SHASTA LAKE
WATER RESOURCES INVESTIGATION

APPENDIX B

Surface Water Storage Options

EXECUTIVE SUMMARY

The primary purpose of the Shasta Lake Water Resources Investigation (SLWRI) Surface Water Storage Options report is to identify the range of potentially viable surface water storage reservoir sites in the Central Valley of California and compare the relative feasibility of storage at these sites to increasing the storage in Shasta Reservoir. This evaluation relies primarily on information obtained as part of other water resources investigations by the U.S. Department of Interior, Bureau of Reclamation (Reclamation), California Department of Water Resources, and U.S. Army Corps of Engineers.

Seventeen onstream surface water storage projects identified as part of previous studies and projects were considered. Of these, six projects were profiled, including a comparison of preliminary costs and accomplishments. Onstream projects include Shasta Dam Enlargement, Round Valley Reservoir, Kosk Reservoir, Cottonwood Creek Project, Red Bank Project, and Auburn Dam Project.

Sixteen potential offstream surface water storage reservoir projects were identified. Of these, four storage projects were profiled including a comparison of preliminary costs and accomplishments. Offstream projects include the Sites (or NODOS) Reservoir Project, Colusa Reservoir Project, Lake Berryessa Enlargement, and Thomes–Newville Reservoir Project.

None of the identified alternative onstream surface water storage projects/sites considered are believed to be viable alternatives to increased conservation storage in Shasta Reservoir. In addition, none of the offstream storage sites considered are believed to be viable substitutes for enlarging Shasta Dam and Reservoir. However, storage in an offstream storage facility could help enhance the effectiveness of increased storage space in Shasta Reservoir.

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CHAPTER I
INTRODUCTION

This chapter describes background information and the purpose and scope of the project, lists previous storage assessment studies, and discusses the organization of the appendix.

BACKGROUND

In 2000, the U.S. Department of Interior, Bureau of Reclamation, Mid-Pacific Region (Reclamation), initiated a feasibility scope investigation focusing on evaluating the potential for enlarging Shasta Dam and Reservoir. The investigation is being conducted at the direction of Congress and to support other and ongoing Federal interests within the study area. The primary study area for the Shasta Lake Water Resources Investigation (SLWRI) is Shasta Lake and the surrounding area, including the Sacramento River downstream to Red Bluff (see **Plate 1**). The extended study area also includes areas potentially affected by enlarging Shasta Reservoir, including the service areas to the Central Valley Project (CVP) and California State Water Project (SWP).

Water resources and related problems and needs in the study area being addressed by the SLWRI include the following:

- **Anadromous Fish Survival –** Due to a number of environmental factors, the population of Chinook salmon has declined in the Central Valley and a residual need exists for effective actions to benefit the salmon, especially in the upper Sacramento River during dry and critically dry years.

- **Water Supply Reliability –** Demands for water in California exceed available supplies and this trend is expected to significantly increase in the future as the population of the State and especially the Central Valley grows.

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

From these problems and needs, a set of primary and secondary planning objectives was identified. Primary objectives are those for which specific alternatives would be formulated to address. Secondary objectives are opportunities that should be considered in the plan formulation process, but only to the extent possible through pursuit of the primary planning objectives.

Primary Objectives

- Increasing the survival of anadromous fish populations in the Sacramento River primarily upstream from the Red Bluff Diversion Dam (RBDD).

- Increasing water supplies and water supply reliability for agricultural, municipal and industrial (M&I), and environmental purposes to help meet future water demands, with a focus on enlarging Shasta Dam and Reservoir.

Secondary Objectives

- Preserving and restoring ecosystem resources in the Shasta Lake area and along the upper Sacramento River.
- Reducing flood damages along the Sacramento River.
- Developing additional hydropower capabilities at Shasta Dam.

PURPOSE AND SCOPE

Although there is a focus in the SLWRI on modifying Shasta Dam and Reservoir to address the primary planning objective of increasing water supply reliability, it is also important to determine if there are other ways of meeting this objective that may be more efficient and effective. One significant water resources management measure to address the primary objective of increasing water supply reliability is through increased system surface water storage. Accordingly, the primary purpose of this report is to describe the results of an evaluation to identify the range of potentially viable surface water storage reservoir sites in the Central Valley and compare the relative feasibility of storage at these sites to increasing the storage in Shasta Reservoir.

This assessment uses, to the maximum extent possible, results from previous investigations. It includes information on various options to modify Shasta Dam and Reservoir and descriptions, primarily from previous studies, of other potential surface water projects.

PREVIOUS STORAGE ASSESSMENT STUDIES

Numerous studies over the years have identified possible surface water storage project sites in the Central Valley of California. It is believed that all potentially viable dam and reservoir sites have been identified and assessed as part of previous water resources studies at one time or another. In addition, the potential to enlarge Shasta Dam and Reservoir has been previously evaluated. Several of the most recent and noteworthy studies include those related to the CALFED Bay-Delta Program and earlier efforts for the Enlarge Shasta Lake Feasibility Study.

CALFED Bay-Delta Program - Initial Surface Water Storage Screening

As part of the CALFED Bay-Delta Program, numerous potential surface water dam and reservoir sites in the Central Valley were evaluated. Results of this evaluation were included in a report titled Initial Surface Water Storage Screening (SWSS), CALFED Bay-Delta Program, August 2000. The primary results of that investigation were that 12 potential surface water storage reservoirs were identified that warranted further study and development. Of these 12, 5 were selected for further study in the Preferred Program Alternative (PPA) in the CALFED Record of Decision (ROD) also dated August 2000. The five included the Shasta Lake Enlargement, In-Delta Storage, Los Vaqueros Reservoir Enlargement, Sites Reservoir, and Upper San Joaquin

River Storage projects. Three of these surface water projects were identified as priority projects or "Stage 1" projects and two (Sites Reservoir and Upper San Joaquin River Storage) were identified as warranting further study (defined here as CALFED Conditional). Each of the potential surface water projects is being investigated by Reclamation and the California Department of Water Resources (DWR) or by Reclamation and the Contra Costa Water Management District (CCWMD). Following is a brief description of each project:

- **Enlarge Shasta Dam and Reservoir –** The PPA included a plan to raise Shasta Dam 6.5-feet to provide an additional 290,000 acre-feet of potential new storage. The primary benefits of a the project would be to increase the cold water pool in Shasta to help lower water temperatures for certain fish in the Sacramento River and help increase water supply reliability. Reclamation is the lead agency for the Shasta Dam Enlargement Feasibility Investigation (renamed the Shasta Lake Water Resources Investigation).

- **In-Delta Storage –** The In-Delta storage investigation for the Delta Wetlands Project would convert two Delta islands comprising 11,000 acres (Webb Tract and Bacon Island) into surface storage facilities and two islands comprising 9,000 acres (Bouldin Island and Holland Tract) into managed habitat. Storage in the Delta would provide improved flexibility for managing Delta fisheries and water quality and would help enhance the flexibility in water supply deliveries south of the Delta. DWR is the lead agency for the In-Delta Storage Investigation.

- **Los Vaqueros Reservoir Enlargement –** The Los Vaqueros Enlargement Project would consist of enlarging the 100,000 acre-foot existing reservoir up to 500,000 acre-feet. The project would help interconnect Bay Area conveyance facilities, and develop stakeholder agreement on integrated operation of water supply facilities. CCWMD is the lead agency for the Los Vaqueros Enlargement Project.

- **Sites Reservoir –** A 1.9 million acre-foot (MAF) Sites Reservoir would serve as an offstream storage reservoir filled primarily through pumped diversions from the Sacramento River and its tributaries during high flow periods. The primary benefits from the added storage would be enhanced operational flexibility for managing fisheries and water quality, improved Sacramento River diversion management, and increased water supply reliability. DWR is the lead agency for the study, a.k.a. North-of-The-Delta Offstream Storage Investigation (NODOS).

- **Upper San Joaquin River Storage –** This project could include adding from 250,000 to about 700,000 acre-feet of new storage in the upper San Joaquin watershed, primarily through enlargement of Millerton Lake at Friant Dam or a functionally equivalent project. The project would be designed to contribute to restoring habitat, improving water quality for the San Joaquin River, and facilitating conjunctive management of water exchanges that improve water quality of deliveries to urban communities primarily in the Tulare Lake basin area. Reclamation is the lead agency for the Upper San Joaquin River Storage Feasibility Investigation.

Reclamation – Studies to Enlarge Shasta Lake

Several studies have been conducted since the early 1960s to assess the potential feasibility of increasing the storage space at Shasta Reservoir. The most significant occurred in the late 1970s and early 1980s. Structural modifications, environmental and related impacts, water supply and hydropower benefits, costs, and Federal interest issues were considered in the evaluations to raise Shasta Dam. In November 1978, Reclamation produced for Congress an appraisal-level cost evaluation for enlarging Shasta Reservoir. Subsequent to this report, Congress directed Reclamation to engage in a feasibility study with the DWR regarding the enlargement of Shasta Lake. Most studies were competed in the early 1980s as part of PL 96-375.

As part of the study, Reclamation identified and assessed a number of potential surface water storage sites. They documented their findings in three reports: (1) Enlarging Shasta Lake, Total Water Management Study, Central Valley Basin, California – Working Document No.13, November 1978; (2) Enlarging Shasta Lake Feasibility Study, Description of Alternative Storage Facilities, August 1982; and (3) Enlarging Shasta Wrap-Up Report, September 9, 1988. The basic conclusion of the 1988 report was that although enlarging Shasta Dam appeared feasible, there was a low demand for new supplies at the time.

In a May 1999 appraisal assessment, Reclamation evaluated three potential dam raise options at Shasta: (1) High Option, (2) Intermediate Option, and (3) Low Option. These potential modifications to Shasta Dam and Reservoir are summarized in **Chapter II**. The basic conclusion of the appraisal assessment was that feasibility scope studies to enlarge Shasta Dam should be undertaken and that a focus of the studies should be on a low dam raise option.

APPENDIX ORGANIZATION

Chapter I describes background information and the purpose and scope of the project, and describes previous studies. **Chapter II** focuses on identifying potential onstream surface water storage sites and options. **Chapter III** focuses on identifying potential offstream surface water storage sites and options. **Chapter IV** is a comparison of various onstream and offstream surface water storage sites and options and a designation of which site/option should be pursued in further studies for the SLWRI. **Chapter V** includes a summary of the findings of this appendix.

CHAPTER II
POTENTIAL ONSTREAM SURFACE WATER STORAGE OPTIONS

This chapter discusses important characteristics of onstream surface water storage and describes potential onstream projects in the Central Valley.

IMPORTANT CHARACTERISTICS

From a water resources development perspective, the primary value of onstream storage is in its ability to capture and store essentially all inflows (with exception of major flood flows) that do not exceed the allowable storage space in the reservoir. In those cases where inflows exceed the allowable storage space, the inflow volume is passed through the reservoir to the downstream creek or river. There is no need to divert, pump, and/or transport water from another river or stream or transfer water from another watershed. Accordingly, there is less likelihood for additional infrastructure, transmission costs, and resource impacts.

POTENTIAL ONSTREAM STORAGE PROJECTS AND SITES

Many potential dam and reservoir sites exist on tributaries to the Sacramento and San Joaquin Rivers in the Central Valley. Following is a highlight of the most significant of these potential projects, as identified in previous investigations.

