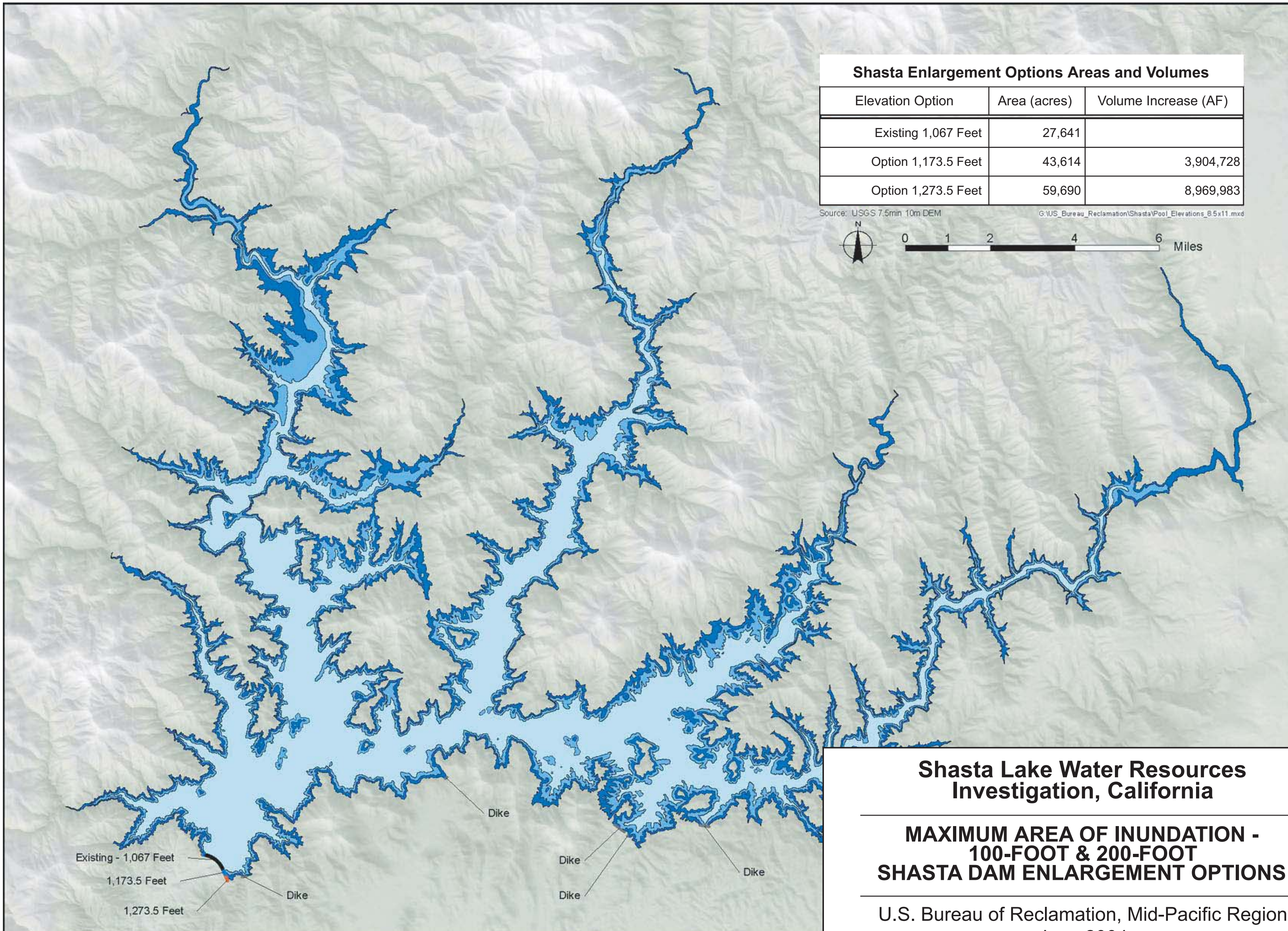
PLATE 14

Shasta Enlargement Options Areas and Volumes

Elevation Option	Area (acres)	Volume Increase (AF)
Existing 1,067 Feet	27,641	
Option 1,173.5 Feet	43,614	3,904,728
Option 1,273.5 Feet	59,690	8,969,983

