DRAFT PROGRAM
ENVIRONMENTAL IMPACT REPORT

STATE DROUGHT WATER BANK

JANUARY 1993

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Foreword

Although California has successfully weathered 6 years of drought (beginning in 1987), it has not been without sacrifice to all segments of the water community. Many urban areas have imposed mandatory water rationing programs, and water rates have gone up by more than 40 percent throughout much of the State. State Water Project agricultural deliveries dropped to an unprecedented *zero* in 1991 and many federal Central Valley Project users were limited to a 25-percent supply in 1991 and 1992. The environment has suffered, particularly California's anadromous fisheries. Waterfowl habitat has also been greatly diminished by low rainfall and reduced water supplies.

Water transfers have come into their own during this drought. A number of successful transfers came about in the early part of the drought, although individual transactions took several months to coordinate. In February 1991, water conditions were more severe than had ever been seen. Severe shortages for critical water needs of more than 1 million acre-feet were forecast. Negotiations for individual transfers were under way but none were close to completion. Possible transfers were small compared to the demand. Governor Wilson formed the 1991 Drought Water Bank as a new institution to respond to the water supply crisis. Through the cooperation of about 350 sellers and 20 buyers, the Water Bank was able to meet eventual critical demands of 400,000 acre-feet while carrying another 265,000 acre-feet for the State Water Project into the next year. The Drought Water Bank continued in 1992 and successfully met the full critical water demands of more than 150,000 acre-feet.

DWR has developed extensive experience over the past 2 years in putting together hundreds of water transfers in a short period of time. This draft environmental impact report reflects that experience and evaluates potential environmental impacts associated with different categories of transfers. It also notes where the 1991 and 1992 Water Bank operations have improved conditions for fish and wildlife by lessening the adverse impacts of the drought.

This document is a program EIR. It is limited to a State-run drought water bank involving short-term transfers during drought periods over the next 5 to 10 years. It is not intended to cover issues related to permanent water transfers or to transfers during nondrought periods. Although future drought water banks will proceed within the scope of this document, they may need to be augmented through further environmental study and documentation.

Steve Macaulay

Steve Macaulay, Manager
Drought Water Bank
Department of Water Resources
State of California

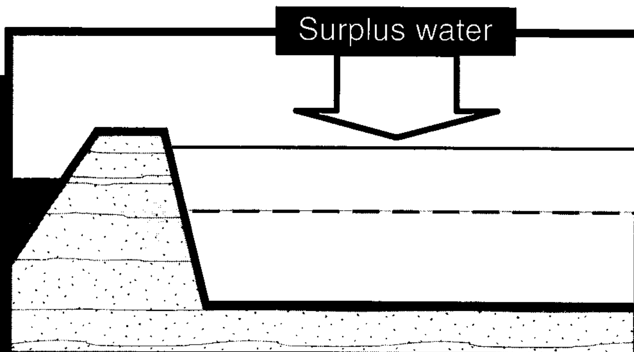
The WATER BANK a

FALLOWING

The Department pays the farmers not to plant crops that were planned for production. The water saved is credited to the bank.

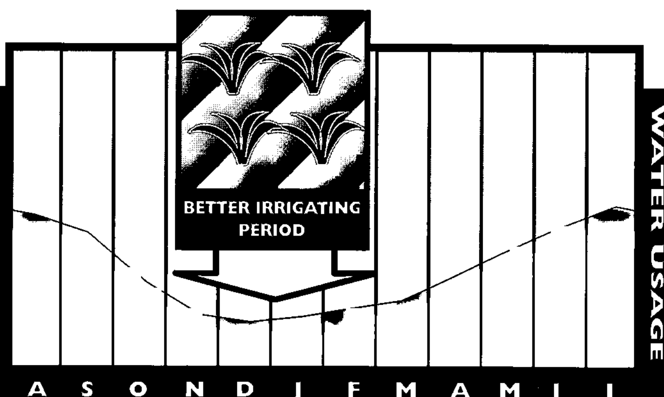
SURPLUS RESERVOIR WATER

The Department buys surplus water stored in reservoirs and credits it to the bank.



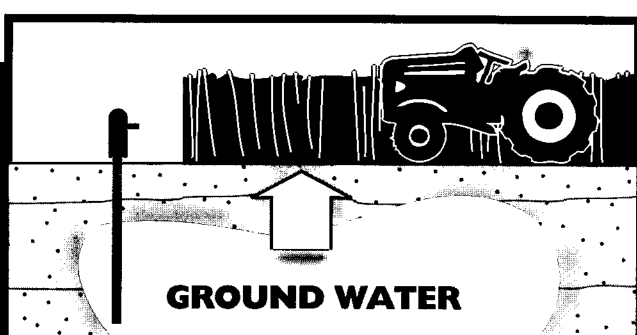
WITHHOLDING IRRIGATION

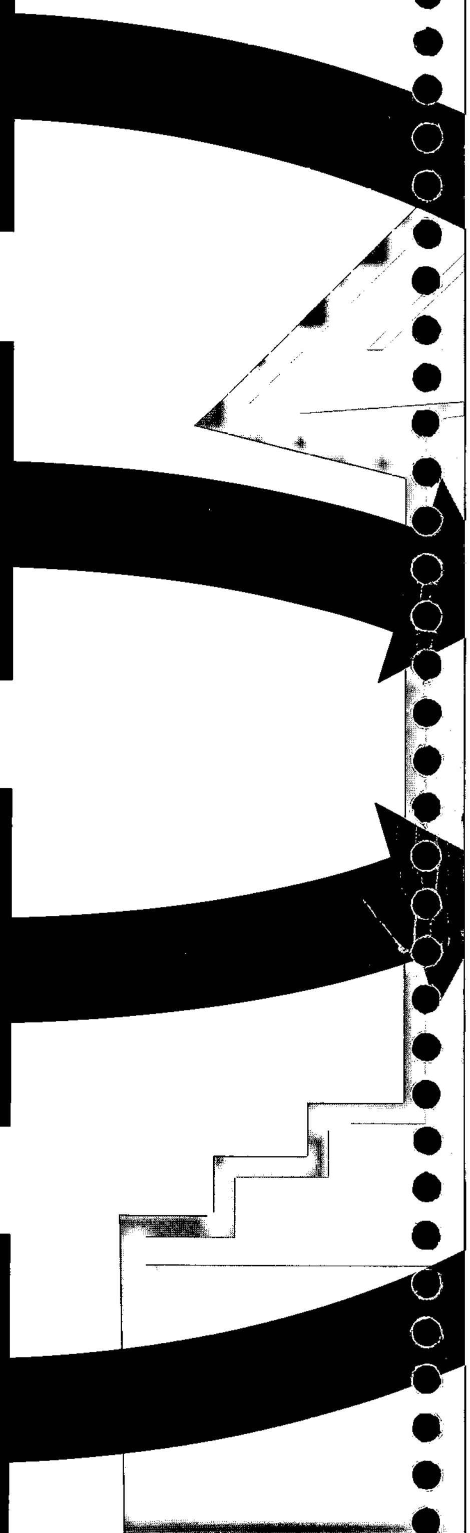
Farmers shift from a high-water-use crop to a low-water-use crop or plant during low-water-use periods and save water that can be sold to the bank.