Sacramento River Basin

Various potential Sacramento River basin onstream dam and reservoir sites worth noting have been identified over the years. Although several sites are located west of the Sacramento River, most are on subwatersheds on the east side of the Sacramento River Basin. Generally, watersheds on the east side of the Sacramento River Valley generate greater average annual runoff volumes per unit of land than those on the west side of the valley. This, and the topography of lands along the west side of the basin, indicates that the potential west-side dam and reservoir sites typically have more potential as offstream storage. Although each has potential to develop some onstream storage, the cost to develop this source would be relatively high compared to some of the other potential projects listed above. Several of the most significant sites identified in past studies are included in **Plate 2** and listed below.

- **Shasta Dam and Reservoir Enlargement (Site 1)** - Shasta Dam and its 4.55 MAF reservoir is located on the Sacramento River drainage basin about 10 miles northwest of the City of Redding, California. Previous studies have assessed raising the dam an additional 200 feet and adding over 9 MAF to the existing capacity. This project is one of the five surface water storage projects in the CALFED ROD.

- **Allen Camp Dam and Reservoir (Site 2) –** Allen Camp Dam and Reservoir would be a new180,000 acre-foot facility on the upper Pit River in Modock County.

- **Round Valley Dam and Reservoir (Site 3) –** Round Valley Dam and Reservoir would be a new 95,000 acre-foot new facility on Ash Creek just upstream from the town of Adin in Modoc County.

- **Kosk Dam and Reservoir (Site 4**) **–** Kosk Dam and Reservoir would be a new 800,000 acre-foot facility located on the Pit River approximately 2 miles downstream from the community of Big Bend in Shasta County.

- **Cottonwood Creek Project (Site 5) –** The Cottonwood Creek Project consists of a new 1.6 MAF two-dam and reservoir project – Dutch Gulch located on North Fork Cottonwood Creek in Shasta County and Tehama Dam located on South Fork Cottonwood Creek in Tehama County west of the Sacramento River.

- **Red Bank Project (Site 6)** – The Red Bank Project consists of a new 359,000 acre-foot two-dam and reservoir project – Dippingvat Dam located on South Fork Cottonwood Creek and Shoenfield Dam located on Red Bank Creek in Tehama County west of the Sacramento River.

- **Auburn Dam Project (Site 7) –** The Federally authorized Auburn Dam Project consists of a new 2.3 MAF dam and reservoir located near the City of Auburn on Middle Fork of the American River in El Dorado and Placer Counties.

- **Marysville Lake Project (Site 8) –** The Marysville Lake Project consists of a 916,000 acre-foot new dam and reservoir located on the Yuba River about 15 miles north of the City of Marysville in Yuba County.

- **Folsom Dam Enlargement (Site 9) –** Folsom Dam and its 1 MAF reservoir is located on the American River about 25 miles east of the City of Sacramento in Placer, El Dorado, and Sacramento counties. Previous studies have assessed raising the dam an additional 12 feet and adding about 157,000 acre-feet to the existing capacity.

- **Gallatin Reservoir (Site 10) –** Gallatin Dam and Reservoir would be a new 183,000 acre-foot facility located on Elder Creek in Tehama County.

- **Deer Creek Meadows Reservoir (Site 11) –** Dear Creek Meadows Dam and Reservoir would be a new 200,000 acre-foot facility located on Dear Creek in Tehama County.

- **Millville Reservoir (Site 12) –** Millville Dam and Reservoir would be a new 206,000 acre-foot facility located on South Cow Creek in Shasta County.

- **Bella Vista Reservoir (Site 13) –** Bella Vista Dam and Reservoir would be a new 146,000 acre-foot facility on Little Cow Creek in Shasta County.

- **Wing Reservoir (Site 14) –** Wing Dam and Reservoir would be a new 244,000 acre-foot facility on Inks Creek in Shasta County.

San Joaquin River Basin

About 62 percent of inflows to the Sacramento and San Joaquin River Delta come from the Sacramento River basin and 15 percent from the San Joaquin River basin. The remaining 9 percent is from east-side tributaries to the Delta, including the Consumes and Mokelumne Rivers and local precipitation. Of the Sacramento and San Joaquin River basins, about 85 percent of expected future water shortages will occur in the San Joaquin basin. Of projects to address future water needs in the CVP, nearly 90 percent of the expected deliveries would be to meet existing and future demands south of the Delta. Although many possible dam and reservoir sites exist south of the Delta, the potential for onstream storage reservoirs to effectively address these needs is significantly limited when compared to the Sacramento River basin.

Three onstream storage projects that have been identified in previous and other ongoing studies that could potentially help supplement water supply reliability in the San Joaquin River basin (see **Plate 2**) include the following:

- **Millerton Lake (Site 15) –** Enlarging the existing Millerton Lake or adding additional storage on the upper San Joaquin River. One of the five surface water storage projects contained in the CALFED ROD.

- **Raising Pardee Reservoir (Site 16) –** Increasing the storage capacity of Pardee Reservoir on the Mokelumne River by about 150,000 acre-feet.

- **Modifying Farmington Dam (Site 17) –** Modifying Farmington Dam on Littlejohns Creek by modifying the foundation and embankment and raising the dam to hold carryover storage of up to 100,000 acre-feet.

INITIAL ONSTREAM SITE SCREENING

An initial screening was conducted on the above 17 onstream surface water storage projects based on existing and available information contained in previous studies by Reclamation, Corps of Engineers, and CALFED. The primary screening criteria includes are similar but not specifically the same as those used in the CALFED SWSS report, include:

- **Capacity –** Consistent with SWSS report, it is believed that potential new project storage capacities less than abut 200,000 acre-feet, as a stand-alone project, would not generate sufficient increases in water supply reliability to the CVP and/or SWP system to warrant further consideration. Accordingly, these potential projects were not considered further. This does not necessarily mean, however, that these sites and potential projects should not be further considered by local interests to address their specific water resources needs.

- **Objective Fulfillment –** Planning objectives identified developed for the SLWRI are listed in **Chapter I**. Potential new storage projects that would have a relatively low potential to generally address one or more of these objectives, were not considered further. These potential projects were deemed to not be viable alternatives to creating new storage in Shasta Reservoir. Conversely, potential projects suggested in previous studies to have potential to significantly address the objectives were retained for further review, regardless of the retention status in the SWSS report.

- **Acceptability –** Acceptably is the workability and viability of a potential action with respect to acceptance by other Federal agencies, State and local governments, and the public. It is a subjective criterion that attempts to measure the overall implementability of an action. All potential dam sites have many factors affecting their acceptability. However, some have been considered many times and rejected from further development or would create overriding environmental or social impacts, and generally are not likely candidates for further consideration. These potential projects/sites were not considered further.

- **Redundant Study –** With one exception (Sites or NODOS Project), if a potential surface water storage project was the subject of another Federal feasibility study, it was eliminated from further review in the SLWRI. This was especially the case for those projects that would not significantly contribute to the SLWRI planning objectives.

Table II-1 provides information on the 17 dam and reservoir sites listed above and primary reasons for selecting them for additional considering or eliminating them in this investigation. The primary reasons for not further considering 11 of the sites further was that they were either too small, were not realistic alternatives to new storage to enlarging Shasta Dam and Reservoir, or had a low likelihood for being implemented.

SITES FOR FURTHER REVIEW

Following is a summary of each of the potential onstream surface water storage projects retained for further review in **Table II-1**.

Shasta Dam and Reservoir Enlargement (Site 1)

Shasta Dam is located on the Sacramento River drainage basin about 10 miles northwest of the City of Redding, California (see **Plate 1**). The capacity of Shasta Reservoir (originally Kennett Reservoir) was originally planned to be approximately 8 MAF, but economic conditions during the 1930s limited the capacity to its present size of 4.55 MAF. At gross pool, Lake Shasta has a water surface area of 29,600 acres. The seasonal flood control storage space in Shasta is 1.3 MAF. Shasta Dam is a curved, gravity-type, concrete structure 533 feet high above the streambed with a total height above the foundation of 602 feet. The dam has a crest length of 3,460 feet. The existing dam has a crest elevation at 1,077.5 feet and a maximum water surface elevation of 1,067 feet for joint-use storage space.

The Sacramento River has a drainage area at Shasta Dam of about 6,700 square miles. Major tributaries to Shasta Reservoir include the Sacramento, McCloud, and Pit rivers. Shasta Dam influences flows along the Sacramento River downstream to the Sacramento-San Joaquin River Delta. The total drainage area of the Sacramento River at the Delta is about 26,300 square miles. The average annual runoff to the Delta from the Sacramento River watershed is about 17.2 MAF, representing about 62 percent of the total inflows to the Delta area.

TABLE II-1
SUMMARY INITIAL SCREENING OF ONSTREAM STORAGE RESERVOIR SITES

Site No.	Offstream Storage Dam Site Name	River/Creek	County	Maximum Storage (Potential) (1,000 acre-feet)	CALFED Retained	Primary Reason for Initial Screening
1	Shasta Dam	Sacramento River	Shasta	9100	Yes	Significant contribution identified in previous studies to increase water supply reliability as well as other SLWRI study objectives.
2	Allen Camp Dam Site	Pit River	Modoc	180	No	Not Considered Further. Limited size & low potential to increase system reliability.
3	Round Valley Dam Site	Ash Creek	Modoc	495	No	Potential for significant contribution identified in previous studies to increase water supply reliability.
4	Kosk Dam Site	Pit River	Shasta	800	No	Potential for significant contribution identified in previous studies to increase water supply reliability.
5	Cottonwood Creek Project	North & South Fork Cottonwood Creek	Shasta & Tehama	1600	No	Potential for significant contribution identified in previous to address the study objectives for the SLWRI.
6	Red Bank Project	South Fork Cottonwood & Red Bank Creeks	Tehama	359	Yes	Potential for significant contribution identified in previous studies to increase water supply reliability.
7	Auburn Dam Project	Middle Fork American River	Placer	2300	No	Potential for significant contribution identified in previous studies to increase water supply reliability.
8	Marysville Lake Project	Yuba River	Yuba	916	No	Not considered further. Although significant contribution identified in previous studies to increasing system water supply reliability, the project would result in very high environmental impacts, be very costly, and has not been the alternative of choice in recent studies for addressing basin specific water resources problems and needs.
9	Folsom Dam	American River	Sacramento, Placer, & El Dorado	157	No	Not considered further. Enlargement for flood control is underway and limited potential to increase water supply reliability.
10	Gallatin Dam Site	Elder Creek	Tehama	183	No	Not considered further. Limited size & low potential to increase system reliability.
11	Deer Creek Meadows Site	Deer Creek	Tehama	200	No	Not considered further. Limited size & low potential to increase system reliability.
12	Millville Dam Site	South Cow Creek	Shasta	206	No	Not considered further. Limited size & low potential to increase system reliability.
13	Bella Vista Dam Site	Little Cow Creek	Shasta	146	No	Not considered further. Limited size & low potential to increase system reliability.
14	Wing Dam Site	Inks Creek	Shasta	244	No	Not considered further. Studies various times and found to be not cost effective with major environmental issues. Not a reasonable alternative for increased storage in Shasta Reservoir.
15	Millerton Lake	San Joaquin River	Fresno	720	Yes	Not considered further. Little potential to address SLWRI study objectives for SLWRI. Redundant study - subject of separate feasibility study.
16	Pardee Dam	Mokelumne River	Calaveras & Amador	150	No	Not considered further. Limited size & low potential to increase system reliability.
17	Farmington Dam	Littlejohns Creek	San Joaquin	100	No	Not considered further. Limited size & low potential to increase system reliability.

