Environmental Consequences

CHAPTER 4

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CHAPTER 4 Environmental Consequences

INTRODUCTION

Approach to Impact Analysis

This chapter describes the regional and site-specific impacts to Reclamation's water contracting alternatives. These impacts are determined for each resource category by comparing predicted 202 environmental conditions under Alternatives 1 through 7 with predicted 2020 baseline environmental conditions under the No-Action Alternative.

The No-Action Alternative assumes full buildout of existing CVP contracts. Such buildout would, for some resource categories, cause major changes between existing (1985) conditions and 2020 No-Action conditions. Although this chapter describes such changes under the No-Action Alternative, these changes are not impacts of entering into new or expanded CVP contracts under Alternatives 1 through 7. These changes can be considered potential impacts of Reclamation's past contracting actions, which cumulatively add to the additional incremental impacts of new contracting under Alternatives 1 through 7.

Impacts described in this chapter are described as beneficial, adverse and less than significant, or adverse and significant. An impact is considered beneficial if environmental conditions would improve compared to 2020 baseline conditions under No-Action. An impact is considered adverse if environmental conditions would worsen compared to 2020 baseline conditions. Thresholds for determining whether adverse impacts would be significant are described in each resource category section of this chapter.

Proposed Action Impacts

Reclamation's proposed contracting action is similar to Alternatives 1B and 2, and the proposed action's regional and site-specific impacts would therefore be expected to be similar to those of Alternatives 1B and 2.

Mitigation Measures

This chapter presents potential mitigation measures to avoid or reduce adverse impacts associated with Reclamation's water contracting alternatives. Reclamation has not selected those mitigation measures to be implemented and invites public comments on the potential mitigation measures described in this chapter and other possible measures. Reclamation will select those mitigation measures to be implemented and present them in

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the Final EIS and Record of Decision once Reclamation's proposed contracting action has been finalized.

Site-Specific Environmental Assessments and Mitigation Measures

Reclamation will require follow-up site-specific NEPA environmental reviews prior to executing new or expanded CVP contracts with individual agencies. These subsequent NEPA environmental reviews could be combined with any necessary site-specific CEQA environmental reviews. The subsequent NEPA environmental reviews will allow the further development of site-specific mitigation measures where necessary and will satisfy any remaining site-specific requirements of related federal environmental laws and policies that may not be fully satisfied by this EIS. These related federal environmental laws include the Endangered Species Act, the National Historic Preservation Act, and Executive Orders on wetlands and floodplains.

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SOILS AND DRAINAGE

Introduction

The following analysis focuses on soils and drainage resources within the SRSA that could be impacted by water contracting activities. Available soils and drainage water data are generally lacking, preventing detailed quantitative analysis in most cases.

The most important issue identified during the scoping process is the potential increase in surface and subsurface drainage discharge that could result from the water contracting alternatives and related impacts to the quality of receiving surface and groundwater bodies.

The Proposed Action or alternatives may have various impacts on the soils and drainage system. These impacts may include a change in the chemical composition of the soil, a change in groundwater levels so that subsurface drainage is required, or a change in the quantity or quality of return flows.

The mechanisms of impact on the soil resource include:

- improved irrigation efficiency,
- development of previously nonirrigated lands,
- substitution of CVP surface water for groundwater for irrigation,
- expanded refuge (wetland habitat) area, and
- enhanced refuge management.

Each of these elements and its relationship to soils and drainage is discussed in the following paragraphs. The discussion is limited to supplying water for irrigated agriculture and wildlife refuge management because supplying CVP water for M&I uses would have no impact on soils and drainage.

Each of the project elements discussed below would affect soil and drainage in some way. In some instances, the effects are opposing and tend to offset one another. The combined effect or impact is therefore a summation of the individual impacts and is highly site specific. The degree to which irrigation efficiency is improved, the irrigation source for existing and newly developed lands, and the management of the refuges and the groundwater resource, all influence potential impacts on soils.

Improved Irrigation Efficiency

Irrigation efficiency is the ratio of the volume of water required for beneficial use to the volume of water delivered. The volume of water required is generally fixed by crops and climate; therefore, efficiency is increased by reducing the amount of water delivered. This can be achieved at the farm level by reducing the amount of water applied (smaller leaching fraction and increased uniformity) and at the district or regional level by increasing reuse of drainage water for irrigation or by reducing conveyance losses. The possible effects of moving a smaller volume of water through the soil profile (reduced delivery) and of using a poorer quality water for irrigation (increased reuse) are:

- o an increase in the soil profile salt concentration due to a smaller leaching fraction and the use of a poorer quality water for irrigation,
- o a decrease in water table levels due to reduced application and resultant deep percolation,
- o an increase in water-table levels if less irrigation water is pumped from groundwater because it has been replaced by recycled drainage water,
- o a decrease in the volume of drainage water produced due to reduced application and reuse,
- o an increase in the salt concentration of drainage water due to the reduced volume, and
- o no significant change in trace element concentrations.

Development of Previously Nonirrigated Lands

Irrigation of previously nonirrigated lands would cause a larger volume of water to move through the soil profile than occurs from rainfall. Depending on the quality of the irrigation water and the initial salt concentration of the soil, the salt concentration of the soil would increase or decrease. However, a recent study (CH2M HILL 1987) indicates that total salinity in the root zone of irrigated soils in the SRSA has been greatly reduced over the span of 25 years. This reduction was attributed to leaching of salts from the soil through irrigation.

Development of newly irrigated lands would affect the groundwater table as follows:

- o a rise where new surface water is applied and the groundwater gradient is not sufficient to remove the amount that is deep percolated, or
- o a fall where new lands are developed by pumping groundwater for irrigation and recharge is insufficient to maintain groundwater levels.

Irrigation usually produces some surface runoff and deep percolation below the root zone. Therefore, irrigation development of new lands is expected to increase the volume

of drainage water from a given area. Based on the assumption that the soils within the newly developed areas are similar to those in the currently irrigated areas, long-term drainage water qualities would be similar. Short-term increases in drainage water salinity would result if reclamation of soils in the newly developed areas occurs.

Substitution of CVP Water for Groundwater for Irrigation

The equilibrium concentration of salts in the soil is a function of irrigation water quality. Assuming that CVP water is of better quality than groundwater currently used for irrigation (CVP water at Red Bluff Diversion: TDS = 81 ppm. Groundwater in the SRSA: TDS = 200 - 500 ppm) (DWR records), the concentration of salts in the soil would be expected to reach a new, lower equilibrium level. The actual level would depend on the relative proportion of groundwater and CVP water used for irrigation.

Substitution of a better quality irrigation water would also produce a long-term reduction in drainage water salinity. Mere substitution of irrigation water source is not expected to cause a change in the volume of return flow.

Expanded Refuge (Wetland Habitat) Area

Development of new wetland areas would result in a larger volume of water moving through the soil profile than occurs under undeveloped conditions. It is reasonable to assume that, like existing refuge lands, the new areas would be located in low-lying, poorly drained, and probably salt-affected soils. Therefore, the increased volume of water percolating through the soil would flush some salts from the soil thereby reducing the concentration of salt in the soil profile.

Development of new refuge lands would also raise the groundwater table if it is not already at the ground surface, except for alternatives that would allocate intermittent water, requiring refuges to pump significant amounts of groundwater.

Application of water to the soil surface under wetlands conditions results in some runoff and deep percolation below the root zone. Therefore, development of new wetlands is expected to increase the volume of drainage water from a given area. Assuming soils in newly developed areas are similar to those in the currently developed areas, long-term drainage water qualities would be similar. Short-term increases in drainage water salinity would result where flushing of salt-affected soils occurs.

Enhanced Refuge Management

Water that is applied to wetlands is lost from the system by evapotranspiration (ET), deep percolation, or runoff. Assuming no change in ET and provided that an ET deficit does not already exist, additional water applied to enhance refuge management would produce a larger volume of drainage water as either deep percolation or runoff. Depending on the quality of newly applied water, the tendency would be for the salt concentration in the soil to be reduced. Similarly, the increased volume of runoff will tend to reduce the

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runoff salt concentration. Water-table levels would not be affected except in these months and areas where evapotranspiration exceeds the water supply and the water table drops to below the soil surface. In these instances, increased water application to enhance refuge management would tend to increase water-table levels.

No-Action Alternative

Regional 2020 Baseline Conditions

Under this alternative, no additional CVP water would be contracted. Regional 2020 baseline conditions were formulated based on four assumptions:

- o existing irrigated lands would continue to be cultivated,
- o the existing trend of gradually increasing irrigation efficiency would continue,
- o no new agricultural lands would be developed by SRSA requestors, and
- o existing interim CVP water deliveries to agricultural lands and refuges, estimated to average 41,000 af/yr, would be eliminated.

The potential regional changes of the No-Action Alternative compared to present conditions, are:

- o decreased groundwater pumpage as a result of more efficient irrigation, tending to improve the quality of applied irrigation water and return flows, and to cause groundwater levels to rise (see also "Groundwater Hydrology and Quality");
- o decreased groundwater recharge, tending to cause groundwater levels to fall (see also "Groundwater Hydrology and Quality");
- o reduced volumes of tailwater and deep percolation; and
- o increased salt and boron concentrations in the soil and in deep percolation.

The effects on groundwater levels would be essentially offsetting, resulting in negligible net change and, therefore, little potential impact on drainage. Similarly, the total mass load of dissolved solids in agricultural return flows is not expected to change significantly because increases in constituent concentrations are directly associated with reduced volumes of return flows. Also no significant change in trace element concentrations or mass loadings would be expected. Finally, it is reasonable to assume that farmers would not improve irrigation efficiencies to the point that higher salt and boron concentrations in the soil would adversely affect profitability.

Site-Specific 2020 Baseline Conditions

Irrigated Areas. Under the No-Action Alternative, the assumptions stated in the preceding regional impacts discussion are expected to apply to individual districts also. Therefore, site-specific impacts are the same as those previously described. It should be noted that the potential increases in boron concentrations in the soil profile and in return flows are associated primarily with the Yolo-Zamora Water District and Yolo-Solano agencies (Yolo County FC&WCD), where groundwater has significant boron concentrations and is pumped for irrigation.

Refuges. Under No Action, existing interim CVP water deliveries to refuges, estimated to average 38,000 af yr, would be eliminated with no increased supplies from alternative sources. Maintenance of the wetland habitat would then depend on rainfall, surface drainage patterns, and the poorly drained soil conditions. Lacking supplemental surface water, several changes from existing (1985) conditions would occur. Salt concentrations in the soil would likely increase due to the reduced volume of water percolating through the soil. The volume of runoff and deep percolation would also be reduced with a corresponding increase in TDS. Water tables would also tend to be lower although they may still remain at or near the soil surface depending on local surface drainage and soil permeability conditions.

Alternative 1

Regional Impacts

Under Alternative 1, agricultural agencies would be provided their full water needs from firm water and from intermittent water used in conjunction with available groundwater. This would facilitate development of the full extent of new irrigated lands. Under Option A, refuges would be provided Level 2 needs from intermittent water used in conjunction with available groundwater, allowing enhanced management of existing refuge lands but not development of additional lands. Under Option B, refuges would be provided Level 4 needs from intermittent water used in conjunction with available groundwater, allowing expansion of wetland habitat area, as well as enhanced management of existing refuge levels.

Elements of Option A that affect soils and drainage are:

- development of previously nonirrigated lands,
- substitution of CVP water for groundwater for irrigation, and
- enhanced refuge management.

The potential regional impacts that would result from these elements, compared to No Action, are:

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- o decreased salt and boron concentrations in new soils as they are reclaimed,
- o increased return flows and total mass load of salt contributed to the Sacramento River system due to irrigation of new lands,
- o slightly decreased salt and boron concentrations in existing irrigated soils and associated return flows (long term) due to better quality irrigation water,
- o localized buildup of shallow groundwater conditions in the Yolo-Zamora Water District and in the vicinity of refuges,
- o slightly decreased salt concentrations in refuge soils and associated return flows, and
- o increased volumes of surface and subsurface drainage from refuges.

As presented in the following section, the magnitude of these impacts is small when compared to the conditions associated with the No-Action Alternative. For this reason, the potential regional impacts of Option A on soils and drainage are considered less than significant.

Site-Specific Impacts

Irrigated Areas. Approximately 52,000 ac of new lands would be irrigated under the Proposed Action, compared to No Action. Following initial reclamation, these lands are expected to contribute about 18,700 af ac of return flows at a TDS concentration of 280 ppm, containing 7,200 tons of salt. About 8 percent of this increase is attributable to Yolo-Solano agencies, where return flows are generally reused and are not discharged to regional waterways. The remaining 92 percent of flow and mass load would be discharged to the Sacramento River, the large majority via the CBD and minor amounts via Stoney and Thomes Creeks, and other smaller streams. The effect of this discharge would be to increase CBD flows and mass loads by 7 percent during the irrigation season and by 5 percent annually. Sacramento River TDS would increase less than 1 part per million (ppm). These potential site-specific impacts are considered less than significant.

CVP water would improve the quality of irrigation water applied to some lands. This would cause a negligible, temporary increase in mass load of return flows as a new soil-water equilibrium is reached; then, salt concentrations and mass loads in return flows would decrease, tending to improve return flow water quality.

In the Yolo-Zamora Water District, 15,000 af/yr (30 percent) of the water provided under the Proposed Action would be used to replace existing groundwater pumping. The purpose in doing so would be to selectively retire wells that produce water containing damaging concentrations of boron. Although this would improve the quality of applied irrigation water, having beneficial effects on crop production, it would also result in a groundwater imbalance, where recharge to the aquifer would exceed discharge by approximately 15,000 af/yr. Consequently, existing shallow water tables would rise further, impeding soil drainage and eventually necessitating artificial drainage to avoid adverse

impacts on agricultural productivity. Preliminary investigations by Reclamation indicate that about one-third of the district, or approximately 8,000 acres, would require drainage. This area is located in the northeastern portion of the district, immediately south of the Colusa Basin Drain.

Refuges. Under Option A, refuges would be provided Level 2 needs on an intermittent basis, equivalent to existing average annual supplies. This water would be firmed up through conjunctive use practices so that existing refuge wetland habitat would be managed more consistently; however, total applied water, return flows, and drainage conditions, on the average, would not change appreciably from existing conditions. In comparison to No Action, under which refuge water supplies would be severely reduced, it is expected that salt concentrations in the soil and return flow would tend to be lower, the volume of drainage water higher, and groundwater levels higher. It is possible that groundwater levels may rise into the root zone on some refuges; however, this is actually desirable from the refuge perspective of maintaining wetland habitat. Potential site-specific impacts would be less than significant.

Option B would deliver approximately 28,000 af/yr more water to the refuges than would Option A. This water would be used for development of new wetland areas and for enhanced management of existing wetlands. Compared to the No-Action Alternative, the impacts due to development of new areas would be a reduction in soil salinity, an increase in drainage water volume, and an increase in the salt load to the Sacramento River system. These impacts would apply to all refuges, with the exception of the Colusa NWR, where there would be no development of new wetlands (all lands presently developed). The impacts due to enhanced management of existing wetlands would be an increased volume of drainage water, and a reduction in soil and return flow salt concentration. Potential site-specific impacts would be less than significant.

Alternative 2

Regional Impacts

Regional impacts under Alternative 2 on soils and drainage would be essentially the same as those described under Alternative 1 - Option B. No significant impacts would result.

Site-Specific Impacts

Irrigated Areas. Site-specific impacts under Alternative 2 would be similar to those of Alternative 1 - Option B except for the Yolo-Solano agencies, which would not receive CVP water. However, since only 76 percent of the water need (compared to 100 percent for Alternative 1) would be delivered, the magnitude of the impacts would be smaller. The increase in total salt load to the CBD and to the Sacramento River system from newly irrigated areas is estimated to be 5,500 tons annually. This represents an approximate 6-percent increase in the CBD salt load during the irrigation season and a 4-percent increase in the annual salt load. The impact on Sacramento River water quality would be to

increase the TDS less than 1 ppm, which is less than significant. As with Alternative 1, a high groundwater condition would eventually develop in the Yolo-Zamora Water District, significantly impacting soils and drainage and eventually requiring some form of mitigation to maintain agricultural productivity.

Refuges. No site-specific impacts would occur under Alternative 2 since 2020 conditions would be the same as those described under the No-Action Alternative. No significant impacts would result.

Alternative 3

Regional and Site-Specific Impacts

Impacts under Alternative 3 would be similar to those described under Alternative 1 - Option A. Significant impacts would occur in the Yolo-Zamora Water District.

Alternative 4 A/B

Regional and Site-Specific Impacts

Regional and site-specific impacts under Alternative 4 A/B would be identical to those described under Alternative 2, except that impacts on refuges would be identical to those described under Alternative 1 - Option B. Significant site-specific impacts would result in the Yolo-Zamora Water District.

Alternative 4 C/D

Regional and Site-Specific Impacts

No significant impacts would occur under this alternative since 2020 conditions would be essentially the same as conditions under the No-Action Alternative, except that conditions at refuges would be identical to those under Alternative 1 - Option A.

Alternative 5

Regional and Site-Specific Impacts

No significant impacts would occur under this alternative since 2020 conditions would be similar to those under the No-Action Alternative, except that conditions at refuges would be identical to those under Alternative 1 - Option B.

Alternative 6

Regional and Site-Specific Impacts

Impacts under Alternative 6 would be similar to those described under Alternative 4 A/B. No significant impacts would result.

Alternative 7

Regional and Site-Specific Impacts

Impacts under Alternative 7 would be identical to those described under Alternative 5. No significant impacts would result.

Mitigation Measures

Regional Impacts

Regional impacts of Alternatives 1-7 to the soils and drainage system would be less than significant. Therefore, no mitigation measures are required.

Site-Specific Impacts

Provide artificial drainage or change cropping patterns for poorly drained Yolo-Zamora Water District lands. The only significant impact on soils and drainage resulting from water contracting is the rise of shallow groundwater in the Yolo-Zamora Water District associated with Alternatives 1, 2, 3, 4A/B, and 6. Possible mitigation measures that maintain agricultural productivity include providing artificial drainage, and change cropping patterns to more water-tolerant species (i.e., rice). To maintain agricultural productivity, approximately 11,000 to 15,000 af/yr would have to be removed with artificial drainage facilities (either underdrains or groundwater pumping) to establish long-term equilibrium of groundwater levels. Estimated annual boron loading would be 80 to 100 tons, assuming boron concentrations of 5 ppm in the drainwater. The maximum effects of discharging this water to the CBD and Sacramento River are shown in Table 4B-1, below.

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Table 4B-1. Estimated annual boron loading resulting from identified mitigation measure

	CBD Above Knights Landing	Sacramento River Above Knights Landing
Base Condition		
Flow, af/yr	323,674	7,500,000
Boron Concentration, ppm	0.20	0.06
Boron Load, tons/yr	92	612
Drainage Discharge		
Flow, af/yr	15,000	15,000
Boron Concentration, ppm	5.0	5.0
Boron Load, tons/yr	100	100
Blended Condition		
Boron Concentration, ppm	0.42	0.07
Boron Concentration, % increase	110	16
Boron Loading, tons/yr	192	712
Boron Loading, % increase	110	16

SURFACE WATER HYDROLOGY AND SEEPAGE

Introduction

The discussion and data presented in this section focus on output from Reclamation's operations and power computer models. Resulting river flows and reservoir levels are compared among the alternatives considered using actual model output with an interpretive discussion on adjustments necessary to account for differences in water allocations for model runs and the EIS water contracting alternatives (or in cases where no model run was made). The computer models operate the CVP system in accordance with set criteria (i.e., instream flow release, Delta outflow to meet D-1485, minimum and maximum reservoir levels) required by agreements, contracts, regulations, or permits and meet those criteria before allocating any releases for the water contracting alternatives. Because of this, hydrologic changes, in and of themselves, are not considered to be environmental impacts. Hydrologic changes may, however, result in impacts to fish, wildlife, recreation, or economic resources from changes in reservoir levels and river flows. Information presented here provides a frame of reference for evaluation of those impacts.

Evaluation Methodology

Reclamation operations and power models were used to estimate CVP water supply available for contracting and identify how changing water demand patterns affect 1) surface water flow throughout the CVP, 2) reservoir storage, and 3) power production. Output from these computer models were used to compare results for the alternatives defined for the water contracting EIS's (see Chapter 2, "Alternatives Including the Proposed Action."). Descriptions of the models and input parameters are summarized in Appendix III and included in Technical Appendix B (bound separately). Output from the model runs is included in Technical Appendix C (bound separately). Data presented in Technical Appendix C for 1985 conditions; the No-Action Alternative (2020 base case); and Alternatives 1B, 2, 3, 4A, 4D, 5, 6, and 7 include monthly flows and percent exceedence values for the 57-year period of record analyzed, percent exceedence by year type (i.e., wet, dry, etc.) and a compilation of data for water years 1961, 1964, 1976, and 1977. The same data are presented for reservoir levels and storage. Output locations include the American River below Nimbus Dam and H Street, the Sacramento River below Keswick Dam, Red Bluff and the American River confluence, the San Joaquin River, Delta inflow and Delta outflow, Shasta and Folsom Reservoir elevations, and Clair Engle, Shasta and Folsom Reservoir storage.

As described in Appendix III, an operations planning model was first used to simulate the coordinated reservoir operations of the CVP to meet existing and proposed demands. Output from the planning model was then used in a power operations model to estimate energy and capacity generation while reserving planning model mandatory releases. Because of the complicated steps and balancing of river flows and reservoir levels, a number of different reservoir levels and river flows could result for each of the alternatives. The values used in analyses for this EIS are considered reasonable for comparison of alternatives but are only one of the possible results.

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Reclamation's models developed flows and storages based on historical flow records for water years 1922-1978 for each water contracting alternative. As noted in Appendix III, water allocations for some of the alternatives were changed after the model runs. In all cases, these changes are small in comparison to the total flow in the northern CVP system (average annual flow of about 18 million acre-feet in the Sacramento River at the Delta) and are not considered significant for the surface water hydrology comparisons among alternatives. For that reason, the model output was used without modification. Where no model run was made or where deliveries were not made in a specific CVP system, reference is made to output from a model run with similar deliveries. Data tabulated for the following locations are applicable to comparisons described in this section.

- o Clair Engle Reservoir storage,
- o Shasta Reservoir storage,
- o Sacramento River flows below Keswick,
- o Sacramento River flows below Red Bluff, and
- o Sacramento River flows below the American River confluence.

Each alternative has different effects on flow in the Sacramento River and storage levels in Shasta and Clair Engle Reservoirs. To evaluate the differences, analyses were made to simplify output from the Reclamation models and allow a comparison between the alternatives. First, minimum flow standards along the Sacramento River were examined to identify the number of months each alternative equalled or exceeded minimum flow levels. Second, flow and storage values generated from the model output were compared to identify flow and storage values in the SRSA for each alternative.

Minimum Flow Standards

Sacramento River. Existing flow standards from the Reclamation-DFG April 1960 agreement were analyzed to identify the frequency with which each alternative met or exceeded the normal year requirement of that agreement. Keswick releases required by the agreement are summarized below:

Period	Normal Year	Critical Dry Year
January 1 through February 28	- 2,600 cfs	2,000 cfs
March 1 through August 31	- 2,300 cfs	2,300 cfs
September 1 through November 30	- 3,900 cfs	3,900 cfs
December 1 through December 31	- 2,600 cfs	2,000 cfs

Note: Letter dated October 8, 1981, changed normal year minimum releases to 3,250 cfs for the period October 1, 1981, through February 28, 1982 (the 3,250 cfs flow standard has continued in effect since that period and has been used for EIS evaluations).

Operations criteria for the models require minimum flows in the Sacramento River that equal or exceed Reclamation - DFG agreement flows. Therefore, minimum flows for all alternatives meet the standards 100 percent of the time.

Trinity River. USFWS is currently conducting a 12-year study of salmon and steelhead production on the Trinity River (initiated in 1984). During this 12-year period, the following guaranteed minimum releases from Lewiston Reservoir to the Trinity River were established by the Secretary of the Interior:

- Normal/wet year: increasing from 287,000 af/yr to 340,000 acre-feet per year, as habitat and watershed restoration measures are implemented and evaluated.
- Dry year: 220,000 af/yr. and
- Critically dry year: 140,000 af/yr.

These Lewiston Reservoir minimum releases are used in the models for all alternatives and are made before any other diversions. Therefore, there are no differences among alternatives in minimum releases to the Trinity River. However, flows in the Trinity River vary during years that spills occur at Lewiston Dam. The volume of these spills ranges from about 600,000 af during the wettest year to 0 af in most years. The total volume of spills for the 57-year period equalled 1.2-1.3 million af. Spills occur during wet years when the natural flow in the Trinity River downstream of Lewiston Dam is already higher than normal and when there is insufficient capacity in Clear Creek Tunnel to bring water to the Sacramento basin. Lower levels of spill occur for Alternatives 4 C/D and 5 because more water is released to the Sacramento for export from the Delta, and for refuge and instream flow needs respectively.

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Flow and Storage Variability

Average monthly and yearly flows in the Sacramento River and average monthly and yearly storages in Shasta and Clair Engle Reservoirs were determined to identify variations among alternatives. Data were compared and plotted on a monthly basis for critically dry, average, and wet years for the period of record for each of the alternatives. These data and plots are included in the following Appendix IV tables and figures:

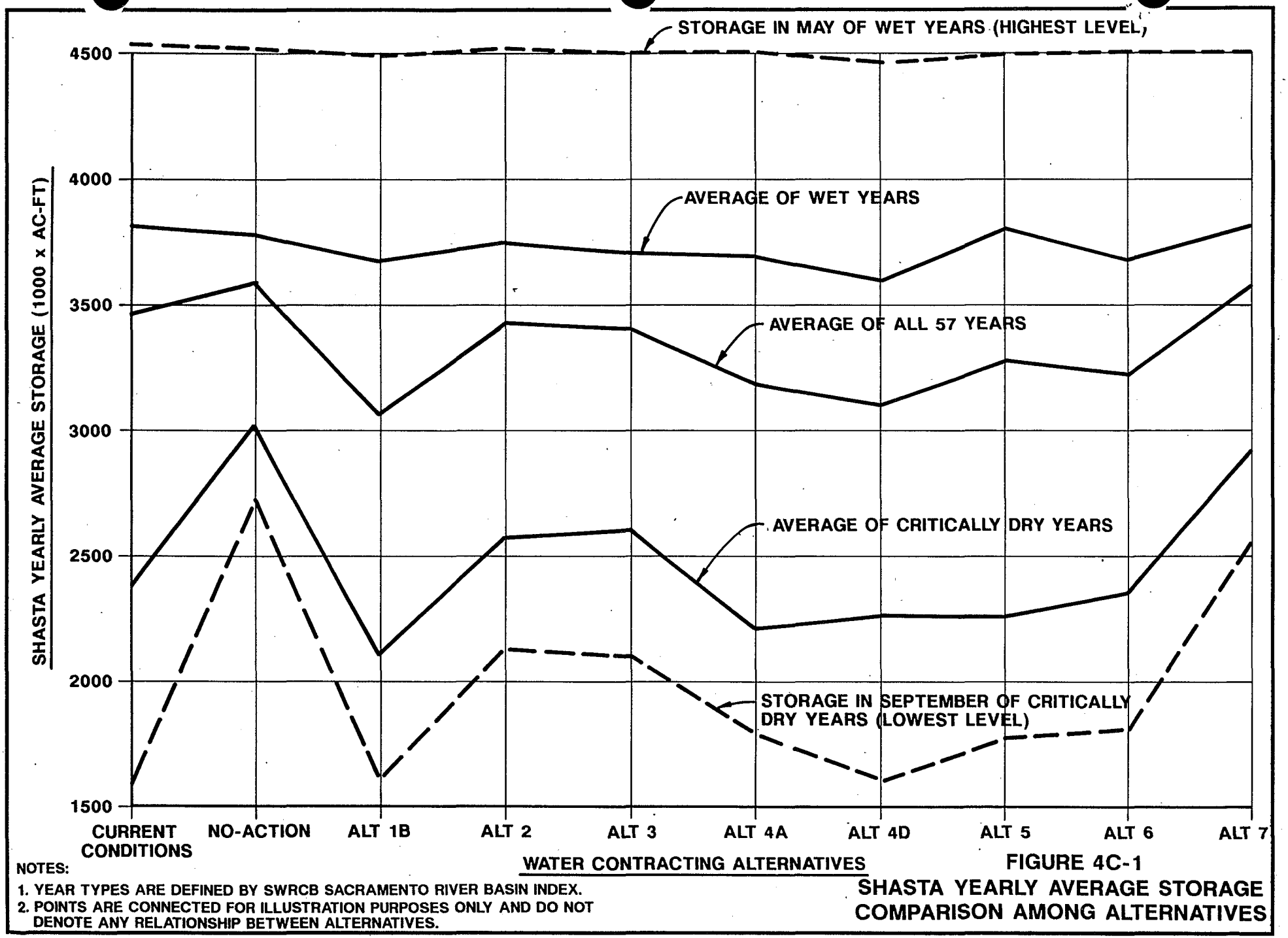
	Appendix IV Tables	Figures
Clair Engle Storage	A	A and B
Shasta Storage	B	C and D
Sacramento River		
Below Keswick	F	K and L
Below Red Bluff	G	M and N
Below American River Confluence	H	O and P

These tables include storage levels in thousand af or flows in cfs for each month and the yearly average plus the percent change (plus or minus) from the No-Action Alternative levels for each water allocation alternative on which a model run was made. Figures include plots of the storage or flow levels and of the percent changes. Annual values from the tables are plotted in Figures 4C-1 through 4C-5 to provide a summary comparison among alternatives.

Surface Water Hydrology Comparisons and Seepage Impacts

Numerous assumptions were made in operating the Reclamation models. These assumptions are described in Appendix III. However, some of the assumptions are presented here to highlight some reasons for differences in river flows and reservoir levels among alternatives.

- The uncommitted CVP firm yield considered for allocation in the SRSA was that which can be produced by existing facilities.
- Current COE flood control reservoir storage criteria defined upper limits of reservoir storage.
- Deficiencies were taken in critically dry years for 1985 conditions only when necessary. That is, when predicted inflows and available reservoir storage were not sufficient to meet one year's demands and maintain at least a desired system storage at the end of the irrigation season, deficiencies were imposed. For all



NOTES:

1. YEAR TYPES ARE DEFINED BY SWRCB SACRAMENTO RIVER BASIN INDEX.
2. POINTS ARE CONNECTED FOR ILLUSTRATION PURPOSES ONLY AND DO NOT DENOTE ANY RELATIONSHIP BETWEEN ALTERNATIVES.

FIGURE 4C-1

SHASTA YEARLY AVERAGE STORAGE COMPARISON AMONG ALTERNATIVES

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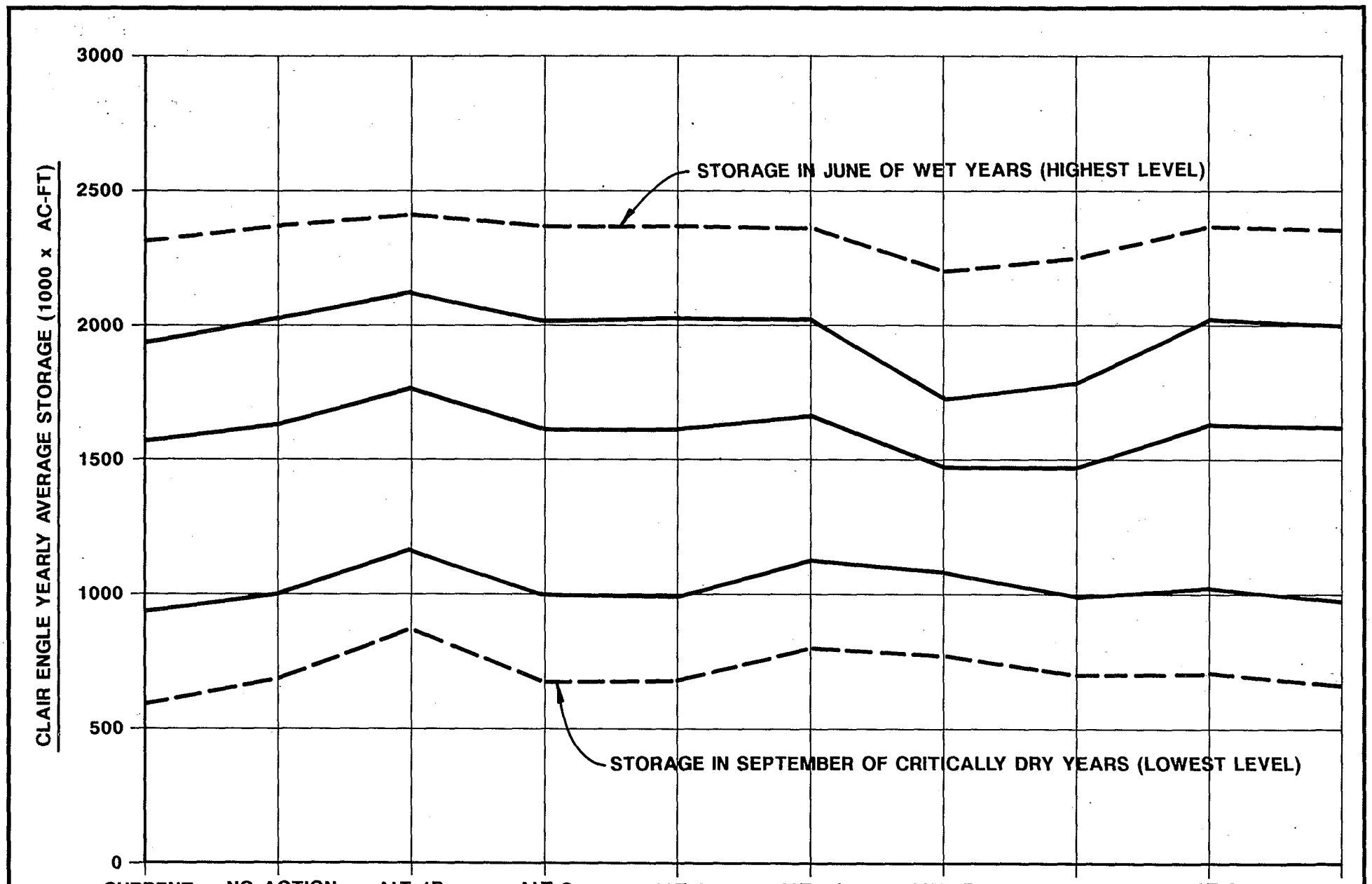

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FIGURE 4C-2
CLAIR ENGLE YEARLY AVERAGE STORAGE COMPARISON AMONG ALTERNATIVES

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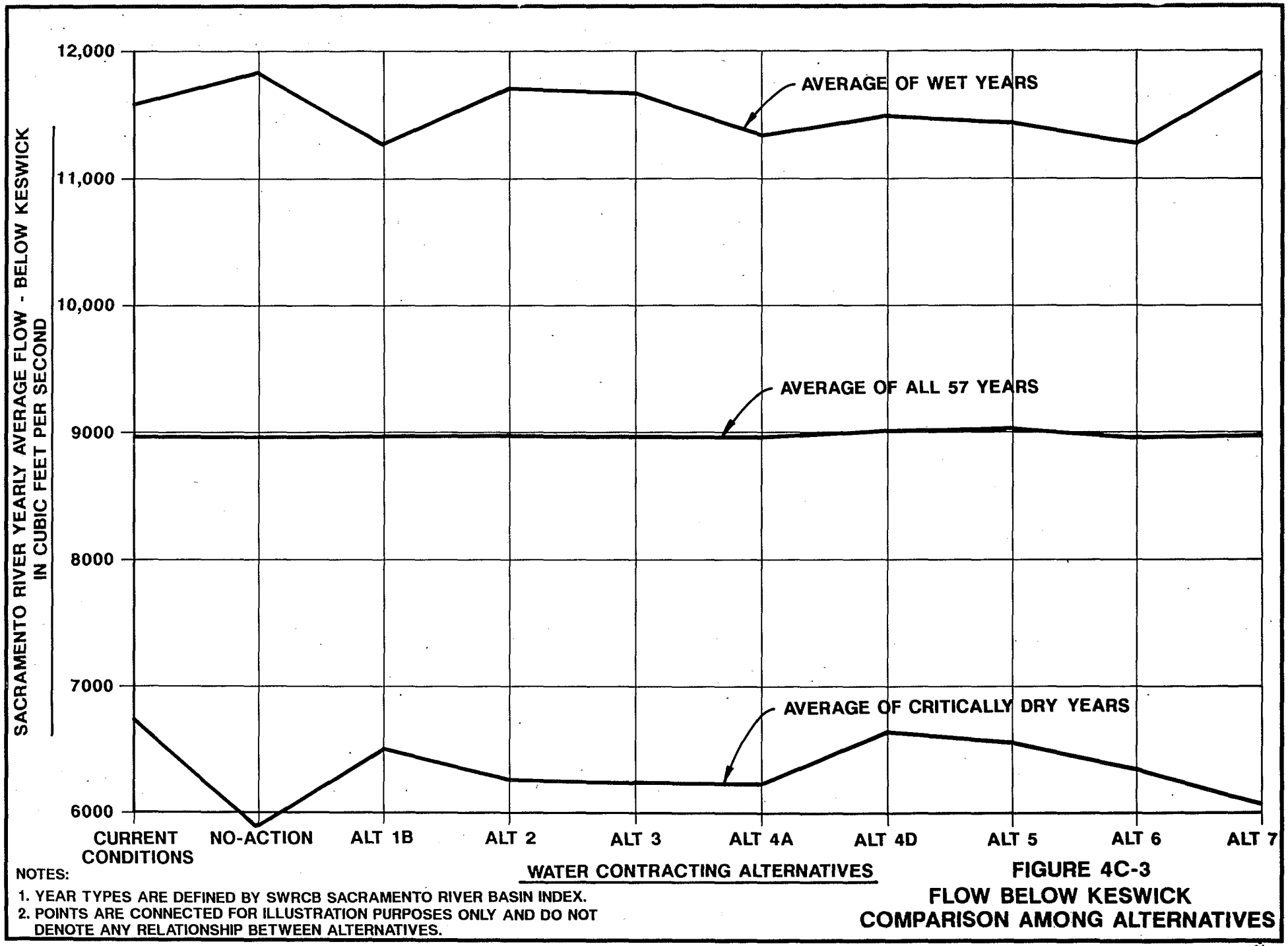

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FIGURE 4C-3
FLOW BELOW KESWICK
COMPARISON AMONG ALTERNATIVES

C—055673

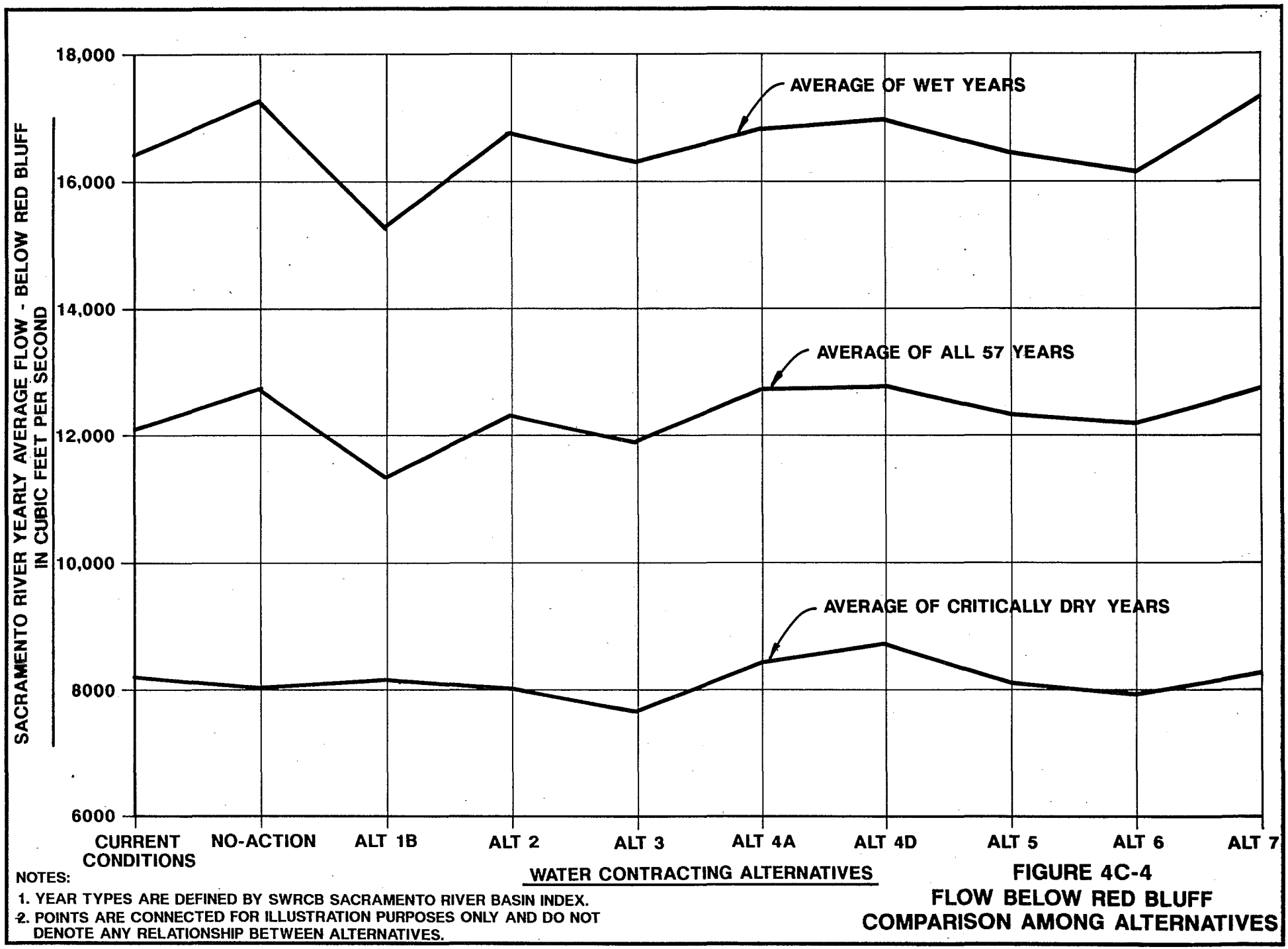

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FIGURE 4C-4
FLOW BELOW RED BLUFF
COMPARISON AMONG ALTERNATIVES

C—055674

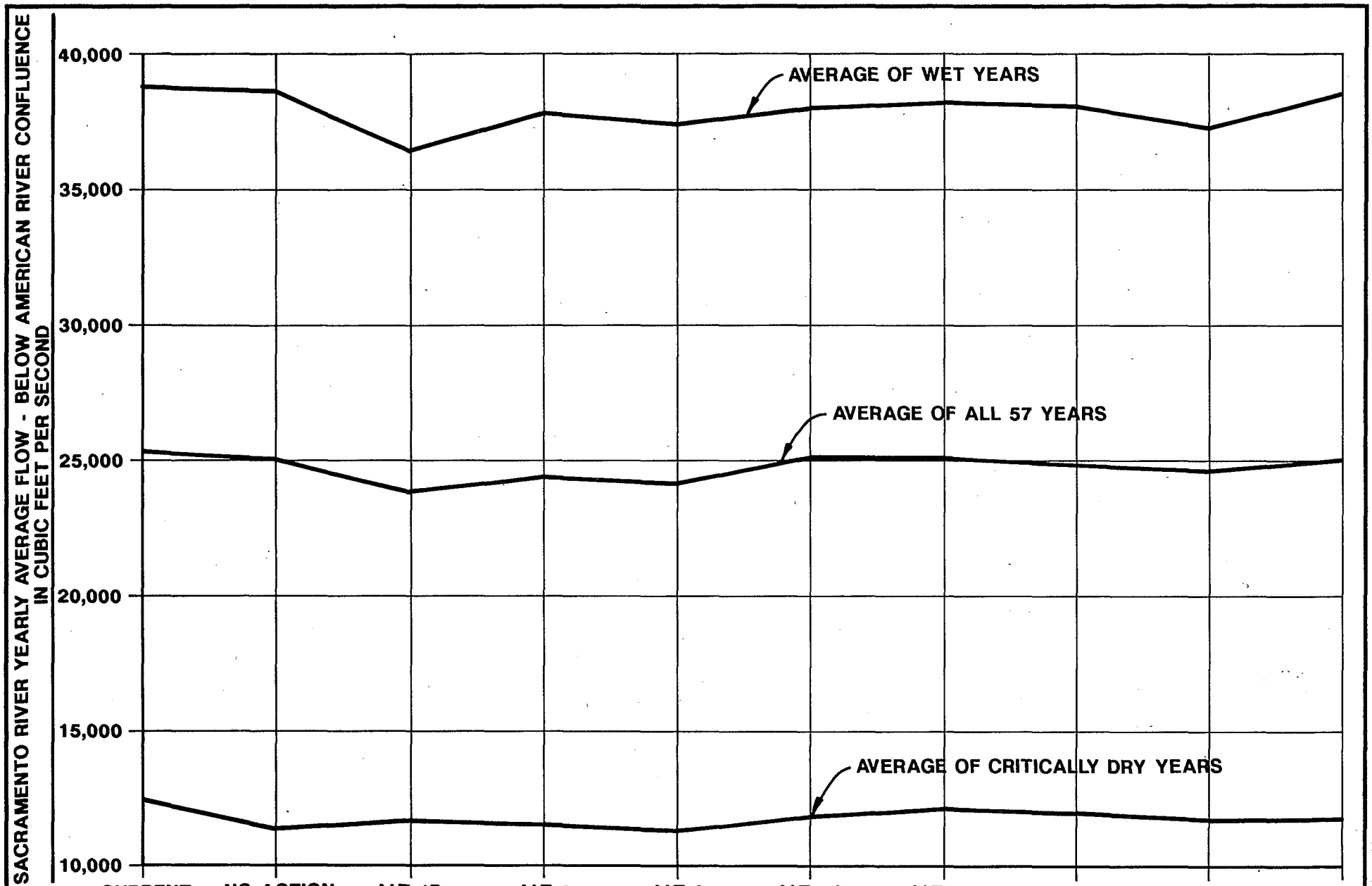

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FIGURE 4C-5

FLOW BELOW AMERICAN RIVER CONFLUENCE
COMPARISON AMONG ALTERNATIVES

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alternatives deficiencies were taken in all critically dry years. This reflects the current method of operation and the method expected to be in place in 2020 following buildout of existing contracts.