GROUND WATER EXCHANGE

The Department purchases the farmer's surface water supply, which is replaced by pumping an equal amount of local ground water.





nd how it works :

The State Drought Water Bank was established in 1991 to supply water to those with critical water needs during times of drought.

The bank is a metaphor for the purchasing and allocating mechanism used by the Department to buy water from willing sellers and sell water to qualified buyers.

Sellers, such as farmers and water districts, can make deposits to the bank by: fallowing, crop shifting, withholding irrigation, exchanging ground water for surface water, and purchasing surplus water stored in local reservoirs.

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Summary

The Department of Water Resources is proposing a Drought Water Bank program. While short–term water transfers are exempt by statute from requirements of the California Environmental Quality Act (CEQA), the State Water Resources Control Board, which must approve any transfers, requires an environmental assessment. Therefore, DWR has prepared a program environmental impact report (EIR). DWR has prepared a program EIR, rather than a project EIR, because the Drought Water Bank may include different, but related, actions in different years.

The goal of the proposed Drought Water Bank program is to meet critical water demands that have been severely curtailed because developed water supplies have been significantly reduced as a result of drought or other unanticipated conditions. Such other unanticipated conditions, which result in extreme water shortages, may include natural disasters or water storage and transfer facilities failures, or significant restrictions on water storage or transfers due to federal or State endangered species acts.

The proposed program is a water purchasing and allocation program whereby DWR will purchase water from willing sellers and remarket the water to buyers under specific critical needs allocation guidelines. The program is intended as a short–term measure in near–emergency conditions due to lack of water. The program is intended to operate, as needed, over the next 5 to 10 years if drought or other near–emergency conditions occur, and is not intended to substitute for long–term water development. The program also does not involve nondrought water transfers that may occur. Such nondrought transfers will be subject to separate environmental analyses.

The program would be implemented as needed for a particular year by an executive order of the Governor or upon a finding by DWR's Director that drought or other unanticipated conditions exist that will significantly curtail water deliveries. The program would continue to operate until water supplies returned to noncritical levels. Each decision to implement a drought water bank will involve a review of the final program EIR and a determination of whether there would be any environmental impacts beyond the scope of those examined in this EIR. If the analysis shows impacts beyond the scope included in this EIR, DWR may then prepare a supplemental EIR or modify the proposed water bank operations so the bank can proceed within the scope set forth in the program EIR. As conditions and knowledge change, DWR may update information through preparation of a supplemental EIR or negative declaration. DWR may also proceed with a water bank outside the scope covered in the program EIR if emergency conditions exist.

Water could be obtained from three sources for the program: 1) ground water substitution or conjunctive use, whereby a portion of a water district's or farmer's surface water supply would be acquired and replaced by pumping an equivalent amount of local ground water; 2) purchase of surface water stored in local reservoirs; and 3) fallowing or withholding irrigation of designated farmland. The first two alternatives would be implemented if demand for water ranges up to 300,000 acre–feet, while the third alternative would be implemented only if demand were significantly greater than that. Major sources for bank water are expected to be water districts, individual farmers, and reservoir operators in areas tributary to the Sacramento, Feather, Yuba, American, and San Joaquin rivers. Other potential sources are areas in the northern San Joaquin Valley that are not in ground water overdraft conditions.

Areas expected to receive water include the San Francisco Bay area, the San Joaquin Valley, and Southern California. Buyers are expected to be individual municipalities, water districts, and other water purveyors, and could include the State Water Project. The principal restriction for purchasers of water would be that their needs would meet specific criteria. For all needs, maximum use would have to be made of all available water supplies. The goal of allocating water for municipal and industrial users is to avoid significant

environmental, economic, or social losses, and damage. Urban area benefits are expected to be primarily in the landscaping and industrial sectors, and are expected to reduce environmental, economic, and employment losses otherwise experienced during water-short periods. For critical agriculture needs, water allocation would be limited to trees, vines, and other permanent or high value crops. Agricultural area benefits are expected to reduce economic losses and unemployment caused by drought conditions. For critical fish and wildlife needs, annual criteria would be developed by the Department of Fish and Game (DFG) based on the condition of fish and wildlife populations and survival conditions. Anticipated benefits include increased water supplies to State and federal wildlife refuges needed to maintain wildlife populations (especially migratory waterfowl) under conditions of moderate to severe reductions in statewide wetlands habitat.

Most water transfers would likely go through the Sacramento-San Joaquin Delta, with water derived largely from Delta tributary rivers. From the Delta, water would be transferred either south to the San Joaquin Valley and Southern California, or west to areas within Alameda, Contra Costa, San Francisco, Solano, and Santa Clara counties. Potential transfers may also occur north of the Delta, and involve a series of water exchanges to get water from the Sacramento River to regions such as western Yolo County, Solano County, and the Tehama-Colusa Canal service area. The exact transfers that would be conducted are not known at this time, and will only become known during the near emergency, critically water short periods.