In the May 1999 appraisal assessment, Reclamation evaluated three potential dam raise options at Shasta: (1) High-Level Raise, (2) Intermediate-Level Raise, and (3) Low-Level Raise. The assessment considered potential costs, technical issues, and relative impacts associated with dam raises of 6.5, 102.5, and 202.5 feet. These options would provide between 290,000 acre-feet and 9.3 MAF of additional storage space in Shasta Reservoir and inundate between about 1,000 and 30,000 additional acres. Included in **Table II-2** is a listing of the major features associated with the three dam raise options.

TABLE II-2
SHASTA DAM AND RESERVOIR ENLARGEMENT FEATURES

Item	Baseline	Low-Level Raise (Site 1-a)	Intermediate-Level Raise (Site 1-b)	High-Level Raise (Site 1-c)
Dam & Appurtenances				
Dam Crest Raise (ft)	NA	6.5	102.5	202.5
Dam Crest Elevation (ft)	1,077.5	1,084	1,180	1,280
Dam Crest Length (ft)	3,460	3,660	4,590	4,930
Gross Pool Elevation (ft)	1,067	1,075.5	1,171.5	1,271.5
Gross Pool Raise (ft)	NA	8.5	104.5	204.5
Reservoir Capacity (MAF)	4.55	4.84	8.47	13.89
Surface Area @ Gross Pool (acres)	29,600	30,660	44,180	60,760
Capacity Increase (MAF)	NA	.29	3.92	9.34
Refill Period (years)	0.8	0.9	1.5	2.4
Spillway Crest Elevation (ft)	1,037	1,050	1,146	1,246
Top of Spillway Gate Elevation (ft)	1,065	1,075.5	1,171.5	1,271.5
Spillway Gates	3-28'x110' Drum	6-27.5'x55' Radial	6-27.5'x55' Radial	6-27.5'x55' Radial
Outlet Works	18 in 3 Tiers	Replace Valves	Replace	Replace
Outlet Works Capacity (1,000 cfs)	81.8	88.0	113.6	133.6
Relocations				
I-5/UPRR Bridges	NA	Minor	Major	Major
Recreation Facilities	NA	Minor	Major	Major
Resort Facilities	NA	Minor	Major	Major
Communities	NA	Minor	Yes	Yes
Related Facilities				
Temperature Control Device	Shutter Structure	Raise Operating Controls	Replace	Replace
Penstocks	5-15' Diameter	Strengthen Supports	Replace Gates & Strengthen Supports	Replace Gates & Strengthen Supports
Powerplant	578 MW Capacity	None	Potential to Add Units	Potential to Add Units
Reservoir Dikes	None	None	2 Major Dikes	4 Major Dikes

Key: cfs – cubic acre feet per second ft – feet MAF – million acre feet NA – not applicable

- **Low-Level Raise -** The Low-Level Raise consists of a structural dam raise of 6.5 feet resulting in a new dam crest elevation at 1,084 feet. This option would establish a new top of joint-use storage space at elevation 1,075.5, corresponding to an additional 8.5 feet of water in the reservoir. The total capacity of this new reservoir would be 4.84 MAF, an increase of 290,000 acre-feet above the existing available storage. The dam raise would be limited to the existing dam crest only, with mass concrete placed in blocks on the existing concrete gravity section and precast concrete panels used to retain compacted earthfill placed on the embankment wingdam sections. A new spillway crest section would be developed within the raised structure. Control features of the existing TCD would be extended up to the new crest elevation and the main TCD enclosure would be extended up to the new gross pool elevation. The main relocations required for this option would be 2 railroad bridges, and about 45 buildings close to the shore of Shasta Lake. Minor impacts would occur to reservoir area terrestrial resources and resident fisheries in Shasta Lake. Benefits would occur to the anadromous fish population downstream from Shasta.

Intermediate- and High-Level Raises - The Intermediate- and High-Level Raise options consist of a structural raise at 102.5 and 202.5 feet to a new crest elevation at 1,280 feet (see **Table II-2**). The High-Level Raise option represents the highest practical dam raise of Shasta Dam. Enlargements beyond this point begin to result in significant topographical and geological problems. For both dam raise options, the existing concrete gravity dam section would be raised using a mass concrete overlay on the existing dam crest and downstream face. The upstream face within the curved non-overflow sections would extend vertically to the new dam crest elevation. The dam crest would be completed with a crest cantilever for the roadway surface, sidewalks, and parapet walls. The existing elevator shafts would be extended to the new dam crest, and new elevator towers would be provided. The spillway sections would require a thicker section to accommodate the gated spillway crest. For both options, saddle dikes would need to be constructed to close off gaps between mountain peaks in the upper watershed. Both options would also include relocation of the Pit River Bridge at Bridge Bay, numerous other bridges, and related transportation infrastructure. In addition, essentially all the recreational facilities and other developments around the lake would to be impacted. Because of the larger lake volume and area, both negative and beneficial impacts would occur to the resident fisheries. Because of the deeper reservoir and larger volume of release during the late spring through summer period, benefits would occur to some populations of anadromous fish along the Sacramento River. However, because of the changes in flow regime due to the storing of greater amounts of winter runoff, lower peak flows would occur along the Sacramento River with some negative resulting impacts.

Included in **Table II-3** are summaries of various performance factors for the low and high dam raise options at Shasta, including preliminary estimates of first and annual costs. Estimated unit costs (costs per acre-foot of average annual drought year yield) are also included in the table. As shown, previously estimated first costs for the Low-Level and High-Level Raises are about $280 million and $5 billion, respectively.

Round Valley Dam and Reservoir (Site 3)

Round Valley Dam would be located on Ash Creek just upstream from the town of Adin in Modoc County. Previous studies have considered a dam consisting of a rock-filled structure with a height of 170 feet above streambed, a crest elevation of 4,360 feet, and a crest length of 3,800 feet.

TABLE II-3
POTENTIAL ONSTREAM RESERVOIR STORAGE INFORMATION

Onstream Project [1]		Physical Characteristics									Economics		
Map #	**Name, River/Creek, and County**	**Drainage Area (sq mi)**	**Dam Height (ft)[2,3]**	**Crest Elevation (ft)[3]**	**Crest Length (ft)[3]**	**Reservoir Area (1,000 acre-ft)[3]**	**Storage Capacity TAF[3]**	**Annual Inflow (TAF/yr)**	**Refill Period (years)[4]**	**Water Supply Reliability (acre-feet/yr)[5]**	**First Cost[6] ($million)**	**Annual Cost[7] ($million)**	**Approx. Unit Cost[8] ($/acre-feet yield)**
Upstream from Shasta Dam													
	Shasta Enlargement												
1.a	Low-Level Raise	6,700	6.5 (487)	1,084	200 (3,460)	0.7 (29.5)	290 (4,552)	5,677	<1	72	280	19	260
1.c	High-Level Raise	6,700	202.5 (487)	1,280	1,470 (3,460)	31.0 (29.5)	9,100 (4,552)	5,677	2 to 3	703	5,200	380	540
3	Round Valley Reservoir	200	170	4,360	3,805	3.26	495	24	-	110	740	52	470
4	Kosk Reservoir	4,900	500	2,008	2,200	4.73	800	3,700	<1	160	1,200	84	520
Downstream from Shasta Dam													
5	Cottonwood Creek Project												
	Dutch Gulch, Dam & Reservoir	390	247	758	20,700	11.2	900	292					
	Tehama Dam & Reservoir	370	215	714	23,000	10.2	700	188					
	Total	760	-	-	43,700	21.4	1,600	480	3 to 4	260	1,300	91	350
6	Red Bank Project												
	Dippingvat Dam & Reservoir	132	251	-	-	-	104	96					
	Shoenfield, Dam and Reservoir	*22*	300	-	-	-	250	16					
	Total	154		-	-	-	359	112	3 to 4	60	450	32	520
7	Auburn Dam Project [9]	970	519	1,135	3,500	10.05	2,300	1,640	1 to 2	330	1,900	133	400
Key:	ft – feet	sq mi – square miles		TAF – thousand acre feet		yr - year							

Notes:

[1]Base information from numerous sources, with majority from CALFED Storage and Conveyance Components Facilities Descriptions and Cost Estimates, October 1997 and prior studies by Reclamation and U.S. Army Corps of Engineers.

[2]Height above streambed.

[3]Information within ( ) is for existing dam and reservoir. Information outside ( ) is added increment.

[4]Reservoir storage capacity divided by annual inflow. Refill time for Round Valley depends on deliveries from nearby streams.

[5]Approximation only. Delivery supply reliability increase measured in increased drought period yield. Based on ratio of average annual yield estimates using CALSIM model for various sizes of increased storage at Shasta Reservoir then proportioned to other projects based on total storage.

[6]Approximation only. Estimate first cost based on previous studies updated to 2003 price levels or ratios to other dam projects based primarily on embankment volume estimates.

[7]Approximation only. Estimated average annual cost based on first cost at 5-5/8 percent interest rate over 100-year project live. Does not include cost adjustments (+ or -) for power.

[8]Average annual cost divided by estimated average annual drought year yield.

[9]Cost for 2.3 MAF authorized project updated by price levels less hydropower generation facilities. Yield is estimated over critical dry period.

Round Valley Reservoir would store flows on Ash, Willow, and Butte creeks, and regulate the releases down Ash Creek. To significantly contribute to increasing system water supply reliability, the project would need to include diversions of excess flows from the Pit River. As identified in previous studies, a potential reservoir at the Round Valley site would have a storage capacity of 495,000 acre-feet. However, this capacity could be smaller depending on the ability to divert flows from the Pit River and on the availability of tributary stream runoff. Stream flows from Willow and Butte Creeks would be diverted for storage in Round Valley Reservoir. A small diversion dam would be constructed on Willow Creek. The diversions would be made to increase the yield of the reservoir; suitable sites are not available on either creek for conservation storage. At gross pool, the reservoir would cover an area of about 3,260 acres.

Most of the reservoir area lands are used for pasture and cattle grazing. About 20 residences would be relocated. Because of the ephemeral nature of the existing creeks, minor impacts would occur to the resident fishery. No designated natural or wilderness areas exist in the reservoir area.

As shown in **Table II-3,** a preliminary estimate of the first costs for the Round Valley Dam and Reservoir is about $740 million.

Kosk Dam and Reservoir (Site 4)

Kosk Dam would be located on the Pit River approximately 2 miles downstream from the community of Big Bend in Shasta County. Previous studies have considered an earth-filled dam with a height of 500 feet above streambed, a crest elevation of about 2,008 feet, and a crest length of 2,200 feet.

Kosk Reservoir would store flows on the Pit River primarily for irrigation and M&I water supplies, and hydroelectric power generation. At gross pool, the reservoir would store about 800,000 acre-feet, cover an area of about 4,730 acres, and inundate about 12 miles of intermittent stream habitat of the Pit River. Gross pool would extend upstream to the PG&E Pit No. 5 Diversion Dam.

The community of Big Bend (between 250 and 300 persons) and several miles of U.S. Forest Service and county roads in the reservoir area would require relocation. Most of the lands in the reservoir area are used for timber and agriculture. Lands are mostly privately owned, except for a portion of the Shasta-Trinity National Forest.

