CHAPTER VIII
COMPARISON OF CONCEPT PLANS

This chapter compares the concept plans described in **Chapter VII** and identifies initial alternatives that should be further developed into alternative plans in the SLWRI.

CRITERIA AND COMPARISON

To help focus the plan formulation process and ensure that the most appropriate project is ultimately selected for implementation, the concept plans in **Chapter VII** were compared to each other using four general criteria. The four criteria are based on the Federal P&G for water resources planning and include: (1) completeness, (2) effectiveness, (3) efficiency, and (4) acceptability. Below is a description of each criterion and its application. **Table VIII-1** shows the comparison of the concept plans based on their relative ability to address each of the four criteria. As can be seen in the table and described below, each plan was assigned a relative ranking ranging from very low to very high for each criterion. Each comparison criterion for the concept plans in the table received the same weighting and resulted in an overall relative ranking. This overall ranking was used, along with other information, to determine if a concept plan should be considered further in the plan formulation process in the SLWRI.

It is important to reiterate that numerous combinations of sizes and applications of each of the measures in **Chapter VI** make up the concept plans in **Chapter VII**. Accordingly, recommendations for further plan development in **Table VIII-1** are more for the application and combination of measures than for specific concept plans.

Completeness Criterion

Completeness is a determination of whether a plan includes all elements necessary to realize planned effects. It is also an indication of the degree that the intended benefits of the plan depend on the actions of others. For the SLWRI, the subcriteria described below are believed only to become important in estimating the relative completeness of the concept plan. Each concept plan is considered complete, with its relative completeness ranking ranging from low to high, primarily depending on the degree of uncertainty (or reliability) of achieving the intended objectives and adequately mitigating significant adverse impacts. Concepts that received the highest relative ranking for this criterion are WSR-1, WSR-2, WSR-4 and, with the exception of CO-3, all of the CO plans. Concepts that received the lowest relative ranking are AFS-1 and WSR-3. Concept plan AFS-1 ranks low because it would provide very little benefit to either planning objective. Concept plan WSR-3 ranks low primarily because it would result in very large environmental and socioeconomic impacts, which would be difficult to adequately mitigate.

TABLE VIII-1
SUMMARY COMPARISON OF CONCEPT PLANS

Concept Plans	Comparison Criteria				Recommendation Status and Relative Ranking
	Completeness	**Effectiveness**	**Efficiency**	**Acceptability**	
AFS-1 – Increase Cold Water Assets with Shasta Operating Pool Raise (6.5 feet)	Can be implemented with minimum social and environmental impact. Only addresses one of the primary objectives – anadromous fish survival. Contributes to flood control and hydropower secondary objectives. Physically and environmentally implementable.	Moderately effective in helping benefit anadromous fish survival. Does not significantly contribute to water supply reliability. Incidental contribution to flood control and hydropower objectives.	Because contributes to only one primary objective (anadromous fish survival), results in greatest cost for that purpose.	Low potential for Federal interest – less costly ways of achieving similar benefits to fishery.	Enlarging Shasta only for increasing the cold water pool is **not recommended** for further consideration as a stand-alone plan. Only addressed one primary objective. Very high cost for meeting single objective. Same conclusion for any sized project with similar component measures.
Relative Rank	*Low*	*Very Low*	*Very Low*	*Very Low*	*Very Low*
AFS-2 – Increase Minimum Anadromous Fish Flow with Shasta Enlargement (6.5 feet)	Can be implemented with minimum social and environmental impact. Does not preclude future actions at Shasta or elsewhere in CVP/SWP. Contributes to flood control and hydropower secondary objectives. High uncertainty in ability to effectively improve fish habitat through storage space dedication to increased minimum flows.	Relatively low increase in fish habitat with uncertain benefit to increased survival. Major trade-off in water supply reliability for relatively minor increased minimum flows. Incidental contribution to flood control and hydropower objectives.	Very high unit costs for increased fish habitat. Also, very high unit cost for water supply reliability. High costs due to dedicating storage space to increasing minimum winter/spring flows with little contribution to water supply.	Generally consistent with the goals of CALFED. However, low potential for Federal interest – less costly ways to achieve similar benefits to fishery.	Enlarging Shasta primarily to increase winter/spring river flows for anadromous fish is **not recommended** for further consideration as a stand-alone plan. Very high costs for marginal increases in meeting objectives. Same conclusion for any sized project with similar component measures. However, potential operational changes to increase fish survival are recommended for further study as part of any plan considered.
Relative Rank	*Moderate*	*Low*	*Low*	*Low*	*Low*

TABLE VIII-1
SUMMARY COMPARISON OF CONCEPT PLANS (CONT.)