Surface water hydrology comparisons are regional in nature. Site-specific impacts resulting from delivery of the surface water are discussed elsewhere in the EIS. All water for contracting is delivered from the upper Sacramento River system, and there are no changes to the Feather River, Putah Creek, and Cache Creek systems caused by the water contracting alternatives defined for this EIS.

The comparisons discussion below is based on data presented in Figures 4C-1 through 4C-5 from model output. It is followed by a similar discussion for each water contracting alternative that uses the model run data in Appendix IV which applies to that alternative. For example, Alternative 1 - Option A uses model output from runs for Alternatives 2 and 3.

Reservoir and Streamflow Comparisons

Differences among alternatives in reservoir storage levels and river flows are discussed below for Clair Engle and Shasta Reservoirs and the Sacramento River below Keswick, Red Bluff and the American River confluence.

Clair Engle Reservoir. The No-Action Alternative results in higher storage levels in Clair Engle Reservoir than current conditions (Figure 4C-1). This reflects the change in operations from taking limited deficiencies to taking full deficiencies. Alternatives 2, 3, 4A, 6, and 7 result in storage levels similar to that of the No-Action Alternative. Alternatives 4D and 5 reduce storage levels in the reservoir, especially during wet years. These two alternatives provide more flow to the Sacramento River for export from the Delta and for refuge and instream flow needs. Alternative 1 - Option B has a positive impact on storage levels at Clair Engle. It results in higher storage levels in the reservoir than any of the alternatives and up to 22 percent more storage during critical dry years than shown by the model run for current conditions. One reason for these higher levels is the maximum use of Shasta and Folsom Reservoirs for Alternative 1 - Option B resulting in less water needed from Clair Engle Reservoir.

Shasta Reservoir. The No-Action Alternative results in slightly higher storage levels in Shasta than shown by the model run for current conditions (especially during critically dry years). This reflects the change in operations from taking limited deficiencies to taking full deficiencies. All of the alternatives except Alternative 7 result in less storage in Shasta, especially in critically dry and average years. Much of the additional water to be delivered to the SRSA, ARSA, and DESA for these alternatives would come from Shasta, resulting in the lower storage levels. Alternative 7, which gives priority to recreation at Shasta, results in approximately the same storage as the No-Action Alternative. Alternative 1 - Option B results in 30 percent less storage in the reservoir than the No-Action Alternative during critically dry years, or about the same as Alternatives 4 and 5.

Sacramento River Below Keswick Dam. The No-Action Alternative results in less flow in the river during critically dry years than shown by the model run for current conditions

This correlates with the additional storage in Shasta and Clair Engle Reservoirs and reflects the change in operations from taking limited deficiencies to taking full deficiencies. All of the other alternatives (in general), when compared to the No-Action Alternative, result in higher flows in the river during critically dry years, about the same flows for the average of all years, and lower flows during wet years. This is due to increased deliveries downstream during dry years and increased contracting of intermittent water during the wet years. Alternative - Option B has much the same pattern as the other alternatives: 10 percent higher flows during critically dry years and about 5 percent lower flows during wet years.

Sacramento River Below Red Bluff. As shown in Figure 4C-4, the No-Action Alternative results in higher flows in the river than under current conditions. Alternatives 2, 3, 5, and 6 have lower flows than the No-Action Alternative. Alternatives 4A/B, 4C/D, and 7 have greater flows during critically dry years than the No-Action Alternative, and slightly lower flows during wet years. All of these alternatives involve more water being released into the Sacramento River for export from the Delta, or instream flow needs. Alternative 1 - Option B has slightly greater flows than does the No-Action Alternative during critically dry years and lower flows on the average and during wet years.

Sacramento River Below American River Confluence. The No-Action Alternative, results in less flow in the river than under current conditions. All of the other alternatives in general, when compared to the No-Action Alternative, result in higher flow in the river during critically dry years, slightly less flow for the average of all years, and less flow during wet years. Alternative 1 - Option B has much the same pattern as the other alternatives: 2 percent higher flow during critically dry years, and up to 5 percent less flows during average and wet years.

No-Action Alternative

The No-Action Alternative comparisons are based on the percent change from current conditions as represented by the 1985 level model run. These are changes that would occur when full use of water under existing contracts takes place. The average change for the 57-year hydrologic period ranges from 27 percent more storage in Shasta to 13 percent less flow below Keswick. The changes are greater during critically dry years and less during wet years. Much of this increase or decrease is due to the change from utilizing limited deficiencies versus full deficiencies (i.e., more water remains in the reservoir during critically dry years). The fish, wildlife, recreation, and economic conditions resulting from the storage and flow changes are also affected by changes in operating assumptions.

Alternative 1 - Option A

Alternative 1 - Option A provides firm yield water deliveries to the same requestors as Alternative 2, with the remaining needs being met with intermittent water. Under Alternative 1 - Option A, the total firm yield delivered is limited to the remaining Tehama-Colusa Canal capacity (143,500 af) plus deliveries made through the Corning Canal and Glen-Colusa Irrigation District system (31,600 af) and to Shasta Dam Area Public Utility District (4,800 af). Deliveries under Alternative 3 are similar but with the

total needs delivered to the above requestors plus deliveries to meet refuge and Yolo-Solano needs. The average Alternative 2 or 3 change for the 57-year hydrologic period ranges from 15 percent less storage in Shasta to 7 percent more flow below Keswick. The changes are greater during critical dry years and less during wet years, but storage levels and river flows are always less than for the No-Action Alternative (except for critically dry year flows below Keswick).

Proposed Action - Option B

Alternative 1 - Option B provides firm yield water deliveries only to requestors with no economical groundwater alternative, with the remaining needs being met with intermittent water. Firm yield deliveries are made at Shasta Dam (4,800 af), Tehama-Colusa Canal (67,400 af) and Corning Canal (7,800 af). The percent change in river flows is about the same as for Alternative 1 - Option A (as indicated by Alternatives 2 and 3), but the change in reservoir levels is substantially greater. This appears to result because Clair Engle Reservoir is operated to maintain higher storage levels with more of the needed water released from Shasta and Folsom, with the resulting lower storage levels. The higher storage levels at Trinity provide greater reserve for in-basin recreation and in-stream flow uses. Shasta Reservoir storage levels under Option A are about the same as under current conditions. However, under Option B, the storage levels are up to 10 percent less on the average and in wet years. Such an operation maximizes the effectiveness of Shasta Reservoir in producing firm and intermittent water for contracting. This meets a major objective of CVP facilities.

Alternatives 2, 3, and 4A/B

Impacts of Alternatives 2 and 3 are the same as those described for Alternative 1 - Option A. Under Alternatives 4A/B, the Alternative 2 deliveries and the Level 4 refuge deliveries (intermittent water) are also made to the SRSA. However, the model runs do not reflect these allocations. The values for Alternative 2 are considered representative of the Alternative 4A/B impacts on the Sacramento River.

Alternatives 4C/D, 5, and 7

No additional firm yield water is allocated to the SRSA under these alternatives. The available yield is released from Shasta Reservoir for Delta export or instream demands. This results in higher river flows (up to 13 percent more than the No-Action Alternative during critically dry years) but reservoir levels up to 14 percent less than the No-Action Alternative, on the average. This is in the order of 10 percent less than current (1985) levels. Alternatives 4C/D and 5 result in lower reservoir levels in both Clair Engle and Shasta Reservoir because they maximize the amount of water for in-stream flow or Delta export.

Alternative 6

Under this alternative, M&I and agricultural water deliveries are the same as for Alternative 2, with water also delivered to meet Level 4 refuge needs. Impacts on Shasta Reservoir are similar to those for Alternatives 4C/D, and 5. However, river flows are less than the No-Action Alternative.

Summary of Reservoir and Flow Impacts

Changes in reservoir levels and river flows can have important impacts on environmental resources such as fisheries, vegetation and wildlife, recreation, aesthetics, and cultural resources. Impacts of such changes on these and other resources are described in later sections of this chapter. From a hydrological standpoint, none of the changes in reservoir levels and river flows identified in this chapter are considered significant.

Seepage Impacts

Seepage is the migration of water through the soil from areas where the water table is high to areas with lower water tables. In the river bed, the water table is generally at or near the surface of the river water. In areas where the water table outside the river banks is lower than the river surface, the tendency is for water to flow out of the river to the nearby areas. The type of soil that the water must flow through also affects the seepage potential, but the only factor that is affected by water contracting is the river level or stage.

Under the worst condition for any water contracting alternatives, water levels in the Sacramento River are not significantly changed. As shown in Figure 4C-4, wet year river flows are all less than the No-Action Alternative. This translates to a decrease in the water table level nearby, resulting in the possibility of less seepage with additional water contracting. Water contracting alternatives would not significantly affect seepage in the Sacramento River area.

Mitigation Measures

No mitigation measures have been developed for surface water hydrology impacts. Mitigation measures are, however, discussed later in this chapter for resources affected by hydrologic changes, such as fisheries, vegetation and wildlife, recreation, aesthetics, and cultural resources.

SURFACE WATER QUALITY

Introduction

The analysis below focuses on upper Sacramento River water quality parameters most likely to be affected by water contracting alternatives. Parameters specifically addressed include temperature and constituent concentrations.

Water quality issues relating to the possible impacts of water contracting identified during the scoping process include effects on agricultural return flows, municipal effluent, dilution of heavy metals, and temperature. CVP storage and diversion facilities affect these issues by controlling the timing, frequency, and quantity of flow during many months of the year. Water quality impacts of water contracting are limited because of the portion of annual runoff being considered for new water contracts (about 7 percent of the 17.8 million af average Sacramento River flow to the Delta). This ranges from about 10 percent on the American River down to 6 percent on the Sacramento River. In addition, much of the water to be allocated for new contracts is currently released for power operations, and flow changes will only be some variation in timing of release.

Regional Impacts

Temperature

Water temperatures in the Sacramento River and Clair Engle and Shasta Reservoirs are affected by each of the alternatives. In general, decreased storage and river flow have the effect of increasing temperatures. Increases in river flow and storage have the opposite effect of lowering temperatures. Impacts of changes in temperature are fish related, and discussions on those changes are included in the fish and wildlife resource section of this chapter.

The percent of years resulting in temperatures at Keswick and Red Bluff of 60°F or higher are given in Tables 4D-1 through 4D-4, with 4D-1 and 4D-2 reflecting conditions assuming a temperature control device is in place at the Shasta Reservoir outlet and 4D-3 and 4D-4 assuming existing conditions without the curtain. The single elevation intake to the Shasta power penstocks does not allow a variance of withdrawal level from the reservoir without a substantial loss of power generation. This limitation could be corrected by providing selective withdrawal capability.

An alternative being considered by Reclamation calls for a temperature control device to be placed upstream of the power penstock intake area. It is proposed to consist of hypalon panels reinforced by a steel wire rope mesh. A steel wire support system would secure the panels to the top and bottom booms, and the device to the dam, headtower, permanent concrete anchors, and the variable buoyancy anchors. The top length would be approximately 880 feet with panel heights ranging from 65 to 255 feet. The maximum upper elevation for the device would be at 875 feet above sea level based on temperature

Table 4D-1. Monthly Mean Water Temperatures at Keswick
(percent of years 60°F equaled or exceeded)

Alternative	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	0	0	0	0	0	0	0	2	5	7	2	0
No Action	0	0	0	0	0	0	0	0	2	2	0	0
1B	0	0	0	0	0	0	0	0	7	9	0	0
2	0	0	0	0	0	0	0	0	0	7	0	0
3	0	0	0	0	0	0	0	0	2	7	0	0
4A	0	0	0	0	0	0	0	0	7	13	0	0
4D	0	0	0	0	0	0	0	2	11	16	2	0
5	0	0	0	0	0	0	0	0	2	7	0	0
6	0	0	0	0	0	0	0	0	19	16	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0

Note: Temperature model results assume Shasta Reservoir temperature curtain in place.

Table 4D-2. Monthly Mean Water Temperatures at Red Bluff
(percent of years 60°F equaled or exceeded)

Alternative	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Current Conditions	0	0	0	0	9	18	21	11	46	11	0	0
No Action	0	0	0	0	2	36	71	45	46	2	0	0
1B	0	0	0	0	13	52	89	43	29	11	0	0
2	0	0	0	0	4	32	75	36	41	7	0	0
3	0	0	0	0	4	30	45	21	21	16	0	0
4A	0	0	0	0	13	48	86	25	34	18	0	0
4D	0	0	0	0	5	45	50	21	27	18	0	0
5	0	0	0	0	7	63	77	59	38	9	0	0
6	0	0	0	0	7	38	75	25	36	21	0	0
7	0	0	0	0	2	59	73	66	61	2	0	0

Note: Temperature model results assume Shasta Reservoir temperature curtain in place.

Table 4D-3. Monthly Mean Water Temperatures at Keswick
(percent of years 60°F equaled or exceeded)

Alternative	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	0	0	0	0	0	0	4	9	11	9	0	0
No Action	0	0	0	0	0	0	0	0	4	2	0	0
1B	0	0	0	0	0	0	5	11	23	16	0	0
2	0	0	0	0	0	0	0	4	11	9	0	0
3	0	0	0	0	0	0	0	7	11	14	0	0
4A	0	0	0	0	0	0	4	7	18	18	0	0
4D	0	0	0	0	0	0	5	18	21	16	0	0
5	0	0	0	0	0	0	9	0	0	0	0	0
6	0	0	0	0	0	0	4	9	25	21	0	0
7	0	0	0	0	0	0	0	2	5	7	0	0

Note: Temperature model results without Shasta Reservoir temperature curtain in place.

Table 4D-4. Monthly Mean Water Temperatures at Red Bluff
(percent of years 60°F equaled or exceeded)

Alternative	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Current Conditions	0	0	0	0	4	11	18	29	82	14	0	0
No Action	0	0	0	0	2	30	50	86	80	11	0	0
1B	0	0	0	0	5	43	73	95	80	23	0	0
2	0	0	0	0	4	27	46	82	82	14	0	0
3	0	0	0	0	4	27	29	71	73	25	0	0
4A	0	0	0	0	7	36	61	71	59	30	0	0
4D	0	0	0	0	2	34	30	71	75	18	0	0
5	0	0	0	0	7	63	77	61	38	4	0	0
6	0	0	0	0	5	27	54	71	61	36	0	0
7	0	0	0	0	2	50	54	95	86	9	0	0

Note: Temperature model results without Shasta Reservoir temperature curtain in place.

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and hydraulic modeling and an evaluation of the operating schedule. As the reservoir surface elevation generally varies between 950 to 1,050 feet above sea level, the device would be submerged during most years. Should the reservoir surface fall below 875 feet, the upper boom would float on the surface. Both the top and bottom of the device would be capable of being positioned to withdraw water from the full range of elevations.

Output from the temperature model run for each of the 56 years of hydrologic data used is included in Technical Appendix C, Operations and Temperature Model Output (bound separately). Data presented in Technical Appendix C for the 1985-level current conditions; the No-Action Alternative; and Alternatives 1B, 2, 3, 4A, 4D, 5, 6, and 7 include monthly river temperatures and exceedence values for the 56-year period of record analyzed. Output locations include the American River at Nimbus Dam, Sunrise Boulevard, Cordova, Arden Way, Watt Ave., Filt Point, H Street, 16th Street and the river mouth, the Sacramento River at Keswick Dam, Cottonwood Creek, and Red Bluff (estimates are provided both with and without a temperature curtain at Shasta); and Clear Creek at Lewiston Dam.

In addition to the monthly temperature model output (description of monthly temperature model included in Technical Appendix B [bound separately]), a daily temperature model was calibrated to provide data for reaches of the Sacramento and American Rivers. However, daily data available for calibration of that model were not compatible with the monthly model and using the monthly data resulted in output that did not show daily variations. For these reasons, output from the daily model was not used in analyses for the EIS's.

Constituent Concentrations

The constituent loadings for both the Sacramento River and the area reservoirs are affected by the changes in flows and storages of the various alternatives. In general, decreased storage and river flow have the effect of increasing constituent concentrations. Increases in river flow and storage have the opposite effect of lowering constituent concentrations. Therefore, both temperature and constituent loading effects correlate with the previous discussion on surface water hydrology and with each other. As noted above, the changes between the No-Action Alternative and other alternatives are small, and changes in constituent concentrations due to water contracting would also be small. More detail on changes in water quality due to additional salt loadings is included in the soils and drainage section of this chapter.

Site-Specific Impacts

Changes in flow and storages among the various alternatives would have site-specific impacts on the following four water quality components: urban runoff, agricultural return flow, acid mine drainage, and M&I discharges.

Urban Runoff

The storm water that runs off an urban area often contains trace metals, polynuclear aromatic hydrocarbons, and other automobile products as well as pesticides and herbicides. In a nationwide study, the EPA determined that copper, lead, and zinc in urban runoff frequently exceeded EPA ambient water quality criteria in samples collected from 22 cities. Other trace elements were also found in high concentrations. (Urban Runoff Discharges from Sacramento, California, RWQCB Report No. 87-1SPSS 1984-85).

In most cases, cities will grow whether remaining CVP water is contracted or not. It is only in cases where growth is limited by water and where water contracting is a deciding factor in water availability that impacts must be assessed. In other words, if water contracting is the only way a city will get the water it needs to grow, the impacts of water contracting on urban runoff must be evaluated for that city. In the SRSA, only Shasta Dam Area Public Utility District falls into this category. Other urban areas will grow, and their urban runoff will increase contaminant concentrations in surface waters, if untreated, but those areas are not impacted by water contracting.

Estimated mass loadings of urban runoff contaminants to the Sacramento River are listed below for the Shasta Dam Area Public Utility District. The various water contracting alternatives are shown. Under the alternatives not shown, no additional CVP water was allocated to the district.

Mass Loading of Urban Runoff Contaminants to the Sacramento River from Shasta Dam Area Public Utility District (kg/year)

	The No-Action Alternative Loading	Loading Under Alternatives 1B, 2, 3, and 4A/B	Background[a] Load in River at Rio Vista	Loading Under Alternatives 1B, 2, 3, and 4A/B as % of Background at Rio Vista
Copper	71.4	175	2.24×10^5	0.08
Lead	198	483	$<2.24 \times 10^5$	>0.08
Zinc	590	1,440	$<2.24 \times 10^5$	>0.08

[a]From "Surface Water Quality" in Chapter 3, Table 3C-1 with average annual flow below American River confluence, under 2020 baseline conditions.

As shown above the urban runoff contaminants from Shasta Dam Area Public Utility District that would be added to the load in the Sacramento River under water contracting alternatives are less than significant.

Agricultural Return Flow

The most prevalent agricultural chemical problem, according to the RWQCB (Schnagl pers. comm.), is the presence of rice herbicides in agricultural drains and the Sacramento River. The particular herbicides that are a nuisance are thiobencarb, molinate, bentazon, methyl parathion, and carbofuran. Thiobencarb and molinate use is restricted, and all five compounds are under study by the California Department of Food and Agriculture (DFA). Molinate was found to be the primary cause for the loss of thousands of fish in agricultural drains, and thiobencarb has caused taste problems in drinking water in the City of Sacramento for several years. Carbofuran is a relatively new herbicide.

All the agencies that requested additional water have alternative sources of water. If they do not get additional CVP water, they will use groundwater or alternative surface waters. Therefore, the amount of contaminated agricultural drainage water that reaches the drains and the Sacramento River does not depend on water contracting. The loading rate of contaminants to the surface waters is fixed. The controlling water quality variable becomes the dilution flow in the receiving water, which will be affected under the water contracting alternatives. A simplistic mixing formula predicts the rice herbicide concentration change from the 2020 baseline conditions (No-Action Alternative) attributable to river (dilution) flows under the water contracting alternatives. These results for the Sacramento River below the American River confluence are summarized here. For example, in May, if the Molinate concentration was 10.00 ppb under the 2020 baseline condition, the concentration would increase by 3.2 percent to 10.32 ppb under Alternative 2. The American River does not have an agricultural chemical drainage problem, according to the RWQCB.

	Alt. 2	Alt. 3	Alt. 4A/B	Alt. 5	Alt. 6	Alt. 7
Potential % Increase in:						
May	3.2	3.5	1.8	5.5	3.5	1.9
June	3.0	1.9	0.1	0.7	-2.0	0.0

Note: A negative value indicates a decrease in concentration under that alternative.

Acid Mine Drainage

The metals-laden acidic waters originating from the Iron Mountain mine site are referred to as acid mine drainage (AMD). AMD originates primarily as water passes through fractures and underground workings of the ore body. Secondary sources of pollution are seeps and surface runoff over and through sulfide deposits, waste rock dumps, and tailings piles. The AMD is a result of the oxidation of the exposed pyritic ore and the flushing of the resulting acid by water. This process produces sulfuric acid and high concentrations of metals, such as copper, zinc, and cadmium.

The portions of the creeks receiving the groundwater discharge provide a vehicle for the contaminated water to migrate from the source down to the Sacramento River. The lower portions of these creeks may provide groundwater recharge. Upper portions of the creeks above the area of mining activity are relatively clean and provide dilution water below their confluence with the contaminated streams.

All surface water leaving the Spring Creek watershed eventually mixes with the AMD and passes through Spring Creek Reservoir. Water from both contaminated and uncontaminated areas mixes together in the reservoir and is contaminated with metals. Other creeks discharge clean water directly into Spring Creek Reservoir. This dilutes the AMD but adds to the total volume of contaminated water.

Control of toxic drainage is attempted by regulating discharges from Spring Creek Reservoir so that when they are mixed with Shasta Reservoir discharges (dilution water), non-lethal concentrations of copper, zinc, and cadmium are achieved in the Sacramento River below Keswick Dam. Mixing takes place in Keswick Reservoir at its confluence with Spring Creek, below Spring Creek Diversion Dam. Additional dilution water is provided in the Spring Creek arm of Keswick Reservoir when power is being generated at the Spring Creek powerhouse. The water discharged from the power plant is water that is piped from Whiskeytown Reservoir to this location.

The monitoring point used by state water quality agencies to determine compliance with water quality objectives is located in the Sacramento River immediately below Keswick Dam. This location has also been chosen by EPA and the state as the point at which compliance with the water quality criteria will be assessed.

The EPA has selected and is implementing a remedial action program for the acid drainage problem. The remediation plan includes capping cracked and caved ground in the area, diverting stream flows around the site, enlarging the Spring Creek Debris Dam, and controlling access to the site. The EPA and Reclamation have entered into an interagency agreement that calls for Reclamation to design three water management components of the approved remedial action. The three water management components include water diversion facilities at Slickrock Creek, Upper Spring Creek, and South Fork Spring Creek.

Approximately 2.5 acres of cracked and caved ground above the Richmond ore body was capped in October 1988 using a soil-cement mixture or other suitable material. Ditches are being constructed to divert surface runoff away from the ore body. This procedure is expected to reduce or prevent rainwater from reaching the ore bodies and thereby reduce the production of acid mine drainage.

Up to 800 cfs of uncontaminated water would be diverted from Upper Spring Creek watershed before it reaches the area affected by the Iron Mountain Mine runoff. The proposed diversion would be accomplished by constructing a low diversion dam or drop outlet structure and an 8- to 10-foot tunnel through the ridge that separates the Spring Creek and Flat Creek watersheds. (Reclamation is currently designing this feature.) The specifications are expected to be available to start the bidding process in October 1989 and construction should be completed by December 1990.

Up to 250 cfs of uncontaminated water would be diverted form the south fork of Spring Creek into Rock Creek, which flows into the Sacramento River below Keswick Dam. This diversion would require a small dam or drop outlet structure and about 4,000 feet of pipeline. (Reclamation is currently designing this feature.) The schedule for completion is the same as for Upper Spring Creek.

Uncontaminated water in upper Slickrock Creek would be diverted around the waste rock and slide debris and tailings where it currently becomes contaminated. This diversion would result in lower concentrations of toxic materials in Slickrock Creek and in Spring Creek Debris Dam. Construction is planned for completion in November 1989.

A pilot study to determine the effectiveness of filling underground mine workings with low-density cellular concrete is being undertaken by EPA. If the results of the program prove favorable, a similar program would be undertaken with the major underground mine workings at the mine.

The Spring Creek Debris Dam would be enlarged from its present 5,800 af capacity to 9,000 af, if required, on completion of the other components of the remedial action. This enlargement would allow for more storage capacity providing greater flexibility in the dam's operation.

On completion of construction of the various components of the remedial action, EPA estimates that it would meet the SWRCB standards in every year type except the worst-case year, at which time EPA standards would be met. This improved water quality is expected to minimize future fish kills.

EPA water quality criteria for protection of aquatic life below Keswick Dam are as follows:

Copper:	0.0054 mg/l
Zinc:	0.047 mg/l
Cadmium:	0.00055 mg/l

SWRCB basin standards are as follows:

Copper:	0.0056 mg/l
Zinc:	0.016 mg/l
Cadmium:	0.00022 mg/l

Reclamation currently operates CVP facilities in accordance with a January 1980 memorandum of understanding with SWRCB and DFG that calls for meeting the following standards:

	Spring Creek Reservoir <5,000 af	Spring Creek Reservoir >5,000 af
Copper	0.01 mg/l	0.015 mg/l
Zinc	0.072 mg/l	0.108 mg/l

EPA based its analysis on what it defined as its worst-case year, water year 1978. It performed its analysis assuming that in the future there would be at least as much water in the river as was there in water year 1978. EPA and Reclamation are working on an agreement whereby both agencies can feel comfortable with this analysis. Recorded water year 1978 flows at Keswick Dam and the flows predicted by the operations model for the alternatives modeled are given on Table 4D-5. Those values indicate the predicted flows are normally equal or greater than the recorded flows. The values, which are slightly less than the recorded flows, are the result of modeling and would not exist in real time operations. Based on the Table 4D-5 comparison, water contracting is not expected to impact AMD.

Municipal and Industrial Discharges

M&I discharges can be organized into three groups as follows: 1) municipal discharge, 2) industrial discharge, and 3) fish hatchery return flows. The level of municipal, industrial, and fish hatchery discharges would not be greatly affected by any of the alternatives. The alternatives would, however, affect the concentration of that discharge in the Sacramento River and its tributaries. Since results of the flow and storage analysis show that flows would generally be higher during critically dry years and lower during average and wet years, the municipal discharge concentrations would be less during the years when they most affect the river, the critically dry years.

Surface Water Quality Comparisons

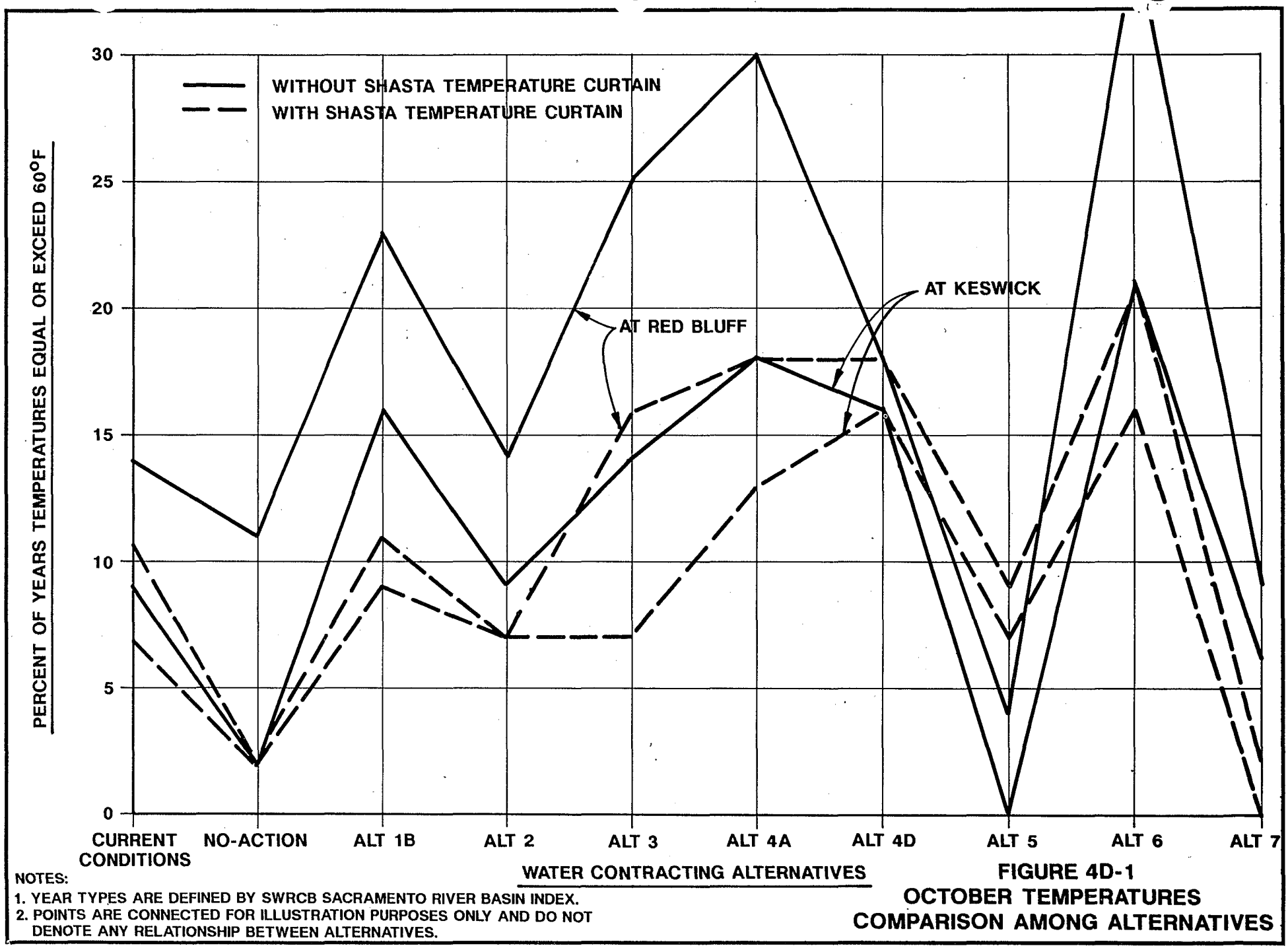
Reclamation's operations and temperature computer model river flow and river temperature output are compared among the alternatives using actual model output with a discussion on adjustments necessary to account for differences in currently proposed water allocations (or for those alternatives that no model run was made). The computer models operate the CVP system in accordance with criteria required by agreements, contracts, regulations or permits (i.e., instream flow releases, Delta outflow to meet D-1485, minimum and maximum reservoir levels, prior right releases, etc.) and meet those criteria before allocating any releases for the water contracting alternatives. Because of this, the applicable surface water quality standards are met before new allocations are made, and impacts that may occur are primarily to other resources (fish, wildlife, recreation, etc.) as the result of temperature and flow changes. For that reason most of the information presented here provides a frame of reference for evaluation of those impacts.

Temperature Effects

Temperatures in the Sacramento River may impact fish resources during a number of months. The October percent of years that water temperature of 60°F was equaled or exceeded is plotted on Figure 4D-1 to provide a comparison among the alternatives. Figure 4D-2 temperatures exceed 60°F the highest percent of years (below Red Bluff) for

Table 4D-5. Recorded and Model-Predicted Sacramento River Flows Below Keswick Dam for Water Year 1978 (in cfs)

Alternative	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
No Action	3,058	3,580	7,950	29,943	13,902	16,086	5,798	12,329	8,252	10,800	11,044	4,017
1B	2,781	7,277	3,497	13,369	13,902	16,086	6,000	12,133	8,807	15,516	9,970	6,000
2	2,960	7,160	5,644	16,671	13,902	16,086	5,798	12,329	8,487	15,175	11,255	4,034
3	2,960	6,286	3,952	18,899	13,902	16,086	5,798	12,329	8,387	16,948	11,678	4,504
4A	2,781	12,403	3,594	3,464	13,091	16,086	5,798	12,329	8,252	9,661	12,263	6,773
4D	3,464	4,252	4,424	3,464	10,930	16,086	5,798	9,141	7,966	16,134	12,133	5,378
5	2,911	5,496	4,847	13,532	13,902	16,086	6,000	12,133	8,252	15,760	10,035	6,000
6	2,781	3,748	2,749	9,271	13,902	16,086	5,798	12,329	8,487	15,939	12,410	6,756
7	7,091	7,815	3,838	29,715	13,902	16,086	5,866	12,329	8,252	15,142	9,271	3,899
Measured 1978 Flows	3,341	4,543	2,847	6,287	9,384	16,360	9,024	8,997	8,888	10,440	10,760	6,714

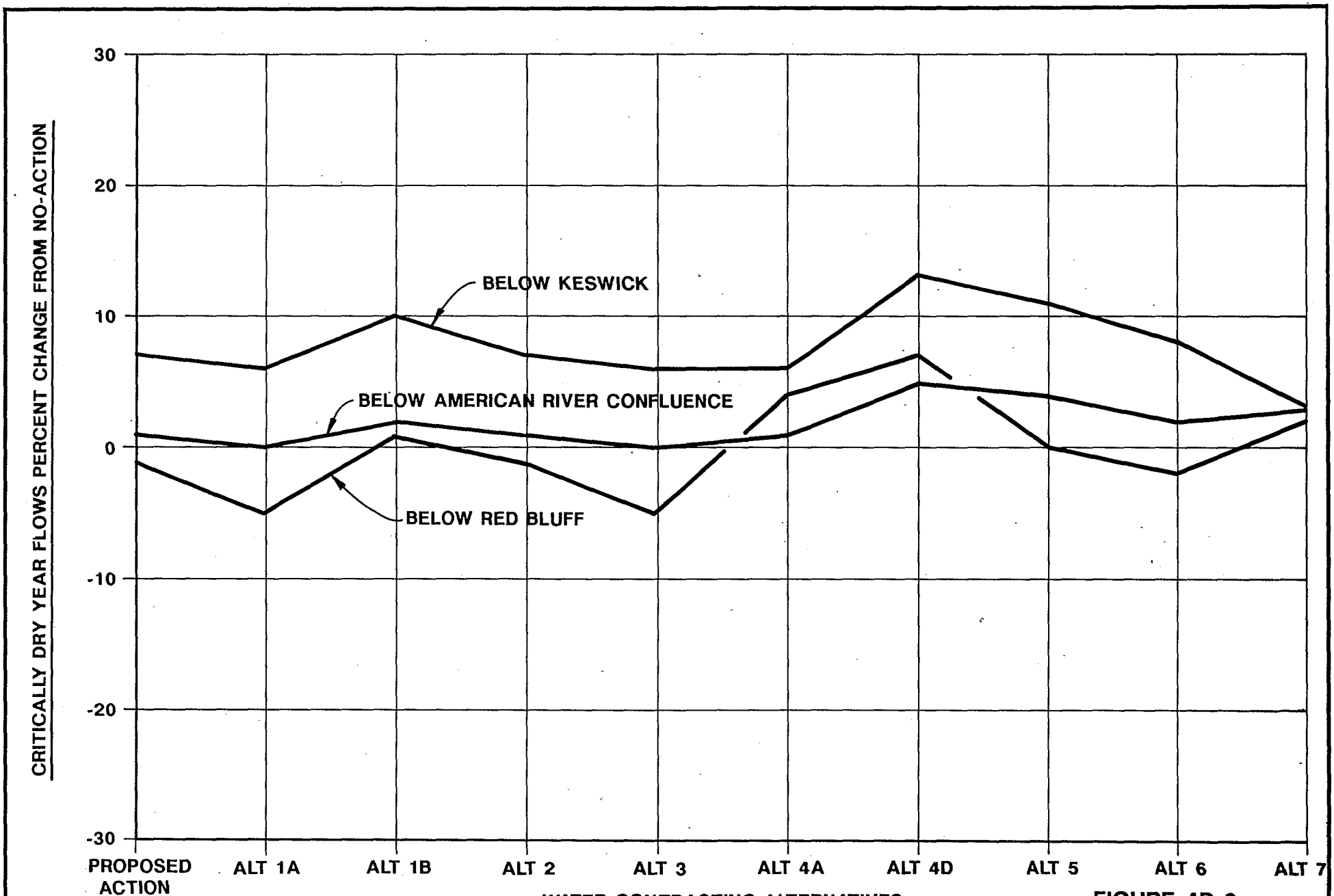


NOTES:
1. YEAR TYPES ARE DEFINED BY SWRCB SACRAMENTO RIVER BASIN INDEX.
2. POINTS ARE CONNECTED FOR ILLUSTRATION PURPOSES ONLY AND DO NOT DENOTE ANY RELATIONSHIP BETWEEN ALTERNATIVES.

FIGURE 4D-1
OCTOBER TEMPERATURES
COMPARISON AMONG ALTERNATIVES

C-055693

C-055693



NOTES:
1. YEAR TYPES ARE DEFINED BY SWRCB SACRAMENTO RIVER BASIN INDEX.
2. POINTS ARE CONNECTED FOR ILLUSTRATION PURPOSES ONLY AND DO NOT DENOTE ANY RELATIONSHIP BETWEEN ALTERNATIVES.

FIGURE 4D-2
CHANGE IN RIVER FLOWS
COMPARISON TO NO-ACTION

C-055694

Alternatives 1B, 4A, 2, 3 and 6 (1A and the Proposed Action would be similar to Alternatives 2 or 3). These seven alternatives have water allocations that require additional diversion of water above Red Bluff resulting in lower flows (and water temperatures) below Red Bluff. At Keswick Dam the higher temperatures are apparent for the same alternatives. Alternative 5 has the lowest temperature because of a priority for high river flows. Figure 4D-1 indicates the temperature control device would lower temperatures for all alternatives except Alternative 5.

Constituent Concentrations

Estimating mass loads for trace metals is a worst-case approach to estimate concentrations and may not be applicable to the Sacramento River because most of this type of loading occurs during storm water runoff when river flows are high. The high concentration that may result during these storms is also of short duration. Water quality in the Sacramento River is expected to meet SWRCB objectives given in Chapter 3 except during short periods of storm water runoff. Impacts which may occur because of water contracting may best be illustrated by changes in river flows under each alternative as compared to the No-Action Alternative. These percent changes in flow provide some indication of increases or decreases that may occur in constituent concentrations (Figure 4D-2). The changes in concentrations are not expected to result in constituents exceeding current standards for the Sacramento River.

Mitigation Measures

The "Fisheries" section of this chapter presents mitigation for temperature-related impacts to fisheries. The following mitigation measure is currently under study for the Sacramento River basin.

Shasta Temperature Control Study

Chinook salmon populations are adversely affected by upper Sacramento River temperatures that would generally be too warm for optimum egg and fry survival in the fall and too cold for optimum growth in the spring. River temperatures could be improved by optimizing the use of the cold water in Shasta Reservoir. The present design does not provide a means to withdraw the warm water and conserve the cold water available in the reservoir during the spring, or to withdraw the coldest remaining water during the late summer and fall.

Several selective withdrawal alternatives have been identified through the Central Valley Fish and Wildlife Management Study, the Shasta Temperature Modification Value Engineering Study, and the Shasta Temperature Control Study. The effectiveness of the alternatives was compared, and hypalon temperature control devices were found to be the most effective in terms of accomplishments and cost.

The device, a permanent installation in Shasta Reservoir, is proposed to have two operation modes: overdraw and underdraw. Typically, the device is to be sealed to the bottom of the reservoir from December to August, with releases withdrawn, "skimmed," over the top of the device. The release of the warmer, clearer near-surface water would improve conditions for fall run juvenile chinook salmon, conserve the cold water for release during the winter run spawning and incubation, and withdraw the least turbid water in the reservoir during the spring. The cold water would be released from the lower reservoir from August through November by raising a corner of the variable buoyancy bottom boom to form an aperture and allow underdraw. Both the top and bottom of the device would be capable of being positioned to withdraw water from the full range of elevations. This would allow use of the device for conservation and withdrawal of specified water temperatures to improve conditions for any salmon run. The operating scenario would vary from year to year depending on water year type and the fishery needs. Reclamation plans to consult regularly with the DFG, USFWS, and NMFS to determine the preferred operating scenario.

The environmental assessment process is underway, with the final report scheduled for December 1988. Design of the device is planned to begin in July 1988. The device is proposed to be installed by June 1990.

GROUNDWATER HYDROLOGY AND QUALITY

Introduction

The analysis below focuses on groundwater resources within the SRSA that would be affected by water contracting alternatives. The analysis is conducted on two accounts: 1) the groundwater balance as it relates to potential changes in water table elevation and 2) groundwater quality as it relates to sustained beneficial use.

Possible impacts of water contracting on groundwater resources were evaluated based on the net change in groundwater storage caused by each alternative, compared to storage predicted to occur under the No-Action Alternative. Groundwater storage is the difference between aquifer recharge and discharge, with pumping being the principal discharge path. Positive storage indicates recharge in excess of discharge and implies rising groundwater; negative storage indicates discharge exceeds recharge and implies declining groundwater levels. Estimates of recharge, pumpage, and storage used in the analyses are presented in Table 4E-1. These are derived from reconnaissance-level water budgets prepared for each agency for present, future without project, and future with project conditions.

The quality of CVP water is generally better than SRSA groundwater, so the long-term effect of providing CVP water to the area is a gradual improvement in groundwater quality. Consequently, water quality is addressed only generally, except for the Yolo-Zamora Water District, where high boron levels present a potential problem.

When evaluating the significance of potential impacts on SRSA groundwater, it is important to consider the magnitude of possible changes in relation to the entire groundwater basin, not just the groundwater associated with CVP water requestors, their lands, and water needs. Whereas CVP water requests are associated with approximately 284,000 acres (232,000 presently irrigated), the total irrigated area in the region (Red Bluff to Yolo County, west of the Sacramento River) is on the order of three times this extent. These nonrequesting lands have groundwater recharge and discharge (pumping) associated with them and, in combination with requesting lands, better indicate the scale of the groundwater system.

