RECLAMATION

Managing Water in the West

Plan Formulation Report

Shasta Lake Water Resources Investigation

U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region

December 2006

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prepared by

Bureau of Reclamation
Mid-Pacific Region

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EXECUTIVE SUMMARY

This Plan Formulation Report (PFR) is an interim product of the Shasta Lake Water Resources Investigation (SLWRI), a study of the United States Department of the Interior, Bureau of Reclamation (Reclamation). The SLWRI is designed to evaluate the feasibility of expanding the capacity of Shasta Reservoir for improved water supply reliability, enhanced anadromous fish survival, and other related resource needs in the primary and expanded study areas. The primary purpose of this PFR is to describe the formulation, comparison, and evaluation of comprehensive alternative plans that address SLWRI planning objectives. It is the intent that one of these alternatives, or a modified version thereof, will be selected as the recommended plan for implementation in the pending Feasibility Report.

BACKGROUND

Reclamation completed the Shasta Dam and Reservoir Project in 1945. Reclamation operates the unit in conjunction with other facilities to provide for flood control, irrigation water supply, municipal and industrial (M&I) water supply, hydropower generation, fish and wildlife conservation, and maintenance of navigation flows. The 602-foot-high Shasta Dam (533 feet above streambed) and 4.55-million-acre-foot (MAF) Shasta Reservoir are located on the upper Sacramento River in Northern California, about 9 miles northwest of the City of Redding.

In 2000, as a result of increases in demands for water supplies and attention to ecosystem needs in the Central Valley of California, Mid-Pacific Region of 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 (PL) 96-375 and the Water Supply, Reliability, and Environmental Improvement Act, also known as PL 108-361.

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 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 CALFED Bay-Delta Program (CALFED).

WITHOUT-PROJECT CONDITIONS

The primary study area for the SLWRI encompasses Shasta Dam and Reservoir; lower reaches of inflowing rivers and streams, including the Sacramento River, McCloud River, Pit River, and Squaw Creek; and the Sacramento River downstream from Shasta Dam to 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 encompasses the Sacramento River and San Joaquin river watersheds, including the Sacramento-San Joaquin River Delta (Delta).

This PFR describes existing and likely without-project future environmental conditions in the primary and extended study areas. These conditions include information available at this level of study on a host of pertinent physical, biological, socioeconomic, and cultural parameters. At this stage of the ongoing SLWRI feasibility study, most of the information included is focused on areas downstream from Shasta Dam. This is primarily due to timing associated with data collection and evaluation in and around Shasta Lake. Significant additional information primarily in the Shasta Dam and Reservoir area will be included in the draft Feasibility Report and its supporting documentation. Cultural resources are critically important issues to the SLWRI. These resources will become a significant component of the SLWRI as the ongoing investigations and coordination activities lead to selection of a recommended plan for implementation in the pending Feasibility Report.

Major identified water and related resources problems and needs in the primary study area include anadromous fish survival, water supply reliability, and other resource needs, as described below.

Anadromous Fish Survival

Due to a number of environmental factors, the population of Chinook salmon has declined in the Central Valley. As with other Delta tributaries, it is believed that the most significant factor affecting Chinook salmon abundance in the Sacramento River is adequate water temperature, especially in dry and critically dry years. Various actions that range from establishing minimum flow requirements in the river to making structural changes at Shasta Dam have been undertaken to address this problem. Despite these steps, the need for additional effective actions continues for the Sacramento River, particularly upstream from the RBDD.

Water Supply Reliability

Demands for water in California exceed available supplies. As the population of the California grows, and the demand for adequate water supplies becomes more acute, the ability to maintain a healthy and vibrant industrial and agricultural economy will become increasingly difficult.

Other Resources Needs

Other identified problems and needs include 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; the need for additional flood protection along the upper Sacramento River; and the need for preserving and increasing recreation opportunities in the north Sacramento Valley.

STUDY OBJECTIVES

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

Primary Planning Objectives

Primarily on the basis of the August 2002 CALFED Record of Decision (ROD), the SLWRI formulated 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 Planning 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 and improve public safety along the Sacramento River.
- Develop additional hydropower capabilities at Shasta Dam.
- Preserve and increase recreation opportunities at Shasta Lake.

ALTERNATIVE PLANS

A resources management measure is a feature or activity that addresses a specific planning objective. Numerous resources management measures were identified to address the primary and secondary planning objectives of the SLWRI. Of the resources management measures for the primary planning objectives, eight were selected to be considered further for potential inclusion in alternative plans. Eight measures to address the secondary planning objectives also were identified to be added, if possible and appropriate, to alternative plans. **Table ES-1** summarizes the 16 water resources management measures carried forward to address the primary and secondary planning objectives.

From the management measures, a series of concept plans were formulated. 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. The concepts were intended to promote discussion and provide a background for the formulation of initial alternatives and comprehensive alternative plans in the remainder of the feasibility study, with input from participating agencies, stakeholders, and the public. The concept plans were presented in a June 2004 Initial Alternatives Information Report (IAIR), presented in a public workshop in Redding in October 2004, and used to help conduct the environmental scoping process in the fall of 2005.

TABLE ES-1
RETAINED MEASURES TO ADDRESS PLANNING OBJECTIVES

Planning Objective	Resources Management Measures	
	Title	**Measure**
Primary Planning Objective		
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	Raise Shasta Dam 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.
	Demand Reduction	Identify and implement, to the extent possible, water use efficiency methods.
Secondary Planning Objective		
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 Control	Modify Flood Control Operations	Update Shasta Dam and Reservoir flood management operations.
	Improve Public Safety at Shasta Dam	Route PMF from top of conservation pool.
Hydropower	Modify Hydropower Facilities	Modify existing/construct new generation facilities at Shasta Dam to take advantage of increased head.
Recreation	Restore and Upgrade Facilities	Restore and upgrade recreation facilities and opportunities.
	Reoperate Reservoir	Increase recreation use by stabilizing early season filling in Shasta Lake.

Key: TCD = temperature control device PMF = Probable Maximum Flood

Two sets of concept plans were developed that focus on a single primary planning objective: anadromous fish survival or water supply reliability. In addition, a set of concept plans was developed that includes a mixture of measures to address both primary and secondary planning objectives, termed combined objective concepts.

On the basis of an evaluation of the concept plans, comments received on the IAIR, input from the public scoping process, and continued coordination, in addition to the No-Action Plan, five comprehensive alternative plans were formulated from the concept plans. Each comprehensive plan (CP) includes raising Shasta Dam. Although any enlargement of Shasta Dam and Reservoir can produce multiple benefits, three of the comprehensive plans focus on water supply reliability and anadromous fish survival with dam raises of 6.5, 12.5, and 18.5 feet. One alternative focuses on benefiting anadromous fish restoration and one includes a combination of features. Each of these last two comprehensive plans includes raising Shasta Dam 18.5 feet, although other dam raise scenarios could be considered. Each of the comprehensive plans includes allowances for several common features. These features include physical modification of the temperature control device (TCD), reservoir reoperation, modification of hydropower facilities, probable maximum flood routing modification, and best management practices for water use efficiency. These comprehensive plans are highlighted below. A summary table of major plan accomplishments is shown in **Table ES-2**.

No-Action Plan (No Additional Federal Action)

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

CP1 – Mini Raise – 6.5 Feet

The focus of CP1 is to increase water supply reliability while contributing to increased anadromous fish survival, actions that are consistent with the 2000 CALFED ROD. In addition to the common features above, CP1 primarily consists of raising Shasta Dam 6.5 feet. This raise would increase the reservoir's gross pool by 8.5 feet, and enlarge the total storage space in the reservoir by 256,000 acre-feet. Under this concept, Shasta Dam operational guidelines would continue unchanged, with the additional storage retained for water supply reliability. This scenario helps to reduce future water shortages through increasing drought and average year water supply reliability. The increased pool depth and volume would also contribute to maintaining lower seasonal water temperatures for anadromous fish on the upper Sacramento River.

TABLE ES-2
COSTS AND ACCOMPLISHMENTS SUMMARY

Item	CP1	CP2	CP3	CP4	CP5
Raise Shasta Dam (feet)	**6.5**	**12.5**	**18.5**	**18.5**	**18.5**
Total Increased Storage (TAF)	256	443	634	634	634
Accomplishments					
Anadromous Fish					
Dedicated Storage (TAF)	--	--	--	378	--
Production Increase (thousand fish)[1]	366	367	509	1,503	509
Water Supply Reliability (TAF/year) [2]	91	106	133	91	133
Ecosystem Restoration (habitat units)	--	--	--	--	--[3]
Hydropower Generation (GWh/year)	17	42	54	94	54
Recreation (increased user days, thousands)	83	141	224	224	[3]
Flood Damage Reduction	Minimal	Minimal	Minimal	Minimal	Minimal
Economics ($ millions) [4]					
Cost					
Construction Cost	531.3	679.2	825.2	825.2	854.9
Annual Cost	31.4	40.2	48.8	48.8	50.6
Annual Benefits					
Existing Conditions [5]	27.9	35.9	43.4	71.0	45.2[6]
Shasta Dam Public Safety [7]	3.0	4.6	6.2	6.2	6.2
Subtotal	30.9	40.5	49.6	77.2	51.4
Total Potential Future Conditions [8]	38.5	50.8	59.9	84.8	61.7
Net Benefits					
Existing Conditions	-0.5	0.3	0.8	28.4	0.8
Potential Future Conditions [8]	7.1	10.6	11.1	36.0	11.1

Key: GWh/year = gigawatt-hours per year; TAF = thousand acre-feet; -- = not applicable

Notes:

1. Average annual increase in juvenile Chinook salmon surviving to migrate downstream from the Red Bluff Diversion Dam. Numbers were derived from Salmod.
2. Total drought period reliability to the Central Valley Project and the State Water Project.
3. The extent of ecosystem restoration and increased recreation due to added facilities is under development. Recreation use will surpass that for CP3 and CP4.
4. Based on October 2006 price levels, 5-1/8 discount rate, and 100-year period of analysis.
5. Anadromous fish survival, water supply reliability, hydropower generation, and general recreation.
6. Annual benefits for ecosystem restoration and additional recreation are assumed at least equal to increases in annual costs. Studies are underway.
7. Benefits to Shasta Dam Public Safety were set equal to increased cost to pass the probable maximum flood with event starting at the top of Shasta Reservoir conservation storage.
8. Includes increase of water supply benefits at 2 percent above inflation to account for growing scarcity of available supplies in the future.

CP2 – Mini Raise – 12.5 Feet

As with CP1, this comprehensive plan focuses on enlargement of Shasta Dam and Reservoir consistent with the goals of the CALFED ROD, and was formulated for the primary purpose of increased water supply reliability. In addition to the common features above, CP2 consists of raising Shasta Dam 12.5 feet, an elevation change that raises the gross pool by 14.5 feet, and enlarges the total storage space in the reservoir by 443,000 acre-feet. This alternative would help reduce future shortages by increasing drought and average year water supply reliability. The increased cold water pool also would contribute to improve seasonal water temperatures for anadromous fish on the upper Sacramento River.

CP3 – Mini Raise – 18.5 Feet

CP3 is similar to CP1 and CP2. It focuses on the greatest practical enlargement of Shasta Dam and Reservoir consistent with the goals of the CALFED ROD, and was formulated for the primary purpose of increasing water supply reliability. In addition to the common features above, CP3 consists of raising Shasta Dam 18.5 feet (raising the gross pool by 20.5 feet, and enlarge the total storage space in the reservoir by 634,000 acre-feet to 5.19 MAF). This concept would help reduce future shortages by increasing drought and average year water supply reliability. The increased pool depth and volume would also contribute to maintaining seasonal water temperatures for anadromous fish on the upper Sacramento River.

CP4 – Mini Raise – Anadromous Fish

The primary function of CP4 is to address anadromous fish survival, while still improving water supply reliability. It focuses on increasing the volume of cold water available to the TCD through reservoir reoperations, and on raising Shasta Dam by 18.5 feet. As with CP3 and the common features above, this raise would increase the gross pool by 20.5 feet and enlarge total reservoir storage space by 634,000 acre-feet. This additional storage space would expand Shasta Lake's cold water supply available to the TCD by 378,000 acre-feet, a feature that would help maintain cooler water temperatures in the upper Sacramento River.

CP5 – Mini Raise – Combination

When formulation is complete, CP5 will address both the primary and secondary planning objectives. It includes enlarging Shasta Dam 18.5 feet, which is consistent with the objectives of the CALFED ROD, and the common features above. In addition, it includes (1) implementing environmental restoration features along the lower reaches of major tributaries to Shasta Lake, (2) constructing shoreline fish habitat around Shasta Lake, and (3) constructing additional recreation features at various locations around Shasta Lake. The environmental restoration features and increased recreation components are under continued development.

PLAN EVALUATION AND COMPARISON

Each of the comprehensive plans has been evaluated against the four Federal criteria of completeness, effectiveness, efficiency, and acceptability. It was found that at this stage of SLWRI planning, each comprehensive plan ranked similarly. As can be seen in **Table ES-2**, all plans differed in overall accomplishments. As mentioned, the environmental restoration and increased recreation components of CP5 are still under development. Even so, it is believed that all of the plans either are, or will be, found to equally meet the completeness criterion. All of the plans are effective in accomplishing the study objectives for which they are formulated. CP2 through CP5 are economically feasible under existing conditions. CP1 would provide the lowest net economic benefits. All plans would be highly cost effective under a future condition when the reliability of sufficient supplies of water is diminished. All plans are estimated to similarly meet the acceptability criteria, although continued coordination of the plans is necessary among other agencies and public interests.

Table ES-2 shows that CP4 would provide the largest net economic benefits when considered under existing or future conditions. This is primarily because enlarging the cold water pool in Shasta Lake is the most effective and economically efficient way to increase anadromous fish resources in the upper Sacramento River. Further studies may either confirm the initial findings regarding CP4 or suggest potential modifications, such as combining features of CP4 and CP5. However, a tentatively selected plan will not be identified until the draft Feasibility Report. For description purposes in this PFR, a preliminary allocation and apportionment of costs was accomplished using CP4 as a potentially selected plan. As can be seen from **Table ES-3**, which shows the results of that process, it is estimated that of the total plan cost, about 74 percent would be a Federal responsibility and 26 percent would be the responsibility of the non-Federal interest. This example cost apportionment will change depending on the outcome of future studies.

TABLE ES-3
PRELIMINARY COST APPORTIONMENT

Purpose/Action	Total		Cost Apportionment			
			Federal		Non-Federal	
	Percent	Cost ($ million)	Percent	Cost ($ million)	Percent	Cost ($ million)
Irrigation Water Supply	15.5	127.8	0	0	100	127.8
Municipal and Industrial Water Supply	5.8	48.2	0	0	100	48.2
Fish & Wildlife Enhancement	63.5	524.2	100	524.2	0	0
Hydropower	2.4	20.0	0	0	100	20.0
Public Safety	12.7	105.1	85	89.3	15	15.8
Total	**100.0**	**825.2**	**74**	**613.5**	**26**	**211.8**

IMPLEMENTATION CONSIDERATIONS

A discussion of implementation considerations, including key uncertainties associated with technical analyses, coordination with stakeholders and interest groups, environmental compliance and permitting, and others is included in the PFR.

STUDY MANAGEMENT AND OUTREACH

Overall management of the SLWRI occurs through a Project Coordination Team (PCT). The PCT includes management-level representatives from Reclamation, the California Department of Water Resources, United States Forest Service, United States Fish and Wildlife Service, California Bay-Delta Authority, and other Federal and State agencies. The Study Management Team (SMT) consists of participating agency individuals at the management and/or policy level. The SMT provides overall advice/suggestions/comments for the study, and ensures participating agency views are addressed.

A public involvement plan was designed to assist communication between the PCT and stakeholders. This plan addresses four objectives, including (1) stakeholder identification, (2) project transparency, (3) issues and concerns resolution, and (4) project implementation. Four primary outreach elements are included within the public involvement plan, including (1) public meetings and workshops, (2) technical work group communication, (3) tribal communication, and (4) PCT and SMT activities. As part of the public involvement plan, a series of briefings and workshops was held in fall 2003 and summer and fall of 2004. The 2003 and 2004 meetings were primarily to discuss the study, its objectives, resources management measures, and initial alternatives. A series of public scoping meetings was held in fall 2005 and an Environmental Scoping Report was completed in February 2006. Future public meetings and workshops will be held at important points in the investigation to coordinate study findings and complete the draft Feasibility Report.

FINDINGS AND FUTURE ACTIONS

The PFR includes a number of significant study findings:

- There is a continuing significant need to implement actions to help increase survival of anadromous fish populations in the upper Sacramento River and to increase the reliability of water supplies for urban, agricultural, and environmental purposes in the Central Valley.

- Each of the comprehensive plans formulated for the SLWRI addresses the primary planning objectives and, to varying degrees, the secondary planning 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.

- Although additional studies remain to be completed, it appears that the three comprehensive plans that include an 18.5-foot raise of Shasta Dam (CP3, CP4, and CP5) would best address each of the primary and most of the secondary objectives.

- Further assessments of specific ecosystem restoration and additional recreation facility opportunities in and around Shasta Lake will help develop final conclusions relating to the economic benefits of the comprehensive plans, and select a preferred plan.

The next major step in the feasibility study process is to further develop the comprehensive plans, define a tentatively preferred plan, and prepare the draft and final Feasibility Reports. The emphasis of upcoming studies will be on identifying environmental and related impacts and potential mitigation features for the alternative comprehensive plans and tentatively preferred plan. Major emphasis also will be placed on continued communication of study findings with other agencies, identified stakeholder groups, and involved groups and individuals.

Continued efforts will be placed on addressing issues related to the California Public Resources Code (Code) 5093.542(c). The Code limits participation of the State of California in actions that could have an adverse effect on the free-flowing condition of the McCloud River, or on its wild trout fishery. An important factor in future study efforts will be resolution of concerns related to the McCloud River.

The draft Feasibility Report, which will incorporate by reference the Environmental Impact Statement, will be available in early 2008. It is estimated that the final Feasibility Report would be completed in the fall of 2008. If Congressional authorization occurs in 2009, detailed project designs could conceivably be initiated in 2009, and any necessary real estate acquisitions and project construction could be initiated as early as 2010. The initial phase of construction would include acquiring any necessary real estate interests, continuing detailed design work, acquiring necessary permits, and performing minor relocations. The construction period would likely range from 4 to 5 years, depending on the plan selected.

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ABBREVIATIONS AND ACRONYMS

A - B	ACHP	Advisory Council on Historic Preservation
	ACID	Anderson Cottonwood Irrigation District
	AF	acre-feet
	AFPA	acre-feet per acre
	AFRP	Anadromous Fish Restoration Program
	AFS	anadromous fish survival
	APE	Area of Potential Effects
	ASIP	Action-Specific Implementation Plan
	Bay-Delta	San Francisco Bay/Sacramento-San Joaquin River Delta
	BLM	United States Department of the Interior, Bureau of Land Management
	BO	Biological Opinion
C	CALFED	CALFED Bay-Delta Program
	CBDA	California Bay-Delta Authority
	CDFG	California Department of Fish and Game
	CEQA	California Environmental Quality Act
	cfs	cubic feet per second
	CNDDB	California National Diversity Database
	CNPS	California Native Plant Society
	CO	combined objectives
	Corps	United States Army Corps of Engineers
	CP	comprehensive plan
	CVP	Central Valley Project
	CVPIA	Central Valley Project Improvement Act
	CVPM	Central Valley Production Model
	CVRWQCB	Central Valley Regional Water Quality Control Board
	CWA	Clean Water Act
D - E	Delta	Sacramento-San Joaquin River Delta
	DMC/CA	Delta-Mendota Canal/California Aqueduct
	DWR	California Department of Water Resources
	EIR	Environmental Impact Report
	EIS	Environmental Impact Statement

	EPA	United States Environmental Protection Agency
	ESA	Endangered Species Act
	ESU	evolutionary significant unit
	EWA	Environmental Water Account
F - G	ºF	degrees Fahrenheit
	GIS	geographic information system
	GPCPD	gallons per capita per day
	GWh	gigawatt-hour
H - M	I-5	Interstate 5
	IAIR	Initial Alternatives Information Report
	IDC	interest during construction
	JPOD	joint point of diversion
	kW	kilowatt
	M&I	municipal and industrial
	MAD	mosquito abatement district
	MAF	million acre-feet
	msl	mean sea level
	MSMR	Mission Statement Milestone Report
	MW	megawatt
N	NED	National Economic Development
	NEPA	National Environmental Policy Act
	NMFS	National Marine Fisheries Service
	NO	nitrogen oxide
	NOI	Notice of Intent
	NOP	Notice of Preparation
	NODOS	North-of-the-Delta Offstream Storage
	NRA	National Recreation Area
O - Q	O&M	operations and maintenance
	OCAP	Operations Criteria and Plan
	P&G	Federal Water Resources Council Principles and Guidelines for Water and Related Land Resources Implementation Studies
	PCT	Project Coordination Team
	PEIS	Programmatic Environmental Impact Statement
	PFR	Plan Formulation Report

	PG&E	Pacific Gas and Electric
	PL	Public Law
	Plan	Strategic Agency and Public Involvement Plan for the SLWRI
	PM	particulate matter
	PMF	Probable Maximum Flood
	PPA	Preferred Program Alternative
R	RBDD	Red Bluff Diversion Dam
	RCD	Resource Conservation District
	Reclamation	United States Department of the Interior, Bureau of Reclamation
	RM	river mile
	ROD	Record of Decision
	ROG	reactive organic gases
	RWQCB	Regional Water Quality Control Board
S	SCAQMD	Shasta County Air Quality Management District
	SCRB	Separable Costs – Remaining Benefits
	SDIP	South Delta Improvements Program
	SHPO	State Historic Preservation Office
	SLWRI	Shasta Lake Water Resources Investigation
	SMT	Study Management Team
	sq-mi	square mile
	SRA	shaded riverine aquatic
	STNF	Shasta-Trinity National Forest
	STNFLRMP	Shasta-Trinity National Forest Land Resource Management Plan
	SVAB	Sacramento Valley Air Basin
	SVWMP	Sacramento Valley Water Management Program
	SWP	State Water Project
	SWRCB	State Water Resources Control Board
T - W	TAC	toxic air contaminant
	TAF	thousand acre-feet
	The Reclamation Board	Reclamation Board of the State of California
	TCD	temperature control device
	TNC	The Nature Conservancy
	TWG	Technical Work Groups

UPRR	Union Pacific Railroad
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WSR	water supply reliability
WUE	water use efficiency

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CHAPTER 1
INTRODUCTION

In 2000, the United States Department of the Interior, Bureau of Reclamation, Mid-Pacific Region (Reclamation), reinitiated a feasibility-scope investigation on the potential for 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.

PURPOSE AND SCOPE

This Plan Formulation Report (PFR) is an interim product of the Shasta Lake Water Resources Investigation (SLWRI), which is being conducted to determine the feasibility of expanding the capacity of Shasta Reservoir to improve water supply reliability, anadromous fish survival, and related resource needs. The primary purpose of this PFR is to describe formulation of comprehensive alternatives to address planning objectives established for the SLWRI. From these alternatives, a tentatively preferred plan will be identified for further development and display in a feasibility report.

The scope of this PFR includes the following topics:

- Description of water resources and related problems and needs in the primary study area warranting Federal consideration; planning objectives to address these problems and needs; and planning constraints, principles, and criteria used to help guide the feasibility study.
- Description of individual water resources management measures, and from these measures, formulation and evaluation of a set of initial and subsequent comprehensive alternatives to address the planning objectives.
- Description of existing and likely future water resources and related conditions and potentially affected environment in the study area.
- Identification of public involvement considerations; compliance with applicable laws, policies, and plans; and likely future actions for the feasibility study.

Additional studies and documentation will follow this PFR during the ongoing SLWRI feasibility study, with opportunities for public review and participation.

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 and 2004 PL 108-361. PL 96-375 authorized the Secretary of the Interior to:

> "…engage in feasibility studies relating to enlarging Shasta Dam and Reservoir, Central Valley Project, California or to the construction of a larger dam on the Sacramento River, California, to replace the present structure."

The authorization also directed the Secretary of the Interior to:

> "…engage in feasibility studies for the purpose of determining the potential costs, benefits, environmental impacts, and feasibility of using the Sacramento River for conveying water from the enlarged Shasta Dam and Reservoir or the larger dam to points of use downstream from the dam."

Under the water storage subsection of Section 103 of Title 1 – California Water Security and Environmental Enhancement in PL 108-361, Congress authorized:

> "...planning and feasibility studies for projects to be pursued with project-specific study for enlargement of (1) the Shasta Dam in Shasta County…"

Other Federal legislation will influence the SLWRI. Two laws of special note include the 1965 PL 89-336 and 1992 PL 102-575. PL 89-336 created the Shasta-Trinity National Recreation Area (NRA) and directed that the area be administered by the United States Forest Service (USFS). PL 102-575, the Central Valley Project Improvement Act (CVPIA), directed numerous changes to the operation of the Central Valley Project (CVP), including adding fish and wildlife protection, restoration, and enhancement as a project purpose, resulting in significant changes to water supply deliveries, river flows, and related environmental conditions in the primary and extended study areas.

STUDY AREA

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 resource 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 1-1**) about 9 miles northwest of the City of Redding (see **Plate 1**); the entire reservoir is within Shasta County. At gross pool, Shasta Reservoir stores 4.55 million acre-feet (MAF), covers an area of about 29,500 acres, and has a shoreline of about 400 miles. 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.

FIGURE 1-1
SHASTA DAM AND RESERVOIR, LOCATED NORTH OF REDDING ON THE SACRAMENTO RIVER

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 travel 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 MAF. This represents about 62 percent of the total 27.8 MAF inflow to the Delta.

FIGURE 1-2
SHASTA DAM UNDER CONSTRUCTION, LOOKING FROM EAST TO WEST

Shasta Dam was constructed from September 1938 to June 1945 (**Figure 1-2**). Storage of water in Shasta Reservoir 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 (Interstate 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.

FIGURE 1-3
TODAY, SHASTA DAM (SHOWN HERE), AND FRIANT DAM ON THE UPPER SAN JOAQUIN RIVER, ARE TWO OF THE PRIMARY FEATURES OF THE CVP

Shasta Reservoir delivers about 55 percent of the total annual water supply developed by the CVP (**Figure 1-3**). The Shasta Dam and Reservoir project was constructed as an integral element of the CVP. Shasta Dam is operated in conjunction with other CVP facilities to provide for the control of flood water, storage of surplus winter runoff for irrigation in the Sacramento and San Joaquin Valleys, municipal and industrial (M&I) use, maintenance of navigation flows, protection and conservation of fish in the Sacramento River and Delta, and generation of hydroelectric energy. The CVPIA added "fish and wildlife mitigation, protection, and restoration" as a second tier priority equal to water supply, and added "fish and wildlife enhancement" as a third tier priority equal to hydropower generation. Shasta Lake also supports extensive 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.

REPORT ORGANIZATION

This PFR is organized into the following chapters and appendices:

- **Chapter 1 – Introduction:** This chapter describes the purpose and scope of the PFR, gives the study authorization, describes the study area and report organization, and presents highlights of pertinent studies, projects, and programs that may influence the SLWRI.
- **Chapter 2 – Without-Project Conditions:** This chapter describes existing and projected future without-project water resources and related conditions in the primary and extended study areas.
- **Chapter 3 – Plan Formulation Process:** This chapter highlights fundamental water resources and related problems and needs being addressed in the SLWRI, and gives highlights of the plan formulation process, including planning objectives, constraints, principles, and criteria, as well as the Mission Statement for the SLWRI.
- **Chapter 4 – Initial Alternatives:** This chapter discusses resources management measures identified to address the study objectives and a set of initial alternatives.
- **Chapter 5 – Comprehensive Plans:** This chapter describes five comprehensive plans (CP).
- **Chapter 6 – Evaluation and Comparison of Comprehensive Plans:** This chapter includes a comparison of the comprehensive plans, a summary description of CP4, and a preliminary cost allocation.

- **Chapter 7 – Implementation Considerations, Study Management and Outreach:** This chapter includes topics related to implementing a potential project including major uncertainties, special considerations, and regulatory and related requirements. It also includes information on public stakeholder and agency involvement in the SLWRI.
- **Chapter 8 – Findings and Future Actions:** This chapter summarizes findings of the PFR and describes next steps in the investigation, including a feasibility report, discusses factors in the investigation process, and presents a schedule.
- **Chapter 9 – References:** This chapter contains sources used in preparing the PFR.
- **Appendix A – Plan Formulation:** This appendix describes the plan formulation process for the PFR.
- **Appendix B – Engineering Summary:** This appendix includes details of engineering work related to the PFR.
- **Appendix C – Economic Analysis:** This appendix presents economic analysis related to the PFR.
- **Appendix D – Technical Support:** This appendix contains attachments on the topics of hydrology and hydraulics, hydropower, CALSIM systems operations, anadromous fisheries (Salmod), and institutional considerations.
- **Appendix E – Recreation:** This appendix discusses recreation resources and opportunities in the context of the SLWRI.
- **Appendix F – Environmental Resources:** This appendix contains additional information on environmental resources.

PRIOR STUDIES, PROJECTS, AND PROGRAMS

Following is a summary of pertinent 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 Corps, are doing work pertinent to the SLWRI. The major facilities associated with these activities are shown in **Plate 3**.

Federal

Department of the Interior, Bureau of Reclamation

The owner and operator of various components of the CVP in the study area, including Shasta Dam and Reservoir, Reclamation has many ongoing projects or continuing programs relevant to the SLWRI.

- **Central Valley Project –** The CVP, the largest surface water storage and delivery system in California, supplies water to more than 250 long-term water contractors in the Central Valley, Santa Clara Valley, and San Francisco Bay Area. Shasta Reservoir delivers about

55 percent of the total annual water supply developed by the CVP. Annually, the CVP has the potential to supply about 6.2 MAF for agricultural uses, 0.5 MAF for urban uses, and 0.3 MAF for wildlife refuges. The CVP also provides flood damage reduction, navigation, power, recreation, and water quality benefits.

- **Prior Studies of Enlarging Shasta Dam –** Several studies have been conducted to assess the feasibility of increasing storage space at Shasta Reservoir. Evaluations of raising Shasta Dam considered structural modifications, environmental and related impacts, water supply and hydropower benefits, costs, and Federal interest. Based on studies done to date (Reclamation 1999; 2004a), it has been recommended that additional studies be conducted that focus on limited dam raise/reservoir enlargement options.
- **Central Valley Project Improvement Act –** The CVPIA addresses conflicts over water rates, irrigation land limitations, and environmental impacts of the CVP. A major goal of the CVPIA is to ensure equal priority and consideration for protection, restoration, and enhancement of fish, wildlife, and associated habitats of the Bay-Delta Estuary when evaluating the purpose of the CVP. 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 CVPIA dedicates 1.2 MAF of water annually to the environment, which, through operation flexibility, amounts to a reduction of 585 thousand acre-feet (TAF) previously available to CVP contractors.
- **Operations Criteria and Plan –** In March 2004, Reclamation and the California Department of Water Resources (DWR) prepared a Long-Term CVP and State Water Project (SWP) Operations Criteria and Plan (OCAP) to address how the CVP and SWP would be operated in the future, as several proposed projects come online and as water demands increase. The 2004 document is a revision of the previous 1992 OCAP release, incorporating numerous additional constraints and criteria that have arisen since 1992 (Reclamation and DWR, 2004). Other OCAP refinements and updates are expected within the next two years.
- **Red Bluff Diversion Dam Fish Passage Improvement Program –** The RBDD, located on the Sacramento River, provides CVP irrigation via the Tehama-Colusa and Corning canals. Ineffective fish passage at the dam led to development of the Red Bluff Diversion Dam Fish Passage Improvement Project, anticipated to relieve conflicts between fish passage and agricultural diversion needs.
- **Trinity River Restoration Plan –** The 2.5 MAF Trinity Reservoir conveys water from the Trinity River to the Sacramento River basin for export to the Central Valley. The Trinity Record of Decision (ROD), which proposes rehabilitation of the Trinity River through restoration, is intended to restore and maintain the river’s fishery resources impacted by Trinity Dam and Reservoir.
- **Battle Creek and Salmon Steelhead Restoration Project –** The Battle Creek Salmon and Steelhead Restoration Project focuses on restoring the winter-run, spring-run, fall- and late-fall-run Chinook salmon and steelhead populations in Battle Creek, one of the most important anadromous fish spawning streams in the Sacramento Valley. Actions will include removing dams, constructing fish screens and ladders, and augmenting flows to increase salmonid habitat.

- **Sacramento River Diversion Feasibility Study (Sacramento River Water Supply Reliability Study) –** The Sacramento River Diversion Feasibility Study intends to pursue 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.

Department of the Interior - Bureau of Land Management

The 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, and is involved in numerous restoration and conservation projects in the study area. BLM designation of lands as National Conservation Areas would prevent construction of dams or other instream infrastructure, and ensure continued public access to the lands.

Department of the Interior – Fish and Wildlife Service

The United States Fish and Wildlife Service (USFWS) has participated in numerous projects and programs within the study area because the upper Sacramento River is recognized as critical habitat for endangered winter-run Chinook salmon and other threatened or endangered species. The Anadromous Fish Restoration Program (AFRP) was developed to accomplish the CVPIA goal of doubling natural production of anadromous fish in California's Central Valley streams on a long-term, sustainable basis through improvement of natural ecosystem functions (i.e. increased stream flows, eliminating entrainment at diversions) (USFWS 1995).

Department of Commerce – National Marine Fisheries Service

The National Marine Fisheries Service (NMFS) is required under the Federal Endangered Species Act (ESA) to assess factors affecting listed salmonid species in the Central Valley, 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. One program to attain these goals, the Proposed Recovery Plan for Sacramento River Winter-Run Salmon, presents restoration goals and actions, including improved water quality and flows, some of which would be applied within the SLWRI study area.

Department of Agriculture – Forest Service

As mentioned, USFS administers the Shasta-Trinity NRA, which includes nearly all lands along the Shasta Lake shoreline. USFS is also 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.

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, significantly reducing acid and metal contamination in surface water.

Department of Defense – Army Corps of Engineers

The Corps prescribed the operating space and developed the operating rules at Shasta Dam and Reservoir for flood damage reduction. In addition to Shasta Dam and Reservoir regulation rules, the Corps has conducted various studies and implemented many projects and programs that affect the upper Sacramento River and its tributaries. Several of the most recent efforts have included the March 1999 Post-Flood Assessment and the Sacramento and San Joaquin River Basins Comprehensive Study.

State

Following are State projects and plans relevant to the SLWRI.

California Department of Water Resources

- **State Water Project –** The SWP delivers water to the Feather River Settlement Contractors and SWP Contract Entitlements in the Feather River basin, San Francisco Bay area, San Joaquin Valley, Tulare basin, and Southern California service areas. The SWP has contracted a total of 4.23 MAF for average annual delivery, about 2.5 MAF 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.
- **California Water Plan –** The California Water Plan, through the Bulletin 160 series, helps define California's agricultural, environmental, and urban water needs and identifies potential solutions to these needs. The most recent plan, distributed in December 2005, evaluates water supplies to quantify the gap between future water demands and supplies.

California Department of Fish and Game

The California Department of Fish and Game (CDFG) manages California's fish and wildlife resources, overseeing the restoration and recovery of California ESA threatened and endangered species. CDFG participates in conservation planning, environmental compliance and permitting, coordinated resource management planning, and restoration and recovery programs within the study area.

Federal-State

Sacramento Valley Water Management Program

The Sacramento Valley Water Management Program **(**SVWMP) is a collaborative effort to increase water supplies for farms, cities, and the environment by responding to water rights issues associated with implementation of the 1995 Delta Water Quality Control Plan.

Since 1996, the State Water Resources control Board (SWRCB) has engaged in proceedings to determine responsibility for meeting water quality standards in the Delta. The SWRCB has completed Phases 1 through 7 of these proceedings, leading to the issuance of D-1641, and continues to focus on Phase 8 involving water right holders on the Sacramento River and its tributaries. Through the SVWMP efforts, a Short-Term Settlement Agreement[1] was executed in December 2002 by more than 40 water suppliers in the Sacramento Valley (Upstream Water Users), Reclamation, DWR, USFWS, CDFG, Contra-Costa Water District, and SWP contractors representing agricultural and municipal water users in Southern California, the central coast, and the San Joaquin Valley. Execution of this agreement resulted in the SWRCB automatically dismissing the Phase 8 process on January 31, 2003.

This Short-Term Settlement Agreement includes stipulations regarding implementing a series of short-term projects (up to 10 years after implementation) to meet unmet demands in the Sacramento Valley, and to provide at least 92,500 AF and up to 185,000 AF of water to augment CVP and SWP water supplies during certain year types. These projects would be owned and operated by the Upstream Water Users.

Reclamation and DWR issued a Notice of Intent (NOI) and Notice of Preparation (NOP), respectively, in August 2003 to prepare a Programmatic Environmental Impact Statement and Report (EIS/EIR) to analyze the potential effects of implementing five categories of short-term projects: water management, reservoir reoperation, system improvements, surface and groundwater planning, and other nonstructural actions such as water transfers.

CALFED Bay-Delta Program

The CALFED Bay-Delta Program (CALFED) is a coordinated Federal and State that was established after the Bay-Delta Accord to address water quality, ecosystem quality, water supply reliability, and levee system integrity. Major CALFED programs include the Conveyance, Water Transfer, Environmental Water Account, Water Use Efficiency, Water Quality, Levee System Integrity, Ecosystem Restoration and Watershed Management, and Storage programs. Included in the CALFED storage program Preferred Program Alternative is the proposed 6.5-foot raise of Shasta Dam, expanding the reservoir by approximately 256,000 acre-feet. Potential benefits of the project include an increased pool of cold water available in Shasta Reservoir to maintain lower Sacramento River temperatures needed by certain fish, and other water management benefits, such as water supply reliability.

Following the issuance of a CALFED Bay-Delta Final Programmatic EIS/EIR in July 2000 (CALFED Bay-Delta Program, 2000a), the CALFED agencies issued a programmatic ROD in August 2000 that identified 12 action plans, including plans for Governance, Ecosystem Restoration, Watersheds, Water Supply Reliability, Storage, Conveyance, Environmental Water Account (EWA), Water Use Efficiency, Water Quality, Water Transfer, Levees, and Science Programs (CALFED Bay-Delta Program, 2000b). The CALFED agencies then began implementing Stage 1 of the ROD, including the first 7 years of a 30-year program for establishing a foundation for long-term actions.

[1] The complete title of the Short-Term Settlement Agreement is “Short-Term Agreement to Guide Implementation of Short-Term Water Management Actions to Meet Local Water Supply Needs and to Make Water Available to the SWP and CVP to Assist in Meeting the requirements of the 1995 Water Quality Control Plan and to resolve Phase 8 Issues.”

Common Assumptions for CALFED Surface Water Storage Projects

Efforts are underway by Reclamation and DWR to identify a series of Common Assumptions for use in developing the without-project conditions for each of the CALFED storage projects. Using the CALSIM II modeling tool, conditions are being established for period of analysis, evaluation levels, water supply demands, water supply system facilities, regulatory standards, including minimum flow and temperature requirements, system operation criteria, and likely foreseeable actions.

Other Programs and Private Organizations

Other programs and private organizations related to the SLWRI include the following:

- Battle Creek Watershed Conservancy
- California Trout
- Cantara Trustee Council
- Clear Creek Coordinated Resource Management Plan
- Cottonwood Creek Watershed Group
- Cow Creek Watershed Management Group
- McCloud River Coordinated Resource Management Plan
- Pit River Watershed Alliance
- Sacramento River Preservation Trust
- Sacramento River Watershed Program
- Sacramento Watersheds Action Group
- Shasta Land Trust
- Sulphur Creek Coordinated Resource Management Plan
- The Nature Conservancy (McCloud River Preserve and Lassen Foothills Projects)
- The Trust for Public Land

Local

Sacramento River Conservation Area Program

The Sacramento River Conservation Area Program is responsible for preserving remaining riparian habitat, 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 Upper Sacramento River Fisheries and Riparian Habitat Management Plan identifies specific actions to help restore the Sacramento River fishery and riparian habitat between the Feather River and Keswick Dam, including actions specific to the study area.

Iron Mountain Mine Restoration Plan

The Iron Mountain Mine Trustee Council developed a plan that identifies restoration actions to address injuries to, or lost use of, natural resources resulting from acid mine drainage from the

Iron Mountain Mine complex, including restoration of salmonid populations, riparian habitat, and in-stream ecological functions.

Riparian Habitat Joint Venture

The Riparian Habitat Joint Venture promotes conservation and restoration of riparian habitat to support native bird populations. Recommended conservation efforts in the SLWRI study area include conservation of lower Clear Creek as a prime breeding area for yellow warblers and song sparrows.

Resource Conservation Districts

Resource Conservation Districts (RCD) are locally governed agencies responsible for conserving resources within their districts by implementing projects on public and private lands and educating landowners and the public about resource conservation. Activities include resource management, watershed management, conservation, and restoration programs. In the Shasta Lake and upper Sacramento River vicinity, districts include the Western Shasta County RCD and 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.

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CHAPTER 2
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 in the affected environment, 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, this chapter describes existing and future without-project conditions for resources within the study area.

Chapter 2 begins with a description of the setting of the primary and extended study areas. This is followed by discussions of existing infrastructure and physical, biological, cultural, and socioeconomic conditions. This chapter concludes with a discussion of without-project future physical, biological, cultural, and socioeconomic conditions. Alternatives and potential environmental consequences are described in **Chapters 5** and **6** and **Appendix F – Environmental Resources**. References and data sources used to develop this chapter are included in **Appendix F – Environmental Resources**.

SETTING

This section describes the geographic location of the study area for the Shasta Lake Water Resources Investigation (SLWRI), which includes both primary and extended components.

Shasta Dam and Reservoir are located on the upper Sacramento River in Northern California. Shasta Dam is located about 9 miles northwest of the City of Redding, and the dam and entire reservoir are located within Shasta County. Because of the potential influence of the proposed modification of Shasta Dam, and subsequent water deliveries over a rather large geographic area, the SLWRI includes both a primary and extended study area, as described in **Chapter 1**.

The primary study area includes the following areas:

- Shasta Dam and Reservoir
- Lower reaches of the primary tributaries draining into Shasta Reservoir (Sacramento, McCloud, and Pit rivers)
- Sacramento River between Shasta Dam and Red Bluff Diversion Dam (RBDD)

The extended study area generally includes the following:

- Sacramento River downstream from the RBDD, including parts of the American River basin
- Sacramento-San Joaquin River Delta (Delta), including parts of the San Joaquin River basin
- Water service areas Central Valley Project (CVP) and State Water Project (SWP) that may be affected by changes at Shasta Dam and Reservoir

Plate 1 shows the geographic extent of the primary study area. This chapter will focus on the primary study area but will also provide information about potentially affected resources in the extended study area.

EXISTING CONDITIONS

This section describes existing conditions in the study area, beginning with a description of existing reservoir area infrastructure and followed by summaries of physical, biological, cultural, socioeconomic, and cultural conditions. While the discussion focuses on the primary study area, information is also included on existing conditions in the extended study area.