Table II-3 includes an order of magnitude estimate of first and annual costs for the Kosk Dam and Reservoir project. As shown, the estimated first cost is about $1.2 billion.

Cottonwood Creek Project (Site 5)

The Cottonwood Creek Project would control the runoff from approximately 760 square miles of the upper Cottonwood Creek watershed. The average annual inflow to the reservoirs totals about 480,000 acre-feet giving a refill period of approximately 3.3 years. As defined in an 1983 General Design Memorandum, the project would include construction of two multipurpose dams and reservoirs in the Cottonwood Creek watershed, about 15 miles west of the Sacramento River near the town of Cottonwood in Shasta and Tehama counties. Cottonwood Creek is a west-side tributary to the Sacramento River about midway between the towns of Redding and Red Bluff. The plan of improvement provided for construction of Dutch Gulch Dam on the mainstem of Cottonwood Creek (extending over portions of North and Middle forks) and Tehama Dam across the South Fork of Cottonwood Creek. Dutch Gulch would have a crest length of about 3.9 miles and reach a maximum height of 247 feet. It would have a gross storage capacity of 900,000 acre-feet. The crest length of Tehama Dam would extend approximately 4.4 miles and reach a height of 215 feet with a gross pool capacity of 700,000 acre-feet. Together, the reservoirs would provide a total storage capacity of 1.6 MAF for flood control, local irrigation, M&I water supply, recreation, and ecosystem restoration proposes.

Cottonwood Creek is the largest unregulated tributary to the Sacramento River upstream from the Sacramento/San Joaquin River Delta. Consequently, it is the largest contributor of peak flood flows to the Sacramento River. It is also a very significant source of sediments and gravels to the river. The Creek provides spawning for fall-run and late-fall-run chinook salmon and supports spring-run chinook salmon in some years. Combined, both Dutch Gulch and Tehama reservoirs would inundate about 28 miles aquatic and riparian habitat.

The estimated first cost of the project is about $1.3 billion (see **Table II-3**).

Red Bank Project (Site 6)

As part of studies for the Cottonwood Creek Project, numerous other dam and reservoir sites were evaluated on surrounding rivers and creeks tributary to the Sacramento River. Beginning in the mid-1980s, DWR investigated various combinations of potential sites. One combination that appeared to have some promise was the Red Bank Project.

The Red Bank Project site would be located in Tehama County approximately 20 miles west of Red Bluff. It primarily consists of Schoenfield Reservoir on Red Bank Creek (which enters the Sacramento River at Red Bluff) and Dippingvat Reservoir on the South Fork of Cottonwood Creek. As envisioned, Dippingvat Dam would be a roller-compacted concrete (RCC) structure 251 feet high and create a reservoir with a gross pool capacity of 104,000 acre-feet. Schoenfield Dam would be about 300 feet high with a gross pool capacity of 250,000 acre-feet. Together the reservoirs would provide a total storage capacity of 359,000 acre-feet primarily for local irrigation and M&I water supply. The project would also provide for a small amount of flood control and the potential for recreation and ecosystem restoration. The total average annual inflow to the system would be 110,600 acre-feet (96,400 acre-feet at Dippingvat and 16,000 acre-feet at Schoenfield), resulting in a refill period of just over 3 years.

The project would also include a conveyance system connecting Dippingvat to Schoenfield reservoirs. The system would consist of three connecting canals and an 800-foot-long tunnel with a total length of about 2.7 miles and two small reservoirs - Lanyan and Bluedoor. Lanyan Reservoir would be 75 feet high and have a gross pool capacity of 1,300 acre-feet. Bluedoor Reservoir would be 115 feet high and have a gross pool capacity of 3,400 acre-feet. The purpose of the conveyance system would be to divert up to 800 cubic feet per second (cfs) of available winter flows from the South Fork Cottonwood Creek to Schoenfield Reservoir.

The estimated first cost of the project is about $450 million (see **Table II-3**).

Auburn Dam Project (Site 7)

Numerous potential dam and reservoir locations have been evaluated for either multiple or single purpose water supply and flood control projects in the American River Watershed in Placer and El Dorado Counties. These studies have tended to focus on the Auburn Dam site, which was identified well over 100 years ago. Other sites considered in the watershed have included Granite Canyon and Giant Gap on the North Fork of the American River, Growlersburg on the Middle Fork, and Coloma, Salmon Falls, and Alder on the South Fork of the American. Today, each of these dam and reservoir sites, with exception of the Auburn Dam site, would be ruled out of serious consideration primarily because of their relative high cost, significant amount of relocations required, and low potential for providing significant additional water supply or flood control benefits.

The Auburn-Folsom South Unit of the CVP was authorized in September 1965 by Public Law 89-161. The unit includes Auburn Dam, Reservoir, and Powerplant on the North Fork American River above Folsom Lake; Folsom South Canal to convey water from Nimbus Dam on the American River approximately 62 miles south; Sugar Pine Dam and Reservoir to serve the Foresthill Divide area; and County Line Dam and Reservoir to serve the Malby area southeast of Folsom.

Construction of Auburn Dam was initiated in 1967. In August 1975, when the foundation for the dam was being constructed, an earthquake occurred near Oroville, California. The earthquake led to inquiries about the safety of the double-curvature concrete-arch dam design then planned for Auburn. Although the foundation contract was completed, no further construction was undertaken on overall dam construction despite consensus from knowledgeable and creditable sources that a safe dam can be constructed at the Auburn site (likely a concrete gravity-type dam). Through 1987, about $233 million had been spent on the dam and related facilities.

Following the disastrous floods of February 1986, the Corps, DWR, and local flood control agencies evaluated alternatives to reduce the flood threat to Sacramento. They concluded that the most effective and efficient way to provide significant increased levels of flood protection was through new storage at or near the Auburn Dam site. On two occasions, the Corps and DWR concluded reports recommending a flood detention dam for the upper American River Canyon. To date, however, concerned public and special interest groups have focused attention on alternatives to new storage upstream from Folsom Reservoir for increased flood protection.

Various sizes of a multipurpose dam and reservoir at Auburn have been considered, ranging from replacing the cofferdam at the original dam site (washed out during the 1986 flood) with a permanent dam, to constructing the originally authorized project size. The authorized project scope consisted of a dam about 685 feet high and with a crest length of about 4,200 feet. If constructed at a size similar to the authorized project plan, the reservoir would have a total capacity of 2.33 MAF. The total average annual inflow to Auburn Dam site is about 1.6 MAF. Accordingly, the refill period for the authorized project size would be between 1 and 2 years.

At gross pool, the authorized project would inundate about 10,050 acres and 33 miles of upper river canyon. It would include a powerplant, relocation of major upstream facilities including State Highway 49 and major recreation facilities. Recent studies have concluded that smaller reservoir sizes might be more feasible. The project would provide for flood control, irrigation and M&I water supply, hydropower, recreation, and ecosystem restoration.

The estimated first cost of the authorized project is about $1.9 billion (see **Table II-3**).

CHAPTER III
POTENTIAL OFFSTREAM SURFACE STORAGE OPTIONS

This chapter discusses important characteristics of offstream surface water storage and describes potential offstream projects in the Central Valley.

IMPORTANT CHARACTERISTICS

As opposed to onstream surface water storage, offstream storage primarily consists of developing reservoirs in smaller drainage basins with seasonal streams that do not significantly contribute to water stored in the reservoir. Onstream reservoirs store essentially all flows from the drainage basin greater than minimum instream flow requirements (up to the maximum allowable storage of the facility); however, offstream storage involves diverting water from another river or another storage reservoir and transporting the water through channels or pipelines to the offstream reservoir, which may be miles away from the initial point of diversion. Therefore, potential offstream storage projects include significant facilities to divert and convey water to and from the offstream storage reservoirs.

If diverted from a stream or river system, the water to be stored in the offstream storage reservoirs is normally water that is in excess of the instream flow requirements at a particular time. If diverted from an existing reservoir, it is usually water in excess of the storage capacity of that reservoir.

Offstream storage serves primarily to bolster water supply reliability particularly in drought periods help reduce the potential for diversions from the major rivers during important periods such as to help protect fish resources. Offstream storage is operated in combination with diversions and/or pumping of river flows when they are in excess of instream flow requirements, and is limited by the capacity of the diversion/pumping facilities.

Offstream storage can be a viable option for developing new water storage. This is especially the case when significant amounts of excess water are in the system; when storage in onstream reservoirs is not available because of topographic, environmental, or other factors; and when the costs to divert and store the excess flows are lower than alternative onstream storage reservoirs. A major advantage of offstream storage is that it can be constructed in relatively smaller drainage basins with the possibility of having significantly less impact on riverine resources, such as anadromous fish and riparian vegetation, because it relies primarily on water diverted from other sources.

POTENTIAL OFFSTREAM STORAGE PROJECTS AND SITES

Many potential offstream dam and reservoir sites have been identified in previous studies in both the Sacramento and San Joaquin Rivers basins. Several of the most significant sites identified in past studies are included in **Plate 3** and listed below.

Sacramento River Basin

- **Sites Reservoir (Site 18**) **–** The Sites Dam and Reservoir Project consists of a 1.8 to 1.9 MAF new storage facility on Stone Corral and Funks creeks about 70 miles northwest of Sacramento and 10 miles west of Maxwell in Antelope Valley in Colusa and Glenn counties. The Sites Project is one of 5 surface water storage projects in the CALFED ROD. Feasibility scope studies are underway on the project.

- **Colusa Reservoir (Site 19) –** The Colusa Dam and Reservoir Project consists of a new 3.3 MAF storage facility primarily on Stone Corrall Creek about 70 miles northwest of Sacramento and 10 miles west of Maxwell in Antelope Valley in Colusa and Glenn counties.

- **Lake Berryessa Enlargement (Site 20) –** The Lake Berryessa Enlargement Project consists of enlarging the size of the existing 1.6 MAF Lake Berryessa up to about 6 MAF. Lake Berryessa is located on Putah Creek about 8 miles west of the town of Winters in Solano County.

- **Thomes-Newville Reservoir (Site 21) –** The Thomes-Newville Dam and Reservoir Project consists of constructing a new storage facility up to 3.08 MAF on Thomes and Stoney creeks in Glenn County west of the Sacramento River**.**

- **Squaw Valley Reservoir (Site 22) –** The Squaw Valley Dam and Reservoir Project consists of a new 400,000 acre-foot storage facility located on Squaw Valley Creek about 8 miles south of the community of McCloud in Shasta County. As envisioned, water for storage would come from (1) natural inflow from Squaw Valley Creek and (2) water diverted from the upper Sacramento River through an 11 mile-long, 500 cfs tunnel.

- **Shasta-Clair Engle Diversion (Site 23) –** The Shasta-Clair Engle Diversion Project consists of increasing the capacity of Clair Engle Lake located on the Trinity River in Trinity County approximately 20 miles north west of the City of Redding by up to a 4.8 MAF, and constructing a system of canals, pipelines, pump stations, and interim holding facilities to connect Clair Engle to Shasta Lake. Excess flows to Shasta Lake would be stored in Clair Engle.

- **Tuscan Buttes Reservoir (Site 24) –** The Tuscan Buttes Dam and Reservoir Project consists of a new 3.7 MAF storage facility located on Paynes and Inks creeks on the east side of the Sacramento River in Tehama County north east of Red Bluff.