No-Action Alternative

Regional 2020 Baseline Conditions

Under the No-Action Alternative, two factors would cause groundwater conditions to change from existing (1985) conditions. The first is that groundwater generally provides the most feasible alternative to CVP water (except for Shasta Dam Area Public Utility District) so that groundwater pumping would be increased to meet increasing needs. However, only M&I needs are expected to increase under the No-Action Alternative because it is assumed that irrigated agricultural acreage would not expand without the provision of CVP water. It was also assumed that the existing trend of gradually increasing

Table 4E-1. Groundwater Balances (acre-feet/year)

Agency	Type Use	Existing Conditions			No Action Alternative			Alternative 1 (Option A)			Alternative 1 (Option B)			Alternative 2			Alternative 3		
		Recharge	Pumpage	Storage Change	Recharge	Pumpage	Storage Change	Recharge	Pumpage	Storage Change	Recharge	Pumpage	Storage Change	Recharge	Pumpage	Storage Change	Recharge	Pumpage	Storage Change
SACRAMENTO RIVER SERVICE AREA																			
Shasta Dam Area PUD	M&I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sacramento River Canals Agencies																			
Colusa County WD	Ag	40700	38700	2000	37700	55000	-17300	43900	26700	17200	43900	26700	17200	33400	20300	13100	43900	26700	17200
Corning WD	Ag	18200	2500	15700	17600	0	17600	21800	10900	10900	21800	10900	10900	16600	8300	8300	21800	10900	10900
Dunnigan WD	Ag	9600	6200	3400	8900	3000	5900	10600	5300	5300	10600	5300	5300	8100	4000	4100	10600	5300	5300
Glenn-Colusa ID	Ag	18700	32400	-13700	14600	26000	-11400	19500	19500	0	19500	19500	0	14800	14800	0	19500	19500	0
Glenn County Lands																			
Glide WD	Ag	1100	0	1100	1100	0	1100	1100	1100	0	1100	1100	0	800	800	0	1100	1100	0
Kanawha WD	Ag	4600	0	4600	4600	0	4600	4600	4600	0	4600	4600	0	3500	3500	0	4600	4600	0
Orland-Artois WD	Ag	4900	0	4900	4900	0	4900	4900	4900	0	4900	4900	0	3700	3700	0	4900	4900	0
Willow Creek MWCo.	Ag	900	0	900	900	0	900	900	900	0	900	900	0	700	700	0	900	900	0
Glide WD	Ag	5700	5100	600	5500	3500	2000	10100	8100	2000	10100	8100	2000	7700	6200	1500	10100	8100	2000
Holthouse WD	Ag	1700	100	1600	1400	0	1400	2400	600	1800	2400	600	1800	1800	500	1300	2400	600	1800
Orland-Artois WD	Ag	28300	26500	1800	26900	23600	3300	34900	26200	8700	34900	26200	8700	26500	19900	6600	34900	26200	8700
Rancho Saucos WD	Ag	2400	2300	100	2300	4300	-2000	2700	1200	1500	2700	1200	1500	2100	900	1200	2700	1200	1500
Tehama Ranch MWCo.	Ag	1200	1700	-500	1100	1900	-800	1300	1400	-100	1300	1400	-100	1000	1100	-100	1300	1400	-100
Yolo-Zamora WD	Ag	57000	56600	400	47000	43300	3700	57000	42000	15000	57000	42000	15000	43300	31900	11400	57000	42000	15000
Subtotal		195000	172100	22900	174500	160600	13900	215700	153400	62300	215700	153400	62300	163900	116600	47400	215700	153400	62300
Yolo-Solano Agencies																			
Yolo County FC&WCD	Ag	244600	256600	-12000	225700	257700	-32000	208400	208400	0	208400	208400	0	225700	257700	-32000	208400	208400	0
City of Davis	M&I	8300	11100	-2800	8300	17500	-9200	8300	8300	0	8300	8300	0	8300	17500	-9200	8300	8300	0
City of Woodland	M&I	10700	11400	-700	10700	22500	-11800	10700	10700	0	10700	10700	0	10700	22500	-11800	10700	10700	0
Solano County	M&I	167300	167300	0	167300	246700	-79400	167300	167300	0	167300	167300	0	167300	246700	-79400	167300	167300	0
Subtotal		430900	446400	-15500	412000	544400	-132400	394700	394700	0	394700	394700	0	412000	544400	-132400	394700	394700	0
Refuges																			
Colusa NWR	Refuge	4900	0	4900	2500	0	2500	4900	6800	-1900	4900	6800	-1900	2500	0	2500	4900	6800	-1900
Delevan NWR	Refuge	6800	0	6800	3400	0	3400	6800	5700	1100	6800	8200	-1400	3400	0	3400	6800	5700	1100
Gray Lodge WMA	Refuge	12000	5300	6700	8000	5300	2700	12000	7500	4500	12000	9800	2200	8000	5300	2700	12000	7500	4500
Sacramento NWR	Refuge	12900	0	12900	6500	0	6500	12900	12700	200	12900	13700	-800	6500	0	6500	12900	12700	200
Sutter NWR	Refuge	3100	0	3100	1500	0	1500	3100	6400	-3300	3100	8200	-5100	1500	0	1500	3100	6400	-3300
Subtotal		39700	5300	34400	21900	5300	16600	39700	39100	600	39700	46700	-7000	21900	5300	16600	39700	39100	600
SRSA TOTAL		665600	623800	41800	608400	710300	-101900	650100	587200	62900	650100	594800	55300	597800	666300	-68400	650100	587200	62900

C-055698

Table 4E-1. Groundwater Balances (acre-feet/year)

Agency	Type Use	Alternative 4A/B			Alternative 4C/D			Alternative 5			Alternative 6			Alternative 7		
		Recharge	Pumpage	Storage Change	Recharge	Pumpage	Storage Change	Recharge	Pumpage	Storage Change	Recharge	Pumpage	Storage Change	Recharge	Pumpage	Storage Change
SACRAMENTO RIVER SERVICE AREA																
Shasta Dam Area PUD	M&I	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Sacramento River Canals Agencies																
Colusa County WD	Ag	33400	20300	13100	37700	55000	-17300	37700	55000	-17300	33400	20300	13100	37700	55000	-17300
Corning WD	Ag	16600	8300	8300	17600	0	17600	17600	0	17600	16600	8300	8300	17600	0	17600
Dunnigan WD	Ag	8100	4000	4100	8900	3000	5900	8900	3000	5900	8100	4000	4100	8900	3000	5900
Glenn-Colusa ID	Ag	14800	14800	0	14600	26000	-11400	14600	26000	-11400	14800	14800	0	14600	26000	-11400
Glenn County Lands																
Glide WD	Ag	800	800	0	1100	0	1100	1100	0	1100	800	800	0	1100	0	1100
Kanawha WD	Ag	3500	3500	0	4600	0	4600	4600	0	4600	3500	3500	0	4600	0	4600
Orland-Artois WD	Ag	3700	3700	0	4900	0	4900	4900	0	4900	3700	3700	0	4900	0	4900
Willow Creek MWCo.	Ag	700	700	0	900	0	900	900	0	900	700	700	0	900	0	900
Glide WD	Ag	7700	6200	1500	5500	3500	2000	5500	3500	2000	7700	6200	1500	5500	3500	2000
Holthouse WD	Ag	1800	500	1300	1400	0	1400	1400	0	1400	1800	500	1300	1400	0	1400
Orland-Artois WD	Ag	26500	19900	6600	26900	23600	3300	26900	23600	3300	26500	19900	6600	26900	23600	3300
Rancho Saucos WD	Ag	2100	900	1200	2300	4300	-2000	2300	4300	-2000	2100	900	1200	2300	4300	-2000
Tehama Ranch MWCo.	Ag	1000	1100	-100	1100	1900	-800	1100	1900	-800	1000	1100	-100	1100	1900	-800
Yolo-Zamora WD	Ag	43300	31900	11400	47000	43300	3700	47000	43300	3700	43300	31900	11400	47000	43300	3700
Subtotal		164000	116600	47400	174500	160600	13900	174500	160600	13900	164000	116600	47400	174500	160600	13900
Yolo-Solano Agencies																
Yolo County FC&WCD	Ag	225700	257700	-32000	225700	257700	-32000	225700	257700	-32000	225700	257700	-32000	225700	257700	-32000
City of Davis	M&I	8300	17500	-9200	8300	17500	-9200	8300	17500	-9200	8300	17500	-9200	8300	17500	-9200
City of Woodland	M&I	10700	22500	-11800	10700	22500	-11800	10700	22500	-11800	10700	22500	-11800	10700	22500	-11800
Solano County	M&I	167300	246700	-79400	167300	246700	-79400	167300	246700	-79400	167300	246700	-79400	167300	246700	-79400
Subtotal		412000	544400	-132400	412000	544400	-132400	412000	544400	-132400	412000	544400	-132400	412000	544400	-132400
Refuges																
Colusa NWR	Refuge	4900	6800	-1900	4900	6800	-1900	4900	0	4900	4900	0	4900	4900	6800	-1900
Delevan NWR	Refuge	6800	8200	-1400	6800	5700	1100	6800	0	6800	6800	0	6800	6800	8200	-1400
Gray Lodge WMA	Refuge	12000	9800	2200	12000	7500	4500	12000	0	12000	12000	0	12000	12000	9800	2200
Sacramento NWR	Refuge	12900	13700	-800	12900	12700	200	12900	0	12900	12900	0	12900	12900	13700	-800
Sutter NWR	Refuge	3100	8200	-5100	3100	6400	-3300	3100	0	3100	3100	0	3100	3100	8200	-5100
Subtotal		39700	46700	-7000	39700	39100	600	39700	0	39700	39700	0	39700	39700	46700	-7000
SRSA TOTAL		615700	707700	-92000	626200	744100	-117900	626200	705000	-78800	615700	661000	-45300	626200	751700	-125500

C-055699

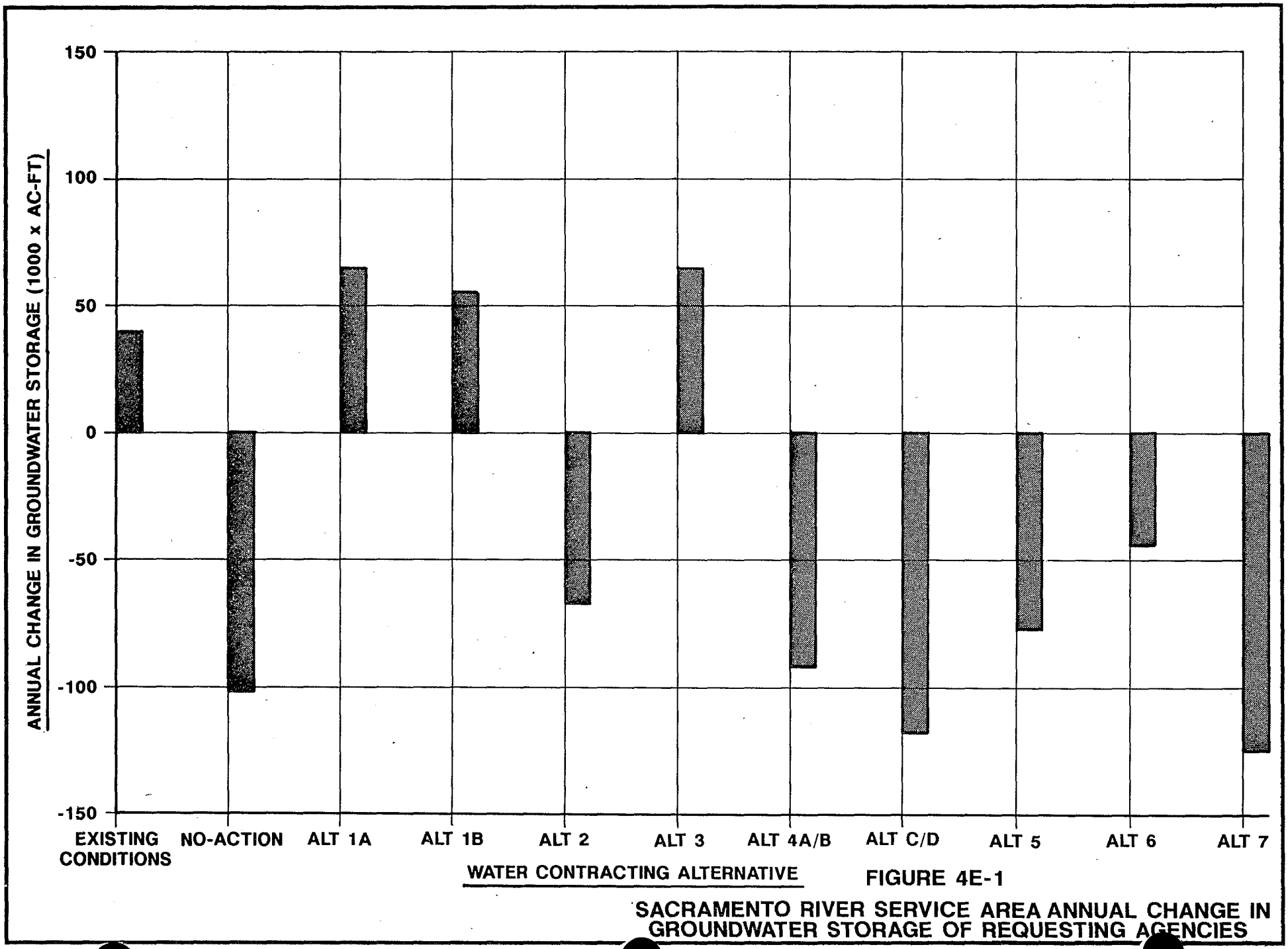


FIGURE 4E-1

SACRAMENTO RIVER SERVICE AREA ANNUAL CHANGE IN GROUNDWATER STORAGE OF REQUESTING AGENCIES

C-055700

As discussed under regional conditions, increased irrigation efficiency would tend to result in higher TDS concentrations in deep percolation of applied water; however, deep percolation volumes would be reduced so that the total TDS mass load flowing into the groundwater system would not change significantly from existing (1985) conditions.

Yolo-Solano Agencies. Under the No-Action Alternative, the existing small overdraft in Yolo-Solano agencies would increase substantially. In Yolo County Flood Control and Water Conservation District, the existing overdraft of 12,000 af/yr would increase to 32,000 af/yr, due primarily to increased groundwater pumping to compensate for reduced surface water yield from the Cache Creek system. In Woodland and Davis, all future water needs would be met from groundwater, increasing the Davis overdraft from 2,800 af/yr under existing conditions to 9,200 af/yr under the No-Action Alternative, while Woodland's overdraft would increase from 700 af/yr to 11,800 af/yr. Available data do not permit a detailed analysis of possible changes in groundwater quality under these conditions.

In Solano County, fairly stable groundwater elevations suggest that existing average pumping is at safe yield levels except in the Dixon area where groundwater levels have been rising over the past several years in areas that were overdrafted prior to the delivery of supplemental surface water from the Solano Project. If supplemental surface water is not obtained, future increased water needs would be met primarily from groundwater, resulting in an overdraft of 79,400 af/yr as indicated in Table 4E-1. The distribution of this overdraft would depend on how the aquifer is pumped and on potential exchanges within the county necessary to fully meet projected needs, because groundwater availability is restricted in some areas. Significant overdraft in southern Solano County could lead to northward migration of poor-quality water from the Delta, resulting in irreversible deterioration of groundwater quality. Otherwise, water quality is not expected to be adversely affected.

Refuges. As shown in Table 4E-1, the five SRSA wildlife refuges presently function as recharge areas, contributing an estimated 34,400 af/yr to the aquifer annually. Only one refuge, Gray Lodge Wildlife Management Area, pumps groundwater, totaling 5,300 af/yr. Under the No-Action Alternative, existing temporary CVP deliveries to refuges would be eliminated, causing a reduction in wetland area. For this analysis, it was assumed that aquifer inflow would be reduced as a result of reduced water applications to about one-half of existing levels. Pumping at Gray Lodge Wildlife Management Area would continue at the same rate. The net effect would be to reduce groundwater storage from 34,400 to 16,600 af/yr annually. Groundwater quality conditions would not change appreciably from existing (1985) conditions.

Alternative 1

As discussed in Chapter 2, "Alternatives Including the Proposed Action," two basic operational strategies are available for using dependable water to meet all needs under Alternative 1. One would be implemented by individual agencies, would require dual systems, and would result in highly variable groundwater pumping. The second would be implemented on a regional basis, would require artificial recharge, and would result in less variable pumping compared to agency-implemented plans. Also, the two Proposed Action

options differ in the extent to which they rely on dependable water contracting and, therefore, in their effect on pumping variability. Although these differences affect the location and timing of potential water level fluctuations, they are not important distinctions over the long-term operation of the project because, on the average, groundwater pumping would be the same for both options. This is because both options would supply the same amount of CVP water on a long-term average basis except refuges, which would receive Level 2 needs under Option A and Level 4 needs under Option B. This long-term perspective provides the basis for evaluating potential impacts of Alternative 1. As mentioned previously, the primary concern is the groundwater balance, which in this case, is defined as long-term average changes in groundwater storage.

Regional Impacts

Under Alternative 1 the regional groundwater balance would change from an overdraft of 101,900 af/yr under the No-Action Alternative to a surplus of 62,900 af/yr for Option A and 55,300 af/yr for Option B. However, this surplus would not be uniformly distributed. Sacramento Valley canals agencies would have a groundwater surplus, and the Yolo-Solano agencies would operate at safe yield capacity. Refuges would operate at essentially safe yield capacity for Option A while Option B would result in an overdraft of 7,000 af/yr. On a regional basis, Alternative 1 impacts to the groundwater balance would be beneficial, due primarily to the avoidance of significant overdraft in Yolo and Solano Counties which would occur under the No-Action Alternative.

Most of the CVP water provided under Alternative 1 would replace groundwater that agencies would otherwise pump. Because CVP water generally has higher quality (lower TDS) than SRSA groundwater, the effect of this replacement would be to improve the quality of source water and, consequently, the quality of recharge to the aquifer from deep percolation and canal seepage, all other factors remaining constant. (Also see Chapter 4, "Soils and Drainage.") Thus, Alternative 1 would have a beneficial impact to regional groundwater quality, compared to the No-Action Alternative.

Site-Specific Impacts

Shasta Dam Area Public Utility District. No significant groundwater resource is available for use in the Shasta Dam Area Public Utility District service area, and groundwater is not an important water source either currently or under any of the alternatives.

Sacramento Valley Canals Agencies. Under Alternative 1, the full needs of these agencies would be met by a combination of firm CVP water plus dependable water used in conjunction with available groundwater. Approximately 52,000 acres of additional land would be brought under irrigation compared to the No-Action Alternative. Average recharge would increase from 174,500 to 215,700 af/yr, while pumping would be reduced from 160,600 af/yr to 153,400 af/yr. The net long-term effect would be to increase groundwater storage from 13,900 af/yr under the No-Action Alternative to 62,300 af/yr resulting in a beneficial impact to the groundwater balance. The generally well-drained nature of most of these lands suggests that this increased groundwater surplus could be

matched by a corresponding increase in groundwater discharge to drains, surface streams, and to the Sacramento River, possibly resulting in no appreciable change in groundwater levels.

Under Option B, maximum pumping in a critically dry year is estimated to be 297,700 af/yr, or 82,000 af/yr in excess of recharge. Back-to-back critically dry years would result in overdraft of 164,000 af/yr, or an average of 1.1 af per irrigated acre. Disregarding changes in lateral flow that could result from drawdown, static water levels would drop by an average of 10-15 feet during such a critical period. Preliminary analyses suggest that aquifer discharge to the Sacramento River would not be significantly reduced under these extreme temporary conditions because the effect of this pumping during droughts would be spread out over several years. Pumping would be reduced in subsequent above normal and wet years, allowing water levels to recover.

About half the water provided under Alternative 1 (Table 2-10) would be used to augment supplies to existing developed lands, and about half would be used to facilitate development of new irrigated lands. As discussed under regional impacts and Chapter 4, "Soils and Drainage," CVP water used to replace pumped groundwater would have beneficial impacts on groundwater quality as compared to the No-Action Alternative. However, where CVP water would be used to develop new lands, deep percolation and TDS mass loading to the aquifer would increase. Preliminary computations indicate that these two processes would essentially offset each other, resulting in no net change in groundwater quality.

For the reasons described above, impacts of Alternative 1 on groundwater resources would be less than significant.

Yolo-Solano CVP Water Service Coordinating Group. Under Alternative 1, the needs of these agencies would be met by intermittent water used in conjunction with available groundwater. Average recharge would decrease from 412,000 af/yr under the No-Action Alternative to 394,700 af/yr, because of improved irrigation efficiency. Groundwater pumping would decrease by 169,300 af/yr from 544,400 af/yr under the No-Action Alternative to 394,700 af/yr under Alternative 1. The net result would be safe yield operation of the aquifer where, over the long term, groundwater pumping (plus other discharge) would equal aquifer recharge and groundwater levels would stabilize at existing elevations. This change would be a beneficial impact compared to the overdraft that would occur under the No-Action Alternative.

Under both options, maximum pumping in critically dry years would be 537,100 af/yr, or 142,400 af/yr in excess of recharge. Back-to-back critically dry years would result in an overdraft of 284,800 af/yr. If this entire amount was associated with irrigated agriculture, the average overdraft would be roughly 0.8 af/yr. Disregarding changes in lateral flow that could result from declining water levels, static water levels would drop by an average of 8-12 feet during such a critical period. Pumping would then be reduced in subsequent above normal and wet years, allowing water levels to recover, with less than significant impact to groundwater.

CVP water provided under Alternative 1 would be used primarily to replace pumping of lower quality groundwater. As described under regional impacts, this would have a beneficial effect on groundwater quality.

Refuges. Under Alternative 1, refuges would be allocated intermittent water, even though their safe yields, including consideration of development costs, have been determined to be zero. It was assumed for analyzing impacts that groundwater would be pumped to make up for intermittent water deficiencies taken in below average water years.

Under Option A, Colusa and Sutter National Wildlife Refuges would have groundwater overdraft that would result in gradually declining groundwater levels. Lateral inflow would increase to these areas until equilibrium was established; however, groundwater pumping costs could increase. The other three refuges would have groundwater surpluses with resulting rising water tables, but no adverse impacts are anticipated. Under Option B, all refuges except Gray Lodge Wildlife Management Area would have groundwater overdraft that would result in gradually declining groundwater levels. As described above, groundwater pumping costs could increase.

In addition to these long-term effects, heavy reliance on groundwater pumping in dry years could cause potentially significant impacts on water levels. Table 4E-2 indicates the cumulative overdraft that could occur in back-to-back critically dry years. Disregarding changes in lateral flow that could result from declining water levels, static water levels could decline by 29-104 feet from elevations occurring prior to drought conditions.

Alternative 2

Regional Impacts

Under Alternative 2, overdraft would be reduced by 33,500 af/yr, as compared to the No-Action Alternative, resulting in a beneficial regional impact to groundwater. No significant impacts to groundwater quality would result.

Site-Specific Impacts

Shasta Dam Area Public Utility District. No significant groundwater resource is available for use in the Shasta Dam Area Public Utility District service area, and groundwater is not an important water source either currently or under any of the alternatives.

Sacramento Valley Canals Agencies. Under Alternative 2, these agencies would receive 76 percent of their full needs on a firm basis, except for Corning Water District and Glenn-Colusa Irrigation District, which would receive 100 percent of their needs. It is estimated that a 47,400-af groundwater surplus would occur under these allocations and that resulting conditions would be essentially the same as described under Alternative 1, except that pumping would be more or less constant from year to year, not varied. All agencies would have modest groundwater surpluses or would operate essentially at safe yield

Table 4E-2. Refuge Groundwater Pumping and Overdraft in Critically Dry Years in Acre-Feet under Alternative 1 - Option B: Sacramento River Service Area

Refuge	Groundwater Recharge[a]	Groundwater Pumping	Groundwater Overdraft[b]	Cumulative Overdraft[c]	Unit Overdraft (af/ac)	Approximate Groundwater Level Decline[d] (ft)
Colusa NWR	4,900	25,000	20,100	40,200	9.9	99
Delevan NWR	6,800	30,000	23,200	46,400	4.7	47
Gray Lodge WMA	12,000	36,000	24,000	48,000	2.9	29
Sacramento NWR	12,900	50,000	37,100	74,200	3.4	34
Sutter NWR	3,100	30,000	26,900	53,800	10.4	104
Total	39,700	171,000	131,300	262,600		

[a] Total of subsurface lateral inflow, deep percolation of applied irrigation water and precipitation, and leakage from surface streams and canals.

[b] The amount of pumping in excess of recharge.

[c] At end of second critically dry year.

[d] Disregards changes in lateral flow induced by drawdown; assumes specific yield of 0.10.

resulting in beneficial impacts, and groundwater quality would not be changed significantly from the No-Action Alternative conditions.

Yolo-Solano CVP Water Service Coordinating Group. No groundwater impacts would occur in Yolo-Solano agencies because 2020 conditions under Alternative 2 would be identical to the No-Action Alternative conditions. No significant impacts would result.

Refuges. No groundwater impacts would occur in the refuges because 2020 conditions under Alternative 2 would be identical to the No-Action Alternative conditions. No significant impacts would result.

Alternative 3

Regional Impacts

Under Alternative 3, the regional groundwater storage would increase by 164,800 af/yr to a groundwater surplus of 62,900 af/yr, as compared to the No-Action Alternative, resulting in a beneficial regional impact on groundwater. The majority of CVP water provided would be to replace pumped groundwater, which, as described under Alternative 1, would have a beneficial impact on groundwater quality.

Site-Specific Impacts

Shasta Dam Area Public Utility District. No significant groundwater resource is available for use in the Shasta Dam Area Public Utility District service area, and groundwater is not an important water source either currently or under any of the alternatives. Therefore, it is not discussed here.

Sacramento Valley Canals Agencies. Site-specific impacts under Alternative 3 would be the same as those described under Alternative 1, except that groundwater pumping would be constant from year to year, not variable as under Alternative 1. Impacts to groundwater would be less than significant.

Yolo-Solano CVP Water Service Coordinating Group. Site-specific impacts under Alternative 3 would be the same as those described under Alternative 1, except that groundwater pumping would be constant from year to year, not variable as under Alternative 1. Beneficial impacts to the groundwater balance as well as groundwater quality would result.

Refuges. Site-specific impacts under Alternative 3, would be the same as those described under Alternative 1 - Option A. Significant impacts could result.

Alternative 4 A/B

Regional Impacts

Under Alternative 4 A/B, regional overdraft would be reduced by 9,900 af/yr, as compared to the No-Action Alternative, resulting in a beneficial regional impact on groundwater. No changes in regional groundwater quality would result.

Site-Specific Impacts

Shasta Dam Area Public Utility District. No significant groundwater resource is available for use in the Shasta Dam Area Public Utility District service area, and groundwater is not an important water source either currently or under any of the alternatives.

Sacramento Valley Canals Agencies. Site-specific impact under Alternative 4 A/B, would be the same as those described under Alternative 2. No significant impacts would result.

Yolo-Solano CVP Water Service Coordinating Group. No groundwater impacts would occur in Yolo-Solano agencies because 2020 conditions under Alternative 4 A/B would be identical to the No-Action Alternative conditions. No significant impacts would result.

Refuges. Site-specific impacts under Alternative 4 A/B would be the same as those described under Alternative 1 - Option B. Significant impacts could result.

Alternative 4C/D

Regional Impacts

Under Alternative 4C/D, regional groundwater overdraft at 16,000 af/yr would occur as compared to the No-Action Alternative, resulting in potentially significant impacts to the groundwater balances of refuges. No changes in groundwater quality would occur.

Site-Specific Impacts

Shasta Dam Area Public Utility District. No significant groundwater resource is available for use in the Shasta Dam Area Public Utility District service area, and groundwater is not an important water source either currently or under any of the alternatives.

Sacramento Valley Canals Agencies. No groundwater impacts would occur in these agencies because 2020 conditions under Alternative 4C/D would be identical to the No-Action Alternative conditions. No significant impacts would result.

Yolo-Solano CVP Water Service Coordinating Group. No groundwater impacts would occur in these agencies because 2020 conditions under Alternative 4C/D would be identical to the No-Action Alternative conditions. No significant impacts would result.

Refuges. Site-specific impacts under Alternative 4C/D would be the same as those under Alternative 1 - Option A. Significant impacts could result.

Alternative 5

Regional Impacts

Under Alternative 5, regional groundwater overdraft would be reduced by 23,100 af/yr as compared to the No-Action Alternative, resulting in a beneficial impact to the groundwater balance. No changes in groundwater quality would result.

Site-Specific Impacts

Shasta Dam Area Public Utility District. No significant groundwater resource is available for use in the Shasta Dam Area Public Utility District service area, and groundwater is not an important water source either currently or under any of the alternatives.

Sacramento Valley Canals Agencies. No groundwater impacts would occur in these agencies because 2020 conditions under Alternative 5 would be identical to the No-Action Alternative conditions. No significant impacts would result.

Yolo-Solano CVP Water Service Coordinating Group. No groundwater impacts would occur in these agencies because 2020 conditions under Alternative 5 would be identical to the No-Action Alternative conditions. No significant impacts would result.

Refuges. Under Alternative 5, refuges would be allocated firm water to satisfy Level 4 needs. The refuges would not pump any groundwater, resulting in a storage surplus of 23,100 af/yr compared to the No-Action Alternative. Water tables would tend to rise, increasing groundwater discharge to surrounding areas resulting in beneficial impacts. Water levels could rise to near the soil surface on the refuges; however, this would not cause adverse impacts because the intent of refuge management is to create a wetlands environment for waterfowl. No changes in groundwater quality would result.

Alternative 6

Regional Impacts

Under Alternative 6, regional groundwater overdraft would be reduced by 56,600 af/yr as compared to the No-Action Alternative, resulting in a beneficial impact to the groundwater balance. Groundwater quality would not be impacted significantly.

Site-Specific Impacts

Shasta Dam Area Public Utility District. No significant groundwater resource is available for use in the Shasta Dam Area Public Utility District service area, and groundwater is not an important water source either currently or under any of the alternatives. Therefore, it is not discussed here.

Sacramento Valley Canals Agencies. Site-specific impacts under Alternative 6 would be the same as those described under Alternative 2. No significant impacts would result.

Yolo-Solano CVP Water Service Coordinating Group. No groundwater impacts would occur in Yolo-Solano agencies because 2020 conditions under Alternative 6 would be identical to the No-Action Alternative conditions. No significant impacts would result.

Refuges. Under Alternative 6, refuges would be allocated firm water to satisfy Level 2 needs. The refuges would not pump groundwater, resulting in a storage surplus of 23,100 af/yr as compared to the No-Action Alternative. Water tables would tend to rise, increasing groundwater discharge to surrounding areas, resulting in beneficial impacts. No changes in groundwater quality would result.

Alternative 7

Regional Impacts

Under Alternative 7, regional groundwater overdraft would increase by 23,600 af/yr as compared to the No-Action Alternative, resulting in potentially significant impacts to the regional groundwater balance. No changes in regional groundwater quality would result.

Site-Specific Impacts

Shasta Dam Area Public Utility District. No significant groundwater resource is available for use in the Shasta Dam Area Public Utility District service area, and groundwater is not an important water source either currently or under any of the alternatives. Therefore, it is not discussed here.

Sacramento Valley Canals Agencies. No groundwater impacts would occur in these agencies because 2020 conditions under Alternative 7 would be identical to the No-Action Alternative conditions. No significant impacts would result.

Yolo-Solano CVP Water Service Coordinating Group. No groundwater impacts would occur in these agencies because 2020 conditions under Alternative 7 would be identical to the No-Action Alternative conditions. No significant impacts would result.

Refuges. Site-specific impacts under Alternative 7 would be the same as described under Alternative 1 - Option B. Significant impacts could result.

Mitigation Measures

Impacts to SRSA groundwater resources are summarized in Table 4E-3, all relative to conditions that would occur under the No-Action Alternative. Impacts are evaluated on two accounts: groundwater storage (or balance) and groundwater quality. Groundwater storage is the difference between aquifer recharge and discharge (primarily pumping) derived from reconnaissance-level water budgets prepared for each agency. Impacts to storage are beneficial where storage increases and less than significant where storage changes are zero or small. Potentially significant impacts are indicated where significant impacts could result, but available information does not adequately support a clear determination.

Groundwater quality impacts are based solely on predicted effects on TDS mass loadings and concentrations. Beneficial impacts are indicated where TDS mass loadings of recharge would decrease, causing TDS concentrations in groundwater to decrease. Similar to storage, potentially significant impacts are shown where significant impacts could result, but available information does not adequately support a clear determination. Mitigation measures for potentially significant impacts are discussed below.

Regional Impacts

All contracting alternatives, except Alternatives 4C/D and 7, have beneficial or less-than-significant impacts to groundwater storage and quality. Potentially significant impacts to groundwater storage occur under Alternatives 4C/D and 7, due to impacts occurring on refuges. Mitigation measures for these impacts are described under site-specific impacts.

Site-Specific Impacts

Implement Off-Refuge Water Banking. Potential adverse site-specific impacts to groundwater storage are limited to refuges when they are allocated intermittent water under Alternatives (Options A and B), 3, 4A/B, 4C/D, and 7. As described for Alternative 1, intermittent allocations cause long-term overdraft situations on some refuges and severe

Table 4E-3. Summary of Groundwater Impacts:
Sacramento River Service Area

	Alternative 1				Alternative 2		Alternative 3		Alternative 4A/B		Alternative 4C/D		Alternative 5		Alternative 6		Alternative 7	
	Option A		Option B															
	Storage	Quality	Storage	Quality	Storage	Quality	Storage	Quality	Storage	Quality	Storage	Quality	Storage	Quality	Storage	Quality	Storage	Quality
Regional Impacts	B	B	B	B	B	N	B	B	B	N	PS	N	B	N	B	N	PS	N
Site-Specific Impacts																		
Shasta Area PUD[a]	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
Sacramento Valley Canals Agencies	B	N	B	N	B	N	B	N	B	N	N	N	N	N	B	N	N	N
Yolo-Solano Agencies	B	B	B	B	N	N	B	B	N	N	N	N	N	N	N	N	N	N
Refuges	PS	N	PS	N	N	N	PS	N	PS	N	PS	N	B	N	B	N	PS	N

Note: Impacts to groundwater are evaluated on two accounts: groundwater storage and quality. Groundwater storage is difference between aquifer recharge and discharge. Groundwater quality was evaluated only on the basis of TDS, or total dissolved solids.

[a] No impacts are indicated for Shasta Dam Area PUD because groundwater availability is essentially zero.

B = beneficial; N = less than significant; PS = potentially significant; S = significant.

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irrigation efficiency would continue through the increased use of tailwater reuse facilities and improved application systems. This would tend to reduce irrigation water requirements resulting in a direct reduction in groundwater pumping. Simultaneously, groundwater recharge would be reduced because more uniform application would reduce deep percolation of applied water. The net effect of increased irrigation efficiency, all other factors remaining constant, would be slightly increased groundwater storage (the difference between recharge and discharge). Also as a result of increased efficiency, the concentration of salts in irrigation deep percolation would increase. However, because the volume of deep percolation would be reduced, the mass load of dissolved solids would not change appreciably, and regional groundwater quality conditions would not change from existing (1985) conditions.

As a result of the factors described above, total groundwater pumping by requesting agencies would increase by approximately 86,500 af/yr, and total aquifer inflow to those areas would decrease by about 57,200 af/yr, relative to present-day conditions. As shown in Table 4E-1, the groundwater balance would change from the present net surplus of 41,800 af/yr to a net deficit of 101,900 af/yr (Figure 4E-1). This deficit would not be distributed throughout the service area, but would be concentrated primarily in Yolo and Solano Counties, where M&I needs would increase significantly.

Site-Specific 2020 Baseline Conditions

Shasta Dam Area Public Utility District. No significant groundwater resource is available for use in the Shasta Dam Area Public Utility District service area, and groundwater is not an important water source either currently or under any of the alternatives.

Sacramento Valley Canals Agencies. Under the No-Action Alternative, it is assumed that the existing trend of gradually increasing irrigation efficiency would continue, that no new lands would be developed for irrigation, and that existing temporary CVP deliveries would be eliminated. With the exception of the Colusa County and Yolo-Zamora Water Districts, only minor changes in pumping and recharge occur. In most agencies, groundwater storage increases slightly as a result of increased irrigation efficiency, as previously discussed.

The groundwater balance for the Colusa County Water District would result in a negative storage (overdraft) of 17,300 af/yr, compared to the present net surplus of 2,000 af/yr. This increased deficit would likely lead to substantial lowering of groundwater levels within the district. The Yolo-Zamora Water District could have a future net surplus of about 3,700 af/yr, compared to today's net surplus of 400 af/yr. This increased surplus could lead to rising water levels; however, it is assumed that sufficient pumping would be maintained so as to prevent damaging buildup of shallow water tables.

The remaining agencies would see a groundwater surplus of 27,500 af/yr, compared to the present surplus of 20,500 af/yr. The generally well-drained nature of these lands suggests that this modest increase would be matched by a corresponding increase in groundwater discharge to drains, surface streams, and to the Sacramento River, possibly resulting in no significant change in groundwater levels.

temporary overdraft on all refuges in critically dry periods. A potential mitigation measure that could be implemented is off-refuge water banking, such as a regional groundwater recharge and recovery system, which could be shared by other SRSA intermittent water users.

ENERGY

Introduction

The amount of energy produced CVP systemwide and the energy consumed at the requesting district level would differ from alternative to alternative. The changes in the amount of energy produced on a CVP systemwide basis are described in Chapter 5. This section focuses on the energy changes at the requestor district level.

Energy use for groundwater pumping was estimated from the amount of water pumped and the depth from which the water would be pumped.

No-Action Alternative

Regional Impacts

Under the No-Action Alternative, M&I use by Solano County and irrigation use by Yolo County Flood Control and Water Conservation District accounts for a majority of the energy use. Table 4F-1 shows the energy use for groundwater pumping by alternative.

Site-Specific Impacts

Sacramento Valley Canals Agencies. Four requestor districts do most of the pumping in the Tehama-Colusa Canal area: Colusa County Water District, Glenn-Colusa Irrigation District, Orland-Artois Water District, and Yolo-Zamora Water District. Together, they account for almost 93 percent of the total energy used in the area (16,472 megawatt hours [mWh] out of 17,774 mWh). All of this pumping is associated with groundwater pumping for irrigation.

Yolo-Solano CVP Water Service Coordinating Group. There are two major groundwater users in the Yolo-Solano area, Yolo County Flood Control and Water Conservation District and Solano County. Yolo County Flood Control and Water Conservation District uses 30,065 mWh in pumping 257,700 af of irrigation water. Solano County uses 28,782 mWh in pumping 246,700 af of M&I water.

Refuges. Approximately 5,300 af of groundwater would be pumped at Gray Lodge Wildlife Management Area, using 353 mWh of energy.

Table 4F-1. Annual Energy Use for Groundwater Pumping

Agency	Type Use	Existing Conditions TDH (feet)	Existing Conditions Pumpage (ac-ft)	Existing Conditions Energy (MWhr)	No Action Alternative TDH (feet)	No Action Alternative Pumpage (ac-ft)	No Action Alternative Energy (MWhr)	Alternative 1 (Option A) TDH (feet)	Alternative 1 (Option A) Pumpage (ac-ft)	Alternative 1 (Option A) Energy (MWhr)	Alternative 1 (Option B) TDH (feet)	Alternative 1 (Option B) Pumpage (ac-ft)	Alternative 1 (Option B) Energy (MWhr)	Alternative 2 TDH (feet)	Alternative 2 Pumpage (ac-ft)	Alternative 2 Energy (MWhr)	Alternative 3 TDH (feet)	Alternative 3 Pumpage (ac-ft)	Alternative 3 Energy (MWhr)
SACRAMENTO RIVER SERVICE AREA																			
Shasta Dam Area PUD	M&I	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0
Sacramento River Canals Agencies																			
Colusa County WD	Ag	85	38700	5483	85	55000	7792	85	26700	3783	85	26700	3783	85	20300	2876	85	26700	3783
Corning WD	Ag	100	2500	417	100	0	0	100	10900	1817	100	10900	1817	100	8300	1383	100	10900	1817
Dunnigan WD	Ag	80	6200	827	80	3000	400	80	5300	707	80	5300	707	80	4000	533	80	5300	707
Glenn-Colusa ID	Ag	55	32400	2970	55	26000	2383	55	19500	1788	55	19500	1788	55	14800	1357	55	19500	1788
Glenn County Lands																			
Glide WD	Ag	45	0	0	45	0	0	45	1100	83	45	1100	83	45	800	60	45	1100	83
Kanawha WD	Ag	65	0	0	65	0	0	65	4600	498	65	4600	498	65	3500	379	65	4600	498
Orland-Artois WD	Ag	50	0	0	50	0	0	50	4900	408	50	4900	408	50	3700	308	50	4900	408
Willow Creek MWCo.	Ag	20	0	0	20	0	0	20	900	30	20	900	30	20	700	23	20	900	30
Glide WD	Ag	45	5100	383	45	3500	263	45	8100	608	45	8100	608	45	6200	465	45	8100	608
Holthouse WD	Ag	80	100	13	80	0	0	80	600	80	80	600	80	80	500	67	80	600	80
Orland-Artois WD	Ag	50	26500	2208	50	23600	1967	50	26200	2183	50	26200	2183	50	19900	1658	50	26200	2183
Rancho Saucos WD	Ag	65	2300	249	65	4300	466	65	1200	130	65	1200	130	65	900	98	65	1200	130
Tehama Ranch MWCo.	Ag	55	1700	156	55	1900	174	55	1400	128	55	1400	128	55	1100	101	55	1400	128
Yolo-Zamora WD	Ag	60	56600	5660	60	43300	4330	60	42000	4200	60	42000	4200	60	31900	3190	60	42000	4200
Subtotal			172100	18365		160600	17774		153400	16442		153400	16442		116600	12498		153400	16442
Yolo-Solano Agencies																			
Yolo County FC&WCD	Ag	70	256600	29937	70	257700	30065	70	208400	24313	70	208400	24313	70	257700	30065	70	208400	24313
City of Davis	M&I	70	11100	1295	70	17500	2042	70	8300	968	70	8300	968	70	17500	2042	70	8300	968
City of Woodland	M&I	70	11400	1330	70	22500	2625	70	10700	1248	70	10700	1248	70	22500	2625	70	10700	1248
Solano County	M&I	70	167300	19518	70	246700	28782	70	167300	19518	70	167300	19518	70	246700	28782	70	167300	19518
Subtotal			446400	52080		544400	63513		394700	46048		394700	46048		544400	63513		394700	46048
Refuges																			
Colusa NWR	Refuge	40	0	0	40	0	0	40	6800	453	40	6800	453	40	0	0	40	6800	453
Delevan NWR	Refuge	40	0	0	40	0	0	40	5700	380	40	8200	547	40	0	0	40	5700	380
Gray Lodge WMA	Refuge	40	5300	353	40	5300	353	40	7500	500	40	9800	653	40	5300	353	40	7500	500
Sacramento NWR	Refuge	40	0	0	40	0	0	40	12700	847	40	13700	913	40	0	0	40	12700	847
Sutter NWR	Refuge	40	0	0	40	0	0	40	6400	427	40	8200	547	40	0	0	40	6400	427
Subtotal			5300	353		5300	353		39100	2607		46700	3113		5300	353		39100	2607
SRSA TOTAL			623800	70798		710300	81641		587200	65097		594800	65603		666300	76365		587200	65097

Notes: TDH = total dynamic head
MWhr = megawatt-hour

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Table 4F-1. Annual Energy Use for Groundwater Pumping

Agency	Type Use	Alternative 4A/B TDH (feet)	Alternative 4A/B Pumpage (ac-ft)	Alternative 4A/B Energy (MWhr)	Alternative 4C/D TDH (feet)	Alternative 4C/D Pumpage (ac-ft)	Alternative 4C/D Energy (MWhr)	Alternative 5 TDH (feet)	Alternative 5 Pumpage (ac-ft)	Alternative 5 Energy (MWhr)	Alternative 6 TDH (feet)	Alternative 6 Pumpage (ac-ft)	Alternative 6 Energy (MWhr)	Alternative 7 TDH (feet)	Alternative 7 Pumpage (ac-ft)	Alternative 7 Energy (MWhr)
SACRAMENTO RIVER SERVICE AREA																
Shasta Dam Area PUD	M&I	N/A	0	0	N/A	0	0	N/A		0	N/A	0	0	N/A	0	0
Sacramento River Canals Agencies																
Colusa County WD	Ag	85	20300	2876	85	55000	7792	85	55000	7792	85	20300	2876	85	55000	7792
Corning WD	Ag	100	8300	1383	100	0	0	100	0	0	100	8300	1383	100	0	0
Dunnigan WD	Ag	80	4000	533	80	3000	400	80	3000	400	80	4000	533	80	3000	400
Glenn-Colusa ID	Ag	55	14800	1357	55	26000	2383	55	26000	2383	55	14800	1357	55	26000	2383
Glenn County Lands																
Glide WD	Ag	45	800	60	45	0	0	45	0	0	45	800	60	45	0	0
Kanawha WD	Ag	65	3500	379	65	0	0	65	0	0	65	3500	379	65	0	0
Orland-Artois WD	Ag	50	3700	308	50	0	0	50	0	0	50	3700	308	50	0	0
Willow Creek MWCo.	Ag	20	700	23	20	0	0	20	0	0	20	700	23	20	0	0
Glide WD	Ag	45	6200	465	45	3500	263	45	3500	263	45	6200	465	45	3500	263
Holthouse WD	Ag	80	500	67	80	0	0	80	0	0	80	500	67	80	0	0
Orland-Artois WD	Ag	50	19900	1658	50	23600	1967	50	23600	1967	50	19900	1658	50	23600	1967
Rancho Saucos WD	Ag	65	900	98	65	4300	466	65	4300	466	65	900	98	65	4300	466
Tehama Ranch MWCo.	Ag	55	1100	101	55	1900	174	55	1900	174	55	1100	101	55	1900	174
Yolo-Zamora WD	Ag	60	31900	3190	60	43300	4330	60	43300	4330	60	31900	3190	60	43300	4330
Subtotal			116600	12498		160600	17774		160600	17774		116600	12498		160600	17774
Yolo-Solano Agencies																
Yolo County FC&WCD	Ag	70	257700	30065	70	257700	30065	70	257700	30065	70	257700	30065	70	257700	30065
City of Davis	M&I	70	17500	2042	70	17500	2042	70	17500	2042	70	17500	2042	70	17500	2042
City of Woodland	M&I	70	22500	2625	70	22500	2625	70	22500	2625	70	22500	2625	70	22500	2625
Solano County	M&I	70	246700	28782	70	246700	28782	70	246700	28782	70	246700	28782	70	246700	28782
Subtotal			544400	63513		544400	63513		544400	63513		544400	63513		544400	63513
Refuges																
Colusa NWR	Refuge	40	6800	453	40	6800	453	40	0	0	40	0	0	40	6800	453
Delevan NWR	Refuge	40	8200	547	40	5700	380	40	0	0	40	0	0	40	8200	547
Gray Lodge WMA	Refuge	40	9800	653	40	7500	500	40	0	0	40	0	0	40	9800	653
Sacramento NWR	Refuge	40	13700	913	40	12700	847	40	0	0	40	0	0	40	13700	913
Sutter NWR	Refuge	40	8200	547	40	6400	427	40	0	0	40	0	0	40	8200	547
Subtotal			46700	3113		39100	2607		0	0		0	0		46700	3113
SRSA TOTAL			707700	79125		744100	83894		705000	81288		661000	76012		751700	84401

Note: TDH = total dynamic head
MWhr = megawatt-hour

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Alternative 1 - Option A

Regional Impacts

Under Option A, groundwater pumping would be increased in the refuges. However, groundwater pumping would decrease from the No-Action Alternative in the Sacramento Valley Canals agencies and the Yolo-Solano agencies. Table 4F-1 shows the energy use for groundwater pumping by alternative.