Existing Reservoir Area Infrastructure

Existing infrastructure in the primary study area includes Shasta Dam and Reservoir, associated water management facilities, numerous recreation amenities, and various other public and private infrastructure, as described below.

Shasta Dam, Reservoir, and Associated 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 4.55 million acre-feet (MAF) and 29,500 acres, respectively. Seasonal flood control storage space in Shasta is about 1.3 MAF. The Shasta Powerplant consists of five main generating units and two station service units with a combined capacity of 663,000 kilowatts (kW). **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.

The existing temperature control device (TCD) at Shasta Dam 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 2-1**. 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 United States Department of the Interior, Bureau of Reclamation (Reclamation) fulfill contractual obligations for both water delivery and power generation while benefiting fish, such as salmon, that require cooler water temperatures.

Shasta Dam is operated in conjunction with Keswick Dam and Reservoir, located about 9 miles downstream from Shasta Dam. In addition to regulating outflow from Shasta Dam, Keswick 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 a discharge capacity of 248,000 cubic feet per second (cfs) at gross pool elevation (587 feet). Storage capacity of Keswick Reservoir 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 kW and can pass about 15,000 cfs at gross pool.

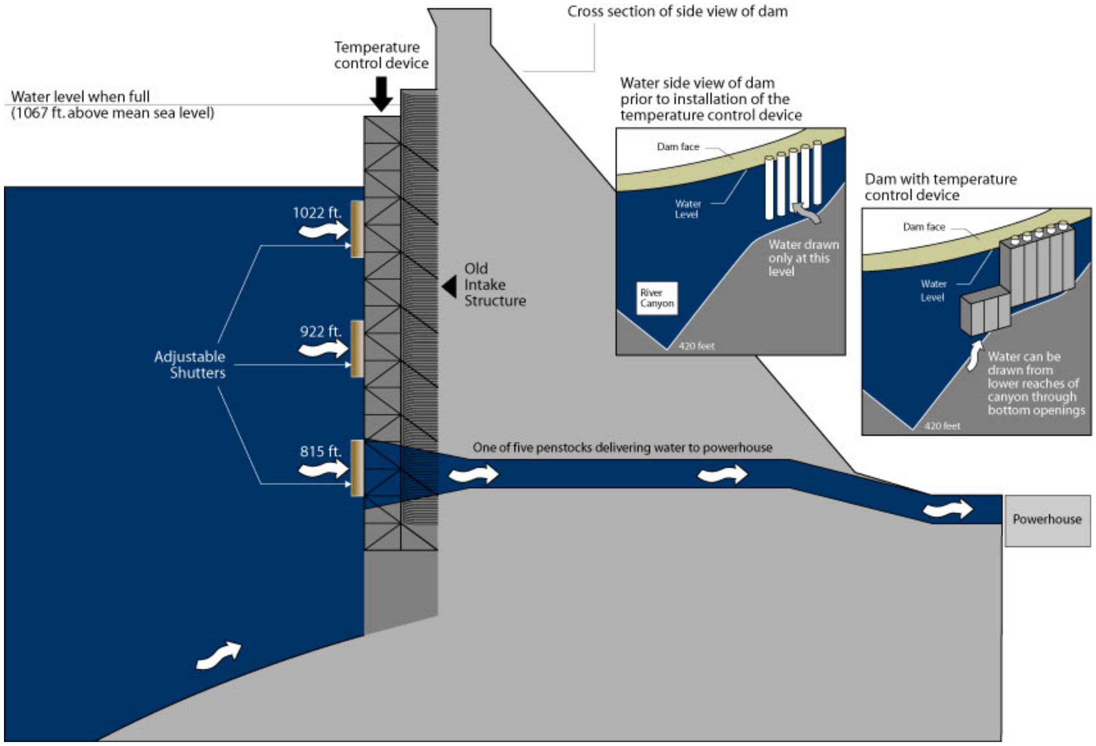


FIGURE 2-1
SHASTA DAM TEMPERATURE CONTROL DEVICE

Table 2-1 summarizes the pertinent data and features of Shasta Dam and Reservoir and Keswick Dam and Reservoir. Shasta Dam operations are summarized later in this chapter in the section on Physical Environment.

Recreation Facilities and Other Reservoir Area Infrastructure

The Whiskeytown-Shasta-Trinity National Recreation Area (NRA) 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 Lake Unit and the Clair Engle-Lewiston Lakes Unit are within the Shasta Trinity National Forest, and are administered by United States Forest Service (USFS). The Whiskeytown Lake Unit is administered by the National Park Service. Facilities at Shasta Lake include USFS operated campgrounds, boat-launching ramps, and beach and picnic areas as well as private resorts and marinas operating under permit. Recreational facilities are described in greater detail in **Appendix E – Recreation**. A map showing locations of the major recreation facilities in the Shasta Lake Unit of the Whiskeytown-Shasta Trinity NRA is shown in **Plate 7**.

Various recreation facilities and other infrastructure are located around the reservoir rim. Infrastructure between the existing gross pool and elevation 1,100 (i.e., within 30 feet of the existing gross pool) is summarized in **Table 2-2**. **Plate 8** shows a plan and profile view of the Pit River Bridge, the most significant structure within 30 feet of gross pool.

TABLE 2-1
PERTINENT DATA – SHASTA AND KESWICK DAMS

GENERAL			
Drainage Areas (excluding Goose Lake Basin)		**Mean Annual Runoff (1908-2006)**	
Sacramento R. at Shasta Dam	6,421 sq-mi	Sacramento R. at Shasta Dam	5,737,000 acre-feet
Sacramento R. at Keswick	6,468 sq-mi	Sacramento R. near Red Bluff	8,421,000 acre-feet
Sacramento R. near Red Bluff	8,900 sq-mi	**Sacramento River Maximum Flows**	
Sacramento R. near Ord Ferry	12,250 sq-mi	At Shasta Lake (16 Jan 1974)	216,000 cfs
Pit R. at Big Bend	4,710 sq-mi	Near Red Bluff (28 Feb 1940)	291,000 cfs
McCloud R. above Shasta Lake	604 sq-mi	At Ord Ferry (28 Feb 1940)	370,000 cfs
Sacramento R. at Delta above Shasta Lake	425 sq-mi		
SHASTA DAM AND RESERVOIR			
Shasta Dam (concrete gravity)		**Shasta Reservoir**	
Crest elevation	1,077.5 feet	Gross pool elevation (msl)	1,067.0 feet
Freeboard above gross pool	10.5 feet	Minimum operating level	840.0 feet
Height above foundations	602 feet	Taking line	Irregular
Height above streambed	487 feet	Surface Area	
Length of crest	3,500 feet	Minimum operating level	6,700 acres
Width of crest	30 feet	Gross pool	29,500 acres
Slope, upstream	Vertical	Taking line	90,000 acres
Slope, downstream	1 on 0.8	Storage capacity	
Structure Volume (cubic yards)	8,430,000	Minimum operating level	587,000 acre-feet
Normal tailwater elevation	585 feet	Gross pool	4,552,000 acre-feet
Spillway (gated ogee)		**Shasta Powerplant**	
Crest Length		Main Units	
Gross	360 feet	5 turbines, Francis type	515,000 hp (total)
Net	330 feet	5 units, 3 @ 125 MW , 2 @ 142 MW	659 MW (total)
Crest Gates (drum type)		Station Units	
Number and size	3@110 feet x 28 feet	2 generators, 2,000 kW each	4,000 kw (total)
Top elevation when lowered	1037.0 feet	Elevation centerline turbines	586 feet
Top elevation when raised	1065.0 feet	Maximum tailwater elevation	632.5 feet
Discharge capacity at pool (1,065 feet)	186,000 cfs	Total discharge at pool (1,065 feet)	14,500 cfs
Flashboard Gates	3@110 feet x 2 feet	Total discharge at pool (827.7 feet)	16,000 cfs
Top elevation when lowered	1067.0 feet	Power outlets (15-foot steel penstocks)	
Bottom elevation when raised	1069.5 feet	5 with invert elevation of intake	807.5 feet
Outlets 102-inch diameter conduit with 96-inch diameter wheel-type gate			
4 with invert elevation	737.75 feet	Capacity at elevation 1,065	81,800 cfs
8 with invert elevation	837.75 feet	Capacity at elevation 827.7	12,200 cfs
6 with invert elevation	937.75 feet		
KESWICK DAM AND RESERVOIR			
Keswick Dam (concrete gravity)		**Keswick Reservoir**	
Crest elevation	595.5 feet	Elevation - maximum operating level	587.0 feet
Freeboard above maximum operating level	8.5 feet	Elevation - minimum operating level	574.0 feet
Height of dam above foundation	159 feet	Surface area at max operating level	643 acres
Height of dam above streambed	119 feet	Storage capacity	
Length of crest	1,046 feet	At maximum operating level	23,800 acre-feet
Width of crest	20 feet	At minimum operating level	16,300 acre-feet
Volume	197,000 cu-yd	**Keswick Powerplant**	
Normal tailwater elevation	487 feet	3 generator units	75,000 kW (total)
Spillway (gated ogee) crest gates - fixed wheel (4 gates, 50 feet x 50 feet each)			
Crest length	200 feet	Discharge capacity at pool, elevation 587	248,000 cfs

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

TABLE 2-2
SUMMARY OF RESERVOIR AREA INFRASTRUCTURE 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: Reclamation, 2003a

Physical Environment

Elements of the existing physical environment described in this section include topography; geology and soils; geomorphology; sedimentation and erosion; climate and air quality; hydrology; water quality; noise and vibration; hazardous materials and waste; and agricultural and important farmlands.

Topography

Shasta Dam and Reservoir are located on the northern edge of the Central Valley. The topography of the area surrounding Shasta Lake is generally steep and mountainous. Ground surface elevations in the vicinity of Shasta Lake range from above 14,000 feet at Mount Shasta to approximately 1,070 feet at Shasta Lake. Other topographic features in the primary study area include major tributary drainages above Shasta Dam - the Sacramento, McCloud, and Pit rivers - and several smaller drainages. Downstream from Shasta Dam, tributaries to the Sacramento River include Clear, Cow, Bear, Battle, Cottonwood, and Paynes creeks.

Much of the extended study area is contained within California's Central Valley, which is almost completely enclosed by mountains and has only one outlet, through San Francisco Bay to the Pacific Ocean. Topography in the extended study area is dominated by the flat expanses of the Sacramento River basin, Delta, and San Joaquin River basin. Topography of the Delta includes a network of over 700 miles of interconnecting waterways forming more than 600 islands and tracts, with land surfaces ranging from 20 feet above sea level to more than 20 feet below sea level.

Geology and Soils

The geology of the study area is highly complex, containing portions of five geomorphic provinces: the Coast Range, Klamath Mountain, 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.

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. Alluvial deposits overlay a large portion of this area, and soils are mainly derived from metamorphic rock and deep alluvium. Limestone caves provide habitat for several cave-dwelling species in the area.

The segment of the study area along the Sacramento River downstream to the RBDD encompasses portions of the Klamath Mountain, Cascade Range, and Great Valley geomorphic provinces. The Cascade Range to the east comprises primarily volcanic formations and volcanic sedimentary deposits. The Great Valley province (also referred to as the Central Valley) is a large structural trough formed between the uplands of the California Coast Ranges to the west and the Sierra Nevada to the east. This trough is filled with a sequence of sediments ranging in age from Jurassic to Recent.

Principal formations downstream along the Sacramento River to Red Bluff 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. The deep alluvial and aeolian soils of the Central Valley floor make up some of the best agricultural land in the State. Delta soils comprise primarily intertidal deposits of soft mud and peat, with organic peat soils up to 60 feet deep in some areas.

Geomorphology

Much of the area around Shasta Lake and adjacent to the lower reaches of its tributaries is characterized by active and historic mass wasting processes. The steep hillsides and coarse soils are subject to mud flows, debris flows, slides, and other forms of mass erosion. Wildfires, which have become increasingly intense and destructive in the last 100 years, have greatly modified stream morphology and generally degraded aquatic habitat along several Shasta Lake tributaries.

The Sacramento River between Shasta Lake and Red Bluff is characterized by steep, vertical banks and the river is primarily confined to its channel with limited overbank floodplain areas, resulting in limited channel migration and meander. 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 and confine movement of much of the lower Sacramento River. Natural geomorphic processes in the Delta and Sacramento River have been highly modified by changes to upstream hydrology (reservoirs and stream flow regulation) and construction of levees, channels, and other physical features.

Sedimentation and Erosion

Sedimentation and erosion are natural processes of the mountainous streams tributary to Shasta Lake. The watershed above Shasta Lake is generally well forested and erosion is not excessive. However, many of the tributaries of Shasta Lake have been significantly altered by a number of factors, including logging and hydraulic mining; construction of dams, roads, reservoirs, and channel modifications; wildfires; and agricultural and urban activities, which cause sediment influxes and accelerated erosion. These changes in stream morphology often have negatively impacted aquatic habitat and adjacent wetlands.

Slides and sheet wash typically supply debris and sediments to the tributary streams of Shasta Lake during the rainy season. Because much of the terrain is steep, landslides are common and vary in intensity. Volcanic eruptions and mudflows have periodically affected channel morphology, often changing habitat conditions in area streams. Sediment and gravel discharge in tributaries changes from year to year depending on hydrology and conditions in the watersheds.

In addition to sediment carried into Shasta Lake via tributaries, shoreline erosion contributes to a portion of sediment deposition in the reservoir. Shoreline erosion is caused by seasonal changes in reservoir water levels and, to some extent, by recreational activities in and around the lake. The shoreline below gross pool elevation is generally steep and devoid of vegetation that might otherwise help stabilize soils.

Shasta and Keswick dams have a significant influence on sediment transport in the Sacramento River because they block sediment that would normally have been transported downstream. The result has been a net loss of coarse sediment, including salmon spawning gravels, in the Sacramento River below Keswick Dam. In the recent past, Reclamation, the California Department of Water Resources (DWR), and California Department of Fish and Game (CDFG) have cooperated to artificially replenish salmon spawning gravel downstream from Keswick Dam. In alluvial river sections, bank erosion and sediment deposition cause river channel migrations that are vital to maintaining instream and riparian habitats, but which 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 constrained by erosion-resistant formations and therefore is more stable.

Climate and Air Quality

This section discusses existing climate and air quality conditions in the study area.

Climate

The northern half of the Central Valley is located in the Sacramento Valley Air Basin (SVAB). The Mediterranean climate of the SVAB is characterized by hot, dry summers and cool, rainy winters. Average temperatures range from about 60 degrees Fahrenheit (°F) in low valley regions to about 40°F in mountain areas. Characteristic of SVAB winters are periods of dense and persistent low-level fog, which are prevalent between storms. Precipitation on the valley floor occurs mostly during winter as rain. Average annual precipitation throughout the Sacramento River basin is 36 inches. Total annual precipitation at higher elevations is as much as 95 inches in the northern Sierra Nevada and the Cascade Range. In the primary study area, measurements recorded at the Shasta Dam station show the normal annual precipitation is approximately 61 inches. The annual average temperature ranges from 52°F to 72°F.

Air Quality

Most of the air pollutants in the study area may be associated with either urban or agricultural land uses. In the SVAB, air pollutants can become concentrated during the summer due to inversion layers forming in the lower elevations, subsequently lowering air quality. Winter winds disperse pollutants, often resulting in clear weather and better air quality over most of the region. Much of the SVAB is designated as nonattainment with respect to the national and State ozone and particulate matter (PM) standards, and the urban Sacramento and Marysville/Yuba City areas are designated as nonattainment for national and State carbon monoxide standards.

For the SLWRI, the Area of Potential Effects (APE) for air quality is defined as the area immediately surrounding Shasta Dam and Reservoir where project construction would occur. The APE is located in Shasta County. Two types of pollutants are monitored in the APE: criteria air pollutants and toxic air contaminants (TAC).

- **Criteria Air Pollutants –** Concentrations of ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, respirable and fine PM, and lead, are used as indicators of ambient air quality conditions and are commonly referred to as “criteria air pollutants.” **Appendix F – Environmental Resources** summarizes the air quality data in Shasta County from the most recent 3 years and shows the most current attainment designations for Shasta County. Shasta County is designated “unclassified” for most monitored pollutants due to insufficient data, and is designated “attainment” for lead.

- **Toxic Air Contaminants –** A TAC (or “hazardous air pollutant,” in Federal terms) is defined as an air pollutant that may cause or contribute to an increase in mortality or serious illness, or that poses a hazard to human health. Levels of most TACs have decreased since 1990.

Hydrology

Hydrologic features of the study area include perennial, intermittent, and ephemeral stream channels, and natural water bodies and wet meadowlands. The hydrology and climate of the primary study area make it favorable to water resources development; consequently, streamflow hydrology on the upper Sacramento River and major tributaries to Shasta Lake has been significantly modified by the development of water control and hydroelectric facilities. Mean monthly inflow, outflow, and storage at Shasta Reservoir are shown in **Table 2-3**. 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.

Historical streamflow in the Sacramento River below Keswick Dam is shown in **Figure 2-2**. Since 1964, an annual average of 1.27 MAF of the Trinity River flow has been exported to the Sacramento River through CVP facilities, or 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 Record of Decision (ROD) to retain more flows in the Trinity River for fish restoration purposes.

TABLE 2-3
MEAN MONTHLY INFLOW, OUTFLOW, AND STORAGE AT SHASTA RESERVOIR

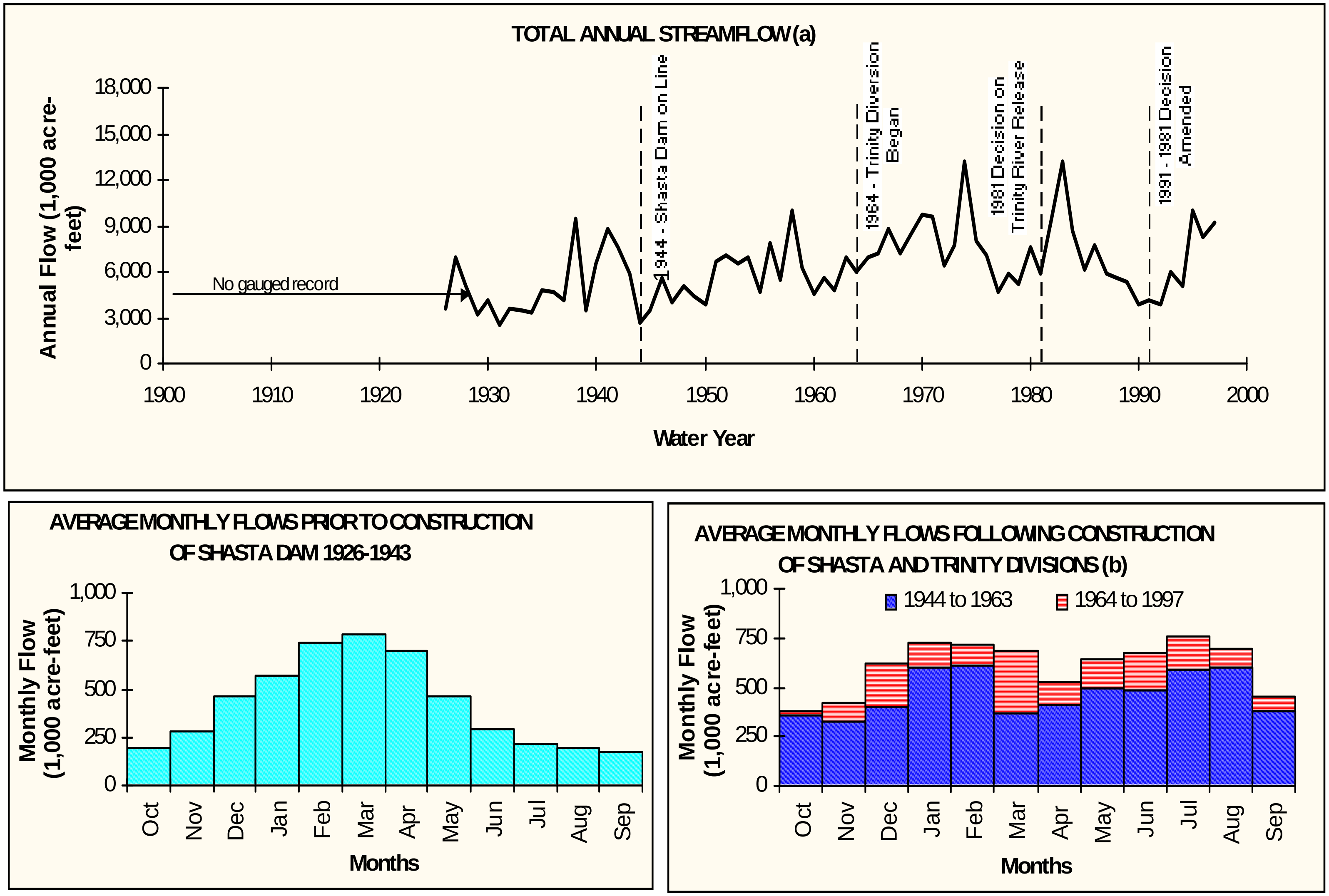
Month	Inflow[1] (1,000 acre-feet)	Outflow[2] (1,000 acre-feet)	Storage[3] (1,000 acre-feet)
January	799	587	3,143
February	836	628	3,366
March	889	511	3,732
April	693	421	3,981
May	537	524	3,965
June	339	536	3,730
July	247	615	3,326
August	223	571	2,967
September	220	377	2,808
October	263	301	2,770
November	365	331	2,793
December	585	465	2,911
Total	**5,991**	**5,868**	**-**
Average	**499**	**489**	**3,291**

Notes:
[1]Computed data based on a period from 1944 to 2002.
[2]Recorded data based on a period from 1944 to 2002.
[3]Computed data based on a period from 1956 to 2005.

For flood events rarer than about 1 chance in 100 in any 1 year, inflows to Shasta would exceed the ability of the reservoir to store the inflow volume and maintain the 79,000 cfs estimated safe channel carrying capacity. Under these circumstances, outflows would need to be increased to prevent uncontrolled conditions. Between Keswick and the RBDD, intermittent levees help prevent flooding of low-lying lands along Sacramento River.

Plates 9 and **10** show peak flow-frequency relationships at Keswick and Bend Bridge, respectively. A storage space of up to 1.3 MAF below gross pool elevation of 1,067 feet is kept available for flood control purposes in the reservoir in accordance with the Flood Control Diagram (see **Plate 11**), as prescribed by the United States Army Corps of Engineers (Corps). Under the diagram, flood control storage space increases from zero on October 1 to 1.3 MAF (elevation 1,018.55 feet) 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 management operation consists of determining the required flood storage space reservation and scheduling releases in accordance with flood operating criteria. This requires 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 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.



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 2-2
HISTORICAL STREAMFLOW IN THE SACRAMENTO RIVER BELOW KESWICK DAM

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.

Table 2-4 shows the historical annual inflow, storage, and outflow history for Shasta Reservoir from 1945 through 2006. Releases for flood control 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. Releases for flood control occur either over the spillway during large events or through river outlets for smaller events. As shown in **Table 2-4**, from about 1950 through 2006, flows over the spillway occurred in 12 years, or in 21 percent of post-1950 years. It is estimated that releases for flood control occurred in 49 years between 1950 and 2006, or nearly 90 percent of the years.

Shasta Lake collects flow in the upper Sacramento River watershed, but many uncontrolled tributaries enter the Sacramento River downstream from the dam. Stream gages located on various uncontrolled tributaries helps the operators of Shasta Dam adjust releases to accommodate downstream peak flows. However, the influence of Shasta's operation on reducing peak flood flows on the Sacramento River diminishes with distance downstream, largely due to these uncontrolled tributaries.

The estimated frequency (percent exceedence) of storage in Shasta Reservoir for the end of September, based on the SLWRI CALSIM II benchmark simulation, is shown in **Figure 2-3**. The 50%-exceedence storage under existing conditions prior to the beginning of flood control operations is about 2.7 MAF. The frequency distribution graph shows that in about 80 percent of the years, the end of September storage is greater than about 1.9 MAF, and 3.3 MAF in approximately 20 percent of the years.

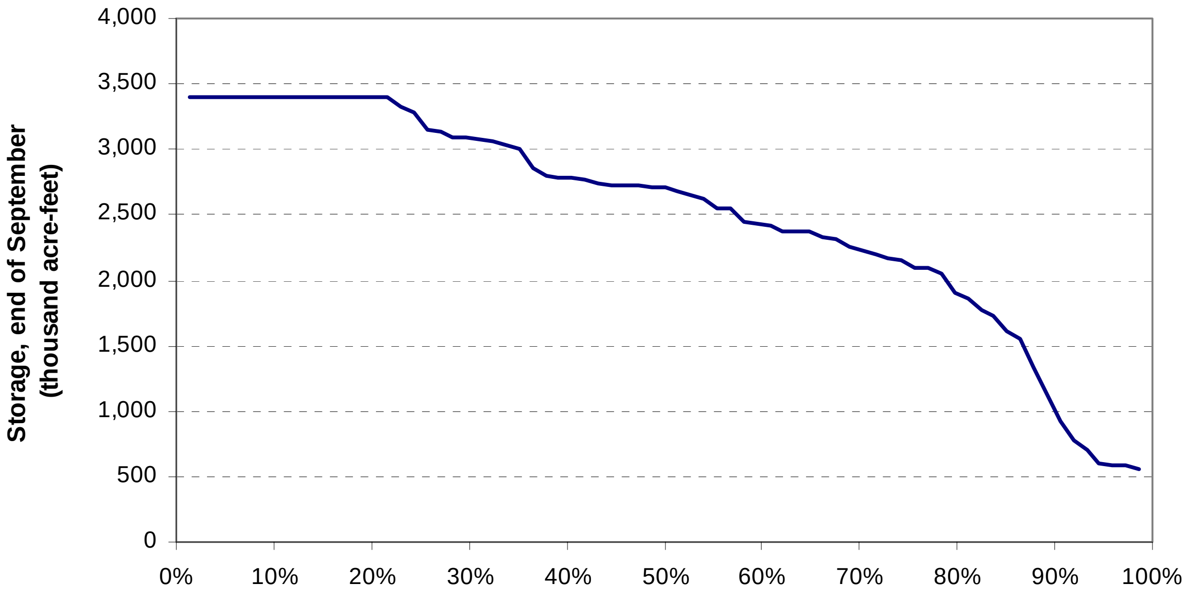
Downstream from the RBDD, flood management projects along the Sacramento River affect the flow and operation of facilities. Major reservoirs include Folsom Lake on the American River, Lake Oroville on the Feather River, and Black Butte Reservoir on Stony Creek. Levees associated with the Sacramento River Flood Control Project begin intermittently downstream from the RBDD and become continuous along both banks between Colusa and the Delta. Weirs located along the Sacramento River divert high flows to overflow basins and bypasses (Butte Basin, Sutter Bypass, and Yolo Bypass).

The flood management system of the San Joaquin River basin includes levees along the tributaries and leveed sections along the San Joaquin River. The Chowchilla Canal Bypass diverts San Joaquin River flow excess and sends it to the Eastside Bypass, which also intercepts flows from minor tributaries and before rejoining the San Joaquin River. The San Joaquin River levee and diversion system is not designed to contain the objective release from each project reservoir simultaneously.

TABLE 2-4
HISTORICAL 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	1976	3,611	1,295	5,813	5,813		
1946	5,906		5,599	3,898		1,700	1977	2,628	631	3,247	3,247		
1947	3,908		3,964	3,571		393	1978	7,837	3,428	4,944	4,538		407
1948	5,416		4,958	4,244		714	1979	4,022	3,141	4,203	4,203		
1949	4,318		4,303	4,303		0	1980	6,415	3,321	6,139	4,773		1,366
1950	4,133		3,784	3,781	1	2	1981	4,103	2,480	4,845	4,845		
1951	6,316		6,486	5,696		790	1982	9,013	3,486	7,910	6,464	253	1,193
1952	7,785		6,800	5,625	9	1,166	1983	10,794	3,617	10,576	7,123	1	3,452
1953	6,540	3,300	6,408	5,067		1,341	1984	6,667	3,240	6,944	6,514		429
1954	6,541	3,059	6,826	5,941		885	1985	3,971	1,978	5,154	5,152	2	
1955	4,112	2,455	4,612	4,612			1986	7,546	3,211	6,225	4,383		1,842
1956	8,834	3,569	7,606	4,926	12	2,668	1987	3,944	2,108	4,957	4,800		157
1957	5,368	3,485	5,341	4,841	17	483	1988	3,931	1,586	4,368	3,973		395
1958	9,698	3,473	9,610	6,672	13	2,924	1989	4,745	2,096	4,154	3,951		203
1959	5,086	2,504	5,952	5,631		321	1990	3,616	1,637	3,999	3,707		292
1960	4,733	2,756	4,380	4,380			1991	3,051	1,340	3,286	2,666		620
1961	5,071	2,333	5,402	5,402			1992	3,622	1,683	3,204	1,755		1,449
1962	5,262	2,908	4,582	4,582			1993	6,825	3,102	5,316	3,728		1,588
1963	7,003	3,242	6,575	6,077	13	485	1994	3,087	2,102	4,002	3,252		750
1964	3,905	2,202	4,849	4,849			1995	9,638	3,136	8,511	5,187		3,324
1965	6,983	3,612	5,475	4,581		894	1996	6,846	3,089	6,781	3,703		3,078
1966	5,299	3,263	5,544	5,544			1997	7,424	2,308	8,106	5,808		2,298
1967	7,404	3,506	7,066	6,131		935	1998	10,294	3,441	9,072	6,698	2	2,372
1968	4,772	2,670	5,515	5,138		377	1999	7,196	3,328	7,202	6,379		824
1969	7,668	3,528	6,714	5,421		1,293	2000	6,839	2,985	7,074	5,573		1,501
1970	7,902	3,440	7,885	5,477	4	2,404	2001	4,141	2,200	4,824	4,823		1
1971	7,328	3,275	7,402	6,824	1	578	2002	5,052	2,558	4,590	4,590		
1972	5,078	3,267	5,000	5,000			2003	6363	3,159	5,659	5,409		250
1973	6,167	3,317	6,026	5,583		443	2004	5738	2,183	6,615	5,617		998
1974	10,796	3,658	10,364	6,796		3,568	2005	5639	3,035	4,692	4,475		217
1975	6,405	3,570	6,384	6,153		231	2006	9241	3,205	8,964	6,608		2,356
							Average	6,039	2,824	5,907	4,986	5	1,159

Key:
TAF = thousand acre-feet



Based on the Interim Common Assumptions CALSIM II Model, 2020 Level of Demand, SDIP Step Modeling Output

FIGURE 2-3
ESTIMATED FREQUENCY OF STORAGE AT THE END OF SEPTEMBER IN SHASTA RESERVOIR, 2000 LEVEL DEMANDS AND D-1641 REQUIREMENTS

Water Quality

The State Water Resources Control Board (SWRCB) and Regional Water Quality Control Boards (RWQCB) 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), which determines water quality objectives for a particular reservoir or river reach as affected by its beneficial uses. Water quality must adequately protect beneficial uses.

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. The CVRWQCB determined that the 25-mile reach of the Sacramento River from Keswick Dam downstream to Cottonwood Creek is impaired because levels of dissolved metals periodically exceed levels identified to protect aquatic organisms (CVRWQCB 2002a).

Water quality in the lower part of the Sacramento River may be affected by agricultural and urban runoff, acid mine drainage, stormwater discharges, and water diversions. The Sacramento River downstream from the RBDD was listed as an impaired water body under Section 303(d) of the Clean Water Act (CWA). The parameters of concern in this reach included diazinon, mercury, and unknown sources of toxicity (CVRWQCB 2002b).

Noise and Vibration

The area immediately surrounding Shasta Dam and Lake, where project construction would occur, is located in an undeveloped canyon of the Sacramento River in Shasta County. Various recreational uses and sensitive receptors are located throughout the vicinity. Existing noise sources are associated with roadway traffic (Interstate 5 [I-5]), railway traffic (the Union Pacific Railroad [UPRR], which runs parallels to I-5), aircraft noise associated with Redding Municipal Airport, watercraft noise associated with boats and personal watercraft on Shasta Lake, and stationary noise sources (e.g., mechanical equipment at existing dam facility). In the SLWRI study area, existing vibration sources are primarily associated with local construction, roadway traffic, and trains.

Hazardous Materials and Waste

This section addresses hazards associated with historic and current land uses in the study area. Note that the section later in this chapter titled Public Health and Safety addresses hazards associated with wildland fires and disease vectors. Potential hazards and associated impacts related to TAC emissions are discussed in a previous section titled Air Quality.

Metals are present in inactive and abandoned mines around Shasta Lake and in the Sacramento River watershed. A records search for the primary study area identified one known site that is listed on the Federal National Priorities List/Superfund: the Iron Mountain Mine. The continuous release of metals from the Iron Mountain Mine since the 1940s is believed to have contributed to a steady decline in the fisheries population in the Sacramento River. In addition, several other former mining operations may currently impact environmental conditions in the primary study area. Of these, Bully Hill is the closest abandoned mine to the current shoreline; portions of the tailings and a debris dam are periodically inundated by the reservoir.

A records search for the primary study area identified California cleanup sites involving the Department of Toxic Substances Control in Shasta and Tehama counties. Because the extended study area covers many counties and regions and a project is unlikely to impact sites outside the primary study area, a records search of the National Priorities List and Department of Toxic Substances Control List was not conducted.

Agricultural and Important Farmlands

Within the primary study area, the valleys of the Sacramento River and its tributaries contain some of the most productive agricultural land in Shasta County. Many hundreds of acres of land in these valleys are classified as prime farmland, unique farmland, or farmland of statewide importance. Although there is little agricultural development immediately adjacent to Shasta Lake, agricultural lands are also present in the upper watersheds of several tributaries, primarily to the east of the reservoir. In the extended study area, the Sacramento River basin downstream from the RBDD to the Delta, the Delta, the San Joaquin River basin to the Delta, portions of the American River basin, and the CVP and SWP service areas are all rich in agricultural resources.

Biological Environment

This section describes the biological environment, including aquatic and fishery resources, vegetation and habitat types, wildlife, special status species, and wild and scenic areas within the primary study area. To a lesser degree, portions of the extended study area are also included, with a focus on the Sacramento River from the RBDD to the Delta, and the Delta itself.

Biological resources in the region result from a wealth and diversity of climatic and vegetative associations within and adjacent to the study areas. Influences from the coastal mountains, southern Cascades, northern Sierra Nevada, Great Basin, and Central Valley provide for a unique mix of biota. The study area supports a variety of habitats, including riparian, grassland, oak woodland, chaparral, scrub, vernal pools, seasonal and permanent wetlands, estuaries, tidal sloughs, and marsh. Each of these habitats supports its own unique assemblage of vegetation and wildlife species.

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. The extensive oak forests and riparian/wetland habitats hosted a diverse and abundant wildlife community. Deforestation, water development, flood protection, and expansion of agriculture onto the floodplains in the early to mid-1800s substantially altered the historical floodplain and channel vegetation.

Agriculture is currently the primary land use in the Central Valley; much of the remaining habitat exists as a mosaic of fragmented upland communities or narrow strips of riparian habitat along the Sacramento River and its tributary creeks and sloughs. Although the remaining riparian habitat along the Sacramento River corridor is limited, it supports wildlife, and also supplies shade, cover, and allochthonous material to the adjacent streamside environment, which benefits both the floral and faunal species that are closely associated with the riparian environment.

Aquatic and Fishery Resources

This section describes aquatic and fishery resources in the study area, focusing on resources in and around Shasta Lake, Keswick Reservoir, and the Sacramento River downstream from Keswick Reservoir to the RBDD. Aquatic and fishery resources in the extended study are also included, with a focus on fisheries in the lower Sacramento River and Delta. **Table 2-5** summarizes fish species found in the study area and their likely locations; species include anadromous and resident salmonids and native warm water river species.

Shasta Lake and Tributaries and Keswick Reservoir

The Shasta Lake and Keswick Reservoir fish species include native and 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 2-5
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/steelhead	*Oncorhynchus mykiss*	X	X	X
Brown trout	*Salmo trutta*	X	X	
Green sturgeon	*Acipenser medirostris*			X
White sturgeon	*Acipenser transmontanus*	X	X	X
Pacific lamprey	*Lampetra tridentata*			X
River lamprey	*Lampetra ayresi*			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	X
California roach	*Hesperolecus symmetricus*	X		X
Speckled dace	*Rhinichthys osculus*	X	X	X
Golden shiner	*Notemigonus crysoleucas*	X	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	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	

The fisheries resources of Shasta Lake are greatly affected by the reservoir's thermal structure. During summer months, warm water surface layer is 30 feet deep and up to 80 °F. Water temperatures above 68°F favor warm water fishes such as bass and catfish. Deeper water layers are colder and suitable for cold water species.

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 from Keswick Dam to Red Bluff

The Sacramento River between Keswick Dam and the RBDD 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 the 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, particularly in the Anderson/Redding area.

Water resources development, including the construction of dams and diversions, has affected the hydrology, geomorphology, and ecology of the sub-area. Many of these effects have been detrimental to local habitats and species. Prior to the construction of Shasta Dam, the Sacramento River typically experienced large fluctuations in flow driven by winter storms. These fluctuations and periodic flows moved large amounts of sediment and gravel out of the mountainous tributaries and down the Sacramento River. The completion of Shasta Dam in 1945 resulted in dampening of historic flows, reducing the magnitude of winter floods while maintaining higher summer flows between 7,000 and 13,000 cfs.

Despite net losses of gravel since construction of Shasta Dam, substrates in much of the reach of the Sacramento River from Keswick to Red Bluff 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 Sacramento River supports a variety of anadromous species, including four races of Chinook salmon, steelhead, white sturgeon, green sturgeon (listed under the Federal Endangered Species Act (ESA) as threatened), striped bass, American shad, and Pacific lamprey. Resident species include rainbow trout, hardhead, California roach, Sacramento sucker, Sacramento pikeminnow, and various species of nonnative catfish, sunfish and black bass. Further detail on the life history requirements for each species is described in **Appendix F – Environmental Resources**.

- **Central Valley fall-run Chinook salmon –** Fall–run Chinook salmon represent about 80 percent of the total Chinook salmon produced in the Sacramento River drainage. On March 9, 1998 (63 Federal Register [FR] 11481), the National Marine Fisheries Service (NMFS) issued a proposed rule to list fall-run Chinook salmon as threatened, but determined the species did not warrant listing, and identified it as a candidate species (64 FR 50393, September 16, 1999). Fall-run Chinook salmon spawn during early October through late December and incubation takes place during October through March. The peak of spawning is in October and November as water temperature drops. Mature fall-run Chinook salmon move upstream from the ocean in the late summer and early fall and spawn soon after arriving at their spawning grounds.

- **Central Valley late-fall-run Chinook salmon** – NMFS determined that both late fall-run and fall-run comprise a single evolutionarily significant unit (ESU), but because they are separate in timing and effects, they are distinguished as separate for the purposes of this document. Late fall-run Chinook salmon mostly inhabit the Sacramento River, with spawning occurring upstream from the RBDD. Late fall-run salmon migrate into the Sacramento River from October through April and spawn from January through April. Spawning activity peaks in February and March.

- **Sacramento River winter-run Chinook salmon –** With the possible exception of Battle Creek, the Sacramento River upstream from the RBDD is the only spawning stream of winter-run Chinook, which have been in a major decline since the 1960s. The sharp decline in escapement during the late 1980s and early 1990s prompted listing of the winter-run Chinook salmon as endangered under the California ESA and Federal ESA (59 FR 440, January 4, 1994) and designation of critical habitat, which includes the Sacramento River downstream from Keswick Dam (58 FR 33212, June 16, 1993). NMFS data indicate that the population increased during the late 1990s through 2001. Winter-run Chinook salmon spawn from mid-April through August.

- **Central Valley spring-run Chinook salmon –** On September 16, 1999, the Central Valley spring-run Chinook salmon ESU was listed as threatened under the Federal ESA by NMFS, and critical habitat was designated, which includes the Sacramento River downstream from Keswick Dam (70 FR 52488, September 2, 2005). Adult spring-run Chinook salmon enter the mainstem Sacramento River in February and March. Spawning occurs in gravel substrates in late August through October.

The adult population of the four runs of salmon and other important fish species (including steelhead), which also spawn upstream from Red Bluff, has significantly declined since the 1950s. 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. 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 and bank protection projects; drought conditions, such as those during the late 1980s and early 1990s; predation; pollution; and entrainment in water diversions on the Sacramento River and in the Delta. Of these factors, water temperature is one of the most important. Cold water released from Shasta Dam significantly supports spawning habitat in the reach below Keswick Dam. However, temperatures still rise to levels harmful to salmon and steelhead trout.

Temperature requirements vary according to life stage of Chinook salmon and habitat conditions. Most adult Chinook salmon migrate upstream when water temperatures are between 51°F and 60ºF. Spring-run hold in waters typically under 60ºF (62 FR 159, August 18, 1997), but because they hold in deep, cold pools, surface water temperatures may be higher. Adults tend to spawn when water temperatures drop between 41°F and 57ºF. The optimal range of water temperatures during egg incubation is between 41°F and 57ºF. On hatching, the young fish (alevins) will remain in the nest until their yolk sac has been resorbed, at which time the young fish (now called fry) move to shallow, lower velocity water to rear. Water temperatures for fry are optimal between 53°F and 60ºF. Chinook salmon smolts (i.e., juveniles that are physiologically ready to enter seawater) begin to migrate downstream toward the ocean. Studies have shown that smoltification and survival can be hindered when water temperatures exceed 62ºF.

For a period after Shasta Dam was constructed, the reservoir was kept relatively full and cold water released from the lower depths 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. 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, municipal and industrial (M&I), and other environmental uses. 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 1993 NMFS Biological Opinion for winter-run Chinook salmon established water temperature objectives for the river upstream from Jellys Ferry (near the RBDD) of 56°F from April 15 through September 30, and 60°F for October. Recent changes in reservoir operations, including greater carryover storage 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 reach between Keswick and Red Bluff. 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.

Vegetation and Habitat Types

This section describes vegetation within the primary study area, focusing on the Shasta Lake area and Sacramento River between Shasta Dam and the RBDD, and providing a general description of vegetation and habitat within the extended study area.

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. Shoreline vegetation around Shasta Lake provides important cover for aquatic species and shade to maintain cooler water temperatures. Also of concern in the Shasta Lake area are nonnative plant species 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.

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. 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.

Timber harvesting, water resource development, and environmental disasters also have affected riparian vegetation systems in this area. 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. Riparian vegetation succession has been hampered on the lower Pit River due to water diversions and flow fluctuations. Urbanization and recreation have contributed to the loss of riparian vegetation along the lower tributaries and shoreline of Shasta Lake.

Sacramento River below Shasta Dam

Although the Central Valley historically contained an estimated 1,400,000 acres of wetlands, only about 123,000 acres remain today. Along most of the Sacramento River and its tributaries, the once productive and extensive riparian areas have been greatly reduced. Riparian and wetland habitats provide food and shelter to aquatic fauna and help attenuate high flows. Wetlands occupy many areas along Sacramento River waterways, and are extensive in the Delta. Grasslands and wooded upland communities are more abundant in this reach of the primary study area, which also includes some agricultural lands. Open-water areas occur mainly on the larger waterways, where waterways converge, and in reservoirs.

