CHAPTER VI
RESOURCES MANAGEMENT MEASURES

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

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

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

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

MEASURES TO ADDRESS PRIMARY PLANNING OBJECTIVE – INCREASE ANADROMOUS FISH SURVIVAL

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

Measures Considered

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

Improved Fish Habitat

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

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

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

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

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

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

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

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

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

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

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

- **Rehabilitate inactive instream gravel mines along Stillwater and Cottonwood creeks –** This measure consists of rehabilitating ecological conditions in former instream gravel

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

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

Improved Water Flows and Quality

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

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

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

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

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

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

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

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

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

Improved Fish Migration

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

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

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

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

Measures Retained for Further Consideration

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

Restore Abandoned Gravel Mines Along the Sacramento River

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

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

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

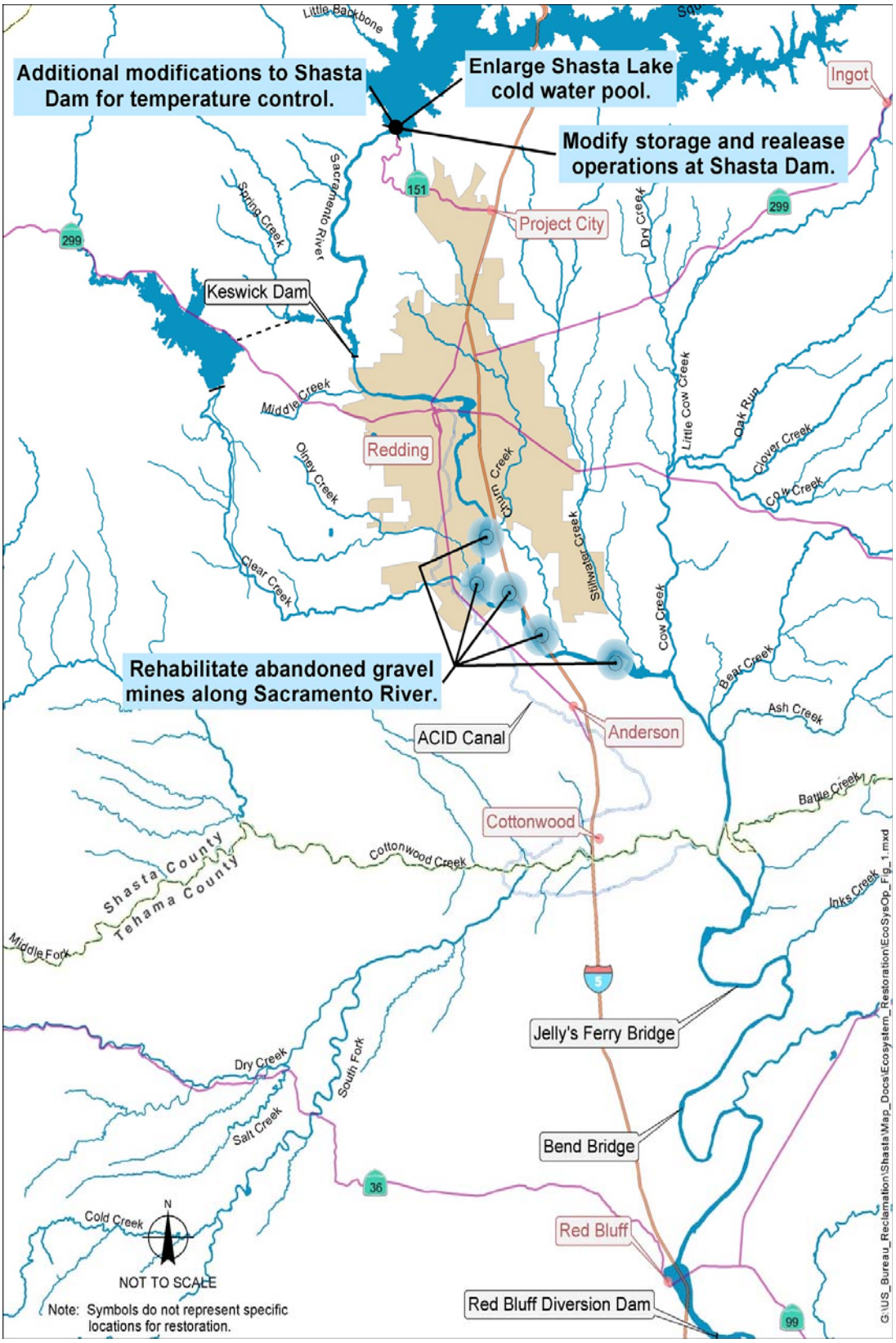

Figure VI-1 - Measures retained to address primary planning objective – anadromous fish survival.

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

Source: M. Kondolf, 1989

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

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

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

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

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

Make Additional Modifications to Shasta Dam for Temperature Control

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

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

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

Accomplishments of this measure would be to increase survival of anadromous fish populations in the Sacramento River by (1) increasing the ability of operators at Shasta Dam to meet

downstream temperature requirements for anadromous fish, (2) providing more flexibility in achieving desirable water temperatures during critical spawning, rearing, and out-migration, and (3) extending the area of suitable spawning habitat in the Sacramento River.