Site-Specific Impacts

Sacramento Valley Canals Agencies. Water deliveries would slightly decrease the amount of groundwater pumped in the area (a reduction of 7,200 af), saving 1,332 mWh.

Yolo-Solano CVP Water Service Coordinating Group. Water deliveries would decrease groundwater pumping by 149,700 af, saving 17,465 mWh of energy.

Refuges. Groundwater would need to be pumped under this alternative, using 2,607 mWh of energy to pump 39,100 af.

Alternative 1 - Option B

Regional Impacts

In Option B, groundwater pumping would be increased in the refuges. However, groundwater pumping would decrease compared to the No-Action Alternative in the Sacramento Valley Canals agencies and the Yolo-Solano agencies. Table 4F-1 shows the energy use for groundwater pumping by alternative.

Site-Specific Impacts

Sacramento Valley Canals Agencies. Water deliveries would slightly decrease the amount of groundwater pumped in the area (a reduction of 7,200 af), saving 1,332 mWh.

Yolo-Solano CVP Water Service Coordinating Group. Water deliveries would decrease groundwater pumping by 149,700 af, saving 17,465 mWh of energy.

Refuges. Groundwater would need to be pumped under this alternative, using 3,113 mWh of energy to pump 46,700 af.

Alternative 2

Regional Impacts

Under Alternative 2, energy use differs from the No-Action Alternative only in the Sacramento Valley Canals agencies. Table 4F-1 shows the energy use for groundwater pumping by alternative.

Site-Specific Impacts

Sacramento Valley Canals Agencies. With the water deliveries to the Sacramento Valley Canals agencies, groundwater pumping would be reduced by 44,000 af, saving 5,276 mWh of energy.

Yolo-Solano CVP Water Service Coordinating Group. There would be no change in pumping compared to the No-Action Alternative.

Refuges. No change from the No-Action Alternative.

Alternative 3

Regional Impacts

Under Alternative 3, water deliveries to the Sacramento Valley Canals agencies and the Yolo-Solano agencies would reduce pumping in those area and refuges would need to pump water to meet their needs. Table 4F-1 shows the energy use for groundwater pumping by alternative.

Site-Specific Impacts

Sacramento Valley Canals Agencies. With the water deliveries to the Sacramento Valley Canals agencies, groundwater pumping would be reduced by 7,200 af, saving 1,332 mWh of energy.

Yolo-Solano CVP Water Service Coordinating Group. Water deliveries would reduce groundwater pumping by 149,700 af, saving 46,048 mWh of energy.

Refuges. 39,000 af of groundwater would need to be pumped at each refuge, using 2,607 mWh of energy.

Alternative 4A/B

Regional Impacts

Under Alternative 4A/B, water deliveries to the Sacramento Valley Canals agencies would reduce pumping, but refuges would need to pump additional water to meet their needs when compared to the No-Action Alternative. Table 4F-1 shows the energy use for groundwater pumping by alternative.

Site-Specific Impacts

Sacramento Valley Canals Agencies. With the water deliveries to the Sacramento Valley Canals agencies, groundwater pumping would be reduced by 44,000 af, saving 5,276 mWh of energy.

Yolo-Solano CVP Water Service Coordinating Group. There would be no water deliveries to this area; therefore, impacts would be the same as those for the No-Action Alternative.

Refuges. Approximately 46,700 af of groundwater would be pumped, using 3,113 mWh of energy. Groundwater would be pumped from each refuge.

Alternative 4C/D

Regional Impacts

Under Alternative 4C/D, all of the available firm yield would go to the DESA. This would cause additional groundwater pumping at the refuges. Table 4F-1 shows the energy use for groundwater pumping by alternative.

Site-Specific Impacts

Sacramento Valley Canals Agencies. No change from the No-Action Alternative.

Yolo-Solano CVP Water Service Coordinating Group. No change from the No-Action Alternative.

Refuges. Same as Alternative 3.

Alternative 5

Regional Impacts

Under Alternative 5, water deliveries to the refuges would eliminate the need for groundwater pumping. Table 4F-1 shows the energy use for groundwater pumping by alternative.

Site-Specific Impacts

Sacramento Valley Canals Agencies. No change from the No-Action Alternative.

Yolo-Solano CVP Water Service Coordinating Group. No change from the No-Action Alternative.

Refuges. No groundwater would need to be pumped under this alternative, saving 353 mWh of energy that would have been consumed at Gray Lodge Wildlife Management Area.

Alternative 6

Regional Impacts

Under Alternative 6, water deliveries to the refuges would eliminate the need for groundwater pumping. Groundwater pumping would also be reduced for Sacramento Valley Canals agencies. Table 4F-1 shows the energy use for groundwater pumping by alternative.

Site-Specific Impacts

Sacramento Valley Canals Agencies. Same as Alternative 2 and 4A/B.

Yolo-Solano CVP Water Service Coordinating Group. Same as the No-Action Alternative.

Refuges. No groundwater would need to be pumped under this alternative, saving 353 mWh of energy that would have been consumed at Gray Lodge Wildlife Management Area.

Alternative 7

Regional Impacts

Under Alternative 7, groundwater pumping would be increased in the refuges. Groundwater pumping would not differ from the No-Action Alternative in the Sacramento Valley Canals agencies and the Yolo-Solano agencies. Table 4F-1 shows the energy use for groundwater pumping by alternative.

Site-Specific Impacts

Sacramento Valley Canals Agencies. No change from the No-Action Alternative.

Yolo-Solano CVP Water Service Coordinating Group. No change from the No-Action Alternative.

Refuges. Groundwater pumping would need to be pumped under this alternative, using 3,113 mWh of energy to pump 46,700 af.

Mitigation Measures

No mitigation measures are necessary because the only effects of the alternatives would be to either reduce or slightly increase the amount of energy used to pump groundwater in the SRSA.

FISHERIES

Introduction

The analysis below focuses on fishery resources within the SRSA that are most likely to be affected by water contracting alternatives and for which sufficient data regarding species' response to specific environmental conditions are available. Species specifically addressed include chinook salmon, American shad, and steelhead trout.

Important issues relating to the possible effects of water contracting alternatives were identified during the scoping process and by resource agencies. These issues include: 1) effects of projected water quality and quantity changes on chinook salmon, steelhead trout, American shad, and striped bass production in the river; 2) effects of potential changes in operations of CVP facilities on anadromous fish migration and production; 3) effects of water level fluctuations and reservoir levels on Shasta and Clair Engle Reservoir; 4) effects of water contracting on threatened and endangered fish species; and 5) effects on spawning gravel quality and quantity.

CVP storage and diversion facilities affect fisheries by controlling the timing, frequency, and duration of water volume or water quality conditions. Fish population impacts (i.e., changes in abundance, distribution, or production) depend primarily on the response of individuals (i.e., survival, growth, reproduction, and migration) to changes in environmental conditions. Several indices that correspond to environmental changes were developed to show the relative degree of impact to fish populations. These indices are discussed below. A detailed discussion of index development methodology and application is presented in Technical Appendix D - Fisheries Impact Assessment Methodology.

The operations, power, temperature, and water quality models provided information on river temperature and discharge, and reservoir volume and water surface elevation. The models are not meant to predict actual environmental conditions, but rather to produce information indicative of relative environmental changes that result under alternative operations.

General environmental changes were described in the preceding "Surface Water Hydrology and Seepage" and "Surface Water Quality" sections. Discharge, temperature, and diversion ratio are the primary affected environmental conditions analyzed in this section in relation to Sacramento River fish population impacts.

Temperature Effects on Chinook Salmon

The Sacramento River provides important spawning and rearing habitat for four chinook salmon runs (fall, late fall, winter, and spring). Fall-run salmon spawn from

September through December, late fall-run salmon spawn from January into May, winter-run salmon spawn from May into August, and spring-run salmon spawn from August through October. Juveniles from all four runs may rear in the river through the summer, although most spring-run fish emigrate during the winter and most fall-run fish emigrate in April, May, and June.

Temperature is a major factor controlling the survival, development, and growth of eggs, alevins, and juvenile fish and is probably the most important environmental condition affecting the Sacramento River chinook salmon populations. The alternative operations studied would produce relatively small changes in temperature (see "Surface Water Quality" section); however, the small changes may significantly impact chinook salmon and other species. A change of 1°F at temperatures near the lethal level for a species can reduce survival by 50 percent or more.

Many factors affect water temperature, including meteorology, reservoir storage, and discharge. Reservoir storage is the main moderating factor. The effect of changing reservoir volume or release temperatures is complicated by the interaction of meteorology, heating or cooling time for the impounded water, and flexibility of the stratified water release mechanism. The lowest fall release temperatures might result from high and low reservoir volumes; however, high reservoir volumes combined with adequate stratified water release mechanisms provide the most reliable year-to-year river temperature control. High reservoir volumes would sustain cool deep water through the summer for release in the fall. Low volumes would cool quickly to ambient temperature, but cooling is dependent on meteorology. Intermediate reservoir volumes may sustain insufficient cool water through the summer for fall release and would cool more slowly than lower volumes.

In addition, reservoir storage moderates meteorological effects through storage of temperature-stratified water that heats or cools slowly and through multilevel release points that enable cool deep water or warm surface water releases. High discharges result in water temperature effects farther downstream.

To determine the impacts of temperature changes on chinook salmon, the analysis focuses on spawning, incubation, and rearing from April through November. Winter temperatures are generally not responsive to CVP operation changes and are below levels detrimental to salmon.

A spawning-incubation index was used to determine temperature impacts on chinook salmon eggs and alevins. An index value of 1.00 means that temperature conditions are optimal for egg survival and development and that other environmental conditions (i.e., dissolved oxygen, scour, predation) control survival and development rates. An index value of 0.00 means that temperature completely controls survival and development rates, and no eggs are expected to survive. High index values mean lower temperature-induced mortality and low index values mean higher temperature-induced mortality. The index is based on monthly mean temperature and declines from 1.00 at about 50°F to 0.00 at about 61°F. The spawning-incubation index is applicable to hatchery and in-river chinook salmon.

A rearing index was used to determine temperature impacts on chinook salmon juveniles. Similar to the spawning-incubation index, an index value of 1.00 means that temperature conditions are optimal for juvenile survival and growth, and that other

environmental conditions (i.e., dissolved oxygen, current velocity, food availability, predation) control survival and growth rates. An index value of 0.00 means that temperature completely controls survival and growth rates and no juveniles are expected to survive. High index values mean lower temperature-induced mortality and low index values mean higher temperature-induced mortality. The index is based on monthly mean temperature and declines from 1.00 at about 53°F to 0.00 at about 69°F. Figures 4G-1 and 4G-2 present September temperature exceedence curves for the Sacramento River below Keswick Dam and at Cottonwood Creek, respectively, based on temperature modeling.

Water temperature in the Sacramento River below the major chinook salmon spawning and rearing areas (i.e., downstream of Butte City) appears to have increased over the last 10 years and may have increased outmigrant juvenile chinook salmon mortality (Reuter and Mitchell 1987). The exact cause of the temperature increase has not been determined, although agricultural drain water could be a contributor. Agricultural drainage patterns that would occur under the CVP operations alternatives could have variable effects on the temperature, and in some cases temperatures may become increasingly detrimental to outmigrant survival. Chinook salmon juveniles originating from the Sacramento River and its tributaries, including the Feather and American Rivers, could be impacted.

Discharge Effects on Chinook Salmon

Discharge affects temperature, water quality, velocity, water surface elevation, food availability, habitat area, diversion ratio, and other environmental conditions. Information is generally lacking on the precise relationships between discharge and most environmental conditions, and between environmental conditions and impacts on fish populations.

Instream flow studies by DFG that will provide data on the relationship between discharge and chinook salmon spawning and rearing habitat area are near completion (Hayes pers. comm.). Currently, optimum spawning and rearing habitat is estimated to occur at a Sacramento River discharge exceeding 6,000 cfs (U. S. Fish and Wildlife Service 1987a). A discharge of less than 6,000 cfs is assumed to provide less habitat, and habitat area is assumed to be positively correlated to spawning and rearing success. A relative measure of spawning and rearing success is the change in frequency of a monthly mean discharge of less than 6,000 cfs over the 57-year period used in the operations models (e.g., spawning and rearing success decline as the frequency of discharges of less than 6,000 cfs increases). Figure 4G-3 presents September flow exceedence curves for the Sacramento River below Keswick Dam.

Diversion Effects on Chinook Salmon

Diversions can temporarily or permanently entrain fish from their riverine habitat. The diversion impact on a fish population depends on the diversion timing and volume, river discharge, species, lifestage, and other factors. Chinook salmon would be the most common species entrained, although diversions may impact other species populations including steelhead, American shad, and striped bass. During chinook salmon outmigration, juveniles are assumed to be diverted from the river in the same proportion as the water

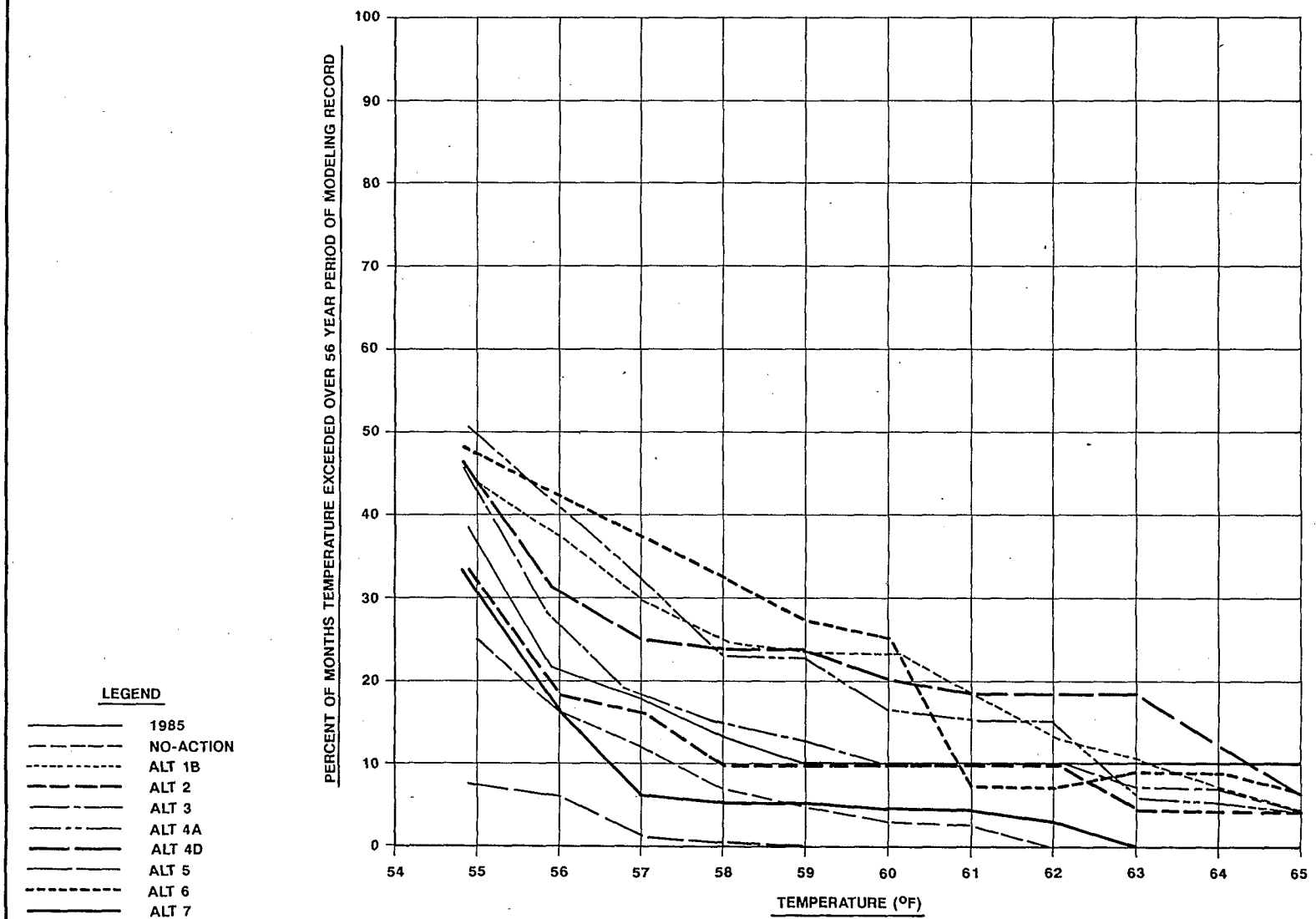

FIGURE 4G-1
EXCEEDANCE CURVES FOR SEPTEMBER TEMPERATURES
IN THE SACRAMENTO RIVER BELOW KESWICK DAM

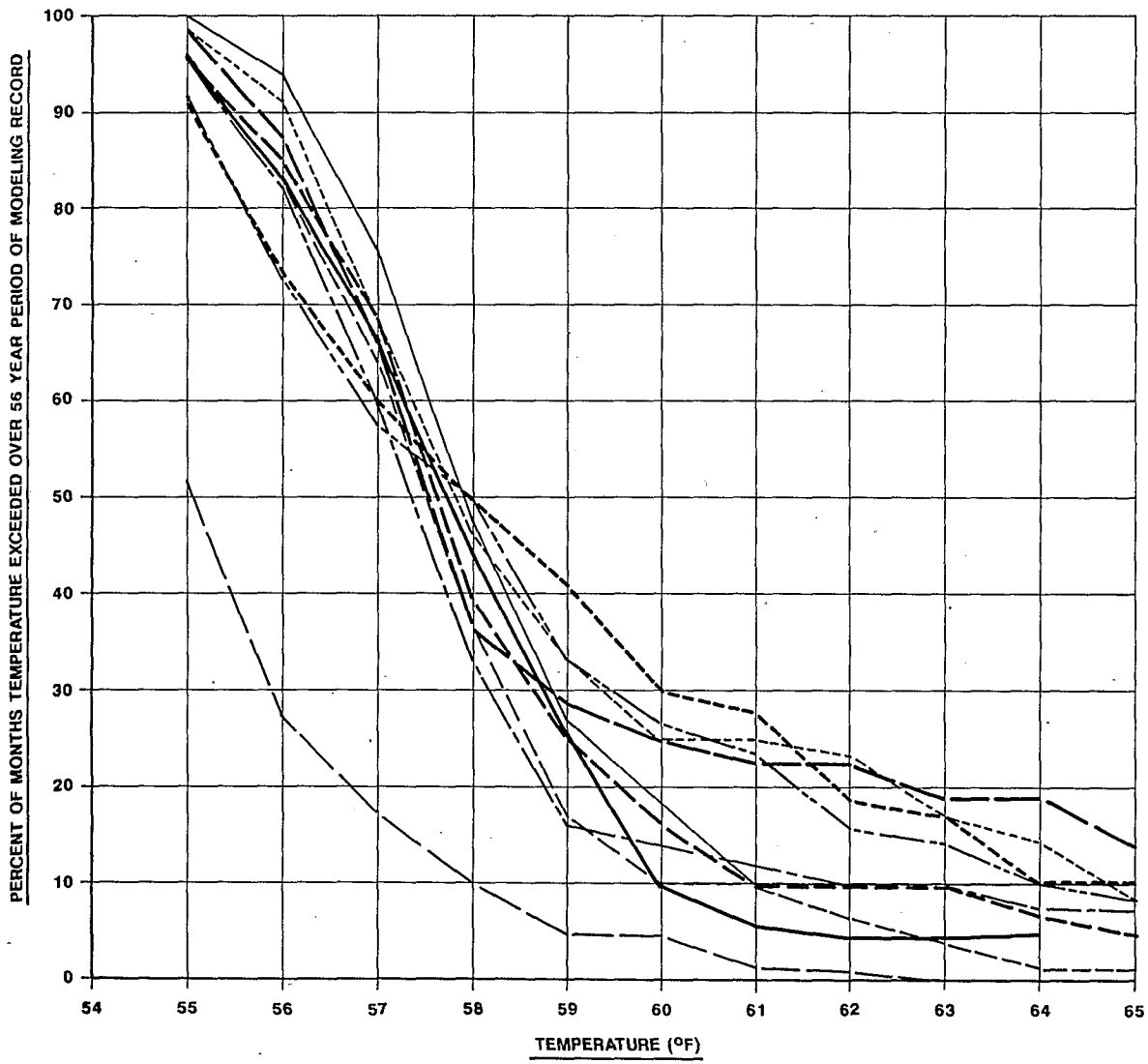

FIGURE 4G-2
EXCEEDANCE CURVES FOR SEPTEMBER TEMPERATURES
IN THE SACRAMENTO RIVER AT COTTONWOOD

C-055727

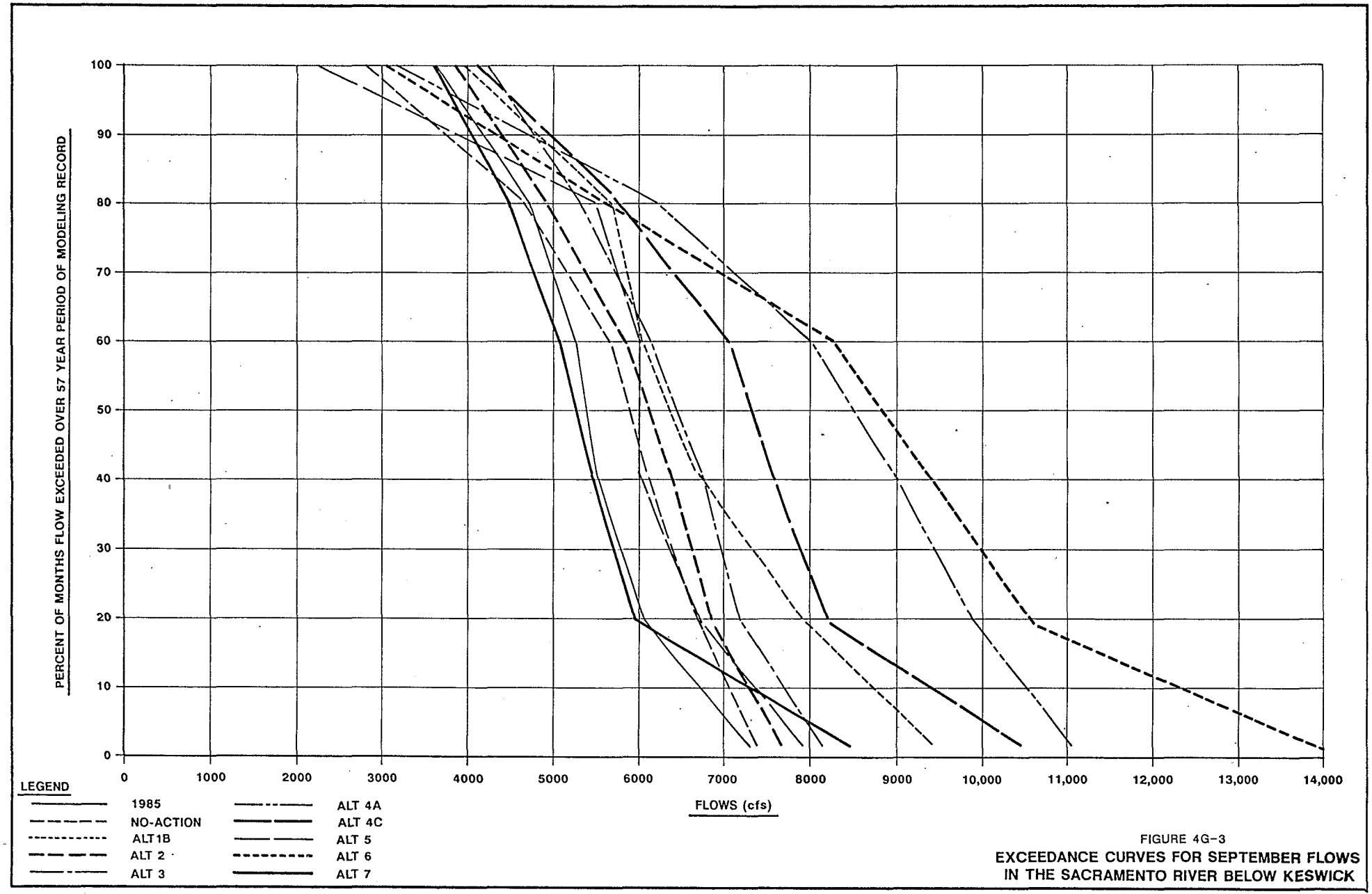

FIGURE 4G-3
EXCEEDANCE CURVES FOR SEPTEMBER FLOWS
IN THE SACRAMENTO RIVER BELOW KESWICK

C-055728

(i.e., diversion volume divided by river discharge). A substantial increase in the proportion of water diverted would significantly increase impacts on fish.

Under the CVP operations alternatives considered, the Sacramento River diversion points of greatest concern would be the Tehama-Colusa Canal, the Corning Canal, and the Glenn-Colusa Canal. Most of the diverted water is for agricultural uses during April through October. April, May, and June are the months of significant juvenile chinook salmon outmigration that coincide with agricultural diversions. The percent of the total annual agricultural diversion for these months is about 4, 8, and 17 percent, respectively.

Impacts are lessened by using screens that effectively prevent permanent entrainment. Salmon will soon be prevented from entering the Tehama-Colusa and Corning Canals by new screens at Red Bluff Diversion Dam (Smith pers. comm.). The new screens are believed to be nearly 100 percent efficient; however, survival is assumed to decrease by at least 15 percent for temporarily entrained fish compared to those unaffected by the diversion (California Department of Fish and Game 1987b). Therefore, even though the screens are effective at preventing fish from entering the canals, an increase in diversions could result in increased mortality. The impact analysis assumes these screens are in place. The fish screens for Glenn-Colusa Canal are believed to be ineffective, which results in impacts to chinook salmon populations proportional to the amount of water diverted.

Effects on Steelhead Trout

Temperature conditions required by steelhead trout are similar to conditions required by chinook salmon. Specific information on Sacramento River steelhead trout is unavailable; therefore, temperature and discharge changes impacting chinook salmon are assumed to impact steelhead trout to the same degree. Chinook salmon spawning-incubation impacts during April and May and rearing impacts during all months represent impacts to steelhead trout.

Diversion effects are clearly different for the two species, since juvenile steelhead emigrate primarily during March and April and are larger than juvenile chinook salmon migrating during the same period. The Red Bluff Diversion Dam screens that will be completed within the next year should exclude nearly 100 percent of the steelhead migrants. The Glenn-Colusa Canal fish screens are assumed ineffective, and impacts to steelhead would be in proportion to the water volume diverted.

Trinity River

Trinity River flows would be the same under all alternatives; however, water temperature could vary due to changes in reservoir operation. A measure of suitable chinook salmon spawning-incubation temperatures is the frequency of mean monthly temperatures exceeding 57°F over the 57-year period used in the operations and temperature models. River temperatures are applicable to hatchery and in-river chinook salmon. A measure of suitable chinook salmon-rearing temperatures is the frequency of mean monthly temperatures exceeding 65°F over the 56-year period used in the operations and temperature models.

Spring Creek

Spring Creek acid mine drainage degrades Sacramento River water quality and can cause dissolved metal concentrations that are harmful to fish. Peak discharge of acid mine waste coincides with high runoff during the wet season. Deleterious environmental conditions are avoided by coordinating the Spring Creek discharge with sufficient Sacramento River discharge to dilute metal concentrations below harmful levels. Some of the proposed CVP water contracting alternatives would reduce the Sacramento River discharge during the wet season and could indirectly increase the concentration of dissolved metals. The EPA has identified appropriate control measures, and remedial action has been initiated to reduce the level of contaminants entering the system. Although a model of the relationship between Spring Creek flows and Sacramento River water quality exists, the precise impacts of the proposed operations alternatives cannot be determined at this time because the model does not take into account remedial measures currently underway at the site. Reduced Sacramento River discharge during the wet season, however, (December through March) is considered detrimental to environmental conditions.

Sacramento River Tributaries

Juvenile salmon and steelhead entering the Sacramento River via tributary streams will be exposed to the same environmental conditions as the fish in the river. The point of entry in the Sacramento River will determine the fisheries impact of changes in environmental conditions. Many chinook salmon and steelhead use the Sacramento River only as a migration corridor and are less affected by changes in environmental conditions than those fish rearing in the river.

Tributaries above Red Bluff Diversion Dam that support anadromous fish populations include Clear Creek, Cottonwood Creek, and Battle Creek. The Coleman Salmon and Steelhead Hatchery on Battle Creek is the single largest tributary contributor of salmon and steelhead to this Sacramento River section. Tributaries below Red Bluff Diversion Dam that support anadromous fish populations include Mill Creek, Butte Creek, Feather River, and American River.

Reservoirs

Shasta and Clair Engle Reservoir fluctuations affect fish population abundance through changes in food availability and spawning success. In general, reduction in reservoir surface area lowers reservoir productivity and reduces fish populations. Spawning success, primarily for sunfish (including bass) during April through July, declines with increased fluctuations in water surface elevation. Both increasing and decreasing water levels reduce spawning success. Decreasing the water level has the greatest impact. Sunfish generally spawn in shallow water (1 to 4 feet); therefore, relatively small drops in water surface elevation can dewater the nest or force adults to abandon the nest, increasing predation on eggs and larvae. Water surface elevation fluctuations are assessed to evaluate these impacts.

Other Effects

Other effects will undoubtedly result from operational changes of CVP-related facilities. The significance of these impacts, and in most cases the impacts themselves, cannot be determined at this time. The complexity of the system can be illustrated by a brief example. Increased temperature may favor a warmwater species, but its primary prey may be a coldwater species that declines at the elevated temperature. A warmwater prey species may replace the coldwater species, or the warmwater predator species may decline due to decreasing food availability. The resulting species assemblage will likely be quite different at the increased temperature level.

Determination of Impact Significance

For purposes of this analysis, a 10-percent change from No-Action Alternative conditions in a measured variable, except for magnitude of water surface elevation change (whether the variable is an index, water surface area, or water volume), is considered indicative of a significant effect. This level of change was used to determine both adverse and beneficial changes. A 10-percent change is believed sufficient to indicate real changes and not model data aberrations.

The temperature indices indicate the level of biological impact resulting from changes in environmental conditions. Actual changes in fish population abundance, distribution, or production, however, may not be reflected in the relative changes of any indices because of the inherent complexity and uncertainty involved with ecosystem modification.

The significance of monthly changes in mean magnitude of reservoir surface elevation could not be evaluated based on the methodology discussed above because changes are relative to zero. Therefore, a difference in mean magnitude of 2 feet between the No-Action Alternative and other alternatives is considered significant, whether the magnitude is for rising or falling elevations. The 2-foot significance level is somewhat arbitrary, although sunfish spawning often occurs in water less than 2 feet deep and a fall of 2 feet in surface elevation would dewater the nest.

No-Action Alternative

Regional 2020 Baseline Conditions

Sacramento River

Chinook Salmon Spawning. Fall, spring and late-fall chinook salmon runs might benefit slightly by the water temperature change that would occur under the No-Action Alternative conditions as compared to 1985 conditions (Appendix V, Table C).

However, winter chinook salmon runs would be adversely affected, especially in the lower portion of their spawning habitat (below Cottonwood). Increased water temperatures due to lower discharge during major spawning months would cause the adverse change. Discharge volumes of less than 6,000 cfs would be generally less common under the No-Action Alternative conditions, and spawning habitat is assumed to be unaffected (Appendix V, Table C).

Chinook Salmon Rearing. Juvenile chinook salmon would be adversely affected by increased water temperatures in rearing habitat below Cottonwood during June, July, and August (Appendix V, Table D). All runs would be adversely affected, but the rearing conditions for the winter and late fall runs, and the migration conditions for the June emigrating fall run would be most affected. As with spawning habitat, rearing habitat is assumed to be unaffected because Sacramento River discharge volumes less than 6,000 cfs would be less common (Appendix V, Table C).

Chinook Salmon Entrainment. Diversions would have no additional effect on chinook salmon populations under the No-Action Alternative. Tehama-Colusa Canal diversions would increase slightly, but the average change in the diversion/Sacramento River discharge ratio would be 1 percent or less. (See "Surface Water Hydrology and Seepage" section.)

Steelhead Trout. Spawning success would probably not be affected by water temperature changes under the No-Action Alternative. Juvenile steelhead trout would be adversely affected by increased water temperatures in rearing habitat below Cottonwood during the summer months. Diversions would have no additional effect on steelhead populations.

Trinity River. Trinity River chinook salmon would not be affected by the changes in conditions under the No-Action Alternative. The water temperature frequencies indicate a slight improvement for both spawning and rearing (Appendix V, Tables E and F).

Spring Creek. Environmental conditions resulting from acid mine waste discharge would be unaffected. See the "Surface Water Quality" section of this chapter.

Shasta and Clair Engle Reservoirs. Reservoir fisheries would not be affected by the operation changes under the No-Action Alternative. Reservoir area would increase slightly, between 2 and 5 percent in the most productive months, and the amplitude and pattern of water surface elevation fluctuations would be the same under the No-Action Alternative and 1985 base conditions (Appendix V, Tables G, H, and I).

Site-Specific 2020 Baseline Conditions

Sacramento Valley Canals Agencies, Yolo-Solano CVP Coordinating Group, and Refuges. Effects on fish populations at the site-specific level under the No-Action Alternative cannot be determined from the available information. Changes in the patterns and frequency of use of natural streams to convey CVP water could adversely affect fish populations. Increased mortality (attributable to removal by diversions, blockage by temporary dams, and exposure to increased predation near diversion facilities) would

probably be the primary effect, and chinook salmon would be the most vulnerable. Water quality changes caused by possible drain water increases would also potentially affect fish populations.

Refuges would not receive CVP water under the No-Action Alternative, which would adversely affect the fishery resources. Information is currently unavailable to describe the effects.

Alternative 1 - Option A

Regional Impacts

Sacramento River

Chinook Salmon Spawning. Spring-run chinook salmon would be significantly impacted, and the fall run would be less-than-significantly impacted by the temperature change that would occur under Alternative 1 - Option A operations as compared to the No-Action Alternative. All other runs would not be impacted. Spawning habitat availability would be impacted only during November when the frequency of Sacramento River discharge would significantly increase. Although Alternative 1 - Option A was not modeled, the environmental conditions would be identical to Alternative 2 during critically dry years, identical to Alternative 3 during wet years, and intermediate between the two for all other year types. The index values for Alternatives 2 and 3 were used to estimate impacts (Appendix V, Tables J and K).

Chinook Salmon Rearing. Juvenile chinook salmon would be less-than-significantly impacted by increased temperatures in the rearing habitat. All runs would be impacted and environmental condition changes would fall somewhere between the index values for Alternatives 2 and 3 (Appendix V, Table L). As with spawning habitat, November rearing habitat would be impacted (Appendix V, Table L).

Chinook Salmon Entrainment. Diversions would less-than-significantly impact chinook salmon populations and the impacts would be nearly the same as under Alternative 2 conditions.

Steelhead Trout. Spawning success would not be impacted and rearing would be less than significantly impacted. Diversions would less-than-significantly impact steelhead trout populations.

Trinity River. Trinity River Chinook salmon would not be impacted by the operation changes under Alternative 1 - Option A. The temperature frequencies are generally unchanged for both spawning and rearing (see Alternatives 2 and 3 in Appendix V, Tables M and N).

Spring Creek. Environmental conditions resulting from acid mine waste discharge would not be impacted. See the "Surface Water Quality" section of this chapter.

Shasta and Clair Engle Reservoirs. Reservoir fisheries would be less-than-significantly impacted. Reservoir area would decrease slightly at Shasta, between 2 and 4 percent in the most productive months, and would not change at Clair Engle. The amplitude of water surface elevation fluctuations would change only in June (Alternatives 2 and 3 in Tables O, P, and Q).

Site-Specific Impacts

Sacramento Valley Canals Agencies, Yolo-Solano CVP Coordinating Group, and Refuges. Fish population impacts in these areas that would result from Alternative 1 - Option A cannot be determined from the available information. Changes in the patterns and frequency of use of natural streams as CVP water conveyance facilities could adversely affect fish populations. Reduced survival (attributable to removal by diversions, blockage by temporary dams, and exposure to increased predation near diversion facilities) would probably be the primary effect, and chinook salmon would be the most vulnerable. Water quality changes caused by possible drainwater increases would also potentially affect fish populations.

Refuges would not receive CVP water and the fishery resources would be adversely affected. Information is currently unavailable to qualify or quantify the effects.

Alternative 1 - Option B

Regional Impacts

Sacramento River

Chinook Salmon Spawning. Winter-, and late-fall, and spring-run chinook salmon would be significantly impacted by the temperature change that would occur under Alternative 1 - Option B operations (Appendix V, Table J) as compared to the No-Action Alternative. Fall-run salmon would be less-than-significantly impacted. Increased summer and early fall temperatures cause the significant impact, and increased temperature may result from lower reservoir levels. The frequency of Sacramento River discharge volumes less than 6,000 cfs would decrease for nearly all months, increasing spawning habitat for all the runs (Appendix V, Table K).

Chinook Salmon Rearing. Juvenile chinook salmon would be significantly impacted by increased temperatures in the rearing habitat (Appendix V, Table L). All runs would be impacted, but summer and early fall (October) rearing conditions for the spring, winter, and late fall runs would be most affected. As with spawning habitat, rearing habitat would increase for all runs (Appendix V, Table L).

Chinook Salmon Entrainment. Diversions would less-than-significantly impact chinook salmon populations, and the impacts would be nearly the same as for Alternative 1 - Option A.

Steelhead Trout. Spawning success would not be impacted. Rearing success would be significantly impacted by increased temperatures during the summer. Diversions would less-than-significantly impact steelhead trout populations.

Trinity River. Trinity River chinook salmon would not be impacted by the operation changes under Alternative 1 - Option B. The temperature frequencies are generally unchanged for both spawning and rearing (Appendix V, Tables M and N).

Spring Creek. Environmental conditions resulting from acid mine waste discharge would not be impacted. See "Surface Water Quality" section of this chapter.

Shasta and Clair Engle Reservoirs. Shasta Reservoir fisheries would be less than significantly impacted and Clair Engle Reservoir fisheries would benefit under Alternative 1 - Option B. The Shasta area decreases and the Clair Engle area increases for all months. The amplitude and pattern of water surface elevation fluctuations would not change (Appendix V, Tables P and Q).

Site-Specific Impacts

Sacramento Valley Canals Agencies, Yolo-Solano CVP Coordinating Group, and Refuges. Fish population impacts that would result from Alternative 1 - Option B are as discussed in Alternative 1 - Option A.

Alternative 2

Regional Impacts

Sacramento River

Chinook Salmon Spawning. Under this alternative, changes in water temperatures from the No-Action Alternative would not result in significant impacts to chinook salmon (Appendix V, Table J). Increased water temperature may be caused by lower reservoir levels (Appendix V, Table P). The frequency of Sacramento River discharge volumes less than 6,000 cfs would not change (Appendix V, Table K).

Chinook Salmon Rearing. Juvenile chinook salmon would be less-than-significantly impacted by increased water temperatures in rearing habitat (Appendix V, Table L). All runs would be impacted, but summer rearing conditions for the winter and late fall runs would be most affected. As with spawning habitat, rearing habitat is assumed to be unaffected because the frequency of Sacramento River discharge volumes less than 6,000 cfs would not change (Appendix V, Table L).

Chinook Salmon Entrainment. Diversions would less-than-significantly impact chinook salmon populations under Alternative 2. The proportion of water diverted from the Tehama-Colusa Canal would nearly double for April, May, and June, increasing from

2, 4, and 7 percent, respectively, under the No-Action Alternative conditions to 5, 7, and 13 percent, respectively, under Alternative 2 conditions. (See "Surface Water Hydrology and Seepage" section.) The expected screening would reduce the impact to migrating salmon.

The additional proportion of water diverted from Glenn-Colusa Canal would be less than 1 percent of the Sacramento River discharge for April, May, and June.

Steelhead Trout. Impacts would be the same as under Alternative 1 - Option A.

Trinity River. Trinity River chinook salmon would not be impacted by the operation changes under Alternative 2. The water temperature frequencies generally would be unchanged for both spawning and rearing (Appendix V, Tables M and N).

Spring Creek. Environmental conditions resulting from acid mine waste discharge would not be affected. See the "Surface Water Quality" section of this chapter.

Shasta and Clair Engle Reservoirs. Reservoir fisheries would be less-than-significantly impacted by the operation changes under Alternative 2. Reservoir area would decrease between 2 and 4 percent at Shasta Reservoir in the most productive months and would not change at Clair Engle Reservoir. The amplitude of water surface elevation fluctuations would change only in June (Appendix V, Tables O, P, and Q).

Site-Specific Impacts

Sacramento Valley Canals Agencies, Yolo-Solano CVP Coordinating Group, and Refuges. Fish population impacts in these areas that would result from Alternative 2 cannot be determined from the information available. Changes in the patterns and frequency of use of natural streams to convey CVP water could adversely affect fish populations. Increased mortality (attributable to removal by diversions, blockage by temporary dams, and exposure to increased predation near diversion facilities) would probably be the primary effect, with chinook salmon the most vulnerable. Water quality changes caused by possible drain water increases would also potentially affect fish populations.

Refuges would not receive CVP water under Alternative 2, so the fishery resources would be adversely affected. Information is currently unavailable to qualify or quantify the effects.

Regional Impacts

Sacramento River

Chinook Salmon Spawning. Under this alternative, changes in temperatures from the No-Action Alternative would significantly impact spring-run chinook salmon (Appendix V, Table J). Fall-run salmon would be less-than-significantly impacted, and the winter and late fall runs would not be impacted. Increased October temperature would cause the significant impact, and increased water temperature may result from lower discharge and lower reservoir levels (Appendix V, Table O). The frequency of Sacramento River discharge volumes less than 6,000 cfs would significantly increase for November, further impacting the fall run (Appendix V, Table K).

Chinook Salmon Rearing. Juvenile chinook salmon would be less-than-significantly impacted by increased water temperatures in rearing habitat (Appendix V, Table L). All runs would be impacted, but early fall (October) rearing conditions for the spring, winter, and late fall runs would be most affected. As with spawning habitat, November rearing habitat would be impacted (Appendix V, Table L).