At the time this document was being completed, the State Water Resources Control Board had just issued its draft Water Right Decision 1630 regarding interim protection standards for the San Francisco Bay / Sacramento-San Joaquin Delta Estuary. The draft decision sets forth proposed additional export pumping and Delta protection standards that would provide more protection to anadromous fisheries than provided by current standards. Water transfers through the Delta under the proposed program would have even less potential adverse impacts than set forth in this document, if the draft decision is adopted in present form. Language in draft Decision 1630 emphasizes the importance of water transfers in meeting near-term dry period needs, and places additional emphasis on transfers that do not go through the Delta.

The proposed program is designed to avoid significant adverse environmental impacts. However, potential adverse environmental effects may occur due to surface water purchases, ground water substitution, fallowing, and pumping water bank supplies in the Delta (Table 1). Water transferred through the Delta would be held in upstream reservoirs and released at times for maximum benefits and minimum potential adverse impacts to the fisheries. Transfers of water from the proposed program will increase instream flows in rivers tributary to the Delta, particularly the Sacramento River. If the transfers were delayed to late summer and early fall, the cooler water temperatures would benefit migrating salmon.

Effects to fisheries are not likely to be significant in reservoirs or streams due to the program, but may be significant in the Delta. Loss of fish due to pumping water from the Delta may include some species protected by the federal and State Endangered Species Acts. Mitigation measures that may be required for fish species will be handled as already provided under existing law and existing water program operation criteria. The Two-Agency Fish Agreement specifies mitigation for water pumped through the Harvey O. Banks Delta Pumping Plant regarding impacts to striped bass populations. Further, the State Water Project and Central Valley Project will continue annual consultations with appropriate federal and State agencies as needed to deal with potential impacts to threatened and endangered species. Consultation under Section 7 of the Federal Endangered Species Act is expected to continue with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. Transporting and pumping water under the proposed program is considered within the scope of existing operations and pumping regimes of these two water projects.

Table 1. Potential Significant Environmental Effects Associated with the Drought Water Bank Program and Mitigation

Activity	Impact	Mitigation
1. Surface water purchase water supply	Decreased carry over	– Consideration of prudent reserves before purchase
	Downstream temperature increase	– Evaluate temperature–storage relationships prior to purchase
	Loss of tail water for wetlands	– Avoid contracts that reduce tail water for wetlands or provide alternative
2. Ground water exchange vulnerable to overdraft	Overdraft	– Discourage substitution of ground water for surface water in areas – Monitor ground water levels during and after project
	Subsidence	– Evaluate potential prior to contracting – Monitor ground levels
	Effects on other pumpers	– Monitor and regulate ground water extraction
	Water quality degradation	– Avoid areas with poor water quality – Monitor ground water quality and regulate pumping
	Effects on surface water flows	– Avoid long–term water banks in recharge area
3. Fallowing	Increased soil salinity due to high water tables	– Avoid soils subject to increases in salinity
	Loss of food supply to wildlife	– Encourage limited planting of grains for food source – Encourage reduced harvest efficiencies of adjacent lands – Encourage planting of cover crops – Discourage disking and weed control where appropriate – Consultation with DFG for appropriate mitigation
	Loss of sensitive plants in pastures	– Literature review to determine likelihood of presence – Consultation with DFG

4. Delta pumping	Entrainment of fish	– Pump primarily from July through September
		– Predator control to reduce prescreening losses
		– Improvements in handling and hauling procedures
		– DWR–DFG Delta Fish Protection Agreement:
		  – compensate calculated losses with fish production from mitigated projects
		  – negotiate with DFG for appropriate mitigation projects
		– Purchasing and stocking of affected species
		– Mitigation fee per acre–foot transferred for projects
		– Discuss mitigation requirements for specific effects with resource protection agencies (DFG, USFWS, NMFS)

A release schedule for water purchased from local reservoirs would be developed in consultation with DFG. Releases would be regulated to augment instream flows, particularly in regard to quantity of water and temperature, for fish at critical times of need.

Wildlife impacts resulting from purchases of water stored in reservoirs and ground water substitution activities have been determined to be minor or nonexistent. However, wildlife impacts from fallowing farmland have the potential to be significant, although opportunities may exist to manage fallowing programs to reduce or eliminate such impacts.