- **Glenn Reservoir (Site 25) –** The Glenn Reservoir and River Diversion Project consists of a new 8.7 MAF storage facility located on the North Fork Stony Creek and mainstem Stony Creek on the west side of the Sacramento River in Glenn and Tehama counties west of Chico.

- **In-Delta Storage (Site 26) –** The In-Delta Storage project consists of several potential alternatives, including converting existing islands in the Sacramento/San Joaquin River Delta into offstream water storage reservoirs with capacities ranging from 230,000 to 600,000 acre-feet. The In-Delta Storage Project is one of five surface water storage projects in the CALFED ROD.

- **Waldo Reservoir (Site 27) –** The Waldo Dam and Reservoir Project consists of a new 300,000 acre-foot storage facility on Dry Creek in Yuba County that would store diverted flows from the Yuba River.

- **Dear Creek Reservoir (Site 28) –** The Deer Creek Dam and Reservoir Project consists of a new 600,000 acre-foot storage facility on Deer Creek (tributary to the Consumnes River) in Sacramento County. The facility would store excess flows either from Folsom Dam on the American River east of Sacramento or from the lower American River via the Folsom South Canal and appurtenant facilities.

San Joaquin River Basin

Numerous offstream storage projects have been considered in previous studies in the San Joaquin Basin. Reclamation, CALFED, and others have evaluated offstream storage projects primarily involving pumping water from the California Aqueduct for storage in expanded or new facilities along the west side of the San Joaquin Valley. To be significantly beneficial, each of these potential projects also relies on the capability to move additional fresh water through the Sacramento and San Joaquin Delta without further degradation of the Delta environment.

CALFED considered 12 offstream storage projects at sites along the California Aqueduct. Of these, five were identified as potentially warranting additional study (see **Plate 3**). They included the following:

- **Los Vaqueros Reservoir Enlargement (Site 29) –** The existing Los Vaqueros Reservoir is located in Contra Costa County, approximately 9 miles southwest of the City of Brentwood. The reservoir receives the majority of its water from the Delta under a contract from the CVP, with the remainder originating from the Los Vaqueros Watershed area. The reservoir has a total storage capacity of 100,000 acre-feet. Los Vaqueros Enlargement is being evaluated as one of the five potential surface water projects recommended by CALFED. The ROD identified a project to expand Los Vaqueros Reservoir by up to 400,000 acre-feet. Feasibility scope studies are under way by CCWMD.

- **Ingram Canyon Reservoir (Site 30) –** The Ingram Canyon Dam and Reservoir Project would be a new 333,000 acre-feet to 1.2 MAF storage facility located in Stanislaus County on Ingram Creek.

- **Quinto Creek Reservoir (Site 31) –** The Quinto Creek Dam and Reservoir Project site is located in Merced and Stanislaus counties on Quinto Creek. The project would consist of a reservoir with a size between 330,000 acre-feet to about 380,000 acre-feet.

- **Panoche Reservoir (Site 32) –** The Panoche Dam and Reservoir Project site is located on Panoche and Silver Creeks in Fresno county. The project would consist of a reservoir with a size ranging from 160,000 acre-feet to 3.1 MAF.

- **Montgomery Reservoir (Site 33) –** The 240,000 acre-foot Montgomery Dam and Reservoir Project site is in northeastern Merced County about 60 miles south of the Delta.

INITIAL OFFSTREAM SITE SCREENING

An initial screening was conducted on the above 16 offstream surface water storage projects based on existing and available information contained in previous studies by Reclamation, the Corps of Engineers, and CALFED. The primary screening criteria are as described for the onstream storage sites (capacity, objective fulfillment, and other studies). **Table III-1** shows the results of an initial screening of the 16 dam and reservoir sites and projects listed above. As can be seen, five offstream surface water storage projects were retained for further review.

SITES FOR FURTHER REVIEW

Following is a summary of the five potential onstream surface water storage projects considered further.

Sites Reservoir (Site 18)

The Sites Reservoir Project site is located about 70 miles northwest of Sacramento and 10 miles west of Maxwell in Antelope Valley, across the Stone Corral and Funks creeks drainages. The main dams and most of the study area would lie within northern Colusa County. The Sites project would receive little natural runoff. Nearly all of the water to fill the reservoir would come from the Sacramento River.

The capacity of a reservoir at Sites being considered in the DWR NODOS feasibility investigation is 1.9 MAF. At this capacity, the project would include 2 main dams and 12 saddle dams. The Sites Dam would be about 240 feet high and have a crest length of about 720 feet. Golden Gate Dam would be about 250 feet high and have a crest length of about 940 feet. Water in the reservoir would vary from a minimum operating pool of 320 feet to 480 feet. At full pool, the reservoir would inundate 15,000 acres.

Various alternative water conveyance concepts are being considered in the NODOS investigation. One concept consists of diverting water from the Sacramento River into the Tehama-Colusa (TC) Canal at the Red Bluff Diversion Dam. The diverted water would flow through the TC Canal 67 miles to the existing 40-foot high and 2,460 acre-foot capacity Funks Dam and Reservoir. Water would then be pumped from Funks Reservoir to Sites Reservoir. The existing capacity of the TC Canal is 2,530 cfs near the Sacramento River but diminishes to about 2,100 cfs near Funks Reservoir. One concept is to enlarge the capacity of the TC Canal to about 5,000 cfs and construct pumping facilities from Funks to Sites also at 5,000 cfs. Included in this concept is a modification to facilities at the Red Bluff Diversion Dam to accommodate the expanded diversion capacity and address likely increased fish resources problems at the facility. Another potential conveyance concept, being considered in current studies by DWR for the NODOS Project, consists of using maximum diversion capabilities in both the TC Canal and the Glenn-Colusa Irrigation District (GCID) Canal, which diverts Sacramento River water near Hamilton City. The combined maximum capacity of the two diversions is about 3,900 cfs. Again, other concepts are being investigated.

TABLE III-1
SUMMARY OF INITIAL SCREENING OF OFFSTREAM STORAGE RESERVOIR SITES

Site No.	Offstream Storage Dam Site Name	River/Creek	County	Maximum Storage (Potential) (1,000 acre-feet)	CALFED Retained	Primary Reason for Initial Screening
18	Sites Reservoir	Stone Corral & Funks Creeks	Colusa & Glenn	1800	Yes	Even though subject of a separate feasibility study, significant potential identified in previous studies to address one or more of SLWRI study objectives.
19	Colusa Reservoir	Stone Corral & Vicinity	Colusa & Glenn	3300	Yes	Potential for significant contribution identified in previous studies to increase water supply reliability.
20	Lake Berryessa Reservoir	Putah Creek	Napa	6000	No	Potential for significant contribution identified in previous studies to increase water supply reliability.
21	Thomes-Newville Reservoir	Thomes & Stony Creeks	Glenn	3080	Yes	Potential for significant contribution identified in previous studies to increase water supply reliability.
22	Squaw Valley Reservoir	Squaw Valley Creek	Shasta	400	No	Not considered further. Very low potential for implementation primarily due to the difficulty in developing water sources to fill the reservoir and the likely very high and difficult to mitigate environmental impacts.
23	Shasta-Clair Engle Reservoir	Trinity River	Trinity	4800	No	Not considered further. Very high first and annual costs, high ecosystem impacts, low likelihood for implementation.
24	Tuscan Buttes Reservoir	Paynes & Inks Creeks	Tehama	5500	No	Not considered further. Studied numerous times and found to be not cost-effective with very high and difficult to mitigate environmental impacts.
25	Glenn Reservoir	Stony Creek	Glenn & Tehama	8700	No	Not considered further. Very low potential for implementation primarily due to large size and resulting very high and significant impacts.
26	In-Delta Storage	Sacramento-San Joaquin Delta	Contra Costa & San Joaquin	220	Yes	Not considered further. Little potential to address SLWRI study objectives. Redundant study - subject of separate feasibility study.
27	Waldo Reservoir	Dry Creek	Yuba	300	No	Not considered further. Little potential to address SLWRI study objectives. Not a reasonable alternative for increased storage in Shasta Reservoir. Studied numerous times and found not to be cost effective or otherwise implementable.
28	Deer Creek Reservoir	Deer Creek	Sacramento	600	No	Not considered further. Little potential to address SLWRI study objectives. Not a reasonable alternative for increased storage in Shasta Reservoir. Studied numerous times and found not to be cost effective or otherwise implementable.
29	Los Vaqueros Reservoir	Kellogg Creek	Contra Costa	400	Yes	Not considered further. Little potential to address SLWRI study objectives. Redundant study - subject of separate feasibility study.
30	Ingram Canyon Reservoir	Ingram Creek	Stanislaus	1200	Yes	Not considered further. Little potential to address SLWRI study objectives. Not a reasonable alternative for increased storage in Shasta Reservoir.
31	Quinto Creek Reservoir	Quinto Creek	Merced & Stanislaus	330	Yes	Not considered further. Little potential to address SLWRI study objectives. Not a reasonable alternative for increased storage in Shasta Reservoir.
32	Panoche Reservoir	Panoche & Silver Creeks	Fresno	3100	Yes	Not considered further. Little potential to address SLWRI study objectives. Not a reasonable alternative for increased storage in Shasta Reservoir.
33	Montgomery Reservoir	Dry Creek	Merced	240	Yes	Not considered further. Little potential to address SLWRI study objectives. Not a reasonable alternative for increased storage in Shasta Reservoir.

Currently, water is diverted from the Sacramento River for agricultural purposes in the Colusa Basin in the spring and summer. As envisioned, under this concept, water would be drawn from the river earlier in the year when there are higher flows in the river and stored in Sites. Later, the stored water would be released for agricultural purposes and possibly to help increase water supply reliability and/or water quality considerations elsewhere. This would have an added benefit of helping restore anadromous fish resources in the Sacramento River by changing the peak diversion timing from lower flow spring/summer periods to higher flow winter periods.

A potential project identified in previous studies for CALFED includes features to both avoid and mitigate potential impacts on anadromous fisheries and the environment. The dam would not block sensitive runs of anadromous fish, would not block the passage of sediments and nutrients to the Sacramento River, and could be constructed in areas with generally less riverine sensitive resources. Potential impacts at the TC Canal and/or GCID Canal diversion points from the Sacramento River would need to be addressed. Also, several concepts include reintroduced some of the stored water back into the Sacramento River for use elsewhere. This could potentially degrade water quality. Accordingly, project features would be included to minimize these impacts.

The reservoir would result in adverse impacts to wildlife species currently residing in the inundation area. There would be likely impacts to several listed wildlife and plant species. At about 250 acres, the presence of wetland areas within the reservoir area is relatively small. An estimated 65 prehistoric sites and 27 historic sites exist in the area.

On the basis of updated information from the previous studies for CALFED, the preliminary estimated first cost of an offstream storage project using the 1.9 MAF Sites Reservoir site is about $1.3 billion (see **Table III-2**).