Chinook Salmon Entrainment. Diversions would less-than-significantly impact chinook salmon populations, with impacts nearly identical to those discussed under Alternative 1 - Option A.

Steelhead Trout. Impacts would be the same as under Alternative 1 - Option A.

Trinity River. Trinity River chinook salmon would not be impacted by the changes in conditions under Alternative 1 - Option A. The water temperature frequencies generally would be unchanged for both spawning and rearing (Appendix V, Tables M and N).

Spring Creek. Environmental conditions resulting from acid mine waste discharge would not be affected. See the "Surface Water Quality" section of this chapter.

Shasta and Clair Engle Reservoirs. Reservoir fisheries would be less-than-significantly impacted, with impacts the same as those for Alternative 1 - Option A.

Site-Specific Impacts

Sacramento Valley Canals Agencies, Yolo-Solano CVP Coordinating Group, and Refuges. Fish population impacts under Alternative 3 would be the same as those discussed under Alternative 1 - Option A. Refuges would receive CVP water under Alternative 3, so the fishery resources would be beneficially affected. Information is currently unavailable to qualify or quantify the effects.

Alternative 4A/B

Alternative 4A/B would have the same impacts as Alternative 2. These impacts would be less than significant.

Alternative 4C/D

Regional Impacts

Sacramento River

Chinook Salmon Spawning. Winter-, late-fall, and spring-run chinook salmon would be significantly impacted by the water temperature change that would occur under Alternative 4C/D conditions (Appendix V, Table J). Fall-run salmon would be less-than-significantly impacted. Increased summer and fall temperatures would cause the significant impact, and increased temperature may result from lower reservoir levels (Appendix V, Table O). The frequency of Sacramento River discharge volumes less than 6,000 cfs would significantly increase for November, further impacting the fall run (Appendix V, Table K).

Chinook Salmon Rearing. Juvenile chinook salmon would be significantly impacted by increased water temperatures in the rearing habitat (Appendix V, Table L) as compared to the No-Action Alternative. All runs would be impacted, but summer and early fall (October) rearing conditions for the spring, winter, and late fall runs would be most affected. As with spawning habitat, November rearing habitat would be impacted (Appendix V, Table L).

Chinook Salmon Entrainment. Diversions under Alternative 4C/D would have no impact on chinook salmon populations since the diversions are nearly the same as those under the No-Action Alternative.

Steelhead Trout. Spawning success would not be impacted. Rearing success would be significantly impacted by increased summer temperatures. Diversions would have no impact on steelhead trout.

Trinity River. Trinity River chinook salmon would not be impacted by the operation changes under Alternative 4C/D. The water temperature frequencies generally would be unchanged for both spawning and rearing (Appendix V, Tables M and N).

Spring Creek. See the "Surface Water Quality" section in this chapter.

Shasta and Clair Engle Reservoirs. Reservoir fisheries would be significantly impacted by the operation changes under Alternative 4C/D, as compared to the No-Action Alternative. Shasta Reservoir surface area would significantly decrease from July through November and decrease in less-than-significant amounts for all other months (Appendix V, Table O). Clair Engle Reservoir would exhibit a similar pattern. Significant change would also occur in water surface elevation; fluctuations would be significantly increased under

Alternative 4C/D conditions (Appendix V, Tables P and Q). These conditions would significantly impact sunfish spawning success.

Site-Specific Impacts

Sacramento Valley Canals Agencies, Yolo-Solano CVP Coordinating Group, and Refuges. Fish population impacts under Alternative 4C/D would be the same as those discussed under Alternative 1 - Option A.

Alternative 5

Regional Impacts

Sacramento River

Chinook Salmon Spawning. Under this alternative, changes in Sacramento River temperatures from the No-Action Alternative would significantly impact winter-run and late fall-run chinook salmon (Appendix V, Table J). Fall-, late fall-, and spring-run salmon would benefit. Increased late spring and summer water temperatures, which may result from decreased discharge, would cause the significant impact. Sacramento River discharge volumes less than 6,000 cfs would decrease for nearly all months, generally improving spawning habitat (Appendix V, Table K).

Chinook Salmon Rearing. Juvenile chinook salmon would be less than significantly impacted by increased water temperatures in the rearing habitat (Appendix V, Table L). June and July rearing conditions would be most affected, having the most impact on late fall and winter runs. Spring-run chinook would benefit under Alternative 5. As with spawning habitat, rearing habitat would be generally improved (Appendix V, Table L).

Chinook Salmon Entrainment. Diversions would have no impact on chinook salmon populations since the diversions would be nearly the same as in the No-Action Alternative.

Steelhead Trout. Spawning and rearing success would be less than significantly impacted. Diversions would have no impact on steelhead trout populations.

Clear Creek. The increased water diverted down Clear Creek from Whiskeytown Reservoir would expand the spawning and rearing habitat area in the creek. The higher discharge would also reduce sediment deposition, improving spawning habitat. Temperatures would decline during spring, summer, and fall, improving conditions for spawning and rearing. Several thousand adult salmon and steelhead would probably be produced by the discharge increase (Boyle Engineering Corporation 1986).

Trinity River. Trinity River chinook salmon would not be impacted by the changes in conditions under Alternative 5. The water temperature frequencies generally would be unchanged for both spawning and rearing (Appendix V, Tables M and N).

Spring Creek. Environmental conditions resulting from acid mine waste discharge would not be affected. (Appendix V, Table O).

Shasta and Clair Engle Reservoirs. Reservoir fisheries would be less-than-significantly impacted by the changes in conditions under Alternative 5, compared to the No-Action Alternative. Both Shasta and Clair Engle Reservoirs would have reduced areas during all months (Appendix V, Table O). The amplitude and pattern of water surface elevation fluctuations would not change (Appendix V, Tables P and Q).

Site-Specific Impacts

Sacramento Valley Canals Agencies, Yolo-Solano CVP Coordinating Group, and Refuges. Fish population impacts under Alternative 5 are as discussed under Alternative 1 - Option B.

Alternative 6

Regional Impacts

Sacramento River

Chinook Salmon Spawning. Winter- and spring-run chinook salmon would be significantly impacted by the temperature change that would occur under Alternative 6 operations (Appendix V, Table J), as compared to the No-Action Alternative. Fall and late fall runs would not be impacted. Increased summer and fall temperatures cause the significant impact and increased temperature may result from lower reservoir levels (Appendix V, Table O). The frequency of discharge volumes less than 6000 cfs would significantly increase for November and December, significantly impacting the fall run (Appendix V, Table K).

Chinook Salmon Rearing. Juvenile chinook salmon would be less-than-significantly impacted by increased temperatures in the rearing habitat (Appendix V, Table L). All runs would be impacted, but summer and early fall (October) rearing conditions for the spring, winter, and late fall runs would be most affected. As with spawning habitat, November and December rearing habitat would be impacted (Appendix V, Table L).

Chinook Salmon Entrainment. Under Alternative 6, diversions would less-than-significantly impact chinook salmon populations, as compared to the No-Action Alternative. The proportion of water diverted from Tehama-Colusa Canal would increase for April, May, and June from 2, 4, and 7 percent, respectively, under the No-Action Alternative 4, 7, and 11 percent, respectively, under Alternative 6. (See "Surface Water Hydrology and Seepage" section.) The expected effective screening reduces the impact on migrating salmon.

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The additional proportion of water diverted by Glenn-Colusa Canal diversions would be less than 1 percent of Sacramento River discharge for April, May, and June.

Steelhead Trout. Spawning success would not be impacted, and rearing would be less-than-significantly impacted. Diversions would less-than-significantly impact steelhead trout.

Trinity River. Trinity River chinook salmon would not be impacted by the operation changes under Alternative 6. The temperature frequencies are generally unchanged for both spawning and rearing (Appendix V, Tables M and N).

Spring Creek. Environmental conditions resulting from acid mine waste discharge would be affected throughout the wet period, December through March. See the "Surface Water Quality" section of this chapter.

Shasta and Clair Engle Reservoirs. Shasta Reservoir fisheries would be impacted by the operation changes under Alternative 6 compared to the No-Action Alternative. Shasta Reservoir surface area would significantly decrease from August through November and decrease less-than-significant amounts for all other months (Appendix V, Tables O, P, and Q). Clair Engle Reservoir fisheries would not be impacted. The amplitude of water surface elevation fluctuations would change only in May and June (Appendix V, Tables O, P, and Q).

Site-Specific Impacts

Sacramento Valley Canals Agencies, Yolo-Solano CVP Coordinating Group and Refuges. Fish population impacts under Alternative 6 are as discussed under Alternative 1 - Option A.

Alternative 7

Regional Impacts

Sacramento River

Chinook Salmon Spawning. Late-fall and winter-run chinook salmon would be significantly impacted by the temperature change that would occur under Alternative 7 operations (Appendix V, Table J), as compared to the No-Action Alternative. All other runs would not be impacted. Increased June temperature causes the significant impact, and increased temperature may result from reduced discharge (Appendix V, Table O). The frequency of discharge volumes less than 6000 cfs would significantly increase for September, impacting primarily the winter and spring runs (Appendix V, Table K).

Chinook Salmon Rearing. Juvenile chinook salmon would be less than significantly impacted by increased temperatures in the rearing habitat (Appendix V, Table L). All runs would be impacted, but summer rearing conditions for the spring and late fall

runs would be most affected. As with spawning habitat, September rearing habitat would be affected, impacting the spring and late fall runs (Appendix V, Table L).

Chinook Salmon Entrainment. Diversions would have no impact on chinook salmon populations since the diversions are nearly the same as in the No-Action Alternative.

Steelhead Trout. Spawning and rearing would be less-than-significantly impacted. Diversions would have no impact.

Trinity River. Trinity River chinook salmon would not be impacted by the operation changes under Alternative 7. The temperature frequencies are generally unchanged for both spawning and rearing (Appendix V, Tables M and N).

Spring Creek. Environmental conditions resulting from acid mine waste discharge would not be affected. See the "Surface Water Quality" section of this chapter.

Shasta and Clair Engle Reservoirs. Reservoir fisheries would be less-than-significantly impacted by the operation changes under Alternative 7 as compared to the No-Action Alternative. Both Shasta and Clair Engle Reservoirs would have reduced areas during some months (Appendix V, Table O). The amplitude and pattern of water surface elevation fluctuations would not change (Appendix V, Tables P and Q).

Site-Specific Impacts

Sacramento Valley Canals Agencies, Yolo-Solano CVP Coordinating Group, and Refuges. Fish population impacts under Alternative 7 are as discussed under Alternative 1 - Option A.

Mitigation Measures

Regional Impacts

Maintain Cooler Sacramento River Temperatures to Improve Chinook Salmon Fishery. Spring-run chinook salmon spawning success would be significantly impacted by increased temperature under Alternative 1 - Options A and B, Alternatives 3, 4A/B, 4C/D, and 6. Winter-run chinook salmon spawning success would be significantly impacted by increased temperature under Alternative 1 - Option B, Alternatives 4C/D, 5, 6, and 7. Alternative 4C/D and Alternative 1 - Option B would produce temperatures that would significantly impact chinook salmon and steelhead trout summer rearing success. Temperatures causing significant impacts are most likely to occur from August through October.

Power generation facility bypass would enable short-term cool water release on a year-by-year basis, reducing impacts during some months but not reducing temperature impacts to less-than-significant levels. Installation of a temperature control curtain on Shasta Reservoir would reduce temperature impacts to less-than-significant levels. The

curtain would enable multilevel release of the temperature-stratified impounded water, saving significant cool water masses for mid-summer or late summer release during temperature-sensitive spawning and rearing periods. Reclamation's temperature model shows that August through November average monthly temperatures could be lowered 1 to 5°F through operation of a temperature curtain, providing cooler-than-existing water temperatures during critical periods. Reclamation is in the process of installing the temperature curtain and installation should be completed by 1990. "See Mitigation Measures" in the "Surface Water Quality" section of this chapter for a more detailed discussion.

Maintain High Fall/Winter Sacramento River Flows to Improve Chinook Salmon Spawning and Rearing Habitat. Reduced discharge causes significant spawning and rearing habitat area impacts under Alternatives 3, 4A/B, 4C/D, 6, and 7. November would be the worst month, followed by December and September. Although mitigation measures are suggested, impact reduction to less-than-significant levels requires more information than is currently available. Completion of the ongoing instream flow study by DFG will provide better information on spacial and temporal habitat needs, which will enable development of more effective mitigation.

Mitigation could entail combinations of activities including discharge pattern adjustment, development of instream spawning and rearing habitat available at reduced discharge levels (i.e., spawning channels), and hatchery production. Development of spawning and rearing habitat could involve additional discharge and habitat enhancement in Clear Creek, similar to the Clear Creek enhancement that occurred under Alternative 5. Hatchery production could be pursued if other mitigation measures failed to increase production of adults at the preproject level; however, it would not reduce impacts and may create additional impacts.

Maintain Current Shasta and Clair Engle Reservoir Sport Fishery Yields. A significant reservoir fisheries impact, caused by reduced surface area and increased water surface elevation fluctuation, would occur under Alternative 4D. Maintenance of major sport fishery yields (rainbow trout and sunfish [including bass]) at current levels through supplementation of natural production with hatchery-reared fish would reduce impacts to less-than-significant levels.

Site-Specific Impacts

The introduction to Chapter 4 describes Reclamation's approach to the development of site-specific mitigation measures, where necessary, in future environmental documents.

VEGETATION AND WILDLIFE

Introduction

This analysis focuses on the vegetation and wildlife resources of the SRSA that are most likely to be affected by water contracting alternatives. The effects of flow changes on lower Sacramento River riparian habitats and potential impacts to special-status species.

Land conversions in the SRSA and flow changes along rivers in the CVP system could directly or indirectly reduce the extent and quality of biological resources in the SRSA. The types of impacts and the mechanisms by which they operate are described below. The status of program compliance with the Endangered Species Act is presented in Chapter 7.

Habitat Reduction

Reductions in the extent of native habitats, development of significant natural communities such as wetlands or riparian habitats, and sites occupied by special-status species can be caused by three mechanisms:

- Facility siting including the construction of conveyance and distribution facilities, pump stations, canals, and other facilities could require the conversion of natural habitats.

- Land conversion to agricultural or urban uses may be induced by increased water deliveries or enhanced flood protection. On refuges, conversion of natural uplands to permanent or seasonal flooded wetlands could also eliminate important natural habitats or populations of special-status species.

- Canal upgrading (e.g. converting earth-lined canals to concrete-lined canals) or maintenance induced by an increased availability of CVP water could eliminate or degrade wetland or riparian habitats and dependent plant and wildlife species.

Changes in the Quality of Riparian Vegetation

Altered flows could change patterns and the magnitude of channel meandering, flood frequency and intensity, and sediment deposition. The growth and reproduction of riparian species, and hence the vigor of riparian communities, are directly influenced by these fluvial and geomorphic factors (see Chapter 3, "Affected Environment"). The effects of flow changes during winter, spring-early summer, and late summer-fall periods are discussed below. The effects of altered sediment loading, although interrelated with the mechanisms described above, are discussed separately.

Altered Winter Flow. Decreasing the magnitude and frequency of peak events and increasing the duration of bankfull or greater flows after major storms from December to March could adversely impact riparian vegetation and habitats.

Decreased Magnitude and Frequency of Peak Runoff. Lower instantaneous peak flows and reduced frequency and intensity of overbank flows can slow reproduction rates of riparian species, change community age class structure and density, and decrease community vigor (i.e., productivity). Low- and high-terrace communities are characterized by thick mulch layers, abundant down wood, dense entangled herb and vine undergrowth, and a dense tree canopy. Seed germination of dominant riparian species is either inhibited or prevented by these conditions, except in valley oak riparian forests. High-intensity floods remove and bury mulch and dense undergrowth, scour overflow channels across low and high terraces, expose bare soil, and create overstory openings where riparian species can germinate and establish.

Decreasing the magnitude and frequency of peak flows and reproduction rates on low and high terraces increases the proportion of older trees in established stands (Strahan 1984), but the density of large-stature trees may also decline. Without a source of new trees, the vigor and productivity of riparian communities could decline as established trees age and dense vine and herb undergrowth choke understory layers.

Flood scour associated with peak flows removes or buries newly established seedlings on gravel bars. Reduced flood scour therefore increases the survivability of gravel bar vegetation and the extent of vegetated gravel bars (Pelzman 1973). Dense vegetation stabilizes gravel bars of some rivers, causing river channels to downcut (Strahan 1987).

Decreased magnitude and frequency of peak flows changes patterns of meandering, bank erosion, point bar formation and overbank sediment deposition. These processes continuously rejuvenate the riparian corridor by providing a constant source of productive vegetation to replace less vigorous and aging tree communities. Older, less productive low-and-high terrace communities are eliminated by bank erosion. Flood disturbance, overflow channel formation, and sediment deposition create favorable conditions for the germination and growth of new plants in older stands showing declining productivities. Point bars are formed and gradually increase in height, thus creating habitat and conditions for the establishment of young growth willow and cottonwood communities.

Increased stabilization of a river within the existing channel could eliminate the habitat conditions under which riparian communities naturally develop. If the balance of hyrdologically induced habitat destruction and creation were shifted, a change in the proportion of riparian communities would be expected without these natural processes (Strahan 1984, 1987). Conceivably, the proportion of older, less productive communities would increase. Most concern is expressed over high-terrace sites because rates of loss appear to outstrip gains resulting from sediment deposition and gradual terrace formations (McGill 1979). These effects will lead to a decrease in the structural and compositional diversity of riparian communities (i.e., vigor) along river corridors.

Increased Duration of Bankfull Flow. High reservoir releases following major storm events increase the water saturation of river banks and the duration of exposure to

erosive flows, leading to increased rates of bank erosion and progressive bank failure, which in turn can require that artificial bank protection measures be increased, causing habitat loss and vegetation removal. A deficit of high-terrace vegetation could result where the river is confined by levees unless rates of terrace loss are balanced by new habitat being created locally throughout sediment deposition and terrace formation.

Altered Spring-Early Summer Flows. Altering the average discharge, the timing and frequency of peak flows, and the rates of flow change from April to July could impact riparian habitat.

Mean Discharge. Higher and more constant summer flows can increase bank erosion, which can lead to an increased need for artificial bank protection. Both factors could reduce the extent of high terrace habitat and vegetation. Rates of bank erosion during summer months are substantially lower than during peak winter flows (Buer et al. 1988); however, the long-term cumulative losses may be substantial.

Vegetation impacts could result when spring-early summer flows decline to a level lower than previously seen. Established plants seeking to thrive despite a more limited water resource and deeper floodplain aquifers are stressed by the lower flows (Smith 1988, Dains and Smith 1986).

Lower summer flows depress the elevation of the floodplain water table. Substantial declines in the amount and extent of riparian vegetation along the Carmel and Salinas Rivers resulted when summer flows were reduced by pumping water from floodplain aquifers (Groenveld and Griepentrog 1985; Holland pers. comm.). Vegetation losses theoretically occurred because less water was available to support plants in a water-limited environment, and because the plants could not adapt to the lower water table.

Riparian vegetation along creeks in the Sierra Nevada showed signs of physiological stress when summer flows were reduced but not eliminated (Smith et al. 1988; Taylor 1988). The effect was most acute during late summer and during years of low rainfall and creek discharge. White alders on high terraces were more stressed during summer than those on gravel bars (Dains 1988). Stressed plants are less productive, which reduces the vigor of riparian communities. Newly established seedlings along diverted streams were more stressed and vulnerable to death than established adults (McBride and Strahan 1984; Strahan 1987). The 1978-79 drought was believed responsible for a number of dead trees on terraces of the Sacramento River (McGill 1979).

Stress resulting from competition for water eliminates individual plants and certain nonadaptable species, reduces growth rates and net productivity, and could conceivably slow rates of community succession. A unit volume of water can support only a finite amount of vegetation if less water is available in the aquifer or if the soils dry earlier in the year, vegetation stress can be expected.

The net long-term effect of vegetation stress would change: 1) the amount and density of riparian vegetation, 2) the types and proportional acreage of riparian communities, 3) vegetation structure and composition, and 4) overall productivity and diversity (species and structure). Seedlings and mature plants high-terrace communities

would be most sensitive to stress from reduced flows. Tree seedlings and marsh vegetation along backwater ponds would also be sensitive to dewatering following reduced flows.

Decreased Flow Variability. Regulation and stabilization of late spring and early summer flows could change the conditions under which gravel bar communities establish. Under natural conditions gravel bars are gradually exposed by receding water levels, providing a wide, wetted margin for seedling establishment. Constant (regulated) flows confine the wetted margin to a narrower band. The density of seedlings on gravel bars of the Sacramento River was lower than along a comparably unregulated river (Strahan 1984).

Summer flow regulation may, however, compensate for the naturally high seedling mortality. Seedling survival on gravel bars is low under natural conditions because of desiccation by receding water levels, or because seedlings are inundated by flow increases (Strahan 1987; Brock 1987). Regulated spring-early summer flows may compensate for the high attrition associated with natural flow changes (Strahan 1984).

Lower flows can shift the location of the establishment zone where new seedlings are able to maintain contact with the aquifer throughout the dry summer (Lisle 1988; Trush, Conner, and Knight 1988). Seedling survival can be prevented if the establishment zone shifts to the active channel where sediment is mobilized by normal high winter flows (Lisle 1988).

Summer flow regulation may result in a change in the location, extent, and possibly the amount of seedlings that successfully establish on gravel bars. If flow regulation compensates for natural high mortality, and if the newly established plants can survive winter floods, then a net change may not be detectable. A reasonable and foreseeable result of flow regulation would arise with a change in the location and width of the zone where gravel bar vegetation establishes.

Summer flows may increase above previously existing conditions on small tributary streams utilized to return agricultural water. The extra water will increase the extent of riparian vegetation along affected reaches.

Rate of Flow Change. Rapid drops in flow levels can increase seedling mortality because of rapid soil desiccation and plant death. Established riparian plants are adapted for water uptake, not growth, and their roots are located within a specific zone relative to the water table. The differentiation of root meristems to facilitate growth requires time, and roots grow at finite rates, about 5 centimeters per day for cottonwood (Groenveld and Griepentrog 1985). Consequently, plants may not adjust fast enough to compensate for rapid drops in floodplain water table elevations (Brock 1987).

Established vegetation could conceivably adjust to a slight and gradual lowering of the water table if the rate of change allowed for a vegetation response, and if the water table was not depressed to levels below which root growth was constrained by soil conditions (Brock 1987).

Rapid drops in flow also expose saturated river banks, which are more prone to failure and collapse. As discussed above, artificial protection is often required following bank failure, which can also reduce the extent of high-terrace vegetation.

Timing and Frequency of Peak Flows. The establishment of vegetation on gravel bars is influenced by the timing of peak flows during early spring-early summer. Willow and cottonwood seed dispersal has evolved to coincide with the periods when springtime flows are receding, assuring that a wide band of wetted alluvium is available for seed germination. Substantially increased flows after seed germination can drown newly germinated seedlings (Strahan 1987). If repeated annually, the rate of establishment of gravel bar vegetation would then be reduced, possibly altering patterns of succession and proportions of different riparian communities.

Altered Late Summer-Fall Flows. Lower late summer-fall flows induce vegetation stress which in turn reduces community vigor, productivity, and seedling survival. High seedling mortality on gravel bars was attributed to late summer desiccation (Strahan 1984, Dains 1988). This effect would be enhanced by reduced flows and would be most pronounced during dry years.

Higher late summer-fall flows could also induce bank erosion if flow levels increase the exposure of high terraces to erosive forces of the river.

Altered Sediment Load. Sedimentation rates decline with the closure of dams. Sediment-free water released from dams, and higher velocity flows below dams, remove fine-grained sediment from reaches below dams (Kleinfelder & Associates 1984, Strahan 1987). The water retention and wicking capacity of fine-grained sediments help ensure the survival of gravel bar vegetation. Most, but not all streams, are reported to downcut following closure of dams (Kleinfelder & Associates 1984). Increased summer flows could contribute to further downcutting and reductions in the amount of fine-grained sediment deposited on gravel bars.

Interrelationship of Riparian Impact Mechanisms. The impacts described above will influence the longevity and reproduction of riparian plant species, hence the development of successional processes. The magnitude, and in some instances the direction of the resulting changes, are unpredictable given present levels of knowledge. Nonetheless, change that is proportional to the magnitude of the effect can be expected.

The above conclusion is substantiated by the dynamic cause-and-effect nature of processes in riparian ecosystems, and the interdependence of fluvial dynamics with vegetation type and success. Riparian species are adapted to specific natural riparian processes for successful growth and reproduction. River equilibrium is a dynamic process that continually reacts to changes in hydrologic conditions and sediment production. Water velocity, channel shape, and sediment transport capacity are adjusted in response to variation in discharge, channel and floodplain morphology, and sediment availability. This interdependence implies that fluvial changes will cause vegetation changes.

Changing the fluvial environment will probably alter rates of change, via succession, of pioneer and early successional communities to the late successional communities, and rates of loss of high-terrace communities via bank erosion. Such perturbations will change

the proportion of different riparian community types, and possibly the composition, age and vigor of individual stands. Where the fluvial environment is most altered, such as on leveed rivers with finite floodplains, successional processes may cease, eventually leading to the elimination of natural riparian plant communities that comprise the mosaic of habitats characteristic of productive riparian ecosystems.

High-terrace riparian communities appear most sensitive to flow changes because available evidence suggests that succession rates will decline and that rates of bank erosion and the need for bank protection will increase.

Reductions or elimination of point bar habitat along channelized or leveed portions of rivers may eliminate gravel bar communities that play a part in determining the structure and composition of low terrace plant communities. Channelized or leveed rivers could, theoretically, eventually undergo a near-total elimination of natural willow-cottonwood vegetation. Willow-cottonwood vegetation will establish only along narrow bands on river banks at the sustained spring-summer water level. Once established, little reproduction will occur in these bands because of heavy shading (Strahan 1987). These narrow riverbank bands of willow-cottonwood vegetation are very different from the dense and wide, multi-aged bands characteristic of gravel bars and low terraces.

As gravel bar formation ceases, the source of low terrace sites is coincidentally eliminated. Species characteristic of the low terrace communities will probably continue to reproduce on river banks, but these sites will not support the natural associations of species and will probably have less willow and cottonwood cover.

The proportion of senescent trees will increase in the low- and high-terrace communities because of reduced flood pruning and reduced reproduction rates within stands associated with lower flood intensity and sedimentation rates.

Natural riverine systems attain a dynamic equilibrium in frequency and magnitude of meander loops (Rosgen 1985, Heede 1986). Changing the flows, effects of flooding, and sedimentation rates will shift the equilibrium. The distribution and amount of different riparian communities varies in response to this equilibrium, which presumably establishes a balance between gains and losses in the number of different riparian communities.

Change in riparian ecosystems is constant and cyclic (Water Engineering Technology 1987) and basically unpredictable because of stochastic weather patterns. Flow regulation reduces this randomness by eliminating the sharp peaks and increasing the frequency and duration of average flows. This less dynamic environment will probably lead to a more stable riparian ecosystem with respect to the location and relative amounts of different riparian communities. Stabilization provides for short-term maintenance of most ecosystem functions, but eventually leads to senescence or death because reproduction is hampered and succession patterns changed. The riparian ecosystem of the Sacramento River is most productive and viable when a mosaic of communities is actively growing and gradually changing in structure and species composition. Viability of the riparian ecosystem depends upon a dynamic fluvial environment. Eventually stabilized, less dynamic riparian ecosystems will therefore be less productive because old stands lose their value to wildlife, resulting in a net loss of habitat and species diversity.

Predicting the effects of river flows on water tables, and hence on vegetation, is difficult with available data. Depending upon the magnitude and timing of change, established vegetation may survive but in a stressed condition, especially during dry years. The most dramatic impact of lower water tables on established vegetation is probably long term as stressed plants suffer from reduced productivity rates and eventually die. Hydrologically, changes can also eliminate sites where reproduction would occur. The most serious effect of a lowered water table is its influence on succession. Severe drawdown can eliminate reproduction or change the location of sites where reproduction can occur.

Riparian Communities Impact Assessment Methodology. The above discussion on riparian vegetation impact mechanisms illustrates the complex relationship between riparian vegetation structure and composition and river flow dynamics. Interpreting the relationship between flow changes and vegetation response is further complicated by the ongoing process of readjustments in vegetation and channel morphology caused by past river flow and sediment load changes, limited knowledge of riparian vegetation community dynamics, and the interactions among various impact mechanisms. Predicting the direction and magnitude of change in riparian vegetation changes is therefore imprecise.

Reclamation's Operation Planning Model was the only tool available to estimate river flows under each of the water contracting alternatives. It provided only mean monthly flow estimates. The model's limitations derive from the absence of data on peak and low flows which are obscured by the used mean monthly flows. Peak and low flows are important factors influencing the impact mechanisms described above.

The mean monthly flow data were analyzed in the following three ways:

- Mean monthly flows were graphed by alternative for three of the five-year types (critically dry, below normal, and wet).
- Percent change in mean monthly flow was calculated and compared with Alternative 1.
- Frequency of flows that duplicate past high and low flow conditions for each alternative was calculated and compared with the No-Action Alternative.

These data were used to qualitatively evaluate impacts to riparian vegetation for each alternative.

It was assumed that changes in the magnitude and frequency of peak flow events correlate with changes in winter mean monthly flows. A higher frequency of flows duplicating past wet year conditions is assumed to correlate with increases in high-terrace bank erosion. Higher frequencies of flows duplicating past critically dry and dry year flows during spring, summer, and fall months were assumed to correlate with increased stress on high-terrace vegetation.

Relationship of Wildlife Habitat to Riparian Vegetation

All of the impact types and mechanisms described above affect the amount and quality of habitat available to riparian-dependent wildlife species. For example, a large section of bank inhabited by bank swallows (near Sacramento River Mile 195.0) collapsed because of high flows in May 1988 and destroyed 624 out of 907 burrows (McKevitt pers. comm.). Efforts to protect banks from erosive flows (e.g., riprapping and bank stabilization) pose the greatest threat to nesting populations of bank swallows. Federal and state bank stabilization projects, if completed as currently proposed, would destroy the nesting habitat of 8,935 breeding pairs (about 55 percent of the Sacramento River population) during the next 5-10 years (Humphrey and Garrison 1986). Other bank-nesting species such as belted kingfishers and northern rough-winged swallows could also be adversely affected by these activities.

Reducing the acreage of riparian vegetation eliminates habitat for a diversity of dependent wildlife species including some with special status. For example, population numbers of yellow-billed cuckoos have declined dramatically and their range has contracted due to the loss and degradation of riparian habitats in the Central Valley (Laymon and Halterman 1987). Therefore, impacts that eliminate or degrade riparian vegetation will cause impacts to dependent wildlife proportional to the magnitude and extent of the vegetation impact.

No-Action Alternative

Regional 2020 Baseline Conditions

Riparian Habitat. The No-Action Alternative would result in only minor changes on upper Sacramento River flows except during spring and summer in dry and critically dry years. Mean monthly flows from Keswick Dam to the Red Bluff Diversion Dam would be reduced in dry and critically dry year types, and the frequency of these low flows would increase. These flow reductions would increase drought stress primarily on high terrace vegetation during years when drought stress is already severe. The effect of these changes would be somewhat buffered because mean spring and summer flows would be higher.

From the Red Bluff Diversion Dam downstream, the main riparian vegetation effects of flow modification associated with Alternative 1 would be caused by increased river flows in the spring, summer, and fall seasons. These flow increases could increase the amount of bank erosion occurring during summer due to high water levels. Increased bank erosion would cause losses of high-terrace riparian vegetation. Most of the loss would occur

from Red Bluff to Colusa because the river sinuosity is greater in this reach and there are more exposed banks with an overall higher proportion of riparian vegetation per river mile. From Colusa to the Delta, the river becomes more confined by levees, and riparian vegetation exists only in remnant strips. Increased summer flows could also induce bank erosion in this channelized reach at locations where the bank has not been riprapped; however, the net volume of vegetation potentially affected is small compared to the reach from Red Bluff to Colusa.

Biological Communities and Special-Status Species. Under the No-Action Alternative, none of the requesting agencies or wildlife refuges would receive CVP water. Changes to biological communities and special-status species would be minimal in the Shasta Dam Area Public Utility District and the Sacramento Valley Canals agencies because few land conversions would occur. Substantial effects on biological communities would occur in the Yolo-Solano CVP Water Service Coordinating Group because growth in these municipalities is not limited by CVP water. Under the No-Action Alternative the state and federal wildlife refuges would not continue to receive interim CVP water. All artificial wetland acreage would be lost, producing adverse effects to waterfowl, waterbirds, and special-status plant and wildlife species.

Site-Specific 2020 Baseline Conditions

Shasta Dam Area Public Utility District. This agency has no substantial alternative water supplies. Without CVP water, future growth is unlikely to occur. Thus, changes to biological communities or special-status plants and wildlife in this agency are not expected.

Sacramento Valley Canals Agencies. Within this group, only the Holthouse Water District would increase irrigated acreage before 2020 without CVP water. Biological communities and special-status plants and wildlife known to occur in this agency could be adversely affected.

Yolo-Solano CVP Coordinating Group. M&I agencies in this group are expected to grow without the provision of CVP water since alternate supplies are available. Changes to biological communities and special-status plants and wildlife are anticipated under this alternative (Appendix VI, Tables J, K, and L). Yolo County Flood Control and Water Conservation District is an agricultural agency, and without CVP water no land use changes are projected (Appendix VI, Tables J, K, and L).

Biological Communities. Within urban agencies, changes are projected for riparian, wetland, and terrestrial plant communities. Approximately 651,000 linear feet of riparian, 1,600 acres of wetlands, and 39,000 acres of terrestrial habitats could potentially be converted to urban uses under the No-Action Alternative. Claypan vernal pools and alkali meadows, both seasonal wetlands, also occur in proposed development areas (Appendix VI, Table J).

Special-Status Plant Species. Three special-status plants are known and another 21 could occur within the proposed development areas (Appendix VI, Table K). These plants could be adversely affected by this development.

Special-Status Wildlife Species. Eight special-status wildlife species are known to occur and another 11 may occur within the proposed development areas (Appendix VI, Table L). These species could be adversely affected by habitat loss.

Refuges. Under this alternative state and federal wildlife refuges would no longer receive interim water supplies. Thus, no artificially maintained wetlands would exist in the refuges.

Biological Communities. Without water, terrestrial communities would replace wetland communities. Marshes and open water acreage would decrease by approximately 19,000 acres, creating 21,000 acres of abandoned lands that would slowly revert to terrestrial habitats (Appendix VI, Table M).

Special-Status Plant Species. Loss of wetland communities would adversely affect one known special-status plant and could possibly affect an additional nine species that may occur in the refuges (Appendix VI, Table N).

Special-Status Wildlife Species. Eight special-status wildlife species are known, and another could be present in the refuges (Appendix VI, Table O). These species would be adversely affected by the loss of wetland habitats.

Alternative 1

Regional Impacts

Riparian Habitat. Alternative 1 - Option A would have only minor impacts on riparian vegetation along the Sacramento River. No significant changes beyond those described under the No-Action Alternative would occur in winter mean monthly flows on any of the river reaches. From Keswick to Red Bluff there would be a slight increase in the mean monthly flows during the fall period in dry years. However, the frequency of dry or critically dry year type low flows would be slightly reduced on this reach. High-terrace communities would therefore be slightly less stressed than under the No-Action Alternative.

Below the Red Bluff Diversion Dam there would be minor reductions in spring, summer, and fall flows. These reductions would partially offset the erosion impacts of high flows identified under the No-Action Alternative. The net impact of the Alternative 1 - Option A on riparian communities would not be significant.

Alternative 1 - Option B would increase mean monthly winter flows during critically dry and dry years and reduce flows in wet years in the river reach from Keswick Dam to the Red Bluff Diversion Dam. Spring, summer, or fall flows would not change significantly, and the frequency of dry year type flows would not change under this alternative. Riparian communities would not be affected substantially by these minor changes in flow along this river reach.

Below the Red Bluff Diversion Dam mean monthly winter flows would be reduced, as compared to the No-Action Alternative, resulting in a negative effect on vegetation. Spring and summer flows would also be reduced; this also would reduce the summertime bank erosion impacts of high summer flows identified under the No-Action Alternative.

These flow modifications below Red Bluff Diversion Dam would probably change the location and reduce the extent of gravel bar communities. Low-terrace communities would probably be less productive, and high-terrace vegetation could undergo reductions in density and changes in structure and composition leading to long-term community senescence and increases in proportion of older, less dense, and less productive stands. These riparian vegetation impacts are considered significant.

Biological Communities and Special-Status Species. Under Alternative 1 (Options A and B), all agencies would receive 100 percent of their water needs. Within the SRSA, CVP water would be used for new agricultural production, M&I uses, and for refuge management. Compared to the No-Action Alternative, an additional approximately 446,000 linear feet of riparian habitat, 1,200 acres of wetlands, and 24,000 acres of terrestrial habitat would be converted to agricultural and M&I uses within the Shasta Dam Public Utility District, Sacramento Valley Canals agencies, and the Yolo-Solano CVP Water Service Coordinating Group (Appendix VI, Table P). Approximately 24 additional special-status plants and also 14 special-status wildlife species could be adversely affected under Alternative 1 (Options A and B). These impacts would be significant.

Aside from reconnaissance-level surveys of the federal refuges, site-specific surveys were not conducted on any lands within this service area. It is not known whether land conversions in individual agencies would actually affect mapped resources. However, possible loss or degradation of riparian habitats, wetlands, native vegetation, and special-status plant and wildlife species were considered potentially significant impacts under each alternative, including Alternative 1. Under each alternative, wildlife populations were assumed to decline in proportion to projected habitat losses. Therefore, everywhere impacts to wetlands, riparian habitats, and terrestrial habitats were identified, it was assumed that commensurate declines in dependent wildlife populations could occur.

Site-Specific Impacts

Shasta Dam Public Utility District. Under Alternative 1, it was assumed that deliveries of CVP water would be used for M&I growth in this agency.

Biological Communities. Within this district, additional impacts to riparian, wetland, and terrestrial biological communities are projected. Approximately 52,000 linear feet of riparian habitat, 80 acres of wetlands, and 5,600 acres of terrestrial habitats would be potentially impacted compared to the 2020 No-Action conditions. These impacts would be significant (Appendix VI, Table P).

Special-Status Plant Species. Although no special-status plant species are known to occur within this district, approximately 10 additional species could be adversely affected because potential habitat exists within proposed conversion areas. These impacts would be significant (Appendix VI, Table Q).

Special-Status Wildlife Species. Although no special-status wildlife species are known to occur within this district, approximately eight additional species could be adversely affected because a potential habitat exists within proposed conversion areas. These impacts would be significant (Appendix VI, Table R).

Sacramento Valley Canals Agencies. Under Alternative 1 all of the 11 requesting agencies would use CVP water to expand irrigated acreage. Within the Sacramento Valley Canals agencies, Rancho Saucos and Yolo-Zamora are the only water agencies where no significant impacts to biological communities and special-status plants and wildlife are anticipated (Appendix VI, Table D).

Biological Communities. Within these agencies, significant impacts to riparian, wetland, and terrestrial communities, in addition to those under the No-Action Alternative, are projected. Approximately 327,000 linear feet of riparian, 1,100 acres of wetland, and 16,000 acres of terrestrial habitats could potentially be converted to agricultural uses under Alternative 1. Impacts to hardpan and claypan vernal pools and alkali meadows could also occur under this alternative. These impacts would be significant (Appendix VI, Table P).

Special-Status Plant Species. One special-status plant is known to occur within proposed conversion areas in these districts and 23 additional species could be adversely affected by Alternative 1 because of their potential occurrence in areas proposed for land conversions. These impacts would be significant (Appendix VI, Table P).

Special-Status Wildlife Species. Four special-status wildlife species are known to occur within these districts and 10 additional species could be adversely affected by Alternative 1 because of their potential occurrence in areas proposed for land conversions. These impacts would be significant (Appendix VI, Table R).

Yolo-Solano CVP Water Service Coordinating Group. Under Alternative 1, the Yolo County Flood Control and Water Conservation District would use CVP water to expand irrigated acreage and all other agencies would use this water for M&I growth. No biological impacts resulting from land conversions are expected in cities in the Yolo-Solano CVP Water Service Coordinating Group beyond those previously described under the No-Action Alternative.

Biological Communities. Within the Yolo County Flood Control and Water Conservation District, approximately 67,000 linear feet of additional riparian habitat could be adversely affected due to land conversions associated with the provision of CVP water. In this district, no changes are projected for wetland habitats but approximately 2,200 acres of terrestrial habitats, including claypan and hardpan vernal pools, could be adversely affected (Appendix VI, Table P). These impacts would be significant.

Special-Status Plant Species. Although no special-status plants are known to occur within this agency, 16 additional special-status plants could be adversely impacted by provision of CVP water to the Yolo County Flood Control and Water Conservation District (Appendix VI, Table Q). This impact would be significant.

Special-Status Wildlife Species. The valley elderberry longhorn beetle is known from the Yolo County Flood Control and Water Conservation District (California Natural Diversity Data Base 1987) and could be adversely affected. The Swainson's hawk may occur within this district and could also be adversely affected (Appendix VI, Table R). These impacts would be significant.

Refuges. Under Option A, refuge water supplies would be used to flood approximately 20,500 acres of permanent and seasonal wetlands and for some crop production, compared to the No-Action Alternative. Approximately 2,500 acres of new wetland habitat would be created on the refuges under Option B compared to Option A. Additional water would also be used to lengthen inundation periods of existing wetlands for waterfowl brooding habitat and for waterfowl food production.

Biological Communities. Under Option A, beneficial impacts to biological communities are anticipated since wetland acreages would be increased substantially compared to the No-Action Alternative conditions (Appendix VI, Table S). Under Option B, creating new wetlands would benefit native vegetation and wildlife (especially waterfowl and other water birds), but some special-status plants, alkali meadows, and vernal pools could be adversely affected. These impacts would be significant (Appendix VI, Table T).

Special-Status Plant Species. No impacts are anticipated for special-status plants under Option A. Under Option B, however, 17 special-status plants (two species with a known occurrence and 15 species with a potential occurrence) could be adversely affected by flooding of 2,500 acres of upland habitats to create new wetlands. These impacts would be significant (Appendix VI, Table U).

Special-Status Wildlife Species. No impacts to special-status wildlife are anticipated under either Option A or B. Special-status wildlife would benefit from the creation of new wetlands on the refuges.

Alternative 2

Regional Impacts

Riparian Habitat. The impacts of Alternative 2 on the riparian vegetation of the Sacramento River are identical to those described under Alternative 1 - Option A and are therefore considered less than significant.

Biological Communities and Special-Status Species. Under Alternative 2, the Sacramento Valley Canals agencies would be allocated 76 percent of their identified CVP water needs. Yolo-Solano agencies and refuges would not receive any CVP water. Although agricultural agencies would receive only 76 percent of their requests, this analysis assumes that the full land conversions proposed by the agencies would occur. This assumption was made because the specific locations of land use conversions under this alternative were unknown.

Significant impacts, in addition to those under the No-Action Alternative, could occur on lands converted to irrigated agriculture. As much as 370,000 linear feet of riparian habitat, 1,100 acres of wetland communities, and 16,000 acres of terrestrial communities could be adversely affected (Appendix VI, Table V). Thirty-seven special-status species could be affected by conversions of habitats known or with the potential to support them.

Site-Specific Impacts

Shasta Dam Area Public Utility District. This agency would receive 100 percent of its water need. Biological impacts within this district are identical to those described under Alternative 1. These impacts would be significant (Appendix VI, Table V).

Sacramento Valley Canals Agencies. Twelve agencies would receive 76 percent of their needs and two would receive 100 percent. Biological impacts within these districts are identical to those described under Alternative 1. Biological impacts would be significant (Appendix VI, Table V).

Yolo-Solano CVP Water Service Coordinating Group. These agencies would receive no CVP water. No significant impacts would occur.

Refuges. No changes would occur beyond those identified in the No-Action Alternative.

Alternative 3

Regional and Site-Specific Impacts

Riparian Habitat. Under this alternative there would be no significant changes in water flows from Keswick Dam to Red Bluff Diversion Dam as compared to the No-Action Alternative. Spring and summer flows would increase slightly, partially offsetting the adverse erosion effects of the No-Action Alternative. Frequency of dry year type flows would be reduced, also reducing vegetation stress. The net impact of this alternative on the riparian communities between Keswick Dam and Red Bluff Diversion would be less than significant.