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

Enlarge Shasta Lake Cold Water Pool

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

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

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

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

support the primary objective of increasing water supply reliability. The estimated certainty of this measure in achieving its intended accomplishments would be high.

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

Modify Storage and Release Operations at Shasta Dam

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

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

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

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

MEASURES TO ADDRESS PRIMARY PLANNING OBJECTIVE – INCREASE WATER SUPPLY RELIABILITY

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

Measures Considered

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

Surface Water Storage

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

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

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

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

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

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

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

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

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

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

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

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

Reservoir Reoperation

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

believed to be limited, this measure was retained for further detailed consideration for possible inclusion in concept plans.

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

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

Conjunctive Water Management

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

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

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

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

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

Coordinated Operation

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

effectively address the primary study objectives and is likely to be implemented, in some form, independent of the SLWRI.

Demand Reduction

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

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

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

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

Water Transfers and Purchases

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

Delta Export and Conveyance

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

- **Expand Banks Pumping Plant –** The current allowable pumping capacity at the SWP Banks Pumping Plant is 6,680 cfs. Efforts are underway by DWR and Reclamation to construct fish protection features under the SDIP to allow increasing the allowable pumping capacity to 8,500 cfs during certain seasonal periods. The maximum installed pumping capacity at Banks is about 10,300 cfs. This measure primarily includes implementing additional physical features and operational improvements aimed at benefiting the overall

water quality of the Delta to further increase the allowable pumping capacity at Banks from 8,500 cfs to 10,300 cfs during certain seasonal periods, and splitting the increased pumping capacity equally between the CVP and SWP. This increased capacity would allow more water that otherwise would flow to the Pacific Ocean to be conveyed south of the Delta. It is estimated that the average annual increase in supplies south of the Delta allocated to the CVP could amount to over 100,000 acre-feet. The estimated unit cost for the increase in water supply reliability would be highly efficient when compared with other potential sources of new water supplies. However, because this measure would not contribute to the SLWRI planning objectives or identified plan formulation constraints, principles, and criteria, it was not viewed as a potential alternative to new storage in Shasta Reservoir. Accordingly, it was eliminated from further consideration in the SLWRI.

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

Measures Retained for Further Consideration

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

Increase Conservation Storage Space in Shasta Reservoir by Raising Shasta Dam

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

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

This measure consists of modifying the operation of Shasta Dam to improve water supply reliability. It can also assist in improving flood control. Potential methods to improve water supply reliability include modifying rainflood parameters in the operation rules for Shasta Lake and modifying the Shasta Dam release schedule. The goal of the operation changes would be to

minimize the required evacuation of the reservoir during the period from about late November through March, and to possibly allow the reservoir to be filled more rapidly in the fall. As mentioned, a primary criterion would be to not reduce the existing level of flood control provided by Shasta Dam and possibly improve it. These possible reoperation opportunities are described in the reference report Assessment of Potential of Shasta Dam Reoperation for Flood Control and Water Supply Improvement.

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

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

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

MEASURES TO ADDRESS SECONDARY PLANNING OBJECTIVE – ECOSYSTEM RESTORATION

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

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

Measures Considered

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

Cold Water and Warm Water Fisheries

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

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

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

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

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

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

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

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

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

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

Riparian and Wetland Habitat

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

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

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

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

- **Promote Great Valley cottonwood regeneration on the Sacramento River –** This measure consists of actively supporting the Great Valley cottonwood regeneration concept along the Sacramento River. This concept includes working to replace lost floodplain sediment, recontouring floodplains that have disconnected from the river, and revegetating floodplain areas that could support Great Valley cottonwoods. This measure was eliminated

from further consideration primarily because (1) there would be major complexities associated with continuing Federal participation in an ongoing broad-scope program in the Sacramento Valley, and (2) it would not directly contribute to accomplishing the primary or other secondary planning objectives.

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

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

Other Fish and Wildlife Habitat Improvements

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

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

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

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

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

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

Measures Retained for Further Consideration

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

Construct Shoreline Fish Habitat Around Shasta Lake

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

habitat for juvenile fish and other adult resident fish species. This measure would improve shallow, warm water fish habitat at specific locations around the shoreline of Shasta Lake using resilient vegetation and aquatic "cover" structures within the upper drawdown area of the lake.