Source: USGS 7.5min 10m DEM

G:\US_Bureau_Reclamation\Shasta\Pool_Elevations_8.5x11.mxd



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MAXIMUM AREA OF INUNDATION - 100-FOOT & 200-FOOT SHASTA DAM ENLARGEMENT OPTIONS

U.S. Bureau of Reclamation, Mid-Pacific Region
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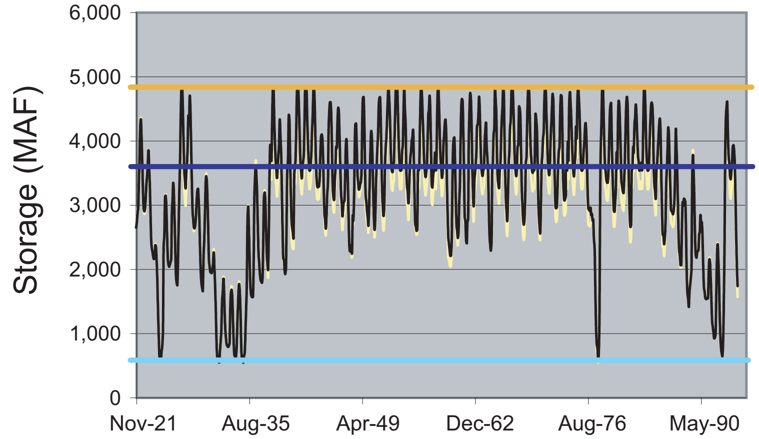
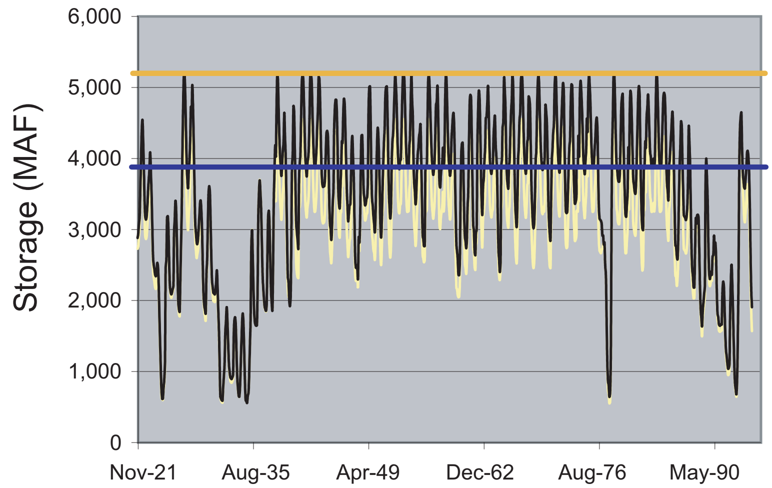
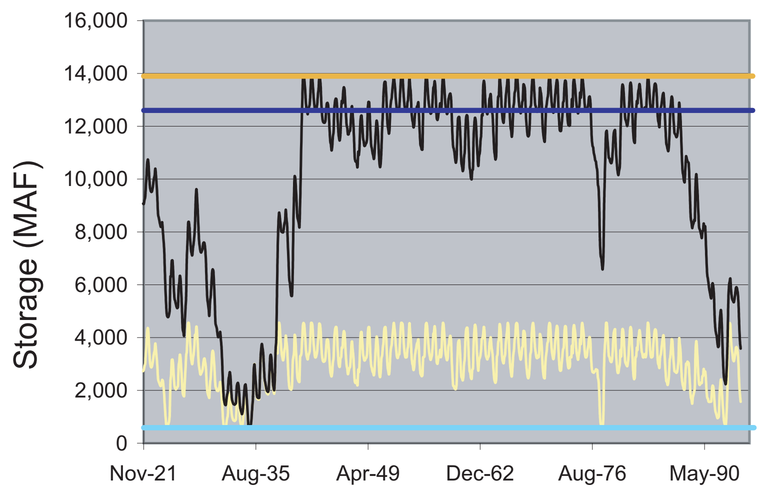
PLATE 15



6.5-Foot Dam Raise



18.5-Foot Dam Raise



200-Foot Dam Raise

- Baseline
- With Dam Raise Scenario
- Top of Flood Control
- Bottom of Flood Control
- Dead Pool