Below Red Bluff Diversion Dam the river mean monthly flows would be reduced in winter and summer months. This would reduce the rate of bank erosion, and thus the loss of vegetation, but would result in such adverse impacts as reductions in the extent of gravel bar communities, long-term community senescence, and increases in the proportion of older, less dense and less productive stands. These riparian vegetation impacts are considered significant.

Biological Communities and Special-Status Species. Regional and site-specific impacts under this alternative would be identical to Alternative 1. Significant biological impacts would occur in the Shasta Dam Public Utility District, Sacramento Valley Canals agencies, and the Yolo-Solano CVP Water Service Coordinating Group. Impacts to wildlife

refuges would be beneficial. Site-specific biological impacts are described in Appendix VI, Tables P, Q, and R.

Alternative 4 A/B

Regional Impacts

Riparian Habitat. The impacts of Alternative 4 A/B on the riparian vegetation of the Sacramento River are identical to those described under Alternative 1 - Option A and are therefore considered less than significant.

Biological Communities and Special-Status Species. Impacts under Alternative 4 A/B would be identical to those described under Alternative 2, except that refuges would receive Level 4 supplies, resulting in significant impacts identical to those described under Alternative 1 - Option B.

Site-Specific Impacts

Shasta Dam Area Public Utility District. This agency would receive 100 percent of requested water. Biological impacts within this district are identical to those described under Alternative 1. These impacts would be significant (Appendix VI, Table V, W, and X).

Sacramento Valley Canals Agencies. Biological impacts would be identical to those described under Alternative 1 and would be significant (Appendix VI, Tables V, W, and X).

Yolo-Solano CVP Coordinating Group. These agencies would receive no CVP water. No significant impacts would occur.

Refuges. Refuges would receive Level 4 water supplies, allowing them to operate under optimal management conditions. Biological impacts would be identical to Alternative 1 - Option B. The increase in wetland area (23,000 acres) would have positive effects on wildlife and wetland plants, but may adversely affect some terrestrial special-status plants. This impact would be significant (Appendix VI, Table Y).

Alternative 4 C/D

Regional Impacts

Riparian Habitat. Under this alternative, annual fluctuation in winter river flows in the Keswick Dam to Red Bluff Diversion Dam reach would be reduced because dry year mean monthly flows would increase and wet year mean monthly flows would decrease during this period. Spring and summer flows in this reach would increase but not to a

degree that would significantly affect bank erosion rates. Gravel bar communities may be reduced in extent by these flow modifications.

Below the Red Bluff Diversion Dam, identical flow modifications would occur but impacts to vegetation would be different. Like the upper reach, the extent of gravel bar vegetation would be reduced. However, unlike the upper reach, increases in spring and summer flows could substantially increase summer erosion due to the higher susceptibility of this reach to erosion. The effect would be a reduction in the extent of gravel bar communities, reduced productivity in low terrace communities, and a reduction in the extent of high terrace communities. These riparian community impacts are considered significant.

Biological Communities and Special-Status Species. Under Alternative 4 C/D, the Sacramento Valley Canals agencies, Shasta Dam Public Utility District, and Yolo-Solano Flood Control and Water Conservation District would not receive requested CVP water supplies and no significant site-specific biological impacts would occur. No adverse CVP-induced site-specific biological impacts are anticipated under Alternative 4 C/D.

Site-Specific Impacts

Shasta Dam Area Public Utility District. This agency would not receive CVP water and no land use changes would occur; therefore, there would be no significant biological impacts.

Sacramento Valley Canals Agencies. These agencies would not receive CVP water and no land use changes would occur; therefore, there would be no significant biological impacts.

Yolo-Solano CVP Water Service Coordinating Group. These agencies would receive no CVP water and no land use changes would occur; therefore, there would be no significant biological impacts.

Refuges. Refuges would receive Level 2 supplies. Biological impacts would be identical to Alternative 1 - Option A. No significant impacts are anticipated.

Alternative 5

Regional Impacts

Riparian Habitat. Flow modifications under Alternative 5 would be similar for all the river reaches. Winter flows would be significantly higher in dry and critically dry years than under the No-Action Alternative. Spring and summer flows would be lower than those of the No-Action Alternative, and would resemble the 1985 base conditions. Fall flows would be slightly higher from Keswick Dam to Red Bluff Diversion Dam and lower downstream of the diversion dam than flows under the No-Action Alternative. The frequency of dry year flows would increase slightly, however.

The probable vegetative response to flows under this alternative would be beneficial as compared to those of the No-Action Alternative. Gravel bar communities would probably be less affected, lower terrace vegetation reproductive rates would increase, and stress to upper terrace vegetation would be reduced as compared to the No-Action Alternative. Winter erosion of upper terrace communities could increase, however. The net impact on riparian communities would be beneficial.

Biological Communities and Special-Status Species. Under Alternative 5, no land use changes would occur within agricultural or M&I agencies beyond those described under the No-Action Alternative, and no significant biological impacts would occur. Refuges would receive Level 4 supplies, sufficient to operate under optimal management conditions, but could experience significant impacts to special-status species, as described for Alternative 1 - Option B.

Site-Specific Impacts

Shasta Dam Area Public Utility District. This agency would receive no CVP water. No significant biological impacts would occur.

Sacramento Valley Canals Agencies. These agencies would receive no CVP water. No significant biological impacts would occur.

Yolo-Solano CVP Water Service Coordinating Group. These agencies would receive no CVP water. No significant biological impacts would occur.

Refuges. Refuges would receive Level 4 water supplies, allowing them to operate under optimal management conditions. Biological impacts would be identical to the Alternative 1 Option B. The increase in wetland area (23,000 acres) would have positive impacts to wildlife and wetland plants, but may adversely affect some terrestrial special-status plants (Appendix VI, Table Y). If this impact occurs, it would be significant.

Alternative 6

Regional and Site-Specific Impacts

Riparian Habitat. Under this alternative, winter flows in both the Keswick Dam-to-Red Bluff Diversion Dam reach and the reach below Red Bluff Diversion Dam would vary less on an annual basis as compared to the No-Action Alternative conditions. Dry year flows would be increased and wet year flows would be decreased, thereby leading to more even flows year to year. There would be little change in spring and summer flows. The frequency of dry year type flows would decrease in the Keswick Dam to Red Bluff Diversion Dam reach and would remain unchanged downstream. These flow modifications are considered to have a less-than-significant impact on riparian communities.

Biological Communities and Special-Status Species. Other regional and site-specific impacts under that alternative are identical to those described under Alternative 4A/B.

Alternative 7

Regional and Site-Specific Impacts

Riparian Habitat. Sacramento River flows under Alternative 7 vary little from the No-Action Alternative conditions. Mean monthly spring and summer flows in the Keswick Dam to Red Bluff Diversion Dam reach would decrease slightly and the frequency of dry year type flows would increase slightly in this reach. These flow modifications are considered too small in magnitude to significantly impact the riparian communities on the Keswick Dam to Red Bluff Diversion Dam reach. There would be no substantial flow modifications below Red Bluff Diversion Dam, and thus no significant riparian community impacts.

Biological Communities and Special-Status Species. Other regional and site-specific impacts under the alternative are identical to those described under Alternative 5. Potentially significant impacts to special-status species could occur on refuges.

Mitigation Measures

Regional Impacts

Compensate for Impacts to Biological Communities Resulting from Changes in Sacramento River Flows. Flow changes associated with Alternative 1 - Option B and Alternative 4 C/D could significantly the extent and quality of riparian habitats. Reclamation could incorporate the concepts described below to compensate for losses resulting from this project and to assist in the recovery of riparian habitats, thereby helping to arrest future acreage declines.

- Participate in the establishment of preserves along the Sacramento River. For example, a Middle Sacramento River Refuge has been proposed by Houghton and Michny (1988), and The Nature Conservancy and DFG are exploring preservation options along the Sacramento and Feather Rivers. Reclamation could promote these concepts, fund additional feasibility studies, and fund land acquisition ventures.

- Monitor acreage of riparian habitats and of various riparian communities for long-term changes. If substantial declines caused by flow modification occur in areas where natural recovery is not assured, Reclamation could fund or assist in funding measures to compensate for new acreage declines by planting riparian vegetation and establishing conservation easements on private land.

- o Coordinate with COE to help establish a new COE policy for bank protection projects that recognizes combined objectives of flood control, protection of private and public property, and maintenance and protection of riparian habitat.

Reclamation could also compensate for adverse impacts by enacting measures that arrest acreage declines caused by other non-Reclamation projects. For example, conservation easements could be established on private lands to prevent clearing riparian vegetation for agricultural land conversion; bank protection projects could use techniques that minimize vegetation and habitat losses; and studies could be developed to document the effects of vegetation establishment on banks protected with rock revetment. Should such studies disclose that vegetation on rock revetment does not substantially threaten the structural integrity of artificial banks, Reclamation could promote policy changes to allow revegetation of rock revetment.

Site-Specific Impacts

The introduction to Chapter 4 describes Reclamation's approach to the development of site-specific mitigation measures, where necessary, in future environmental documents.

RECREATION

Introduction

This analysis of the recreational impacts of CVP water contracting alternatives focuses on variations in water-dependent recreational visitation at eight CVP sites. They are: Shasta Reservoir, Clair Engle Reservoir, the Sacramento River, the Sacramento National Wildlife Refuge, Colusa National Wildlife Refuge, Delevan National Wildlife Refuge, Sutter National Wildlife Refuge, and Gray Lodge Wildlife Management Area.

Hydrologic changes associated with the various alternatives, and variations in demand for visitation resulting from such hydrologic changes, are essentially confined to these sites. The hydrologic conditions of other CVP sites within the SRSA, such as Whiskeytown Reservoir and Keswick Reservoir, are not expected to be significantly affected by the water contracting alternatives.

In this analysis, water-dependent activities are assumed to include boating, fishing, swimming, and picnicking for Shasta Reservoir, Clair Engle Reservoir, and the Sacramento River, and hunting and nonconsumptive uses at the wildlife areas. Demand for other activities often classified as water enhanced, such as camping and hiking, could also change in response to water supply, but demand changes for these activities associated with the range of water supplies being considered are assumed to be minor.

Recreation impacts of the considered alternatives were assessed using the QED Research, Inc. Freshwater Recreation Demand Model (Wade et al 1988) and an economic model of hunting participation at Central Valley wildlife refuges (Loomis and Cooper 1988). The QED Research, Inc. model projects visitation to California's freshwater recreation sites by county of origin in relation to relative travel costs and attractiveness of sites. CVP water contracting alternatives are assumed to affect recreation visitation by changing the relative attractiveness and capacity of sites through variations in streamflow and reservoir levels. Limitations of the QED Research, Inc. model as developed for this analysis are:

- The model does not directly consider the effects of changes in fishery resources on recreation demand although it does consider changes in fishing activity caused by changes in flows and reservoir levels.

- The model does not directly account for any changes in the recreation demand resulting from aesthetic changes in landscapes surrounding recreation sites caused by shifts in the hydrologic regime.

- The model considers visitation changes only at recreation sites impacted by changes in streamflows or reservoir levels.

The QED Research, Inc. model was applied to each alternative using hydrologic data corresponding to median water supplies, (i.e., streamflows and reservoir levels) that

were exceeded in 29 of the 57 years of hydrologic record. These conditions were considered to represent a "normal" water year.

The waterfowl hunting model used historical hunting use and water supply data from the refuges and wildlife management areas considered in this analysis. Hunting use was found to have a statistically significant relationship to water supply for the hunting areas studied.

Impacts of flow changes in the Trinity River were not analyzed with the QED Research, Inc. model because, with the exception of Alternative 7, none of the alternatives would change Trinity River flows, relative to the No-Action Alternative. Alternative 7, which emphasizes recreation, allocates an incremental 500 cfs in the Trinity River during July, August, and September. This flow increment is expected to enhance water-dependent recreational use at the Trinity River. Increases in Trinity River recreation under Alternative 7 are estimated based on an analysis of changes in visitation with respect to streamflow changes at the Sacramento River by QED Research, Inc. (1988). This analysis found that a 1-percent change in summer streamflow resulted in increases in visitation ranging from 0 to 0.24 percent (Johns pers. comm.).

For reservoirs, significance of impacts that would result from adoption of each alternative was determined using the following criteria pertaining to average monthly reservoir volumes associated with normal (i.e., 50-percent probability of exceedence) water years. For Shasta Reservoir, impacts were considered significant if the average reservoir volume in August would be less than 3,230,000 af. For Clair Engle Reservoir, impacts were considered significant if the average August reservoir volume would be less than 1,700,000 af. These criteria are based on water levels below which costly movements in marina facilities are required to maintain their operability. Because these reservoirs typically contain progressively less water as the summer advances, the last full month of the summer season was used in the significance test. Figures 4I-1 and 4I-2 present August storage exceedence curves for Shasta and Clair Engle Reservoirs, respectively, based on hydrologic modeling.

Significance of recreation impacts on the Sacramento River and at waterfowl hunting areas was determined based on projected changes in recreation visitation. Impacts were considered significant if annual visitation would be less than 90 percent of visitation expected to occur in 2020 under the No-Action Alternative.

No-Action Alternative

Regional 2020 Baseline Conditions

Water-dependent recreational use at the eight CVP sites within the SRSA considered in this analysis totalled 7,250,000 visitor-days in 1985. Total use under the No-Action Alternative in 2020 was projected to be 14,070,000 visits (Table 4I-1). The change in recreation use between 1985 and 2020 is attributable primarily to the positive effect of projected increases in California population and income, tempered somewhat by the negative effect of reduced water supplies associated with full delivery of volumes currently contracted for.

Table 4I-1. Estimated Changes in Visitor Days at Selected Reservoir Sites: Sacramento River Service Area

Alternative	Sacramento River	Shasta Reservoir	Clair Engle Reservoir
No Action			
Total Number of Visitor Days	2,765,000	8,768,000	2,433,000
1B			
Total Number of Visitor Days	2,717,000	7,661,000	2,867,000
Change	(48,000)	(1,107,000)	434,000
Percent Change	(2)	(13)	18
2			
Total Number of Visitor Days	2,737,000	8,545,00	2,420,000
Change	(28,000)	(223,000)	(13,000)
Percent Change	(1)	(3)	(1)
3			
Total Number of Visitor Days	2,791,000	8,347,000	2,430,000
Change	26,000	(421,000)	(3,000)
Percent Change	1	(5)	(0)
4A/B			
Total Number of Visitor Days	2,792,000	7,906,000	2,498,000
Change	27,000	(862,000)	65,000
Percent Change	1	(10)	3
4C/D			
Total Number of Visitor Days	2,787,000	8,047,000	1,880,000
Change	22,000	(721,000)	(553,000)
Percent Change	1	(8)	(23)
5			
Total Number of Visitor Days	2,734,000	8,216,000	1,922,000
Change	(31,000)	(552,000)	(511,000)
Percent Change	(1)	(6)	(21)
6			
Total Number of Visitor Days	2,783,000	7,990,000	2,499,000
Change	18,000	(778,000)	66,000
Percent Change	1	(9)	3
7			
Total Number of Visitor Days	2,766,000	8,945,000	2,475,000
Change	1,000	177,000	42,000
Percent Change	0	2	2

Note: Parentheses indicate negative change
Changes shown are from the No-Action Alternative

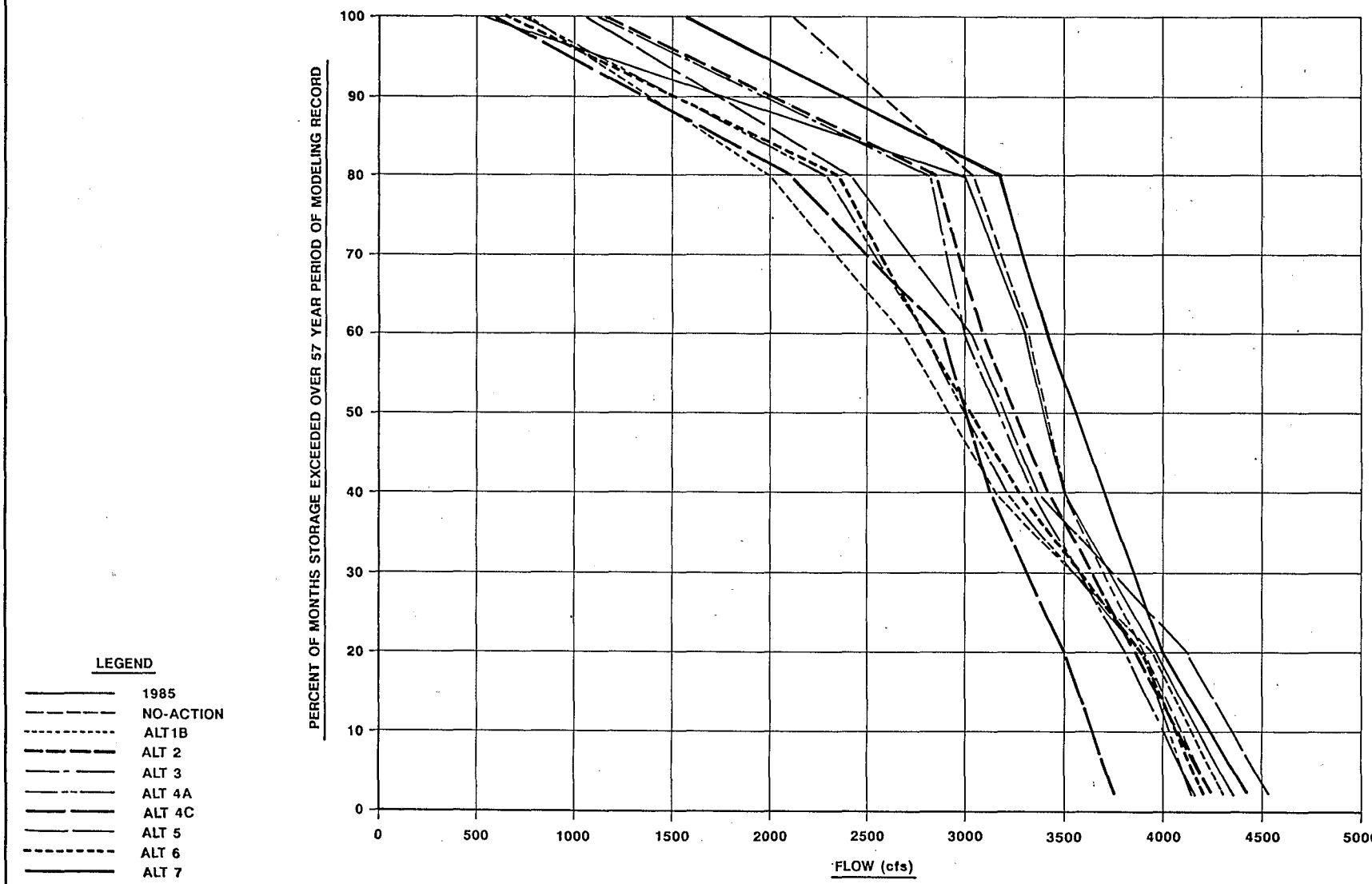

FIGURE 4I-1
EXCEEDANCE CURVES FOR AUGUST STORAGE
SHASTA RESERVOIR

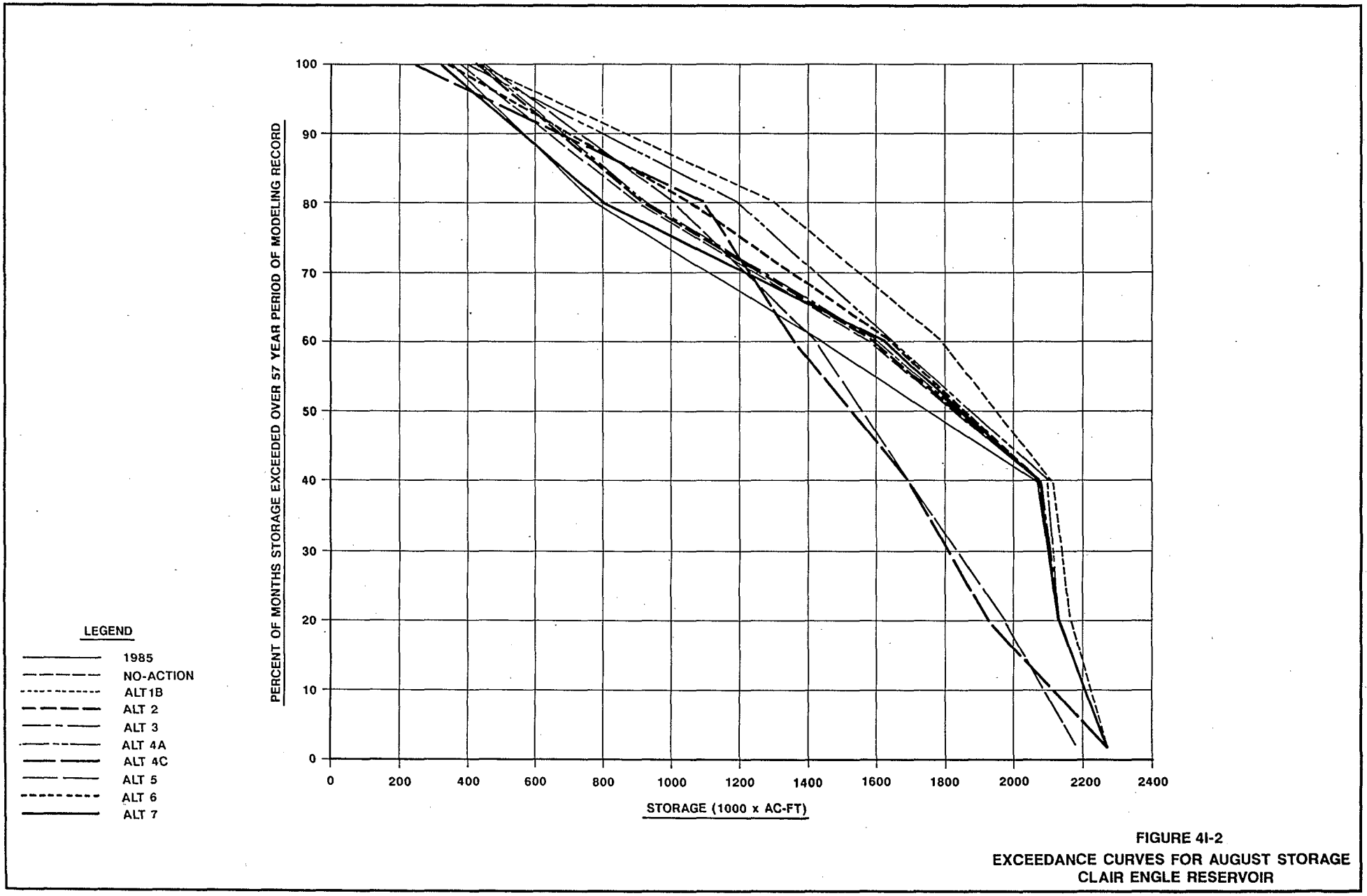

FIGURE 4I-2
EXCEEDANCE CURVES FOR AUGUST STORAGE
CLAIR ENGLE RESERVOIR

C-055769

Recreation Site 2020 Baseline Conditions

Shasta Reservoir. Water-dependent recreational use at Shasta Reservoir was about 4,107,000 visitor-days in 1985. Use would increase to 8,768,000 by 2020 under the No-Action Alternative. This increase is due almost entirely to demographic forces, since monthly average reservoir levels in normal water years under the No-Action Alternative differ from their historical averages by a maximum of only 44,000 af.

Clair Engle Reservoir Water-dependent recreational use at Clair Engle Reservoir was about 1,372,000 visitor-days in 1985. Use is projected to increase to 2,433,000 visitor-days in 2020 under the No-Action Alternative. Under the No-Action Alternative, normal water-year reservoir volumes would exceed their historical averages in every month.

Sacramento River. Water-dependent recreational use on the Sacramento River between Keswick Reservoir and the Yolo-Solano County boundary would total 2,765,000 visitor-days under the No-Action Alternative in 2020 compared with 1,589,600 visitor-days in 1985, a 73 percent increase. Approximately 23 percent of this use would occur in the upper reach, 21 percent in the middle reach, and 56 percent in the lower reach.

Trinity River. Water-dependent recreational uses on the Trinity River between Lewiston Dam and the confluence with the North Fork totaled 72,000 visitor-days in 1985. Under the No-Action Alternative, recreational visitor-days are projected to increase to 111,600, a 55-percent increase. This increase is attributable to projected increases in California population and income.

Colusa National Wildlife Refuge. By 2020, interim water supplies would no longer be available under the No-Action Alternative, thereby largely eliminating waterfowl hunting and other recreational uses at Colusa National Wildlife Refuge (Table 4I-2).

Delevan National Wildlife Refuge. Recreational use would be largely eliminated by 2020 under the No-Action Alternative due to elimination of interim water supplies.

Sacramento National Wildlife Refuge. No recreation would occur at the Sacramento National Wildlife Refuge by 2020 under the No-Action Alternative because interim water supplies would be discontinued.

Sutter National Wildlife Refuge. Under the No-Action Alternative, recreation would be eliminated by 2020 due to discontinuation of interim water supplies.

Gray Lodge Wildlife Management Area. Under the No-Action Alternative, hunting at Gray Lodge would total 20,828 visitor-days and nonconsumptive uses would total 129,037 visitor-days by 2020. Use levels in 1985 were 29,800 and 104,078 visitor-days for consumptive and nonconsumptive recreation, respectively.

Table 4I-2. Estimated Changes in Visitor Days at Wildlife Refuges: Sacramento River Service Area

Alternative	Sacramento National Wildlife Refuge		Colusa National Wildlife Refuge		Delavan National Wildlife Refuge		Gray Lodge National Management Area		Sutter National Wildlife Refuge	
	Waterfowl Hunting	Non-Consumptive Uses	Waterfowl Hunting	Non-Consumptive Uses	Waterfowl Hunting	Non-Consumptive Uses	Waterfowl Hunting	Non-Consumptive Uses	Waterfowl Hunting	Non-Consumptive Uses
No Action										
Total Number of Visitor Days	0	0	0	0	0	0	20,828	83,250	0	0
1B										
Total Number of Visitor Days	6,482	33,000	4,061	3,100	6,216	2,200	32,534	168,000	3,540	0
Change	6,482	33,000	4,061	3,100	6,216	2,200	11,706	84,750	3,540	0
Percent Change	N/A	N/A	N/A	N/A	N/A	N/A	56	102	N/A	N/A
2										
Total Number of Visitor Days	0	0	0	0	0	0	20,828	83,250	0	0
Change	0	0	0	0						
Percent Change	N/A	0	0	0						
3										
Total Number of Visitor Days	6,319	32,900	4,061	3,100	5,608	2,200	29,800	135,400	3,117	0
Change	6,319	32,900	4,061	3,100	5,608	2,200	8,972	52,150	3,117	0
Percent Change	0	N/A	N/A	N/A	N/A	N/A	43	63	N/A	N/A
4A/B										
Total Number of Visitor Days	6,482	33,000	4,061	3,100	6,216	2,200	32,534	168,000	3,540	0
Change	6,482	33,000	4,061	3,100	6,216	2,200	11,706	84,750	3,540	0
Percent Change	N/A	N/A	N/A	N/A	N/A	N/A	56	102	N/A	N/A
4C/D										
Total Number of Visitor Days	6,319	32,900	4,061	3,100	5,608	2,200	29,800	135,400	3,117	0
Change	6,319	32,900	4,061	3,100	5,608	2,200	8,972	52,150	3,117	0
Percent Change	N/A	N/A	N/A	N/A	N/A	N/A	43	63	N/A	N/A
5										
Total Number of Visitor Days	6,482	33,000	4,061	3,100	6,216	2,200	32,534	168,000	3,540	0
Change	6,482	33,000	4,061	3,100	6,216	2,200	11,706	84,750	3,540	0
Percent Change	N/A	N/A	N/A	N/A	N/A	N/A	56	102	N/A	N/A
6										
Total Number of Visitor Days	6,319	32,900	4,061	3,100	5,608	2,200	29,800	135,400	3,117	0
Change	6,319	32,900	4,061	3,100	5,608	2,200	8,972	52,150	3,117	0
Percent Change	N/A	N/A	N/A	N/A	N/A	N/A	43	63	N/A	N/A
7										
Total Number of Visitor Days	6,482	33,000	4,061	3,100	6,216	2,200	32,534	168,000	3,540	0
Change	6,482	33,000	4,061	3,100	6,216	2,200	11,706	84,750	3,540	0
Percent Change	N/A	N/A	N/A	N/A	N/A	N/A	56	102	N/A	N/A

N/A = Not Applicable. Percent increases from zero cannot be calculated.
Note: Changes shown are from the No-Action Alternative
Parentheses indicate negative change

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Regional Impacts

Under Alternative 1 - Option A, water-dependent recreation within the service area would decrease by 264,000-280,000 visitor-days per year in normal water years. This is approximately a 2-percent decrease in recreation.

Recreation Site Impacts

Shasta Reservoir. Under the Alternative 1 - Option A, recreation at Shasta Reservoir would decrease as compared to the No-Action Alternative by 223,000-421,000 annual visitor-days, or by 3-5 percent, in normal water years. This alternative would draw the reservoir's volume down to 3,157,000 af in August of normal water years. The impacts of this alternative on recreation would be significant.

Clair Engle Reservoir. Under the Alternative 1 - Option A, recreation at Clair Engle Reservoir would decrease, as compared to the No-Action Alternative, by 3,000-13,000 visitor-days, or by less than 1 percent, in normal water years. The Reservoir's volume would exceed 1,738,000 af throughout June, July, and August, the principal recreation season. This alternative's recreation impact is less than significant.

Sacramento River. Under Alternative 1 - Option A, changes in recreation at the Sacramento River, as compared to the No-Action Alternative, would range from a positive 26,000 annual visitor-days to a negative 28,000 annual visitor-days in normal water years. This impact is considered less than significant.

Trinity River. No changes in recreation use would occur under this alternative. No significant impacts are anticipated.

Colusa National Wildlife Refuge. Under Alternative 1 - Option A, recreation at Colusa National Wildlife Refuge is projected to increase from 0 to 4,061 visitor-days for hunting and from 0 to 4,805 visitor-days for nonconsumptive uses. Compared to the No-Action Alternative, under which no recreation would occur, this alternative represents a beneficial impact.

Delevan National Wildlife Refuge. Under Alternative 1 - Option A, use at Delevan would increase from 0 to 5,608 annual visitor days for hunting and from 0 to 3,410 visitor-days for nonconsumptive uses. Compared to the No-Action Alternative, these use levels would represent a beneficial impact.

Sacramento National Wildlife Refuge. Under Alternative 1 - Option A, recreation at Sacramento National Wildlife Refuge would increase from 0 to 6,319 visitor-days for hunting and from 0 to 50,995 visitor-days for nonconsumptive uses. These use levels represent a beneficial impact relative to the No-Action Alternative.

Sutter National Wildlife Refuge. Under Alternative 1 - Option A, hunting use at Sutter National Wildlife Refuge would increase from 0 to 3,117 annual visitor-days, and no nonconsumptive uses would occur. Compared to the No-Action Alternative, this action represents a beneficial impact.

Gray Lodge Wildlife Management Area. Hunting and nonconsumptive uses at Gray Lodge would increase by up to 43 percent and 63 percent, respectively, under Alternative 1 - Option A, as compared to the No-Action Alternative. This alternative, therefore, would result in a beneficial impact on recreation.

Alternative 1 - Option B

Regional Impacts

Under Alternative 1 - Option B, water-dependent recreation within the service area would decrease by 565,945 visitor-days, or by 4 percent, in normal water years, as compared to the No-Action Alternative.

Recreation Site Impacts

Shasta Reservoir. Under Alternative 1 - Option B, recreation at Shasta reservoir would decrease by 1,107,000 visitor-days annually, or by 13 percent, compared to the No-Action Alternative. Reservoir volume averages 2,995,000 af in August of normal water years. This change is considered a significant adverse impact.

Clair Engle Reservoir. Under Alternative 1 - Option B, recreation at Clair Engle Reservoir would increase by 434,000 visitor-days, or 18 percent, as compared to the No-Action Alternative. Reservoir levels would be maintained above the threshold level of 1,700,000 af throughout the summer months of normal water years. The impact on recreation of this action would be beneficial.

Sacramento River. Under Alternative 1 - Option B, recreation at the Sacramento River would decrease by 48,000 visitor-days, or by 2 percent. This impact is less than significant.

Trinity River. No changes in Trinity River flows, as compared to the No-Action Alternative, would occur, and no significant impacts would result.

Colusa National Wildlife Refuge. Under Alternative 1 - Option B, hunting at Colusa National Wildlife Refuge would equal 4,061 visitor-days, and nonconsumptive uses would equal 4,805 visitor-days annually. Compared to the No-Action Alternative, under which no recreation would occur, this represents a beneficial impact.

Delevan National Wildlife Refuge. Under Alternative 1 - Option B, hunting and nonconsumptive uses at Delevan National Wildlife Refuge would equal 6,216 and 3,410

annual visitor-days, respectively. These levels represent a beneficial impact as compared to the No-Action Alternative.

Sacramento National Wildlife Refuge. Under Alternative 1 - Option B, annual recreation use would equal 6,482 hunting visits and 51,150 nonconsumptive visits. The impact of this action would be beneficial.

Sutter National Wildlife Refuge. Hunting would increase under this alternative by 3,540 annual visitor-days compared to the No-Action Alternative. This represents a beneficial recreation impact.

Gray Lodge National Wildlife Refuge. Hunting and nonconsumptive uses would increase at Gray Lodge by 11,706 and 131,362 visitor-days, respectively, under Alternative 5. This represents a beneficial recreation impact.

Alternative 2

Regional Impacts

Under Alternative 2, recreation in the service area would decline by 984,000 annual visitor-days, or by 2 percent, as compared to the No-Action Alternative.

Recreation Site Impacts

Shasta Reservoir. Under Alternative 2, recreation at Shasta Reservoir would decline by 223,000 visitor-days per year, or 3 percent, as compared to the No-Action Alternative. Reservoir volume would exceed 3,230,000 af throughout the June-August recreation season in normal water years. This level of impact is considered less than significant.

Clair Engle Reservoir. Under Alternative 2, recreation at Clair Engle Reservoir would decrease by 13,000 yearly visitor-days, or by 1 percent, compared to the No-Action Alternative. Reservoir volume would exceed 1,700,000 af throughout the June-August recreation season in normal water years. This alternative's impact on recreation is considered less than significant.

Sacramento River. Under Alternative 2, recreation would decrease by 28,000 annual visitor-days, or 1 percent, at the Sacramento River. This impact is considered less than significant.

Trinity River. No changes in Trinity River flow would occur under this alternative, and no significant recreation impacts are anticipated.

Sacramento Valley National Refuges. Under Alternative 2, hunting and nonconsumptive uses would be unchanged from the No-Action Alternative at all five waterfowl hunting areas, so this alternative would have no impact on recreation at these sites.

Alternative 3

Regional Impacts

Under Alternative 3, a decrease in water-dependent recreation of 279,573 annual visitor-days (2 percent) would occur relative to the No-Action Alternative.

Recreation Site Impacts

Shasta Reservoir. Under Alternative 3, recreation at Shasta Reservoir would decrease by 421,000 visitor-days each year relative to the No-Action Alternative. Average reservoir level in August of normal water years would be 3,157,000 af. This represents a significant adverse impact on recreation.

Clair Engle Reservoir. Relative to the No-Action Alternative, recreation at Clair Engle Reservoir would decrease by 3,000 annual visitor-days. Reservoir volume would exceed 1,700,000 af throughout the recreation season. This impact is considered less than significant.

Sacramento River. Under Alternative 3, recreation at the Sacramento River would decrease by 26,000 visitor-days yearly, or by 1 percent. This impact would be less than significant.

Trinity River. No changes in flows would occur under this alternative, and no significant recreation impacts would result.

Sacramento Valley Refuges. Impacts under this alternative would be identical to those described under Alternative 1 - Option A. These impacts are considered beneficial.

Alternative 4A/B

Regional and Recreation Site Impacts

The impacts of this alternative are identical to those described under Alternative 2, except for refuges. Impacts to refuges would be identical to Alternative 1 - Option B. These impacts would be beneficial. Significant impacts to recreation uses on the Sacramento River would result.

Alternative 4C/D

Regional Impacts

Recreation would decrease by 1,133,573 annual visitor-days (8 percent) in the SRSA under Alternative 4 C/D as compared to the No-Action Alternative. This is considered a less-than-significant impact.

Recreation Site Impacts

Shasta Reservoir. Under Alternative 4C/D, recreation at Shasta Reservoir would decrease by 721,000 yearly visitor-days annually (8 percent), as compared to the No-Action Alternative. In August of normal water years, average reservoir volume would be 2,989,000 af. This represents a significant adverse impact.

Clair Engle Reservoir. Under Alternative 4C/D, recreation at Clair Engle Reservoir would decrease by 553,000 visitor-days per year, or by 23 percent, as compared to the No-Action Alternative. In normal water years, average July and August reservoir volumes would be 1,685,000 af and 1,480,000 af, respectively. The impacts of this alternative on recreation would be significant.

Sacramento River. Recreation at the Sacramento River would decrease by 22,000 annual visitor-days (1 percent) under Alternative 4C/D compared with the No-Action Alternative. This impact is considered less than significant.

Trinity River. No changes in Trinity River flows would occur under this alternative, and no significant recreation impacts would result.

Sacramento Valley Refuges. Under Alternative 4C/D, recreational uses at refuges would be identical to Alternative 1 - Option A. These impacts would be beneficial.

Alternative 5

Regional Impacts

Alternative 5 would result in a decrease in annual recreation use of 938,945 visitor-days, as compared to the No-Action Alternative.

Recreation Site Impacts

Shasta Reservoir. Under Alternative 5, 552,000 fewer recreation days (6 percent) would occur at Shasta Reservoir each year than under the No-Action Alternative. Average reservoir volumes in August would be 3,200,000 af in normal water years. This would be a significant impact.

Clair Engle Reservoir. Under Alternative 5, recreation at Clair Engle Reservoir would decrease by 511,000 annual visitor-days (21 percent). Reservoir volume would be 1,698,000 af in July and 1,520,000 af in August of normal water years. This would be a significant impact.

Sacramento River. Under Alternative 5, recreation at the Sacramento River would decrease by 31,000 annual visitor-days (1 percent) compared to the No-Action Alternative. This impact would be less than significant.

Trinity River. No flow changes in the Trinity River would occur, and no significant impacts would result.

Sacramento Valley Refuges. Under this alternative, recreational uses at the refuges would be identical to Alternative 1 - Option B. These impacts would be beneficial.

Alternative 6

Regional Impacts

Under Alternative 6, recreation in the SRSA would decrease by 575,573 visitor-days per year (4 percent) as compared to the No-Action Alternative.

Recreation Site Impacts

Shasta Reservoir. Under Alternative 6, recreation at Shasta Reservoir would decline by 778,000 yearly visitor-days (9 percent), as compared to the No-Action Alternative. In normal water years, reservoir volume would average 2,969,000 af in August. This impact on recreation is considered significant.

Clair Engle Reservoir. Recreation at Clair Engle Reservoir would increase by 66,000 visitor-days per year (3 percent) under Alternative 6, as compared to the No-Action Alternative; this would be a beneficial impact. Reservoir volume would exceed 1,700,000 af throughout the recreation season in normal water years.

Sacramento River. Under Alternative 6, recreation at the Sacramento River would increase by 18,000 annual visitor-days relative to the No-Action Alternative. This represents a beneficial impact.

Trinity River. No flow changes would occur under this alternative, and no significant recreation impacts are anticipated.

Sacramento Valley Refuge. Impacts of Alternative 6 on hunting and nonconsumptive uses at the five waterfowl hunting areas would be identical to those described for Alternative 1 - Option A. Alternative 6 would, in each case, have a beneficial impact on recreation.

Alternative 7

Regional Impacts

SRSA recreation would increase by 375,055 annual visitor-days (3 percent) under Alternative 7, as compared to the No-Action Alternative. This estimate excludes increases in recreation at the Trinity River resulting from incremental summer flows under Alternative 7.

Recreation Site Impacts

Shasta Reservoir. Recreation at Shasta Reservoir would increase by 177,000 annual visitor-days (2 percent) under Alternative 7 a beneficial impact as compared to the No-Action Alternative. Reservoir volume would exceed 3,230,000 af throughout the recreation season in normal water years.

Clair Engle Reservoir. Under Alternative 7, recreation at Clair Engle Reservoir would increase by 42,000 annual visitor-days (2 percent), a beneficial impact as compared with the No-Action Alternative. Recreation-season reservoir volume would exceed 1,700,000 af in normal water years.

Sacramento River. Recreation at the Sacramento River would increase by 1,000 annual visitor-days under Alternative 7 relative to the No-Action Alternative. This represents a beneficial impact.

Trinity River. Under Alternative 7, recreation on the Trinity River between Lewiston Dam and the confluence with the North Fork of the Trinity would increase by 21,186 annual visitor-days, or by 19 percent. This represents a beneficial impact.

Sacramento Valley National Refuges. Impacts of Alternative 7 on hunting and nonconsumptive uses at the five waterfowl hunting areas would equal those described under Alternative 1 - Option B. Alternative 7 would, in each case, have a beneficial impact on recreation.

Mitigation Measures

Recreation Site Impacts

Maintain Reservoir Elevations as High as Possible During Summer Months. Significant impacts on Shasta Reservoir recreation would occur under and Alternatives 1, 3, 4 C/D, 5, and 6. Significant impacts on Clair Engle Reservoir recreation would occur under the Alternative 1 - Option A, 4 C/D, and 5. These impacts could be mitigated

through reservoir operations designed to keep the average August reservoir volumes above 3,230,000 af at Shasta Reservoir and above 1,700,000 af at Clair Engle Reservoir.

AESTHETICS

Introduction

The aesthetic effects of reduced flows may be classified as primary or secondary (Sands 1985). Primary effects are those that directly alter the intactness, vividness, and variety of the visual resources through manipulation of water as a visual element in the landscape. Secondary effects are the result of long-term flow reductions on other visual elements combine with water to form the visual resources of the landscape. These issues were the primary issues raised during the scoping process and are therefore the focus of the analysis below.

Primary Impact Mechanisms

Primary visual resource impacts are those caused by direct manipulation of water, which in turn causes a change in the balance of the visual scene. Examples of primary effects that could occur along the Sacramento River include larger expanses of exposed banks and gravel bars, reduced expanses of water, and changes in the amount of rapid or riffle area. The major primary visual resource impact that could occur at reservoirs would be a larger, more exposed bathtub ring or a more frequently exposed ring.

Secondary Impact Mechanisms

Examples of secondary impacts along the river include vegetation changes, reduction in wildlife use, and drying up of pond or wetland areas adjacent to the river.

In the long term, vegetation along the river could be altered in several ways by flow changes including a dying-back of high-terrace riparian vegetation, willow encroachment on gravel bars, reduced regeneration potential due to drier soils and lower groundwater levels. (See "Vegetation and Wildlife" section of this chapter.) These mechanisms could result in less peripheral vegetation for the focusing and framing of views and could detract from the visual buffer between the river and adjacent agriculture or urban activities. The species composition of the vegetation along the river could also change with differences in the flow regime, thus affecting the balance of the visual scenes.

Sacramento River

No visual assessment studies have been done to determine benchmark flows at which primary visual quality impacts can be perceived on the Sacramento River. To evaluate the impact of the water contracting alternatives on the aesthetic quality of the river, it was assumed that low flows associated with critically dry or dry years in the past were less intact and vivid than those of wetter years. Based on this assumption, each alternative was evaluated with regard to changes in the frequency of low flows. It was assumed that changes in high flow would not have a significant primary effect on visual quality of the

river. For each alternative the frequency of flows equal to or less than the mean monthly flows from the 10 years in the 57 years of record designated as dry years were compared to the frequency of dry-year flows under the No-Action Alternative. A primary visual impact index was developed for each water contracting alternative using this comparison. This analysis was done for two stations: below Keswick Dam and below the Red Bluff Diversion Dam. The comparisons were done on a monthly basis using mean monthly flows for all 12 months of the year. No-Action Alternative flows were compared to the 1985 flows. All other alternatives were then compared to No-Action Alternative.

Although this index methodology cannot detect subtle changes to visual quality caused by small reductions in flows, it is useful as a tool to compare the degree of impact caused by each alternative. Index values that lead to a 50 percent or greater increase in the frequency of low flows are considered to represent significant impacts.

Estimated changes in vegetation (see the "Vegetation and Wildlife" section of this chapter) were used to evaluate the secondary impacts of altered river flows on the aesthetic values of the Sacramento River. The results of the vegetation impact assessment were combined with the primary impact index values to determine overall aesthetic impacts of each water contracting alternative.