Colusa Reservoir (Site 19)

The Colusa Reservoir Project, as defined in previous studies, would be similar to the Sites Project. It would be located in Colusa and Glenn Counties, and include the features generally described for Sites Reservoir. However, it would include a larger reservoir with a total capacity of about 3.3 MAF. The larger reservoir would require two additional dams (Hunters and Logan) at low points in the reservoir rim. Hunters Dam on Hunters Creek would be 283 feet high and Logan Dam on Logan Creek would be 272 feet high. At gross pool storage, the reservoir would inundate about 20,000 acres. As with Sites Reservoir, the water for the reservoir would be diverted from the Sacramento River into the TC Canal at the Red Bluff Diversion Dam, or both the TC and GCID canals. Water diverted from Sacramento River would flow to Funks Dam and Reservoir. From Funks, the water would be pumped into Colusa Reservoir. The enlarged capacity of the canal and pumping facilities at Funks could be up to an estimated 5,000 cfs. Also included would be a modification to facilities at the Red Bluff Diversion Dam to accommodate the expanded diversion capacity and address likely fishery resource problems at the facility. It is believed that the Colusa Reservoir Project could be configured to not directly harm anadromous fish resources. The dam would not block sensitive runs of anadromous fish, would not block the flow of sediments and nutrients to the Sacramento River, and could be constructed in areas with generally less riverine sensitive resources. Potential added impacts at the Red Bluff Diversion

Dam would need to be addressed. Also, if water were reintroduced to the Sacramento River for use elsewhere, adverse impacts to water quality could occur.

TABLE III-2
OFFSTREAM STORAGE POJECT INFORMATION

Item	Offstream Storage Project[1]				
Project Name	Sites Reservoir (1.9 MAF)	Colusa Reservoir (3.3 MAF)	Lake Berryessa Enlargement (6.0 MAF) [2]	Thomes-Newville Reservoir (3.08 MAF)	Thomes-Newville Reservoir (1.84 MAF)
Number	18	19	20	21-a	22-b
Location	Funks/Stone Corral Creeks - Colusa & Glenn County	Funks/Stone Corral Creeks – Colusa & Glenn County	Putah Creek - Napa County	Thomes/Stoney Creeks - Colusa & Glenn County	Thomes/Stoney Creeks – Colusa & Glenn County
Dam Heights (ft)	294 Sites 302 Golden Gate	294 Sites 302 Golden Gate 282 Hunters 271 Logan	470 (271)	400 Newville 112 Tehenn	320 Newville 112 Tehenn
Conveyance	Tehama-Colusa Canal Expansion	Tehama-Colusa Canal Expansion	Lake Berryessa Intertie	Tehama-Colusa Canal Expansion	Tehama-Colusa Canal Expansion
Dam(s) Crest Elevation (ft msl)	541	541	199 (456)	1,000	920
Reservoir Area (1,000 acres)	15	206	16 (19.4)	17	14
Storage Capacity (1,000 acre-feet)	1,800	3,300	4,400 (1600)	3,080	1,840
Refill Period (years) [3]	1 to 2	2 to 3	3 to 4	2 to 3	1 to 2
Water Supply Reliability (acre-feet/year) [4]	280	420	500	390	280
Economics					
First Cost ($billions) [5]	1.3	2	2.8	2.5	2
Annual Cost ($millions) [6]	90	140	200	180	140
Unit Cost ($/acre-feet) [7]	320	330	390	450	500
Key: MAF – million acre feet msl – mean sea level					

Notes:
[1]Source: Majority of information from CALFED Storage and Conveyance Components Facility Descriptions and Cost Estimates, October 1997.
[2]Information in ( ) is for existing dam and reservoir. Information outside ( ) is added increment..
[3]Reservoir refilled at assumed constant rate of 5,000 cfs from Sacramento River through expanded TCC and/or GCID Canals over a 4-month period from about February through May of each year.
[4]Approximation only. Delivery supply reliability increase measured in increased drought period yield. Based on ratio of average annual yield estimates for Sites (NODOS) project at 1.9 MAF assuming TC and GCID Canal use and Banks (South Delta) pumping capacity of 8,500 cfs. Actual yield depends on available supplies, which could be much lower.
[5]Approximation only. Undated price levels to 2003 using Construction Price Index.
[6]Approximation only. Estimated average annual cost at 5-5/8 percent interest rate over 100 year project life. Does not include energy costs related to filling reservoirs.
[7]Average annual cost divided by estimated average annual drought year yield and rounded.

The reservoir would adversely impact wildlife species currently residing in the inundation area. There likely would be impacts to several listed wildlife and plant species. The presence of wetland areas within the reservoir area is relatively small. Prehistoric and historic sites exist in the area.

The estimated first cost of a dam and offstream storage project using the 3.3 MAF Colusa Reservoir site is about $2 billion (see **Table III-2**).

Lake Berryessa Enlargement (Site 20)

The Lake Berryessa Enlargement Project, as defined in previous studies, primarily includes expanding Lake Berryessa from its existing gross pool capacity of 1.6 MAF to 6.0 MAF. Larger increases also have been evaluated in previous studies. Lake Berryessa is located on Putah Creek about 8 miles west of the town of Winters in Solano County.

Enlarging Lake Berryessa would primarily include raising the existing dam crest from 456 feet (msl) to 655 feet (msl). This would allow for an increase in gross pool from 440 feet (msl) to 600 feet (msl). The larger gross pool would increase the surface area from 19,400 acres to about 35,000 acres. It would also include construction of a new outlet/inlet structure on the TC Canal, extension of the TC Canal (or alternative water delivery facilities) and connecting canal, a 25-foot diameter tunnel from the canal to the reservoir, and supporting pump stations. The project also would include new dam outlet works, stilling basin, and a host of necessary relocations.

As with the Sites Reservoir Project, the project would not directly harm anadromous fish resources other than at the point of diversion from the Sacramento River. The existing fishery in Lake Berryessa would not be significantly impacted by expanding the dam and reservoir. The effects of enlarging the lake on wildlife would be mixed as habitat for deer, small game animals, and birds in the area would be reduced but habitat for waterfowl would be increased. Potentially impacted special wildlife species would include the Valley elderberry longhorn beetle, northern spotted owl, bank swallow, and California freshwater shrimp. Several candidate species reside in the area. Several species of sensitive plants reside in the enlarged inundation area.

Over 200 archaeological and 4 ethnographic sites have been recorded in the Lake Berryessa enlargement area.

The estimated first cost of a project to increase the storage space in Lake Berryessa Reservoir from 1.6 MAF to 6 MAF is about $2.8 billion (see **Table III-2**).

Thomes-Newville (Sites 21-a and 21-b)

The Thomes-Newville Reservoir Project would store flows from Stony and Thomes Creeks as well as surplus flows diverted from the Sacramento River at the Red Bluff Diversion Dam, transported via the TC Canal. Two storage alternatives have been considered in previous studies, each with a dam and reservoir on North Fork Stony Creek: 1.08 MAF and 3.08 MAF. Each would include a gravity diversion structure on Thomes Creek; connecting canal to Thomes-Newville Reservoir; Tehenn Reservoir immediately downstream from Thomes-Newville Reservoir; connecting canals from Tehenn Reservoir to Black Butte Reservoir and from Black Butte Reservoir to the TC Canal; and four pumping plants. As envisioned, the plan includes modifications to the TC Canal and intake structure on the Sacramento River to increase its flow capacity to up to 5,000 cfs, similar to the Sites Reservoir Project.

Newville Dam would be an estimated 320 feet high (dam crest at 920 feet (msl)) for the 1.84 MAF plan and 400-feet high (crest at 1,000 feet (msl)) for the 3.08 MAF plan. Newville Reservoir would inundate, at gross pool about 14,000 acres for the 1.84 MAF plan and about 17,000 acres for the 3.08 MAF plan. Tehenn Reservoir would be about 112 feet high (crest elevation 610 feet (msl)) for both plans. Tehenn would have a total capacity of 32,500 acre-feet.

The Thomes Creek Diversion Structure would be a dam with an overflow section in Thomes Creek about 90 feet high. The conveyance canal would have a capacity of 10,000 cfs and be about 2.5 miles long for both plans.

As with Sites Reservoir, the Thomes-Newville Project would operate by drawing water from the Sacramento River earlier in the year when there are higher flows in the river. Some added inflow would be provided from Thomes Creek and local inflow. Stored water would later be released for agricultural purposes and possibly to help improve water supply reliability elsewhere. This would help restore anadromous fish resources in the Sacramento River by changing the timing of river diversions from lower flow spring/summer periods to higher flow winter periods. The project could also help improve overall water supply reliability in the system.

The project would result in reduced flows in Thomes Creek. This would impact spawning and rearing habitat in the creek for small populations of chinook salmon and steelhead trout. The flow reductions could also limit spawning and rearing opportunities for non-game species. Potential impacts at the Red Bluff Diversion Dam would need to be addressed. Also, if water were reintroduced to the Sacramento River for use elsewhere, adverse impacts could occur to water quality.

The reservoir would adversely impact wildlife species currently residing in the inundation area. Impacts likely would occur to several listed wildlife and plant species. At over 500 acres, the presence of wetland areas within the reservoir area is relatively small. Over 240 prehistoric and 65 historic sites exist in the study area.

The estimated first cost of a Thomes-Newville Project with a capacity of 1.84 MAF is about $2 billion and for 3.08 MAF about $2.5 billion.

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CHAPTER IV
COMPARISON OF SURFACE WATER STORAGE OPTIONS

Table IV-1 provides a summary comparison of the most favorable of the potential dam and reservoir projects profiled in **Chapters II** and **III** and included in **Tables II-1** and **III-1**. Either because of their cost, location, likely beneficiaries, or potential implementation issues, the other onstream and offstream storage projects mentioned above were not considered as realistic or viable alternatives to modifying Shasta Dam and Reservoir and were therefore not considered further. The comparison factors in **Table IV-1** include effectiveness, efficiency, and completeness:

- **Effectiveness –** Effectiveness is the extent to which an potential plan alleviates the identified problems and achieves the specified objectives. Here, effectiveness is measured by the relative increase in system water supply reliability and identified by the estimated average annual drought year system yield. A project with an estimated high average annual drought year yield would rate higher than a potential project with a relatively low yield.

- **Efficiency –** In this assessment, efficiency is measured by two factors. One is the estimated cost for each acre-foot of added system yield from the potential project. A project with a low cost to develop an acre-foot of new yield would rate higher than a project with a high unit cost. The second factor is the estimated rate at which the potential project can replenish its storage space evacuated by to meet the water demands. A project with a rapid refill rate such as at Shasta or Folsom lakes with a very high inflow to storage ratio would rate higher than a project that would take many years to refill.

- **Completeness –** Completeness is the extent to which a potential plan provides and accounts for all necessary investments or other actions to ensure realization of planned effects. Here, completeness is measured as the estimated extent of successfully implementing a project and preventing, avoiding, or mitigating likely environmental and socio-economic impacts.

Included in **Table IV-1** is an estimate of the overall ranking of each potential project.

ONSTREAM STORAGE

Six potential onstream surface water storage projects are compared in **Table IV-1**. Of these six, it is estimated that new storage in Shasta Lake has the highest potential for meeting the above comparison factors. This is not to say that the other projects should not be considered in future efforts by others to help address water resources problems and needs in the Central Valley. Following is a summary of the factors to support the relative ranking in **Table IV-1**.