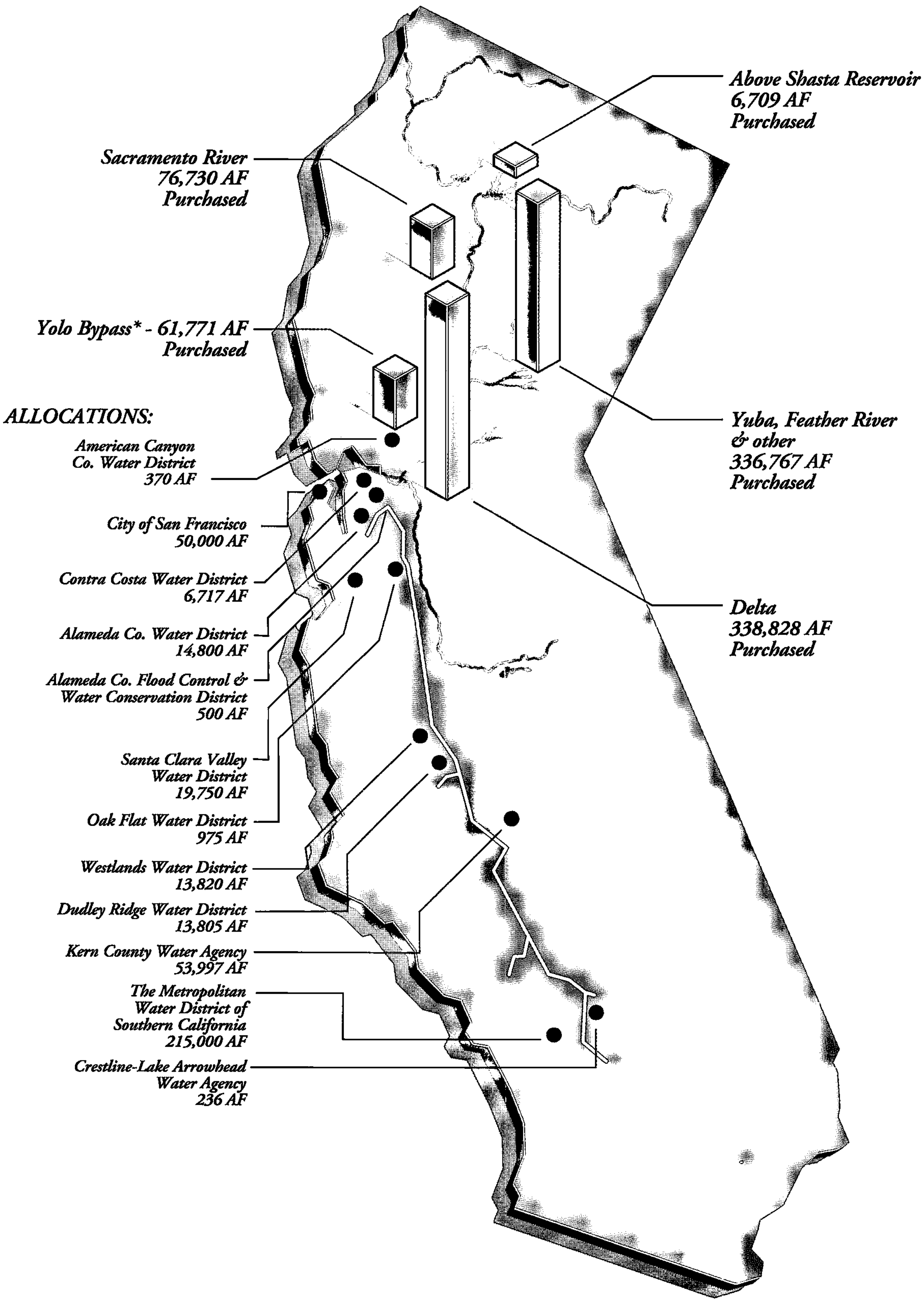
The harvesting of some grain crops, such as rice and corn, leaves behind a substantial amount of waste grain that provides food for wildlife. Areas of particular importance may be flooded following harvest to provide habitat for migratory waterfowl, principally for hunting. To the extent that such grain crops are not grown, there would be reduced food supply available for migratory waterfowl in the immediate region. The consequences range from reduced bird weight prior to migration back to nesting areas to increased pressure on surrounding farmlands with either higher bird populations or increased crop losses, or both. A proposal being examined is the substitution of one grain crop for another, where some water savings could be made. A specific proposal is the substitution of wheat for corn, which is currently being studied by DWR in coordination with the DFG and Delta farming representatives. Other suggested mitigation measures include developing enhanced nesting areas and dedicating some percentage of purchased water for temporary adjacent waterfowl area development.

The proposed program will involve expanded conjunctive use of surface and ground waters, such as has occurred in many areas of California for many decades. Ground water monitoring will be conducted as a part of purchases that involve ground water pumping. Pumping would be restricted or curtailed under the proposed program if monitoring information indicated a significant potential for subsidence or significant adverse impacts on ground water quality or ground water levels.

Agricultural activity is not expected to be altered in areas that transfer surplus stored water or surface water supplies where ground water is substituted. Areas where fallowing may be used to transfer water to the program may experience some adverse environmental effects, but opportunities also exist for benefits.

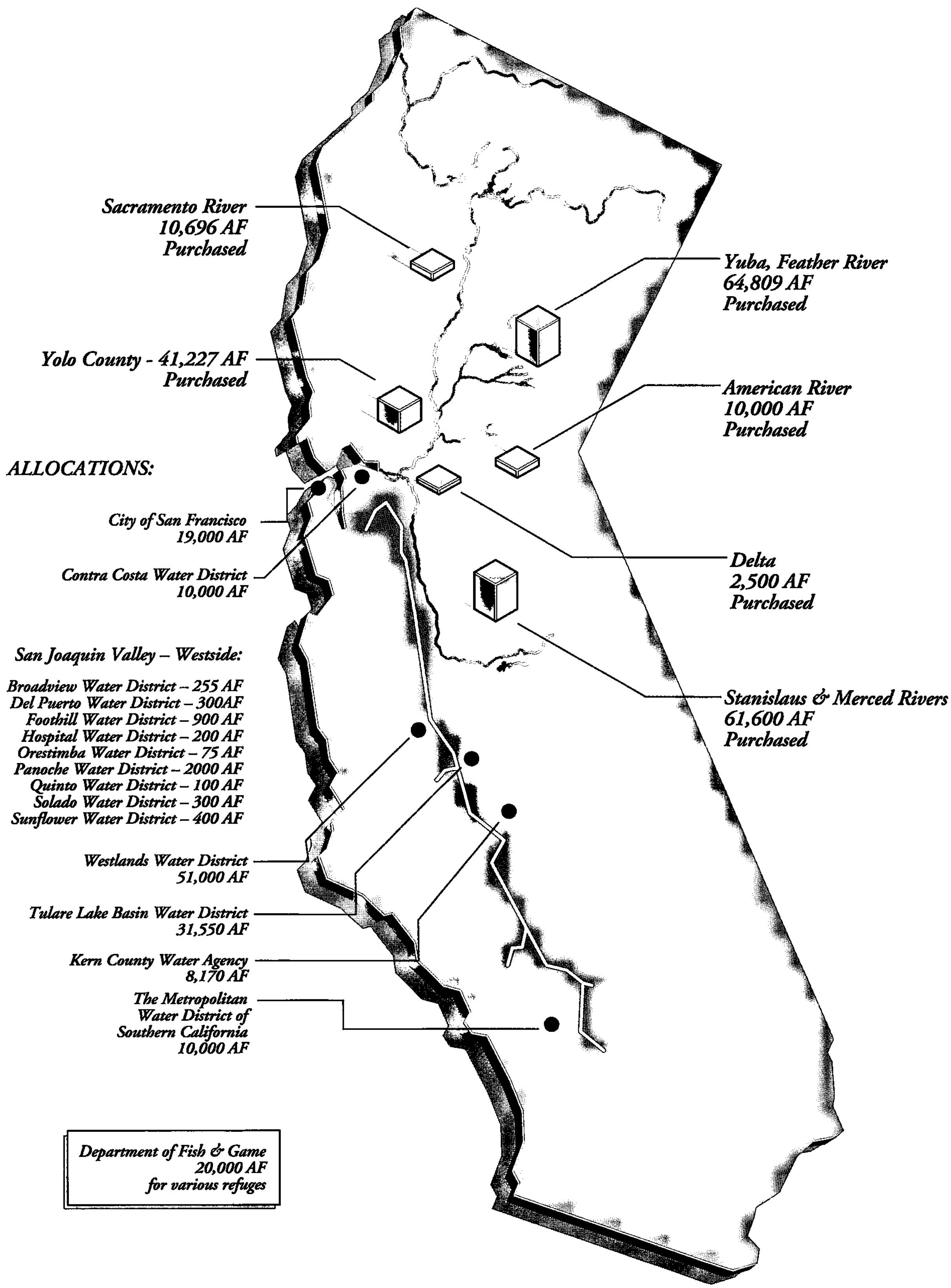
Mitigation measures may include environmental benefits to areas receiving water bank supplies, including water provided specifically for environmental needs. Transfers from reservoirs will consider potential impacts to downstream fisheries as the result of any altered reservoir release schedule. Coordination on such matters will continue with DFG. Wildlife will also receive benefits from the water bank program. Supplemental water can be provided for wildlife refuges, which will principally benefit migratory waterfowl. Benefits at refuges also apply to resident wildlife. Mitigation measures proposed for the program are designed to allow compliance with water quality standards for the Delta and other areas, instream flow requirements for fisheries protection, and other environmental requirements. If other potential adverse effects become known upon implementation of the Drought Water Bank program, DWR will consult with appropriate environmental and regulatory agencies to minimize or mitigate such effects.