Concept Plans	Comparison Criteria				Recommendation Status and Relative Ranking
	Completeness	**Effectiveness**	**Efficiency**	**Acceptability**	
AFS-3 – Increase Anadromous Fish Flow and Restore Aquatic Habitat with Shasta Enlargement (6.5 feet)	Similar to AFS-2. However, increased certainty in ability to improve fish habitat through physical fish spawning area improvements.	Similar to AFS-2. Increased effectiveness in anadromous fish habitat through gravel mine restoration.	Similar to AFS-2. Very high unit costs t0 meet primary objective.	Similar to AFS-2.	Similar to AFS-2, **not recommended** for further consideration as a stand-alone plan. High costs for marginal increases in meeting objectives. However, potential for increased fish habitat downstream from Keswick Dam recommended for further assessment and possible inclusion in future plans.
Relative Rank	*Moderate*	*Low*	*Low*	*Low*	*Low*
WSR-1 – Increase Water Supply Reliability with Shasta Enlargement (6.5 feet)	Can be implemented with minimum impact and would not require future elements. Does not preclude future action at Shasta or elsewhere in CVP. Addresses primary objectives.	Relatively low potential to effectively increase water supply reliability and improve fish survival. Incidental contribution to flood control and hydropower objectives.	High cost-efficiency. Unit cost for water supply reliability highly competitive with other new sources, including potential surface water storage projects.	Meets goals of CALFED and consistent with plan in CALFED ROD. High potential for avoiding perceived impacts.	Enlarging Shasta primarily for water supply reliability from sizes 6.5 feet to about 18.5 feet is **recommended** for further development primarily because (1) consistent with goals of the CALFED ROD, (2) high-cost-efficiency compared to other new sources, and (3) provides significant incidental benefits to anadromous fish and secondary study objectives.
Relative Rank	*Very High*	*Low*	*Moderate*	*High*	*Moderate to High*
WSR-2 – Increase Water Supply Reliability with Shasta Enlargement (18.5 feet)	Similar to WSR-1. Significant potential for avoiding/mitigating potential increased impacts.	Moderate potential to effectively address primary objectives. Significant contribution to water supply reliability. Incidental contribution to flood control and hydropower objectives.	Very high cost-efficiency. Superior to all other known new sources, including potential surface water storage projects.	Consistent with goals of CALFED. Significant potential for avoiding perceived impacts.	**Recommended** for further development for reasons similar to WSR-1. Also, enlarging Shasta to maximum extent possible without major relocations can maximize cost-efficiency.
Relative Rank	*Very High*	*Moderate*	*Very High*	*High*	*High to Very High*

TABLE VIII-1
SUMMARY COMPARISON OF CONCEPT PLANS (CONT.)

Concept Plans	Comparison Criteria				Recommendation Status and Relative Ranking
	Completeness	**Effectiveness**	**Efficiency**	**Acceptability**	
WSR-3 – Increase Water Supply Reliability with Shasta Enlargement (High Level)	Can be physically implemented with high confidence. However, numerous impacts would occur, primarily in reservoir area with reduced certainty for successful mitigation.	High potential to significantly address primary planning objectives. Significantly addresses water supply reliability. Can contribute significantly to cold water salmon resources. Provides major opportunities to address secondary objectives.	Very high implementation cost. Relatively high unit cost for new water supplies.	Low potential for Federal interest – likely less costly ways of achieving similar benefits to water supply reliability.	**Not recommended** for further consideration. High social and environmental impacts in Shasta Lake area. Very high implementation cost.
Relative Rank	*Low*	*High*	*Low*	*Low*	*Low*
WSR-4 – Increase Water Supply Reliability with Shasta Enlargement (18.5 feet) and Conjunctive Water Management	Significant potential for avoiding/mitigating potential increased impacts. Some degree of uncertainty about implementing conjunctive water management plan element due to likely contract modifications.	Similar to WSR-2 with increased contribution to water supply reliability through conjunctive use management.	Very high cost-efficiency for water supply reliability. Results in the lowest unit cost of all plans considered and of all other known potential water supply reliability projects.	Similar to WSR-2.	Enlarging Shasta to maximum extent possible without major relocations and including conjunctive water management component is **recommended** for further development. Recommended primarily due to consistency with goals of the CALFED ROD. WSR-4 is also believed highly cost efficient.
Relative Rank	*High*	*Moderate*	*Very High*	*High*	*High*
CO-1 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (6.5 feet)	Can be implemented with minimum impact and would not require future elements. Does not preclude future action at Shasta or elsewhere in CVP. Addresses all planning objectives.	Potential to address primary planning objectives with emphasis on spawning habitat restoration. Contributes to cold water salmon resources and reduced mortality. Includes features to increase reservoir reoperation for flood control and water supply.	Unit cost for water supply reliability competitive with other new sources, including potential surface water storage projects. High potential for efficient salmon habitat restoration along upper river.	Similar to WSR-1. Consistent with goals of CALFED and other local area restoration goals.	**Not recommended** for further consideration as a stand-alone plan. Major components are redundant with WSR-1 and CO-2, which are recommended for further development.
Relative Rank	*High*	*Moderate*	*Moderate*	*High*	*Moderate to High*

TABLE VIII-1
SUMMARY COMPARISON OF CONCEPT PLANS (CONT.)