TABLE IV-1
POTENTIAL RESERVOIR STORAGE PROJECT COMPARISON

		Effectiveness		Efficiency			Completeness				
							Environmental Considerations				
Map #	Name	Drought Year Yield (AF/yr) [1]	Relative Potential Increase System Water Reliability	Approx. Unit Cost ($/AF yield) [2]	Refill Period [3]	Relative Efficiency	Avoid Fishery Impacts	Avoid Wildlife Impacts	Avoid Social Impacts	Relative Potential to Mitigate Impacts	Relative Ranking
Onstream Reservoir Storage											
1-a	Shasta Lake Enlargement –Low	72	Low	260	<1	Very High	High	High	High	High	**High** – Highly efficient & implementable with minimal impacts along with significant yield.
1-c	Shasta Lake Enlargement –High	703	Very High	540	2 to 3	Moderate	Low	Low	Low	Moderate	**Moderate** – Highly effective but costly and potential for very high impacts.
3	Round Valley Reservoir	110	Low	470	– [4]	Low	Moderate	Moderate	High	Moderate	**Low** – Low effectiveness with very high unit cost.
4	Kosk Reservoir	160	Moderate	520	<1	Moderate	Moderate	Moderate	Moderate	Moderate	**Moderate** – Moderate efficiency but very high unit cost.
5	Cottonwood Creek Project	260	Moderate	350	3 to 4	Moderate	Very Low	Low	Moderate	Low	**Moderate** – Moderate effectiveness but low efficiency and potential to mitigate impacts.
6	Red Bank Project	60	Low	520	3 to 4	Moderate	Low	Moderate	High	Moderate	**Low** – Low effectiveness with high unit cost.
7	Auburn Reservoir Project	330	High	400	1 to 2	Moderate	High	Low	Moderate	Moderate	**Moderate**– Efficient & effective but little demonstrated support.
Offstream Reservoir Storage											
18	Sites Reservoir	280	High	320	1 to 2	Moderate	High	Low	Moderate	Moderate	**Moderate** – High effectiveness & being considered as separate project by DWR (lead agency).
19	Colusa Reservoir	420	Moderate	330	2 to 3	Moderate	High	Low	Moderate	Moderate	**Moderate** – Moderate effectiveness with high unit cost.
20	Lake Berryessa Enlargement	500	Moderate	390	3 to 4	Low	High	Low	Low	Moderate	**Moderate**– Moderate effectiveness but with low efficiency.
21 a	Thomes-Newville Res. (3.08 MAF)	390	Moderate	450	2 to 3	Low	High	Low	Moderate	Moderate	**Moderate**– Moderate effectiveness with low efficiency.
21 b	Thomes-Newville Res. (1.84 MAF)	280	High	500	1 to 2	Low	High	Low	Moderate	Moderate	**Moderate** – High effectiveness with low efficiency.
Key: AF – acre feet MAF – million acre feet yr – year											

Notes:

[1]Approximation only.

[2]Does not include net energy costs for offstream storage projects.

[3]Reservoir capacity divided by annual inflow for onstream storage projects and by the capacity of conveyance facilities to the reservoir site during February though May period for offstream storage projects.

[4]Depends on deliveries from nearby streams.

- **Shasta Dam Enlargement -** As mentioned, several sizes of enlarging Shasta Dam and Reservoir have been considered in studies to date. **Tables II-2** and **II-3** provide information on the low (6.5 foot) and high (200 foot) dam raise options. A 6.5-foot dam raise would allow for increasing the gross pool elevation by about 8.5 feet and result in an increase in the storage capacity in Shasta Reservoir of about 290,000 acre-feet. With an estimated average annual cost amounting to about $19 million and a average annual drought year yield of about 72,000 acre-feet per year, the unit cost would be about $260 per acre-foot. Raising the dam by about 200 feet would result in an increase in storage capacity of about 9.5 MAF. The resulting estimated net increase in average annual drought year yield would be over 700,000 acre-feet per year. With an average annual cost for the enlarged project of about $440 million, the resulting unit cost would be about $540 per acre-feet. In addition to contributing to an increase in water supply reliability while being highly cost-efficient, it is also estimated that the low dam raise could be implemented with relatively few environmental and socio-economic impacts. It is believed that even though the high dam raise could significantly contribute to water supply reliability in the Central Valley, major environmental and socioeconomic impacts would occur in the primary study area that would be difficult to adequately mitigate.

- **Round Valley Dam and Reservoir** - Round Valley Dam and Reservoir and appurtenant facilities would have the potential to increase the average annual drought year yield by about 110,000 acre-feet. As shown in **Table II-3**, the estimated unit cost for the yield would be about $470 per acre-foot. At the currently identified size of nearly 500,000 acre-feet and to develop the full yield potential, a project would need to include diversions from the Pit River. A smaller reservoir could be considered, but without Pit River diversions and depending only on in-basin runoff, it would have a negligible impact on the potential to increase the water supply reliability of the CVP/SWP systems. In addition, the unit cost of the resulting yield would be very high. Accordingly, as shown in **Table IV-1**, it is believed that this dam and reservoir site would rate relatively low in comparison to new storage in Shasta Reservoir or other potential added storage sites.

- **Kosk Dam and Reservoir -** The Kosk Dam and Reservoir would have the potential to increase the average annual drought year yield by about 160,000 acre-feet. As shown in **Table II-3**, the estimated unit cost for the yield would likely be about $520 per acre-foot. The annual inflow to the reservoir is about 3.7 MAF, which would allow the reservoir to refill on average every year. Although this facility would have the potential to materially help increase the dry and average annual yield to the CVP/SWP systems, it would be significantly more costly than a modification to Shasta Dam and Reservoir. In addition, even with mitigation features, it would cause adverse environmental impacts to sensitive reaches of the Pit River that would be difficult to mitigate.

- **Cottonwood Creek Project -** It is estimated that the Cottonwood Creek Project would have the potential to increase the average annual drought year yield by about 260,000 acre-feet. As shown in **Table II-3**, the estimated unit cost for the added yield would be about $350 per acre-foot. The annual inflow to the two reservoirs is approximately 480,000 acre-feet, which would result in an average refill period of over 3.3 years. Accordingly, the project would primarily benefit dry period conditions and have a very limited ability to significantly increase average year supplies.

Cottonwood Creek and its tributaries are an important source of sediments to the Sacramento River. In addition, Cottonwood Creek provides spawning for fall-run and late-fall-run chinook salmon and supports spring-run chinook salmon in some years. The project would inundate about 28 miles of this habitat as well as important riparian habitat. Although previous studies have identified measures to mitigate these and other potential adverse environmental impacts, it is believed highly unlikely that this project could be implemented at the present time. Because of the limited ability of the Cottonwood Creek project to significantly contribute to average year water supplies, and high impact on riverine resources without major features to mitigate these impacts, this potential dam and reservoir site was not considered as a viable substitute for modifying Shasta Dam and Reservoir.

- **Red Bank Project** - The Red Bank Project would have the potential to increase the average annual drought year yield by about 60,000 acre-feet. As shown in **Table II-3**, the estimated unit cost for the added yield would be about $520 per acre-foot. The annual inflow to the reservoir is approximately 112,000 acre-feet per year (96,400 acre-feet at Dippingvat and 16,000 acre-feet at Schoenfield), which would yield an average refill period of over 3 years. Accordingly, this project would have a very limited ability to significantly add to the average year supplies.

  As with the Cottonwood Creek Project, without significant mitigation measures included in the project, major impacts could occur to sediment flows to the Sacramento River and subsequent spawning of anadromous fish. Because of the limited ability of the project to contribute to average annual system water supplies, relatively low drought period yield capability, high unit cost, and adverse environmental impacts, this potential dam and reservoir site was not considered as a viable substitute for modifying Shasta Dam and Reservoir.

- **Auburn Dam Project -** The Auburn Dam Project could significantly contribute to increasing the reliability of the CVP/SWP systems by adding up to approximately 330,000 acre-feet of average annual drought year yield with a reservoir having a gross pool capacity of about 2.3 MAF. The estimated cost per acre-foot of the added yield from the project would be about $400. The average annual inflow to Auburn Reservoir would be about 1.6 MAF, resulting in a refill period of about 1.4 years. A dam and reservoir at Auburn would have a high potential to avoid adverse impacts to anadromous fish downstream from Folsom Dam. It would, however, adversely impact the resident fishery and wildlife habitat in the reservoir area without appropriate mitigation features.

  The Auburn Dam project has been considered several times not only as a multiple purpose project but also as a single purpose project to significantly reduce flood damages and provide public health and safety values to the Sacramento area. Further, the Auburn Dam Project is an authorized Federal project. However, each time it has been recommended to proceed, opposition to the project has resulted in its deferment. Because of the relatively high unit cost and apparent limited ability of the project to be implemented at this time due to significant opposition, this potential dam and reservoir site was not considered as a viable substitute for modifying Shasta Dam and Reservoir.

OFFSTREAM STORAGE

As mentioned, the major offstream surface water storage projects considered in this review include the Sites Reservoir Project, Colusa Reservoir Project, Lake Berryessa Enlargement Project, and Thomes-Newville Reservoir Project. Following is a summary of the factors to support the relative ranking in **Table IV-1**.

- **Sites Reservoir Project (NODOS)** - A 1.9 MAF Sites Reservoir operated to take advantage of excess flows in Sacramento River (without reoperation of Shasta Reservoir) would have the potential to increase average annual drought year system yield by about 280,000 acre-feet. Depending on the availability of excess flows in the Sacramento River for diversion into either an expanded TC Canal or combined TC and GCID Canal system and various other hydraulic, environmental, and institutional conditions, it would take several years to refill the reservoir following an extended drawdown period. The estimated unit cost for the added yield (excluding energy cost) is about $320 per acre-foot (see **Tables III-2** and **IV-1**). Of the offstream storage projects considered, Sites Project (and the Colusa Reservoir project listed below) appears to be one of the most cost-effective when considering the reduced time required to refill the reservoir following a prolonged drawdown period (see **Table IV-1**). It is estimated that this project would have the potential to significantly benefit the reliability of the existing water delivery system by increasing the average drought year yield.

- **Colusa Reservoir Project** - A preliminary estimate of potential increases in average annual drought year yield from the Colusa Reservoir Project is about 420,000 acre-feet. The reservoir refill period would be on the order of 3 years with essentially all of the refilled volume needing to be pumped from diverted water from the Sacramento River. The estimated unit cost for the additional yield (excluding energy cost) is about $330 per acre-foot (see **Tables III-1** and **IV-1**). As with Sites, the Colusa Reservoir project appears to be one of the most cost-effective of those identified (see **Table IV-1**). The Colusa Projects would have the potential to significantly benefit the reliability of the existing water delivery system by increasing the drought period yield.

- **Enlarge Lake Berryessa Project** - The estimated potential increase in average annual drought year yield from a project to enlarge Lake Berryessa 4.4 MAF is about 500,000 acre-feet. The reservoir refill period would be on the order of 4 years with essentially all of the refilled volume needing to be pumped from diverted water from the Sacramento River. The estimated unit cost for added yield (excluding energy cost) is about $390 per acre-foot (see **Tables III-1** and **IV-1**).

- **Thomes-Newville Project** - The preliminary estimated increase in average annual drought year yield from the Thomes-Newville Project ranges from about 280,000 acre-feet to 390,000 acre-feet for the 1.84 MAF and 3.08 MAF project sizes, respectively. It is estimated that the reservoir refill period would be on the order of 1.5 years for the 1.84 MAF project to nearly 3 years for the larger sized project. The estimated unit costs for the added yield (excluding energy cost) ranges from about $450 per acre-foot for the 3.08 MAF plan to about $500 per acre-foot for the 1.84 MAF plan (see **Tables III-2** and **IV-1**).