Note: CALSIM II Simulation Period 1921 to 1994

Shasta Lake Water Resources Investigation, California

SIMULATED SHASTA RESERVOIR STORAGE FLUCTUATIONS - BASELINE & DAM RAISE SCENARIOS

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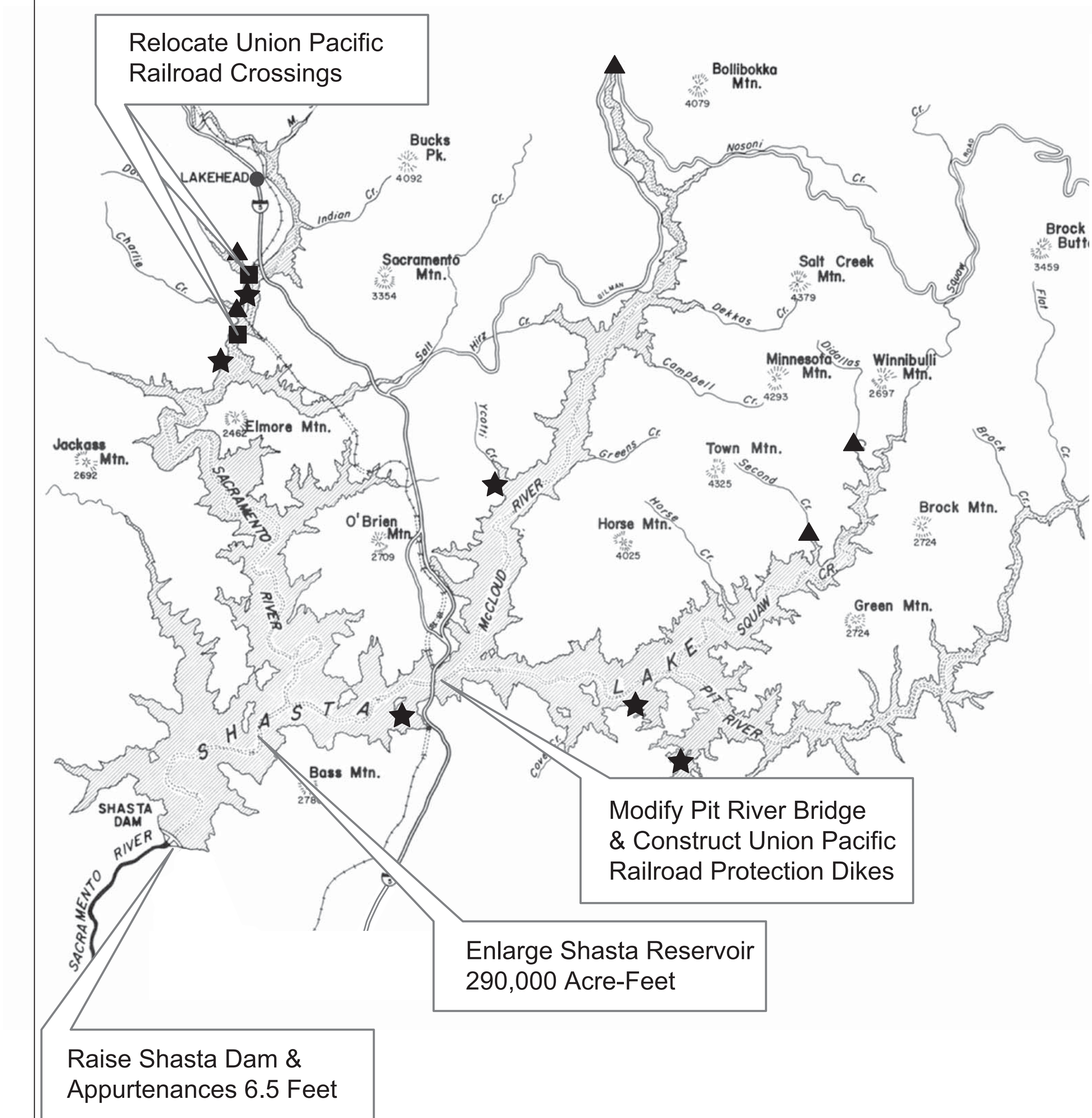
June 2004

PLATE 16



■ Union Pacific Railroad Bridge Modification

▲ Vehicle Bridge Relocation

★ Major Recreation, Marina, & Related Modification

Shasta Lake Water Resources Investigation, California

INCREASE WATER SUPPLY RELIABILITY WITH 6.5-FOOT SHASTA ENLARGEMENT PLAN (WSR-1)