Riparian and wetland communities in the primary study area may be subject to CDFG regulation under Section 1602 of the California Fish and Game Code if they are associated with stream banks. Riparian communities are identified as sensitive natural communities by CDFG because of their declining status statewide and because of the important habitat values they provide to both common and special-status plant and animal species. These habitat types are tracked in the California National Diversity Database (CNDDB), a statewide inventory of the locations and conditions of the State's rarest plant and animal taxa and vegetation types (CDFG, 2005). These communities in the primary study area may also be subject to Corps jurisdiction under Section 404 of the CWA, if they meet the wetland criteria or are contained within a jurisdictional water of the United States. Vernal pools are considered sensitive because they provide potential habitat for Federally listed species, including slender orcutt grass, vernal pool fairy shrimp, and vernal pool tadpole shrimp; provide important ecological values and functions; and are likely considered waters of the state subject to jurisdiction of the CVRWQCB under the Porter-Cologne Act.

Vegetation within the Sacramento River Valley includes a variety of both upland and lowland plant communities, including common and sensitive communities. A discussion of each of the plant communities present in the primary study area between Shasta Dam and the RBDD follows.[1] These descriptions are generally applicable to the extended study area as well.

Common Plant Communities – Common plant communities present within the primary study area include annual grassland, blue oak woodland/savanna, foothill pine-oak woodland, chaparral, and agricultural lands. The upper banks along steep-sided, bedrock constrained segments of the Sacramento River and its tributaries are characterized primarily by upland communities including blue oak woodland, foothill pine-oak woodland, and chaparral. These incised segments occur primarily between Shasta Dam and Redding.

Sensitive Plant Communities – Sensitive plant communities include those that are of special concern to resource agencies or are afforded specific consideration through the California Environmental Quality Act (CEQA), Section 1602 of the California Fish and Game Code, Section 404 of the Federal CWA, and the State's Porter Cologne Act. Sensitive natural communities are of special concern to these agencies and conservation organizations for a variety of reasons, including their locally or regionally declining status, or because they provide important habitat to common and special-status species. Many of these communities are tracked in CDFG's CNDDB. In addition, oak trees present in the study area may be eligible for protection under local ordinances.

Downstream from the Central Valley's rivers, the Delta includes extensive areas of fresh and brackish tidal marsh, and submerged aquatic plant communities. Additional natural plant communities occur in the extended study area outside the Central Valley and adjacent foothills, but are not a focus of this study. Agricultural and urban vegetation occupies nearly 70 percent of the Central Valley, and a larger portion of terrestrial habitats in the Delta. Urban area plant communities also occupy an increasingly greater portion of the extended study area.

The extensive conversion of natural vegetation to agricultural and urban vegetation has reduced the extent of some natural plant communities more than others. Riparian and wetland communities have experienced the most extensive reductions in their acreage, with approximately 90 percent of riparian vegetation converted to agriculture or development, and the remainder substantially altered by dams, diversions, gravel mining, grazing practices, and invasive species. Consequently, riparian and wetland communities are considered sensitive. Because of this status, and their association with river corridors, these communities are described separately in the Special-Status Species section.

Wildlife

This section discusses wildlife present in the study areas. See **Appendix F – Environmental Resources** for additional information on wildlife.

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[1] Plant community names and descriptions used in this report are based primarily on the *Preliminary Descriptions of the Terrestrial Natural Communities of California* (Holland, 1986). Additional plant community information was obtained from *A Manual of California Vegetation* (Sawyer and Keeler-Wolfe, 1995), *A Guide to Wildlife Habitats of California* (Mayer and Laudenslayer, 1988), and from the *Shasta Lake Water Resources Investigation Initial Alternatives Information Report* (Reclamation, 2004b).

Shasta Lake and Vicinity

A variety of wildlife is present in the areas surrounding Shasta Lake and lower reaches of its tributaries, 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 few bat sightings have been confirmed. 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.

Sacramento River from Shasta Dam to the RBDD

The variety of habitats along the Sacramento River in the Shasta Dam to RBDD portion of the primary study area supports a wide range of wildlife species. The composition, abundance, and distribution of wildlife are directly related to the accessibility of these habitats. The range of wildlife species present includes a variety of waterfowl, raptors, and migratory and resident avian species, plus a variety of mammals, amphibians, and reptiles that inhabit both aquatic and upland habitats within the upper Sacramento River study area. 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 depend on riparian woodland, oak woodland, marsh, and grassland habitats have declined. The region also supports a variety of exotic species, some of which are detrimental to survival of native species.

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. Grasslands and oak woodlands host a variety of seasonal game species and other wildlife. The grasslands and foothills also support vernal pools and other seasonal wetlands that provide unique habitat for waterfowl, various small aquatic organisms, and breeding habitat for amphibians. More arid chaparral habitat and scrub habitat support a variety of reptiles, small and large mammals, and bird species. Higher elevation forest habitats support bird species, forest-floor amphibians, 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.

Much of the wildlife described above for the Sacramento River corridor have the potential to occur in the Central Valley portion of the extended study area, with additional species occurring in upland and foothill areas.

Special-Status Species

Special-status species addressed in this section include plants and animals in the study area that are legally protected or are otherwise considered sensitive by local, State, or Federal resource conservation agencies and organizations. These include species that are State-listed and/or Federally listed as rare, threatened, or endangered; those considered as candidates or proposed for listing; species identified by CDFG as Species of Special Concern; species identified as species of concern by the United States Fish and Wildlife Service (USFWS); plants considered by the California Native Plant Society (CNPS) to be rare, threatened, or endangered; and species afforded protection under local planning documents. The special-status species discussion covers critical habitat types, vegetation, and wildlife.

Critical Habitat Types

As defined in the ESA, critical habitat is a specific geographic area that is essential for the conservation of a threatened or endangered species and that may require special management and protection. It may include an area that is not currently occupied by the species but that will be needed for its recovery. Critical habitats are designated to ensure that actions authorized by Federal agencies will not destroy or adversely modify critical habitat, thereby protecting areas necessary for the conservation of the species. Actions must not adversely modify critical habitat to the point that it will no longer aid in the species recovery. This protection is similar to that already granted to listed species under the "jeopardy standard"; the difference is that critical habitat also applies to unoccupied areas needed for the recovery of the species.

Critical habitat within the primary study area includes habitat for Chinook salmon (all runs), Central Valley steelhead, vernal pool fairy shrimp, vernal pool tadpole shrimp, and slender orcutt grass. Critical habitat within the extended study area includes habitat for species found in the primary study as well as Delta smelt, conservancy fairy shrimp, Hoover's spurge, hairy orcutt grass, and Greene's tuctoria.

Vegetation

A list of special-status plant species known, or with potential, to occur in the primary study area was developed through a review of biological studies previously conducted in the area and by performing database searches of the CNPS 2006 Electronic Inventory of Rare and Endangered Vascular Plants of California and CDFG's CNDDB for the Shasta Dam, Redding, Enterprise, Cottonwood, Ball's Ferry, Bend, and Red Bluff East United States Geological Survey (USGS) quadrangles. In addition, a list of Federal endangered and threatened plant species that could occur in or be affected by projects occurring in these quadrangles was obtained from USFWS. A number of special-status plant species that have been documented in the region are not addressed in this report because they are restricted to higher elevations or to habitats that are not present in the primary study area. Based on habitat present and the elevation range of the dam, 10 special-status plant species were identified as having the potential to occur near Shasta Dam. Five additional special-status plant species have been identified as having potential to occur in the area along the Sacramento River between Shasta Dam and the RBDD.

All potential special-status plant species and their listing status, habitat, blooming period, and potential for occurrence are provided in **Appendix F – Environmental Resources**. Most of the special-status plant species listed in **Appendix F– Environmental Resources** have potential to occur within the extended study area. Numerous additional special-status plant species could occur in the extended study area in plant communities that are not present in the primary study area. Additional species that are endemic to the Bay Area, Delta, or Coast Ranges, as well as other species whose distribution ranges do not extend into the primary study area, could occur in the extended study area. Also, numerous species have been documented in the CNDDB or

CNPS in USGS quadrangles in the extended study area, but not in the quadrangles searched within the primary study area.

The list of special-status plant species that could potentially occur in the extended study area is extensive and it is not within the scope of this study to provide a complete list. The CALFED Bay-Delta Program (CALFED) Multi-Species Conservation Strategy provides a comprehensive list of the special-status plant species that could be affected by water projects in the region, including the extended study area under consideration by the SLWRI.

Wildlife

Within the primary study area, suitable habitat exists for a wide variety of wildlife species listed as threatened or endangered under the Federal ESA and/or State ESA. These species are provided protection by one or both of these acts. Any actions that could result in the take must be permitted by USFWS and CDFG. In addition, the study areas contain suitable habitat for a variety of wildlife species of special concern to both State and Federal agencies. While not offered protection under the Federal ESA and State ESA, wildlife species of special concern require analysis and mitigation under CEQA.

Wildlife species lists from both USFWS and CDFG were generated by querying their databases for species that are known by the agencies to occur or have the potential to occur within the USGS 7.5-minute quadrangle maps that are within the study areas. Habitat requirements, preferences, and known occurrences of the species contained within the query results are included in **Appendix F – Environmental Resources**, which lists the special-status fish and wildlife species known, or with potential, to occur in the primary study area. The list of special-status wildlife species that could potentially occur in the extended study area is extensive and are not included in this report.

Wild and Scenic Rivers

This section describes existing wild and scenic rivers in the study areas that could be affected by the project. Wild and scenic rivers in the study areas addressed in this analysis include any national or State wild and scenic rivers in the primary or extended study areas. The National Wild and Scenic Rivers Act of 1968, as amended (Public Law [Pl} 90-542; 16 U.S.C. 1271-1287), established the National Wild and Scenic Rivers System, which identifies distinguished rivers of the nation that possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values. This Act preserves the free-flowing condition of rivers that are designated and protects their local environments. The California Wild and Scenic Rivers Act of 1972, as amended (Public Resources Code Sec. 5093.50 et seq.), aims to preserve designated rivers possessing extraordinary scenic, recreation, fishery, or wildlife values.

There are no formally designated components of the national or state wild and scenic rivers programs in the primary study area. However, the free-flowing stretches of the McCloud River were protected in 1989 under the California Wild and Scenic River Act (Public Resources Code Section 5093.50). 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 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.

Cultural Environment

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

California is geologically diverse, with a wide range of fossil-bearing sedimentary rock formations. Sedimentary deposits are prominent in the Shasta Lake area. The Triassic Hoselkus Limestone contains marine invertebrates and vertebrate remains. The McCloud Limestone Formation, in the northeastern portion of the area around Shasta Lake and its tributaries, is a formation 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. Solution caves in the Permian McCloud Limestone also contain a significant Pleistocene fauna.

Investigations have revealed repeated occupation of the Shasta Lake area as early as 8,000 years ago. 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 of 1,076. Around the reservoir, to elevation 1,276, are an additional estimated 55 archaeological sites. Areas above gross pool appear to have been surveyed haphazardly and surveys are highly incomplete.

The Wintu is a group whose language belongs to the Penutian family. These people are believed to have arrived in California around 1,000 B.C, and were the primary occupants of the Shasta area after A.D. 900. Several local groups of Wintu lived within the Shasta Lake area, including the Nomtipom, Winnemem, and Waimuk. The Okwanuchu were a group related to the Hokan-speaking Shasta people of southern Oregon that lived in the McCloud River drainage. The Madesi band of Achumawi lived farther east along the Pit River. In addition, the Central Yana people held territory in the Cow Creek drainage. Archaeological remains have been found that represent ancestors of the Yana people. Numerous sacred sites are located immediately above the existing gross pool of Shasta Reservoir, including burials and cemeteries, places of spiritual power, named villages, and other sites of special concern. The California Native American Heritage Commission identified several locations of particular concern.

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. Mining was an important activity in the Shasta Lake area during the latter half of the nineteenth century. Later activities included settlement by farmers and ranchers. 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), and include historical buildings, lodges, and hiking and fishing trails.

Socioeconomic Environment

This section describes the socioeconomic resources within the primary study area and, to a lesser degree, in portions of the extended study area. These resources are detailed in **Appendix F – Environmental Resources**.

Population

This section describes the existing population numbers, housing, and demographic profile of residents in the primary study area (Shasta and Tehama counties); the extended study area analysis speaks more generally about population and demographic characteristics in the broader area.

Shasta and Tehama Counties

In Shasta County, Redding serves as the primary center for development and economic activity, while Red Bluff, although much smaller than Redding, plays that role in Tehama County. Due to the area's limited urbanization, residents live a more rural lifestyle than in many other areas of California. In total, the populations of Shasta and Tehama counties make up less than 1 percent of the total population in California. Although Shasta and Tehama counties are still comparatively small, both counties have been growing substantially over the past 15 years. According to the California Department of Finance in 2004, Shasta County's population is expected to increase at twice the expected population increase for the State as a whole. Growth in Tehama County during this time is expected to be more consistent with State trends (California Department of Finance, 2005).

Extended Study Area

California's population totaled an estimated 35 million in 2000. Approximately 2.7 million and 1.9 million of this population resided in the Sacramento and San Joaquin river basins, respectively. The growth rate in the Sacramento River and San Joaquin River basins was over 20 and 30 percent from 1990 to 2000, respectively, significantly greater than the statewide rate of 15 percent for the same period. About three-fourths of the population in the Sacramento River basin resides in or near the City of Sacramento.

According to the 2000 census, the Sacramento Valley region had a population of approximately 2.4 million people with about three-fourths of this total residing in the greater Sacramento metropolitan area. Similarly, most of the population of the CVP service area is concentrated within urban areas. The CVP service area includes various M&I water contractors and water districts that serve portions of the Sacramento, Stockton, and Bay Area metropolitan areas. Outside of these population centers, most of the CVP service area is rural, with irrigated agriculture the predominant land use and economic driver.

Population growth throughout the State has created demands for land and water resources for residential, commercial, and infrastructure uses. Population increases also have included increased demand for a more dependable water supply.

Land Use

The primary land uses in the vicinity of Shasta Lake include public and private lands managed for habitat and wildlife, residential, and some commercial industries. Portions of the Shasta-Trinity National Forest are located within Shasta County. Primary land uses along the Sacramento River between Shasta Dam and the RBDD include urban, residential, and agricultural. Land use in the extended study area varies greatly because of the differences in demographics and environment. Major urban development is concentrated in the Sacramento

River Valley along the transportation corridor provided by I-5, Highway 273, and the UPRR. Within 5 to 8 miles to the east and west of this corridor, the development is characterized by rural communities. Development in the upland areas consists of agriculture, grazing, and timber operations, with small rural community centers and individual homes dispersed throughout.

Employment and Labor Force

This section summarizes the employment and labor force characteristics in the study area that could be affected by the project. The analysis of the primary study area focuses on Shasta and Tehama counties. Analysis of the extended study area speaks more generally about employment and labor force conditions in the broader area. Additional detail is provided in **Appendix F – Environmental Resources**.

Trends in employment and labor force represent key considerations within rural communities like those in the primary study area, and provide useful insight into the area economy. As the economy shifts away from natural resource-based industries and agriculture, employment opportunities in rural areas diminish. Based on trends in unemployment within Shasta and Tehama counties, the economy within the primary study area appears to be in such a transition. At the same time, agriculture and its related support activities remain comparatively strong and provide employment opportunities in the remainder of the CVP service area.

In the extended study area, the agricultural industry and that portion of the service industry that serves agricultural enterprises are the major sources of employment within the service areas of the CVP's agricultural water contractors. Employment in the service areas of CVP M&I contractors is more diverse, with a wider range of businesses found in the dominant service industry and in the manufacturing and wholesale and retail industries.

Business and Industrial Activity

Established industries near the study area include non-farm industries of trade, transportation, and utilities, professional and business services, and government services. Tourism, recreation, and related hospitality industries are a major source of economic development in the primary study area. 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. The economy in the vicinity of Shasta Lake has historically been dependent on natural resources for its livelihood. The industrial makeup and major employers within the study area are discussed in detail in **Appendix F – Environmental Resources**.

Local Government and Finance

This section briefly provides background information on recent trends within the study areas. Additional information related to local government and finance is presented in **Appendix F – Environmental Resources**.

Rural jurisdictions generally dominate the primary study area. Local officials allocate financial resources for a diverse collection of activities, including the provision of police and public safety, development review, and educational services within their jurisdictions. The two largest sources of revenue for most local jurisdictions are property taxes and funding received from the

Federal and State governments. These two sources provide a relatively stable revenue base for funding local programs. Public health and safety and social services of various forms represent the two biggest expenditures at the local level. These programs serve as a safety net for the local population and are frequently the most visible local programs.

Shasta and Tehama counties each maintain one primary urban center, represented by Redding in Shasta County and Red Bluff in Tehama County. Beyond these two centers, each county is characterized by a limited number of small cities and large amounts of rural land. As largely-rural jurisdictions, total revenues and expenditures in both counties are relatively low when compared to other jurisdictions in the State. Similarly, expenditures in each jurisdiction are tailored to rural needs more than might be seen in other California jurisdictions.

Public Health and Safety

This section contains background information on water-related hazards, disease transmission by insect vectors, and fire hazard. Other sections that provide information related to public health and safety include those titled Hazardous Materials and Waste and Utilities and Public Services.

In Shasta Lake, water hazards are generally associated with recreational use; water management operations at a reservoir the size of Shasta Lake typically do not pose specific hazards to humans because water levels do not fluctuate rapidly. Downstream from Shasta Dam, water-related hazards may be associated with rapid increases in flow in the Sacramento River, as during flood events. Operations at Shasta and Keswick dams have historically helped to dampen rapid changes in flow in the Sacramento River, particularly in the reach between Shasta Dam and the RBDD. Downstream from the RBDD, Shasta Dam has a decreasing influence on flow conditions and associated water-related hazards.

Mosquitoes are the primary vectors for disease in the Sacramento River region. Two mosquito abatement districts (MADs) are in the primary study area, the Shasta Mosquito and Vector Control District and Tehama County Mosquito Vector Control District, use a combination of abatement procedures, including biological agents, source reductions, pesticides, and ecological manipulation of breeding habitat.

Fire hazards consist of wildland and human-made material fires. Federal, State, and local fire control agencies in the study area include the USFS (responsible for wildland fire control on USFS-administered lands and private lands adjacent to or within USFS boundaries), California Department of Forestry and Fire Protection (responsible for wildland fire control outside of USFS or city boundaries), and local fire agencies (primarily responsible for non-wildland fires).

Recreation and Public Access

This section describes existing recreation and public access resources in the study area. Recreation is the focus of ongoing data collection and analysis activities for the SLWRI; the general information provided below will be supplemented as new data becomes available. Preliminary data on recreational resources in the study area is described in **Appendix E - Recreation**.

Much of the outdoor recreation and tourism in Shasta County is related to 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. The USFS also maintains 11 group or boat-in campgrounds. Public access is limited at Shasta Dam. The road across the dam and the area immediately below the dam is closed to public use for safety and security reasons.

The area along the Sacramento River from Shasta Dam to the RBDD contains the main recreation resources and public access sites within the primary study area. These include day use sites, boat launches, trail accesses, fishing accesses, RV parks, wildlife areas, and undeveloped open space areas. Beyond Lake Red Bluff and the RBDD on the Sacramento River, it is not expected that recreation or public access would be affected by implementation of the project and therefore an in-depth review of recreation activities and facilities downstream is not presented in this analysis.

Aesthetics

Visual resources in the study area include views to and from Shasta Dam and viewsheds or viewpoints along the Sacramento River downstream from Shasta Dam to the RBDD. Issues related to the Federal and State Wild and Scenic Rivers programs are addressed in the Physical Environment section of the chapter.

Several highways located in the primary study area are designated or eligible for designation as State or County Scenic Highways. California's Scenic Highway Program was created to preserve and protect scenic highway corridors from change that would diminish the aesthetic value of lands adjacent to highways. Potential Class A visual features include Federal and State park and recreation areas, such as Whiskeytown-Shasta-Trinity NRA and Lassen Volcanic National Park. The Sutter Buttes, Mount Lassen, and Mount Shasta are prominent mountain features visible from a large portion of the north Central Valley.

Many human-made improvements since the 1940s have disrupted the natural environment, although clearing and road building does allow certain views to be experienced. Human-made visual features include four water control structures (Shasta, Keswick, Anderson-Cottonwood Irrigation District, and Red Bluff Diversion dams).

Traffic and Transportation

Major transportation routes in the study area include I-5, State Routes 299, 99, 70, 29, 20, 162, and 36. Excluding Chico, traffic within the central and northern portions of the Central Valley usually is moderate to light. Southern Pacific is the main rail line serving the Sacramento River basin area as a whole. Travel and navigation by water in the primary study area is primarily for recreational purposes. The extended study area includes numerous major and minor transportation features, including several rail lines, commercial and industrial ports, and a deep-water ship channel that runs from the Delta to the Port of Sacramento.

Many figures and plates included in this document show the location of major roadways in the primary study area for reference, and because of the relevance of transportation features when considering the relationship between the natural and built environments.

Utilities and Public Services

This section provides an overview of existing utilities and public services for the study area, including wastewater treatment facilities and infrastructure, and infrastructure, solid waste management, electrical service, natural gas infrastructure, law enforcement, and emergency services. Fire protection services are discussed under the Public Safety Section.

Various county and local agencies provide the primary study area with solid waste and wastewater removal and management, emergency services, public safety, and law enforcement services. Pacific Gas and Electric (PG&E) is responsible for providing electrical and natural gas service to the primary study area. Gas is delivered to the study area through portions of PG&E's 40,000 miles of natural gas pipelines. Many areas scattered throughout Shasta and Tehama counties are serviced by individual septic systems.

Utilities and public services in the extended study area include wastewater infrastructure, stormwater infrastructure, solid waste management, electrical service, hydropower generation, natural gas infrastructure, and public services. These services are provided by various private providers and public departments throughout the region.

Water Supply

The section provides information on water supplies within the study area. Additional discussions of water supply reliability in the Central Valley, as it relates to the primary objective of the SLWRI, are also included in **Appendix A – Plan Formulation**.

From 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 2-6**). To address this demand, available total statewide supplies under average and drought year conditions were 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 decline to about 73 percent of the available supplies and nearly all of the remainder comes from groundwater. More recent information is contained in the 2005 update to the Water Plan. The 2005 update did not separate water use and supplies, similar to the 1998 Water Plan. In addition, the 2005 update shows a significant increase in water uses primarily for environmental purposes. It also indicates that there are likely greater water supplies from existing sources than previously estimated. However, it appears from data in the 2005 Water Plan update that the basic conclusions are similar to those in the 1998 update.

TABLE 2-6
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	2.4		1.6		4.0		32.1	
Urban Use Rate (GPCPD)	289	313	322	327	302	319	244	251
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	0.8	0.8	0.6	0.6	1.4	1.4	8.8	9.0
Agricultural	8.1	9.1	7.0	7.2	15.1	16.3	33.8	34.5
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***	***79.5***	***64.7***
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***	***13.2***	***10.7***	***8.9***	***25.4***	***22.2***	***77.9***	***59.6***
Shortage (MAF)	**0**	**0.9**	**0.3**	**0.8**	**0.3**	**1.7**	**1.6**	**5.1**

Source: DWR, 1998

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

Conditions similar to that for the State for 1995 existed in the Central Valley. As can be seen in **Table 2-6**, estimated 1995 water use (demands) during average and drought years for the combination of 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 was about 1.6 MAF. Under average year conditions for 2000 in the 2005 update, the combined water use was estimated at 35.3 MAF. Although water uses for urban and agricultural proposes were very similar between the two plans, the estimate use for environmental purposes was reported as significantly increased in the 2005 update.

The CVP is the largest water storage and delivery system in California, covering 29 of the State’s 58 counties. Operated by Reclamation, the CVP consists of 21 reservoirs capable of storing 12 MAF of water, 11 powerplants, 500 miles of major canals and aqueducts, and many other tunnels, conduits, and power transmission lines. The CVP irrigates about 3.25 million acres of farmland and supplies water to more than 2 million people through more than 250 long-term water contractors. Most of the CVP service area is inside the Central Valley. About 90 percent of the south-of-Delta contractual delivery is for agricultural uses.

When deficiencies in the ability of the system to deliver full entitlements occur, 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 and Energy

This section discusses power and energy resources in the study area, summarizing the major power providers and facilities and infrastructure.

Major energy generators in the study areas include the CVP, SWP, and private suppliers. The California Independent Systems Operator synchronizes all major electrical loads and generators within State boundaries to operate as a single cohesive system. In addition, the CVP and SWP interact with a much broader system of electric generation and transmission called the Western Systems Coordinating Council, which could extend over the entire West Coast and inland to the desert regions of the Southwest.

The SWP uses its power primarily to run the pumps that move SWP water to where it can be applied for economically beneficial uses, and to provide peak power to California utilities. SWP long-term power contracts act as exchange agreements with utility companies. These exchange agreements allow the SWP and a utility to integrate the use of their individual power resources in a mutually beneficial manner. In these agreements, the SWP provides on-peak energy to the utility in exchange for the return of a greater amount of mid-peak and off-peak energy. The SWP may also receive other compensation in the form of annual monetary payments and/or reduced transmission service rates for SWP facilities served by the utility. Except during surplus conditions in extremely wet years, all SWP power is used for peak power exchange agreements and to operate pumping facilities. In all years, the SWP must purchase additional power to meet pumping requirements.

CVP hydropower facilities in the primary study area include Shasta Powerplant at the foot of Shasta Dam and Keswick Powerplant below Keswick Dam. These and other CVP and SWP hydroelectric facilities provide power to a large portion of the extended study area.

The CVP hydropower system consists of eight powerplants and two pump-generating plants. Power produced by the CVP hydropower system first meets water pumping loads at CVP pumping facilities. The primary purpose of the SWP power generation facilities is to meet energy requirements of the SWP pumping plants. The SWP operates six major pumping plants, and 25 major power plants and generation facilities. In addition to CVP and SWP hydroelectric facilities, other hydroelectric facilities are present in the primary and extended study areas.

Social Environment

The social environment is composed of local communities and social population groups. The major communities found within the primary study area are Redding, Anderson, Cottonwood, and Red Bluff. It is within these communities that many social and public services are provided, and where a range of resource-dependent cultural activities take place.

Minority and low-income populations in the study area, many of which are employed by local agricultural operations, are especially susceptible to changes in employment opportunities. The owners of businesses that rely on CVP water and power face increasingly complex challenges and difficulties in controlling their operating costs as water supplies become less reliable and the uncertainty associated with the deregulation of the power industry continues. Low-income customers of the M&I water utilities that purchase CVP water, and the municipal power utilities that purchase CVP power, are vulnerable to future rate hikes.

WITHOUT-PROJECT FUTURE CONDITIONS

Future conditions without a project in place (or the "without-project future condition") are used as the baseline against which the effects of the project alternatives will be evaluated. This section describes the changes in the environment (physical, biological, socioeconomic, and cultural) expected in the primary and extended study areas assuming that no project is implemented. Because it can be difficult to predict future conditions, this section begins with a discussion of alternative baselines to be used in the SLWRI.

Alternative 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 comprehensive alternative plans to be formulated to address these problems/needs. These baselines are described below:

- **California Environmental Quality Act Baseline** – This baseline is important for developing an EIR to meet requirements of CEQA. Under this baseline, future conditions are assumed to be equal to existing conditions. An EIR should also discuss future no-project conditions that are reasonably expected to occur.

- **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 "without-project future condition" includes actions reasonably expected to occur in the future. This includes projects and actions that are currently authorized, funded, and permitted.

Predicting future changes to the physical, biological, socioeconomic, and cultural environments in the primary and extended study areas is complicated by ongoing programs and projects primarily related to CALFED and the CVPIA. Several ecosystem restoration, water quality, water supply, and levee improvement projects are likely to be implemented in the future. Collectively, these efforts may improve Delta water quality, water supply, levees, and ecosystem restoration. Much of this improvement would be based on separate opportunities that are not integrated in a single plan or part of an approved and funded program.

Several significant projects are expected to be implemented in the future in and near the study area, including the following:

- **Sacramento River National Wildlife Refuge Expansion –** This is a land acquisition and habitat restoration program along the Sacramento River between Colusa and Ord Bend.

- **Folsom Dam Projects –** Several projects have been congressionally authorized at Folsom Dam and Reservoir including outlet modifications, a small dam raise, and various dam safety improvements. Refinement of project features is ongoing, however, a project to reduce flood damages along the lower American River will very likely be implemented.

- **Environmental Water Account –** The Environmental Water Account (EWA) was authorized as a cooperative short-term management program to protect fish of the Bay-Delta estuary through changes in CVP/SWP operations with no uncompensated water costs to project water users. The program received extended authorization through 2010 under the Water Supply, Reliability, and Environmental Improvement Act (2004). The corresponding EIS/EIR (currently under preparation) is evaluating a planning horizon through 2030 (DWR and Reclamation, 2003).

- **Water Use Efficiency –** CALFED seeks to accelerate implementation of cost-effective actions of its water use efficiency program to conserve and recycle water throughout the State. As with the EWA, this program will likely develop and continue into the long-term future.

- **South Delta Improvements Program –** DWR and Reclamation are responsible for implementing the CALFED South of Delta Improvements Program (SDIP), which includes providing for more reliable long-term export capability by Federal and State water projects, protecting local diversions, and reducing impacts on San Joaquin River salmon. Specifically, 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. Although the project is currently in the planning phase and not yet approved, it is likely that it will be implemented in the future. Accordingly, the potential influence of increasing the pumping capacity at Banks Pumping Plant to 8,500 cfs is included in the SLWRI analysis.

- **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 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. Further, 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 Operation Criteria and Plan (OCAP) will be implemented to address how the CVP and SWP would be operated in the future as several projects come online and as water demands increase.

Various other projects and programs are expected to be implemented in the future, including the Battle Creek Salmon and Steelhead Restoration Project, CVP Contract Renewals, and further implementation of CVPIA (b)(2) water accounting.

The remainder of this chapter describes some of the future changes in physical, environmental, socioeconomic, and cultural conditions expected to occur in the study area.

Physical Environment

Basic physical conditions in the primary and extended study areas are expected to remain relatively unchanged in the future. Continued development in urban and some suburban areas is expected. Ongoing restoration efforts along rivers are expected to marginally improve natural riverine processes. Without major physical changes to the river systems, hydrologic conditions will probably remain unchanged. 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. Without major changes in hydrology, topography, or geology, sedimentation and erosion are also likely to remain unchanged.

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 remain unchanged and similar to existing conditions.

It is unclear whether changes to the region's climate may occur in association with global climate change. As the population continues to grow and agricultural lands are converted to urban and industrial uses, a general degradation of air quality conditions could occur. However, because of technological innovation and stringent regulations, air quality could improve over time. While similar types and sources of hazardous materials and waste are likely to be present in the future, increasing population will likely increase the potential for hazardous waste issues. Similarly, increasing population will likely affect increases in environmental noise and vibration.

Biological Environment

Efforts are underway by numerous agencies and groups to restore various biological conditions throughout the primary and extended study areas. 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 and plant species especially dependent on woodland, oak woodland, and grassland habitats may be adversely affected.

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. Although increases in anadromous and resident fish populations in the Sacramento River could continue through implementation of projects such as the Battle Creek Salmon and Steelhead Restoration Project, some degradation will likely occur through actions that reduce Sacramento River flows or elevate water temperatures. Accordingly, populations of anadromous fish are expected to remain generally similar to existing conditions.

No rivers or streams in the primary study area are expected to be added to the list of State and/or Federal wild and scenic resources. The wild and scenic status of the McCloud River is expected to remain as under existing conditions.

Cultural Environment

In the vicinity of Shasta Lake, any paleontological, archaeological, historic, or ethnographic resources currently 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. Similarly, conditions related to the cultural environment downstream from Shasta Dam are unlikely to change significantly.

Socioeconomic Environment

The population of the State is estimated to increase from about 35 million in 2000 to about 44 million by 2020, and to about 55 million by 2050. Over the next 45 years, Shasta and Tehama counties are expected to continue their historic growth trends. According to the California Department of Finance (2005), Shasta County's population is expected to increase by 70 percent by 2050 to a total of approximately 334,000 residents (current population 178,000). This represents almost twice the expected percent increase in population as for the State as a whole. Growth in Tehama County during this period is expected to be more consistent with the projected State trends (California Department of Finance, 2005).

To support these expected increases in population, some conversion of agricultural and other rural land to urban uses is anticipated. More 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 will also impact visual resources as areas of open space on the valley floor are converted to urban uses.

Increases in population will increase demands for electric, natural gas, and wastewater utilities; public services such as fire, police protection, and emergency services; and water-related and communication infrastructure. The increase in population and aging "baby boomer" generation will increase the need for health services. The region's superior outdoor recreational opportunities and moderate housing opportunities are expected to attract increasing numbers of retirees from outside the region and state. An increasing population will produce employment gains, particularly in retail sales, personal services, finance, insurance, and real estate. Recreation is expected to remain an important element of the community and economy in the region.

Anticipated increases in population growth in the Central Valley will also increase demands on water resources systems for additional and reliable water supplies, energy supplies, water-related facilities, recreational facilities, and flood control facilities. **Table 2-7** 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. Although there were significant changes in the mix in water uses between the 1998 and 2005 updates, the shortages projected in **Table 2-7** are generally similar to those that can be estimated from the 2005 update. As shown in the table, estimated future shortages of water supplies in drought years are expected to be significant. However, for many reasons it is believed that the potential water shortages under 2020 (1998 update) and 2030 (2005 update) demands will be greater than shown in **Table 2-7** (see discussion in Chapter 3)**.**

TABLE 2-7
ESTIMATED WATER DEMANDS, SUPPLIES, AND SHORTAGES FOR 2020

Item	Sacramento and San Joaquin Hydrologic Basins Two-Basin Total		State of California	
	Average Year	Drought Year	Average Year	Drought Year
Population	6.8		47.5	
Urban Use Rate (GPCPD)	274	288	226	233
Acres In Production (mil)	4.1		9.2	
Agricultural Use (AFPA)	3.6	3.9	3.4	3.5
Applied Water (MAF)				
Urban	2.1	2.2	12.0	12.4
Agricultural	14.4	15.5	31.5	32.3
Environmental	9.3	6.1	37.0	21.3
Total	***25.8***	***23.9***	***80.5***	***66.0***
Water Supply (MAF)				
Surface Water	20.7	16.0	65.0	43.3
Groundwater	4.9	6.2	12.7	16.0
Recycled/Desalted	0	0	0.4	0.4
Total	***25.6***	***22.2***	***78.1***	***59.7***
Shortage (MAF)	***0.2***	***1.7***	***2.4***	***6.3***

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

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

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CHAPTER 3
PLAN FORMULATION PROCESS

The focus of this chapter is on identifying the need for formulating potential alternatives consistent with the study authorizations, and on establishing the study objectives. 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.
- Identifying resources management measures and formulating potential alternative plans to meet study objectives.
- Comparing and evaluating alternative plans.
- Selecting a plan for recommended implementation.

The process is (1) led by a multiagency planning team of professional water resources planners, engineers, environmental scientists, and experts, (2) involves the input and participation of concerned stakeholders, advisory groups, regulatory agencies, and members of the general public, and (3) is consistent with Federal, State, and local planning and environmental guidance, laws, and policies.

Following is a description of the identified water resources problems and needs, and the planning objectives, constraints, and criteria.

WATER AND RELATED RESOURCES PROBLEMS AND OPPORTUNITIES

Based on the overall authority of the Shasta Lake Water Resources Investigation (SLWRI), and concerns expressed about existing and likely future water and related resources issues, following is a description of identified major water resources problems and needs 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 unsuitable water temperature for Chinook salmon. 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 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 Sacramento - San Joaquin River Delta (Delta) reach about 73 degrees Fahrenheit.

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 National Marine Fisheries Service Biological Opinion (BO) for winter-run Chinook salmon, the State Water Resources Control Board established certain operating parameters for Shasta Reservoir (NMFS, 1993). This BO set surrogate or minimum flows in the river downstream from Keswick Dam primarily to affect water temperatures during key periods. Implementation of Central Valley Project Improvement Act (CVPIA) (b)(2) fish actions is another important minimum flow assumption used in operational studies for surface water storage projects in the CALFED Bay-Delta Program (CALFED) Record of Decision (ROD).

In addition to flow requirements, structural changes at Shasta Dam have been made, such as completing the temperature control device (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 Chinook 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 River ROD flow reductions would offset some of the benefits derived from the TCD.

Findings in the 2000-2001 Biennial Report of the California Department of Fish and Game (CDFG) on Sacramento River winter-run Chinook salmon indicate that the total number of fish is increasing (CDFG, 2002). This is likely due primarily to minimum release requirements at Shasta Dam and to the TCD. However, a residual need exists for generally cooler water in the Sacramento River, especially in dry and critically dry years.

Water Supply Reliability Needs

Predicting expected future water shortages under without-project conditions in the Central Valley of California is difficult. There are numerous variables and, just as important, numerous opinions regarding these variables. As mentioned, **Table 2-6** is from the California Water Plan and is intended to describe existing water uses and supplies in the Central Valley and for the State under existing conditions. **Table 2-7** is used to identify how conditions may change in the future. Although both tables are primarily based on the 1998 Water Plan Update, information in the 2005 Water Plan Update considers similar conditions and draws consistent conclusions. One of these conclusions is that California must invest in reliable, high quality, sustainable, and affordable water conservation; efficient water management; and development of water supplies to protect public health, and improve California's economy, environment, and standard of living.

One major factor in California's future water picture is population growth. In the Sacramento and San Joaquin valleys, population is expected to increase by nearly 130 percent by 2050. This is compared to just over 60 percent population growth in the State of California. Under without-project future conditions, there would be no new water storage projects would be constructed, and population growth would force existing water supplies for agriculture uses to be redirected to urban uses. Certainly, there will be a reduction in agricultural lands in the Central Valley due to population expansion, which will somewhat offset the agricultural to urban water conversion. However, this will only account for up to about 40 percent of expected conversion needs; the remainder will be required just to help sustain urban growth primarily in other areas of the State.

Another important factor related to the agriculture to urban conversion is the potential for an overall reduction in future demands for agricultural water supplies, as predicted by the 1993, 1998, and 2005 Water Plans. One reason for this is as mentioned above – conversion of agricultural to urban land uses. Another potential reason would be the implementation of more efficient irrigation water applications. While agricultural interests are applying ever increasing improvements in irrigation efficiencies, they are also using this technology to be more efficient with all the supplies they can acquire. Also, there has been a steady increase in cropping patterns from lower value to higher value crops throughout the Central Valley but with little decrease in demands. Examples include the Interstate 5 corridor in the San Joaquin Valley where current irrigation practices have allowed for the conversion of primarily cattle grazing lands (low value) to high value tree crops. Review of the above mentioned water plan updates indicates that the demands for irrigation water supply appear to be increasing, not decreasing, even with ongoing agricultural to urban land use conversions.

Added to the above is the uncertainty of available future supplies. One significant factor is the increasing need to convert some of the existing space from water supply and other purposes to flood control. This is especially the case for reservoirs immediately upstream from large urban areas such as Folsom Dam on the American River, upstream from the City of Sacramento. Another potentially significant factor is climate change. The California Department of Water Resources identified some of the impacts associated with climate change on various water resources areas. Potential impacts due to climate change are many and complex (DWR, 2006). They range from sea level increases, which could impact coastal areas as well as water quality, to changes in rainfall runoff relationships important for flood control, to impacts to overall system storage for water supply. One important change will be a reduction in total system storage.

Precipitation held in snowpacks make up a significant quantity of the total annual supplies needed for irrigation, urban, and many environmental uses. It is expected that in the future, climate changes will significantly reduce water held in snowpacks in the Sierra Nevada Mountains.

Under average year and existing climatic conditions, the estimated increase in shortages over existing conditions in the Sacramento and San Joaquin Valleys would be at least 800,000 acre-feet to 1.2 million acre-feet (MAF) by 2030 and 2050, respectively. Factoring in climatic changes only, it is anticipated that these shortages could increase from about 3.5 to 5.2 MAF by 2030 and 2050, respectively. During drought periods, expected supplies will be further reduced and expected shortages would be significantly greater.

Accordingly, even with major efforts by multiple agencies to address the complex water resources issues in the State, demands are expected to significantly exceed supplies in the future. Much of the emphasis in future water planning for the State will be on increases in urban water use efficiency and recycling municipal supplies. Water use efficiency will play a large role in actions related to the CALFED ROD. Even so, it is believed that to avoid major impacts to the economy, overall environment, and standard of living in California, a critically important element in any future water resources plan will be development of additional water sources to increase the reliability of existing supplies for expanding municipal and industrial (M&I) uses and to maintain adequate supplies for agricultural and environmental purposes.

Other Environmental Needs

The health of the Sacramento River ecosystem, as elsewhere in the Central Valley, has been 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 San Francisco Bay/Sacramento-San Joaquin River Delta (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 Shasta-Trinity National Forest (STNF), the United States Forest Service (USFS) has prepared the Shasta-Trinity National Forest Land and Resource Management Plan (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 losses of 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 Federal and State Endangered Species Acts (ESA) 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 CALFED, the Senate Bill 1086 Program, CVPIA, and 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 and Shasta Dam Public Safety

Residual Flood Problems Along Sacramento River

Large and small communities and agricultural lands in the Central Valley are under the threat of flooding along the Sacramento River. The United States Army Corps of Engineers 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 a 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 the 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.

Shasta Dam Public Safety Needs

When Shasta Dam and Reservoir was constructed, it was capable of safely accommodating a spillway design flood with a peak inflow to Shasta Reservoir of 450,000 cubic feet per second (cfs) with a 13-day volume of 2.06 MAF. The spillway design flood was based on the maximum probable storm, which was assumed to occur at a time when antecedent conditions were optimum for high flood runoff. If constructed today, Shasta Dam would be required to safely pass the Probable Maximum Flood (PMF). The PMF is similar to the notion of the spillway design flood. The PMF is the largest flood that may reasonably be expected to occur at a given point on a stream from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible on a particular watershed. It is currently estimated that the PMF at Shasta Dam has a peak inflow of 633,400 cfs with a 15-day volume of 3.96 MAF.

It has been determined that Shasta Dam can safely accommodate the PMF. However, it can only do so assuming that all of the seasonally dedicated flood control storage space of 1.3 MAF is available at the beginning of the PMF event. If Shasta Dam were to be substantially modified, would need to be capable of safely passing the PMF, assuming that flood space is not available at the beginning of the event. In other words, Shasta Dam would need to have the capability to safely pass the PMF from the top of the new conservation storage elevation. This would add a significant increase in public safety over existing conditions from catastrophic flooding resulting from the rarest of flood events.

Hydropower Needs

Were California a nation, it would be the twelfth largest consumer of electricity, using roughly the same amount as South Korea or 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 Nation’s 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 megawatts (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.

Recreation Needs

As the population of the State of California continues to grow, demands will increase significantly for water-oriented recreation at and near the lakes, reservoirs, streams, and rivers of the Central Valley. This increase in demand will be especially pronounced at Shasta Lake. As mentioned, USFS manages the recreation uses at Shasta Lake. USFS has expressed concern about seasonal capacity problems at existing marinas and USFS facilities. There is a significant and increasing need to improve recreation related facilities and conditions at Shasta Lake. Any increase in the water surface area at the lake would be one element of a plan to help meet future recreation demands.