Concept Plans	Comparison Criteria				Recommendation Status and Relative Ranking
	Completeness	**Effectiveness**	**Efficiency**	**Acceptability**	
CO-2 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)	Similar to CO-1.	Similar to CO-1 but with increased potential to address primary and several secondary planning objectives due to increased storage space.	High cost-efficiency. Unit cost for water supply reliability highly competitive with other new sources, including potential surface water storage projects. High potential for efficient salmon habitat restoration along upper river.	Similar to CO-1.	Enlarging Shasta to maximum extent possible without major relocations and including features to increase anadromous fish habitat is **recommended** for further development. Recommended primarily because this plan is (1) consistent with goals of the CALFED ROD, (2) highly cost efficient, and (3) addresses most of the planning objectives.
Relative Rank	*High*	*High*	*High*	*High*	*High*
CO-3 – Increase Anadromous Fish Flow/Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)	Similar to AFS-2 and AFS-3.	Low to moderate potential to effectively address primary objectives. Potential to significantly benefit salmon resources through restoring fish habitat. Provides major opportunities to address secondary objectives.	Reduced cost-efficiency for water supply reliability due to dedicated increased minimum flows.	Generally consistent with the goals of CALFED. However, high cost with marginal benefits for dedicated storage to anadromous fish minimum flows.	For reasons similar to AFS-2 and AFS-3, enlarging Shasta with significant storage space dedicated to increased winter/spring flows for anadromous fish is **not recommended** for further consideration as a stand-alone plan at this time. Very high costs for marginal increases in meeting objectives. However, potential operational changes to increase fish survival are recommended further study as part of any plan considered.
Relative Rank	*Moderate*	*Moderate*	*Moderate*	*Low to Moderate*	*Moderate*

TABLE VIII-1
SUMMARY COMPARISON OF CONCEPT PLANS (CONT.)

Concept Plans	Comparison Criteria				Recommendation Status and Relative Ranking
	Completeness	**Effectiveness**	**Efficiency**	**Acceptability**	
CO-4 – Multipurpose with Shasta Enlargement (6.5 feet)	Similar to CO-1. Some degree of uncertainty about implementing conjunctive water management plan element due to likely contract modifications.	Moderate potential to address primary planning objectives with emphasis on spawning habitat restoration. Contributes to cold water salmon resources and reduced mortality. Includes features to increase reservoir reoperation for flood control and water supply. Includes features to help restore ecosystem resources along upper Sacramento River and near Shasta Lake.	Most cost-efficient plan for a 6.5-foot dam raise. Moderate potential for efficient salmon habitat restoration along upper river. High potential for helping restore ecosystem resources along upper Sacramento River and near Shasta Lake.	Similar to WSR-1 and CO-1.	**Not recommended** for further consideration as a stand-alone plan with a 6.5-foot raise primarily due to reduced effectiveness and efficiency. Major components are redundant with WSR-1 and CO-5, which are recommended for further development.
Relative Rank	*High*	*Moderate*	*Moderate*	*High*	*Moderate to High*
CO-5 – Multipurpose with Shasta Enlargement (18. 5 feet)	Similar to CO-1. Some degree of uncertainty about implementing conjunctive water management plan element due to likely contract modifications.	High potential to address primary planning objectives with emphasis on spawning habitat restoration. Significantly contributes to cold water salmon resources and reduced mortality. Includes features to increase reservoir reoperation for flood control and water supply. Includes features to help restore ecosystem resources along upper Sacramento River and near Shasta Lake.	High cost-efficiency for water supply reliability. High potential for efficient salmon habitat restoration along upper river. High potential for helping restore ecosystem resources along upper Sacramento River and near Shasta Lake.	Consistent with the goals of the CALFED for various programs, including water supply reliability and ecosystem restoration.	Enlarging Shasta to maximum extent possible (without major relocations), including features for conjunctive water management, anadromous fish habitat, and ecosystem restoration is **recommended** for further development. Recommended primarily because this plan is (1) consistent with goals of the CALFED ROD, (2) highly cost-efficient, and (3) addresses all planning objectives.
Relative Rank	*High*	*High*	*High*	*High*	*High*

Authorization/Objectives

This subcriterion is an estimate of a plan's consistency with the basic study authorization and whether it addresses each of the primary planning objectives and provides opportunities to address the secondary objectives. For example, AFS-1 specifically addresses only one primary planning objective – anadromous fish survival – and therefore receives a low ranking for completeness.