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

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

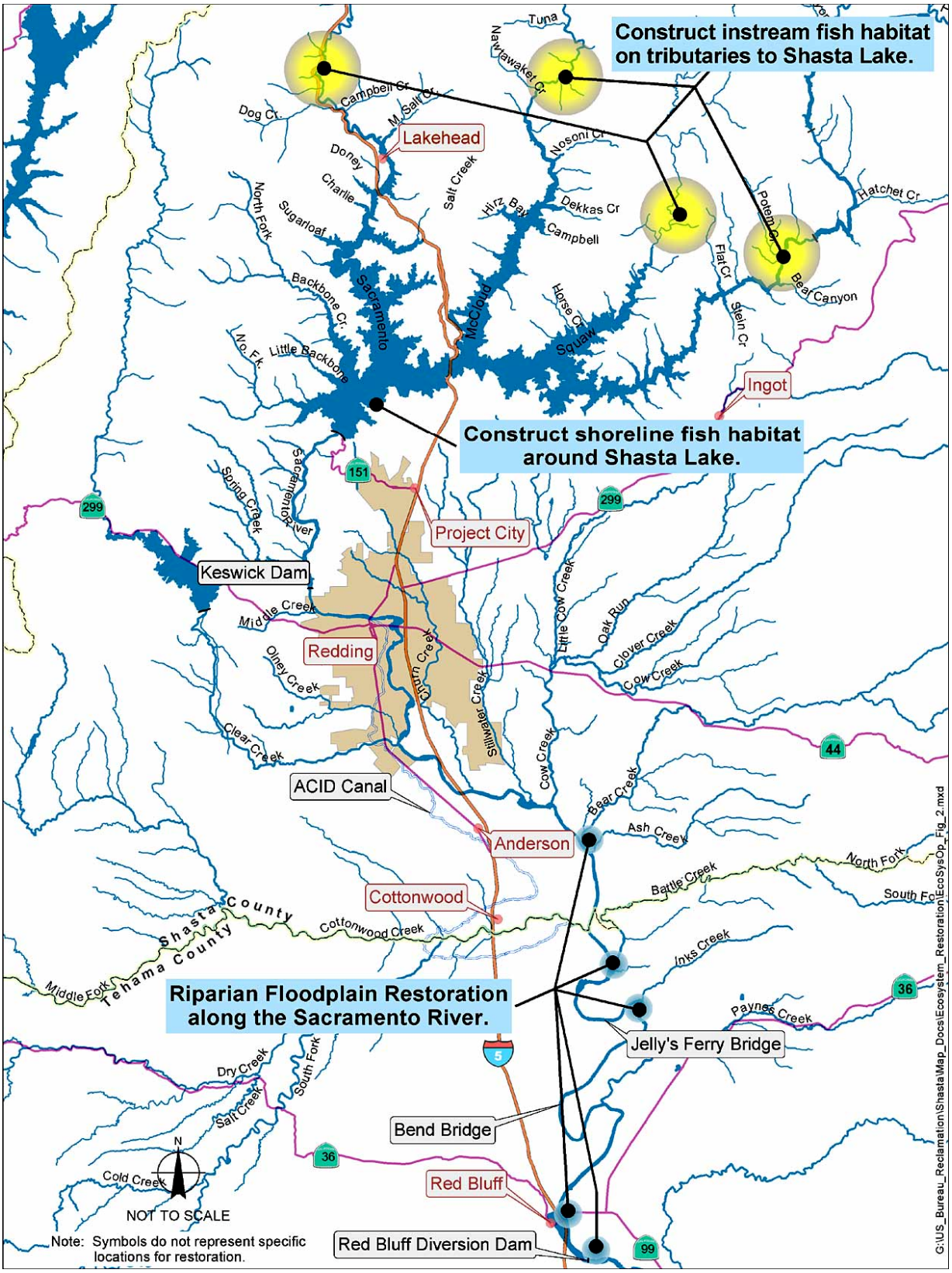

Figure VI-4 - Measures retained to address secondary planning objective – ecosystem restoration.

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

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

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

Construct Instream Fish Habitat on Tributaries to Shasta Lake

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

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

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

streamflow hydrology and the occurrence of large flood events. It is estimated that many of the restoration activities would be conducted on Federal lands.

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

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

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

Riparian and Floodplain Restoration Along the Sacramento River

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

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

contouring and imported fill material would be required at several locations where the historic floodplain has been disconnected from the river or disturbed by human activity.

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

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

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

MEASURES TO ADDRESS SECONDARY PLANNING OBJECTIVE – FLOOD DAMAGE REDUCTION

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

- **Update Shasta Dam and Reservoir the flood management operations –** This measure consists of revising the established rules for operating Shasta Dam and Reservoir for flood management. This measure would include reassessing existing seasonal flood control storage space needs at Shasta using updated information on regional hydrologic and meteorological conditions and rainfall/runoff characteristics in the drainage basin. Potential methods to improve flood control would include improved long-range weather forecasting, implementing a forecast-based reservoir drawdown for flood control, changing the rate of

outflows from Shasta Dam for flood control, and modifying target peak flows at Bend Bridge. These possible reoperation opportunities are described in the reference document Assessment of Potential Shasta Dam Reoperation for Flood Control and Water Supply Improvement. This measure was retained for further development primarily because it would be compatible with any potential modification of Shasta Dam and Reservoir. It would not conflict with other secondary planning objectives or planning constraints/criteria. As with reoperation for water supply reliability, although the concept of this measure is being retained for inclusion in initial alternatives, its specific features and their influence on water supply reliability and flood damage reduction will not be developed until detailed operational modeling can be accomplished in further investigations as part of detailed alternative plan formulation in the SLWRI.

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

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

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

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

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

MEASURES TO ADDRESS SECONDARY PLANNING OBJECTIVE - HYDROPOWER

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

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

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

MEASURES SUMMARY

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

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

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

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

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

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