PLANNING OBJECTIVES

This section discusses national planning objectives and objectives specific to the study.

National Objectives

The national or Federal objective of water and related land resources planning is to contribute to national economic development (NED) consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are direct net benefits that accrue in the planning area and the rest of the Nation.

Study-Specific Objectives

On the basis of the previously identified and defined problems and needs in the study area, and in relation to study authorities and other pertinent direction, the planning objectives below 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 planning objectives are those for which specific alternatives would be formulated to address. Secondary planning 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 Planning Objectives –** Primarily on the basis of the August 2000 CALFED ROD, formulate alternatives specifically to address the following:
    - Increasing the survival of anadromous fish populations in the Sacramento River primarily upstream from the the Red Bluff Diversion Dam (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, restoring, and enhancing ecosystem resources in the Shasta Lake area and along the upper Sacramento River.
    - Reducing flood damages and improving public safety along the Sacramento River.
    - Developing additional hydropower capabilities at Shasta Dam.
    - Preserving and increasing recreation opportunties at Shasta Lake.

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 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.*

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 feasibility study. Some planning constraints are more rigid than others. Examples of more rigid constraints include Congressional direction; current applicable laws, regulations, and policies; and physical conditions (e.g., topography, hydrology). Other planning constraints are less restrictive for the feasibility study but still influential in guiding the process. Examples include existing water resources projects and programs such as CALFED and the CVPIA. Accordingly, several significant constraints identified in helping formulate an implementable plan to meet the 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 the National Environmental Policy Act (NEPA), Fish and Wildlife Coordination Act, Clean Air Act, Clean Water Act, California Public Resources Code, Federal and State ESAs, California Environmental Quality Act (CEQA), and the CVPIA.

- **CALFED ROD –** The CALFED ROD includes program goals, objectives, and projects primarily to benefit the Bay-Delta system. The ROD has been adopted by various Federal and State agencies for further consideration. In addition to enlarging Shasta Reservoir, the Preferred Program Alternative 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 in determining which alternatives best address the planning objectives. Many of the planning principles and guidelines are included in the Federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (U.S. Water Resources Council, 1983) 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 a minimum, each of the identified primary planning objectives and, to the extent possible, the secondary planning objectives.
- Measures to address secondary planning 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 consider the purposes, operations, and limitations of existing projects and programs and be formulated to not adversely impact those projects and programs.
- Alternatives are to be formulated and evaluated based on a 100-year period of analysis.

- Construction 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 the 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 6**. An extended discussion of the plan formulation process is contained in **Appendix A – Plan Formulation**.

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CHAPTER 4
INITIAL ALTERNATIVES

Once the water resources problems and needs have been identified and study objectives, constraints, and criteria have been developed, the next major elements of the plan formulation process are (1) identifying resources management measures, (2) formulating potential alternative plans to meet study objectives, (3) comparing and evaluating alternative plans, and (4) selecting a plan for recommended implementation. Presented below is a description of the resources management measures considered in the Shasta Lake Water Resources Investigation (SLWRI), initial plans formulated, a set of comprehensive plans, and a comparison of the comprehensive plans. A detailed discussion of the plan formulation process for the SLWRI is contained in **Appendix A – Plan Formulation**.

MANAGEMENT MEASURES

A management measure is any structural or nonstructural action or feature that could address the study objectives. Alternative plans were formulated in the SLWRI by combining the most applicable measures that address the primary planning objectives. These alternatives were then modified considering the measures to address the secondary planning objectives. Following is a summary of the measures initially considered and those selected for further development into initial and later comprehensive plans for the investigation.

Measures Considered

Numerous potential measures were identified based on information from previous studies, programs, and projects to address the primary and secondary planning objectives. These measures were reviewed and others developed during study team meetings, field inspections, environmental scoping, and outreach for the SLWRI. Of the measures considered, several were selected for detailed development into alternative plans. Various reasons exist for either retaining or not retaining a measure for further consideration. One important factor is the potential for a measure to directly address a planning objective without adversely impacting other objectives. In most cases, measures that were identified as moderately addressing a planning objective were deleted from further consideration. 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 3**.

Tables 4-1 through **Table 4-4** list the management measures that address the study objectives, status of the measures (retained or deleted from further consideration), and rationale for the status determination. More detailed information about each measure, and rationale for retaining or deleting the measure from the SLWRI, can be found in **Appendix A – Plan Formulation**.

TABLE 4-1
RESOURCES MANAGEMENT MEASURES ADDRESSING THE PRIMARY PLANNING OBJECTIVE OF ANADROMOUS FISH SURVIVAL

Measure Description	Study Status	Status Rationale
Improved Fish Habitat		
Restore abandoned gravel mines along the Sacramento River	**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	**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 sustained success.
Replenish spawning gravel in the Sacramento River	**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	**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	**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	**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	**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	**Retained**	High likelihood of combining with measures involving increasing Shasta storage. Although existing TCD at Shasta effectively meets objectives, potential may exist to further modify the device to benefit anadromous fish with increased storage at Shasta.
Enlarge Shasta Lake cold water pool	**Retained**	High potential for combining with other measures. Consistent with other primary objective and secondary objectives. Consistent with goals of CALFED.
Modify storage and release operations at Shasta Dam	**Retained**	Potential to combine with other measures, including Shasta Dam and Reservoir enlargement. Potential to conflict with other primary planning objectives and a secondary planning objective. Consistent with goals of CALFED and other programs/projects to benefit anadromous fish.
Modify ACID diversions to reduce flow fluctuations	**Deleted**	Conflicts with other primary planning objective of water supply reliability.
Increase instream flows on Clear, Cow, and Bear creeks	**Deleted**	Independent of hydraulic/hydrologic conditions in upper Sacramento River.

TABLE 4-1
RESOURCES MANAGEMENT MEASURES ADDRESSING THE PRIMARY PLANNING OBJECTIVE OF ANADROMOUS FISH SURVIVAL (CONTD.)

Measure Description	Study Status	Status Rationale
Construct a storage facility on Cottonwood Creek to augment spring instream flows	**Deleted**	Independent of hydraulic/hydrologic conditions in upper Sacramento River. Adverse environmental impacts expected to exceed benefits.
Transfer existing Shasta Reservoir storage from water supply to cold water releases	**Deleted**	Violates basic plan formulation criteria – causes significant reduction in water supply reliability without development of a replacement supply.
Remove Shasta Dam and Reservoir	**Deleted**	Violates basic plan formulation criteria and no known project or projects could replace the lost benefits provided by Shasta and Keswick dams, reservoirs, and appurtenant facilities at any price.
Improved Fish Migration		
Improve fish trap below Keswick Dam	**Deleted**	Although helps fish populations, would not contribute to favorable conditions for sustained spawning and rearing of anadromous fish along mainstem Sacramento River.
Screen diversions on Old Cow and Cow creeks	**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	**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	**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 migration corridor from the Sacramento River to the Pit River	**Deleted**	Extremely high cost. Multiple physical obstructions of effective fish passage even after implementation. Very low certainty of success.
Cease operating or remove the Red Bluff Diversion Dam	**Deleted**	Potential modifications to the RBDD are under consideration by another Federal investigation - Red Bluff Diversion Dam Fish Passage Improvement Project.
Reoperate the CVP to improve overall fish management	**Deleted**	See above measure regarding the RBDD. Issues regarding reoperating facilities on the Trinity River were addressed in the Trinity River Record of Decision in 2000. Any further modification within that system would violate planning criteria for the SLWRI.
Construct a fish ladder on Shasta Dam	**Deleted**	Extremely high cost, relatively small benefit on limited stream system, and very low potential for physically implementing a workable ladder.
Reintroduce anadromous fish to areas upstream from Shasta Dam	**Deleted**	Likely high cost, low potential for successful recapture of out-migrants, and potential for major impacts to existing warm and cold water species in the upper river.

Key:
ACID = Anderson Cottonwood Irrigation District
CALFED = CALFED Bay-Delta Program
CVP = Central Valley Project
O&M = operations and maintenance
RBDD = Red Bluff Diversion Dam
SLWRI = Shasta Lake Water Resources Investigation
TCD = temperature control device

TABLE 4-2
RESOURCES MANAGEMENT MEASURES ADDRESSING THE PRIMARY PLANNING OBJECTIVE OF WATER SUPPLY RELIABILITY

Measure Description	Study Status	Status Rationale
Surface Water Storage		
Increase conservation storage space in Shasta Reservoir by raising Shasta Dam	**Retained**	Consistent with primary planning objective and directly contributes to secondary objectives.
Construct new conservation storage reservoir(s) upstream from Shasta Reservoir	**Deleted**	Upstream storage sites capable of CVP system-wide benefits would be very costly, result in environmental impacts difficult to mitigate, and would be inconsistent with the CALFED ROD.
Construct new conservation storage on tributaries to the Sacramento River downstream from Shasta Dam	**Deleted**	Although potentially feasible sites/projects exist that could increase water supply reliability, 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	**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 108-361.
Construct new conservation surface water storage south of the Sacramento-San Joaquin River Delta	**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 108-361.
Increase total or seasonal conservation storage at other CVP facilities	**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.
Dredge bottom of Shasta Reservoir	**Deleted**	Extremely high cost for a very small potential benefit and severe environmental impacts.
Reservoir Reoperation		
Increase effective conservation storage space in Shasta Reservoir by increasing efficiency of reservoir operation for water supply reliability	**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	**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	**Deleted**	Very low potential for implementation due to significant adverse impacts on flood control.

TABLE 4-2
RESOURCES MANAGEMENT MEASURES ADDRESSING THE PRIMARY PLANNING OBJECTIVE OF WATER SUPPLY RELIABILITY (CONTD.)

Measure Description	Study Status	Status Rationale
Conjunctive Water Management		
Develop conservation offstream surface storage near the Sacramento River downstream from Shasta Dam	**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 108-361.
Develop conservation groundwater storage near the Sacramento River downstream from Shasta Dam	**Retained**	In-lieu groundwater 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	**Deleted**	Not as effective as storage north of the Delta and would not contribute to other study objectives.
Coordinated Operation and Precipitation Enhancement		
Improve Delta export and conveyance capability through coordinated CVP and SWP operations	**Deleted**	JPOD is being actively pursued in other programs. A likely without-project condition.
Implement additional precipitation enhancement	**Deleted**	Not an effective alternative to new storage. Very limited potential to benefit drought period water supply reliability. Being actively pursued under without-project condition.
Demand Reduction		
Implement water use efficiency methods	**Retained**	Although water use efficiency does not increase supplies, conservation is being actively pursued as part of the CALFED program. Conservation needs to be considered as an element of any plan considered in addressing California's future water picture.
Retire agricultural lands	**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.
Water Transfers and Purchases		
Transfer water between users	**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	**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	**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.

TABLE 4-2
RESOURCES MANAGEMENT MEASURES ADDRESSING THE PRIMARY PLANNING OBJECTIVE OF WATER SUPPLY RELIABILITY (CONTD.)

Measure Description	Study Status	Status Rationale
Surface Water Treatment Improvement		
Implement treatment/supply of agricultural drainage water	**Deleted**	Not a viable alternative to new water storage. Very high unit water cost.
Construct desalination facility	**Deleted**	Not an alternative for drought period supplies. Not an alternative to new storage at Shasta. Very high unit water cost.

Key:
CALFED = CALFED Bay-Delta Program
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-the-Delta Offstream Storage
PL = Public Law
ROD = Record of Decision
Reclamation = United States Department of the Interior, Bureau of Reclamation
SWP = State Water Project

TABLE 4-3
RESOURCES MANAGEMENT MEASURES ADDRESSING THE SECONDARY PLANNING OBJECTIVE OF ECOSYSTEM RESTORATION

Measure Description	Study Status	Status Rationale
Cold Water and Warm Water Fisheries		
Construct shoreline fish habitat around Shasta Lake	**Retained**	Would complement measures to increase storage in Shasta Lake.
Construct instream fish habitat on tributaries to Shasta Lake	**Retained**	Would complement measures to increase storage in Shasta Lake. High local interest.
Increase instream flows on the lower McCloud River	**Deleted**	Significant impacts to hydropower.
Reduce acid mine drainage entering Shasta Lake	**Deleted**	Significant implementation, O&M, and liability issues.
Reduce motorcraft access to upper reservoir arms	**Deleted**	Motorcraft management is under the purview of USFS.
Increase instream flows on the Pit River	**Deleted**	Significant impacts to hydropower.
Riparian and Wetland Habitat		
Restore riparian and floodplain habitat along the 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	**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	**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	**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	**Deleted**	High uncertainty for Federal participation and low potential to contribute to primary and other secondary planning objectives.
Preserve riparian corridor along Cow Creek	**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 Creek and Cottonwood Creek watersheds	**Deleted**	Significant benefit to tributaries. Independent action and would not contribute to primary or secondary planning objective conditions along mainstem Sacramento River.

TABLE 4-3
RESOURCES MANAGEMENT MEASURES ADDRESSING THE SECONDARY PLANNING OBJECTIVE OF ECOSYSTEM RESTORATION (CONTD.)

Measure Description	Study Status	Status Rationale
Other Fish and Wildlife Habitat Improvements		
Create a parkway along the Sacramento River	**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	**Deleted**	Likely a without-project condition; is an element of forest recovery plans by USFS.
Remove and control nonnative plants around Shasta Lake	**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	**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	**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	**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

TABLE 4-4
RESOURCES MANAGEMENT MEASURES ADDRESSING THE SECONDARY PLANNING OBJECTIVES OF FLOOD DAMAGE REDUCTION AND INCREASING HYDROPOWER

Measure Description	Study Status	Status Rationale
Planning Objective - Flood Control		
Update Shasta Dam and Reservoir flood management operations	**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 or planning constraints/criteria.
Increase flood control storage space in Shasta	**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	**Deleted**	Independent action and not directly related to accomplishing the primary or other secondary planning objectives.
Implement traditional flood damage reduction measures	**Deleted**	Independent action and not directly related to accomplishing the primary or other secondary planning objectives.
Rout PMF from top of conservation pool	**Retained**	Compatible with major modifications of Shasta Dam and Reservoir. Potential to realize an increase in public safety at Shasta Dam. Would not conflict with other secondary planning objectives or planning constraints/criteria.
Planning Objective - Increased Hydropower		
Modify existing/construct new generation facilities at Shasta Dam to take advantage of increased hydraulic head	**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	**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.
Planning Objective - Recreation		
Restore and upgrade recreation facilities and opportunities	**Retained**	Compatible with any potential modification of Shasta Dam and Reservoir. Would be consistent with established planning guidelines for Federal water storage projects and with existing recreation uses at Shasta Reservoir.
Develop new National Recreation Area recreation plan	**Deleted**	Developing, coordinating, and implementing a new National Recreation Area is believed a separate Federal action outside the scope of this investigation.
Reservoir reoperation for recreation	**Retained**	Compatible with any potential modification of Shasta Dam and Reservoir. Potential to realize an increase in recreation experiences with increasing size of Shasta Reservoir for primary planning objectives. Would not conflict with other secondary planning objectives or planning constraints/criteria.

Measures to Address Primary Planning Objectives

Anadromous Fish Survival - A number of potential measures to address anadromous fish population improvement and other ecosystem restoration opportunities were identified. Most are listed in the November 2003 Ecosystem Restoration Office Report (Reclamation, 2003) included in the reference section. These measures were separated into three broad categories: (1) improved fish habitat, (2) improved water flows and quality, and (3) improved fish migration. Of 24 measures identified specifically to address the primary objective of anadromous fish survival in the Sacramento River, as shown in **Table 4-1**, 4 were retained for possible inclusion in initial plans.

Water Supply Reliability - Various potential water resources management measures were identified to address the primary planning objective of increasing water supply reliability for agricultural, municipal and industrial, and environmental purposes to help meet future water demands. They were 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) Sacramento-San Joaquin River Delta (Delta) export and conveyance. Of 22 measures considered to help increase water supply reliability (see **Table 4-2**), 4 were retained for possible inclusion in initial plans.

Measures to Address Secondary Planning Objectives

Ecosystem Restoration - Identification of potential ecosystem restoration opportunities includes measures to address the secondary objective of ecosystem restoration in the Shasta Lake vicinity and along the Sacramento River downstream from Shasta Dam. The measures were separated into three categories: (1) cold water and warm water fisheries, (2) riparian and wetland habitat, and (3) other fish and wildlife habitat improvements. Of the 19 management measures identified to address the secondary planning objectives, 3 were retained for possible inclusion in initial plans (see **Table 4-3**).

Flood Control - Five management measures were identified to help reduce flood damages along the Sacramento River. They are listed in **Table 4-4** and described in **Appendix A – Plan Formulation**. Of the five, two were retained for further development and possible inclusion in initial plans.

Hydropower – Two measures were considered to increase hydropower potential in the study area. They included (1) modifying the existing/constructing new generation facilities at Shasta Dam to take advantage of increased hydraulic head and (2) constructing new hydropower facilities in the area. As shown in **Table 4-4**, the first measure was retained for further development in initial plans.

Recreation – Three general management measures were identified to help preserve and increase recreation opportunities at Shasta Lake. Of these three measures, two (see **Table 4-4**) were retained for further development in initial plans. They include restoring and upgrading recreation facilities and opportunities and increasing recreation use by stabilizing early season filling in Shasta Lake. Measures Retained for Further Development

Following is a brief description of the resources management measures retained for potential further consideration in formulating initial plans.

Anadromous Fish Survival

Restore Abandoned Gravel Mines Along the Sacramento River – Protecting and restoring spawning and rearing anadromous fish habitat has been identified by the National Marine Fisheries Service as a primary goal in the recovery of Sacramento River winter-run Chinook salmon. One method of accomplishing this is rehabilitating lands formerly mined for gravel along the Sacramento River. 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 exist along the Sacramento River between Keswick and the Red Bluff Diversion Dam (RBDD). Most of these sites consist of one or more deep pits surrounded by partially disturbed land, often requiring minimal restoration actions. This measure would support the primary planning objective of increasing the survival of anadromous fish populations by improving (1) spawning success by increasing the amount of suitable spawning habitat along the Sacramento River for anadromous fish and (2) health and vitality of self-sustaining riverside riparian ecosystems by restoring their connection with natural geomorphic processes, thus increasing the amount of shaded riverine aquatic habitat.

Make Additional Modifications to Shasta Dam for Temperature Control – This measure consists of first assessing if modifications to the temperature control device (TCD) are possible and feasible and if so, implementing those modifications. 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, or replacement of, the existing structure would become more significant for increasingly higher dam raises. This measure would support the primary objective of increasing the survival of anadromous fish populations 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.

Enlarge Shasta Lake Cold Water Pool – As mentioned, cold water released from Shasta Dam significantly influences water temperature conditions on the Sacramento River between Keswick and the RBDD, 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 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 are important to fish populations. This measure would support the primary planning objective of increasing survival of anadromous fish populations by (1) improving water temperature control, (2) extending suitable spawning habitat, and (3) improving overall physical aquatic habitat conditions in the Sacramento River.

Modify Storage and Release Operations at Shasta Dam – In addition to water temperature, flow conditions in the upper Sacramento River are 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 Anadromous Fish Restoration Program (AFRP) included as part of the Central Valley Project Improvement Act (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 help provide additional control and dilution of acid mine drainage from Spring Creek.

Water Supply Reliability

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. 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 Preferred Program Alternative for the CALFED Bay-Delta Program (CALFED) Record of Decision (ROD) (CALFED, 2000a). 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.

Increase Effective Conservation Storage Space in Shasta Reservoir by Increasing Efficiency of Reservoir Operation – 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 – those which address space for flows from winter rainfall – 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 spring. As mentioned, a primary criterion would be to not adversely affect the existing level of flood control provided by Shasta Dam, and possibly improve flood control.

Develop Conservation Groundwater Storage near the Sacramento River Downstream from Shasta Dam – This in-lieu conjunctive water resources 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 Central Valley Project (CVP) and possibly State Water Project (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.

Implement Water Use Efficiency Methods – Water use efficiency (WUE) methods can help reduce future water shortages by allowing a more effective use of existing supplies. As population and resulting water demands continue to grow, and available supplies continue to remain relatively static, by more effectively using these supplies, potential critical impacts to agricultural and urban resources resulting from water shortages can be reduced. The California Water Plan 2005 Update identified a host of agricultural and urban water use efficiency measures (DWR, 2005). Included in CALFED Common Assumptions as a without-project condition is "Projection Level One" from the 2005 Update, which includes agricultural and urban conservation savings. It is estimated that additional WUE measures, although costly and difficult to implement, will play a major role in California's future water picture. WUE will constitute a significant element in helping to reduce demands and should be vigorously pursued by CALFED and local interests to help offset future shortages in water supplies. Accordingly, the concept of WUE was retained for consideration as a potential project element for any plan to be considered for the SLWRI.

Ecosystem Restoration

Construct Shoreline Fish Habitat Around Shasta Lake – The mostly barren shoreline of Shasta Lake does not contribute to supporting juvenile fish. In addition, there is a lack of suitable shallow water fish habitat around the lake. 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) installing artificial fish cover, including anchored complex woody structures (root wads, trunks, and other large woody structures) and boulders, (2) planting water-tolerant and/or erosion-resistant vegetation at prescribed locations within the reservoir drawdown area, and (3) selective reservoir rim clearing. This measure would support the secondary planning objective of preserving and restoring ecosystem resources in the Shasta Lake area by (1) increasing the survival of juvenile fish through improving the quantity of available cover and overall quality of shallow water habitat, and (2) benefiting land-based species that inhabit the shoreline of Shasta Lake through establishing resilient vegetation.

Construct Instream Fish Habitat on Tributaries to Shasta Lake – This measure would improve and restore instream aquatic habitat along the lower reaches of major tributaries to Shasta Lake. It 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.

Restore Riparian and Floodplain Habitat Along the Sacramento River – 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. It 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.

Flood Control

Update Shasta Dam and Reservoir Flood Management Operations – As mentioned, 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. Several possible reoperation opportunities are described in *Assessment of Potential Shasta Dam Reoperation for Flood Control and Water Supply Improvement* (Reclamation, 2004). This measure would not conflict with other secondary planning objectives or planning constraints/criteria.

Route Probable Maximum Flood from Top of Conservation Pool – Shasta Dam can safely pass the computed Probable Maximum Flood (PMF). To do so, however, existing routings are started at the bottom of the flood control pool (total storage of 3.2 million acre feet (MAF)). Routing the PMF from the top of the conservation pool (4.5 MAF) would provide an additional margin of public safety in the case of an extremely rare flood event approaching or equaling the PMF. This measure would not conflict with other secondary planning objectives or planning constraints/criteria.

Hydropower

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 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 create the potential to reduce these flood releases in winter and allow water to pass through the generators later in the year when the water and power are usually more valuable. Further, with higher water surface elevation, greater energy levels (head) would be available for operating the turbines. With a 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).

Recreation

Restore and Upgrade Recreation Facilities and Opportunities – Recreation is not a specific purpose to the Shasta Division of the CVP and no formal recreation facilities were developed as part of the original project. However, in 1965, Congress established the Whiskeytown-Shasta-Trinity National Recreation Area (NRA). Resulting from that act and subsequent direction, the United States Forest Service manages the NRA, which includes managing numerous water resources and related recreation activities at Shasta Lake. Increasing the storage in Shasta Lake would provide a larger water surface for recreation than exists today. Accordingly, this measure would focus on restoring any potential adverse impacts that raising Shasta Dam and Reservoir would have on the lake and related recreation activities. It would also include enhancing those activities primarily related to taking advantage of a larger lake surface.

Reservoir Reoperation for Recreation – This measure consists of resizing the established rules for operating Shasta Dam and Reservoir for flood management for the purpose of benefiting recreation resources at Shasta Lake. A claim by many of the recreation interests around Shasta Lake is that often the lake is forced to draw down in early spring for flood control and then, due to limited inflows in the remainder of the season, the lake cannot recover, which adversely impacts recreation (as well as water supply). Local residents cite 2004 as an example and they also claim that the existing reservoir operation rules for flood control are outdated (based on a report dated 1977, nearly 30 years ago), and that by using more recent data and current technologies, the drawdown would not be required, or be as significant.

Measures Summary

Table 4-5 summarizes the water resources management measures carried forward for potential inclusion in initial plans to address the primary and secondary planning objectives. 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 phase 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 4-5
RETAINED MEASURES TO ADDRESS PLANNING OBJECTIVES

Planning Objective	Resources Management Measure	
	Title	**Measure Description**
Primary Planning Objectives		
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	Raise Shasta Dam 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
	Demand Reduction	Identify and implement, to the extent possible, water use efficiency methods
Secondary Planning Objectives		
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 Control	Modify Flood Control Operations	Update Shasta Dam and Reservoir flood management operations
	Increase Public Safety at Shasta Dam	Rout PMF from top of conservation pool
Hydropower	Modify Hydropower Facilities	Modify existing/construct new generation facilities at Shasta Dam to take advantage of increased head
Recreation	Restore and Upgrade Facilities	Restore and upgrade recreation facilities and opportunities
	Reoperate Reservoir	Increase recreation use by stabilizing early season filling in Shasta Lake

Key: PMF = probable maximum flood TCD = temperature control device

INITIAL PLANS

A set of initial (or concept) plans was formulated from the retained measures that address the primary planning objectives. Because a vast array exists of potential measure combinations and sizes, the strategy was not to develop an exhaustive list of initial plans or to optimize 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 initial plans that may warrant further development into initial alternatives, and subsequently comprehensive alternatives. The initial plans 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. Presented below is a summary of the initial plans. More details for each of the plans are included in **Appendix A – Plan Formulation**.

Two sets of initial plans were first developed that focus on a single primary planning objective: either anadromous fish survival (AFS) or water supply reliability (WSR). Although the AFS and WSR initial plans focus on single planning objectives, each generally contributes to both primary planning objectives. In the three AFS initial plans, for example, emphasis was placed on combinations of measures that could best address the fish survival goals while considering incidental benefits to water supply reliability, if possible. Second, two initial plans were developed that include a mixture of measures to address both primary and, to a lesser degree, the secondary objectives. These are termed combined objective (CO) initial plans.

Each of the initial plans (and later comprehensive plans) included various common features. They include (1) modifications to the TCD, (2) reoperation of Shasta Dam for flood control, and (3) facilities to take advantage of the increased head for hydropower.

Initial Plans Focused on Anadromous Fish Survival

Three initial plans were formulated from the resources management measures retained to address the primary planning objective of anadromous fish survival. In developing these initial plans, it was important to determine (1) how each measure addressing anadromous fish survival could be combined, and (2) how their potential benefits compared. Consequently, 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 initial plan includes raising Shasta Dam 6.5 feet and enlarging the reservoir by 256,000 acre-feet, but the initial plans differ in how the additional storage would be used to benefit anadromous fish. Again, 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 initial plans could be compared. The primary difference between the three AFS initial plans is in how the additional storage gained by the raise would be used to benefit anadromous fish.

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

The primary focus of AFS-1 is to maintain cooler water temperatures in the upper Sacramento River through increasing the minimum end-of-October carryover storage target from 1.9 MAF to about 2.2 MAF by increasing the minimum operating pool to 880,000 acre-feet (an increase of 256,000 acre-feet). These actions 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. It was found that this plan had a significant potential to benefit anadromous fish in the upper Sacramento River. At a dam raise of 6.5 feet, there would be no additional increase in water supply reliability (all the increase would be for increasing the minimum pool). However, at higher dam raises, while maintaining the same increase in carryover storage, this plan could benefit water supply reliability. In addition, the higher water surface in the reservoir would result in a net increase in power generation of about 51 gigawatt-hours per year and provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area. The major features of this plan were retained for further development into comprehensive alternatives.

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 cubic feet per second (cfs) to about 4,200 cfs. It also includes raising Shasta Dam by 6.5 feet to develop the water supply necessary for increasing minimum flows. Although the enlarged reservoir volume would improve temperature conditions for downstream fish, AFS-2 differs from AFS-1 in that the additional storage would be used primarily to increase minimum flow. No changes would be made to the carryover target volume or minimum operating pool. Initially, it was estimated that this plan could significantly contribute to anadromous fish survival. However, after further evaluation, it was concluded that although at various stages of development the concept of increasing minimum flows would be beneficial for fish, at other life stages increasing minimum flows would be detrimental. Accordingly, this plan was deleted from further development.

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

AFS-3 is similar to AFS-2, except in addition to increasing minimum seasonal flows, it also includes implementing instream habitat restoration along the upper Sacramento River. Under this plan, one or more inactive gravel mining operations along the upper Sacramento River would be acquired, restored, and reclaimed to restore about 150 acres of aquatic and floodplain habitat. 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. Side channels and other features would be created to encourage spawning and rearing, and restored floodplain lands would be revegetated using native riparian plants. As mentioned above, increasing minimum flows did not result in a significant benefit to anadromous fish. Initial findings were that restoring the aquatic and floodplain habitat might have the potential to benefit fish. However, subsequent concerns were expressed regarding significant uncertainties about offstream areas being able to successfully support viable fish spawning and rearing. Accordingly, this plan element was deleted from further consideration at this time. Future evaluations may, however, demonstrate the feasibility of this element.

Initial Plans Focused on Water Supply Reliability

Four initial plans were formulated from the resources management measures retained to address the primary planning objective of increasing water supply reliability. Although each WSR initial plan 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 initial plans because storage size is the most influential factor in determining benefits to water supply reliability. Hence, three dam raises were considered in the WSR initial plans: 6.5 feet, 18.5 feet, and 200 feet.

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

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. WSR-1 would increase water supply reliability by increasing critical and dry year yield of the CVP and SWP through increasing critical and dry period supplies by at least 72,000 acre-feet per year. In addition to water supply reliability, and as with each of the dam raise plans, there would be benefits to anadromous fish in the upper Sacramento River, increases in power generation, and the potential for increases in reservoir area recreation. This plan was retained for further development.

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

WSR-2 focuses on the primary planning objective of water supply reliability by raising Shasta Dam by 18.5 feet. 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 634,000 acre-feet to a total of 5.19 MAF. WSR-2 would increase water supply reliability by increasing the critical and dry year yield of the CVP and SWP by at least 125,000 acre-feet per year. This plan was retained for further development.

WSR-3 – Increase Water Supply Reliability with Shasta Enlargement (high level)

WSR-3 focuses on the primary planning objective of water supply reliability through raising Shasta Dam by the maximum amount considered to be technically feasible. This plan consists of raising Shasta Dam by 200 feet. This raise would increase the capacity of the reservoir by 9.3 MAF to a total of 13.9 MAF. The magnitude of this raise would require significant modifications or replacement of most facilities associated with the dam. In addition, the plan includes reconstructing the existing dam, and constructing various dikes at low points around the reservoir rim. In addition, it includes modifications to hydropower facilities, replacing the switchyard, and modifying Keswick Dam and its powerplant. It was found that with this plan, there would be a major increase to water supply reliability, anadromous fish, hydropower, flood control, and recreation resources. However, it is estimated that because of the relatively high cost (about $6 billion) that this plan would likely not be financially feasible at this time. Accordingly, this plan was deleted from further consideration in this Plan Formulation Report.

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

As with WSR-2, this plan consists of raising Shasta Dam by 18.5 feet and other features similar to WSR-2. In addition, however, this plan includes implementing a conjunctive water management component that would consist largely of contract agreements between the United States Department of the Interior, Bureau of Reclamation (Reclamation), and certain Sacramento River basin water users. The conjunctive use component of the plan includes downstream facilities, such as additional river diversions and transmission and groundwater pumping 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. Preliminary estimates of a conjunctive use component to a dam-raise-only alternative indicated that water supply yield could be increased between 10 to 20 percent. However, little to no estimated increase would occur in benefits to fish resources. In addition, no strong indication of non-Federal participation in a conjunctive use component was identified either during outreach activities or through the environmental scoping process. Accordingly, this plan element was subsequently deleted from further consideration.

Initial Plans Focused on Combined Objectives

Numerous combinations of the water resources management measures could be assembled; several variations are included in **Appendix A – Plan Formulation**. Below are two basic combinations to represent a reasonable balance between the two primary planning objectives. The combined objective initial plans also include measures to actively address the secondary planning objectives, as appropriate. As with previous initial plans, numerous potential sizes and combinations of components are possible. The combined objective initial plans identified below are believed to be reasonably representative, although not exhaustively, of the range of potential and applicable actions.

CO-1 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (6.5 to 18.5 feet)

CO-1 addresses both primary planning objectives by restoring anadromous fish habitat and raising Shasta Dam from about 6.5 feet to a maximum of 18.5 feet. In addition, this plan would include reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create additional aquatic and floodplain habitat. Potential relocations would be similar to WSR-1 and WSR-2, depending on the amount of the dam raise. CO-1 would dedicate some of the added space to increasing the minimum carryover storage in Shasta to make more cold water releases for regulating water temperature in the upper Sacramento River. Habitat restoration could add aquatic and floodplain resources to the Sacramento River between Keswick and Battle Creek, a critical spawning reach. The plan could result in an increase in average drought period water supply reliability to the CVP and SWP systems. A higher water surface elevation in the reservoir would result in a net increase in power generation and increase the maximum surface area, which would benefit recreation. As mentioned, continued evaluations concluded that increasing fish habitat through modifications to existing gravel mines along the upper Sacramento River would have a low likelihood for successfully contributing to benefiting salmon resources. Further, during public scoping activities in late 2005, there was little to no interest demonstrated for plan increments to restore floodplain habitat. Accordingly, elements of this plan were retained for further development. However, the gravel mine and floodplain habitat restoration component was deleted from further consideration.

CO-2 – Multipurpose with Shasta Enlargement (6.5 to 18.5 feet)

CO-2 addresses both primary and secondary planning objectives of the SLWRI through a combination of measures. It includes raising Shasta Dam from 6.5 feet to a maximum of about 18.5 feet in combination with habitat restoration and additional recreation facilities in the Shasta Lake area. Enlarging the reservoir and limited reservoir reoperation would also help improve operations for flood control and recreation. The secondary objective of environmental restoration also would be addressed through shoreline and tributary habitat improvements, including restoring (1) resident fish habitat in Shasta Lake and (2) riparian habitat at locations along the lower arms of the Sacramento River, McCloud River, and Squaw Creek. This plan was retained for further development.

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CHAPTER 5
COMPREHENSIVE PLANS

This chapter provides an overview of the five comprehensive plans for the Shasta Lake Water Resources Investigation (SLWRI), including a discussion of comprehensive plan formulation, resources management measures common to all comprehensive plans, major components of dam raise scenarios, and costs and benefits of each comprehensive plan. Also included is a general description of the No-Action Plan and five comprehensive plans. For each of the five comprehensive plans, major components, accomplishments, primary impacts and economics are described.

OVERVIEW OF COMPREHENSIVE PLANS

The five comprehensive plans include the following:

- **Comprehensive Plan 1 (CP1) – Mini Raise – 6.5 Feet**: Raise dam 6.5 feet, enlarge reservoir by 256,000 acre-feet
- **Comprehensive Plan 2 (CP2) - Mini Raise – 12.5 Feet**: Raise dam 12.5 feet, enlarge reservoir by 443,000 acre-feet
- **Comprehensive Plan 3 (CP3) - Mini Raise – 18.5 Feet**: Raise Dam 18.5 feet, enlarge reservoir by 634,000 acre-feet
- **Comprehensive Plan 4 (CP4) – Mini Raise – Anadromous Fish**: Enlarge facilities and modify operations to improve anadromous fish resources
- **Comprehensive Plan 5 (CP5) – Mini Raise – Combination:** Combination plan to address all planning objectives

Formulation of Comprehensive Plans

As described in **Chapter 4** and **Appendix A – Plan Formulation**, numerous water resources management measures were identified, evaluated, and screened. From the retained measures and concept plans, various initial plans were developed to encompass the range of potential alternatives to address the planning objectives. From these initial plans, the following plan types were identified for further development into comprehensive plans:

- Plan(s) to raise Shasta Dam by about 18.5 feet, focusing on water supply reliability, but with benefits to anadromous fish survival and various secondary planning objectives
- Plan(s) to raise Shasta Dam by about 18.5 feet, focusing on increased anadromous fish survival, but also including water supply reliability and other secondary planning objectives
- Plan(s) to raise Shasta Dam by about 18.5 feet, focusing on all planning objectives

Considering the retained initial plans and these basic plan types, numerous combinations of comprehensive alternatives can be formulated. In addition, features can be added to any comprehensive alternative involving raising Shasta Dam to address increased recreation in the lake area. To develop a significant distinction between the dam-raise-only plans, the approach for this report was to first formulate plans simply focusing on different dam raise heights within the range of 6.5 to 18.5 feet. This is generally addressed by the first bullet above. Following this, the approach was to formulate comprehensive plans to focus on anadromous fish survival and the other objectives.

Measures Common to All Comprehensive Plans

Seven of the measures retained (see **Chapter 4**) are included, to some degree, in all of the comprehensive plans. These measures were included because they (1) would either be incorporated/required with any dam raise, (2) were logical and convenient additions that would significantly improve any alternative, or (3) should be considered with any new water increment developed in California. The seven measures include enlarge Shasta Lake cold water pool, modify temperature control device (TCD), increase conservation storage, demand reduction, modify flood control operations, increase Shasta Dam pubic safety, and modify hydropower facilities.

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. At a minimum, all comprehensive plans include enlarging the cold water pool by raising Shasta Dam and enlarging Shasta Reservoir. Some alternatives also increase the seasonal carryover storage in Shasta Lake.

Modify Temperature Control Device

The minimum modifications to the TCD for all comprehensive plans include raising the existing structure and modifying the shutter control. Additional modifications to increase the operating range or effectiveness of the TCD might also be included in future alternatives. More understanding about operation of the existing TCD is needed to identify possible improvements. Future studies will determine which modifications to the TCD are possible and practical, and how they could be included in comprehensive alternatives. For the purpose of this analysis, the existing shutter configuration was used for all simulations.

Increase Conservation Storage

All comprehensive plans include increasing the conservation space within Shasta Reservoir by raising Shasta Dam. The comprehensive plans include a range of dam enlargements and various increases in conservation space.

Demand Reduction

The CALFED Bay-Delta Program Common Assumptions work group has identified water use efficiency measures to at least Projection Level 1, as defined in the *California Water Plan*

Update 2005 (Bulletin 160-05) (DWR, 2005). In addition, a series of best management practices focuses on improving the efficient use of agricultural water supplies in the Central Valley as part of the Central Valley Project (CVP). It is the intent that the recommended plan identified as part of the SLWRI includes, to the extent possible, further implementation of these demand reduction practices.

Modify Flood Control Operations

Physical enlargement of Shasta Reservoir would require alterations to the existing flood control operational guidelines or rule curves. The guidelines could be adjusted to reflect the physical increase in dam/spillway elevation.

Increase Public Safety at Shasta Dam

Physical enlargement of Shasta Reservoir would provide the opportunity to rout the Probable Maximum Flood (PMF) from the top of the total conservation pool as opposed to the bottom of the flood control pool, as is the case today. This routing improvement would further increase the reliability to public safety of Shasta Dam passing extremely rare flood events such as the PMF.

Modify Hydropower Facilities

Physical enlargement of Shasta Dam would require various minimum modifications to the existing hydropower facilities at the dam to enable their continued use. However, modifications could also be included to further increase the power production capabilities of the reservoir (e.g., additional penstocks and generators) commensurate with the magnitude of the enlargement.

Physical Features of Dam Raise Scenarios

Three mini raise options were considered for the comprehensive plans. They include 6.5-foot, 12.5-foot, and 18.5-foot dam raises. Certainly, other mini raise options up to 18.5 feet are possible; however, it is believed that the above three mini raises adequately represent the extent of benefits, impacts, and costs associated with any raise within the range considered in this Plan Formulation Report (PFR). Included in **Table 5-1** is a summary of the major components associated with the three mini raises.

Costs

Table 5-2 includes a summary of estimated construction and annual costs for each of the comprehensive plans. These costs are developed to an appraisal level. Detailed information regarding estimated construction costs for the comprehensive plans is included in **Appendix B - Engineering Summary**. The costs are based on October 2006 price levels. Total investment cost is the sum of total construction costs and interest during construction (IDC) costs. The IDC cost is computed using Reclamation-defined practices, and is based on an estimated construction period for all plans of 4 years. Total investment cost is annualized over the project's assumed 100-year lifespan at the Federal interest rate of 5-1/8 percent to compute interest and amortization. Total annual cost is the sum of interest and amortization and estimated annual operation and maintenance costs.

TABLE 5-1
PHYSICAL FEATURES OF MINI-DAM RAISE SCENARIOS

Item	Existing	6.5-Foot Raise	12.5-Foot Raise	18.5-Foot Raise
Shasta Dam				
Type	Concrete Gravity	Concrete gravity	Concrete gravity	Concrete gravity
Construction Means	-	Block raise (crest)	Block raise (crest)	Block raise (crest)
Crest Elevation (feet)	1,077.5	1,084.0	1,090.0	1,096.0
Height Above Stream Bed (feet)	487	493.5	499.5	505.5
Dam Crest Length (feet)	3,460	3,660	3,720	3,770
Dam Crest Width (feet)	30	30	30	30
Shasta Lake				
Elevation Change				
Increase in Gross Pool (feet)	-	8.5	14.5	20.5
Elevation of Gross Pool (feet)	1,067.0	1,075.5	1,081.5	1,087.5
Elevation Min Operating Pool (feet)	840	840	840	840
Capacity (1,000 acre-feet)				
Capacity Increase	-	256	443	634
Total at Gross Pool[1]	4,552	4,808	4,995	5,186
Min. Operating Pool	587	587	587	587
Surface Area Increase (acres)	-			
Area Increase		1,110	1,750	2,570
Total at Gross Pool[1]	29,540	30,650	31,290	32,110
Shoreline Length (miles)	408	395	397	398
Reservoir Dikes	None	2 Minor Dikes	3 Minor Dikes	3 Minor Dikes
Spillway & Outlet Works				
Spillway Crest Elevation (feet)	1,037	1,048	1,054	1,060
Top of Gates Elevation (feet)	1,065	1,075.5	1,081.5	1,087.5
Number & Type of Gates	3 Drum gates 28-foot x 110-foot	6 Radial gates 27.5-foot x 55-foot	6 Radial gates 27.5-foot x 55-foot	6 Radial gates 27.5-foot x 55-foot
Total Outlet Capacity (cfs)	81,800	88,000	90,000	92,100
Hydropower Features				
Penstocks	5- to 15-foot diameter	Strengthen supports	Strengthen supports	Strengthen supports
Powerplant	578 MW	No major modification	No major modification	No major modification
Switchyard	-	No change	No change	No change
Keswick Dam and Powerplant	-	No change	No change	No change
Temperature Control Device	Shutter Structure	Raise/modify controls	Raise/modify controls	Raise/modify controls

TABLE 5-1
PHYSICAL FEATURES OF DAM RAISE SCENARIOS (CONTD.)