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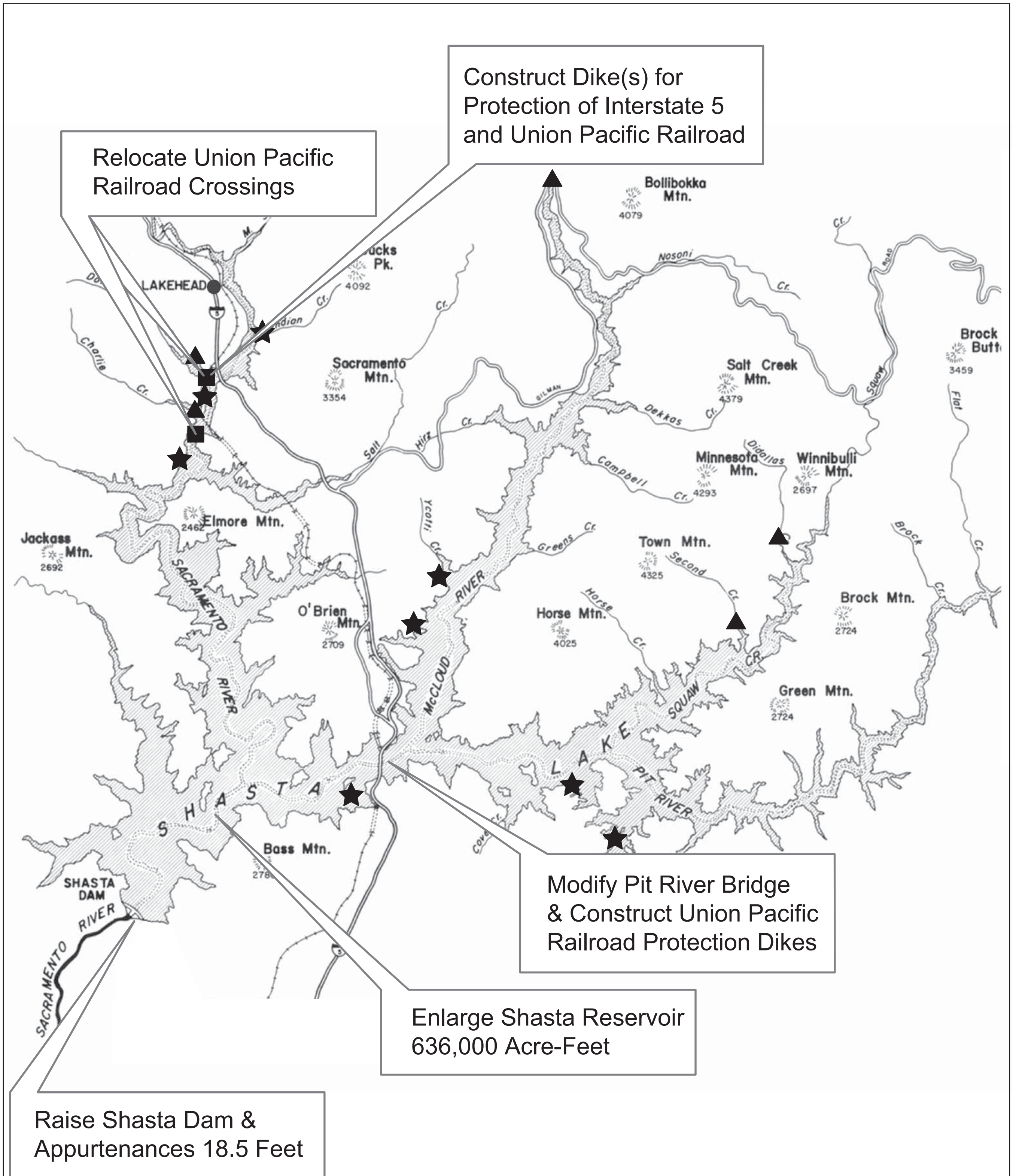
PLATE 17