Reservoirs

Aesthetic quality data are also lacking for Shasta and Clair Engle Reservoirs. No benchmark water surface elevations below which visual quality is significantly reduced have been identified. Primary visual quality impact indices were developed for Shasta and Clair Engle Reservoirs in a way similar to that described for the Sacramento River except that only the months of June, July, and August were used. The analysis was limited to these months because the majority of the recreational user days occur on these reservoirs during summer.

No secondary visual quality impacts would occur at the reservoirs.

Site-Specific Service Areas

The only impacts of the water contracting alternatives on upland areas would be secondary impacts associated with urban growth at the site-specific level. In most cases these impacts would be associated with growth likely to occur with or without the project and thus cannot be attributed solely to water contracting. These secondary impacts could also vary greatly depending on local land use planning. Because specific development areas and development types are not clearly defined, the aesthetic impacts of water contracting on upland areas were only generally evaluated.

No-Action Alternative

Regional 2020 Baseline Conditions

Under this alternative, buildout of existing water contracts would negatively affect the aesthetic value of Shasta Reservoir, but it would also improve aesthetic conditions on the Sacramento River and at Clair Engle Reservoir.

Sacramento River. Under the No-Action Alternative, the frequency of low flows in both the Keswick Dam to Red Bluff reach and in reaches below Red Bluff would decrease. Thus the primary visual quality indices for this alternative are positive (see Table 4J-1).

There would be some riparian vegetation changes associated with this alternative but the aesthetic changes (secondary effects) caused by these vegetation changes would be minor. The combined primary and secondary effects of this alternative are expected to have a minor effect on the aesthetic quality of the river.

Reservoirs. Under the No-Action Alternative, the visual quality index for Shasta Reservoir would be -8, indicating that out of the 171 summer months of record (3 months x 57 years of record), 8 more months had severe drawdowns than under existing conditions (Table 4J-2). This represents a 15-percent increase in the frequency of severe drawdowns. Clair Engle Reservoir has a +12 index value under this alternative, indicating a reduction in the frequency of severe summer drawdown in that reservoir.

Site-Specific 2020 Baseline Conditions

Under this alternative, growth would occur only in urban agencies in Yolo and Solano Counties. Secondary aesthetic effects associated with urban development in these counties would include loss of open space vistas along major highways due to conversions of oak woodland, grassland, and wetlands to urban uses, and loss of scenic rural roadway vistas due to urban conversions. Existing wetlands in refuges would be converted to upland habitat, resulting in some visual changes, but no open space or scenic vistas would be lost.

Alternative 1 - Option A

Regional Impacts

Sacramento River. Alternative 1 - Option A would reduce the frequency of low flows on the Sacramento River from Keswick Dam to Red Bluff (primary visual impact index of +20) and increase the frequencies of low flows below Red Bluff (index value of -10). Table 4J-3 presents the Sacramento River primary visual quality impact indices.

There would be no significant secondary aesthetic impacts of Alternative 1 - Option A because there would be no significant vegetative changes as compared to the No-Action

Table 4J-1. Aesthetic Effects of the No-Action Alternative:

Sacramento River Service Area

Location	Months												Visual Quality Index	Percent Change from 1985
	O	N	D	J	F	M	A	M	J	J	A	S		
Keswick Dam	+7	+3	0	-3	+1	+3	-1	-1	+1	-3	-5	+3	+5	2
Red Bluff	+10	+5	0	+3	+3	+4	+1	+5	+17	+8	+16	+7	+79	36

Note: A negative value indicates an increased frequency in low flow conditions.

Table 4J-2. Visual Quality Effects of the No-Action Alternative at Shasta and Clair Engle Reservoirs:

Sacramento River Service Area

Location	Months			Visual Quality Index	Percent Change from 1985
	June	July	August		
Shasta	-4	-2	-2	-8	15
Clair Engle	+4	+4	+4	+12	22

Note: Table compares the No-Action Alternative to 1985 storage levels.

Index is based on the change in frequency of low water levels in each reservoir during summer months. The values shown for each month represent the change in the number of years in which the average monthly water storage level falls into or below the dry year category (as defined using the 57 years of record).

A negative value indicates an increase in the frequency of severe summer reservoir drawdown.

Table 4J-3. Visual Quality Effects of Water Contracting Alternatives on the Sacramento River

Sacramento River Service Area

Alternative	Location	Months												Index	Percent Change from No Action
		O	N	D	J	F	M	A	M	J	J	A	S		
1A, 2, 4A/B	Keswick Dam	+6	-6	+5	+4	+1	-1	-2	0	+1	+4	+7	+1	+20	9
	Red Bluff	+3	-4	+7	+3	+1	0	-4	+4	-5	0	-3	-12	-10	7
1B	Keswick Dam	+9	+9	+15	+17	+14	+14	+7	-2	-2	-4	0	+8	+85	40
	Red Bluff	-12	-15	-1	+7	+2	-3	-6	0	-3	-4	-11	-18	-64	47
3	Keswick Dam	+1	-12	-2	0	+1	0	0	+4	+1	+7	+10	+6	+16	8
	Red Bluff	-8	-11	-8	0	-2	-12	-7	+4	-3	+1	-2	-16	-64	47
4C/D	Keswick Dam	+6	0	-4	-3	+5	+1	+2	-2	-1	-4	+18	+4	+22	10
	Red Bluff	+7	-6	+3	0	+2	+4	+3	+9	-3	+1	0	+3	+23	17
5	Keswick Dam	+10	-6	+14	+18	+14	+13	+7	-5	-7	-2	-9	+6	+53	25
	Red Bluff	+5	-15	+11	+11	+11	+6	+3	+2	-4	-2	-16	-3	+9	7
6	Keswick Dam	+4	-19	-11	-5	-1	-1	-1	+1	+3	-2	+18	+5	-9	4
	Red Bluff	-17	-20	-6	-3	-2	+1	-3	+3	-4	-1	0	-1	-53	39
7	Keswick Dam	0	+4	-9	-2	+2	+1	0	0	-12	-7	-13	-8	-44	21
	Red Bluff	-1	+4	-1	+2	0	0	0	+10	-1	0	-6	-3	+4	3

Note: A negative value indicates an increase in the frequency of low flow conditions. Index values that lead to a 50-percent or greater increase in the frequency of low flows compared to the No-Action Alternative are considered to represent significant impacts.

Alternative. Overall, the riverine aesthetic impacts of this proposed action option would be less than significant.

Reservoirs. Alternative 1 - Option A would slightly increase the frequency of summer month drawdowns in Shasta and Clair Engle Reservoirs. The visual quality impact indices are -1 and -4 respectively (Table 4J-4) as compared to the No-Action Alternative. These drawdowns would have a less-than-significant aesthetic impact on the reservoir viewsheds.

Site-Specific Impacts

Under Alternative 1 - Option A, secondary site-specific aesthetic impacts associated with the Alternative 1 - Option A would occur in Shasta Dam Area Public Utility District and in refuges. On refuges, upland habitat would be converted to wetland and agricultural uses. No open space would be lost and no scenic vistas would be affected. The amount of land that would be converted within the Shasta Dam Area Public Utility District (approximately 2,000 acres) would be small relative to available open space.

Alternative 1 - Option B

Regional Impacts

Sacramento River. Alternative 1 - Option B has differing effects on the Keswick Dam to Red Bluff reach and downstream of Red Bluff. The primary visual quality index for the reach from Keswick Dam to Red Bluff has an index value of +85, a 40-percent increase in value as compared to the No-Action Alternative. However, below Red Bluff the index value is -64, representing a 47-percent increase in the frequency of low flow events as compared to the No-Action Alternative (Table 4J-3). This increase is below the assumed threshold of significant aesthetic impact.

Alternative 1 - Option B would have little effect on vegetation from Keswick Dam to Red Bluff but could alter the vegetation structure and density below Red Bluff and thus impact aesthetics. The combined impacts of this alternative on the aesthetic value of the river would be less than significant.

Reservoirs. The frequency of summer month reservoir drawdowns would significantly increase on Shasta Reservoir (69 percent) but would decrease on Clair Engle Reservoir as compared to the No-Action Alternative (Table 4J-4). The increased drawdowns on Shasta Reservoir would be a significant aesthetic impact.

Site-Specific Impacts

Impacts associated with Alternative 1 - Option B are identical to those described under Alternative - Option A. No significant aesthetic impacts would result. On refuges, upland habitat would be converted to wetland and agricultural uses. No open space would

Table 4J-4. Visual Quality Impact Indices
for Water Contracting Alternatives at
Shasta and Clair Engle Reservoirs

Sacramento River Service Area

Alternative	Reservoir	Months			Index[a]	Percent Change from No Action
		June	July	August		
1A, 2, 4A/B	Shasta	-2	+1	0	-1	-2
	Clair Engle	-1	-2	-1	-4	-9
1B	Shasta	-13	-14	-16	-43	-69
	Clair Engle	+3	+3	+3	+9	+21
3	Shasta	-7	-9	-13	-29	-47
	Clair Engle	-1	-2	-1	-4	-9
4C/D	Shasta	-10	-11	-15	-36	-58
	Clair Engle	+1	+3	+1	+5	+12
5	Shasta	-10	-10	-10	-30	-48
	Clair Engle	-4	-5	-5	-14	-33
6	Shasta	-11	-13	-14	-38	-61
	Clair Engle	-1	-1	-1	-3	-7
7	Shasta	0	+4	+8	+12	+19
	Clair Engle	-1	-1	-1	-3	-7

[a] Index is based on the change in frequency of low water levels in each reservoir during summer months. The values shown for each month represent the change in the number of years in which the average monthly water storage level falls into or below the dry year category (as defined using the 57 years of record). A negative value indicates an increase in the frequency of severe summer reservoir drawdown. Indices that lead to a 50-percent or greater increase in the frequency of dry year flows are considered to represent significant impacts.

be lost and no scenic vistas would be affected. The amount of land that would be converted within the Shasta Dam Area Public Utility District (approximately 2,000 acres) would be small relative to available open space.

Alternative 2

Regional and Site-Specific Impacts

Regional and site-specific impacts associated with this alternative would be identical to those described under Alternative 1 - Option A. Aesthetic impacts would be less than significant.

Alternative 3

Regional Impacts

Sacramento River. Alternative 3 has a slightly positive primary visual impact index for the Keswick Dam to Red Bluff reach, and a negative index for the rivers below Red Bluff, representing a 47-percent increase in low flow frequency (Table 4J-3). The magnitude of this negative index is just below the level assumed to represent a significant impact.

Vegetation changes associated with Alternative 3 on the river below Red Bluff (see Chapter 4, "Vegetation and Wildlife") would add to the degradation of the river's aesthetic quality. The combination of the primary and secondary impacts represent a significant aesthetic impact.

Reservoirs. Both reservoirs would be negatively impacted by an increase in the frequency of summer drawdown. However, the degree of change would be less than significant (Table 4J-4).

Site-Specific Impacts

Impacts associated with Alternative 3 are identical to those described under Alternative 1 - Option A. No significant aesthetic impacts would result.

Alternative 4 A/B

Regional and Site-Specific Impacts

Under this alternative, regional and site-specific impacts would be identical to those described under Alternative 1 - Option A. There would be less-than-significant aesthetic impacts on the Sacramento River, Shasta and Clair Engle Reservoirs, and upland areas.

Alternative 4 C/D

Regional Impacts

Sacramento River. Alternative 4 C/D would slightly decrease the frequency of low flows in both reaches of the river as compared to the No-Action Alternative, thus the primary visual index values for the river are positive. Secondary aesthetic impacts could occur on the river due to changes in the vegetative structure and extent along this reach (see the "Vegetation and Wildlife" section of this chapter). The aesthetic impacts of this alternative on the river are potentially significant.

Reservoirs. This alternative would slightly reduce the frequency of summer month drawdown at Clair Engle Reservoir but would increase the frequency of drawdown at Shasta Reservoir by 58 percent, as compared to the No-Action Alternative (see Table 4J-4). This would be a significant aesthetic impact.

Site-Specific Impacts

No site-specific aesthetic impacts attributable to water contracting for urban growth would occur under this alternative. Aesthetic impacts resulting from the refuge conversion of upland habitat to wetland acreage would be identical to Alternative 1 - Option A.

Alternative 5

Regional Impacts

Sacramento River. The primary visual quality impact indices for this alternative are positive for both the Keswick Dam to Red Bluff reach and the river below Red Bluff as compared to the No-Action Alternative (see Table 4J-3). Vegetation effects of the alternative are expected to be minor, thus the secondary visual impacts would also be minor. Overall, the aesthetic impacts of this alternative on the river would be less than significant.

Reservoirs. This alternative would increase the frequency of summer month drawdowns at both reservoirs as compared to the No-Action Alternative (Table 4J-4);

however, the percentage changes are less than the level considered necessary for a significant aesthetic impact to occur.

Site-Specific Impacts

No site-specific aesthetic impacts attributable to water contracting for urban growth would occur under this alternative. Aesthetic impacts resulting from refuge conversion of upland habitat to wetland acreage would be identical to Alternative 1 - Option A.

Alternative 6

Regional Impacts

Sacramento River. Alternative 6 would slightly increase the frequency of low flows in the river from Keswick Dam to Red Bluff as compared to the No-Action Alternative. The effect would be more pronounced downstream of Red Bluff but the change is less than significant (Table 4J-3).

Secondary visual impacts due to induced vegetation changes would be minor (see the "Vegetation and Wildlife" section of this chapter), thus the overall aesthetic impact on the river would be less than significant.

Reservoirs. Alternative 6 would have a negative aesthetic effect on both reservoirs. The changes at Clair Engle Reservoir would be minor but the increased frequency of summer drawdown at Shasta Reservoir (61 percent) would be a significant aesthetic impact as compared to the No-Action Alternative (Table 4J-4).

Site-Specific Impacts

Impacts associated with Alternative 6 are identical to those described under Alternative 1 - Option A. No significant aesthetic impacts would result.

Alternative 7

Regional Impacts

Sacramento River. Alternative 7 would increase the frequency of low flows in the Sacramento River by 21 percent (Table 4J-3) from Keswick Dam to Red Bluff as compared to the No-Action Alternative. Downstream from Red Bluff there would be little change in the frequency of low flows.

Vegetation changes are expected to be minor under this alternative, thus secondary aesthetic impacts would be negligible. Overall, this alternative would have a less-than-significant impact on the aesthetics along the river.

Reservoirs. The visual quality indices for Shasta and Clair Engle Reservoirs are +12 and -3 respectively (Table 4J-4). Both values are below the level assumed to be a significant aesthetic impact.

Site-Specific Impacts

No site-specific aesthetic impacts attributable to water contracting for urban growth would occur under this alternative. Aesthetic impacts resulting from refuge conversion of upland habitat to wetland acreage would be identical to Alternative 1 - Option A.

Mitigation Measures

Potentially significant aesthetic impacts have been identified under various alternatives for both the Sacramento River and Shasta Reservoir. Mitigation measures to reduce these impacts involve maintaining reservoir levels and reducing the frequency of low Sacramento River flows. It may not be possible to mitigate both impacts since Sacramento River flows are directly related to releases from Shasta Reservoir.

Prevent Primary Aesthetic Impacts Attributable to Increased Frequency of Low Sacramento River Flows

Alternatives 3 and 4 C/D could have significant impacts on the aesthetic resources of the Sacramento River. The primary visual quality impacts of the water contracting alternatives on the Sacramento River could be mitigated only through reducing modification of the flow regime.

Prevent Primary Aesthetic Impacts Attributable to Increased Frequency of Severe Shasta Reservoir Drawdown

Alternatives 1 - Option B, 4 C/D, and 6 would have significant impacts on Shasta Reservoir aesthetic resources. To mitigate this impact Reclamation could maintain Shasta Reservoir elevations as high as possible during summer months.

ECONOMICS

Introduction

During the scoping process, important issues were identified relating to the possible economic impacts of water contracting. These issues include: 1) the effect of new water deliveries on agricultural production, 2) the effect of M&I deliveries on economic activity in the area, and 3) the effect of changes in the availability and timing of water supplies for recreation.

This section identifies the impacts on earnings and employment within the service area that would likely occur from water contracting deliveries for each of the alternatives. These impacts include direct, indirect, and induced effects as changes in economic activity ripple through the economy. The total economic impact would be the combination of direct, indirect, and induced effects on the regional economy.

Direct, indirect, and induced earnings and employment effects were estimated using the Regional Interindustry Modeling System (RIMS) of the Bureau of Economic Analysis, U. S. Department of Commerce. RIMS multipliers provide measures of the indirect impacts that arise as the result of interindustry linkages and the impacts induced by household spending. These multipliers were obtained for each river basin, the entire CVP service area, and the State of California. Estimates of changes in economic activity for each purpose were then applied to the appropriate multiplier to arrive at direct, indirect, and induced impacts.

For irrigation deliveries, gross farm income for each alternative when compared to the No-Action Alternative was used as the basis for measuring changes in economic activity for the impact analysis. Because M&I water supply is assumed not to be growth limiting, there would be no difference in economic activity between the No-Action Alternative and other alternatives related to M&I contracting and consequently, earnings and employment would not be impacted. Recreation impacts were measured on the basis of changes in expenditures by recreation visitors from outside the service area. A detailed description of the methodology is presented in Technical Appendix E - Economics and Recreation. For irrigation deliveries, the economics analysis made two assumptions that result in estimates of gross farm income that may be low, and in some cases, negative. The economics model assumed no shift to higher value crops, and constant demands. In reality, gross farm income from irrigation deliveries would likely be higher because crops may change and demand may increase.

No-Action Alternative

The No-Action Alternative is based on no new long-term contracts being signed with agencies in the SRSA. The No-Action Alternative assumes that existing firm yield contractors reach their contract maximums and exercise any renewal rights when their contracts expire. If no additional CVP water contracts are signed, it is assumed that SRSA needs are met with groundwater and other needs are not met because of a lack of a

feasible alternative supply. M&I needs for Shasta Dam Public Utility District and the Yolo-Solano CVP Water Service Coordinating Group are met by groundwater.

Regional 2020 Baseline Conditions

In the No-Action Alternative, gross farm income would be $190 million (Table 4K-1) for the requesting agencies.

Site-Specific 2020 Baseline Conditions

Sacramento Valley Canal Agencies. The Sacramento Valley Canal agencies that requested water generate $105 million in gross farm income. The major agencies in the area include Colusa County Water District, Orland-Artois Water District, Yolo-Zamora Water District, and the Colusa Drain MWC.

Yolo-Solano CVP Water Service Coordinating Group. The Yolo-Solano area requesting agencies generate $80 million in gross farm income.

Alternative 1 - Option A

The Alternative 1 - Option A would allocate firm yield water to requestors within constructed CVP units and intermittent water to requestors outside constructed units who would need to use CVP water in conjunction with other supplies. The benefit analysis does not distinguish between firm and intermittent water except to add costs for developing the other conjunctive supply.

Regional Impacts

The irrigation of additional crop acreage in the SRSA under Alternative 1 - Option A would cause farm prices to decrease slightly. However, this new acreage being irrigated would increase gross farm income in the SRSA by about $39 million. In terms of overall gross farm income of requestor districts in the service area, this represents an increase of 21 percent. This increase in gross farm income would cause earnings to increase by approximately $24 million (Table 4K-2), with a gain of approximately 1,500 jobs (Table 4K-3). Recreation expenditures would decrease by about $6 million (Table 4K-1), causing earnings to drop by approximately $3 million, with the loss of approximately 224 full-time equivalent jobs.

Site-Specific Impacts

Sacramento Valley Canals Agencies. The increase in gross farm income for the SRSA would occur because of an increase in irrigated acreage in the Sacramento Valley Canals area.

TABLE 4K-1. CHANGES IN FINAL DEMAND: SAL[illegible]O RIVER SERVICE AREA

INDUSTRY CLASSIFICATION	DESCRIPTION	BASE LEVEL FINAL DEMAND	CHANGE IN FINAL DEMAND BY ALTERNATIVE /1									
		NO ACTION ALTERNATIVE ($1,000)	1 OPTION A ($1,000)	1 OPTION B ($1,000)	2 ($1,000)	3 ($1,000)	4A ($1,000)	4B ($1,000)	4C ($1,000)	4D ($1,000)	5 ($1,000)	6 ($1,000)	7 ($1,000)
AG:													
2.0100	COTTON	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.0201	FOOD GRAINS	$44,213	$6,851	$6,851	$6,851	$6,851	$6,851	$6,851	$0	$0	$0	$6,851	$0
2.0202	FEED GRAINS	$21,258	$723	$723	$723	$723	$723	$723	$0	$0	$0	$723	$0
2.0203	GRASS SEEDS	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.0401	FRUITS	$11,913	$8,981	$8,981	$8,981	$8,981	$8,981	$8,981	$0	$0	$0	$8,981	$0
2.0402	TREE NUTS	$38,403	$3,087	$3,087	$3,087	$3,087	$3,087	$3,087	$0	$0	$0	$3,087	$0
2.0501	VEGETABLES	$37,586	$6,288	$6,288	$6,288	$6,288	$6,288	$6,288	$0	$0	$0	$6,288	$0
2.0502	SUGAR CROPS	$10,123	$5,286	$5,286	$5,286	$5,286	$5,286	$5,286	$0	$0	$0	$5,286	$0
2.0503	MISCELLANEOUS CROPS	$21,663	$8,350	$8,350	$8,350	$8,350	$8,350	$8,350	$0	$0	$0	$8,350	$0
2.0600	OIL BEARING CROPS	$832	($395)	($395)	($395)	($395)	($395)	($395)	$0	$0	$0	($395)	$0
	SUBTOTAL	$185,991 /2	$39,171	$39,171	$39,171	$39,171	$39,171	$39,171	$0	$0	$0	$39,171	$0
RECREATION:													
69.02	RETAIL TRADE		($3,314)	($5,619)	($3,049)	($3,578)	($7,593)	($7,593)	($14,272)	($14,272)	($11,868)	($6,960)	$4,838
74.00	EATING AND DRINKING		($336)	$683	($583)	($88)	($544)	($544)	($2,247)	($2,247)	($1,711)	($566)	$1,978
72.01	HOTELS AND LODGING		($1,257)	($2,953)	($1,140)	($1,373)	($2,976)	($2,976)	($4,316)	($4,316)	($3,614)	($2,735)	$1,601
79.03	GOVERNMENT ENTERPRISES		($990)	($1,684)	($818)	($1,162)	($2,331)	($2,331)	($4,457)	($4,457)	($3,734)	($2,084)	$1,042
	SUBTOTAL		($5,896)	($9,573)	($5,590)	($6,201)	($13,444)	($13,444)	($25,292)	($25,292)	($20,927)	($12,345)	$9,459

1/ CHANGE IN FINAL DEMAND IS DEFINED AS THE CHANGE IN GROSS INCOME FOR THE AGRICULTURAL SECTOR AND CHANGE IN EXPENDITURES FOR THE RECREATION SECTOR.

2/ GROSS INCOME FOR REQUESTOR AGENCIES ONLY

TABLE 4K-2. EARNINGS IMPACTS: SACRAMENTO RIVER SERVICE AREA

INDUSTRY CLASSIFICATION	DESCRIPTION	EARNINGS MULTIPLIER	CHANGE IN EARNINGS BY ALTERNATIVE										
			1 OPTION A ($1,000)	1 OPTION B ($1,000)	2 ($1,000)	3 ($1,000)	4A ($1,000)	4B ($1,000)	4C ($1,000)	4D ($1,000)	5 ($1,000)	6 ($1,000)	7 ($1,000)
AG:													
2.0100	COTTON	0.0000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.0201	FOOD GRAINS	0.4949	$3,391	$3,391	$3,391	$3,391	$3,391	$3,391	$0	$0	$0	$3,391	$0
2.0202	FEED GRAINS	0.4719	$341	$341	$341	$341	$341	$341	$0	$0	$0	$341	$0
2.0203	GRASS SEEDS	0.5541	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2.0401	FRUITS	0.6831	$6,135	$6,135	$6,135	$6,135	$6,135	$6,135	$0	$0	$0	$6,135	$0
2.0402	TREE NUTS	0.7347	$2,268	$2,268	$2,268	$2,268	$2,268	$2,268	$0	$0	$0	$2,268	$0
2.0501	VEGETABLES	0.7068	$4,444	$4,444	$4,444	$4,444	$4,444	$4,444	$0	$0	$0	$4,444	$0
2.0502	SUGAR CROPS	0.6225	$3,291	$3,291	$3,291	$3,291	$3,291	$3,291	$0	$0	$0	$3,291	$0
2.0503	MISCELLANEOUS CROPS	0.5363	$4,478	$4,478	$4,478	$4,478	$4,478	$4,478	$0	$0	$0	$4,478	$0
2.0600	OIL BEARING CROPS	0.0000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL		$24,348	$24,348	$24,348	$24,348	$24,348	$24,348	$0	$0	$0	$24,348	$0
RECREATION:													
69.02	RETAIL TRADE	0.7374	($2,443)	($4,143)	($2,248)	($2,638)	($5,599)	($5,599)	($10,524)	($10,524)	($8,751)	($5,132)	$3,568
74.00	EATING AND DRINKING	0.5673	($190)	$387	($331)	($50)	($309)	($309)	($1,275)	($1,275)	($971)	($321)	$1,122
72.01	HOTELS AND LODGING	0.6056	($761)	($1,788)	($690)	($831)	($1,802)	($1,802)	($2,614)	($2,614)	($2,189)	($1,656)	$970
79.03	GOVERNMENT ENTERPRISES	0.0000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	SUBTOTAL		($3,395)	($5,544)	($3,269)	($3,520)	($7,710)	($7,710)	($14,413)	($14,413)	($11,911)	($7,110)	$5,659
	TOTAL IMPACT		$20,953	$18,803	$21,078	$20,828	$16,638	$16,638	($14,413)	($14,413)	($11,911)	$17,238	$5,659

MULTIPLIER DATA SOURCE: RIMS II, REGIONAL ECONOMIC ANALYSIS DIVISION, BUREAU OF ECONOMIC ANALYSIS, DEPARTMENT OF COMMERCE.

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TABLE 4K-3. EMPLOYMENT IMPACTS: SACRAMENTO RIVER SERVICE AREA

INDUSTRY CLASSIFICATION	DESCRIPTION	EMPLOYMENT MULTIPLIER	CHANGE IN EMPLOYMENT BY ALTERNATIVE /1										
			1 OPTION A (JOBS)	1 OPTION B (JOBS)	2 (JOBS)	3 (JOBS)	4A (JOBS)	4B (JOBS)	4C (JOBS)	4D (JOBS)	5 (JOBS)	6 (JOBS)	7 (JOBS)
AG:													
2.0100	COTTON	0.0	0	0	0	0	0	0	0	0	0	0	0
2.0201	FOOD GRAINS	30.5	209	209	209	209	209	209	0	0	0	209	0
2.0202	FEED GRAINS	28.7	21	21	21	21	21	21	0	0	0	21	0
2.0203	GRASS SEEDS	34.3	0	0	0	0	0	0	0	0	0	0	0
2.0401	FRUITS	42.2	379	379	379	379	379	379	0	0	0	379	0
2.0402	TREE NUTS	45.9	142	142	142	142	142	142	0	0	0	142	0
2.0501	VEGETABLES	44.1	277	277	277	277	277	277	0	0	0	277	0
2.0502	SUGAR CROPS	38.9	206	206	206	206	206	206	0	0	0	206	0
2.0503	MISCELLANEOUS CROPS	32.7	273	273	273	273	273	273	0	0	0	273	0
2.0600	OIL BEARING CROPS	0.0	0	0	0	0	0	0	0	0	0	0	0
	SUBTOTAL		1,506	1,506	1,506	1,506	1,506	1,506	0	0	0	1,506	0
RECREATION:													
69.02	RETAIL TRADE	47.2	(156)	(265)	(144)	(169)	(358)	(358)	(674)	(674)	(560)	(329)	228
74.00	EATING AND DRINKING	58.7	(20)	40	(34)	(5)	(32)	(32)	(132)	(132)	(100)	(33)	116
72.01	HOTELS AND LODGING	38.4	(48)	(113)	(44)	(53)	(114)	(114)	(166)	(166)	(139)	(105)	61
79.03	GOVERNMENT ENTERPRISES	0.0	0	0	0	0	0	0	0	0	0	0	0
	SUBTOTAL		(224)	(339)	(222)	(227)	(505)	(505)	(971)	(971)	(799)	(467)	406
	TOTAL IMPACT		1,282	1,168	1,284	1,280	1,002	1,002	(971)	(971)	(799)	1,040	406

1/ CHANGE IN NUMBER OF JOBS FOR EACH ADDITIONAL ONE MILLION DOLLARS' CHANGE IN FINAL DEMAND

MULTIPLIER DATA SOURCE: RIMS II, REGIONAL ECONOMIC ANALYSIS DIVISION, BUREAU OF ECONOMIC ANALYSIS, DEPARTMENT OF COMMERCE.

Yolo-Solano CVP Water Service Coordinating Group. There would be no significant change in gross farm income in the Yolo-Solano area.

Alternative 1 - Option B

The Alternative 1 - Option B would allocate firm yield water to requestors who do not have developable groundwater. The benefit analysis does not distinguish between firm and intermittent water except to add costs for developing the other conjunctive supply.

Regional Impacts

The irrigation of additional crop acreage in the SRSA under Alternative 1 - Option B would cause impacts from irrigation similar to those of Option A. Recreation expenditures would decrease by about $10 million, causing earning to drop by approximately $6 million, with the loss of approximately 340 full-time equivalent jobs.

Site-Specific Impacts

Sacramento Valley Canals Agencies. Economic impacts from irrigation would be the same as those for Alternative 1 - Option A.

Yolo-Solano CVP Water Service Coordinating Group. There would be no significant change in gross farm income in the Yolo-Solano area.

Alternative 2

This alternative recognizes original CVP authorizing legislation giving first preference to navigation and flood control, followed by irrigation and domestic uses, and finally power generation. This alternative also gives priority to M&I use and to needs within constructed CVP units where the Bureau's past water contracting programs have not been completed; i.e., the Sacramento Valley canals.

Available capacity in the Tehama-Colusa Canal is adequate for delivering only 76 percent of the water needs. No deliveries were made to the Yolo-Solano agencies because they were not within a constructed unit.

Regional Impacts

The irrigation of additional crop acreage in the SRSA under Alternative 2 would cause impacts from irrigation similar to those of Alternative 1 - Option A. Recreation

expenditures would decrease by about $6 million, causing earnings to drop by approximately $3 million, with the loss of approximately 220 full-time equivalent jobs.

Site Specific Impacts

Sacramento Valley Canals Agencies. Economic impacts from irrigation would be the same as those for Alternative 1 - Option A.

Yolo-Solano CVP Water Service Coordinating Group. There would be no significant change in gross farm income in the Yolo-Solano area.

Alternative 3

This alternative is similar to Alternative 2 in that it gives preference to agricultural and M&I needs, meeting the total needs of the agricultural and M&I requestors in the SRSA.

Regional Impacts

The irrigation of additional crop acreage in the SRSA under Alternative 3 would cause impacts from irrigation similar to those of Alternative 1 - Option A. Recreation expenditures would decrease by about $6 million, causing earnings to drop by approximately $3 million, with the loss of approximately 230 full-time equivalent jobs.

Site-Specific Impacts

Sacramento Valley Canals Agencies. Economic impacts from irrigation would be the same as those for Alternative 1 - Option A.

Yolo-Solano CVP Water Service Coordinating Group. There would be no significant change in gross farm income in the Yolo-Solano area.

Alternative 4A/B

Regional and Site-Specific Impacts

Alternative 4A/B would emphasize allocations to irrigation and M&I requestors in the DESA. Economic Impacts from irrigation for Alternative 4A/B would be identical to those discussed under Alternative 1 - Option A. However, there is a substantial decrease in recreation expenditures. Recreation expenditures would decrease by about $13 million, causing earnings to drop by approximately $8 million, with the loss of approximately 500 jobs.

Alternative 4C/D

Regional and Site-Specific Impacts

Alternative 4C/D would emphasize allocations to the DESA. There would be no scheduled deliveries to irrigation or M&I in this alternative. Recreation expenditures would decrease by about $25 million, causing approximately a $14 million drop in earnings, with a loss of approximately 970 jobs.

Alternative 5

Regional and Site-Specific Impacts

Alternative 5 would give preference to maintenance and enhancement of Central Valley fish and wildlife resources. Available water would be committed to maintaining American River instream flows established by USFWS and DFG to the extent possible. No water would be contracted to consumptive water users. Because visitation would decrease at Shasta and Folsom Reservoirs, recreation expenditures would decrease by about $21 million, causing earnings to drop by approximately $12 million, with a loss of approximately 800 jobs.

Alternative 6

This alternative would allocate water to agricultural and M&I needs in constructed units and also maintains American River instream flows for both fisheries and recreation. Water would be supplied to Tehama-Colusa Canal agencies only.

Regional Impacts

The irrigation of additional crop acreage in the SRSA under Alternative 6 would cause impacts from irrigation similar to those of Alternative 1 - Option A. Recreation expenditures would decrease by about $12 million, causing earnings to drop by approximately $7 million with the loss of approximately 470 full-time equivalent jobs.

Site-Specific Impacts

Sacramento Valley Canals Agencies. Economic impacts from irrigation would be the same as those for Alternative 1 - Option A.

Yolo-Solano CVP Water Service Coordinating Group. There would be no significant change in gross farm income in the Yolo-Solano area.

Regional and Site-Specific Impacts

Alternative 7 would give preference to selected recreational needs associated with Shasta Lake, the lower American River, and Folsom Reservoir. No water would be contracted to consumptive water users. Because visitation would increase at Lake Shasta and Folsom Reservoirs, recreation expenditures would increase by about $9 million, causing earnings to rise by approximately $6 million, with a gain of approximately 400 jobs.

LAND USE

Introduction

The land use impact analysis below focuses on the relationship of the water contracting alternatives with urban development and expansion of irrigation in the SRSA. The following discussion describes the issues that are important in determining land use impacts associated with the water contracting alternatives and the methods that were used to identify those impacts. The biological impacts of wetland and other habitat conversions are discussed in the "Vegetation and Wildlife" section of this chapter.

Place of Use

As described in Chapter 3, Reclamation holds several permits from the SWRCB that define the area where CVP water may be used. In addition, Reclamation has petitioned the SWRCB to expand its existing place of use. Several requesting agencies have proposed to use CVP water outside of the existing and proposed places of use. Reclamation policy prohibits contracting of CVP water for use outside Reclamation's existing place of use until the SWRCB acts on Reclamation's petition. The land use impact of an agency using water outside the existing place of use is potentially significant. However, Reclamation policy prohibits such use of water until the SWRCB has approved Reclamation's petition to expand its place of use.

Irrigable Lands

Several agencies are proposing to irrigate lands not eligible to receive CVP water because they are Class 6 or because they have not been classified. Reclamation policy prohibits long-term commitments for delivery of CVP to irrigate Class 6 or nonirrigable lands until such lands have been classified or reclassified as appropriate. Land use impacts of irrigating such lands are potentially significant. However, Reclamation policy prohibits long-term commitments of CVP water to irrigate such lands until the lands are properly classified and certified.

Floodplains and Wetlands

As described in Chapter 3, "Land Use," EO 11988 is designed primarily to reduce the risk of flood hazards that could result from actions undertaken by federal agencies in urban areas. The Shasta Dam Area Public Utility District is located in Shasta County. Shasta County is part of the National Flood Insurance Program, which discourages floodplain development that could be damaged or that could affect the ability of a floodway to carry floodflow. Therefore, no significant impacts are anticipated and no further analysis is undertaken.

EO 11990 is designed to protect the values of wetland habitats, which have greatly declined nationwide from their historical occurrence. Potential impacts associated with water contracting relate to the conversion of wetland habitats to agricultural or urban uses resulting from or accommodated by provision of CVP water. The impact analysis below therefore examines the occurrence of wetlands within areas where requesting agencies have identified likely land use changes. The analysis estimates the number of acres impacted within each jurisdiction under each alternative.

Prime and Unique Farmlands

Potential impacts to prime and unique farmlands associated with the water contracting alternatives would occur where such lands would be converted from agricultural to urban uses and where such conversions are directly associated with the provision of CVP water. No lands within water-constrained agencies are designated as prime or unique and, therefore, no further analysis was undertaken.

Consistency with Local Plans and Policies

Providing water to water-constrained M&I agencies could induce or accommodate growth within those agencies. Such growth may not be consistent with local plans and policies. This analysis discusses the consistency of proposed development within agencies that have no alternative water supplies and the significance of any impacts identified at the site-specific level.

No-Action Alternative

Regional 2020 Baseline Conditions

Under the No-Action Alternative, few land use changes would occur within Sacramento Valley canals agencies. Refuges would receive no water supplies. Yolo-Solano CVP Coordinating Group agencies, however, would grow to projected levels using other sources of water.

A total of 165 acres would be converted to irrigated agricultural uses. Another 35,000 acres would be converted to urban uses. Finally, 20,000 acres would be converted from wetland uses to upland habitat on the wildlife refuges (Table 4L-1).

While several agencies would experience growth within the SRSA under this alternative, this growth would not result from new or expanded CVP water service contracts, so no issues relating to place of use, irrigable lands, floodplains and wetlands, or consistency with local planning would be involved.

Table 4L-1. Land Use Impacts Associated with Water Contracting:

No-Action Alternative
Sacramento River Service Area

Agency	Acres and Type of Land Converted	Proposed Development Outside the Existing Place of Use	Proposed Development Outside the Expanded Place of Use	Proposed Development Inconsistent with Irrigable Land Classification	Wetlands Within Proposed Areas of Development
Shasta Dam Area Public Utility District	None				
Sacramento Valley Canals Agencies					
Holthouse Water District	Approximately 165 acres of dryland farming and grazing lands to irrigated agriculture.	N/A	N/A	N/A	N/A
All other agencies	None				
Yolo-Solano CVP Water Service Coordinating Group					
Yolo County Flood Control and Water Conservation District	None				
Davis, City of	Approximately 2,400 acres of agricultural lands to urban uses located in designated growth areas surrounding present city limits.	N/A	N/A	N/A	N/A
Woodland, City of	Approximately 4,200 acres of agricultural lands to urban uses.	N/A	N/A	N/A	N/A
Benicia, City of	Approximately 6,000 acres of agricultural and undeveloped land to urban uses.	N/A	N/A	N/A	N/A
Fairfield, City of	Approximately 6,000 acres of agricultural and undeveloped land within city limits to urban uses.	N/A	N/A	N/A	N/A
Suisun City, City of	Approximately 1,150 acres of undeveloped land to urban uses.	N/A	N/A	N/A	N/A

Table 4L-1. Continued

Agency	Acres and Type of Land Converted	Proposed Development Outside the Existing Place of Use	Proposed Development Outside the Expanded Place of Use	Proposed Development Inconsistent with Irrigable Land Classification	Wetlands Wit[illegible] Proposed Areas of Development
Vacaville, City of	Approximately 5,200 acres of agricultural and undeveloped land to urban uses.	N/A	N/A	N/A	N/A
Vallejo, City of	Approximately 200 acres of agricultural and undeveloped land to urban uses.	N/A	N/A	N/A	N/A
Rio Vista, City of	Approximately 760 acres of agricultural and undeveloped land to urban uses.	N/A	N/A	N/A	N/A
Dixon, City of	Approximately 1,540 acres of agricultural and undeveloped land to urban uses.	N/A	N/A	N/A	N/A
Collinsville area	Approximately 6,000 acres of agricultural land to urban uses.	N/A	N/A	N/A	N/A
Wildlife Refuges					
Delevan NWR	Approximately 3,350 acres of managed wetlands andagriculturalland to upland habitat.	N/A	N/A	N/A	N/A
Colusa NWR	Approximately 4,000 acres of managed wetlands andagriculturalland to upland habitat.	N/A	N/A	N/A	N/A
Sutter NWR	Approximately 2,000 acres of managed wetlands andagriculturalland to upland habitat.	N/A	N/A	N/A	N/A
Gray Lodge WMA	Approximately 3,300 acres of managed wetlands andagriculturalland to upland habitat.	N/A	N/A	N/A	N/A
Sacramento NWR	Approximately 7,150 acres of managed wetlands andagriculturalland to upland habitat.	N/A	N/A	N/A	N/A

Site-Specific 2020 Baseline Conditions

Shasta Dam Area Public Utility District. This agency has no substantial alternate water supply, so only minor growth is expected to occur under this alternative.

Sacramento Valley Canals Agencies. As described above and shown in Table 4L-1, only Holthouse Water District would increase irrigated agricultural acreage under this alternative. A total of 165 acres would be converted.

Yolo-Solano CVP Water Service Coordinating Group. All urban agencies in this group have other water supplies and are expected to grow to projected levels under this alternative. A total of 35,000 acres would be converted to urban uses. Table 4L-1 describes projected land use changes by individual agency.

Solano County staff (Weiss pers. comm.) has indicated that other water supplies would be adequate to provide for anticipated population growth on a countywide basis. County staff has indicated, however, that if no surface water supplies become available to cities within Solano County that do not overlie usable groundwater supplies (e.g., Benicia, Vallejo, and Fairfield), growth in the county may occur outside city boundaries in areas where groundwater is available. This growth could result in inconsistencies with current county policy, which attempts to protect remaining agricultural lands in Solano County and to direct growth to areas where agriculture is not viable.

Refuges. Under this alternative, refuges in the SRSA would receive no CVP water supplies, and their current interim CVP water supplies would no longer be available. Land use changes under this alternative would involve a reduction of wetland acreage and a corresponding increase in upland habitat. The conversions occurring on each refuge are shown in Table 4L-1. The effects of such conversions are described in the "Vegetation and Wildlife" section of this chapter.

Alternative 1

Regional Impacts

Under Alternative 1, it is assumed that all agencies would grow to projected levels and that all land conversions identified by requestors, beyond those identified under the No-Action Alternative, would occur.

A total of 53,000 acres, in addition to those described under 2020 no-action conditions, would be converted to irrigated agricultural uses. Another 2,000 acres would be converted to urban uses. Finally, 20,000 acres would be converted to wetland uses on the wildlife refuges under Option A (Level 2 supplies); 2,700 additional acres would be converted under Option B (Level 4 supplies).