Item	Existing	6.5-Foot Raise	12.5-Foot Raise	18.5-Foot Raise
Major Relocations [2]				
Pit River Bridge		Minor skirting around Piers 3 and 4	Skirting around Piers 3 and 4	Skirting around Piers 3 and 4
Other Bridges		Replace 7 bridges	Replace 7 bridges	Replace 7 bridges
Recreation Facilities [3]		Minor	Moderate	Moderate
Structures		45	100	130
Roads		About 75 small segments (45 paved and 30 unpaved) of existing roads impacted, including portions of Lakeshore Drive, Gilman and Fender Ferry roads, Bully Hill Road, and Silverton Road	About 95 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 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
Reservoir Area Environmental Impacts				
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 1,820 acres (6 percent)	Maximum inundation area would increase by about 2,500 acres (8 percent)
Habitat Along Shasta Lake Tributaries		Infrequent increased inundation along lower tributaries: Sacramento River – 1,100 lf Squaw Creek – 500 lf North Fork Squaw Ck – 500 lf McCloud River – 1,420 lf	Infrequent increased inundation along lower tributaries: Sacramento River – 2,100 lf Squaw Creek – 1,100 lf North Fork Squaw Ck – 1,100 lf McCloud River – 2,450 lf	Infrequent increased inundation along lower tributaries: Sacramento River – 3,100 lf Squaw Creek – 1,700 lf North Fork Squaw Ck – 1,700 lf McCloud River – 3,480 lf

Key: cfs = cubic feet per second; lf = linear feet; min = minimum; MW = megawatt; UPRR = Union Pacific Railroad; I-5 = Interstate 5; Ck = creek

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 radial spillway gates that would replace the existing drum gates.
2. 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.
3. The recreation facilities affected under each raise scenario, the ratings of these effects, and the explanation of the ratings assigned are detailed in **Appendix E – Recreation**.

TABLE 5-2
ESTIMATED CONSTRUCTION AND ANNUAL COSTS
($ MILLIONS)[1]

Item	CP1 Mini Raise 6.5 feet	CP2 Mini Raise 12.5 feet	CP3 Mini Raise 18.5 feet	CP4 Mini Raise Anadromous Fish	CP5 Mini Raise Combination
Construction Cost					
Lands	3.8	6.6	9.4	9.4	9.4
Relocations					
Roads	16.1	21.7	26.0	26.0	26.0
Bridges	201.3	212.4	223.4	223.4	223.4
Buildings & Facilities	37.5	68.4	99.3	99.3	99.3
Utilities & Related	4.7	7.4	10.1	10.1	10.1
Dam & Appurtenance	63.6	85.0	106.5	106.5	106.5
Spillway & River Outlets	41.0	43.4	45.9	45.9	45.9
Reservoir Dikes	8.8	34.5	60.2	60.2	60.2
Power Outlets & Related	17.2	22.0	26.7	26.7	26.7
Reservoir Clearing & Related	5.8	10.2	14.5	14.5	14.5
Recreation Facilities					15.0[2]
Environmental Restoration					8.0[2]
Cultural Resources	4.0	5.0	6.1	6.1	6.4
Environmental Mitigation	39.6	50.5	61.3	61.3	62.8
Engineering & Designs	52.8	67.3	81.6	81.6	84.6
Supervision & Administration	35.2	44.8	54.4	54.4	56.4
Total Construction Cost	531.3	679.2	825.2	825.2	854.9
Investment Cost					
Interest During Construction	57.0	72.8	88.5	88.5	91.6
Total Investment Cost	588.3	752.0	913.7	913.7	946.6
Annual Cost					
Interest & Amortization	30.4	38.8	47.1	47.1	48.8
Operation & Maintenance	1.1	1.4	1.7	1.7	1.7
Total Annual Cost	31.4	40.2	48.8	48.8	50.6

Notes:
1. October 2006 price levels, 100-year period of analysis, and 5-1/8 percent interest rate.
2. Preliminary estimates to account for these features. Efforts are underway to further define these features and their costs.

Economic Benefits

Each of the comprehensive plans will address, to some extent, most of the planning objectives. Accordingly, monetary benefits will be generated for most objectives. Following is a summary of the basis for these benefits. A more detailed description of benefits associated with anadromous fish survival, water supply reliability, hydropower generation, and recreation is included in **Appendix C – Economic Analysis**. Three potential benefit categories associated with all comprehensive plans are not included in the following discussion: flood damage reduction, ecosystem restoration, and Shasta Dam public safety. All alternatives would provide an incidental increase in flood protection to areas along the upper Sacramento River. The associated economic benefits would, however, be small. Ecosystem restoration facilities and associated economic benefits around Shasta Lake which would be included in CP5 are under development and will be included in the draft feasibility report. An additional benefit category unique to the SLWRI includes Shasta Dam public safety. It consists of increases to public safety along the upper Sacramento River resulting from routing the PMF through Shasta Reservoir with the event beginning at the top of conservation pool. It is described in **Chapter 6**.

Anadromous Fish Survival

Various approaches can be used for valuing the monetary benefits for increasing anadromous fish populations in the upper Sacramento River. Included in **Appendix D – Technical Support** are estimates of increases in anadromous fish for each of the comprehensive plans. One of the approaches is a market valuation approach. This approach consists of estimating the increase in benefits accrued to ocean commercial and sport and inland sport fishing. Although this approach could be applied to the SLWRI, it generally is inconsistent with the primary study objective associated with increasing the survival of anadromous fish in the upper Sacramento River.

Another approach is known as "least cost alternative." As applied to the SLWRI, under this approach, estimates are made of the costs to raise Shasta Dam solely for anadromous fish production. This included evaluation of three separate dam raises operating solely for increased anadromous fish production, estimated using habitat units. Habitat units were based upon 1,000 smolt passing Red Bluff Diversion Dam. A cost per habitat unit estimate was calculated for each alternative by dividing the alternative's annual costs by the expected change in habitat units. The lowest cost per habitat unit estimate was used as a per habitat unit benefit estimate. Anadromous fish benefits were computed by multiplying the per habitat unit benefit estimate by the change in habitat units expected under each of the project alternatives (**Table 5-3**).

TABLE 5-3
LEAST COST ALTERNATIVE ESTIMATES OF AVERAGE ANNUAL SALMON PRODUCTION FOR PROJECT ALTERNATIVES

Item	CP1	CP2	CP3	CP4	CP5
Change in Average Annual Salmon Production Relative to Without Project (thousands of fish)	365.9	366.5	508.7	1,502.7	508.7
Total Benefits ($ millions)	$11.1	$11.1	$15.4	$45.5	$15.4

Key: CP = comprehensive plan

Water Supply Reliability

The CALSIM II model was used to estimate the potential increases in water supply reliability to the CVP and to the State Water Project (SWP) for raising Shasta Dam from 6.5 to 18.5 feet. Included in **Table 5-4** are the results of the modeling effort to determine drought year and average (weighted average) conditions for the three mini raises.

Irrigation Water Supply

Traditionally, agricultural production methods are used to estimate the monetary benefits of adding new increments to the CVP. The current model is the Central Valley Production Model (CVPM). The CVPM was developed to estimate the impact on irrigated agriculture of implementing provisions of the Central Valley Project Improvement Act (CVPIA). In the CVPM, parameters ranging from crop mixes, prices, and yields to irrigation efficiency are modeled for the entire CVP and then a potential new increment, such as increased storage at Shasta Reservoir is added, and the net increase in the value of increased production is estimated.

The CVPM model was run for the three mini raise scenarios. In addition, to ensure that a representative estimate of increased benefits was considered, benefit estimates were reviewed from the 1992 CVPIA Programmatic Environmental Impact Statement and for the recently completed economic reevaluation for the Auburn-Folsom South Unit of the CVP. Economic values of increased supplies from these three evaluations, in conjunction with the average increases in irrigation water supply from **Table 5-4**, were used to estimate the increase in benefits for each of the comprehensive plans. As can be seen in **Table 5-4**, average annual benefits ranged from about $8.7 million per year for CP1 to $14.1 million for CP3.

TABLE 5-4
WATER SUPPLY RELIABILITY – IRRIGATION AND M&I YIELD INCREASES AND BENEFITS

Item	CP1	CP2	CP3	CP4	CP5
Irrigation Water Supply - Central Valley Project					
Drought Period (TAF/year)	73.9	81.3	119.0	73.9	119.0
Weighted Average (TAF/year)	40.4	49.2	65.9	40.4	65.9
Annual Benefit ($ millions)	8.7	10.5	14.1	8.7	14.1
M&I Water Supply – State Water Project					
Drought Period (TAF/year)	17.0	25.0	14.0	17.0	14.0
Weighted Average (TAF/year)	9.3	15.1	7.8	9.3	7.8
Annual Benefit ($ millions)	4.6	7.6	3.9	4.7	3.9
Total Benefit – Existing Conditions($ Millions)	13.3	18.1	18.0	13.3	18.0
Total Benefit – Future Conditions ($ Millions) [1]	20.9	28.4	28.3	20.9	28.3

Key: CP = comprehensive plan M&I = municipal and industrial TAF = thousand acre-feet
Notes:
1. Water supply reliability benefits based on a rate of increased values of 2 percent above inflation.

Municipal and Industrial Water Supply

Municipal and industrial (M&I) water supply reliability benefits were also estimated based on the average annual deliveries shown in **Table 5-4**. These benefits were based on the results of modeling accomplished by the State of California (State) for estimating M&I water supply benefits for the North-of-the-Delta Offstream Storage (NODOS) Investigation. Benefit estimates shown in the table are based on unit values for M&I supplies in the San Joaquin Valley through the SWP.

<u>*Uncertainty*</u>

According to the California Water Plan, demands for water in California exceed available supplies. It is expected that the difference between available supplies and demands for water will increase significantly in the not too distant future, especially during drought periods. No material increases in supply have been added to the CVP or the SWP for nearly 40 years. To date, increases in water demands have primarily been met through operational changes in the existing system. The population of the Central Valley is expected to nearly triple, and that of the State is expected to increase by over 60 percent by 2050. This rapid increase in population alone, coupled with lack of new sources of supply, is expected to appreciably transform the future of water in California. One of the expected results will be a significant increase in water transfers from agricultural to urban uses. In addition, major declines are likely in otherwise available supplies for reasons ranging from increased local and regional needs for a number of purposes to ongoing climatic changes.

Certainly the traditional approaches, using the methods above, and described more fully in **Appendix C – Economic Analysis,** for estimating water benefits have been adequate as accounting tools and in estimating benefits for increases in reliability today. However, these methods do not account for the increasing complexities resulting from increasing demands and dwindling supplies. Current models used to help estimate water benefits are static models and only useful for estimating the increase in production at one point of time, given numerous highly constrained assumptions.

To account for the significant uncertainties associated with adequately estimating the value of new supplies, an estimate was made of the value of the increased supplies from the comprehensive plans assuming the value of water increases above the inflation rate. Increased rates up to 2 percent were considered. Accordingly, a water supply reliability benefit based on a 2 percent rate above inflation is included in **Table 5-4**.

Hydropower

Increasing the size of Shasta Dam and Reservoir would also result in the ability to increase hydropower generation at Shasta generating facilities. As can be seen in **Table 5-5**, raising Shasta Dam by 6.5 feet to 18.5 feet would result in a net CVP system increase in power generation of 17 to 94 gigawatt-hours (GWh) per year. These net generation estimates are in addition to the energy requirements required for pumping the increased water supplies. With CP4, since more water would be held in storage for anadromous fish purposes, the net generation capacity from the higher hydraulic head would result in an estimated 94 GWh per year. In addition, there is a recognized benefit of hydropower generation because of its lack of emissions that are associated with other forms of energy generation. Each unit of energy produced through traditional fossil fuel sources produces emissions, including carbon dioxide. Accordingly, included in **Table 5-5** is an estimate of the Climate Exchange market value (at $4.30 per 100 metric tons of carbon dioxide equivalent) associated with the increased generation of the five comprehensive plans. As can be seen in **Table 5-5**, hydropower generation benefits of the five plans range from abut $1 million per year for CP1 to about $5 million for CP4.

TABLE 5-5
HYDROPOWER GENERATION BENEFITS

Item	CP1	CP2	CP3	CP4	CP5
Net Increased Generation (GWh/year)	17	42	54	94	54
Value ($ millions)	0.7	2.0	2.4	4.5	2.4
CO_2 Displaced (1,000 metric tons)	15.1	37.5	48.2	83.4	48.2
Value ($ millions)	0.07	0.16	0.21	0.36	0.21
Total Hydropower Benefit ($ millions)	0.8	2.1	2.6	4.8	2.6

Key:
CO_2 = carbon dioxide CP = comprehensive plan GWh/yr = gigawatt-hours per year

Recreation

Shasta Lake is a major recreational venue, featuring at least 27 camp sites, 11 marinas, and 54 picnic units. A recent study of recreation sites in northern California performed by the California Department of Water Resources (DWR) as part of the Oroville Dam Relicensing project places the estimated number of annual visitors at 2.5 million. Enlarging Shasta Dam alone, without adding new recreation facilities, would affect recreation participation by increasing reservoir surface area throughout the year. **Table 5-6** compares user days (visitor days) and estimated recreation values for each of the comprehensive plans to the without-project condition. The estimated resulting increase in user values is based on a recreation unit day value of $32.87. The estimated benefit to increased recreation due to a larger reservoir surface area ranges from about $2.7 million to $7.4 million per year. It should be mentioned that the estimated recreation value for CP5 may significantly exceed the value shown. Studies are underway to identify increases in recreation facilities and recreation uses to be included in this plan.

TABLE 5-6
PREDICTED VISITOR DAYS AND RECREATIONAL VALUES

Item	Without Project	CP1	CP2	CP3	CP4 [1]	CP5
Predicted Visitor Days (millions)	2.58	2.67	2.72	2.81	2.81	[2]
Change in Visitor Days (millions)		0.08	0.14	0.22	0.24	[2]
Total Recreation Value ($ millions)	84.9	87.7	89.6	92.3	92.3	[2]
Change in Value ($ millions)		2.74	4.63	7.37	7.73	[2]

Key: CP = comprehensive plan
Notes:
1. Visitor days and recreation values at least equal to numbers shown. Likely significantly increased due to an annual increased water surface elevation with this plan.
2. Values would be significantly greater than those shown for all other plans following completion of studies to identify increases in facilities and uses with this plan.

Benefit Summary

Table 5-7 is a summary of the estimated benefits from **Table 5-3** through **Table 5-6** above. Again, this summary does not include potential benefits to public safety described in **Chapter 6**.

TABLE 5-7
ANNUAL ECONOMIC BENEFIT SUMMARY [1]
($ MILLIONS)

Benefit Category	CP1	CP2	CP3	CP4	CP5
Anadromous Fisheries	11.1	11.1	15.4	45.5	15.4
Water Supply Reliability [2]	13.3	18.1	18.0	13.3	18.0
Hydropower Generation	0.8	2.1	2.6	4.8	2.6
Recreation	2.7	4.6	7.4	7.7	9.1 [3]
Total Existing Conditions	27.9	35.9	43.4	71.0	45.2
Total Future Conditions [4]	35.5	46.2	53.7	78.6	55.5

Key: CP = comprehensive plan
Notes:
1. Does not include benefits to Shasta Dam public safety (see Chapter 6).
2. Includes irrigation and municipal and industrial water supply.
3. Includes benefits for CP3 plus benefits equal to annual costs for CP5 from Table 5-2.
4. Includes water supply reliability benefits for existing conditions increased at a rate of 2 percent above inflation.

DESCRIPTIONS OF NO-ACTION AND COMPREHENSIVE PLANS

No-Action Plan (No Additional Federal Action)

Under the No-Action Plan, the Federal Government would take no additional 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 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 actions have had an adverse effect on Sacramento River habitat accomplishment. These include implementing requirements of the Trinity River December 2000 Record of Decision (ROD), which 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 River ROD are fully implemented, some of the benefits derived from flow changes and the Shasta TCD might be offset by the reduction in 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. The population of California is expected to double over the next 50 years. Significant increases in population will occur in the Central Valley. As this takes place, 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. 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. One example could include higher water costs resulting in a further shift in agricultural production to areas either outside California and/or outside the United States.

Environmental Restoration, Flood Control, Hydropower, and Lake Area Recreation

As opportunities arise, some local-sponsored efforts will likely continue to improve environmental conditions on tributaries to Shasta Lake and along the upper Sacramento River. However, overall, future environmental-related conditions in these areas will likely be similar to existing conditions. The quantity, quality, diversity, and connectivity of riparian, wetland, and riverine 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 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 flood damages along the Sacramento River. Shasta Dam and Reservoir was constructed at a total cost of about $36 million. During the 1983, 1986, and 1997 flood events, Shasta Dam, in combination with the Sacramento River Flood Control Project, prevented an estimated $14 billion in property losses due to flooding. Accordingly, from a flood damage perspective only, Shasta has far more than paid for itself. However, residual risks to human life, health, and safety along the Sacramento River 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. Under the No-Action Plan, the threat of flooding would continue.

California's demand for electricity is expected to significantly increase in the future. Under the No-Action Plan, no new hydropower facilities would be constructed to help meet this growing demand.

As the population of the State continues to grow, significant growing demands will exist for water oriented recreation at and near the lakes, reservoirs, streams, and rivers of the Central Valley. This increase in demand will be especially pronounced at Shasta Lake.

Comprehensive Plan 1 (CP1) – Mini Raise – 6.5 Feet

CP1 was formulated to represent a likely minimum raise of Shasta Dam of 6.5 feet.

Major Components

CP1 includes the following major components:

- Raising Shasta Dam and appurtenances by 6.5 feet
- Implementing the set of common features described above

As shown in **Table 5-1**, by raising Shasta Dam 6.5 feet from a crest at an elevation of 1,077.5 feet above mean sea level (elevation 1,077.5) to elevation 1,084, this plan would result in an increase in height of the gross pool by 8.5 feet. This increase in gross pool height would add approximately 256,000 acre-feet of additional storage to the overall reservoir capacity. Accordingly, the overall gross pool storage would be increased from 4.55 million acre-feet (MAF) to 4.81 MAF. The additional 2-foot increase in the height of the gross pool above the dam raise height would result from replacing the three drum gates with six radial gates.

The enlarged dam and reservoir would be operated primarily for water supply reliability to the CVP and SWP, under existing operational guidelines. As mentioned, this plan (and all comprehensive plans) includes extending the existing TCD for efficient use of the expanded cold water pool. The plan also includes revisions to the operational rules for flood control such that the facility could possibly be managed more efficiently for flood control and recreation. Although evaluations are continuing, it is estimated that this benefit might result from using advanced weather forecasting tools and enhanced basin monitoring. A primary constraint of this component is that the existing level of flood protection provided by Shasta Dam would not be adversely impacted.

Accomplishments

Major accomplishments of this comprehensive plan are described below.

Anadromous Fish Survival

Water temperature is one of the most important factors in achieving recovery goals for anadromous fish in the Sacramento River. CP1 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 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. It is estimated that improved water temperature conditions could result in an average annual increase in the salmon population of an average of about 366,000 Chinook salmon (see **Appendix F – Environmental Resources** for further details).

Water Supply Reliability

CP1 would increase water supply reliability through increasing firm water supplies for irrigation and M&I purposes primarily during drought periods. This action would contribute to replacement of supplies redirected to other purposes in the CVPIA. This would help reduce estimated future shortages by increasing the reliability of firm water supplies by at least 91,000 acre-feet per year and average annual yield by about 50,000 acre-feet per year. For this report, firm yield is considered equivalent to the estimated increase in the reliability of supplies during dry and critically dry periods. This increase in reliability would help reduce CVPIA-redirected supplies during drought years by about 15 percent.

Hydropower

The higher water surface elevation in the reservoir would result in a net increase in power generation of about 17 GWh per year. This net generation value is the expected increased generation from Shasta Dam, reduced by system losses and pumping-related power, needed to deliver water to the service areas.

Other Accomplishments

CP1 does not include any specific measures to address the secondary objective of environmental restoration. Further, the plan does not include specific features to benefit recreation resources. However, a small benefit would occur 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 1,110 acres (3 percent), from 29,600 acres to about 30,700 acres. In addition, development of a more efficient flood control diagram could help recreation resources at Shasta Lake by reducing the frequency of early season reservoir drawdown. In addition, during the estimated 4- to 5-year construction period, there would be a significant boost to the regional employment rate and overall economy due to construction activities.

Primary Impacts

Following is a summary of potential environmental consequences of this comprehensive plan. Additional information on potential consequences is contained in **Appendix F - Environmental Resources.**

Shasta Lake Area

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 real estate acquisitions and relocations 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 Shasta Lake, are located within a few feet of the existing gross pool elevation.

As mentioned, under without-project conditions, Shasta Reservoir fills to (or near) gross pool levels about once every 4 years (about 25 percent of the years). Shasta Reservoir fills to 80 percent capacity in about 72 percent of the years. With this plan, Shasta would fill to the new gross pool storage of 4.79 MAF at the same frequency as under without-project conditions. **Plate 13** shows an exceedence probability relationship of maximum annual storage in Shasta Lake for this and other dam raises. Shasta Lake would also fill to 80 percent of the new capacity in about 71 percent of the years. Accordingly, annual operations in the reservoir would generally mirror existing operations except the water surface in the reservoir would be about 8.5 feet higher. The primary difference in the reservoir area would be that during extended drought periods, the reservoir would be drawn down to the level it would have been under without-project conditions. As shown in **Table 5-1**, the increased area of inundation for this plan is 1,110 acres. This equates to an average increase in lateral zone of about 21 feet. **Plate 14** shows the changes from without-project conditions for a dam raise of 6.5 feet for a representative period of 1972 to 1992.

Accordingly, within the reservoir area, the primary impacts of this and other comprehensive plans would be due to the increased water surface elevations and inundation area. An example of the extent of inundation for the 6.5-foot dam raise (as well as other dam raises) is provided in **Plate 15**. 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.

The McCloud River is 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 16** illustrates the estimated increase in area of inundation on the McCloud River upstream from the McCloud Bridge for the 6.5-foot (and 18.5-foot) dam raise. As shown in **Table 5-1** and in **Plate 16**, 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. Studies are underway to estimate the potential level of impact on the wild trout fishery, if any.

The duration of inundation at given drawdown levels (e.g., 10 feet from top of gross pool) would be similar to existing conditions. Water would inundate the highest levels of the reservoir for periods ranging from several days to about 1 month. Much of the vegetation in the enlarged drawdown zone on steeper lands would be removed during construction. In addition, some vegetation in the expanded drawdown zone would eventually be lost over time. However, it is expected that significant amounts of vegetation could remain on the lower slopes because of the infrequent inundation. As summarized in **Table 5-1**, the lower reaches of tributaries to Shasta Lake also would experience increased inundation.

Sacramento River

Potential impacts on flow and stages of the upper Sacramento River from this plan and other comprehensive plans would be minimal. **Plate 17** shows an estimate of the percent change in river flows downstream from Bend Bridge for this and other dam raise scenarios under average, wet, and dry year conditions. As can be seen, in average and wet years, river flows would decrease slightly during the December through February period. This is due to Shasta Reservoir filling the increased space, usually following an extended dry period. Again, as described above, during most years, annual operations of Shasta Reservoir would be unchanged. Also, flows and stages would increase slightly during the June through August period. Although small, this increase would be most pronounced during dry periods as more water is released from Shasta Dam for water supply reliability purposes. However, also during dry periods, few to no changes would occur in water flows or changes during the winter and spring periods. All potential noticeable changes in flows and stages would diminish rapidly downstream from Red Bluff.

Changes in river flows and stages are not expected to have any impacts on geomorphic conditions along the river nor to existing riparian vegetation or other wildlife resources. As mentioned above, the changes in flows are expected to have a beneficial impact on anadromous fish resources. A possibility exists, however, that by benefiting anadromous fish, a slightly altered flow and temperature regime may adversely impact warm water species in the Sacramento River. This impact is not expected to be significant.

Economics

Costs

As shown in **Table 5-2**, the estimated construction cost for CP1 is about $531 million. The estimated total annual cost of this plan is $31.4 million.

Benefits

As can be seen in **Table 5-7**, the estimated average annual benefits of CP1 under existing conditions, excluding Shasta Dam public safety (see **Chapter 6**), is about $27.9 million. The largest monetary benefit is increased dry year water supply reliability. This benefit could exceed about $35.5 million per year if allowances are made to account for future shortages in water supply reliability due to increasing population and dwindling available supplies.

Comprehensive Plan 2 (CP2) – Mini Raise – 12.5 Feet

CP2 consists primarily of enlarging Shasta Dam by raising the crest 12.5 feet and enlarging the reservoir by 443,000 acre-feet.

Major Components

- Raising Shasta Dam and appurtenant facilities by 12.5 feet
- Implementing the set of common features described above

A dam raise of 12.5 feet was chosen because it represents a mid-point between the likely smallest dam raise considered and the largest practical dam raise that does not require relocating the Pit River Bridge. The 12.5-foot raise would result in an increase in the gross pool elevation of 14.5 feet. This would increase the capacity of the reservoir by 443,000 acre-feet to a total of 5.0 MAF. 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 the previous plan, this plan 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 CP2 are described below in relation to their contributions to the objectives of the SLWRI.

Anadromous Fish Survival

Raising Shasta Dam by 12.5 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 366,500 fish per year.

Water Supply Reliability

CP2 would increase water supply reliability through increasing firm water supplies for irrigation and M&I purposes primarily during drought periods. This action would contribute to replacement of supplies redirected to other purposes in the CVPIA. This would help reduce estimated future shortages by increasing the reliability of firm water supplies by at least 106,000 acre-feet per year and average annual yield by about 64,000 acre-feet per year.

Hydropower

The higher water surface elevation in the reservoir would result in a net increase in power generation of about 42.4 GWh per year.

Other Accomplishments

As with the previous plan, CP2 does not include specific measures to include features to benefit the secondary planning objectives of environmental restoration, recreation, or flood control. However, there would be incidental benefits 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 1,750 acres (6 percent), from 29,600 to about 31,290 acres. In addition, during the estimated 4- to 5-year construction period, there would be a significant boost to the regional employment rate and overall economy due to construction activities.

Primary Impacts

Following is a summary of potential environmental consequences of this comprehensive plan. Additional information on potential consequences is contained in **Appendix F – Environmental Resources**.

Shasta Lake Area

As with CP1, raising the gross pool of the reservoir would cause direct impacts due to higher water levels, and indirect impacts related to real estate acquisitions and possibly necessary relocations of displaced parties (under Public Law [PL] 91-646). CP2 includes modifying the Pit River Bridge, replacing 7 other bridges, relocating about 90 structures, and inundating a number of small segments of existing paved and nonpaved roads. Two power transmission lines, several water storage tanks, and three United States Forest Service (USFS) fire stations also would be impacted. Portions of Lakeshore Drive, Fenders Ferry Road, Gilman Road, and Silverthorn Road would be relocated. Embankments would be constructed to protect Interstate 5 (I-5) at Lakeshore and the Union Pacific Railroad (UPRR) at Bridge Bay.

With CP2, Shasta Reservoir would fill to the new gross pool storage of 5.0 MAF at the same frequency as under without-project conditions. Shasta Reservoir would also fill to 80 percent of the new capacity in about 71 percent of the years. Accordingly, annual operations in the reservoir would generally mirror existing operations except the water surface in the reservoir would be about 12.5 feet higher. The primary difference in the reservoir area would be that during extended drought periods, the reservoir would be drawn down to without-project minimum levels. As shown in **Table 5-1**, the increased area of inundation for CP2 is 1,750 acres.

Also, as shown in **Table 5-1**, raising Shasta Dam 12.5 feet would result in inundating an additional 2,450 lineal feet of the lower McCloud River. This represents about 2 percent of the 24-mile reach of river between the McCloud Bridge and the McCloud Dam, which controls flows on the river. As mentioned, studies are underway to estimate the potential level of effort for the wild trout fishery on the McCloud River from this plan.

As with the previous plan, much of the vegetation in the enlarged drawdown zone on steeper lands would be removed during construction. In addition, some vegetation in the expanded drawdown zone would eventually be lost over time. However, it is expected that significant amounts of vegetation could remain on the lower slopes because of infrequent inundation. The lower reaches of tributaries to Shasta Lake also would experience increased inundation.

Although recreation would generally improve under this plan, water in the reservoir would be drawn down to existing conditions during the late fall and winter periods of some dry years, representing a drawdown 14.5 feet greater than under existing conditions. 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. The estimated minimum clearance at the new gross pool would be about 20 feet between Piers 6 and 7.

Sacramento River

As with the previous plan, potential impacts on flow and stages of the upper Sacramento River from this plan and other comprehensive plans would be minimal. As with the other plans (see **Plate 17**), changes in river flows are not expected to have any impacts on geomorphic conditions along the river nor on existing riparian vegetation or other wildlife resources. As mentioned above, the changes in flows are expected to have a beneficial impact on anadromous fish resources. A possibility exists, however, that by benefiting anadromous fish, a slightly altered flow and temperature regime may adversely impact warm water species in the Sacramento River. This impact is not expected to be significant.

Economics

Costs

The estimated construction cost and annual costs of CP2 are included in **Table 5-2**. As shown, the estimated construction cost is $679 million. The estimated total annual cost of this plan is $40.2 million.

Benefits

As shown in **Table 5-7**, the estimated average annual monetary benefit of this plan under existing conditions, excluding Shasta Dam public safety (see **Chapter 6**), is $35.9 million. This benefit could exceed about $46 million per year if allowances are made to account for future shortages in water supply reliability.

Comprehensive Plan 3 (CP3) - Mini Raise – 18.5 Feet

CP3 consists primarily of enlarging Shasta Dam and Reservoir by raising the dam crest 18.5 feet and enlarging the reservoir by 634,000 acre-feet.

Major Components

- Raising Shasta Dam by 18.5 feet
- Implementing set of common features described above

Although higher dam raises are technically and physically feasible, 18.5 feet is the largest dam raise that would not require extensive and very costly reservoir area relocations such as moving the Pit River Bridge, I-5, and the UPRR. The 18.5-foot raise would increase the capacity of the reservoir by 634,000 acre-feet to a total of 5.19 MAF. 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, this plan 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 CP3 are described below in relation to their contributions to the objectives of the SLWRI.

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 509,000 fish per year.

Water Supply Reliability

CP3 would increase water supply reliability through increasing firm water supplies for irrigation and M&I purposes primarily during drought periods. This action would contribute to replacement of supplies redirected to other purposes in the CVPIA. This would help reduce estimated future shortages by increasing the reliability of firm water supplies by at least 133,000 acre-feet per year and average annual yield by about 63,000 acre-feet per year. This increase in reliability would help reduce CVPIA-redirected supplies during drought years by about 20 percent.

Hydropower

The higher water surface elevation in the reservoir would result in a net increase in power generation of about 54.5 GWh per year.

Other Accomplishments

As with the previous plans, CP3 does not include specific measures for features to benefit the secondary planning objectives of environmental restoration, recreation, or flood control. However, there would be incidental benefits 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 2,500 acres (8 percent), from 29,600 to about 32,100 acres. In addition, during the estimated 4- to 5-year construction period, there would be a significant boost to the regional employment rate and overall economy due to construction activities.

Primary Impacts

Following is a summary of potential environmental consequences of this comprehensive plan. Additional information on potential consequences is contained in **Appendix F – Environmental Resources**.

Shasta Lake Area

Major impacts include modifying the Pit River Bridge, replacing seven other bridges, acquisition of real estate interest, possibly impacts to displaced parties (under PL 91-646), and/or relocation of about 130 structures, and replacing numerous small segments of existing paved and nonpaved roads. Two power transmission lines, several water storage tanks, and three USFS fire stations would also need to be relocated. 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.

Although recreation would generally improve under this plan, 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 these 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 5-1** 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 exceed 16 feet in height. 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.

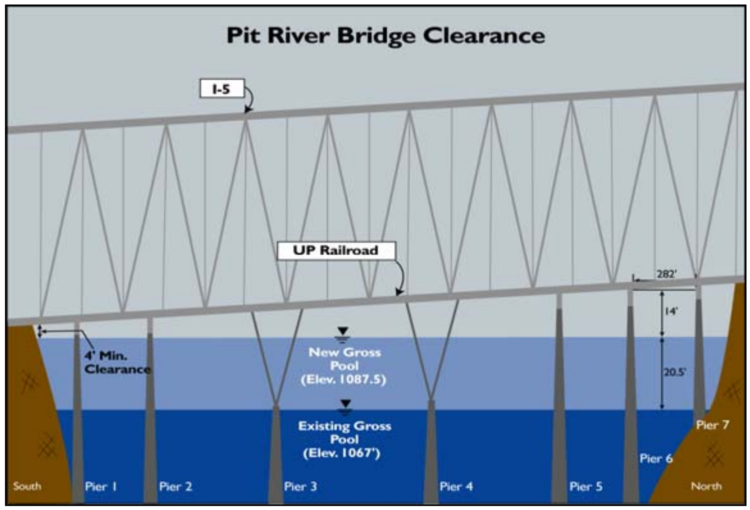

**FIGURE 5-1
MINIMUM CLEARANCES FOR BOAT TRAFFIC AT PIT RIVER BRIDGE, GROSS POOL WITH 18.5-FOOT DAM RAISE**

With CP3, Shasta Reservoir would fill to the new gross pool storage of 5.2 MAF at the same frequency as under without-project conditions. Shasta Reservoir would also fill to 80 percent of the new capacity in about 71 percent of the years (see **Plate 13**). Accordingly, annual operations in the reservoir would generally mirror existing operations except that the water surface in the reservoir would be about 18.5 feet higher. The primary difference in the reservoir area would be that during extended drought periods, the reservoir would be drawn down to without-project minimum levels. As shown in **Table 5-1**, the increased area of inundation for this plan is 2,570 acres.

As shown in **Table 5-1**, raising Shasta Dam 18.5 feet would result in inundating an additional 3,480 lineal feet (about 9 acres) of the lower McCloud River. This represents about 3 percent of the 24-mile reach of river between the McCloud Bridge and the McCloud Dam, which controls flows on the river.

As with the previous plans, much of the vegetation in the enlarged drawdown zone on steeper lands would be removed during construction. In addition, some vegetation in the expanded drawdown zone would eventually be lost over time. However, it is expected that significant amounts of vegetation could remain on the lower slopes because of infrequent inundation. As summarized in **Table 5-1**, the lower reaches of tributaries to Shasta Lake also would experience increased inundation.

Sacramento River

As with the previous plans, potential impacts on flow and stages of the upper Sacramento River from this plan and other comprehensive plans would be minimal. Changes in river flows and stages (see **Plate 17**) are not expected to have any impacts on geomorphic conditions along the river nor on existing riparian vegetation or other wildlife resources. The changes in flows are expected to have a beneficial impart on anadromous fish resources. A possibility exists, however, that by benefiting anadromous fish, a slightly altered flow and temperature regime may adversely impact warm water species in the Sacramento River. This impact is not expected to be significant.

Economics

Costs

The estimated construction cost and annual costs of CP3 are shown in **Table 5-2**. As shown, the estimated construction cost is about $825 million. The estimated total annual cost of this plan is $48.8 million.

Benefits

As shown in **Table 5-7**, the estimated average annual monetary benefit of this plan under existing conditions, excluding Shasta Dam public safety (see **Chapter 6**), is $43.4 million. This benefit could exceed about $53 million per year if allowances are made to account for future shortages in water supply reliability.

Comprehensive Plan 4 (CP4) – Mini Raise – Anadromous Fish

CP4 primarily focuses on increasing anadromous fish resources by raising Shasta Dam 18.5 feet and while still improving water supply reliability.

Major Components

Major components of this plan include the following:

- Raising Shasta Dam by 18.5 feet
- Dedicating 378,000 acre-feet of the increased storage in Shasta Lake to maintaining cold water volume
- Implementing the set of common features described above

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 634,000 acre-feet to a total of 5.19 MAF. Of the increased storage space, about 378,000 acre-feet would be dedicated to increasing the cold water supply for anadromous fish purposes. The existing TCD would be extended to achieve efficient use of the expanded reservoir. This plan 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.

Accomplishments

The accomplishments of CP4 are described below in relation to the objectives of the SLWRI.

Anadromous Fish Survival

CP4 would significantly 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 nearly 1,503,000 salmon.

Water Supply Reliability

CP4 would increase water supply reliability through increasing firm water supplies for irrigation and M&I purposes primarily during drought periods. This action would contribute to replacement of supplies redirected to other purposes in the CVPIA. This would help reduce estimated future shortages by increasing the reliability of firm water supplies by at least 91,000 acre-feet per year and average annual yield by about 50,000 acre-feet per year. This increase in reliability would help reduce CVPIA-redirected supplies during drought years by about 15 percent.

Hydropower

Higher water surface elevations in the reservoir would result in a net increase in power generation of about 94 GWh per year.

Other Accomplishments

CP4 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 plans 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. In addition, during the estimated 4- to 5-year construction period, there would be a significant boost to the regional employment rate and overall economy due to construction activities.

Primary Impacts

Primary impacts associated with CP4 are similar to CP3. They are summarized above and described in more detail in **Appendix F – Environmental Resources**.

Economics

Costs

The estimated construction cost and annual costs of CP4 are shown in **Table 5-2**. As shown, the estimated construction cost is $825 million. The estimated total annual cost of this plan is $48.4 million.

Benefits

As shown in **Table 5-7**, the estimated average annual monetary benefit of this plan under existing conditions, excluding Shasta Dam public safety (see **Chapter 6**), is $71.0 million. This benefit could exceed about $78 million per year if allowances are made to account for future shortages in water supply reliability.

Comprehensive Plan 5 (CP5) - Mini Raise – Combination

CP5 primarily focuses on increasing water supply reliability, Shasta Lake area environmental resources, and recreation opportunities.

Major Components

Major components of this plan include the following:

- Raising Shasta Dam by 18.5 feet
- Constructing additional resident fish habitat in Shasta Lake and along the lower reaches of the Sacramento River, McCloud River, and Squaw Creek
- Constructing shoreline fish habitat around Shasta Lake
- Improving operation and facilities for recreation at various locations around Shasta Lake
- Implementing the set of common features described above

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 634,000 acre-feet to a total of 5.19 MAF and the existing TCD would be extended to achieve efficient use of the expanded reservoir.

CP5 includes restoring (1) resident fish habitat in Shasta Lake and (2) fisheries and riparian habitat at several locations along the lower reaches of the upper Sacramento River, McCloud River, and Squaw Creek (see **Figure 5-2**).

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 component also includes features to trap spawning gravel in deficient areas, creating pools and riffles, providing instream cover, and improving overall instream habitat conditions on the lower reaches of tributaries to Shasta Lake. Treatments could include installing gabions, log weirs, boulder weirs, and other anchored structures. Spawning and rearing habitat would be created by installing instream cover (e.g., large root wads), 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.

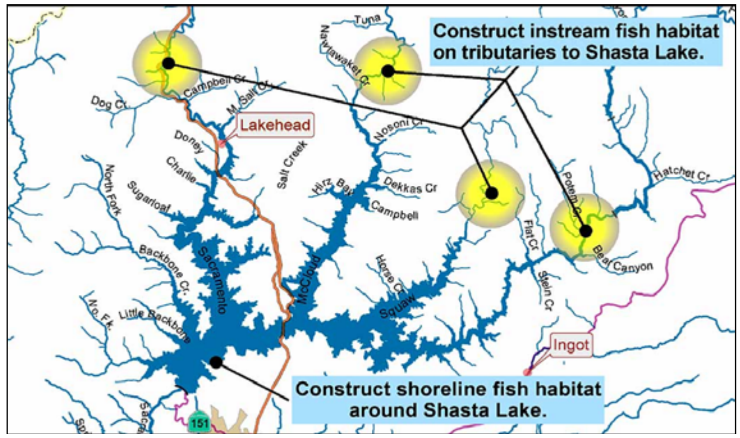

FIGURE 5-2
POTENTIAL ECOSYSTEM RESTORATION FEATURES IN THE SHASTA LAKE AREA

CP5 also includes features to avoid and offset adverse impacts to existing recreation facilities at Shasta Lake, and constructing additional facilities for recreation. In addition, CP5 would result in (1) more stable springtime reservoir filling due to changes in flood operations and (2) a larger surface area for water-oriented recreation in all but the driest of years. Accordingly, it is believed that a significant net increase would occur in recreation opportunities with all plans considered. Potential additional recreation features will be summarized in the draft Feasibility Report.

Accomplishments

Accomplishments of CP5 are described below in relation to the objectives of the SLWRI.

Anadromous Fish Survival

CP5 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 509,000 salmon.

Water Supply Reliability

CP5 would increase water supply reliability through increasing firm water supplies for irrigation and M&I purposes primarily during drought periods. This action would contribute to replacement of supplies redirected to other purposes in the CVPIA. This would help reduce estimated future shortages by increasing the reliability of firm water supplies by at least 133,000 acre-feet per year and average annual yield by about 63,000 acre-feet per year. This increase in reliability would help reduce CVPIA-redirected supplies during drought years by about 15 percent.

Hydropower

The higher water surface elevation in the reservoir would result in a net increase in power generation of about 45 GWh per year.

Environmental Restoration

Specific locations and total area of restoration in the Shasta Lake area will be the subject of future studies.

Recreation

CP5 would provide a significant benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area.

Other

In addition, during the estimated 4- to 5-year construction period, there would be a significant boost to the regional employment rate and overall economy due to construction activities.

Primary Impacts

Primary impacts associated with CP5 are similar to CP3 and CP4. 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 construction cost and annual costs of CP5 are included in **Table 5-2**. As shown, the estimated construction cost is $854.9 million. As can be seen in the table, an allowance of $15 million is assigned to new recreation facilities and $8 million for the above-mentioned reservoir area environmental restoration facilities. These features and costs are conceptual and will be fully developed in upcoming studies for the Feasibility Report. The estimated total annual cost of this plan is $50.6 million.

Benefits

As shown in **Table 5-7**, the estimated average annual monetary benefit of CP5 under existing conditions, excluding Shasta Dam public safety (see **Chapter 6**), is $45.2 million. This benefit could exceed $55 million per year if allowances are made to account for future shortages in water supply reliability. Added benefits for ecosystem restoration recreation features in and around Shasta Lake are estimated to equal the annual cost of these facilities in the table. It should be reiterated that specific ecosystem restoration and additional recreation facility opportunities in and around Shasta Lake are not complete at this time. Completion of these activities may change final conclusions relating to economic benefits.

CHAPTER 6
EVALUATION AND COMPARISON OF COMPREHENSIVE PLANS

This chapter compares and evaluates all five comprehensive plans (CP) based on completeness, effectiveness, efficiency, and acceptability for the Shasta Lake Water Resources Investigation (SLWRI). This information is used to develop a preliminary allocation of costs, for demonstration purposes, based on one of the comprehensive plans.

COMPREHENSIVE PLAN COMPARISON

A critically important element of the plan formulation process is the evaluation and comparison of alternative plans. Below is the result of this evaluation and comparison for the comprehensive plans described in **Chapter 5**. This evaluation is based on consideration of four evaluation criteria identified in the Federal Water Resources Council Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) for water resources planning. These criteria include (1) completeness, (2) effectiveness, (3) efficiency, and (4) acceptability. Also included is a description of several important subfactors making up each criterion. **Table 6-1** is a summary comparison of the comprehensive plans with respect to the four criteria. Below is a summary of the application of evaluation criteria to the comprehensive plans.

Completeness

Completeness is a determination of whether a plan includes all elements necessary to realize planned effects, and the degree that the intended benefits of the plan depend on the actions of others. Several pertinent subfactors that are important in measuring this criterion include: (1) authorization, (2) spectrum of objectives being addressed, (3) reliability, (4) physical implementability, and (5) environmental effects and mitigation.