■ Union Pacific Railroad Bridge Modification

▲ Vehicle Bridge Relocation

★ Major Recreation, Marina, & Related Modification

Shasta Lake Water Resources Investigation, California

INCREASE/ENHANCE WATER SUPPLY RELIABILITY WITH 18.5-FOOT SHASTA ENLARGEMENT PLANS (WSR-2 & -4)

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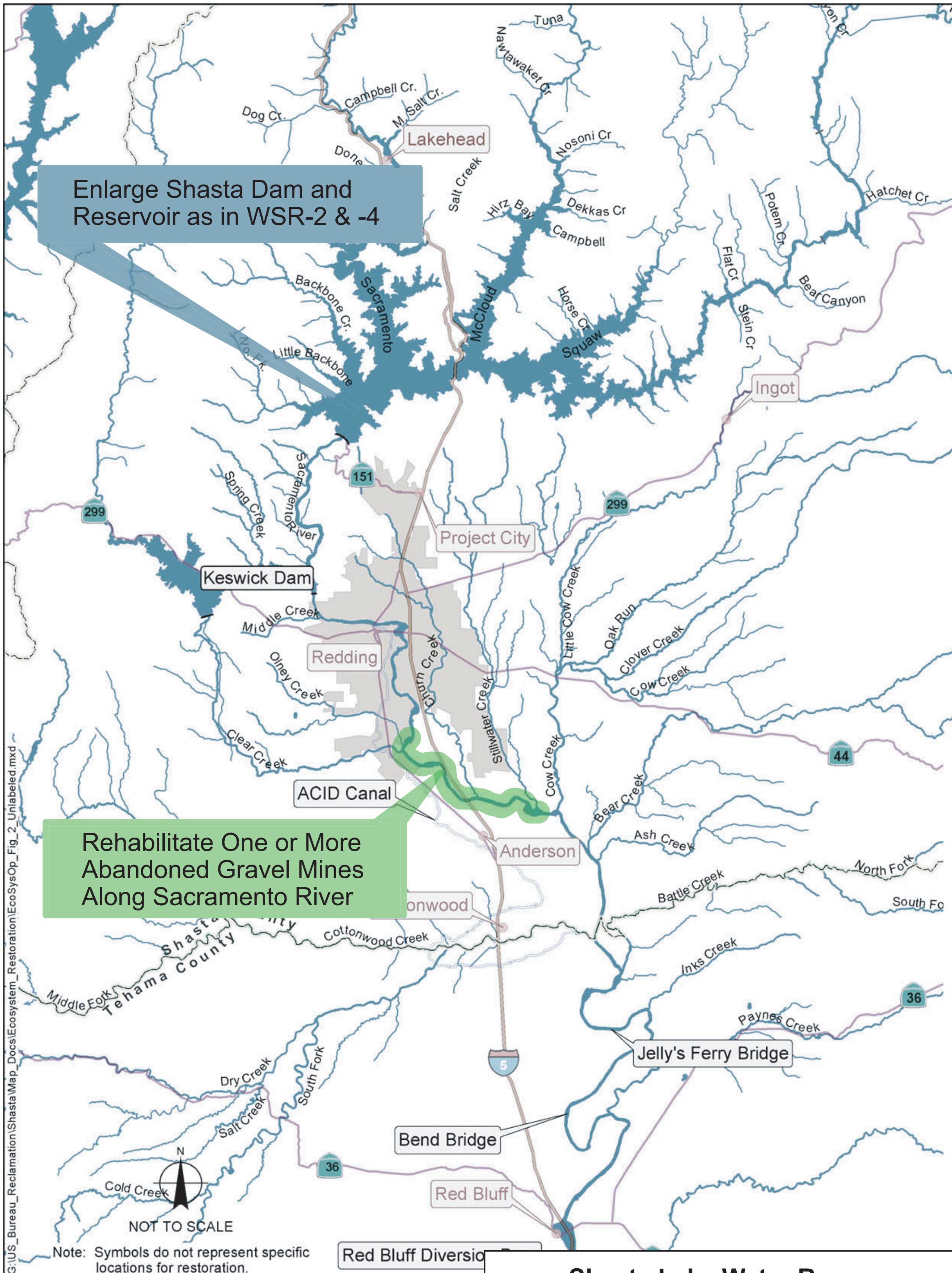
June 2004