Reliability

Reliability is a measure of a plan's capability to provide, over the life of a project, the specific and sustained benefits for which the plan was intended. It also includes a determination of whether other projects, programs, or actions are necessary to implement the project and develop the full level of benefit for which the plan was intended. It includes determining whether future actions, other than normal and identified O&M, are required for full and successful implementation of the plan. Concept plans that include increasing minimum flows for anadromous fish purposes (AFS-2, AFS-3, and CO-3) have a higher uncertainty than other plans. This is primarily because few definitive links exist between increased minimum flows, in the range being considered with the concepts, and increased fish survival. Concept plans including conjunctive water management also have a higher uncertainty than other plans primarily due to of the peripheral actions likely required for their implementation, such as existing contract modifications and service area structural modifications.

Physical Implementability

Physical implementability is the potential for a plan to be constructed or implemented within the study area, with disclosure of any unusual construction challenges potentially impacting project construction. All of the concept plans have a high potential for physical implementability.

Environmental Resources

This subcriterion estimates the relative ability of a plan to either avoid potential adverse environmental impacts or successfully mitigate for unavoidable adverse impacts. All concept plans, with the exception of WSR-3, are believed to have a high potential to either avoid or successfully mitigate environmental impacts (see also Hydraulic Conditions, below).

Water and Related Resources

This subcriterion is a determination of whether or not a plan can be implemented to mitigate any unavoidable impacts to water, power, recreation, flood control, and/or related resources. All concept plans, with the exception of WSR-3, are believed to have a high potential for implementation with minimum impacts to water and related resources. WSR-3 could provide significant net increases in hydropower resources. However, WSR-3 would also adversely impact existing generating facilities. All plans could indirectly benefit flood control and hydropower generation. Plans with dam raises greater than 6.5 feet would negatively impact near-lake recreation facilities.

Hydraulic Conditions

This subcriterion measures the ability of a plan to avoid potentially adverse hydraulic impacts to other areas or to mitigate any unavoidable impacts. Since all concept plans include increasing the water surface of Shasta Reservoir, each would inundate greater areas than under without-project conditions – 1,100, 2,600, and 31,000 acres for the 6.5-, 18.5-, and 200- foot dam raises, respectively. Once full, the range for the reservoir in annual inundation would be similar to without-project conditions for all alternatives considered, except during dry and critically dry years. Little can be done to avoid impacts associated with increased areas of inundation. Mitigation would include working to reduce the effects of the inundation with soil erosion control measures and introducing water-tolerant vegetation plantings. Acquisition and management of other areas to mitigate impacts also would be considered. The ability to successfully mitigate impacts from low-level dam raises (6.5 and 18.5 feet) would be high.

All concept plans would result in relatively minor changes in flow conditions downstream from Keswick Dam. Each would tend to reduce flows in the river from about December through March annually, and increase flows in spring and summer from about May through August. Average annual peak winter and spring/summer releases from Keswick Dam are about 10,000 and 14,000 cfs, respectively. Estimated maximum decreases in winter flows would range from about 300 and 600 cfs for the 6.5- and 18.5-foot dam raises (3 to 6 percent of without-project flows), respectively, to about 2,000 cfs (21 percent) for the 200-foot dam raise. Average maximum spring and summer increases in flows would range from about 200 and 300 cfs for the 6.5- and 18.5-foot dam raises (2 to 3 percent of the without project flows), respectively, to about 840 cfs (8 percent) for the 200-foot dam raise. These changes in flows become less significant further downstream from Keswick Dam due to the influence of tributaries to the Sacramento River.

Cultural Resources

This subcriterion measures the ability of a plan to avoid potential adverse impacts to present or historic cultural resources or to successfully mitigate for adverse unavoidable impacts. Each of the concept plans, with the exception of WSR-3, would have relatively minimal impact on reservoir area cultural resources. This is primarily due to the relatively small increased inundation area at full pool for all concepts except WSR-3.