As can be seen in **Table 6-1**, each plan rates from high to very high for this criterion. Two distinguishing subfactors are (1) objectives being addressed and (2) reliability. CP1, CP2, and CP3 primarily address anadromous fish survival and water supply reliability; however, each alternative indirectly contributes to each of the other objectives, with the exception of ecosystem restoration. Further, the likely reliability and certainty of each of these three plans to meet their intended objectives is very high. These alternatives do not significantly rely on any other actions. However, CP4 specifically focuses on anadromous fish through increasing the minimum carryover storage space in Shasta Reservoir each year, and CP5 focuses on environmental restoration and recreation. With both CP4 and CP5, there would be an increase in operation and maintenance requirements. Accordingly, the overall reliability would be reduced for each alternative.

TABLE 6-1
SUMMARY COMPARISON OF COMPREHENSIVE PLANS

Concept Plans	Comparison Criteria				Relative Ranking
	Completeness	**Effectiveness**	**Efficiency**	**Acceptability**	
CP1 – Mini Raise – 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. Contribution to hydropower and recreation objectives.	Low cost-efficiency. Unit cost for water supply reliability is likely superior to other new sources.	Meets goals of CALFED and consistent with plan in CALFED ROD. High potential for avoiding perceived impacts.	*Moderate*
Relative Rank	*Very High*	*Low*	*Low*	*High*	
CP2 – Mini Raise – 12.5 Feet	Similar to CP1. Significant potential for avoiding/mitigating potential increased impacts.	Moderate potential to effectively address primary objectives. Significant contribution to water supply reliability. Contribution to hydropower and recreation objectives.	Moderate cost-efficiency. Unit cost for water supply reliability is likely superior to other new sources.	Consistent with goals of CALFED. Significant potential for avoiding perceived impacts.	*Moderate to High*
Relative Rank	*Very High*	*Moderate*	*Moderate*	*High*	
CP3 – Mini Raise – 18.5 Feet	Similar to CP1. Significant potential for avoiding/mitigating potential increased impacts.	High potential to effectively address primary objectives. Contribution to hydropower and recreation objectives.	High cost-efficiency. Unit cost for water supply reliability is likely superior to other new sources.	Consistent with goals of CALFED. Significant potential for avoiding perceived impacts.	*High*
Relative Rank	*Very High*	*High*	*High*	*High*	

TABLE 6-1
SUMMARY COMPARISON OF COMPREHENSIVE PLANS (contd.)

Concept Plans	Comparison Criteria				Relative Ranking
	Completeness	**Effectiveness**	**Efficiency**	**Acceptability**	
CP4 – Mini Raise – Anadromous Fish	Significant potential for avoiding/mitigating potential increased impacts. Moderate degree of uncertainty about permanently implementing changed operation for anadromous fish.	Major increases in benefits to anadromous fish but relatively low potential to effectively increase water supply reliability.	Overall cost efficiency very high. Moderate cost-efficiency for water supply reliability.	Consistent with the goals of CALFED for various programs, including water supply reliability.	*High*
Relative Rank	*High*	*Moderate*	*Very High*	*Moderate to High*	
CP5 – Mini Raise – Combination	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.	High potential to address primary planning objectives with emphasis on ecosystem restoration and recreation.	Similar to CP3. High potential for helping restore ecosystem resources and additional recreation near Shasta Lake.	Consistent with the goals of CALFED for various programs, including water supply reliability and ecosystem restoration.	High
Relative Rank	*High*	*High*	*High*	*Moderate to High*	

Key:
CALFED = CALFED Bay-Delta Program CP = comprehensive plan CVP = Central Valley Project ROD = Record of Decision

Another significant subfactor is environmental effects and mitigation. **Table 6-2** is a summary of potential impacts and environmental consequences identified for the comprehensive plans. Impacts are generally comparable between alternatives; some impacts are exacerbated by larger dam raises and the associated scale of those impacts, such as a prolonged construction period and increased area of inundation around Shasta Lake. Generally, the impacts would be mitigable with the measures identified in **Table 6-2**. Some impacts, including the short-term generation of construction-generated emissions in excess of Shasta County Air Quality Management District thresholds, and the temporary exceedence of Shasta County noise level standards, could remain significant and unavoidable despite mitigation measures. Altered flow regimes, changes to the areas inundated by the Sacramento River and Shasta Lake, and disturbances associated with construction activities have the potential to impact environmental resources. These impacts would be largely mitigable. Detailed discussion of the impacts to environmental resources within the primary study area and the appropriate mitigation measures is included in **Appendix F - Environmental Resources**.

Effectiveness

Effectiveness is the extent to which an alternative 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 (decreasing salmon mortality) and (2) increasing habitat for spawning. For the primary planning objective of increasing water supply reliability, ranking was based on the relative amount of new drought period (firm) yield that could be derived from each plan. For the secondary objectives, four relative ranking factors were considered: (1) whether a plan included ecosystem restoration, (2) potential to affect flood peaks downstream from Keswick Dam, (3) potential to increase net power generation, and (4) amount of increased recreation opportunities at Shasta Lake.

As indicated in **Table 6-1**, the plans with the greatest effectiveness in meeting planning objectives appear, at this time, to be CP3 and CP5. This is primarily because both plans would provide the largest contribution toward water supply reliability with significant additional benefits to anadromous fish, hydropower generation, and recreation. Ratings for CP2 and CP4 also ranked well because they would significantly contribute to water supply reliability, as well as provide major benefits to anadromous fish.

TABLE 6-2
SUMMARY OF POTENTIAL ENVIRONMENTAL EFFECTS AND MITIGATION

Resource Area	Impact Description	Applicable Plans[1]	LOS[2]	Mitigation	LOS[3]
Physical Environment					
Topography, Geology, and Soils	Under development				
Geomorphology, Sedimentation, and Erosion	Under development				
Climate and Air Quality	Short-term construction-generated criteria air pollutant and precursor	All	S	Implement measures to reduce short-term construction-generated ROG, NO_x, and PM_{10} emissions	SU
Hydrology	Small decrease in some winter peak flows	All	PS	TBD	TBD
Water Quality	Short-term degradation of water quality during construction	All	S	Avoid or minimize sediment input, prepare Stormwater Pollution Prevention Plan	LTS
				Avoid or minimize construction equipment/vehicle-related contaminants	LTS
Noise and Vibration	Temporary exposure to short-term construction source noise levels	All	S	Implement measures to prevent exposure of sensitive receptors to temporary construction source noise	SU
Hazardous Materials and Waste	Potential exposure of construction workers to hazardous materials and conditions	All	PS	Complete a hazardous materials record search and Phase I Environmental Site Assessment, and implement appropriate measures to prevent exposure of construction workers to on-site hazardous materials	LTS
				Reduce the potential for damage to existing utilities and resulting hazards to construction workers	LTS
Biological Environment					
Aquatic and Fishery Resources	Short-term increase in sedimentation and turbidity during construction	All	S	See mitigation measures described above for water quality	LTS
	Short-term degradation of water quality and fish habitat from accidental spills or seepage of hazardous materials during construction	All	S	See mitigation measures described above for water quality	LTS
Vegetation and Habitat Types	Temporary disturbance and/or permanent loss of oak communities resulting from construction-related disturbances	All	PS	Avoid impacts to oak communities and implement an Oak Woodland Mitigation Plan to compensate for unavoidable impacts	LTS
	Altered structure and species composition and loss of oak communities	All	PS	Compensate for unavoidable impacts to oak communities resulting from altered flow regime	LTS
	Temporary disturbance and/or permanent loss of riparian or wetland plant communities resulting from construction-related disturbances	All	PS	Avoid construction-related disturbance and/or loss of riparian and wetland communities to extent feasible, comply with Corps and CDFG processes to mitigate unavoidable effects	LTS
	Altered structure and species composition and loss of riparian and wetland plant communities	All	PS	Develop and implement a Riparian and Wetland Communities Mitigation Plan to avoid and compensate for impact of altered flow regimes on these communities	LTS
Special-Status Species	Disturbance or removal of habitat for special-status wildlife associated with dam construction	All	PS	Avoid construction impacts on special-status wildlife and their habitats, and mitigate for unavoidable impacts	LTS
	Disturbance or removal of upland habitat for special-status plants due to dam construction, staging areas, and aggregate mining	All	PS	Avoid impacts to special-status plant species in the primary study area	LTS

TABLE 6-2
SUMMARY OF POTENTIAL ENVIRONMENTAL EFFECTS AND MITIGATION (CONTD.)

Resource Area	Impact Description	Applicable Plans[1]	LOS[2]	Mitigation	LOS[3]
Biological Environment (continued)					
Special-Status Species (contd.)	Impacts to special-status wildlife resulting from modifications to existing flow regimes	All	PS	Implement measures to reduce impacts to special-status wildlife resulting from modifications to existing flow regimes	LTS
	Disturbance or removal of wetland or in-channel habitat for special-status plants due to altered flow regimes, changes in seasonal water availability, and increased inundated width of the Sacramento River and affected tributaries	All	PS	Develop and implement a Riparian and Wetland Communities Mitigation Plan to avoid and compensate for the impact of altered flow regimes on riparian and wetland communities	LTS
Cultural Environment					
	Under development				
Socioeconomic Environment					
Business and Industrial Activity	Potential temporary reduction in project water or hydropower to extended study area during construction	All	PS	Secure replacement water or hydropower	LTS
Public Health and Safety	Potential wildland fire hazard	All	PS	Prepare an Emergency Response Plan and implement recommended measures	LTS
	Public exposure to health risks associated with insect vectors (mosquitoes)	All	PS	Implement measures to reduce public exposure to health risks associated with insect vectors (mosquitoes)	LTS
Aesthetics	Long-term changes in scenic vistas, scenic resources, and existing visual character	All	PS	Design the dam raise to be consistent with and maintain the existing aesthetic qualities of Shasta Dam; prepare visual simulations to further analyze potential visual impacts	TBD
Traffic and Transportation	Temporary construction-related traffic delays and access restrictions, including potential delays in emergency response	All	PS	Prepare a Traffic Impact Analysis and implement recommended mitigation measures	LTS
	Temporary construction-related increases in traffic hazards on local roadways near construction areas	All	PS	Prepare and implement a Traffic Control and Safety Assurance Plan for short-term construction-related traffic	LTS
	Potential for temporary construction-related disruptions to transit service	All	PS	Prepare and implement a Traffic Control and Safety Assurance Plan, and coordinate with transit providers to ensure that disruptions are minimized	LTS
Utilities and Public Services	Damage of public utility infrastructure and temporary disruption of service during construction	All	PS	Reduce the potential for damage to existing utilities	LTS
	Relocation or modification of utility infrastructure from construction and operation of the project	All	PS	Reduce the potential for damage to existing utilities	LTS
Social Environment (including Environmental Justice)	Short-term and adverse effects caused by construction activities	All	PS	Under development	

Key: NO_x = nitrogen oxide PM_{10} = fine particulate matter ROG= reactive organic gas
Notes:
1. Excluding No-Action Plan
2. LOS = Level of Significance: PS = Potentially Significant S = Significant
3. LOS = Level of Significance with Mitigation: TBD = To Be Determined SU = Significant (Unavoidable) LTS = Less Than Significant

Efficiency

Efficiency is the measure of how efficiently an alterative alleviates identified problems while realizing specified objectives consistent with protecting the Nation's environment. The relative rank in **Table 6-1** is based primarily on likely net benefits obtained for each plan. CP1, which would provide the lowest net benefits, was assigned a relative efficiency rank of low and CP4, which would provide the highest net benefits, was assigned a rank of very high (see net benefits in **Table 6-3**). Based on estimated net benefits, the other plans were assigned ranks between these two values. **Table 6-3** includes an estimate of the monetary costs and benefits as well as net benefits for each of the comprehensive plans, and under two conditions – existing and future. As shown, under existing conditions, all of the plans except CP1 would be economically feasible and under future conditions, all plans would be economically feasible. The future conditions in **Table 6-3** are an attempt to account for the relative increasing value of water supplies due to demand increases and supply reductions. As mentioned, under either condition, it appears that CP4 has the potential to provide the greatest net economic benefits. This is primarily because of the significant high potential increase in anadromous fish. However, the water supply reliability benefits of this plan would be moderate.

As can be seen in **Table 6-3,** there is a separate benefit category for Shasta Dam Public Safety that has been added to the monetary benefits shown in **Table 5-7**. This benefit is set equal in this report to a preliminary estimate of the annual costs associated with obtaining increases in public safety at Shasta Dam. As mentioned, it is estimated that Shasta Dam and Reservoir can currently pass all of the estimated Probable Maximum Flood (PMF) from the upper tributary watershed, but only if all of the seasonally dedicated flood control storage space of 1.3 million acre-feet (MAF) is available at the start of the event. Raising Shasta Dam offers the opportunity to further increase the reliability of safely passing the PMF through accomplishing the event routing under an assumption that the reservoir would be full at the beginning of the PMF. It is not practical to accurately estimate the extent of monetary benefits from increasing the reliability of preventing catastrophic flooding throughout the Northern California watershed. Accordingly, as mentioned for this report, the benefits of accomplishing this increase to public safety have been set equal to the annual costs. For this evaluation, it is estimated that about 20 percent of the construction costs related to raising Shasta Dam would be attributable to safely passing the PMF. **Table 6-4** includes an estimate of the construction and annual costs attributable to Shasta Dam Public Safety for each of the comprehensive plans.

TABLE 6-3
SUMMARY OF PLAN ACCOMPLISHMENTS AND COSTS

Item	CP1	CP2	CP3	CP4	CP5
Raise Shasta Dam (feet)	**6.5**	**12.5**	**18.5**	**18.5**	**18.5**
Total Increased Storage (TAF)	256	443	634	634	634
Accomplishments					
Anadromous Fish					
Dedicated Storage (TAF)	--	--	--	378	--
Production Increase (thousand fish) [1]	366	367	509	1,503	509
Water Supply Reliability (TAF/year) [2]	91	106	133	91	133
Ecosystem Restoration (habitat units)	--	--	--	--	--[3]
Hydropower Generation (GWh/year)	17	42	54	94	54
Recreation (increased user days, thousands)	83	141	224	224	--[3]
Economics ($ millions) [4]					
Cost					
Construction Cost	531.3	679.2	825.2	825.2	854.9
Annual Cost	31.4	40.2	48.8	48.8	50.6
Annual Benefits					
Existing Conditions [5]	27.9	35.9	43.4	71.0	45.1 [6]
Shasta Dam Public Safety [7]	3.0	4.6	6.2	6.2	6.2
Subtotal	30.9	40.5	49.6	77.2	51.4
Potential Future Conditions [8]	38.5	50.8	59.9	84.8	61.7
Net Benefits					
Existing Conditions	-0.5	0.3	0.8	28.4	0.8
Potential Future Conditions [8]	7.1	10.6	11.1	36.0	11.1

Key:
CP = Comprehensive Plan   GWh/year = gigawatt-hours per year   TAF = thousand acre-feet
-- = not applicable
Notes:
1. Average annual increase in juvenile Chinook salmon surviving to migrate downstream from the Red Bluff Diversion Dam. Numbers were derived from Salmod (see **Appendix F – Environmental Resources**).
2. Total drought period reliability to the Central Valley Project and State Water Project.
3. The extent of ecosystem restoration and increased recreation due to added facilities is under development. Recreation use will surpass that for CP3 and CP4.
4. Based on October 2006 price levels, 5-1/8 discount rate, and 100-year period of analysis.
5. Economic benefits from **Table 5-7**.
6. Annual benefits for ecosystem restoration and additional recreation are assumed at least equal to increases in annual costs. Studies are underway.
7. Benefits set equal to average annual costs for Shasta Dam Public Safety shown in Table 6-4.
8. Includes increase of water supply costs at 2 percent above inflation to account for growing scarcity of available supplies in the future. Complete sensitivity analyses for changes in water supply and hydropower benefits are included in **Appendix C – Economic Analysis**.

TABLE 6-4
SHASTA DAM PUBLIC SAFETY COSTS/BENEFITS

Item	CP1	CP2	CP3	CP4	CP5
Construction Cost					
Total	531.3	679.2	825.2	825.2	854.9
Shasta Dam Public Safety	50.6	77.8	105.0	105.0	105.0
Annual Cost					
Total Annual Cost	31.4	40.2	48.8	48.8	50.6
Shasta Dam Public Safety	3.0	4.6	6.2	6.2	6.2

Key:
CP = Comprehensive Plan

Acceptability

Acceptability is the workability and viability of a plan with respect to its potential acceptance by other Federal agencies, State and local governments, and public interest groups and individuals. This evaluation criterion will be very important following completion of the Plan Formulation Report (PFR) and endorsement by a non-Federal sponsor of the comprehensive plans. However, at this stage of planning, it appears that all of the comprehensive plans would be similarly ranked. Each of the plans needs to be coordinated with other agencies and public interests.

SUMMARY OF COMPARISONS

It should be noted that, overall, each of the plans is complete, each is effective in achieving its intended objectives, and each is cost efficient.

Table 6-1 includes an overall comparison of the five comprehensive plans. At this stage of plan formulation, it appears that the three comprehensive plans involving a mini raise of 18.5 feet (CP3, CP4, and CP5) best address the planning objectives. This is primarily because of (1) a high certainty (completeness) that the plan could achieve its intended benefits and (2) relatively high effectiveness and economic efficiency. Specific ecosystem restoration and additional recreation facility opportunities in and around Shasta Lake are not complete at this time. Completion of these activities will contribute to final conclusions on the economic benefits of the plans.

It is important to understand that none of the plans include environmental restoration or further developed recreation facilities around Shasta Lake. For this reason, no plan is specifically identified as a preferred plan in this PFR. The full potential for environmental restoration and increased recreation opportunities remains under development at this time. The United States Forest Service (USFS) is very interested in adding recreation features as part of any project to modify Shasta Dam and Reservoir. Accordingly, as part of future studies, either additional environmental restoration and/or recreation features could be added to any or all of the comprehensive plans. When all relevant information is gathered, a plan will be chosen as the Tentatively Selected Plan (TSP) for the draft Feasibility Report. At that time, a complete cost allocation and apportionment will be developed for that plan.

At this stage in the planning process, the alternative that appears to provide the greatest net economic benefits is CP4 (see **Table 6-3**). Accordingly, a summary description of this plan is provided in the next section. In addition, an example of a cost allocation and apportionment was developed using the specific costs and benefits of CP4. This treatment of costs is preliminary and provided for illustration purposes only.

CP4 Project Description

An initial summary of CP4 is contained in **Chapter 5**. Following is a supplemental description of this plan. This description is presented here for illustration purposes. It will evolve into a detailed description of the TSP in the draft Feasibility Report. It is also included here to illustrate in the next section how cost allocation is being considered for the SLWRI.

Major Components

As mentioned in **Chapter 5**, major components of CP4 include the following:

- Raising Shasta Dam by 18.5 feet
- Dedicating 378,000 acre-feet of the increased storage in Shasta Reservoir to maintaining cold water volume
- Acquiring, restoring, and reclaiming one or more inactive gravel mines along the upper Sacramento River
- Implementing common features as follows:
    - **Modify Temperature Control Device (TCD) –** Raising existing structure and modifying the shutter control to increase the operating range or effectiveness of the structure.
    - **Modify Flood Control Operations –** Modify existing flood control operational guidelines or rule curves.
    - **Increase Public Safety At Shasta Dam –** Route PMF from the top of Shasta Reservoir conservation pool.
    - **Modify Hydropower Facilities –** Modify to the existing hydropower facilities at the dam to enable their continued use.
    - **Demand Reduction –** Implement best management practices focusing on improving the efficient use of agricultural water supplies in the Central Valley as part of the Central Valley Project (CVP).

With a dam raise of 18.5 feet, the gross pool elevation in Shasta Reservoir would be raised by 20.5 feet. The capacity of the reservoir would increase by 634,000 acre-feet to a total of 5.19 MAF. Several specific features of the plan are listed below. Detailed information about these features is included in **Appendix B – Engineering Summary**.

- **Lands –** CP4 would result in an increase in gross pool area of about 2,570 acres. This amounts to an average increase in landward encroachment of water surface around the reservoir at gross pool of about 50 feet. This distance would be greater along inflowing streams and creeks.

Nearly all of the increased gross pool area is on Federal property. Small amounts of lands at the headwaters of several inflowing streams and possible in the Lakeshore area may require acquisition.

- **Clearing of Reservoir Area –** Additional acreage that would be inundated at the new gross pool would need to be cleared. This would include trees and other vegetation from around the reservoir shoreline.
- **Dam Crest Structure Removal –** Existing structures on the dam crest would need to be removed. These structures include the gantry crane, existing spillway drum gates and frames, spillway bridge, concrete in the spillway crest and abutments, the parapet walls and crest cantilever, sidewalks, curbing, crane rails, cantilever support walls, and control equipment.
- **Main Gravity Dam –** A raise of Shasta Dam would be accomplished by placing mass concrete corresponding in width to the existing dam monolith blocks on 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 –** The existing wing dams at Shasta would be raised to tie the concrete gravity section into the left and right abutments. Wing dams would be composed of compacted clayey gravel, similar to the material used in the original wing dam construction.
- **Spillway –** The three existing 110-foot-wide by 28-foot-high drum gates would be removed and replaced with six radial gates, two each in the existing three bays. Each gate would be approximately 52 feet wide by 38 feet high, which is a size needed to pass the desired future spillway discharge and provide a minimum of 6 inches of freeboard with respect to the normal maximum headwater level.
- **River Outlets –** Shasta Dam has 18 river outlets arranged in three tiers. The lower tier tube valves would require replacement.
- **Temperature Control Device –** Modifications to the TCD 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/replacing the shutter operating cables.
- **Reservoir Area Dikes –** Diking would be required in the areas of Antlers/Lakeshore and at the Union Pacific Railroad (UPRR) track between Tunnels 1 and 2 at the south end of Bridge Bay for protection of major existing infrastructure from increased gross pool elevations. The typical section estimated for all dike locations is a zoned embankment (impervious core with pervious shell material).
- **Pit 7 Dam and Powerplant –** Raising Shasta Dam would back up water onto the downstream spillway flip bucket lip and onto the powerhouse wall. However, no revisions are recommended for the Pit 7 spillway, provided operating procedures are developed that limit the Shasta gross pool to elevations below the existing bucket lip during periods of the year when

discharges at Pit 7 are likely to exceed 40,000 cubic feet per second. If this method of operation, or level of risk, is found unacceptable as part of future studies, the flip bucket would need to be modified. Future studies are needed to assess the effect of the potential for increased uplift due to higher water surface elevations on the stability of the powerhouse and afterbay dam. There may be periods during which generating capacity is reduced at Pit 7 facilities.

- **Pit River Bridge Modifications –** Raising Shasta Dam 18.5 feet and increasing the gross pool elevation by 20.5 feet would result in inundation of the tops of Piers 3 and 4. To mitigate this impact, CP4 includes constructing reinforced concrete structures that would be attached to the existing piers and extend out as cantilevers in the direction parallel to the tracks with a closure wall around the perimeter. The concrete structure would be designed to provide protection to the bridge lower chord steel, allowing for a minimum freeboard of 4 feet above the gross pool.

- **Railroad Bridge Relocations –** Two UPRR bridges would need to be relocated: Doney Creek Bridge and Sacramento River Bridge, Second Crossing.

- **Vehicle Bridge Relocations –** The following vehicle bridges would need to be relocated due to the increased reservoir levels: Charlie Creek Bridge, Doney Creek Bridge, McCloud River Bridge, Didallas Creek Bridge, and Second Creek Bridge.

- **Major Roads and Road Segments –** About 115 road segments of existing paved and unpaved roads would be impacted and require either abandonment or relocation.

- **Buildings – Resort/Marina, Residential, USFS Facilities** - Based on a 2003 infrastructure inventory at Shasta Reservoir, an estimated 130 buildings would be impacted by the 18.5-foot dam raise (20.5-foot gross pool raise). The types of buildings have been categorized into three groups: residential (cottages, homes, etc.), commercial (resorts, marinas, stores, etc.), and USFS sites (stations, campground buildings, recreation site restrooms, etc.). The main communities with buildings that would be affected by an 18.5-foot dam raise are Sugarloaf and Lakeshore. Bridge Bay Resort and Marina is the largest resort and marina complex on Shasta Lake, and one of the largest inland marinas in the western United States. Several of the main buildings are located within a few feet of the current joint use pool elevation and would require relocation.

- **Utilities and Miscellaneous Minor Infrastructure –** CP4 includes relocating various utility facilities, septic systems, and other miscellaneous minor infrastructure.

Major Accomplishments

Following are the major accomplishments of CP4:

- **Anadromous Fish Survival –** Raising Shasta Dam by 18.5 feet would increase the cold water pool and benefit seasonal water temperatures along the Sacramento River. As mentioned, this plan includes dedicating about 60 percent (378,000 acre-feet) of the increased storage to increasing the cold water pool at Shasta. It is estimated that improved water temperature conditions could result in an average increase in the salmon population of about 1,503,000 fish per year.

- **Water Supply Reliability –** CP4 would increase water supply reliability by adding to replacement of supplies redirected to other purposes of the Central Valley Project Improvement Act (CVPIA). This would help reduce estimated future shortages by increasing critical and dry period supplies by at least 91,000 acre-feet per year. This increase in reliability would help reduce CVPIA-redirected supplies during drought years by about 15 percent.

- **Hydropower –** The higher water surface elevation in the reservoir would result in a net increase in power generation of about 54.5 gigawatt-hours per year.

- **Other Accomplishments –** CP4 does not include specific measures to benefit the secondary planning objectives of environmental restoration, recreation, or flood control. However, there would be incidental benefits 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 2,500 acres (8 percent), from 29,600 to about 32,100 acres.

Economics

- **Costs –** The estimated total construction cost of CP4 is $825.2 million. The estimated total annual cost of this plan is $48.8 million.

- **Benefits –** The total estimated average annual monetary benefit for existing conditions of CP4 is $77.2 million (all benefit categories including Shasta Dam public safety). The resulting net economic benefit, again for existing conditions, is about $28.4 million.

Cost Allocation and Apportionment

Below is a summary description of cost allocations for Federal water resources projects. Also included is a preliminary example allocation and apportionment of costs for CP4. A more detailed description of cost allocation and its application for the SLWRI is included in **Appendix A – Plan Formulation**.

Basic steps associated with cost allocation and apportionment includes the following:

- Identify costs to be allocated
- Allocate costs to project purposes
- Apportion costs to beneficiaries

Costs to be allocated include construction costs, other costs (sunk costs), interest during construction, and annual operation, maintenance, and replacement costs. It should be noted that cost allocation is a financial exercise rather than an economic evaluation. Consequently, project costs may be presented differently in a cost allocation than in an economic analysis.

Once all project costs have been identified, they are allocated to the project purposes. *Specific costs* are for project components that contribute to a single purpose, for example, the cost of recreation facilities around a multipurpose reservoir. *Separable costs* are the costs that are specifically necessary because a purpose is included in a multipurpose project. Separable costs include specific costs and may include a portion of joint costs. They are estimated as the reduction in financial costs that would result if a purpose were excluded from an alternative. Remaining *joint costs* are the costs remaining after specific and separable costs have been removed.

The cost allocation process is designed so that costs associated with project purposes can be apportioned to beneficiaries for repayment. Once costs are allocated to appropriate purposes, they can be apportioned to the Federal Government and non-Federal sponsor(s) based on specific project authorization and/or established Federal cost-sharing laws and regulations.

Federal costs are designated as either reimbursable or nonreimbursable. Reimbursable costs are those that, through some form of up-front cost sharing, repayment, or other financial agreement, are repaid to the Government. Nonreimbursable costs are those borne entirely by the Federal Government. Based on existing legislation, costs allocated to irrigation and municipal and industrial water supply, fish and wildlife enhancement, environmental restoration, flood control, and hydropower purposes are either fully or partly reimbursable by project beneficiaries. Existing legislation that provides cost-sharing relationships for purposes that may be included in the SLWRI is summarized in **Table 6-5**.

It should be noted in **Table 6-5** that Shasta Dam public safety opportunities are not included at this time. This is because, although public safety is associated with flood control, it is not yet a formal project purpose at Shasta Dam. However, for cost allocation purposes public safety is being treated in this PFR similarly to traditional dam safety, although it does not fall under the Reclamation Safety of Dams Program. At this time, CP4, as described above, does not include features for recreation or environmental restoration. These purposes will be further evaluated as part of the feasibility study for possible inclusion into the TSP for the draft Feasibility Report.

TABLE 6-5
EXISTING AUTHORITIES FOR FEDERAL FINANCIAL PARTICIPATION IN MULTIPURPOSE WATER RESOURCES PROJECTS[1]

Purpose	Pertinent Legislation	Description
Irrigation Water Supply	Reclamation Act of 1902, as amended	Reimbursable. These acts provide for up-front Federal financing of irrigation water supply purposes, with 100% repayment of capital costs and O&M costs by non-Federal.
M&I Water Supply	Reclamation Act of 1902, as amended	Reimbursable. These acts provide for up-front Federal financing of M&I water supply purposes, with 100% repayment of capital costs (including IDC and interest over the repayment period); 100% of O&M costs are non-Federal.
Hydropower	Reclamation Act of 1906, as amended	Reimbursable. Similar to M&I Water Supply.
Fish and Wildlife Enhancement	(research underway)	Nonreimbursable. Provides for 100% Federal cost-sharing of certain purposes of a project viewed as National in scope.
	Federal Water Project Recreation Act of 1965 (PL 89-72), as amended	PL 89-72 provides Federal cost-sharing of up to 75% for fish and wildlife facilities, including planning, design, and IDC. Annual O&M and replacement costs would be a non-Federal responsibility.
Recreation [2]	Whiskeytown-Shasta-Trinity National Recreation Area (PL 89-336)	Nonreimbursable. Provides authority for implementation at 100% Federal cost-sharing of recreation facilities in Whiskeytown-Shasta-Trinity NRA.

Key:
IDC = interest during construction
NRA = National Recreation Area
O&M = operation and maintenance
M&I = municipal and industrial
PL = Public Law

Notes:
1. Public safety was not addressed in this table. It is considered a reimbursable cost similar to flood control and is apportioned in this PFR accordingly. It will be included in further efforts for the SLWRI.
2. Although recreation is not a feature of CP4 for the SLWRI, potential exists for adding recreation as part of further studies for the Feasibility Report.

Preliminary Cost Allocation

The following provides an example of how the cost of CP4 might be allocated to project purposes. The separable costs-remaining benefits (SCRB) analysis shown below was performed based on information developed to date and will be further modified in future evaluations. It is also important to note that the largest portion of CP4 costs (total cost of $825 million) is to implement plan features required to accomplish the study objectives (currently estimated at $720 million). About $105 million of CP4 is believed needed specifically to address public safety features to enhance the potential to pass the PMF. The allocation of costs to meeting the planning objectives and costs for public safety will be developed in further studies. For the allocation below, the annual economic benefits of public safety opportunity features are assumed to equal the annual costs. These costs are included in the total project cost during the allocation process and for cost apportionment.

The first step in the cost allocation process, described in **Appendix A – Plan Formulation**, included defining single purpose alternatives for each of the four planning objectives included in CP4. Following this, separable costs of each project were defined. Separable costs are the difference between the cost of the multipurpose project and the cost of a project with the specific purpose omitted. Next, the estimated joint use cost was defined. As mentioned, the joint use cost is the cost for the combined use of all five purposes of CP4 and cannot be separated into individual purposes. This cost is the difference between the cost of the multipurpose project and the sum of the separable costs. The joint cost is allocated to each purpose based on remaining benefits, which is the difference of the total benefits minus the total separable cost.

A summary of the allocation of costs for CP4 using the SCRB method is summarized in **Table 6-6**.

TABLE 6-6
COST ALLOCATION SUMMARY ($ MILLIONS)[1]

Item	Irrigation Water Supply	M&I Water Supply	Fish and Wildlife Enhan.	Hydro-power	Public Safety	Total
Allocation of Annual Costs						
Average Annual Benefits	8.7	4.6	45.5	4.8	6.2	69.8
Alternative Costs	25.5	5.9	46.1	2.4	6.2	86.1
Annual Benefits Limited by Costs	8.7	4.6	45.5	2.4	6.2	67.4
Separable Annual Costs	6.5	1.2	16.9	0.0	6.2	30.7
Remaining Annual Benefits	2.2	3.4	28.6	2.4	0.0	36.7
Percent Remaining Benefits	6.1%	9.4%	77.9%	6.5%	0.0%	100.0%
Allocated Joint Annual Costs	1.1	1.7	14.1	1.2	0.0	18.1
Total Allocated Annual Costs	7.6	2.9	31.0	1.2	6.2	48.8
Allocated Construction Costs						
Specific Investment Cost	0.0	0.0	0.0	0.0	0.0	0.0
Joint Use Investment	141.5	53.4	580.4	22.1	116.3	913.7
Joint Use IDC	13.7	5.2	56.2	2.1	11.3	88.5
Joint Use Construction Cost	127.8	48.2	524.2	20.0	105.1	825.2
Percent Construction Joint Use	15.5%	5.8%	63.5%	2.4%	12.7%	100.0%
Total Construction Cost	**127.8**	**48.2**	**524.2**	**20.0**	**105.1**	**825.2**

Key:
Enhan. = enhancement IDC = interest during construction M&I = municipal and industrial
Note:
1. All numbers are rounded for display purposes, and therefore line items may not sum to totals.

Preliminary Cost Apportionment

Table 6-6 shows a preliminary estimate of the apportionment of costs for CP4 for the SLWRI. The apportionment percentages shown are based on those included in **Table 6-5**. As can be seen, the apportionment of costs includes costs to accomplish four study objectives plus public safety. These costs amount to $825.2 million. As can be seen in **Table 6-7**, of the costs allocated to achieving CP4, approximately 74 percent are estimated to be a Federal responsibility and about 26 percent a non-Federal responsibility.

TABLE 6-7
PRELIMINARY COST APPORTIONMENT [1]

Purpose/Action	Total		Cost Apportionment			
			Federal		Non-Federal	
	Percent	Cost ($ million)	Percent	Cost ($ million)	Percent	Cost ($ million)
Irrigation Water Supply	15.5	127.8	0	0	100	127.8
M&I Water Supply	5.8	48.2	0	0	100	48.2
Fish & Wildlife Enhancement	63.5	524.2	100	524.2	0	0
Hydropower	2.4	20.0	0	0	100	20.0
Public Safety	12.7	105.1	85	89.3	15	15.8
Total	**100.0**	**825.2**	**74**	**613.5**	**26**	**211.8**

Key: M&I = municipal and industrial
Notes:
1. All numbers are rounded for display purposes, and therefore line items may not sum to totals.

CHAPTER 7
IMPLEMENTATION CONSIDERATIONS, STUDY MANAGEMENT, AND PUBLIC OUTREACH

Development of this Plan Formulation Report (PFR) revealed several factors, considerations, and other related requirements that will need to be evaluated as part of the Shasta Lake Water Resources Investigation (SLWRI). Combined, these various issues represent implementation considerations this investigation will seek to resolve through its study management structure, and with the active participation of stakeholders and the public. This chapter describes the various implementation considerations: uncertainties, special considerations, regulatory and related requirements, the SLWRI study management structure, and the investigation's current and future public outreach and involvement activities.

UNCERTAINTIES

With each aspect of this report, certain assumptions were made based on engineering and scientific judgment. Careful consideration was given to the methodologies and evaluations for hydrology and system operations, cost estimates, and biological analyses. Analyses were developed with advanced modeling and estimating tools using historical data and trends. While this is an effective way to predict outcomes for future operations, biological conditions, and costs, many uncertainties could affect the findings of this PFR. Various uncertainties associated with the SLWRI are discussed below.

Hydrology

Uncertainties associated with hydrology include the potential for climate change, which could possibly produce conditions that are different from those for which current water management operations were designed. The potential for, and magnitude of climate change is widely debated. The State is investing significant resources in studying how global climate changes could affect the way California receives and stores water. Results indicate that climate changes in the State could affect hydrology, water temperatures for fish, and future operations for both flood control and water supply deliveries.

According to the 2005 California Water Plan Update, California could see changes in temperature, precipitation, and snow level (DWR, 2005). Any measurable change in these climate indicators could affect future water operations in California. It is unlikely that changes in snow levels would significantly affect Shasta Reservoir because the reservoir is primarily filled by direct rainfall runoff, as opposed to snowmelt. However, changes in water management operations downstream and in the Sacramento-San Joaquin River Delta (Delta) could affect Shasta Reservoir operations. If precipitation increases, it may further enhance the benefits of increased reservoir capacity. According to the California Water Plan Update (2005), more studies are needed before definitive answers can be given:

> In general, while modeling of projected temperature changes is broadly consistent across most modeling efforts, there are disagreements about

> precipitation estimates. Considerable uncertainties about precise impacts of climate change on California hydrology and water resources will remain until we have more precise and consistent information about how precipitation patterns, timing, and intensity will change. Further work is in progress to extend and improve these modeling efforts, and to use watershed-scale hydrological models that will be of more direct value to planners.

Future System Operations

System water operations modeling performed for this report was based on the implementation of currently projected projects identified in the without-project condition. Federal planning policies were used to determine which future projects may or may not be implemented; projects were either included or excluded from these models and evaluations. Many of the projects included in the without-project condition, if not implemented, could influence the findings of this PFR. Additionally, some projects not accounted for in the model could change the findings if they are implemented. Changes in Delta exports could also influence future operations. In addition, changes in hydrology could produce conditions that are different than current operations were designed for.

Cost Estimates

Cost estimates developed for comprehensive plans included this report are based on 2006 price levels. Varying uncertainties are associated with the material and unit costs used to develop the estimates. Unknowns include the price of construction materials (which have risen dramatically in the Nation and the State in recent years), the proximity of materials to the project site, and labor costs. Recent history has shown that material prices, in particular, have increased significantly faster than inflation. Trends from the past few years were used to try to predict the cost of materials in the future, but outside factors could further influence price changes.

Anadromous Fish Population

Anadromous fish are highly affected by changes to their surrounding conditions. Trying to predict fish survival is difficult because of the many factors that influence their survival. The Salmod model used to predict fish survival for this PFR contains assumptions with varying levels of uncertainty. A key uncertainty stems from Salmod using the same number of returning spawners in each year of the simulation. This does not allow for population growth over time; benefits are seen only in the number of survivors in a given year. Independent of the model, uncertainty is also related to water conditions outside the area of influence of the dam raise. These include conditions downstream from the modeled reach of the Sacramento River, in the Delta, and in the Pacific Ocean. Lastly, potential climate change also has the potential to influence fish survival, as described in the 2005 California Water Plan Update:

> Of considerable concern, if California temperatures rise significantly, would be managing salmon and steelhead fisheries. Warmer air temperatures will make it more difficult to maintain rivers cold enough for cold-water fish, including anadromous fish. As a result, river water temperature could warm beyond a point that is tolerable for the salmon and steelhead that currently

stay in these rivers during the summer. Under this scenario, it is doubtful that the existing, cold-water temperature standards in the upper Sacramento River would be able to be maintained.

SPECIAL CONSIDERATIONS

With any large-scale water resources project, no single solution solves all issues for all parties involved. The primary goal for this project is to increase anadromous fish survival and water supply reliability, but not to the detriment of the interests of others. Several aspects of this PFR require special consideration and will need active involvement of the stakeholders in the Shasta area and throughout the state.

- **McCloud River –** Raising Shasta Dam would inundate part of the lower McCloud River. California Public Resources Code 5093.542(c) restricts State participation 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 fisheries. Coordination will continue with landowners on the McCloud River arm, and plan formulation efforts will consider potential impacts to the McCloud River.

- **Native American and Cultural Resources –** The Feasibility Report and Environmental Impact Statement (EIS) will be in compliance with the National Historic Preservation Act and Section 106, and will include a description of supporting analyses, studies, coordination, impacts, and mitigation, as necessary. Although no Federally recognized tribes reside in the immediate Shasta Lake area, the Winnemem band of the Wintu Indians has raised concerns about potential impacts of enlarging Shasta Dam on sites they value for historic and cultural significance. The Winnemem Wintu will have the opportunity to participate and provide input in the Feasibility Report and EIS through the Section 106 process as an invited consulting party as well as through the National Environmental Policy Act (NEPA) process.

- **Recreation –** Detailed study has shown that several marinas and campgrounds will be inundated with gross pool raises of 6.5, 12.5, and 18.5 feet. Although recreation is not an existing project purpose, recreation has been identified as a secondary objective of the SLWRI. Shasta Lake is within the Shasta-Trinity National Recreation Area (NRA); successful implementation of a project that modifies Shasta Dam and Reservoir will require the active involvement of recreation interests.

- **Real Estate –** Real estate, both privately owned and leased from the United States Forest Service (USFS) may be inundated with a raise in the gross pool elevation at Shasta Reservoir. Assessments are underway to determine the extent of potential impacts to lands as well as residences, marinas, commercial facilities, and other reservoir area infrastructure.

- **Water Rights –** Improving the reliability of water supplies is a primary objective of the SLWRI. The water supply reliability accomplishments of each alternative are described in **Chapters 4** and **5**, while water supply modeling results are detailed in **Appendix D – Technical Support, Attachment I – Hydrology, Hydraulics, and Hydropower**. The United States Department of Interior, Bureau of Reclamation (Reclamation), will need to petition the State Water Resources Control Board (SWRCB) for a permit for new or amended water rights. To issue a permit, the SWRCB must find that unappropriated water is available to supply the applicant, and that the applicant's appropriation is in the public interest. Evaluation of water rights will remain a focus of the SLWRI.

REGULATORY AND RELATED REQUIREMENTS

The project will be subject to the requirements of various Federal, State, and local laws, policies, and regulations. Reclamation will be the lead agency for NEPA compliance, and all products will be compliant with the California Environmental Quality Act (CEQA). Moreover, Reclamation will need to obtain various permits and regulatory authorizations before beginning any project construction, and comply with a number of environmental regulatory requirements as part of the NEPA compliance process. **Table 7-1** summarizes background permit information and environmental compliance strategies that may apply to implementation of a project at Shasta Dam. Additional information is provided on these requirements in **Appendix D- Technical Support, Attachment IV – Institutional**.

In addition to the major Federal, State, and local environmental requirements detailed in **Table 7-1,** the alternatives considered may be subject to other laws, policies, or plans. **Table 7-2** summarizes these other laws, policies, and plans that may potentially affect the development of any alternative.

Two important examples of laws, policies, and plans not directly relating to typical environmental compliance and coordination activities include the Whiskeytown-Shasta-Trinity NRA Management Plan and Shasta-Trinity National Forest Management Plan. These plans prescribe management practices for much of the Shasta Lake area and will be important in the formulation and evaluation of alternatives of the SLWRI. Shasta Lake is located within the Whiskeytown-Shasta-Trinity NRA, which consists of the Shasta and Trinity units (managed by USFS) and the Whiskeytown unit (managed by the National Park Service). The Whiskeytown-Shasta-Trinity NRA Management Plan addresses the management of resources, changes in technology, and recreation trends in the Shasta-Trinity National Forest and vicinity. The Shasta-Trinity National Forest Management Plan is subject to the NRA Management Plan. It contains the USFS goals and objectives, USFS standards and guidelines, management prescriptions to be applied to land areas, and management area direction. Alternatives will be developed in coordination with USFS. Other examples include coordinating with the California Department of Boating and Waterways because alternatives may require the relocation of bridges or other structures that may affect boating safety, or obtaining minor permits, such as grading or encroachment permits, from the Shasta County Department of Public Works that will likely be required for all alternatives.