Likely impacts on annual costs and unit costs of the offstream storage projects are difficult to predict due to the effects of energy to pump water into the offstream storage sites. However, to be comparable with onstream storage, the net energy costs need to be included with other costs associated with increasing water supply reliability. Net energy costs depend on various factors, including the volume of water to be pumped, the availability and timing of the water to be pumped, the cost of energy to pump the water, and the potential energy to be generated when the water is released back into the system. This added cost would likely be very significant.

As mentioned, estimates of potential annual costs not including net energy costs associated with diverting and pumping into the reservoirs, range from about $90 million for Sites Reservoir to about $200 million for Lake Berryessa Enlargement with unit drought year yield costs ranging from about $320 for Sites to about $500 for a small Thomes-Newville. Accordingly, the resulting unit costs for additional drought year water supplies are significantly greater than developing new storage space in smaller sizes of Shasta Reservoir. Feasibility scope studies are underway for the Sites (NODOS) project. These studies are not only focusing on water supply reliability, but on addressing other critical water resources issues in the Delta. The studies demonstrate that although new offstream storage in the upper Sacramento River watershed is likely more costly than additional storage in Shasta Reservoir, it could be highly compatible with new onstream storage and a valuable increment in addressing future water resources needs in the Central Valley. Potential offstream dam and reservoir projects were not considered as viable substitutes for modifying Shasta Dam and Reservoir. They were not considered further in the SLWRI.

CHAPTER V
SUMMARY OF FINDINGS

Major findings of this appendix include the following:

- Numerous surface water storage projects in the Central Valley have been assessed as part of various water supply and multipurpose water resources studies over the years.

- Previous studies by Reclamation have shown that raising Shasta Dam by an additional 200 feet would likely be technically and economically feasible, but would have major socioeconomic and environmental impacts.

- Of numerous onstream reservoir projects considered within the Sacramento River Watershed, in addition to enlarging Shasta Dam and Reservoir, two have consistently been shown to be superior: Cottonwood Creek Project and Auburn Reservoir Project. For various reasons, these potential onstream reservoir projects are not considered to be viable alternatives to increasing the storage space in Shasta Reservoir.

- Of numerous offstream storage sites considered within the Sacramento River Watershed, several potential project sites along the west side of the Sacramento River Valley appear to have the greatest potential for implementation. Studies are underway by the State of California on the NODOS Project to help increase water supply reliability to the SWP and CVP systems. Although not considered a viable alternative to new storage in Shasta Reservoir, potential new offstream storage associated with NODOS could be compatible with new storage in Shasta and a valuable increment to addressing future water resources needs in the Central Valley.

- Although numerous onstream and offstream reservoir sites exist south of the Sacramento and San Joaquin River Delta, with several significant candidates for effectively increasing the reliability of the existing water supply system, none are considered as substitutes for enlarging Shasta Dam and Reservoir.

- Of the numerous onstream and offstream storage sites considered to date, raising or modifying Shasta Dam and Reservoir appears to have the potential to provide the greatest opportunity to increase the reliability of existing water supplies at the lowest cost.

- Nothing concluded in this assessment should preclude continued investigations of either sites as part of the NODOS Project or other efforts being considered under the CALFED Bay-Delta Program.

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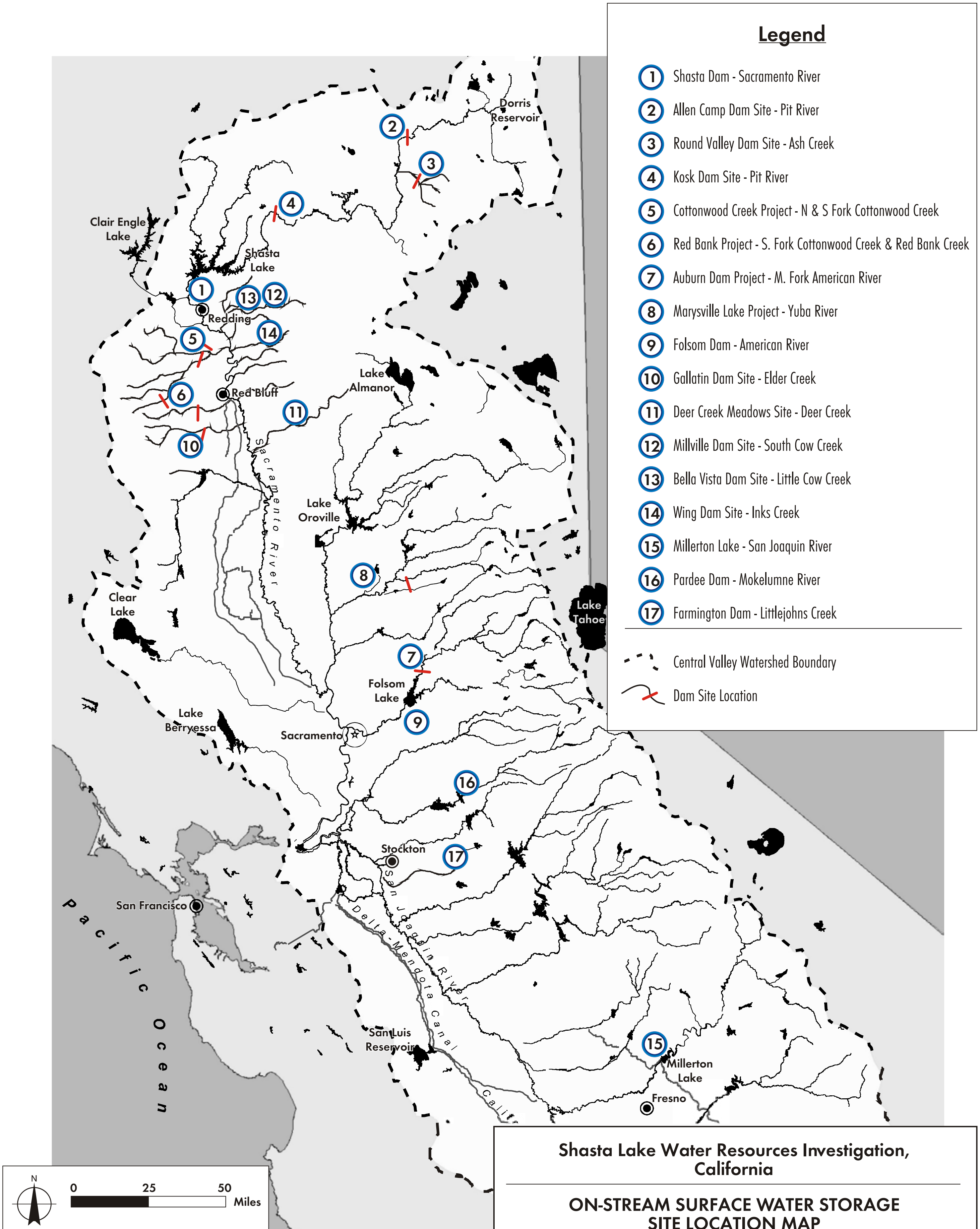
APPENDIX B
PLATES

Shasta Lake Water Resources Investigation, California

PRIMARY STUDY AREA

U.S. Bureau of Reclamation, Mid-Pacific Region
June 2004

APP B PLATE 1

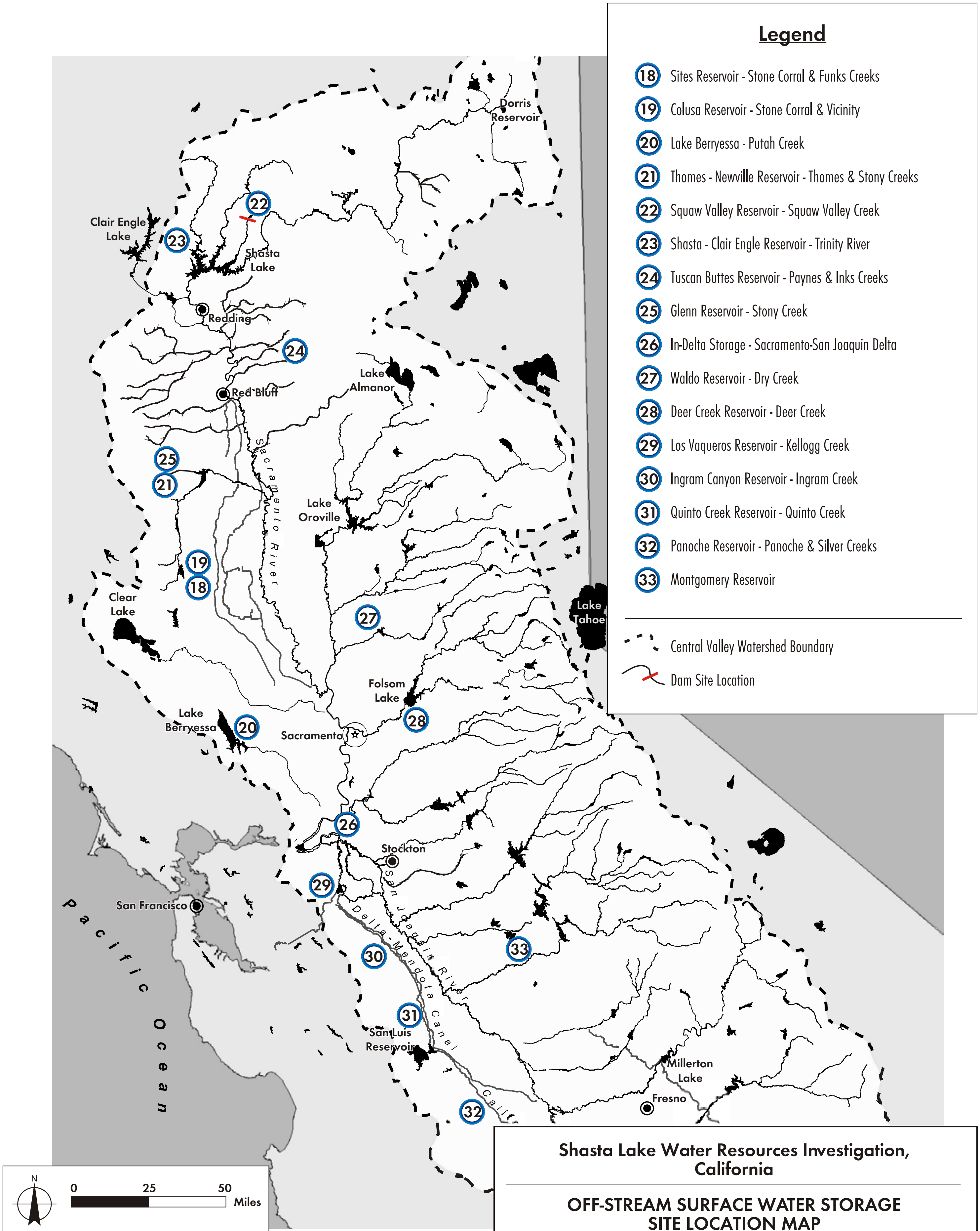


Shasta Lake Water Resources Investigation, California

ON-STREAM SURFACE WATER STORAGE SITE LOCATION MAP

U.S. Bureau of Reclamation, Mid-Pacific Region
June 2004

PLATE 2



Shasta Lake Water Resources Investigation, California

OFF-STREAM SURFACE WATER STORAGE SITE LOCATION MAP

U.S. Bureau of Reclamation, Mid-Pacific Region
June 2004

PLATE 3