Effectiveness Criterion

Effectiveness is the extent to which a plan alleviates problems and achieves objectives. For the primary planning objective of anadromous fish survival, two major relative ranking factors were considered: (1) increasing salmon survival (decreased salmon mortality) and (2) increasing habitat for spawning. For water supply reliability, ranking was based on the relative amount of new drought period yield that could be derived from each concept plan. For the secondary objectives, three relative ranking factors were considered: (1) whether a plan included ecosystem restoration, (2) potential to affect flood peaks downstream from Keswick Dam, and (3) potential to increase net electric energy. Primary planning objectives received 80 percent of the weight and secondary objectives received 20 percent of the weight for this criterion.

As indicated in **Table VIII-1**, concept plans with the greatest effectiveness in meeting planning objectives are WSR-3, CO-2, and CO-5. This is primarily because, of the 12 concept plans, these 3 would result in the greatest combined contribution to both primary planning objectives. Each AFS-focused plan, when compared to other concept plans, ranks low primarily because they would provide limited benefits to other study objectives. The same conclusions apply to the larger sizes of raising Shasta Dam.

Anadromous Fish Survival

This subcriterion is the relative ability of a plan to help increase the survival of anadromous fish populations in the Sacramento River primarily upstream from the RBDD. Included in **Table VIII-2** is a preliminary estimate of the average annual increase in salmon populations resulting from the increase in the cold water pool in Shasta Reservoir for three dam enlargements and reservoir operations. Also included in the table is a ratio of the increase in storage space in Shasta Reservoir to the estimated average annual increase in salmon population for each of the concept plans. This ratio is an attempt to help estimate the relative effectiveness of each plan for anadromous fish survival. For dam raises of 6.5 feet, the greatest benefit to fish survival and the greatest storage-to-increased-fish-survival ratio would occur with AFS-1 because all additional space would be dedicated to the goal of increasing the cold water pool. However, AFS-1 would not significantly contribute to the other planning objectives. The next greatest increase in fish survival with a dam raise of 6.5 feet would occur with WSR-1 and similarly with CO-1. Each plan also could provide significant benefits to the other objectives. The least apparent benefit in increased salmon survival would occur with AFS-2 and AFS-3. This is because increasing minimum flows on the upper Sacramento River would deplete the cold water pool, which may be needed later in the year for temperature regulation during the warm summer months. Also for these two concept plans, the potential to benefit other objectives would be low. It is expected that similar relationships would occur for larger dam raises but with effectiveness increasing for anadromous fish survival.

The estimated difference in increased fish survival benefits between WSR-1 or CO-1 and CO-4 (dam raises of 6.5 feet) or WSR-2 and WSR-4 or CO-5 (dam raises of 18.5 feet) is because operating to include a conjunctive management component in the concept plans lessens the amount of cold water available during critical periods compared to operations without the conjunctive management component. The greatest benefit to anadromous fish from an increase in the cold water pool would be with WSR-3 (dam raise of 200 feet). It is believed, however, that this plan could have adverse impacts not yet defined that would discount the apparent increase in salmon survival.

Also included in **Table VIII-2** is an estimate of the increase in spawning habitat resulting from both restoring several abandoned gravel mines and increasing minimum winter-spring flows for the anadromous fish consistent with the goals of the AFRP. It is estimated that dedicating the increased storage space in Shasta Reservoir to increasing minimum winter and spring flows for AFS-2 and AFS-3 would increase the area of potential successful fish spawning by nearly 150 acres (riverine area that would be dewatered without the increase in increased flows). It is expected that for higher dam raise scenarios, the increases in spawning habitat would be generally proportionally greater. However, it is believed also that based on increase in spawning area only, greater amounts of increased habitat could be obtained by restoring historical spawning areas such as abandoned gravel mining areas.