THE 1991 DROUGHT WATER BANK



** excluding areas within the Delta*

THE 1992 DROUGHT WATER BANK
as of November 15, 1992



Chapter 1. Program Description

There is a demonstrated need to provide water supplies to meet critical water needs during significant water-short periods, such as droughts or other conditions described below. This discussion sets forth a proposed program to meet such needs, based on recent practical experience in the current drought.

Description and Objectives of Proposed Program

The proposed program is a State Drought Water Bank, a water supply augmentation program to be implemented by the California Department of Water Resources (DWR) during periods of drought and other severe water-short periods. The program is planned to meet water demands created by significant reductions in developed water supplies caused by drought conditions. This is not intended to substitute for long-term water development or demand-reducing programs or facilities, but rather as a drought measure under water-short, near-emergency conditions. The scope of the proposed program is the next 5 to 10 years, on an as-needed basis. Within the next 10 years, a subsequent environmental analysis will be conducted to reexamine actual conditions under which the proposed program will have operated.

While this proposed program was being developed, there was substantial statewide dialogue regarding the future form of water transfers in California. It is possible that some sort of nondrought State water bank might coexist with nonbank water transfer transactions in the future. In any event, water transfer activities under conditions not covered by the proposed program would be subject to a separate environmental analysis.

Definition of Drought Water Bank

The proposed program is intended for implementation during extreme water-short periods only, generally anticipated to occur during drought conditions. For this program, *drought* shall mean prolonged periods when annual regional or statewide water supplies are significantly below normal water supply conditions and significant reductions in projected deliveries to urban and agricultural areas are forecasted to be at critical levels. However, other unanticipated conditions could lead to extreme water-short periods, such as possible future significant restrictions on water storage and pumping that could result from actions taken pursuant to the State and federal endangered species acts. Another possibility is water delivery system outages due to facility failures or natural disasters. In such cases, the proposed program would presumably include development of water transfer mechanisms to augment deliverable water supplies within conditions allowable by endangered species act or other restrictions or facility limitations.

The proposed program is modeled after the successful 1991 and 1992 Emergency Drought Water Banks. For the purpose of this program, *water bank* shall mean a water purchasing and allocation mechanism whereby DWR buys water from willing sellers or pays water users to forego use of a portion of their supplies, and remarkets the water to buyers under specific critical needs allocation rules.

Significant is intended to apply to reductions below water supply deficiency levels that form the basis for water project planning and facilities in project service areas. For example, the level of *significant reductions* in the State Water Project service area on this basis would be water deliveries projected to be less than fifty percent of contracted supplies or delivery requests, whichever is less. For the proposed program, *normal water supply conditions* means levels of water deliveries expected to occur in years of median or greater precipitation, runoff, and reservoir storage conditions. Water demands are based on 1987 actual water use (the most recent year of fairly normal water supply availability) and adjusted by subsequent population changes.

Critical needs as used for this program means additional water supplies made available to reduce or avoid significant economic, environmental, or social disruption and losses in areas receiving the water. The relatively high price of water from transfers compared to alternatives such as increased conservation, rationing, and other actions, assumes that water bank supplies would be requested only after other reasonable and practicable alternatives have been implemented.

The proposed program is a drought water bank. Criteria to implement the proposed program includes limitations on deliveries from water supply projects that exceed the minimum drought planning delivery amounts. For many projects, this is defined as the *firm yield* of the project. Implementation may be complex for those areas that rely on a number of water resources projects that draw water from a variety of locations, such as occurs in Southern California. Water deliveries projected to result in a 50 percent deficiency are used as a *trigger* for areas receiving water from the SWP. Of course, any trigger will need to consider all sources of water to such areas, including supplies from the Colorado River Aqueduct, the Owens River Aqueduct, local projects, and local ground water resources. The 50 percent trigger is a general guideline; an actual trigger will be a function of the overall supply and demand situation in any given year. There should be no absolute limits in triggering the proposed program, since future circumstances in terms of water project reliability could change as occurred with the reevaluation of delivery capability of a number of water projects following the 1976–77 drought period.