TABLE 7-1
SUMMARY OF MAJOR PERMITS AND APPROVALS POTENTIALLY REQUIRED FOR PROJECT IMPLEMENTATION

Agency and Associated Permit or Approval	Recommended Prerequisites for Submittal[1]	Estimated Processing Time[2]	Anticipated Fees
Federal			
Corps Clean Water Act Section 404 Individual Permit Rivers and Harbors Act Section 10 Permit	• Application • ASIP for submittal to USFWS/NMFS/CDFG • Section 401 Water Quality Certification permit or application • NEPA documentation (environmental compliance documents) • Section 106 compliance documentation • Wetland delineation • Alternatives analysis • Mitigation and monitoring plan	24 months	$100 for Individual permit
USFWS/NMFS Endangered Species Act Section 7 Consultation	• Informal technical consultation regularly • ASIP • Draft environmental compliance document	12 months	None
USFWS/NMFS/CDFG Fish and Wildlife Coordination Act Report	• Informal technical consultation regularly • ASIP • Draft environmental compliance documents	12 months	None
SHPO/ACHP National Historic Preservation Act, Section 106	• Cultural Survey Report • Documentation of consultation with Native American representatives	9 months	None
State			
RWQCB Clean Water Act Section 401 Water Quality Certification	• Application • Fish and Game Code Section 1602 Application • CWA Section 404 permit or application • Draft environmental compliance documents • Mitigation and monitoring plan (if needed)	6 months	$500+
CDFG California Endangered Species Act Section 2081: Incidental Take Permit or 2080.1 Consistency Determination	• Informal technical consultation • Application, if requesting a 2081 Incidental Take Permit • Biological opinion and incidental take statement, if requesting a consistency determination (preferred approach)	6 months after Biological Opinions issued	None
CDFG Fish and Game Code Section 1602 Streambed Alteration Agreement	• Application • Section 401 Water Quality Certification permit or application • CWA Section 404 permit or application • Draft environmental compliance documents • Mitigation plan	9 months	$4,000
The Reclamation Board California Code of Regulations, Title 23: Encroachment Permit	• Application	9 months	None
SWRCB Amended water right	• Application • Draft (possibly final) environmental compliance documents	12 months	$440,000
State Lands Commission Land Use Lease	• Application • Draft environmental compliance documents	9 months	$25
Local			
SCAQMD Authority to Construct and Permit to Operate	• Application • Pre-application meeting (encouraged)	6 months	$75

Note:
1. All permit applications require detailed project description information. Anticipated processing time is estimated based on initial permit applications submittal to permit issuance.
2. From accepted permit application submittal

Key:
ACHP = Advisory Council on Historic Preservation
ASIP = Action-Specific Implementation Plan
CDFG = California Department of Fish and Game
Corps = United States Army Corps of Engineers
CWA = Clean Water Act
NEPA = National Environmental Policy Act
NMFS = National Marine Fisheries Service
RWQCB = Regional Water Quality Control Board
SCAQMD = Shasta County Air Quality Management District
SHPO = State Historic Preservation Office
SWRCB = State Water Resources Control Board
USFWS = United States Fish and Wildlife Service

TABLE 7-2
SUMMARY OF APPLICABLE LAWS, POLICIES, AND PLANS POTENTIALLY AFFECTING THE PROJECT

Level	Laws, Policies, and Plans
Federal	Federal Endangered Species Act
	Section 404 of the Clean Water Act
	Rivers and Harbors Act Section 10
	National Historic Preservation Act, Section 106
	Migratory Bird Treaty Act
	Fish and Wildlife Coordination Act
	Executive Order 11990 (Wetlands Policy)
	Executive Order 11988 (Flood Hazard Policy)
	Executive Order 12898 (Environmental Justice Policy)
	Indian Trust Assets
	Farmland Protection Policy
	Federal Transit Administration
	Essential Fish Habitat
	Executive Order 11312 (National Invasive Species Management Plan)
	National Wild and Scenic Rivers System
	Federal Land Use Policies
	Whiskeytown-Shasta-Trinity National Recreation Area Management Plan
	Whiskeytown-Shasta-Trinity National Recreation Act
	Shasta-Trinity National Forest Management Plan
	Federal Energy Regulatory Commission
	U.S. Coast Guard
	Uniform Relocations Assistance and Real Properties Acquisition Act of 1970, as amended (PL 91-646 and PL 100-17)
State	California Public Resources Code
	Clean Water Act Section 401
	California Endangered Species Act
	California Fish and Game Code—Fully Protected Species
	California Fish and Game Code Section 1602—Streambed Alteration
	Porter-Cologne Water Quality Control Act
	California Native Plant Society Species Designations
	Reclamation Board Encroachment Permit
	California Water Rights
	State Lands Commission Land Use Lease
	State of California General Plan Guidelines
	California Department of Transportation
	California Land Conservation Act of 1965 (Williamson Act)
	California Native Plant Protection Act
	California Department of Boating
	California Scenic Highway Program
	California Wild and Scenic Rivers Act
Local	SCAQMD Authority to Construct and Permit to Operate
	Shasta County Building Division Grading Permit
	Shasta County Zone Plan
	Shasta County Department of Public Works Encroachment Permit
	Shasta County General Plan
	Other Local Permits and Requirements

Key:
PL = Public Law
SCAQMD = Shasta County Air Quality Management District

STUDY MANAGEMENT

Reclamation has established a study management structure primarily consisting of a Project Coordination Team (PCT), Study Management Team (SMT), and Technical Work Groups (TWG). Responsibilities for each team and group are summarized as follows:

- **Project Coordination Team –** The PCT consists of the Project Manager; an interdisciplinary team consisting of engineering, environmental resources, hydropower, recreation, reservoir water operations, archaeology, public involvement, and project support resources; the consultant team; and representatives from participating resource agencies, such as the California Department of Water Resources, United States Fish and Wildlife Service, National Marine Fisheries Service, and USFS. The PCT directs work performed by the TWG, directs public involvement activities, coordinates general public input, and coordinates results into the investigation.

- **Study Management Team –** The SMT consists of management and/or policy level individuals from participating agencies. Each team member is responsible for ensuring that PCT members are provided sufficient resources and direction to efficiently participate in the development of the investigation. The SMT provides policy direction for the investigation, and ensures participating agency views are addressed. The Project Manager participates in the SMT by providing administrative and technical information and ensures coordination between the PCT and SMT.

- **Technical Work Groups –** The TWG will focus on specific technical studies such as designs and costs, environmental studies, plan formulation, hydrologic and hydraulic modeling, and recreation issues. The TWG will work closely with the PCT, stakeholders, and the public.

At the onset of the investigation, it was recognized that stakeholder and public participation is critical to the success of the investigation. Both the PCT and TWG coordinate closely with stakeholder and public involvement efforts.

Public Involvement Plan

A Strategic Agency and Public Involvement Plan (Plan) for the SLWRI, which continues to evolve, is designed to help the PCT develop methods to effectively communicate with individuals, groups, and agencies that are affected by, or could benefit from, enlarging or modifying Shasta Dam. Compliance with 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 are critical components of the Plan.

The four objectives of the Plan are as follows:

- **Stakeholder Identification –** This effort is ongoing and consists of identifying and involving individuals, groups, and other entities that have an expressed or implied interest in the investigation.

- **Project Transparency –** Success of the investigation will rely on project transparency, i.e., keeping stakeholders and the public informed of study results in a timely, unbiased fashion. To accomplish this, the distribution of information will occur through a variety of methods, including stakeholder and/or public meetings, Web postings, and mailings.

- **Issues and Concerns Resolution –** Equally important as project transparency is gaining awareness of the issues and concerns of stakeholders and the public, and establishing a mechanism for the PCT to learn of problems early. Using various public involvement processes, the PCT has addressed, and will continue to address, issues and concerns in an effective and timely manner.

- **Project Implementation –** Critical to developing an implementable project is ensuring policy-makers understand the project purpose and benefits, and conclude that the project has met all requirements necessary to be implemented. Ensuring policy-makers receive the necessary information to make this informed decision is an important component of the Plan.

The Plan maintains two primary themes: outreach and information. Within these themes are procedures that enable the overall investigation not only to satisfy the public involvement requirements of NEPA and California Environmental Quality Act (CEQA), but to ensure stakeholders and the public have the opportunity to effectively participate in the development of the investigation.

Outreach

Within the Plan are four main outreach elements to assist in coordinating the study efforts. Outreach efforts include (1) stakeholder/public meetings/workshops, (2) tribal coordination, (3) TWG coordination, and (4) PCT and SMT activities.

Stakeholder/Public Meetings/Workshops – Stakeholders/public meetings/workshops have had, and will continue to play, a major role in the overall study process. A series of meetings/workshops have been held to date (see next section) with future public meetings and/or workshops to be scheduled at critical milestones in the investigation.

Tribal Coordination – Consistent with the President’s April 29, 1994, Memorandum, Reclamation will actively engage Federally recognized tribal governments in planning and development of the investigation, and will consult with each tribe on a government-to-government basis prior to taking actions that could 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 will receive comments and/or alternatives. Outreach efforts for this component will mirror outreach efforts developed under this Plan. In addition, several groups, such as the Winnemem Wintu and Shasta Nation, have expressed significant interest in the investigation. They, too, will have the opportunity to participate and provide input in the study and the Section 106 process.

Environmental Justice – Consistent with Executive Order 12898, Reclamation will actively engage with minority populations and low-income populations in planning and developing the investigation. Outreach efforts for this component will mirror outreach efforts developed under this Plan and will be modified to meet any specific communication needs necessary to effectively communicate with minority populations.

Technical Work Group – Efforts will also continue in developing effective TWG. As the comprehensive alternative plans become more defined, the TWG will also become more focused. Resources areas of importance include water supply reliability, ecosystem and environmental restoration and enhancement, water marketing and exchange, water policy and legislation, local land and property rights, regional economic impacts, environmental justice, recreation, and others to be identified through the public involvement process.

PCT and SMT Activities – As previously described, the PCT includes the Project Manager and technical experts from various disciplines and organizations, while the SMT comprises key policy and decision-makers with direct influence over policy guidance for the study.

Information Dissemination

To ensure project transparency and to keep stakeholders and the public informed, study-related information has, and will continue to be, disseminated in a number of ways.

- **Project Updates –** Project update notices have been developed and more are planned. The timing of the notices to date has corresponded with major study milestones. This will continue in the future. The purpose of the updates is to keep stakeholders and the public informed of the study progress and alert them to major upcoming events.

- **Project Information Papers –** Two project information papers have been prepared. One supported outreach efforts for the 2003 Mission Statement Milestone Report (MSMR) and the second was released in the summer of 2004 to support the Initial Alternative Information Report (IAIR). It is intended that future information papers will be prepared and distributed to support the PFR and draft 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 for the study include news releases, media advisories, calendar advisories, editorial board visits, letters to the editor, and opinions/editorials. The media relations effort is flexible to ensure prompt responses to comments, questions, or information regarding the study.

- **Speakers Bureau –** Outreach for the study has employed speakers from the PCT at the request of stakeholder groups to present information on study topics of interest. Numerous presentations have been made by the Reclamation Project Manager and others to date on various topics. The speakers bureau program will continue to serve as an outreach mechanism for gathering comments and providing responses.

OUTREACH EFFORTS

As previously indicated, significant efforts have been made to date to communicate with stakeholders and the public about the SLWRI. Following is a summary of the major outreach efforts. In addition, not listed are numerous focused meetings and presentations that have taken place and were aimed at coordinating study status, results to date, and direction.

Initial Stakeholder Briefings

During October and November 2003, following completion of the MSMR, six TWG and tribal briefings were held:

- **Congressional Briefing –** This briefing was held on October 15, 2003, at the State Capitol Building in Sacramento. It focused on providing Federal and State legislators and their aides information about the SLWRI and its direction.
- **Local Elected Officials Briefing –** This briefing was held on October 16, 2003, in Redding and focused on providing information about the study to Northern California State, local, city, and county government representatives.
- **Tribal Briefing –** This briefing was held on October 17, 2003, also in Redding. It focused on providing study information to representatives from local tribes.
- **Immediate Study Area Interests Briefing –** This briefing was held on October 22, 2003, at Shasta Lake. The goal of the meeting was to inform individuals, businesses, and groups around Shasta Lake about the study and its direction.
- **Water and Hydropower Interests Briefing –** On October 24, 2003, a briefing was held at Reclamation in Sacramento that focused on explaining the SLWRI to representatives from water and hydropower interests.
- **Environmental Interests Briefing –** This briefing was held on November 5, 2004, in Willows with representatives from various Federal, State, and local environmental groups to inform them about the study and future efforts.

Stakeholder Workshops

Following completion of the MSMR and IAIR, workshops were held to explain the results of studies to date at that time, and gain input on future study efforts.

- **Workshop Number 1 –** Held December 11, 2003, at the Red Bluff Community Center. The primary objectives of the workshop were to present information about the purpose and objectives of the SLWRI, status and current activities, and identified water resources related problems and needs, and describe potential solutions to those problems. It was also to elicit input on resources management measures and review future actions and the study schedule.

- **Workshop Number 2 –** Held August 11, 2004, at the Redding Convention Center. The primary purpose of the workshop was to coordinate with stakeholders on the status of the investigation, initial alternatives being considered, and the next steps in the feasibility study.

Public Scoping

Scoping allows agencies, stakeholders, and interested parties the opportunity to identify or suggest resources to be evaluated, issues that may require environmental review, reasonable alternatives to consider, and potential mitigation if significant adverse effects of a planned action are identified.

Consistent with NEPA, Reclamation initiated public scoping in October 2005. A Notice of Intent appeared in the Federal Register on October 7, 2005, and Reclamation issued a press release on October 20, 2005. Between October 24 and November 3, 2005, Reclamation held public scoping meetings in Sacramento, Fresno, Los Angeles, Concord, Dunsmuir, Redding, and Red Bluff, California.

The PCT staffed informational workstations and interacted with meeting participants to provide information and answer questions. An opportunity to submit written comments on the investigation was also provided. An Environmental Scoping Report, dated February 2006, describes the scoping process, comments received during scoping, and how these comments would be addressed as part of the investigation.

Input received through stakeholder/public outreach has been, and will continue to be, incorporated into the development of the investigation.

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CHAPTER 8
FINDINGS AND FUTURE ACTIONS

This chapter summarizes major findings to date for this Plan Formulation Report (PFR). Based on these findings, significant future actions are identified followed by a schedule of major actions and milestones for the Shasta Lake Water Resources Investigation (SLWRI).

FINDINGS

The 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 (CALFED). A continuing significant need exists to implement actions to help increase survival of anadromous fish populations in the upper Sacramento River. Meanwhile, demands for water in the Central Valley and elsewhere in the State of California exceed available supplies, and this condition is expected to become more pronounced in the future. Developing projects to increase the reliability of water supplies for urban, agricultural, and environmental purposes is necessary to meet future demands.

On the basis of the identified water resources problems and needs, two primary and four secondary planning objectives were developed:

- **Primary Planning Objectives –** Formulate alternatives specifically to address the following:
  - Increase the survival of anadromous fish populations in the Sacramento River primarily upstream from the Red Bluff Diversion Dam.
  - Increase water supplies and water supply reliability for agricultural, municipal and industrial, and environmental purposes to help meet future water demands, with a primary focus on enlarging Shasta Dam and Reservoir.
- **Secondary Planning 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 and improve public safety along the Sacramento River.
  - Develop additional hydropower capabilities at Shasta Dam.
  - Preserve and increase recreation opportunities at Shasta Lake.

As part of studies to address the above planning objectives, the following findings have been developed:

- Of the numerous water resources management measures identified and evaluated, eight were retained for potential inclusion in alternative plans to address the two primary planning objectives, and an equal number of measures were identified to address the four secondary planning objectives.

- A set of initial concept plans was formulated focusing primarily on anadromous fish survival and water supply reliability, with consideration given to the secondary objectives.
- From these initial concept plans, further coordination among the study team members, and comments received during the public scoping process, the No-Action Plan and five comprehensive plans (CP) were formulated:
  - **No-Action Plan (No Federal Action) –** The Federal Government will take no additional action at Shasta Dam to address water supply reliability problems in California, help increase anadromous fish survival in the Sacramento River, help restore ecosystem values, provide additional hydropower generation, or increase recreation opportunities.
  - **CP1 – Mini Raise – 6.5 Feet –** Increased water supply reliability with some benefit to anadromous fish resources and other resources through a 6.5-foot raise of Shasta Dam and 256,000-acre-foot enlargement of Shasta Reservoir.
  - **CP2 – Mini Raise – 12.5 Feet –** Increased water supply reliability with some benefit to anadromous fish resources and other resources through a 12.5-foot raise of Shasta Dam and 443,000-acre-foot enlargement of Shasta Reservoir.
  - **CP3 – Mini Raise – 18.5 Feet –** Increased water supply reliability with some benefit to anadromous fish resources and other resources through an 18.5-foot raise of Shasta Dam and 634,000-acre-foot enlargement of Shasta Reservoir.
  - **CP4 – Mini Raise – Anadromous Fish–** Increased anadromous fish habitat with some benefit to water supply reliability and other resources through an 18.5-foot Shasta Reservoir enlargement similar to CP3.
  - **CP5 – Mini Raise – Combination –** Combined plan similar to CP3 that includes features for ecosystem restoration and additional recreation facilities around Shasta Reservoir.
- Each of the comprehensive plans addresses the primary planning objectives and to varying degrees, the secondary planning objectives. Each plan is economically feasible.
- Each of the comprehensive plans would contribute directly and indirectly to the four CALFED objectives of water quality, water supply reliability, ecosystem restoration, and Sacramento-San Joaquin River Delta levee system integrity.
- Environmental impacts are generally comparable between alternatives; generally, the impacts would be mitigable. Some impacts could remain significant and unavoidable despite mitigation measures.
- At this time, CP4 appears to result in the greatest net economic benefit of the five plans considered. However, evaluations of specific ecosystem restoration and additional recreation facility opportunities in and around Shasta Lake are not complete at this time. Completion of these activities will help form final conclusions relating to economic justification.

FUTURE ACTIONS

Major upcoming actions include accomplishing numerous tasks related to formulating a specific plan for recommended implementation and addressing various investigation process factors.

Alternatives Formulation

The next major steps in the SLWRI will be to better develop and define the comprehensive plans for inclusion into the draft and final Feasibility Reports. Other important future actions include the following:

- Completing environmental baseline studies.
- Completing identification of potential impacts and mitigation features of the comprehensive alternative plans.
- Confirming a Tentatively Selected Plan (TSP) from the comprehensive alternative plans.
- Completing designs, cost estimates, and cost allocation studies, and defining the requirements for non-Federal participation in the plan.
- Completing the environmental compliance investigations.
- Preparing and completing a Federal decision document that will incorporate the National Environmental Policy Act/California Environmental Quality Act compliance documentation by reference.

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 comprehensive plans, and later the TSP, are defined. Currently, however, at least three subject areas 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

The California Department of Water Resources (DWR) is the non-Federal sponsor for the SLWRI. However, as mentioned in **Chapter 3**, the California Public Resources Code 5093.542(c) restricts State involvement in the study. Because of this code, DWR's involvement in the SLWRI has been limited primarily to coordination and participation in Study Management Team activities. 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.

It is believed that none of the comprehensive plans described in this PFR (see **Chapter 5**), would have significant residual adverse effects on the free-flowing conditions of the McCloud River or on its wild trout fishery.

Relationship to CALFED and Other Programs and Projects

As mentioned, the SLWRI is being conducted following direction contained in Public Law (PL) 96-375 and PL 108-361 (both of which were 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 planning objectives consistent with the study criteria, and selecting, if appropriate, a plan for implementation when a Federal interest exists. For the SLWRI, a specific set of planning objectives was developed (see **Chapter 3**) to address identified water resources problems and needs. The influence of the comprehensive plans described in **Chapter 5** on the goals and objectives of CALFED, defined in the 2000 CALFED Record of Decision, are included in **Chapter 3** and will be included in the draft and final Feasibility Reports.

Other Requirements of Local Cooperation

Currently, two likely purposes exist for a project resulting from the SLWRI: (1) environmental enhancement (ecosystem restoration), which includes anadromous fish survival, and (2) water supply reliability. Incidental benefits would also exist, primarily to hydropower generation. Strong support has been expressed for the SLWRI by representatives from contractors to the Central Valley Project, and other water supply interests. In addition, much interest has been identified for implementing environmental restoration features, especially projects to benefit anadromous fish survival, as part of CALFED.

As mentioned, CP5 includes implementing additional recreation facilities at several sites around Shasta Lake. The specific features and sites are under development. Recreation facilities would be sited on existing Federal project lands within the Shasta-Trinity National Recreation Area (NRA) managed by the United States Forest Service (USFS). Ultimately, the facilities would be part of an updated NRA plan. Development of these facilities, and how they would be treated by both the United States Department of the Interior, Bureau of Reclamation (Reclamation) and USFS, will be described in the draft and final Feasibility Reports.

SCHEDULE

Schedules showing estimated major actions to complete the feasibility study, and future milestones leading to project implementation are shown in **Figures 8-1** and **8-2**, respectively. A draft Feasibility Report, which will incorporate by reference the Environmental Impact Statement, is currently scheduled for release to the public and other Federal agencies for review in early 2008. The final Feasibility Report is scheduled to be provided for Washington-level review through Reclamation in late 2008. If Congressional authorization occurs in 2009, detailed project designs could conceivably be initiated in 2009, and any necessary real estate acquisitions and project construction could be initiated as early as 2010. The initial phase of construction would include acquiring any necessary real estate interests, continuing detailed design work, acquiring necessary permits, and performing minor relocations. The construction activities would likely span, at minimum, 4 years.

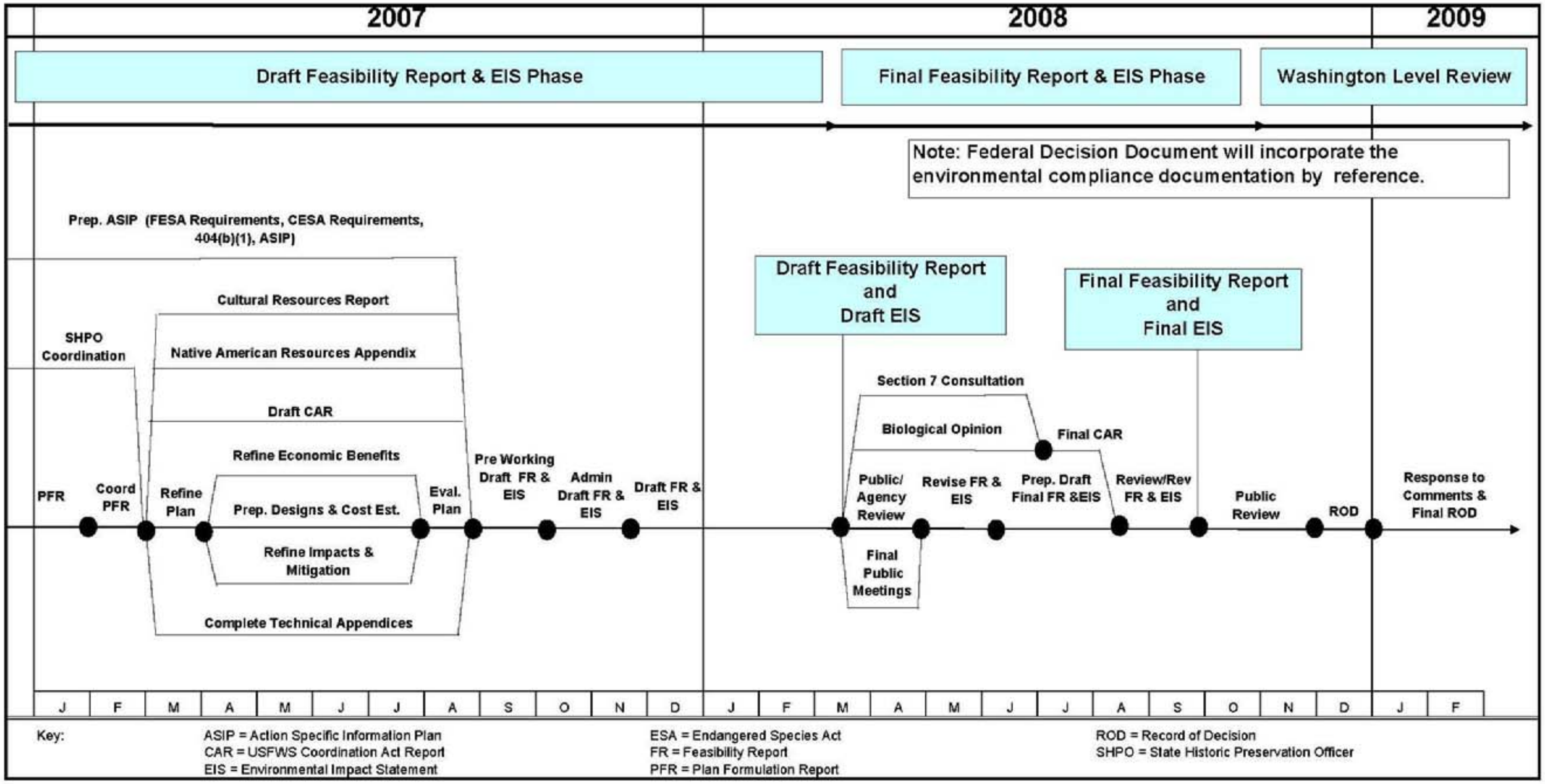

FIGURE 8-1
SHASTA LAKE WATER RESOURCES FEASIBILITY INVESTIGATION SCHEDULE

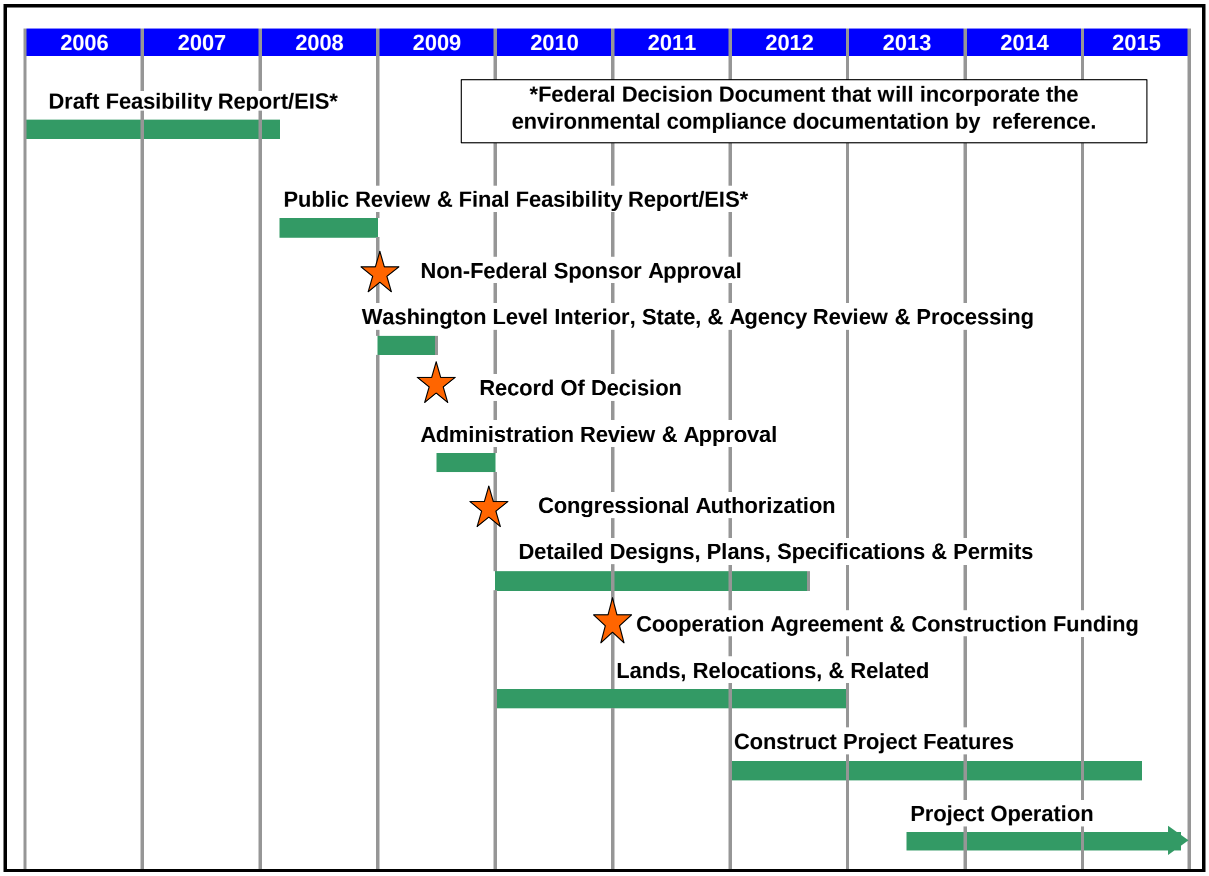

FIGURE 8-2
SHASTA LAKE WATER RESOURCES INVESTIGATION PROJECT SCHEDULE

CHAPTER 9
REFERENCES

References cited in or used in the preparation of the Plan Formulation Report are listed below. Detailed listings of technical references and other data sources are included with individual appendices to the Plan Formulation Report.

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Plan Formulation Report

Shasta Lake Water Resources Investigation
Plan Formulation Report

Plates

U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region
Sacramento, California

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PRIMARY STUDY AREA

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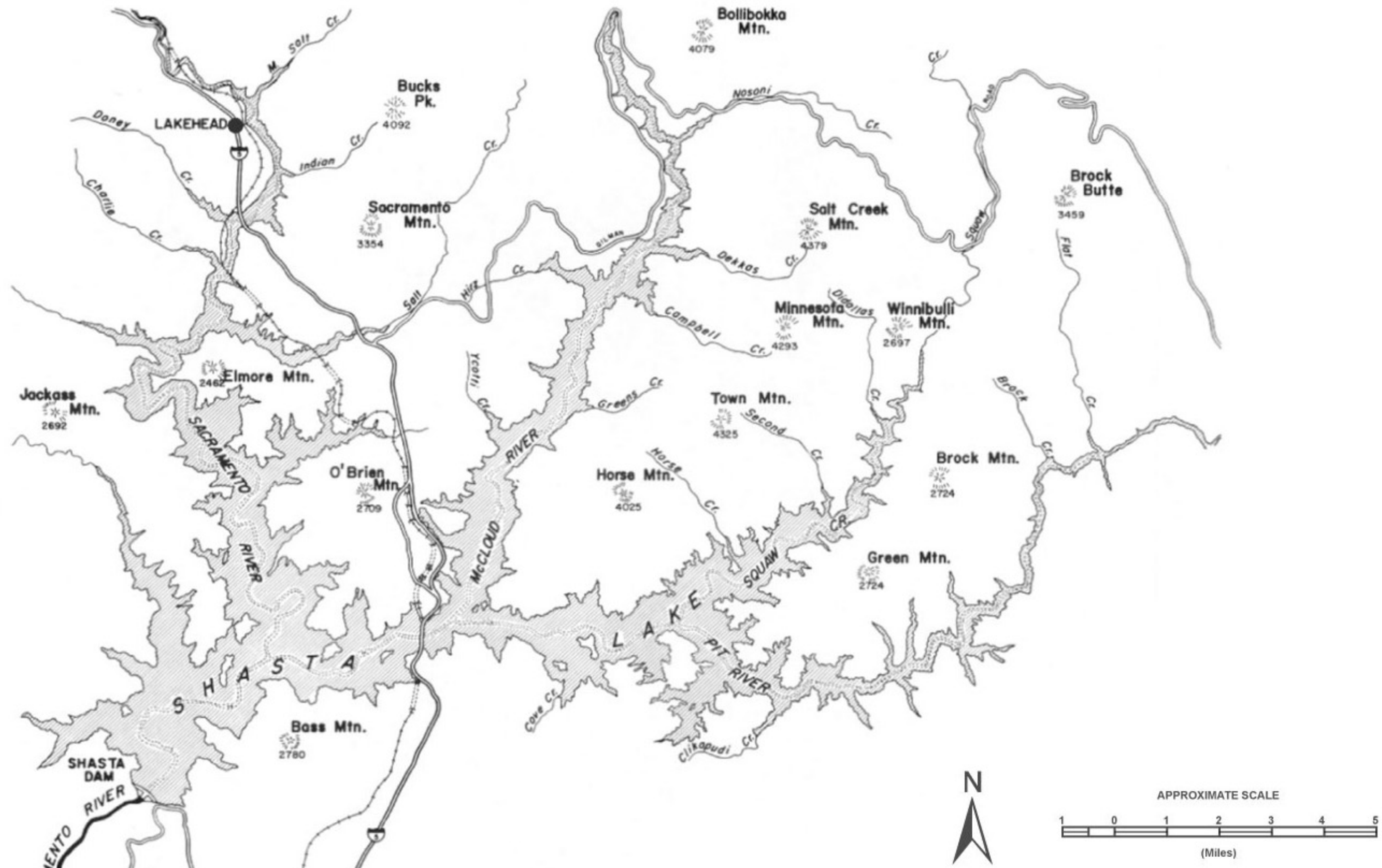
PLATE 1



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 RESERVOIR AREA

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PLATE 2

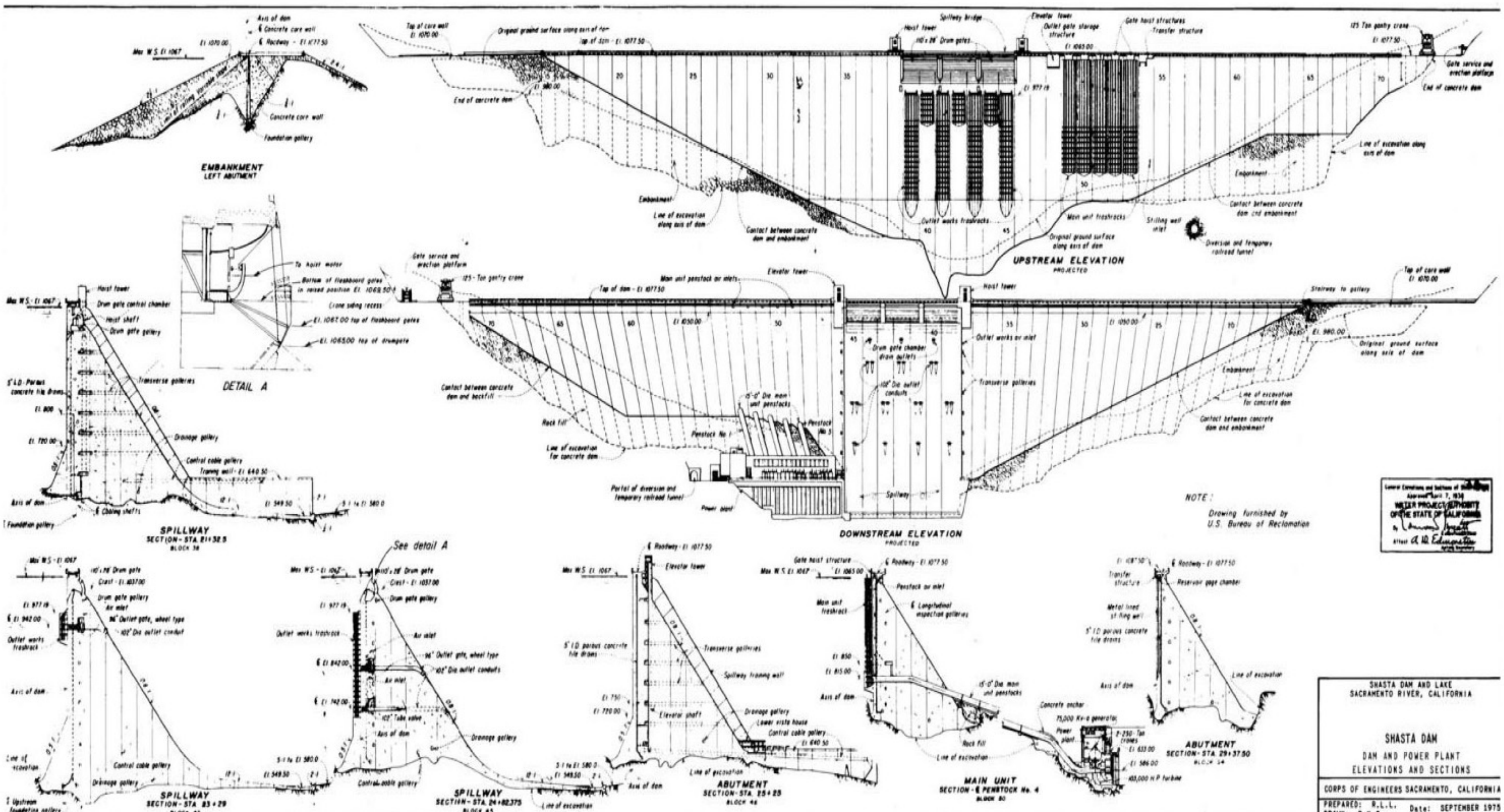
Shasta Lake Water Resources Investigation, California

MAJOR CVP AND SWP FACILITIES

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

December 2006

PLATE 3



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 AND POWERPLANT ELEVATIONS AND SECTIONS

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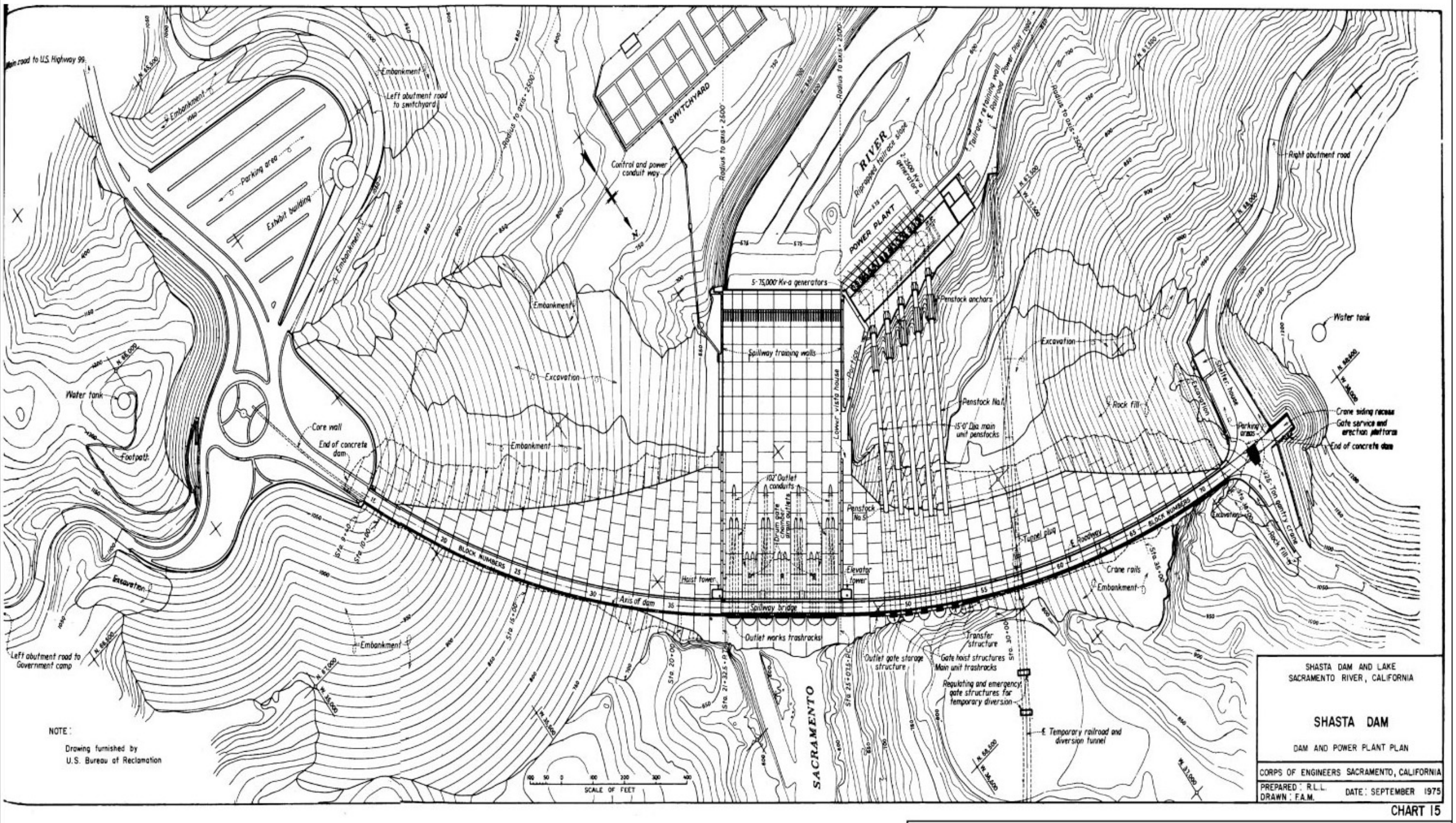
PLATE 4



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SHASTA DAM AND POWERPLANT PLAN

U.S. Bureau of Reclamation, Mid-Pacific Region
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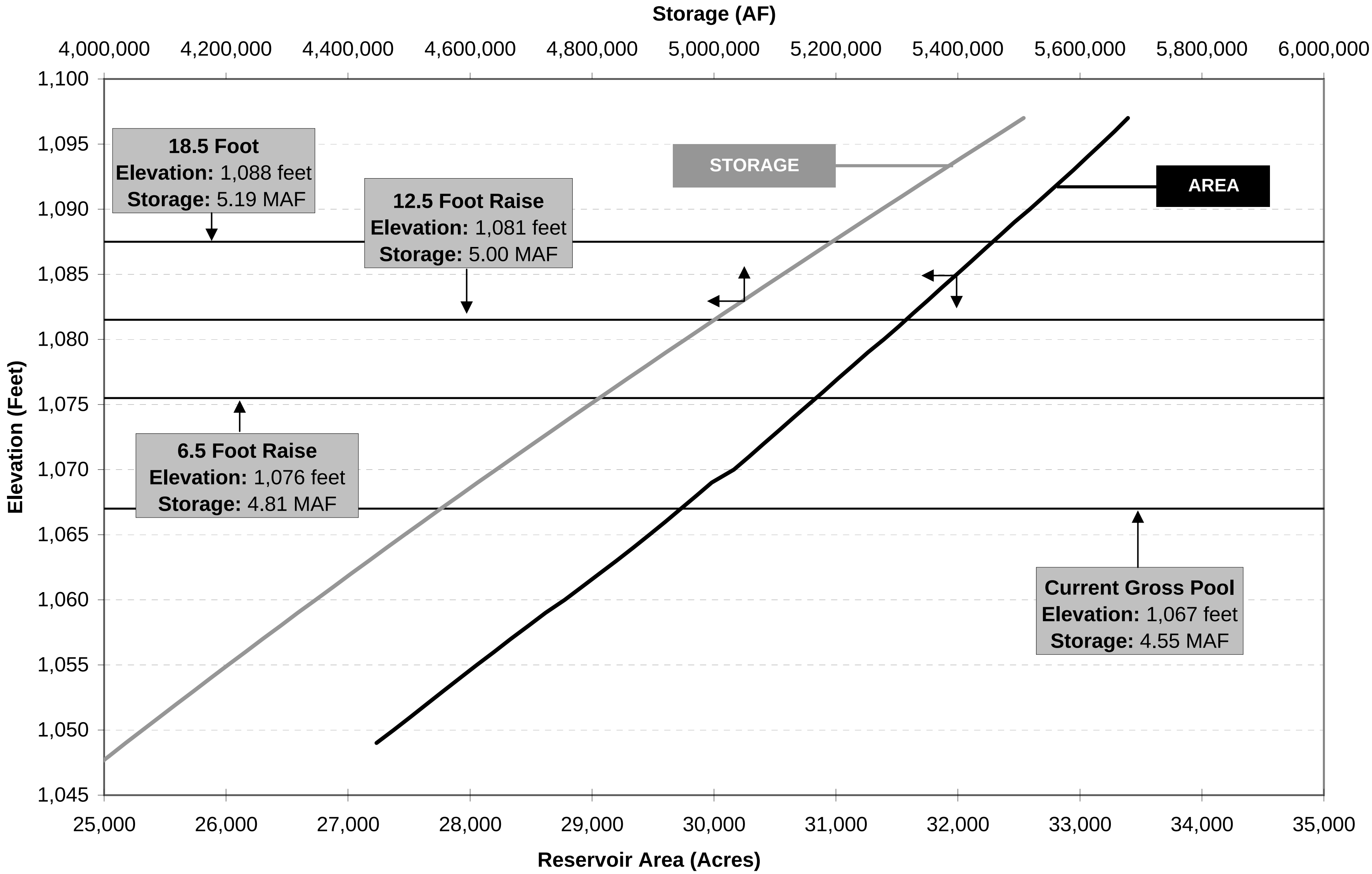
Source: U.S. Army Corps of Engineers, Shasta Dam and Lake, Sacramento River, California, Report on Reservoir Regulation for Flood Control, Rev. January 1977