Several agencies are proposing to irrigate a total of 15,000 acres outside Reclamation's current place of use. These agencies are identified in Table 4L-2. Table 4L-2 also identifies agencies that are proposing to irrigate lands outside Reclamation's

Table 4L-2. Land Use Impacts Associated with Water Contracting:

Alternatives: Alternative 1 - Option A and Alternative 3
Sacramento River Service Area

Agency	Acres and Type of Land Converted	Consistency of Proposed Development with Existing Place of Use	Consistency of Proposed Development with Expanded Place of Use	Consistency of Proposed Development with Irrigable Land Classification	Acres of Wetlands Within Proposed Areas of Development
Shasta Dam Area Public Utility District	Approximately 6,000 acres of agricultural land and undeveloped lands to urban uses.	Development is proposed on 220 acres outside the existing place of use.	District is within expanded place of use.	N/A	80
Sacramento Valley Canals Agencies					
Colusa County Water District	Approximately 1,000 acres of annual grassland to irrigated agriculture.	District is proposing to irrigate 2,500 acres outside existing place of use.	District is within expanded place of use.	District is proposing to irrigate approximately 1,600 acres of Class 6 lands.	100
Corning Water District	Approximately 5,525 acres of dryland farming and grazing lands to irrigated agriculture.	District is proposing to irrigate 3,700 acres outside existing place of use.	District is within expanded place of use.	District is proposing to irrigate approximately 250 acres of Class 6 lands.	70
Dunnigan Water District	Approximately 1,900 acres of dryland farming and grazing lands to irrigated agriculture.	District is within existing place of use.	District is within expanded place of use.	District is proposing to irrigate approximately 365 acres of Class 6 lands.	45
Glenn-Colusa Irrigation District	Approximately 5,300 acres of dryland farming to irrigated agriculture.	District is within existing place of use.	District is within expanded place of use.	Lands are not classified.	800
Glenn County Lands					
Glide Water District	Approximately 960 acres of dryland farming to irrigated agriculture.	District is within existing place of use.	District is within expanded place of use.	Lands are not classified.	35
Kanawha Water District	Approximately 4,000 acres of dryland farming to irrigated agriculture.	District is proposing to irrigate 1,027 acres outside existing place of use.	District is within expanded place of use.	Lands are not classified.	0
Orland-Artois Water District	Approximately 4,000 acres of dryland farming to irrigated agriculture.	District is proposing to irrigate 160 acres outside existing place of use.	District is within expanded place of use.	Lands are not classified.	0

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Table 4L-2. Continued

Agency	Acres and Type of Land Converted	Consistency of Proposed Development with Existing Place of Use	Consistency of Proposed Development with Expanded Place of Use	Consistency of Proposed Development with Irrigable Land Classification	Acres of Wetlands Within Proposed Areas of Development
Willow Creek Mutual Water Company	Approximately 500 acres of dryland farming to irrigated agriculture.	District is within existing place of use.	District is within expanded place of use.	Lands are not classified.	0
Glide Water District	Approximately 3,750 acres of dryland farming to irrigated agriculture.	District is within existing place of use.	District is within expanded place of use.	No Class 6 lands within the district are proposed for irrigation.	2
Holthouse Water District	Approximately 1,000 acres of dryland grazing and farming to irrigated agriculture.	District is within existing place of use.	District is within expanded place of use.	District is proposing to irrigate approximately 110 acres of Class 6 lands. An additional 80 acres are not classified.	30
Orland-Artois Water District	Approximately 10,400 acres of dryland farming to irrigated agriculture.	District is proposing to irrigate 160 acres outside existing place of use.	District is within expanded place of use.	District is proposing to irrigate 10 acres of Class 6 lands.	5
Rancho Saucos Water District	Approximately 250 acres of dryland farming to irrigated agriculture.	District is within existing place of use.	District is within expanded place of use.	District is proposing to irrigate 220 acres of Class 6 lands.	0
Tehama Ranch Mutual Water Co.	Approximately 250 acres of dryland farming to irrigated agriculture.	District is within existing place of use.	District is within expanded place of use.	District is proposing to irrigate 75 acres of Class 6 lands.	2
Yolo-Zamora Water District	Approximately 9,000 acres of dryland farming to irrigated agriculture.	District is proposing to irrigate approximately 128 acres outside existing place of use.	District is within expanded place of use.	District is proposing to irrigate approximately 1,830 acres of Class 6 lands.	0
Yolo-Solano CVP Water Service Coordinating Group					
Yolo County Flood Control and Water Conservation District	Approximately 5,000 acres of dryland farming to irrigated agriculture.	District is proposing to irrigate approximately 3,800 acres outside existing place of use.	District is proposing to irrigate approximately 1,200 acres outside expanded place of use.	Lands are not classified.	0
All other agencies	None				

Table 4L-2. Continued

Agency	Acres and Type of Land Converted	Consistency of Proposed Development with Existing Place of Use	Consistency of Proposed Development with Expanded Place of Use	Consistency of Proposed Development with Irrigable Land Classification	Acres of Wetlands Within Proposed Areas of Development
Wildlife Refuges					
Delevan NWR	Approximately 3,350 acres of upland habitat to managed wetland and agricultural uses.	Refuge is within existing place of use.	Refuge is within expanded place of use.		0
Colusa NWR	Approximately 4,000 acres of upland habitat to managed wetland.	Refuge is within existing place of use.	Refuge is within expanded place of use.		0
Sutter NWR	Approximately 2,000 acres of upland habitat to managed wetland and agricultural uses.	Refuge is within existing place of use.	Refuge is within expanded place of use.		0
Gray Lodge WMA	Approximately 3,300 acres of upland habitat to managed wetland and agricultural uses.	Refuge is outside existing place of use.	Refuge is within expanded place of use.		0
Sacramento NWR	Approximately 7,150 acres of upland habitat to managed wetland and agricultural uses.	Refuge is within existing place of use.	Refuge is within expanded place of use.		0

Note: N/A = Not applicable.

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proposed place of use. The total amount of such acreage is 1,200. Use of CVP water outside Reclamation's existing place of use would be inconsistent with its water rights permits and is considered a potentially significant impact. However, Reclamation policy prevents such use of CVP water and no significant impacts would result.

Several agencies are also proposing to irrigate 4,500 acres of land identified as Class 6 by Reclamation or that has not been classified. Irrigation of Class 6 or unclassified lands would be inconsistent with Reclamation policy and is considered a potentially significant impact. However, Reclamation policy prevents such use of CVP water and no significant impacts would result.

Land conversion proposed by many of the agencies could affect substantial amounts of wetlands. These impacts would be significant. A total of approximately 1,200 acres of wetlands in addition to those described in the No-Action Alternative may be affected. Such conversions require findings be made pursuant to EO 11990. These findings are contained in Chapter 7, "Consultation and Coordination."

Site-Specific Impacts

Shasta Dam Area Public Utility District. The agency contains wetlands that could be affected by growth. Impacts to wetlands may occur within the agency, so findings pursuant to EO 11990 are presented in Chapter 7, "Consultation and Coordination." Substantial areas within the agency are designated in the agencies general plan as urban growth areas, so the amount of development accommodated by the provision of CVP water (approximately 6,000 acres) would not be inconsistent with local land use planning.

Sacramento Valley Canals Agencies. These agencies propose to irrigate an additional 47,000 acres of currently nonirrigated land beyond that occurring under 2020 no-action conditions. Many agencies in this area are proposing to irrigate a total of 7,700 acres outside Reclamation's existing place of use. In addition, a few agencies propose to irrigate 3,300 acres of Class 6 and unclassified lands. The specific agencies proposing such conversions are listed in Table 4L-2. These impacts are potentially significant, but Reclamation policy prevents such use of CVP water and no significant impacts would result.

None of the agencies in this group is an M&I agency that would be growth constrained in the absence of CVP water. Therefore, no assessment of FEMA-identified floodplains is necessary. Several agencies in this group, however, are proposing to convert wetlands to irrigated agricultural uses. Approximately 1,200 acres of wetlands would be affected. The agencies are listed in Table 4L-2. These impacts would also be significant, so findings pursuant to EO 11990 are presented in Chapter 7, "Consultation and Coordination.

Yolo-Solano CVP Water Service Coordinating Group. These agencies are proposing to convert 5,000 acres to irrigated agricultural uses beyond conversions occurring under 2020 no-action conditions. Approximately 3,800 acres are outside the existing place of use, and 1,200 acres are outside of the proposed place of use. The district lands have not been classified, and approximately 5,000 acres of unclassified lands are proposed for irrigation.

These impacts are potentially significant, however Reclamation policy prevents such use of CVP water and no significant impacts would result.

No wetlands occur within the district and other additional land use changes would occur under this alternative, beyond those identified under the No-Action Alternative, above.

Refuges. Under this alternative, refuges would convert acreage from upland habitat uses to wetland uses. The conversions estimated for each refuge are shown in Tables 4L-2 (Level 2 supplies) and 4L-3 (Level 4 supplies) and total 20,000 and 22,700 acres, respectively. No significant impacts from changes in land use would result.

Gray Lodge Wildlife Management Area is outside the existing place of use. Delivery of water to this refuge is considered a significant impact. If this refuge is provided water through exchange agreements by DWR or some other agency, no significant impacts would result.

Alternative 2

Regional Impacts

Under this alternative, Shasta Dam Area Public Utility District would be allocated 100 percent of its need and Sacramento Valley canals agencies would be allocated 76 percent of their needs. The Yolo-Solano CVP Water Service Coordinating Group and refuges, however, would not receive any new or expanded CVP contracts. Although agricultural agencies would receive only 76 percent of their needs, this analysis assumes that full land conversions proposed by the agencies would occur because specific data regarding the location of land use conversions under this alternative are lacking. Significant land use impacts would result.

This alternative would result in the conversion of 53,000 acres to irrigated agricultural uses in addition to those converted under the No-Action Alternative. Approximately 7,900 acres are proposed for irrigation outside the existing place of use. In addition, 2,000 acres would be converted to urban uses.

Site-Specific Impacts

Shasta Dam Area Public Utility District. Impacts within this district would be identical to those described under Alternative 1 (Table 4L-2). No significant land use impacts would result.

Sacramento Valley Canals Agencies. Impacts within these agencies would also be identical to those described under Alternative 1 (Table 4L-2). These land use impacts would be significant.

Yolo-Solano CVP Coordinating Group. No changes in land use, beyond those occurring under the No-Action Alternative would result, and no significant land use impacts would occur.

Refuges. No CVP water would be provided under this alternative, so no significant land use impacts would result.

Alternative 3

Regional and Site-Specific Impacts

Regional and site-specific impacts under this alternative would be identical to those of the Proposed Action. Significant land use impacts would occur within Sacramento Valley canals agencies, the Yolo County Flood Control and Water Conservation District, and refuges. Site-specific land use impacts are described in Table 4L-2.

Alternative 4A/B

Regional and Site-Specific Impacts

Agricultural and M&I agency impacts under this alternative would be identical to those described under Alternative 2 and would be significant. Refuges would receive Level 4 supplies under this alternative (Table 4L-3) and would convert 22,700 acres from upland habitat to wetland uses. Impacts would be identical to Alternative 1 - Option B and would be significant.

Alternative 4C/D

Regional and Site-Specific Impacts

No land use impacts would occur in agricultural and M&I agencies because 2020 conditions under this alternative would be identical to the No-Action Alternative. Under this alternative, refuges would receive Level 2 supplies (Table 4L-2), resulting in the conversion of 20,000 acres of upland habitat to wetland uses. Impacts would be identical to Alternative 1 - Option A and would be less than significant.

Table 4L-3. Land Use Impacts Associated with Water Contracting:

Alternatives: 1 - Option B, 5
Sacramento River Service Area

Agency	Acres and Type of Land Converted	Consistency of Proposed Development with Existing Place of Use	Consistency of Proposed Development with Expanded Place of Use	Consistency of Proposed Development with Irrigable Land Classification	Acres of Wetlands Within Proposed Areas of Development
Wildlife Refuges					
Delevan NWR	Approximately 4,300 acres of upland habitat to managed wetland and irrigated agricultural uses.	Refuge is within existing place of use.	Refuge is within expanded place of use.	N/A	0
Colusa NWR	Approximately 4,100 acres of upland habitat to managed wetland and irrigated agricultural uses.	Refuge is within existing place of use.	Refuge is within expanded place of use.	N/A	0
Sutter NWR	Approximately 2,200 acres of upland habitat to managed wetland and irrigated agricultural uses.	Refuge is within existing place of use.	Refuge is within expanded place of use.	N/A	0
Gray Lodge WMA	Approximately 4,300 acres of upland habitat to managed wetland and irrigated agricultural uses.	Refuge is outside existing place of use (11,300 acres).	Refuge is within expanded place of use.	N/A	0
Sacramento NWR	Approximately 7,650 acres of upland habitat to managed wetland and irrigated agricultural uses.	Refuge is within existing place of use.	Refuge is within expanded place of use.	N/A	0

Note: N/A = Not applicable.

Alternative 5

Regional and Site-Specific Impacts

No land use impacts would occur within agricultural or M&I agencies because 2020 conditions under this alternative would be identical to conditions under the No-Action Alternative. Under this alternative, refuges would receive Level 4 water supplies, resulting in the conversion of 22,700 acres of upland habitat to wetland uses (Table 4L-3). Impacts would be identical to Alternative 1 - Option B and would be significant.

Alternative 6

Regional and Site-Specific Impacts

Agricultural and M&I agency impacts would be identical to those described under Alternative 2 and would be significant. Refuges would receive Level 2 supplies and would convert 20,000 acres to wetland uses (Table 4L-2). Impacts would be less than significant.

Alternative 7

Regional and Site-Specific Impacts

No land use impacts would occur within agricultural or M&I agencies since 2020 conditions under this alternative would be identical to conditions under the No-Action Alternative. Under this alternative, refuges would receive Level 4 water supplies, resulting in conversion of 22,700 acres of upland habitat to wetland uses (Table 4L-3). Significant land use impacts would occur.

Mitigation Measures

Include Provisions in New and Expanded CVP Water Service Contracts That Prohibit Use of CVP Water Outside Reclamation's Existing Place of Use

Several agencies propose to use CVP water outside Reclamation's existing place of use. To ensure that no significant impacts result this impact, contracts for new or expanded CVP water supplies could include the following provision:

- No CVP water will be delivered to areas outside the existing place of use until the SWRCB approves the petition by Reclamation to expand its place of use.

In addition, to prevent potential future impacts that could result if CVP water were used to irrigate lands outside the place of use proposed by Reclamation if approved by the SWRCB, no water should be provided to requestors to serve areas outside the expanded place of use.

Prevent Use of CVP Water on Nonirrigable Lands

Several agencies have proposed to use CVP water to irrigate lands that are Class 6 or unclassified. To ensure this impact does not occur, contracts for new or expanded CVP water supplies could include the following provisions:

- No long-term commitment for delivery of CVP water will be made to lands that are defined by Reclamation as nonirrigable unless such nonirrigable lands are reclassified to an irrigable category.

- No long-term commitment for delivery of CVP water will be made to lands that have not been classified until they have been classified and have been determined to be irrigable.

POPULATION GROWTH AND RELATED SOCIAL IMPACTS

Introduction

The magnitude, location, and timing of population growth within a region is ultimately determined by an array of interlinking economic, institutional, and social variables. A change in a single variable can sometimes slow or stop growth within a small area; however, a change in a single variable will rarely cause growth to occur.

The availability of water is one variable that influences the magnitude and location of population growth within an area. Other variables include the adequacy of transportation facilities, the availability of land, the supply and cost of housing, the quality of local schools, the cost of energy, the adequacy of public services such as police and fire protection, the adequacy of wastewater treatment facilities, the geographic location of an area in relation to employment centers and recreational amenities, and the employment opportunities and trends within an area.

While the availability of water and water-related facilities may permit growth to occur within a specific area, it does not cause growth to occur. Providing water to an area that does not have alternative supplies, however, can be considered growth inducing since the availability of adequate water supplies removes a primary barrier to growth. For this EIS, the alternatives are considered to be growth inducing only when they supply CVP water to an area that is assumed to not have a secondary source of water. The Shasta Dam Area Public Utility District is the only requesting agency within the SRSA that is considered to be without a secondary source of water. For areas or districts with secondary water sources, CVP water provided by the alternatives is not considered to be growth inducing. For those areas or districts, population growth is assumed to occur at levels projected by regional planning agencies, and the population-related impacts on public services, traffic systems, and air quality are assumed to be the same as under the No-Action Alternative.

The following assumptions and relationships between water availability and growth were incorporated into the evaluation of project-related population growth impacts and related social impacts.

- Population-related impacts were evaluated for the year 2015 to be consistent with the evaluation year for the CVP water needs analysis.

- Population projections prepared by DOF, SACOG, and ABAG (modified when necessary to represent population levels in 2015), are assumed to represent future growth levels for cities and counties, given the availability of water. It should be noted that the projections prepared by SACOG and ABAG for local jurisdictions were prepared from a regional perspective. Although projections at the regional and county level are likely to be reasonably accurate given current information, subcounty and local jurisdiction area projections by these agencies are subject to considerable uncertainty. This is particularly true of long-term projections for areas undergoing rapid or unanticipated change. Because of the inherent lack of precision in long-term, local-level projections, the

projections used in this EIS may not correspond with those prepared by local governments and districts requesting CVP water are presented in Table 4M-1 and formed the basis for the Technical Appendix A - Water Needs Analysis.

- The cost of secondary sources of water, when higher than CVP water, may cause short-term shifts in population growth within a region. Over the 30-year planning period, however, the cost of water is not expected to play a major role in the magnitude or location of growth within a region. A study of the relationship between population growth and water resources policy undertaken by the National Water Commission (RivKin/Carson, Inc. 1971) concluded that the per capita cost for water is relatively small compared with costs of other essential public services such as roads, schools, and police and fire protection. The cost of water alone does not play a major role in the location decision of households or most businesses and would not cause population levels to deviate noticeably from long-term projections.

- It is assumed that water allocated for agricultural uses would not generate population growth above the levels projected by DOF for the counties in which the agricultural districts are located. Water allocated for agricultural uses is not considered to induce measurable population growth or lead to adverse growth-related secondary impacts.

No-Action Alternative

Regional 2015 Baseline Conditions

Population. Under the No-Action Alternative, none of the water-requesting entities would receive new or expanded CVP water contracts. As shown in Table 4M-1, all agencies requesting CVP water for M&I uses except for the Shasta Dam Area Public Utility District would have available secondary sources of water that would allow them to grow to the levels projected by DOF, SACOG, and ABAG as presented in Table 4M-1. Within the six-county area potentially affected by the project, the combined population is projected to increase from its 1985 level of 604,500 to a 2015 level of 1,055,500. This 75-percent increase represents a 30-year average annual growth rate of 2.5 percent.

Within Shasta County, implementation of the No-Action Alternative would limit the population in the Shasta Dam Area Public Utility District area at 2015 (Table 4M-1). The population growth would probably shift to other areas of Shasta County, including Redding and unincorporated areas south and east of the district.

Housing. Population growth projected for the six-county area under the No-Action Alternative would require the addition of an estimated 164,000 du to the existing housing stock by 2015, based on estimates of average household sizes prepared by DOF (1986) for 1985 (Table 4M-2). The required regional housing stock growth would represent a 72-percent increase over existing (1985) housing levels. Approximately 70 percent of the estimated regional housing required by the projected population growth would be located

Table 4M-1. Projected Populations at 2015 Under the Alternatives

Agency	Existing (1985) Population	No-Action	Alternative 1	Alternative 2	Alternative 3	Alternative 4A/B	Alternative 4C/D	Alternative 5	Alternative 6	Alternative 7
Counties										
Shasta County	129,700	216,000	216,000	216,000	216,000	216,000	216,000	216,000	216,000	216,000
Tehama County	43,800	72,900	72,900	72,900	72,900	72,900	72,900	72,900	72,900	72,900
Glenn County	22,950	31,100	31,100	31,100	31,100	31,100	31,100	31,100	31,100	31,100
Colusa County	14,450	22,100	22,100	22,100	22,100	22,100	22,100	22,100	22,100	22,100
Yolo County	122,600	194,400	194,400	194,400	194,400	194,400	194,400	194,400	194,400	194,400
Solano County	271,000	519,000	519,000	519,000	519,000	519,000	519,000	519,000	519,000	519,000
Cities										
Davis, City of	40,400	74,700	74,700	74,700	74,700	74,700	74,700	74,700	74,700	74,700
Woodland, City of	33,050	60,300	60,300	60,300	60,300	60,300	60,300	60,300	60,300	60,300
Dixon, City of	9,550	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000
Vacaville, City of	50,200	118,300	118,300	118,300	118,300	118,300	118,300	118,300	118,300	118,300
Fairfield, City of	65,900	138,300	138,300	138,300	138,300	138,300	138,300	138,300	138,300	138,300
Suisun City, City of	13,900	38,900	38,900	38,900	38,900	38,900	38,900	38,900	38,900	38,900
Vallejo, City of	89,500	129,700	129,700	129,700	129,700	129,700	129,700	129,700	129,700	129,700
Benicia, City of	20,850	32,000	32,000	32,000	32,000	32,000	32,000	32,000	32,000	32,000
Rio Vista, City of	3,410	10,700	10,700	10,700	10,700	10,700	10,700	10,700	10,700	10,700
Other Areas										
Shasta Dam Area PUD	8,250	10,360	18,500	18,500	18,500	18,500	10,360	10,360	18,500	10,360

Note: Projections for all areas other than the Shasta Dam Area PUD assume the availability of a non-CVP source of water and that cities and counties will grow to the levels shown in Table 3M-2 regardless of the availability of new or expanded CVP water contracts. Projections for the Shasta Dam Area PUD assume a water supply of at least 2,750 af/yr.

Sources: Existing populations for cities and counties: California Department of Finance 1986.

Existing populations for Shasta Dam Area PUD: U. S. Bureau of Reclamation 1988.

Projected populations for cities and counties: See Table 3M-2.

Projected populations for Shasta Dam Area PUD: U. S. Bureau of Reclamation 1988.

Water needs analysis projections: U. S. Bureau of Reclamation 1988.

Table 4M-2. Additional Housing Required at 2015 Under the Alternatives

Agency	Existing (1985) Housing Stock	Additional Dwelling Units Required to House Projected Populations								
		No-Action	Alternative 1	Alternative 2	Alternative 3	Alternative 4A/B	Alternative 4C/D	Alternative 5	Alternative 6	Alternative 7
Counties										
Shasta County	53,270	32,430	32,430	32,430	32,430	32,430	32,430	32,430	32,430	32,430
Tehama County	18,600	11,180	11,180	11,180	11,180	11,180	11,180	11,180	11,180	11,180
Glenn County	9,170	3,030	3,030	3,030	3,030	3,030	3,030	3,030	3,030	3,030
Colusa County	5,870	2,790	2,790	2,790	2,790	2,790	2,790	2,790	2,790	2,790
Yolo County	47,410	28,150	28,150	28,150	28,150	28,150	28,150	28,150	28,150	28,150
Solano County	93,750	86,440	86,440	86,440	86,440	86,440	86,440	86,440	86,440	86,440
Cities										
Davis, City of	16,440	14,230	14,230	14,230	14,230	14,230	14,230	14,230	14,230	14,230
Woodland, City of	12,210	10,030	10,030	10,030	10,030	10,030	10,030	10,030	10,030	10,030
Dixon, City of	3,140	2,340	2,340	2,340	2,340	2,340	2,340	2,340	2,340	2,340
Vacaville, City of	16,600	23,690	23,690	23,690	23,690	23,690	23,690	23,690	23,690	23,690
Fairfield, City of	21,380	24,500	24,500	24,500	24,500	24,500	24,500	24,500	24,500	24,500
Suisun City, City of	4,410	7,510	7,510	7,510	7,510	7,510	7,510	7,510	7,510	7,510
Vallejo, City of	32,490	14,580	14,580	14,580	14,580	14,580	14,580	14,580	14,580	14,580
Benicia, City of	7,760	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100
Rio Vista, City of	1,450	3,010	3,010	3,010	3,010	3,010	3,010	3,010	3,010	3,010
Other Areas										
Shasta Dam Area PUD	3,150	810	3,940	3,940	3,940	3,940	810	810	3,940	810

Note: Projections for all areas other than the Shasta Dam Area PUD assume the availability of a non-CVP source of water and that cities and counties will grow to the levels shown in Table 3M-3 regardless of the availability of new or expanded CVP water contracts. Projections for the Shasta Dam Area PUD assume a water supply of at least 2,750 af/yr.

Sources: Existing housing for cities and counties: California Department of Finance 1986.

Existing housing for Shasta Dam Area PUD: U. S. Bureau of Reclamation 1988.

Projected housing for cities and counties: See Table 3M-3.

Projected housing for Shasta Dam Area PUD: based on population projections shown in Table 4M-1 and estimated average household size of 2.60.

in Yolo and Solano Counties. The projected regional housing stock growth would occur regardless of the availability of new or expanded CVP contracts.

Traffic. Under the No-Action Alternative, population growth within the SRSA would result in an increased number of vehicle trips throughout the service area. Future traffic conditions will depend on roadway facility improvements and the rate and location of increased traffic volumes. Table 3M-4 illustrates traffic impacts on selected highway segments that might result from population and economic growth.

Air Quality. Under the No-Action Alternative, emissions in Sacramento, Yolo, and Solano Counties would probably continue to exceed air quality standards unless revised AQMPs are successfully implemented. Each of the regional agencies responsible for air quality planning for these areas will be required by EPA to update its AQMP to show how standards will be met. As described in Chapter 3, "Affected Environment," SACOG is already revising its AQMP. If these new AQMPs are prepared and fully implemented, air quality conditions could improve and standards may be met.

Site-Specific 2015 Baseline Conditions

Population. Projected population levels for cities and counties under the No-Action Alternative are presented in Table 4M-1. These projections are the same as the projections discussed in Chapter 3, "Affected Environment" for cities and counties because these areas would have access to secondary sources of water and would be expected to grow to levels projected by DOF, SACOG, and ABAG. The lone exception would be the Shasta Dam Area Public Utility District, which would be constrained by the availability of water under the No-Action Alternative.

Under the No-Action Alternative, population within the Shasta Dam Area Public Utility District would increase from an estimated existing population of 8,250 to an estimated ultimate population of 10,360. This projected population level assumes full use of a current temporary water contract with Reclamation and the long-term renewal of the contract that would provide 2,750 af/yr to the district. Population within the district is projected to increase at an annual rate of approximately 3 percent over the next 10 years (U. S. Bureau of Reclamation 1988), indicating that the district would reach its ultimate population level and become growth constrained within 7 to 8 years.

Housing. The estimated housing requirements of cities and counties at 2015 under the No-Action Alternative are presented in Table 4M-2. These housing requirements do not differ from the housing-need projections discussed in the Chapter 3 - "Affected Environment" since the population growth in the cities and counties at 2015 would be the same regardless of the availability of new or expanded CVP contracts.

Within the water-constrained Shasta Dam Area Public Utility District, additional housing requirements would be limited to an estimated 810 du based on the projected population level within the district under the No-Action Alternative and an estimated average household size of 2.60. The projected housing requirements would represent a 26-percent increase over existing housing within the district. Based on projected population

growth rates, the housing would be required within the first 7 to 8 years of the 30-year study period.

Alternative 1

Regional Impacts

Population. Under the Proposed Action, all agricultural and M&I requesters within the SRSA would receive CVP water allocations equalling 100 percent of their need. The water allocations would allow population growth within the six-county area to reach the levels projected by DOF, ABAG, and SACOG as shown in Table 4M-1. The regional population growth projected for 2015 under Alternative 1 would not differ substantially from population growth projected under the No-Action Alternative since secondary water supplies exist for all requesters other than the Shasta Dam Area Public Utility District. Because of the availability of non-CVP water, impacts of Alternative 1 on regionwide population growth would not be significant.

Housing. As discussed above, regional population growth, and therefore regional housing requirements, would not differ from the No-Action Alternative at 2015, as shown in Table 4M-2.

Traffic. Under this alternative, regional traffic conditions would be similar to those occurring under the No-Action Alternative, and thus would not be significant.

Air Quality. Alternative 1 would not result in increased regional population growth, as compared to No-Action Alternative 2020 baseline conditions. Therefore, impacts from Alternative 1 on regional air quality problems, such as ozone standard attainment, would not be significant. Because Alternative 1 induces local population growth in the Shasta Dam Area Public Utility District, localized growth-related air quality impacts (e.g., increased carbon monoxide and particulate emissions) could occur, but these impacts cannot be predicted without detailed knowledge of specific development projects.

The Clean Air Act prohibits federal actions that do not conform to the EPA-approved SIP. (42 USC Sec. 7506). Because the portions of the California SIP applicable to the SRSA are outdated and in the process of revision, it is not possible to determine conformity of Alternative 1 with the SIP. For example, it is not possible to determine whether 2015 growth projections assumed in Alternative 1 are accounted for by the SIP because the growth and emission projections set forth in applicable portions of the SIP stop at 1987.

Site-Specific Impacts

Population. Projected 2015 populations for cities and counties under Alternative 1 are shown in Table 4M-1. Except for the population level projected for the Shasta Dam Area Public Utilities District, the projected populations are the same as under the No-Action Alternative.

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As shown in Table 4M-1, the population levels projected under Alternative 1 do not directly correspond with the population projections used to prepare the water needs analysis. For some jurisdictions, the CVP water allocation under Alternative 1 would support population growth greater than that projected to occur by 2015 by SACOG and ABAG; for other jurisdictions, the growth supported by the water allocation would be less than projected levels. Ultimately, the increment of population increase supported by the water allocations to nonconstrained areas would not affect actual population growth levels because secondary sources of water are available to these areas.

The Shasta Dam Area Public Utility District, which would be constrained by the availability of water under the No-Action Alternative, would grow to a projected population of approximately 18,500 by 2015 under Alternative 1 (Table 4M-1). This projected population level would represent an increase of 8,140, or 79 percent, over the projected no-action level. This increment of population growth within the Shasta Dam Area Public Utility District would be directly induced by Alternative 1 because population growth in the district would otherwise be constrained by the lack of water.

The increment of population growth accommodated by the project would increase the level of demand for school, police, fire protection, and wastewater treatment services above levels projected for the No-Action Alternative. The school districts serving the area are currently overcrowded and would require additional facilities to accommodate students generated by future growth. The population growth under Alternative 1 is substantially greater than under the No-Action Alternative and would increase the demand for police and fire protection services within the Shasta Dam Area Public Utility District. These services would be funded by state and local agencies and would be provided at the local level. No significant impacts would occur provided funding is adequate.

Alternative 1 would provide enough water for approximately 3,940 du within the Shasta Dam Area Public Utilities District. As discussed under the No-Action Alternative, the district is planning to connect to the City of Redding's proposed regional wastewater treatment system. This intertie will alleviate wastewater treatment capacity problems within the district, and would reduce the impact of this alternative to a less-than-significant level.

Housing. Additional housing required at 2015 for cities and counties potentially affected by Alternative 1 is presented in Table 4M-2. Except for projected housing requirements in the Shasta Dam Area Public Utility District, the projected housing requirements are the same as under the No-Action Alternative.

Based on an average household size of 2.60, an additional 3,940 du would be required within the Shasta Dam Area Public Utility District at 2015 under this alternative (Table 4M-2). This projected housing level would represent an increase of 3,130 du over housing required under the No-Action Alternative. The housing requirements induced by the Proposed Action would generate increased construction-related activity within the Shasta Dam Area Public Utility District, but would also generate indirect effects on land use. These impacts are discussed in the "Land Use" sections of this report.

Alternative 2

Regional and Site-Specific Impacts

Under Alternative 2, population, housing, traffic, and air quality impacts would be identical to those of Alternative 1. No significant impacts would result.

Alternative 3

Regional and Site-Specific Impacts

Under this alternative, population, housing, traffic, and air quality impacts would be identical to Alternative 1. No significant impacts would result.

Alternative 4A/B

Regional and Site-Specific Impacts

Under this alternative, population, housing, traffic, and air quality impacts would be identical to those of Alternative 1. No significant impacts would result.

Alternative 4C/D

Regional and Site-Specific Impacts

No population, housing, traffic, or air quality impacts would occur under this alternative because 2015 conditions would be identical to those of the No-Action Alternative.

Alternative 5

Regional and Site-Specific Impacts

No population, housing, traffic, or air quality impacts would occur under this alternative because 2015 conditions would be identical to those of the No-Action Alternative.

Alternative 6

Regional and Site-Specific Impacts

Under this alternative, population, housing, traffic, and air quality impacts would be identical to those of Alternative 1. No significant impacts would result.

Alternative 7

Regional and Site-Specific Impacts

No population, housing, traffic, or air quality impacts would occur under this alternative because 2015 conditions would be identical to those of the No-Action Alternative.

Mitigation Measures

Regional and Site-Specific Impacts

Regional and site-specific impacts of the alternatives on population, housing, and related social concerns would be less than significant. Therefore no mitigation measures are required.

C-055826

CULTURAL RESOURCES

Introduction

The analysis below focuses on the known cultural resources within the SRSA that are most likely to be affected by water contracting alternatives. These include prehistoric and historic sites located within the Shasta Reservoir pool area and sites listed on the National Register of Historic Places located in or near requesting agencies.

The National Inundation Study (National Park Service 1981) and investigations conducted by Henn and Sundahl (1986) indicate that cultural resources located at elevations included within the maximum reservoir drawdown zone (MDDZ) are subject to potentially damaging natural processes and human activities. Numerous cultural resources occur within the Shasta Reservoir pool area and could be affected by water contracting activities. These potential impacts are addressed at the regional level.

For purposes of this EIS, assessment of potential site-specific impacts to cultural resources was confined to sites listed on the National Register of Historic Places. Because few areas within the requesting agencies have been surveyed for cultural resources, it is difficult to assess the number of local sites that may be affected by site-specific activities resulting from water contracting, such as construction of new conveyance facilities and development of new irrigated lands. According to the requirements of NEPA, CEQA, and 36 CFR 800, cultural resource inventories will be conducted prior to project development. In the event that significant cultural resources are affected, procedures as outlined in Reclamation Instruction 376.11 I and in the (to be developed) Programmatic Memorandum of Agreement between Reclamation, State Historic Preservation Officers, and the Advisory Council on Historic Preservation will be followed. However, other sites eligible for the National Register probably exist.

Currently, the American Indian Religious Freedom Act and regulations established by the Department of the Interior allow Native American Indians to catch fish for religious and ceremonial purposes. Trinity River fisheries would not be adversely affected by the Proposed Action or alternatives (Chapter 4, "Fisheries") and their use by the Hoopa and Yurok Tribes should not be significantly changed.

The primary impacts to cultural resources within the Shasta pool area result from their being exposed during reservoir operations. When exposed, cultural resource sites in the MDDZ are subject to vandalism, erosion, siltation, redeposition and mixing of artifacts, and chemical alteration of site deposits (Henn and Sundahl 1986, National Park Service 1981). Sites frequently exposed are eroded by wave action or mass slumping, or are exposed along lakeshore margins where they are vandalized, or inadvertently disturbed by recreational activities. All of these elements tend to have adverse effects on cultural resource sites.

No-Action Alternative

Regional 2020 Baseline Conditions

The maximum ranges of projected reservoir elevations at Shasta Reservoir for existing and the No-Action Alternative conditions are presented in Table 4N-1, along with the number of cultural resource sites within the indicated ranges. Currently, 84 cultural resource sites are located within the MDDZ. Under the No-Action Alternative, the MDDZ would decrease and only 64 cultural resource sites would be within the MDDZ. Thus, a comparison of 1985 conditions to conditions under the No-Action Alternative shows that the number of cultural resource sites affected by reservoir drawdown would actually decrease under this alternative based on the operations planning model studies used to evaluate the various alternatives.

Site-Specific 2020 Baseline Conditions

Shasta Dam Area Public Utility District. No national register sites are located in this district. In addition, little growth would occur under this alternative. Therefore, no effects to existing or potential sites would result.

Sacramento Valley Canals Agencies. If no CVP water is contracted to these agricultural requestors, no new water conveyance facilities would be constructed and development of new lands would not occur. No effects to existing or potential national register sites would occur compared to existing (1985) conditions.

Yolo-Solano CVP Water Service Coordinating Group. Under the No-Action Alternative, M&I needs of the various requesting communities would be met from groundwater, and projected development is assumed to occur. National register sites in the requesting communities are summarized in Table 4N-2. Most of these are located along main streets within cities; therefore, changes from 1985 conditions are not expected.

Refuges. Under the No-Action Alternative, no CVP water would be contracted to refuges, and no effects to prospective national register sites in the Sacramento National Wildlife Refuge would occur. Cultural resource sites have been recorded at the other refuges.

Alternative 1

Regional Impacts

The potential impacts to cultural resource sites within the MDDZ are dependent on the magnitude and frequency of the drawdowns. Table 4N-1 displays the maximum drawdowns in the 57 years of record as calculated using the operations planning model and the number of sites that would be exposed for each alternative.

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Table 4N-1. Cultural Resources Within Folsom Reservoir Pool Area: Sacramento River Service Area

Type	Existing (1985) Conditions 855-1068[a]	No-Action Alternative (2020) 947-1068[a]	Alternative 1 836-1068[a]	Alternative 2 836-1068[a]	Alternative 3 884-1068[a]	Alternatives 4A/B and 4C/D 836-1068[a]	Alternative 5 869-1068[a]	Alternative 6 838-1068[a]	Alternative 7 901-1068[a]
Prehistoric	77	62	81	76	76	81	77	81	69
Historic	3	0	3	0	0	3	0	3	0
Historic/ prehistoric	4	2	5	3	3	5	4	5	3
Total	84	64	89	79	79	89	81	89	72

[a] Numbers represent the maximum reservoir drawdown zone, the range between minimum and maximum water surface elevations, measured in feet above mean sea level, that would result under each alternative as predicted by the Operations Planning Model.

Table 4N-2. National Register Sites:
Sacramento River Service Area

Agency	National Register Site	Location
Sacramento River Canals Agencies		
Corning Water District	Bridge No. 8C-14	Carries Rawson Road over Red Banks Creek
	Bridge No. 5C-32	Carries Rawson Road over Thomes Creek
	Molino Lodge Building	3rd and C Streets, Tehama
Glenn-Colusa Irrigation District	Willows U.S. Post Office	315 W. Sycamore Street
	Colusa High School and Grounds	745 10th Street
	Colusa Grammar School	425 Webster Street
Yolo-Solano Agencies		
Davis, City of	Dresbach-Hunt Boyer House	604 2nd Street
	Southern Pacific Railroad Station	H and 2nd Streets
	Joshua Tufts House	434 J Street
	Animal Science Building	University of California-Davis
Woodland, City of	William B. Gibson House	512 Gibson Road
	Porter Building	501-511 Main Street
	Woodland Opera House	320 2nd Street
	Woodland Public Library	250 1st Street
	R.H. Beamer House	19 3rd Street
	Woodland I.O.O.F. Building	723 Main Street
	James Moore House	SW of Woodland
	Nelson Ranch	Woodland vicinity between CA113 and 102
Benicia, City of	Benicia Arsenal	Army Pt. and I-680
	Benicia Capitol Courthouse	1st and G Streets
	Crooks Mansion	285 W. G Street
	Old Masonic Hall	106 W. J Street
	S.S. Jeremiah O'Brien	Benicia vicinity, east at Suisun Bay
	Carr House	165 E. D Street
	Joseph Fischer House	135 G Street
Suisun, City of	Suisun Masonic Lodge No. 55	623 Main Street
	Samuel Martin House	293 Suisun Valley Road
Vacaville, City of	Vacaville Town Hall	620 E. Main Street
	Pena Adobe	2 miles SW of Vacaville
	Will H. Buck House	301 Buck Avenue
Vallejo, City of	Mare Island Naval Shipyard (National Historic Landmark)	No specific locational information
	Vallejo City Hall and County Building Branch	734 Main Street
	Old City Historic District	Sonoma Boulevard and Monterey, Carolina and York Streets

Compared to the No-Action Alternative, Alternative 1 would result in 25 more sites being subjected to the elements described above; therefore, impacts to cultural resources could be significant.

Site-Specific Impacts

Shasta Dam Area Public Utility District. No national register sites are located within this district. No significant impacts to national register sites are expected to occur under Alternative 1.

Sacramento Valley Canals Agencies. Six national register sites are located within these agencies as shown in Table 4N-2. Four sites are buildings located in downtown areas, and two sites are roadway bridges located in rural areas. It is not expected that any of the sites would be affected by construction of conveyance systems or conversion of land to irrigated agriculture. Therefore, compared with the No-Action Alternative, impacts to national register sites would be less than significant.

Yolo-Solano CVP Water Service Coordinating Group. Water contracting under Alternative 1 would facilitate development of new irrigated lands in the Yolo County Flood Control and Water Conservation District and may require construction of major new conveyance facilities. However, because most of the 27 national register sites are historic buildings and residences located in urban areas and along major streets or highways, impacts to them are expected to be less than significant as compared to the No-Action Alternative.

It should be noted that numerous historic sites that have not been evaluated according to national register criteria are located in Davis, Benicia, Woodland, Vacaville, Suisun City, and Vallejo (California Department of Parks and Recreation 1986). However, because of their locations, these sites would probably not be impacted as a result of distribution and conveyance system construction or land conversion.

Refuges. No national register sites are located within any of the five wildlife refuges; however, several California Conservation Corps buildings and structures eligible for national register listing are located within the Sacramento National Wildlife Refuge. Under Option A, the refuges would be allocated Level 2 needs, and additional lands would be developed for wetland habitat as compared to the No-Action Alternative. The amount and locations are expected to be identical to 1985 conditions. Consequently, no impacts to cultural resource sites would occur compared to the No-Action Alternative. Under Option B, provision of Level 4 needs could result in construction of new water distribution facilities and would result in conversion of upland habitat to wetland habitat. Effects to cultural resources on the Sacramento National Wildlife Refuge could result from these activities.

Alternative 2

Regional Impacts

Table 4N-1 shows that 79 cultural resource sites occur within the MDDZ under Alternative 2, or 15 more sites than under No-Action Alternative. Significant impacts could result for the reasons described above.

Site-Specific Impacts

Shasta Dam Area Public Utility District. Impacts under this alternative would be identical to Alternative 1. Significant impacts to unrecorded cultural resource sites could result.

Sacramento Valley Canals Agencies. Impacts within these agencies would be essentially the same as described above. Impacts to existing national register sites would be less than significant.

Yolo-Solano CVP Water Service Coordinating Group. Under this alternative, impacts would be identical to those under the No-Action Alternative. Consequently, no significant cultural resource impacts would occur.

Refuges. Under this alternative, conditions would be identical to those under the No-Action Alternative. Consequently, no significant impacts would result.

Alternative 3

Regional Impacts

Regional impacts under Alternative 3 would be identical to those described under Alternative 2.

Site-Specific Impacts

Shasta Dam Area Public Utility District. Impacts under this alternative would be identical to those described above unrecorded cultural resource sites could occur.

Sacramento Valley Canals Agencies. Under this alternative, impacts would be identical to those of Alternative 1.

Yolo-Solano CVP Water Service Coordinating Group. Under this alternative, impacts would be identical to those of Alternative 1.

Refuges. Impacts under this alternative would be identical to Alternative 1 - Option A. No significant cultural resource impacts are expected.

Alternative 4A/B

Regional Impacts

Regional impacts of Alternative 4A/B would be identical to those of Alternative 1. Significant cultural resource impacts could result.

Site-Specific Impacts

Shasta Dam Area Public Utility District. Under this alternative, impacts would be identical to Alternative 1.

Sacramento Valley Canals Agencies. Impacts under this alternative would be identical to Alternative 1.

Yolo-Solano CVP Water Service Coordinating Group. No significant impacts to cultural resources would occurs under this alternative since 2020 conditions would be identical to the No-Action Alternative.

Refuges. Impacts under this alternative would be identical to those under Alternative 1 - Option B.

Alternative 4C/D

Regional Impacts

Regional impacts of Alternative 4C/D are the same as those of Alternative 1. Significant cultural resource impacts could result.

Site-Specific Impacts

Shasta Dam Area Public Utility District. No significant cultural resource impacts would occur since 2020 conditions under this alternative would be identical to those under the No-Action Alternative.

Sacramento Valley Canals Agencies. No significant cultural resource impacts would occur under this alternative since 2020 conditions would be identical to those of the No-Action Alternative.

Yolo-Solano CVP Water Service Coordinating Group. No significant cultural resource impacts would occur under this alternative since 2020 conditions would be identical to those under the No-Action Alternative.

Refuges. Under this alternative, impacts would be identical to those described under Alternative 1 - Option A. No significant cultural resource impacts would result.

Alternative 5

Regional Impacts

Table 4N-1 shows that 81 cultural resource sites occur within the MDDZ under Alternative 5, or 17 more sites than under the No-Action Alternative. Significant cultural resource impacts would result for the reasons described under Alternative 1.

Site-Specific Impacts

With the exception of refuges, no significant impacts would occur under this alternative since 2020 conditions would be identical to those under the No-Action Alternative.

Alternative 6

Regional Impacts

Regional impacts under Alternative 6 are the same as those described under Alternative 1. Significant cultural resource impacts could result.

Site-Specific Impacts

Under this alternative, impacts would be identical to those described under Alternative 2.

Alternative 7

Regional Impacts

Table 4N-1 shows that 72 cultural resource sites occur within the MDDZ under Alternative 7, or eight sites more than under the No-Action Alternative. Significant impacts would result for the reasons described under Alternative 1.

Site-Specific Impacts

With the exception of refuges, no significant impacts would occur under this alternative since 2020 conditions would be identical to those under the No-Action Alternative.

Mitigation Measures

Potentially significant impacts are those associated with cultural resources that probably exist, but are not yet adequately inventoried to determine that significant impacts would result.

As required by Section 106 of the National Historic Preservation Act and Reclamation instructions, mitigation measures will be developed in consultation with the SHPO. A Programmatic Memorandum of Agreement could be developed to address possible impacts to cultural resources. This memorandum would describe the actions that Reclamation would use to mitigate, if required, adverse effects to significant cultural resources.

Regional Impacts

Prevent Impacts from Reservoir Fluctuations. Fluctuating reservoir levels that occur under the Proposed Action and Alternatives 1-7 could result in significant impacts to cultural resources as compared to the No-Action Alternative. Mitigation measures could be undertaken for sites that would be adversely affected. Mitigation for historic sites would include site stabilization, archival research, scientific excavations, and detailed photographing. Mitigation measures for prehistoric sites could include site stabilization (i.e., Ware 1981) and data recovery. These measures would comply with Section 106 of the National Historic Preservation Act 36 (CFR 800.7).

In cases where vandalism is a problem, site monitoring is recommended. Monitoring could be accomplished by law enforcement agents or by the use of electronic devices.

Site-Specific Impacts

The introduction to Chapter 4 describes Reclamation's approach to the development of site-specific mitigation measures, where necessary in future environmental documents.