Different approaches for operating a water transfer program include letting water transfers occur by a *market* mechanism without State sponsorship or any determination of *critical water needs*, and eliminate or reduce the role of water districts in approving transfers from farmers in their districts. The 1991 Emergency Drought Water Bank was created when a market mechanism was not working. The Water Bank was intended to meet near–emergency needs and complies with the Governor's subsequent water policy regarding water transfers. A market mechanism for water transfers has not proved to be a realistic alternative for meeting all critical needs during short–term drought conditions. However, a market mechanism may be a dominant factor in long–term transfers. The proposed program does not foreclose successful water marketing transactions for meeting critical needs during droughts. To the extent that market transfers are successful during severe water shortage conditions, the demand for the proposed program would be reduced. The second approach to reducing the role of water districts in approving water transfers is counter to existing State law and is not considered an option.

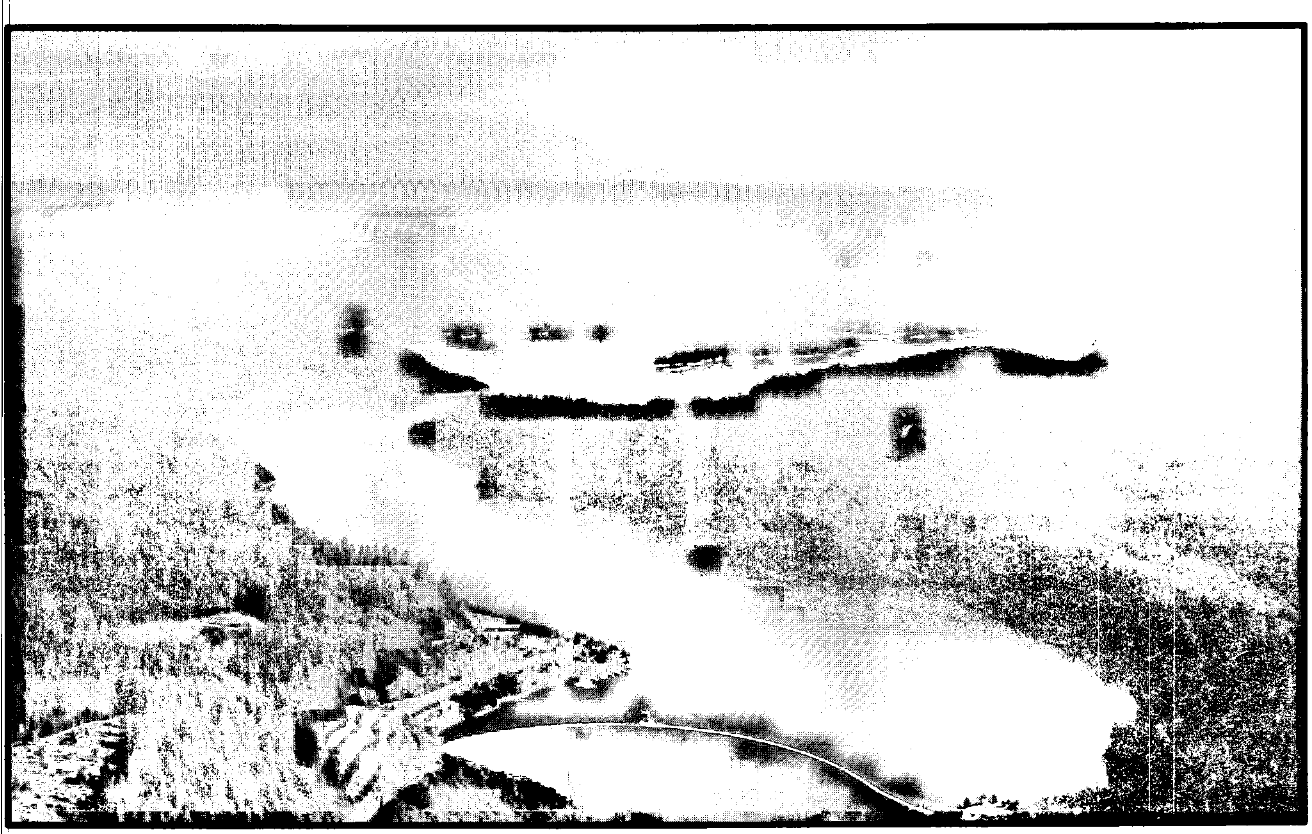
Potential Sources of Water Under the Proposed Program

Water could be acquired through three alternative methods or combinations of sources. The first is ground water substitution or conjunctive use, whereby a portion of a water district's or farmer's surface water supply would be replaced by pumping an equivalent amount of local ground water. This approach would be accompanied by ground water monitoring to evaluate any impacts of the program on the local ground water aquifer. Contracts to acquire water through this alternative would require that pumping be reduced or curtailed to the extent such pumping is identified as a source of significant degradation of ground water levels or ground water quality, or is identified as a cause of subsidence.

The second alternative source is surface water stored in local reservoirs. Acquisition of water stored under post–1914 appropriative water rights would need to be approved by the State Water Resources Control Board (SWRCB) as required by law. Obtaining water stored under pre–1914 appropriative water rights would not require SWRCB approval. Either way, a release schedule would be developed in consultation with the Department of Fish and Game (DFG). In 1991, water was acquired from Yuba County Water Agency's New Bullards Bar Reservoir and from Oroville–Wyandotte Irrigation District's reservoir, for a combined total of about 140,000 acre–feet. An additional 30,000 acre–feet was acquired on behalf of DFG as a related but nonbank purchase. In 1992, reservoir water was purchased from Oroville–Wyandotte Irrigation District, Placer County Water Agency, and Merced Irrigation District for a combined total of 35,000 acre–feet. In the future, the same sellers could be involved. Other reservoir operators may also be involved in future water transfers although they cannot be identified since no interest has been expressed.

Although water was not specifically acquired from the Water Bank for fish, the operation of State, federal, and local reservoirs depended more on instream flow needs of fish during 1991 and 1992 than ever before. Through consultation with federal and State fishery agencies, reregulation of reservoir releases augmented instream flows (quantity and quality) for fish at the most critical times of need. Fish are expected to continue to receive similar benefits whenever the proposed program is implemented.