TABLE VIII-2
COSTS AND ACCOMPLISHMENTS SUMMARY

Item	CONCEPT PLANS											
	Anadromous Fish Survival Focus			Water Supply Reliability Focus				Combined Objective Focus				
	AFS-1	AFS-2	AFS-3	WSR-1	WSR-2	WSR-3	WSR-4	CO-1	CO-2	CO-3	CO-4	CO-5
Raise Shasta Dam (ft)	**6.5**	**6.5**	**6.5**	**6.5**	**18.5**	**200**	**18.5**	**6.5**	**18.5**	**18.5**	**6.5**	**18.5**
Total Increased Storage (1,000 AF)	290	290	290	290	636	9340	636	290	636	636	290	636
Accomplishments												
Anadromous Fish												
- Spawning Habitat - Restore Gravel Mines (acres)	-	-	150	-	-	-	-	150	150	150	150	150
- Minimum Flows (acres)	-	170	170	-	-	-	-	-	-	170	-	-
- Summer/Fall Mortality Reduction (no. fish)[1]	862	373	373	406	1107	10624	1024	406	1107	975	406	1024
Water Supply Reliability (1,000 AF/year)[2]	0	20	20	72	125	703	146	72	125	90	89	146
Ecosystem Restoration (acres)	-	-	-	-	-	-	-	-	-	-	548	548
Hydropower Generation (GWh/yr)	51	32	32	15	44	2,254	44	15	44	61	12	44
Annual Cost												
Total for Alternative ($millions)	19.4	19.4	20.1	19.4	28.1	383.0	32.3	20.1	28.8	28.8	25.4	34.0
Independent Increments ($millions)[3]												
- Gravel Mine Restoration	-	-	1.0	-	-	-	-	1.0	1.0	1.0	1.0	1.0
- Ecosystem Restoration	-	-	-	-	-	-	-	-	-	-	1.2	1.2
- Subtotal	-	-	1.0	-	-	-	-	1.0	1.0	1.0	2.2	2.2
Creditable to Water Supply Reliability ($millions)[4]	0	5.4	5.4	19.4	28.1	383.0	32.3	19.1	27.8	20.2	23.2	31.8
Creditable to Anadromous Fish ($millions)[5]												
- Spawning Habitat	-	14.0	13.7	-	-	-	-	-	-	7.6	-	-
- Mortality Reduction	19.4	-	-	-	-	-	-	-	-	-	-	-
Relative Anadromous Fish Benefit												
Relative Mortality Reduction Ratio (fish/1,000 AF)[6]	3.0	1.3	1.3	1.4	1.7	1.1	1.6	1.4	1.7	0.6	1.4	1.6
Spawning Habitat ($1,000/acre)[7]												
- Minimum Flow Improvement	-	82	81	-	-	-	-	-	-	34	-	-
- Gravel Mine Restoration	-	-	7	-	-	-	-	7	7	7	7	7
Unit Cost for Water Supply ($millions/AF)[8]	-	270	270	270	225	550	220	265	220	230	260	220

Key: AF – acre-feet AFS – anadromous fish survival CO – combined objective GWh/yr – gigawatt hours per year WSR – water supply reliability

Notes:
[1]Average annual increase in chinook salmon population.
[2]Increased water supply yield based on drought year conditions with Banks Pumping capacity at 6,680 cfs. At 8,500 cfs pumping capacity, yield about 18 percent greater.
[3]Average annual cost of plan elements that can be implemented independent of other features.
[4]Portion of average annual cost to develop water supply yield based on expected yield multiplied by unit cost for similar-sized WSR alternatives.
[5]Annual cost creditable to anadromous fish = (total average annual cost) – (annual costs for independent features) – (annual costs creditable to water supply reliability).
[6]Average annual increase in salmon population divided by total increase in storage.
[7]Average annual cost of each acre of increased spawning habitat.
[8]Unit water cost based on portion of annual cost creditable to water supply reliability divided by estimated increase in water supply reliability (drought period yield).

Water Supply Reliability

This subcriterion is the relative potential of a plan to help increase water supplies and water supply reliability to the CVP and SWP to help meet future water demands, with a primary focus on modifying Shasta Dam and Reservoir. Included in **Table VIII-2** is an estimate of the increase in drought period water supply reliability for the concept plans. As can be seen, the increase in water supply reliability ranges from about 20,000 acre-feet per year for dam raises of 6.5 feet (including dedication of increased storage to increasing spring fish flows) to over 700,000 acre-feet per year for a dam raise of 200 feet. The exception is concept plan AFS-1, which would only provide an incidental amount of water supply yield.

Ecosystem Restoration

This subcriterion is a measure of the ability of a plan to address the secondary objective of ecosystem restoration. Through pursuit of the primary planning objectives, significant potential is created to implement features to help preserve and restore ecosystem resources in the Shasta Lake area and along the upper Sacramento River. Concept plans CO-4 and CO-5 include ecosystem restoration features in the Shasta Lake area and along the upper Sacramento River.

Flood Damage Reduction

This subcriterion is a measure of the ability of a plan to reduce flood damages along the upper Sacramento River. Each of the concept plans incidentally provides increased flood control opportunities, especially in the reach of the Sacramento River upstream from Cottonwood Creek. Concepts CO-1 through CO-5 also include opportunities to reoperate Shasta Dam and Reservoir to increase its efficiency for flood control. Further evaluations are needed to identify specific operation changes and the relative magnitude of potential flood control benefits.

Hydropower

This subcriterion is a measure of the ability of a plan, through pursuit of the primary planning objectives, to help increase hydropower capabilities at Shasta Dam. Each of the plans incidentally provides increased opportunities for hydropower generation (see **Chapter IX**). From **Table VIII-2**, increases in hydropower generation range from about 12 GWh/year for CO-4 to over 2,200 GWh/year for WSR-3 (not including loss of generation at the Pit 7 Dam).