PLATE 18

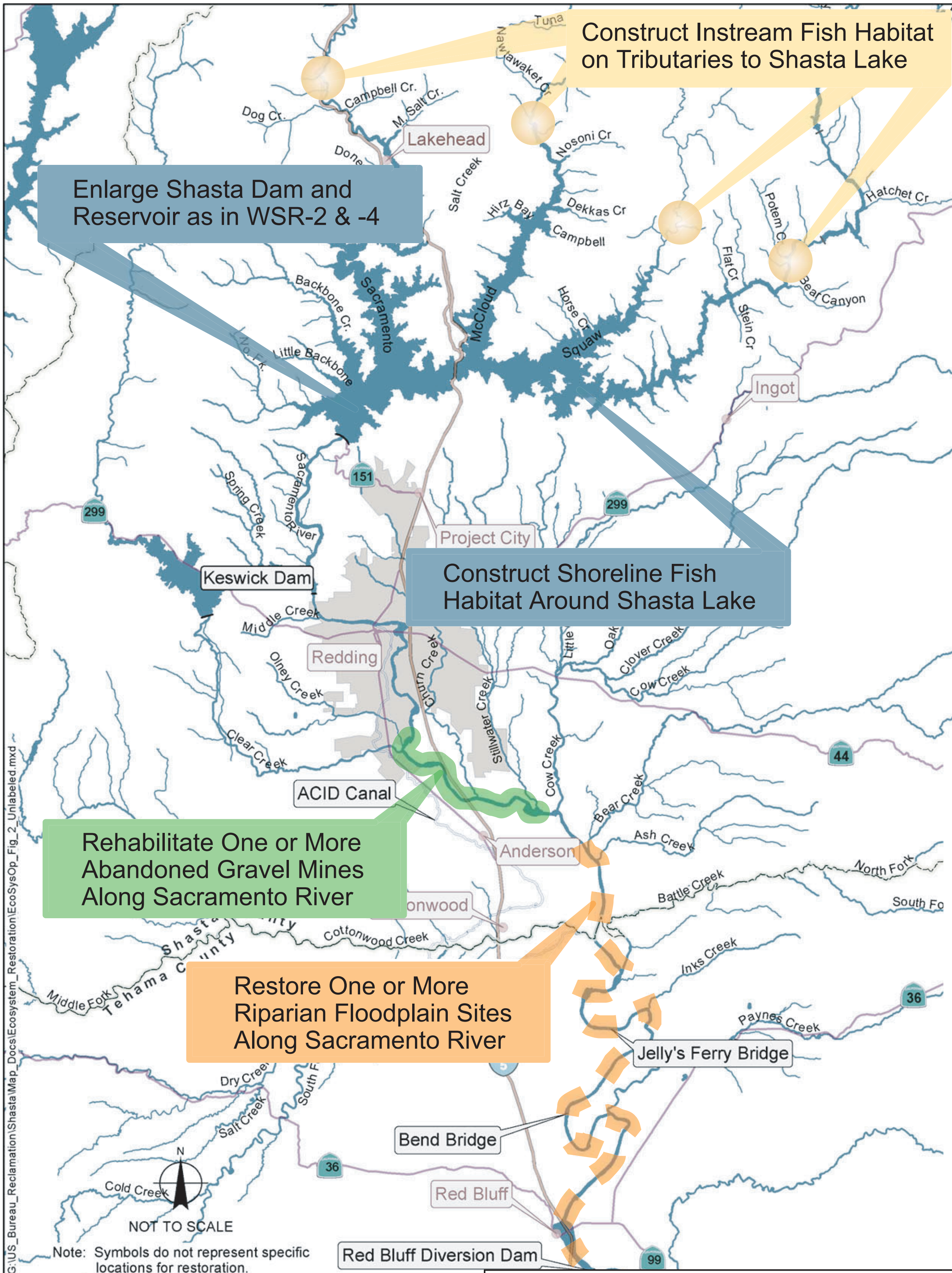


Shasta Lake Water Resources Investigation, California

INCREASE ANADROMOUS FISH HABITAT AND WATER SUPPLY RELIABILITY WITH 18.5-FOOT SHASTA ENLARGEMENT (CO-2)

U.S. Bureau of Reclamation, Mid-Pacific Region
June 2004

PLATE 19



Shasta Lake Water Resources Investigation, California

MULTIPURPOSE WITH 18.5-FOOT SHASTA ENLARGEMENT PLAN (CO-5)

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