The third alternative is *fallowing*. Under this alternative, farmers would be paid to withhold or reduce the irrigation water normally applied to their farm land. This could be done under three circumstances. The first curtails irrigation water from crops already planted. Examples of crops suitable for this alternative are alfalfa, wheat, and sugar beets. The second circumstance pays farmers not to plant crops planned for production such as tomatoes, corn, and rice. This alternative is to be accompanied by specific measures to avoid or lessen local economic and environmental impacts (financial compensation to local governments for identified increased costs, limits on acreage and types of crops fallowed, or allocation of a portion of the water for wildlife mitigation). The third circumstance is crop substitution, which would involve substituting a lower–water–use crop for a higher–water–use crop. As discussed later, such a scheme could be designed to mitigate for potential impacts to wildlife, and possibly provide net benefits. It would also keep land in crop



The 1991 Water Bank created more storage than would have been available, although storage at New Bullards Bar Reservoir was less than normal. This photograph was taken in 1989, the third year of drought. The 1991 Yuba County Water Agency transferred 130,000 acre–feet of water from New Bullards Bar Reservoir to the Drought Water Bank and an additional 30,000 acre–feet to the Department of Fish and Game.

production and avoid or significantly reduce local economic impacts.

Major source areas are expected to be water districts, individual farmers, and reservoir operators in areas tributary to the Sacramento, Feather, Yuba, American, and San Joaquin rivers. Areas expected to receive water include the San Francisco Bay area, San Joaquin Valley, and Southern California. Another potential source is areas within the northern San Joaquin Valley that are not in ground water overdraft conditions.

Option Contract. A likely future element of drought year water transfers will be an option contract. Such a contract would provide a payment of money to a seller for the right of the buyer to exercise an *option* to acquire a specific quantity of water at a specified price in a future drought year. Option contracts could involve any of the potential sources of water that were components of the 1991 and 1992 emergency drought water banks. Such contracts will need to provide appropriate decision timeframes to allow implementation of mitigation measures, as well as allow enough time for the seller to alter operations to make the water available.

Priority of Implementation

Under the proposed program, the three alternative sources of water would be implemented to reduce economic and environmental impacts. The priority of source implementation will be a function of the magnitude of critical needs for water. If the demand is not great, 200,000 acre–feet of water or less, the strategy would be to proceed on a parallel track with ground water substitution arrangements and acquisition of stored water from reservoirs. If demand is substantially greater than 200,000 to 300,000 acre–feet, a fallowing or crop substitution program would be necessary. Experiences of the 1991 and 1992 water banks demonstrated some practical limits to the quantities of water available from ground water substitution and reservoir water acquires during drought conditions.

Participant Guidelines

The proposed program would involve participation by willing sellers. Consequently, there would be no restrictions on who could participate, although specific measures would be developed for each water source as described in this document to avoid or lessen local economic and environmental impacts. The principal restriction for purchasers of water would be that their needs meet specific criteria for critical water needs. Such criteria are set forth below.

Critical Municipal and Industrial Needs. Maximum use of all available supplies would be required, considering prudent carryover reserves for future years. In general, water could be allocated if total water supplies were less than 80 percent of normal water demands at the retail level. *Normal water demands* shall mean projected water demands in urban areas based on demands in 1987 (the most recent year of normal demand), adjusted for subsequent population growth. However, water could be delivered above the 80 percent level of normal water demands if significant environmental, economic, or social loss or damage might otherwise occur if water deliveries were not made. Notwithstanding this provision and recognizing the extraordinary measures taken to implement the proposed program, no water would be allocated to urban areas with total supplies available to meet more than 85 percent of normal water demands.

Critical Agricultural Needs. Maximum use of all available supplies would be required, considering prudent carryover reserves for future years. Water allocation would be limited to trees, vines, permanent crops, and other crops where the acquired water would have a high unit value.

Critical Fish and Wildlife Needs. Maximum use of all available supplies would be required, considering prudent carryover reserves for future years. Annual criteria would be developed by DFG for this category and would depend on the annual condition of fish and wildlife populations and survival conditions.

There are several ways of acquiring water for environmental needs. First, water can be acquired from a Drought Water Bank similar to purchases made by DFG from the 1992 Drought Water Bank. The 1992 Bank provided that DFG could purchase water as a buyer, and would receive at no cost, 10 percent of all Water Bank supplies above a level of 200,000 acre–feet. This provision was included in the 1992 Water Bank contract since it was contemplated that purchases above that amount could have adverse environmental effects. The 200,000 acre–foot level was judged as being the rough threshold beyond which land fallowing might be needed to meet demand. While this approach may be considered in the future, a more direct approach would be to provide on–site mitigation directly for fallowed fields or other actions with potential adverse environmental effects. Another alternative for acquiring water for environmental needs would be to purchase water outside of a drought water bank. This was also done by DFG, both in 1991 and 1992 for cost savings and other needs.

An additional option would be to impose an environmental tax of 10 percent of either the water or money on all water transfers. Such a tax would be directed at providing environmental benefits to augment current environmental protection standards, such as existing water quality and other standards, to protect the Delta, Suisun Marsh, and San Francisco Bay. This option continues to be discussed in a number of forums; there are a number of advantages and disadvantages. Many transfers that occurred as part of the 1991 and 1992 Water Banks provided net benefits to both fish and wildlife without imposition of a tax.

Additional Needs. Exceptions would be made for allocation of water needed for extreme critical needs such as domestic use, health, sanitation, and fire protection.

Potential Areas Receiving Water and Delivery Pathways

Most water transfers under the proposed program would likely go through the Sacramento–San Joaquin Delta, with water derived largely from Delta tributary rivers. Water would be transferred from the Delta, either south to the San Joaquin Valley and Southern California or west to areas within Alameda, Contra Costa, San Francisco, Solano, and Santa Clara counties. Potential transfers could also include north–to–north arrangements, which might involve a series of water exchanges among water users to get water from the Sacramento River to regions such as western Yolo County and the Tehama–Colusa Canal service area. Under near–emergency conditions, it is difficult to predict the pathways that transfers might take. An example of an uncontemplated transfer under critical water–short conditions was the construction of the temporary pipeline across the Richmond–San Rafael Bridge during 1977 to provide drought relief water supplies to Marin County.