Efficiency Criterion Description

Efficiency is the measure of how efficiently a plan alleviates identified problems while realizing specified objectives consistent with protecting the Nation's environment. Concept plans ranking highest for this criterion are WSR-2, WSR-4, CO-2, and CO-5. This is primarily because each of these plans provides a significant increase in water supply reliability at a relatively low unit cost while significantly contributing to other planning objectives. Each of the AFS-focused concept plans and WSR-3 rank low. For the AFS-focused plans, this is primarily because the increased storage space would be dedicated to either increasing the cold water pool or instream flows. These plans would provide very little economic benefit to the other planning objectives. The same conclusion applies to larger sizes of raising Shasta Dam. Also, concept plan WSR-3 ranks low because of its very high implementation cost.

Anadromous Fish Survival

This is a measure of the potential for a plan to increase the long-term survivability of anadromous fish in the upper Sacramento River at the lowest incremental cost. As shown in **Table VIII-2**, the estimated annual unit cost for each acre of increased habitat resulting from an increase in the winter/spring minimum flows for concept plans AFS-2, AFS-3 and CO-3 is many times more costly than for habitat increases resulting from physically restoring historical spawning areas.

Water Reliability Unit Cost

This is a measure of the potential for a plan to increase the reliability of the CVP and SWP by developing a reliable additional increment of water at the lowest unit cost (dollars per acre-foot of drought period yield). As shown in **Table VIII-2**, it is estimated that concept plans WSR-2, WSR-4, CO-2, and CO-5 would result in the lowest unit water costs compared to the other plans. Costs would range from a low of about $220 per acre foot to about $550 per acre-foot, which is the total cost creditable to water supply reliability divided by the estimated average annual yield. Excluding AFS-1, concept plans that would result in the highest unit cost for increased water supply reliability are AFS-2, AFS-3, WSR-1, and WSR-3.

Secondary Planning Objective Costs

This is a measure of the potential for a plan to also include benefits for ecosystem restoration, flood damage reduction, and hydropower with the lowest incidental and economically justified additional cost. All dam raise scenarios provide some amount of increased seasonal storage space that can contribute to increased efficiency in flood operations and a higher head for power generation. The relative efficiency to provide flood control and hydropower increases with larger reservoirs and higher dam raises. The efficiency of a plan in providing ecosystem restoration relative to enlarging Shasta Dam and Reservoir will require additional evaluation.

Acceptability Criterion

Acceptability is the workability and viability of a plan with respect to its potential acceptance by other Federal agencies, State and local governments, and public interest groups and individuals. At the current stage of plan formulation for the SLWRI, little is known about the ultimate likelihood for Federal agency acceptance or non-Federal sponsorship. Accordingly, the likelihood of Federal interest and consistency with the CALFED ROD are the primary factors used to assess acceptability at this current stage in the planning process. Other factors important to acceptability that will be focused on in future studies to further develop and evaluate alternative plans include (1) non-Federal sponsorship, (2) potential for broad spectrum acceptance, and (3) likely compliance with existing laws, regulations, and policies.

Concept plans that are estimated to rank highest for this criterion are WSR-1, WSR-2, WSR-4, CO-1, CO-2, CO-4, and CO-5. This is primarily because these plans generally address the primary planning objectives and some or all of the secondary objectives, and are generally consistent with the goals and objectives of CALFED. Concept plans that rank lowest are AFS-1 and WSR-3, primarily because they address only one primary objective, as for AFS-1, or would

likely lack Federal interest due to their very high cost and high and difficult-to-mitigate socioeconomic and environmental impacts.

Likelihood for Federal Interest

Potential for Federal interest exists for each of the concept plans providing the plans are economically feasible and a non-Federal sponsor(s) is capable and willing to share in implementing the cost for a potential project. For those plans with high costs for a specific unit of benefit to the anadromous fishery, ecosystem, or water supply reliability, potential for Federal interest is greatly diminished because of the likely lack of economic feasibility. This is believed to especially true for concept plans similar to AFS-1, AFS-2, AFS-3, WSR-3, and CO-3 (see **Table VIII-2**).

CALFED Consistency

This is a measure of the relationship of the plan to the overall goals and objectives of the CALFED ROD or other ongoing projects and programs. To rank high, a plan must neither preclude nor enhance the potential for development of other projects and programs. All of the concept plans, with the exception of AFS-1 and WSR-3, are believed to be fundamentally consistent with the CALFED ROD.