PLATE 5



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ENLARGED SHASTA RESERVOIR AREA - CAPACITY RELATIONSHIPS

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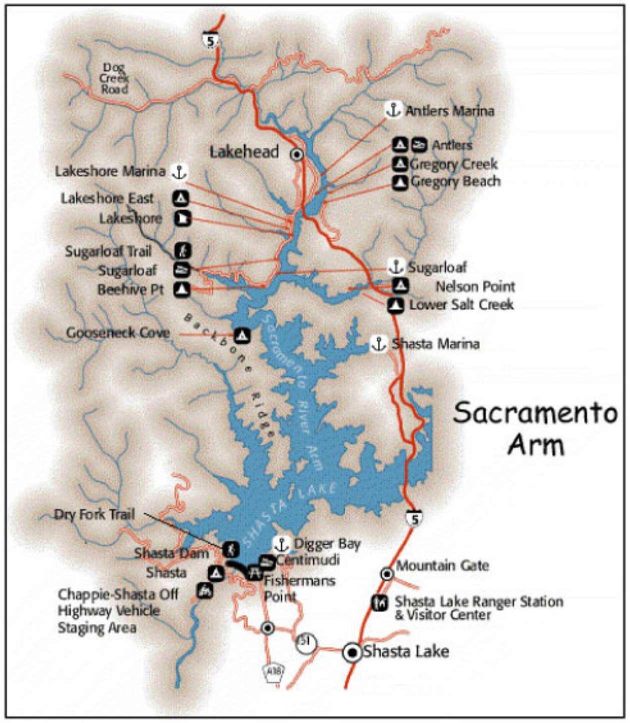
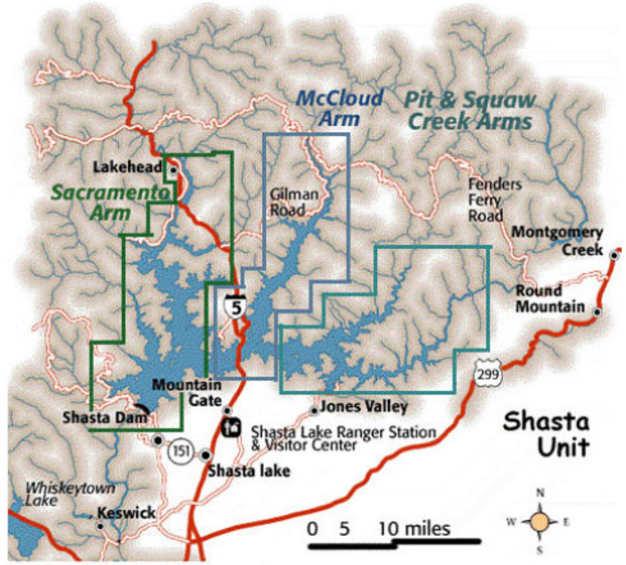
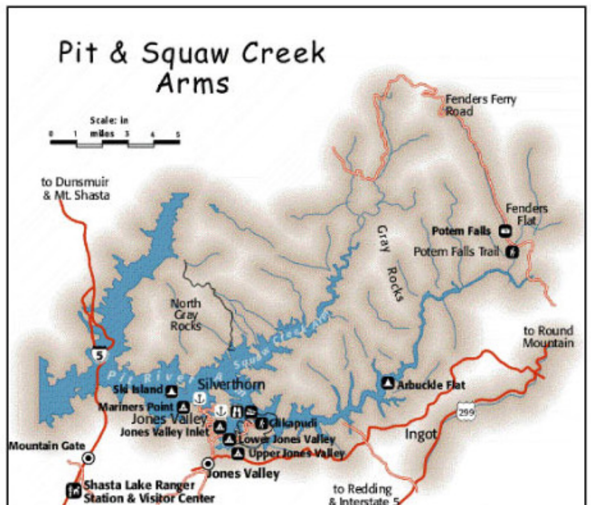
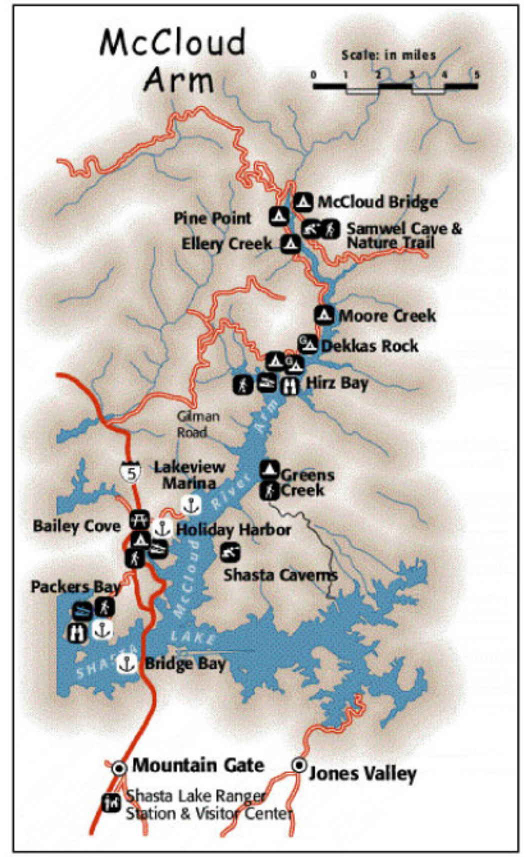
PLATE 6









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SHASTA RECREATION FACILITIES

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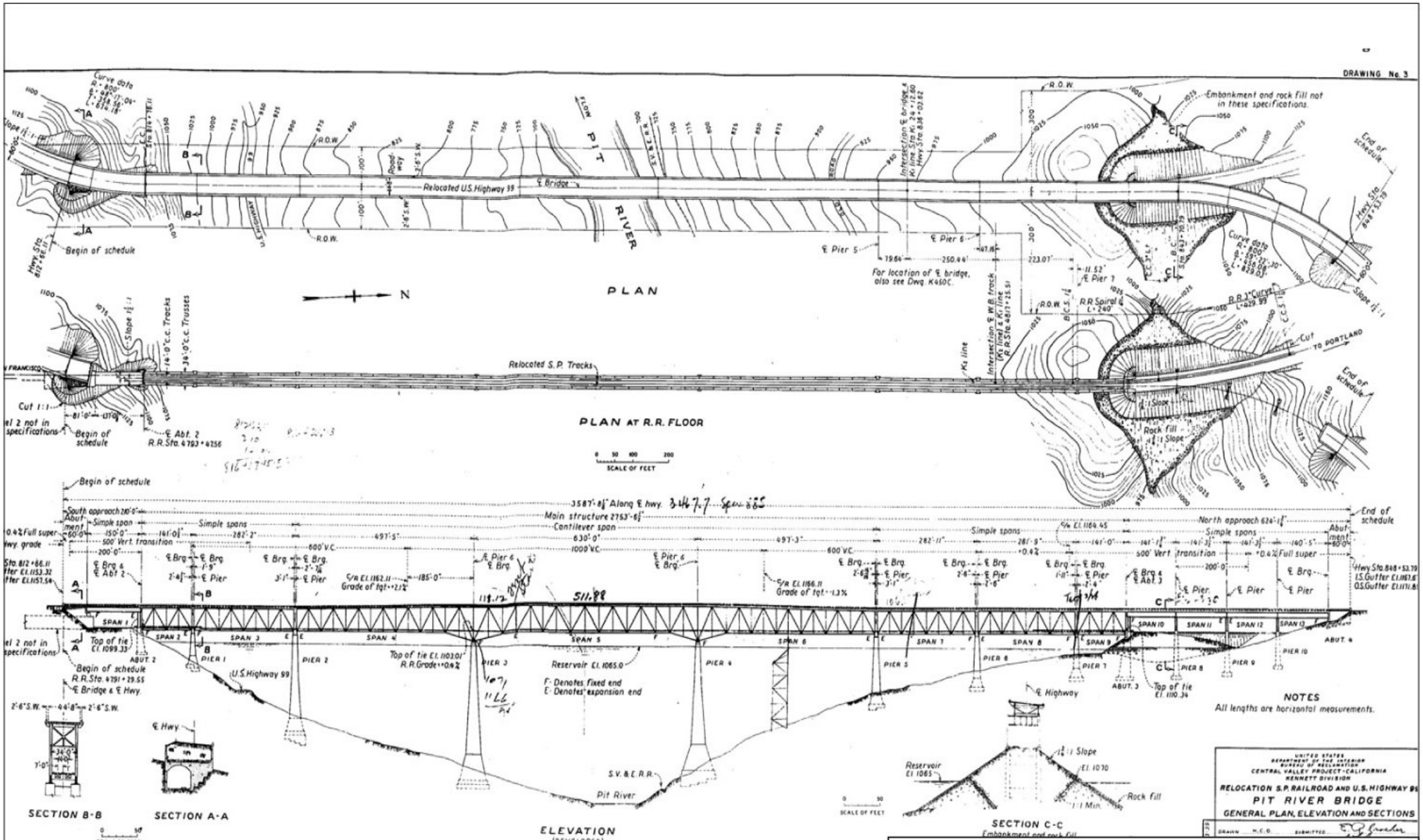
PLATE 7



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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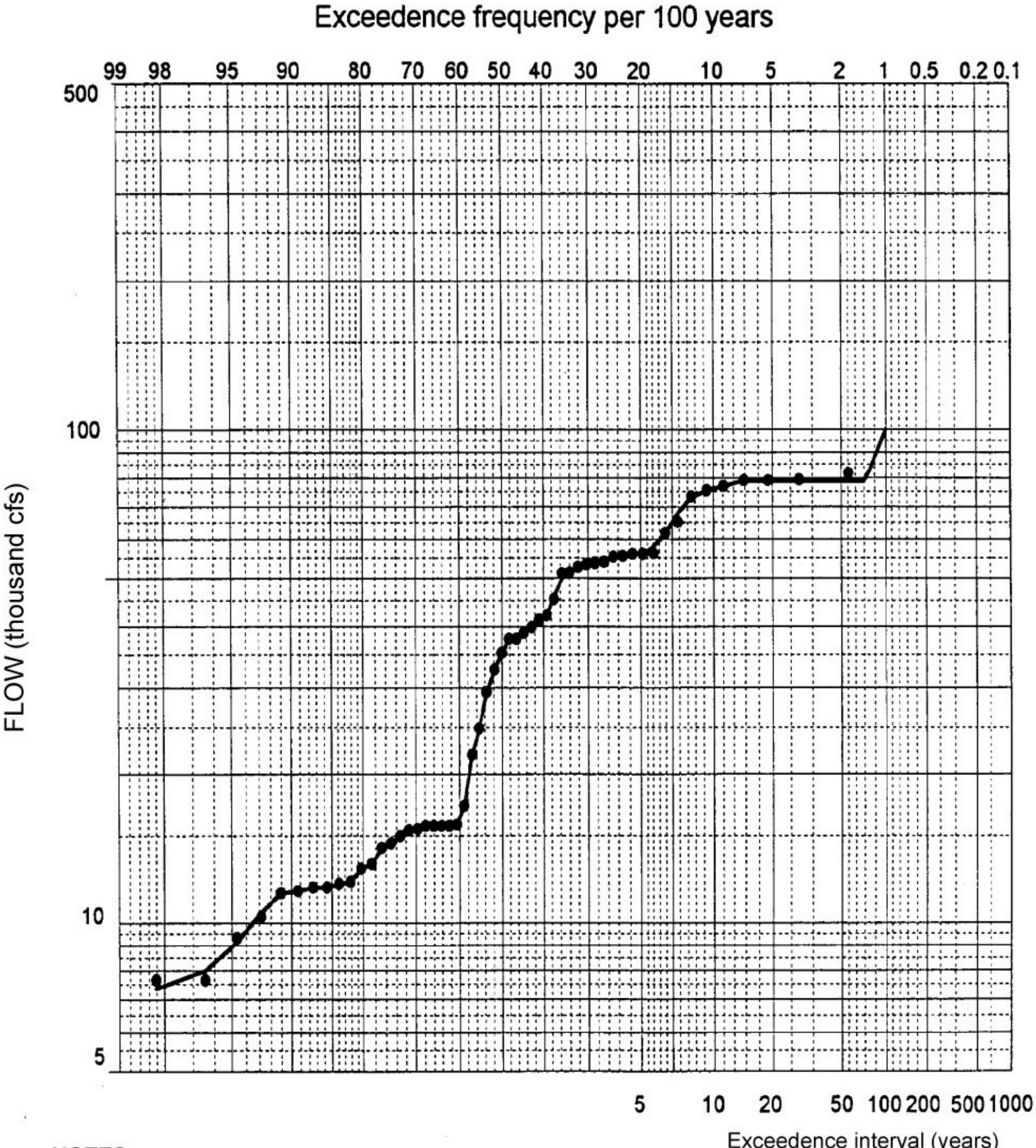
PLATE 8



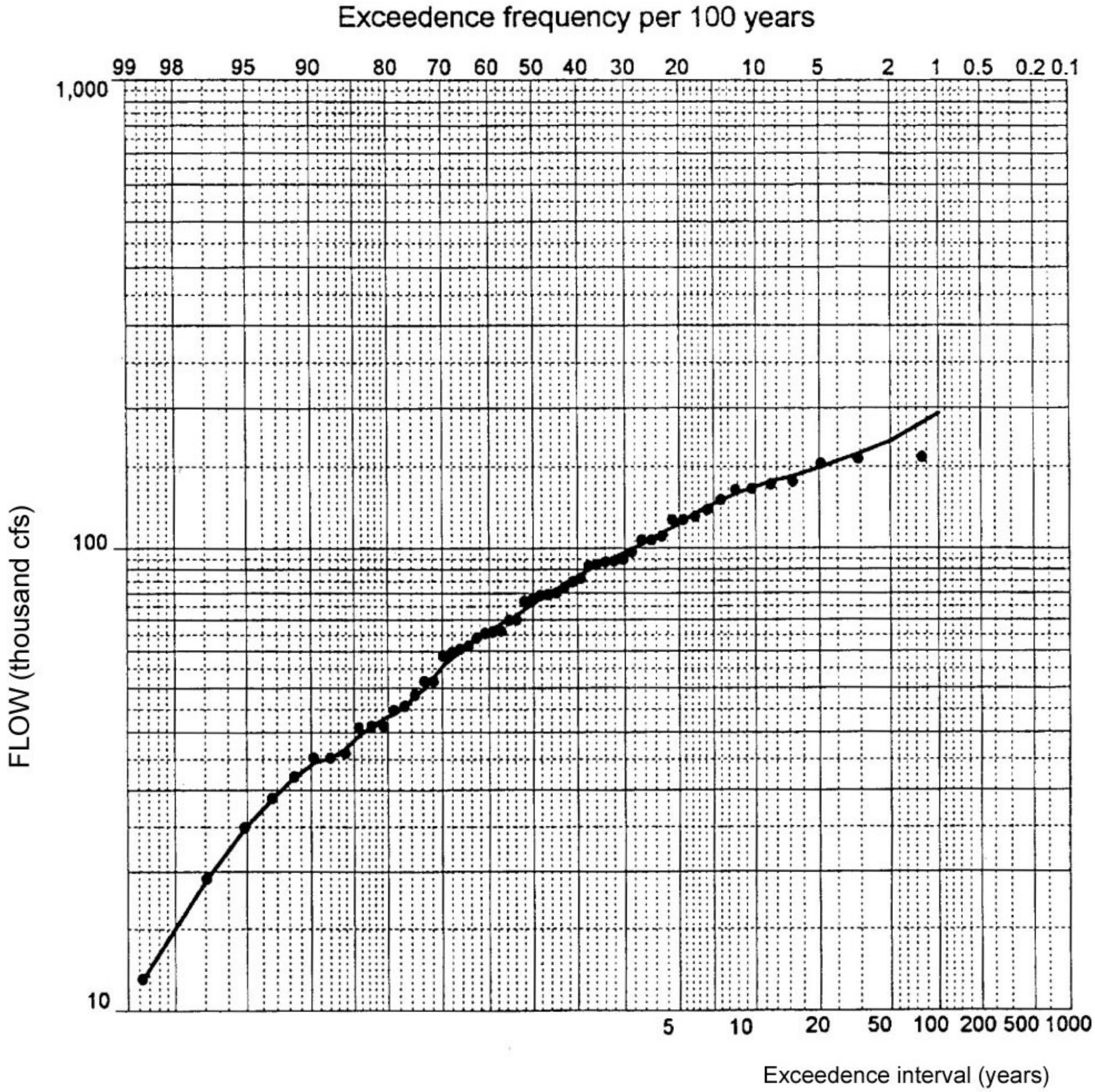
NOTES
1. Drainage area 6,468 sq. mi.
2. Median plotting positions
3. Period of record: 1944-1998

Source: U.S. Army Corps of Engineers, Sacramento and San Joaquin River Basins, California. Post-Flood Assessment, 1999.

Shasta Lake Water Resources Investigation, California

PEAK RAIN FLOOD FREQUENCY SACRAMENTO RIVER AT KESWICK REGULATED CONDITION

U.S. Bureau of Reclamation, Mid-Pacific Region
December 2006



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.

Shasta Lake Water Resources Investigation, California

PEAK RAIN FLOOD FREQUENCY SACRAMENTO RIVER ABOVE BEND BRIDGE REGULATED CONDITION

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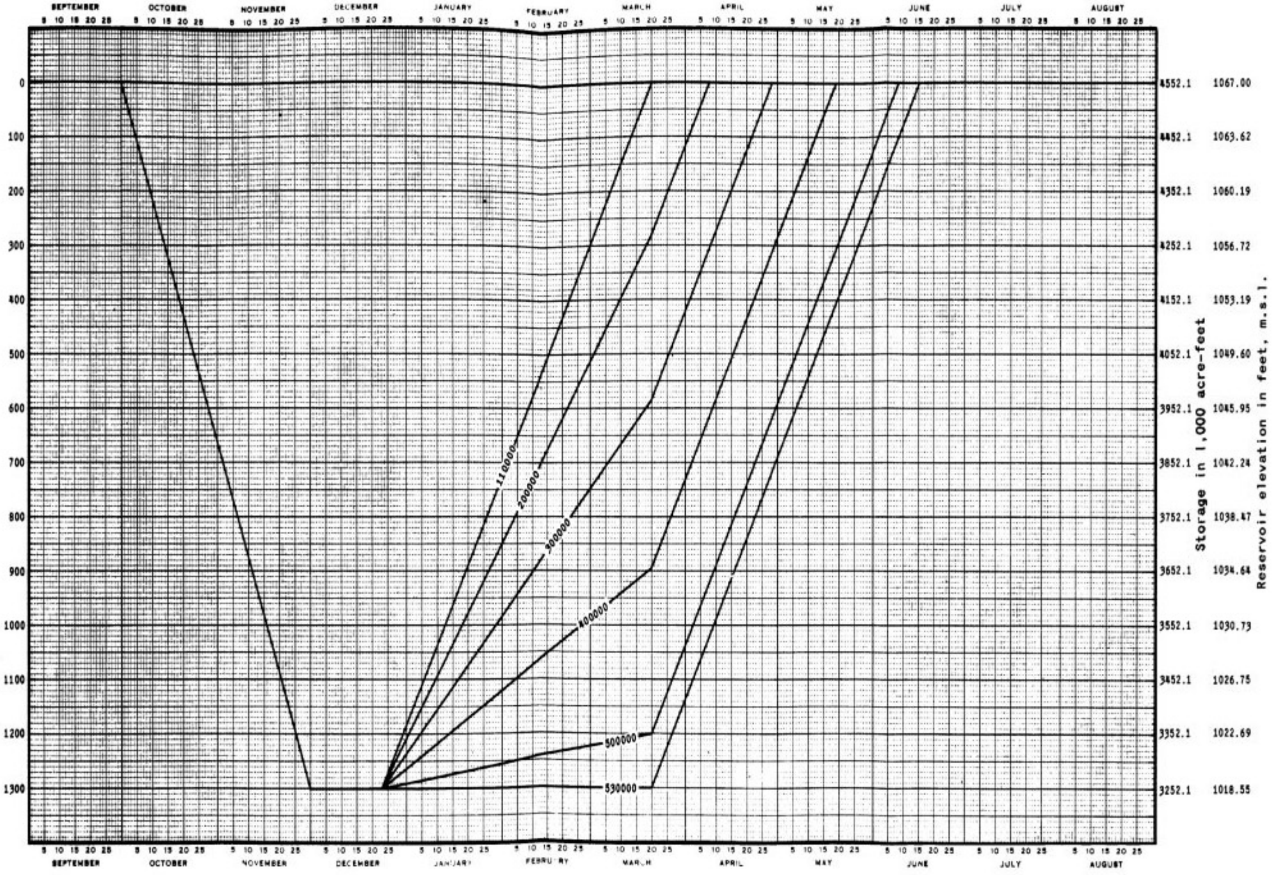


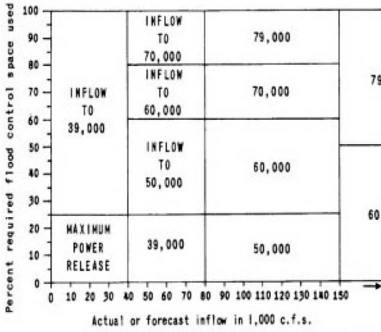
USE OF DIAGRAM

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: 8 JUL 1977 File No. SA-17-26-13

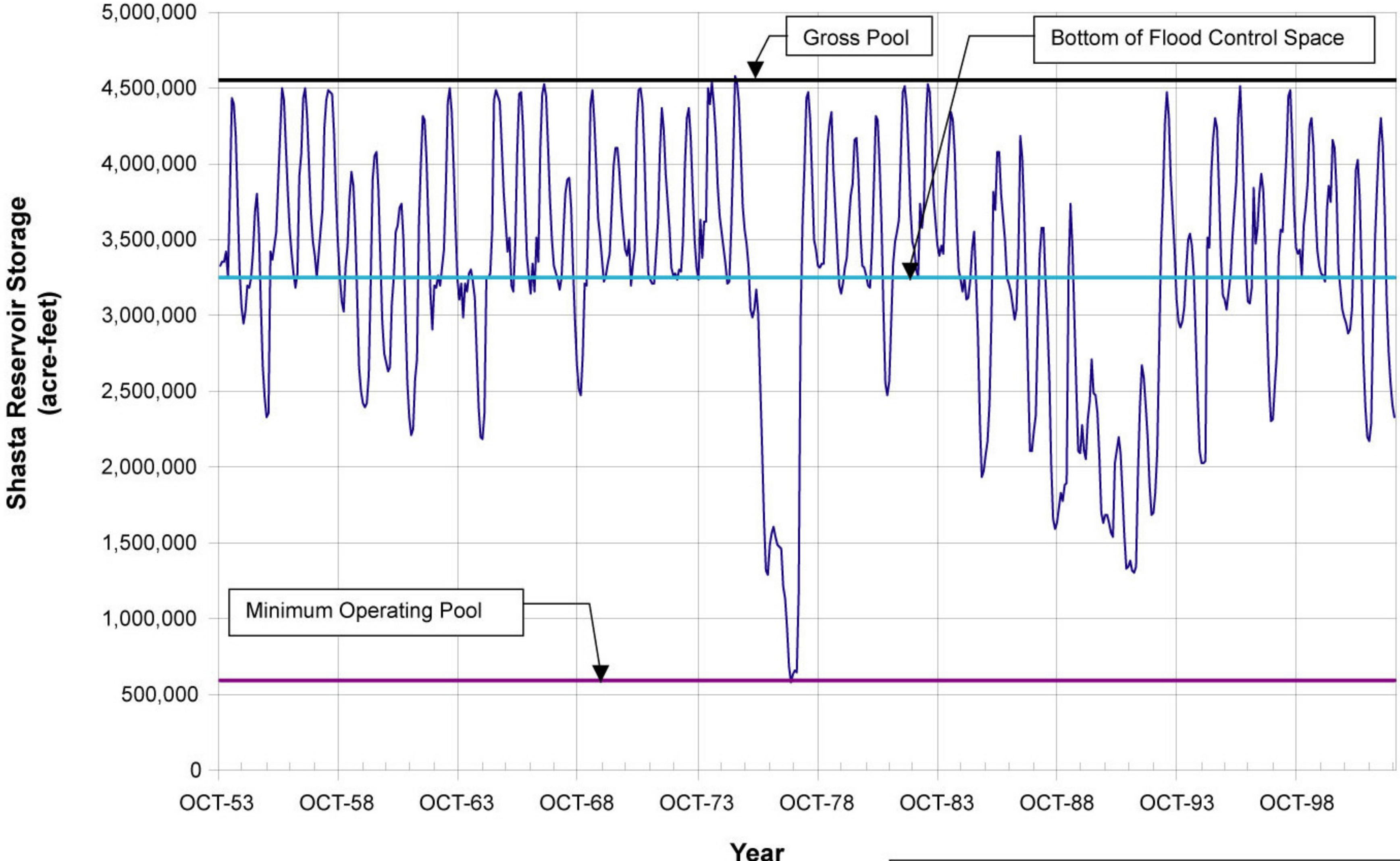
Shasta Lake Water Resources Investigation, California

SHASTA DAM FLOOD CONTROL DIAGRAM

U.S. Bureau of Reclamation, Mid-Pacific Region
December 2006

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 11



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SHASTA RESERVOIR STORAGE MONTHLY AVERAGE

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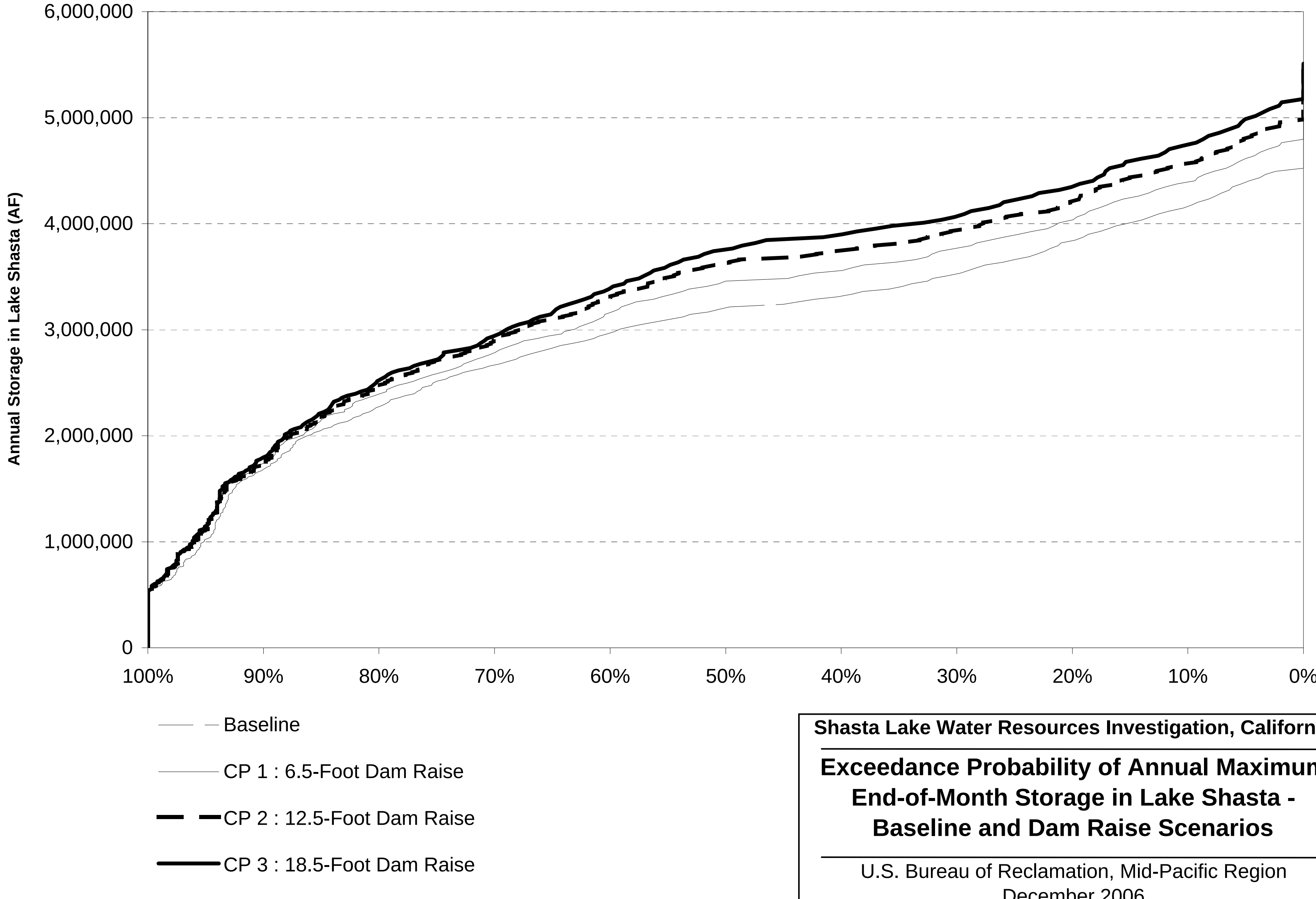
PLATE 12



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Exceedance Probability of Annual Maximum End-of-Month Storage in Lake Shasta - Baseline and Dam Raise Scenarios

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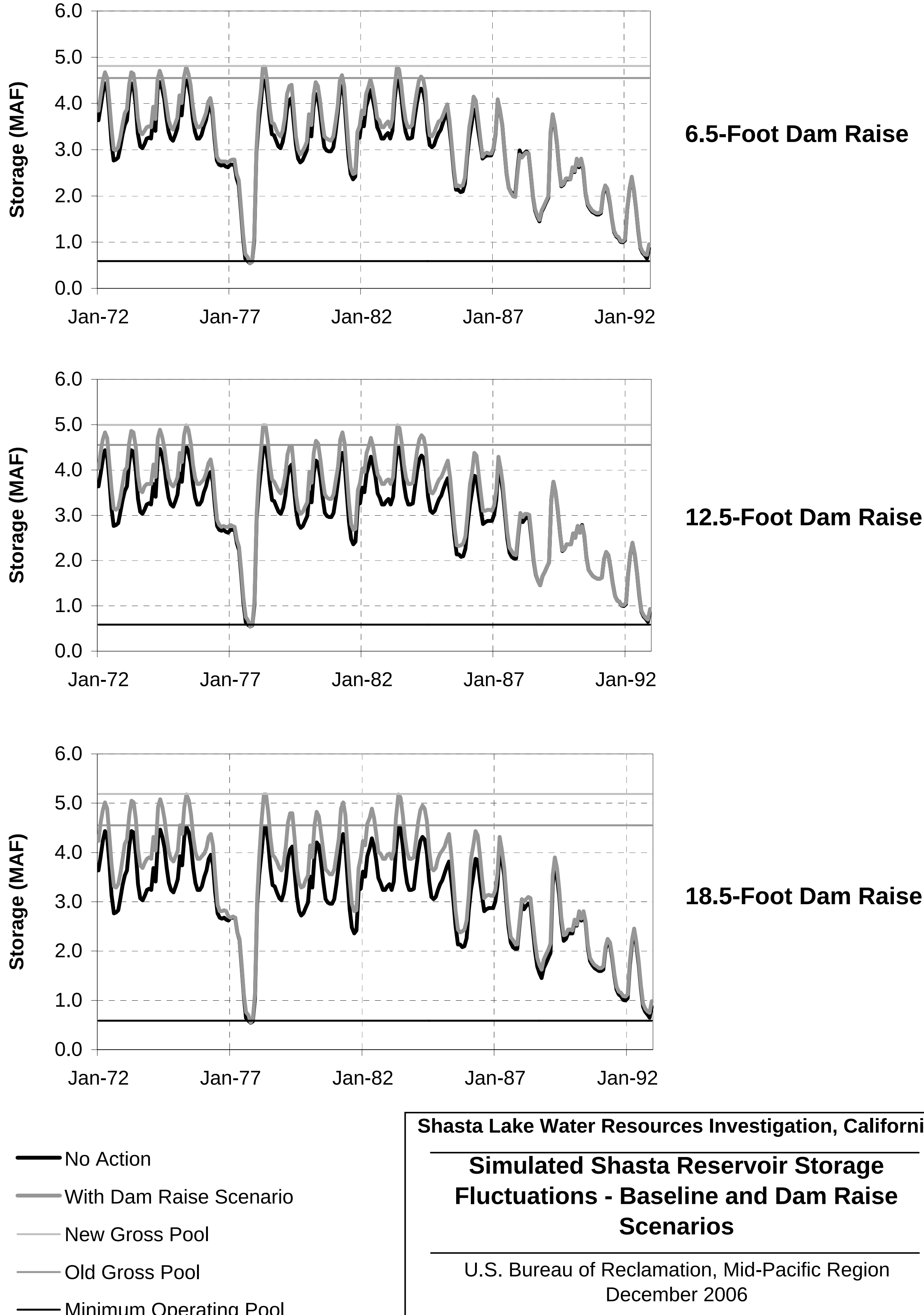
PLATE 13



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Simulated Shasta Reservoir Storage Fluctuations - Baseline and Dam Raise Scenarios

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PLATE 14

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

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PLATE 15

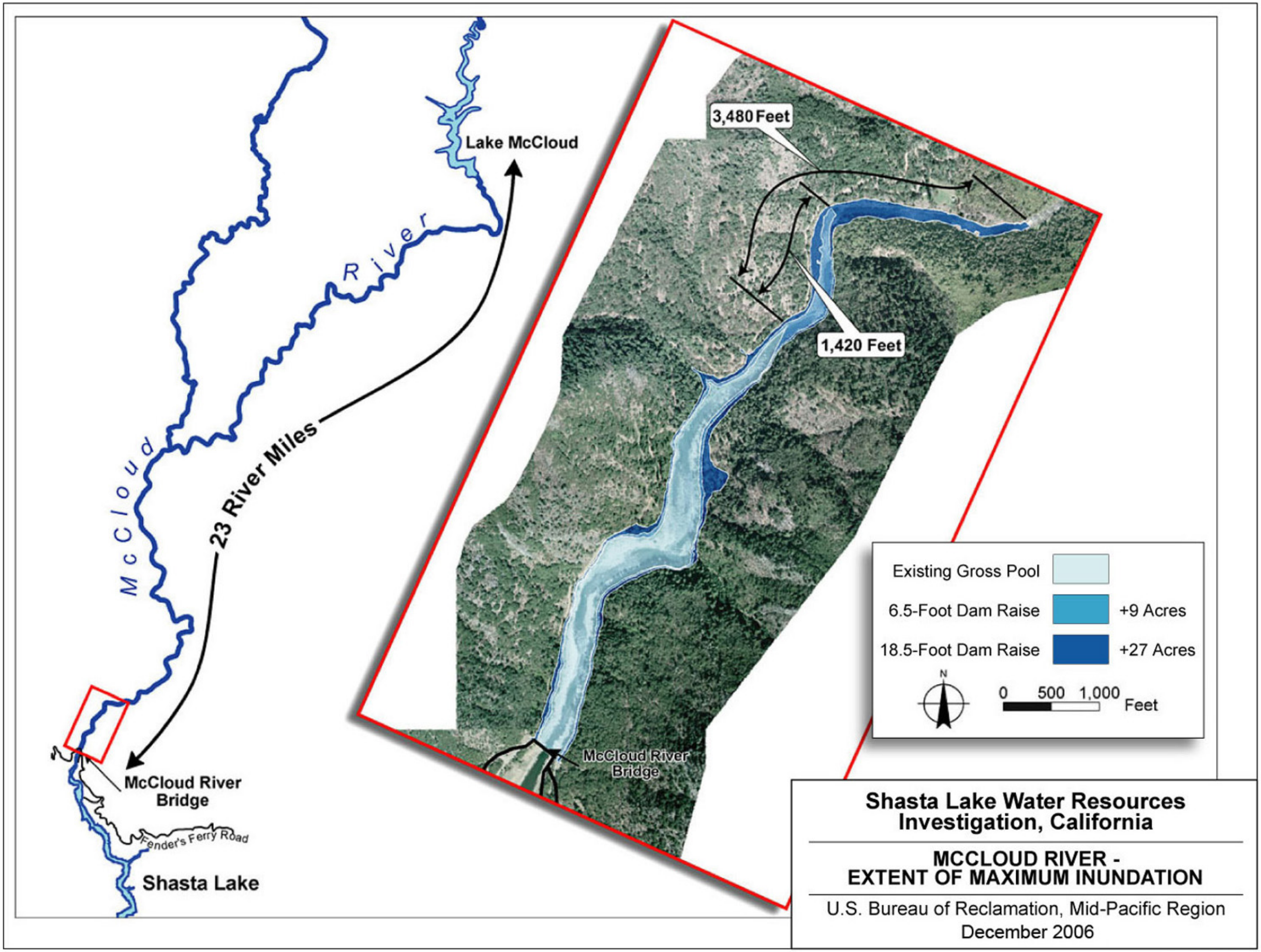
Lake McCloud
McCloud River
23 River Miles
McCloud River Bridge
Fender's Ferry Road
Shasta Lake
3,480 Feet
1,420 Feet
McCloud River Bridge
Existing Gross Pool
6.5-Foot Dam Raise +9 Acres
18.5-Foot Dam Raise +27 Acres
N
0 500 1,000 Feet
Shasta Lake Water Resources Investigation, California
MCCLOUD RIVER - EXTENT OF MAXIMUM INUNDATION
U.S. Bureau of Reclamation, Mid-Pacific Region
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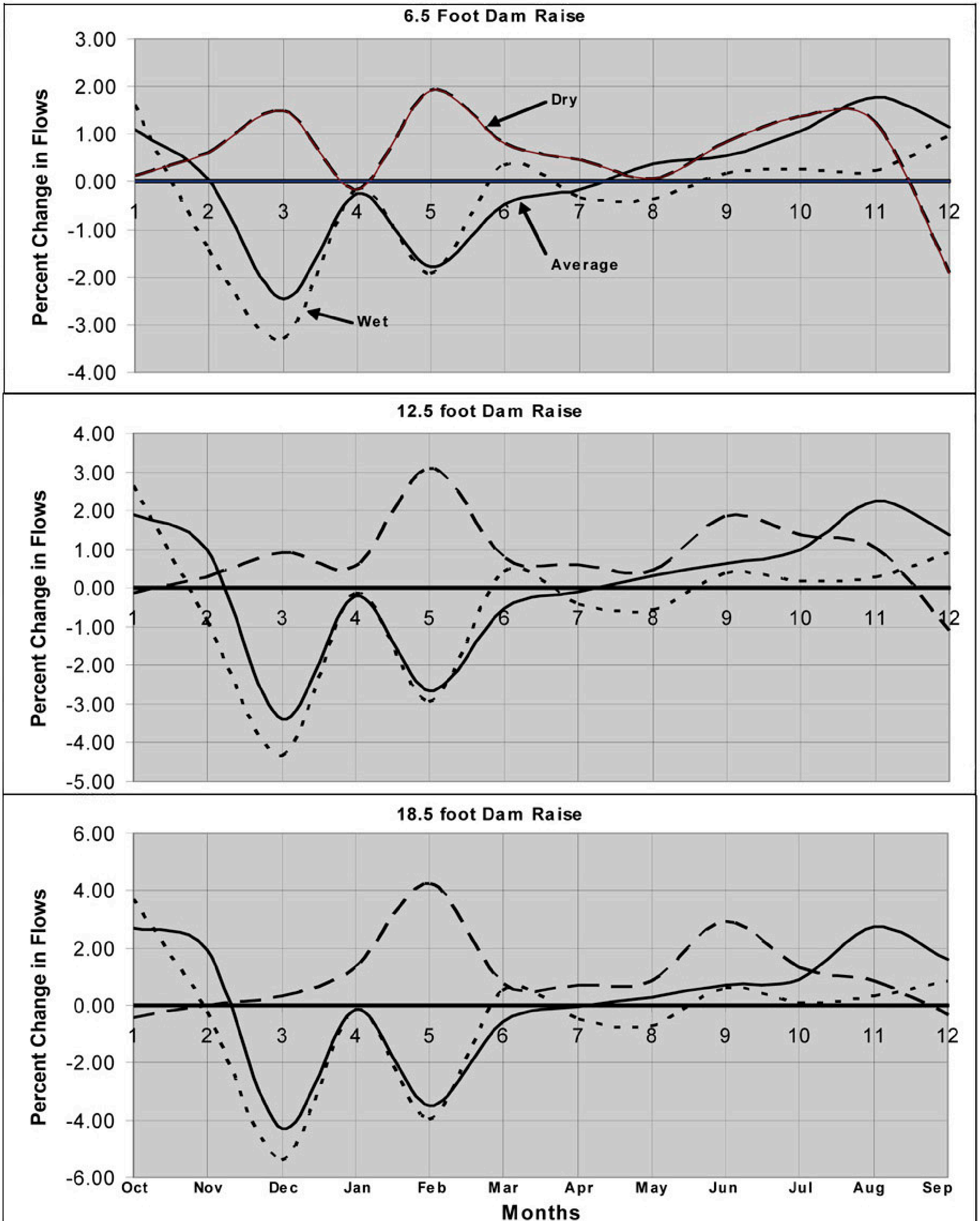
PLATE 16



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PERCENT CHANGE IN FLOWS AT BEND BRIDGE UNDER DRY, AVERAGE, AND WET YEAR CONDITIONS

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PLATE 17