INITIAL ALTERNATIVES

After comparing each concept plan to the planning criteria above, five plans appeared superior in **Table VII-1** and in supporting analyses. Accordingly, these five plans and the required No-Action plan are recommended for further development as full initial alternatives in the SLWRI. Features and combinations of feature sizes in the initial alternatives will likely change in future studies. Some of the initial alternatives may be combined with others or dropped from further development. Further, other measures and combinations of measures may emerge and warrant development into full initial alternatives. Concept plans recommended as initial alternatives include the following:

- No-Action
- WSR-1 –Increase Water Supply Reliability with Shasta Enlargement (6.5 feet)
- WSR-2 – Increase Water Supply Reliability with Shasta Enlargement (18.5 feet)
- WSR-4 – Increase Water Supply Reliability with Shasta Enlargement (18.5 feet) and Conjunctive Water Management
- CO-2 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)
- CO-5 – Multipurpose with Shasta Enlargement (18.5 feet)

No-Action (No Federal Action)

Under this No-Action plan, the Federal Government would take no action toward implementing a specific plan to help increase anadromous fish survival opportunities in the upper Sacramento

River nor help address the growing water reliability issues in the Central Valley of California through the assistance of Shasta Dam and Reservoir.

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

The primary purpose of this plan is to be consistent with the CALFED ROD, with a focus on increasing water supply reliability while contributing to increased anadromous fish survival. It includes raising Shasta Dam 6.5 feet, raising the Shasta Reservoir gross pool by 8.5 feet, and enlarging the total storage space in Shasta Reservoir by 290,000 acre-feet to 484 MAF (see **Plate 17**). This plan would help reduce estimated future water shortages through increasing drought year supplies by about 72,000 acre-feet per year. Increased pool depth and volume also could contribute to seasonal water temperature benefits to spring-run salmon. In addition, incidental benefits to flood control and hydropower would be achieved.

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

This plan focuses on increasing water supply reliability through the likely greatest practical enlargement of Shasta Dam and Reservoir consistent with the goals of the CALFED ROD. It includes raising Shasta Dam 18.5 feet, raising the Shasta Reservoir gross pool by 20.5 feet, and enlarging total storage space in Shasta Reservoir by 636,000 acre-feet to 5.19 MAF (see **Plate 18**). This plan would help reduce estimated future shortages through increasing drought year water supply reliability by about 125,000 acre-feet per year. The increased pool depth and volume also could contribute to seasonal water temperature benefits to anadromous fish.

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

The goal of this plan is to increase water supply reliability of the CVP and SWP through a combination of conjunctive water management and enlargement of Shasta Dam and Reservoir consistent with the goals of the CALFED ROD. This plan is similar to Plan WSR-2. However, it also includes implementing a conjunctive water management component consisting primarily of contract agreements between Reclamation and certain Sacramento River basin water users. These agreements would focus on exchanging additional surface water supplies in normal water years for reduced deliveries in dry and critically dry years, at which time participants would rely more heavily on groundwater supplies to meet demands (see **Plate 18**). This plan would help reduce estimated future shortages through increasing drought year water supply reliability by about 146,000 acre-feet per year. Increased pool depth and volume also could contribute to seasonal water temperature benefits to anadromous fish.

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

The primary purpose of this plan is to address both primary planning objectives with a focus on increasing anadromous fish habitat and enlarging Shasta Reservoir by 18.5 feet. This plan includes enlarging Shasta Dam and Reservoir as WSR-2. In addition to increasing cold water pool depth and volume in Shasta Lake to help benefit anadromous fish, the plan includes restoring inactive gravel mines along the Sacramento River (see **Plate 19**). Also, the plan

includes further investigation of and potential modifications to the existing TCD at Shasta Dam for enhanced temperature management, and increasing the operational efficiencies of Shasta Dam and Reservoir for water supply reliability and flood control.

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

This plan addresses both primary planning objectives through enlarging Shasta Dam and Reservoir consistent with the goals of the CALFED ROD, including increased water supply reliability and increased fish spawning habitat in the upper Sacramento River. The plan also contains features to address the secondary objectives. For water supply reliability, this plan includes enlarging Shasta Dam and Reservoir as in WSR-2. For anadromous fish survival, this plan includes an increased cold water pool depth and volume in Shasta Reservoir and restoring inactive gravel mines and floodplain habitat along the Sacramento River (see **Plate 20**). In addition, the plan includes further investigation of and potential modifications to the existing TCD at Shasta Dam for enhanced temperature management, and increasing the operational efficiencies of Shasta Dam and Reservoir for water supply reliability and flood control. Finally, the plan includes (1) implementing conjunctive water management as in Plan WSR-4, (2) constructing warm water fish habitat in the Shasta Lake area, and (3) restoring one or more riparian habitat areas between Redding and Red Bluff on the Sacramento River.

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