It is also possible that under severe water–short conditions the State would act to create a water bank in coastal areas (such as the Santa Barbara and Monterey regions) to facilitate purchases and sales to meet critical water needs. In such cases, DWR will provide advice to these areas for establishing local water banks.

Annual Schedule of Implementation

The proposed program would be implemented annually as needed by an executive order of the Governor or upon a finding of the Director of DWR that drought conditions existed and would remain in force until water supplies returned to noncritical levels.

Water transfer contracts for program water banks are likely to be similar to those used for the 1991 and 1992 Emergency Drought Water Banks. That is, the contracts will cover each transfer for just the year of the transfer and creation of the annual Drought Water Bank. Transfers from the same sellers in subsequent years would be handled by separate contract. This is partly due to the fact that there would likely be a different mix of buyers each year that a water bank is created. In addition, annual negotiation of contracts allows for all parties to correct problems and take into account a widening body of institutional and factual knowledge about water transfers. The definition of *critical needs* would be as set forth in the overall operational contract among DWR and the buyers. Such a contract, as in 1991 and 1992, would set forth allocation procedures among competing buyers, as well as the details of determination of critical needs.

Program Benefits

The proposed program is intended to meet critical water needs when developed water supplies are otherwise inadequate. Water was acquired through the 1991 and 1992 Water Banks for urban areas, farming, and for State and federal wildlife refuges. Urban area benefits are expected to be primarily in the landscaping and industrial sectors and are expected to reduce environmental and economic losses otherwise experienced during drought or other legitimate water–short periods. Agricultural area benefits are expected to go largely to regions and farms for survival of permanent crops (such as trees and vines) and other high–value crops. Agricultural area benefits are expected to reduce economic losses and unemployment resulting from drought conditions. Wildlife area benefits are expected to increase water supplies to State and federal wildlife refuges to maintain wildlife populations (especially migratory waterfowl) at survival levels under conditions of moderate to severe reductions to nonpublic wetlands habitat. Fishery benefits are expected to derive from greater instream flows and timing transport of the water through the Delta.

Proposed Actions to Avoid Adverse Environmental Impacts

The proposed program is designed to avoid potential adverse environmental impacts summarized in the following paragraphs. Changes in land use create some potential impacts. Other impacts are associated with changes in stream flow regimes.

Ground Water Basins. The proposed program will involve expanded conjunctive use of California's surface and ground waters similar to past decades. The proposed program will be modeled after the 1991 and 1992 Water Banks, which established ground water monitoring programs as part of purchases that involved ground water pumping as a component of the program. Similar to conditions set forth in 1992 Water Bank contracts, pumping would be restricted or curtailed under the proposed program if monitoring information indicated a potential significant adverse impact to subsidence, ground water quality, or ground water levels.

Recent changes in the California Water Code that go into effect on January 1, 1993, include the following provisions regarding water transfers:

> 1745.10. A water user that transfers surface water pursuant to this article may not replace that water with ground water unless the ground water use is either of the following:
>
> (a) Consistent with a ground water management plan adopted pursuant to State law for the affected area.
>
> (b) Approved by the water supplier from whose service area the water is to be transferred and that water supplier, if a ground water management plan has not been adopted, determines that the transfer will not create, or contribute to, conditions of long–term overdraft in the affected ground water basin

The provisions of these new changes in State law are intended to reduce potential impacts of water transfers to the local economy, as well as reduce potential impacts to regional ground water resources. Future State drought water banks (and, in fact, many or all future water transfers) will operate to these provisions.

Fish. Water transferred through the Delta would be held in upstream reservoirs and released when opportunities for fisheries are maximized and potential adverse impacts to the fishery are minimized. Transfers of water under the proposed program will increase instream flow in rivers tributary to the Delta, particularly the Sacramento River. In addition, delaying water transfer to the late summer and early fall is expected to provide cooler temperatures for migrating salmon in the Sacramento River system.

Mitigation measures required for other species will be handled as already provided under existing law and existing scope of water project operations. For example, the Two–Agency Fish Agreement provides mitigation for water pumped through the Harvey O. Banks Delta Pumping Plant regarding impacts to striped bass populations. Further, the SWP and CVP will continue annual consultations with appropriate federal and State agencies to deal with potential impacts to threatened and endangered species. Consultation under Section 7 of the Federal Endangered Species Act is expected to continue with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. Transporting and pumping water under the proposed program is considered within the scope of existing operations and pumping regimes of these two water projects.

Mitigation measures will consider any environmental benefits to areas receiving water bank supplies, including water provided specifically for environmental needs. Reservoir transfers will consider potential impacts to downstream fisheries as the result of any altered reservoir release schedule. Coordination on such matters will continue with DFG, U.S. Fish and Wildlife Service, and others, as appropriate.

Wildlife. As part of the 1991 and 1992 Water Banks, DFG obtained supplemental water for wildlife refuges, principally for migratory waterfowl. Benefits were also provided at the refuges for resident wildlife. Wildlife impacts resulting from reservoir storage purchases and ground water substitution activities are assumed to be minor or nonexistent. However, wildlife impacts from fallowing farmland may be significant.

Some grain crops, such as rice and corn, leave behind a substantial amount of waste grain after harvest that provides food for wildlife. Of particular importance are areas that may be flooded following harvest to provide habitat for migratory waterfowl, principally for hunting. If such grain crops are not grown, there may be reduced food supply in the immediate region available for migratory waterfowl. Consequences range from reduced bird weight before migration back to nesting areas, to increased pressure on surrounding farmlands with either higher bird populations, increased crop losses, or both.

A proposal being examined is the substitution of one grain crop for another, where some water savings could be made. The substitution of wheat for corn is currently being studied by DWR in coordination with DFG and Delta farming representatives. Suggested mitigation measures include developing enhanced nesting areas and dedicating some percentage of acquired water for temporary adjacent waterfowl area development.

Descriptions of 1991 and 1992 Drought Water Bank

In both 1991 and 1992, the Governor created drought water banks to meet critical water needs. Each water bank is described briefly below. More detailed descriptions are available separately.

1991 Drought Water Bank. This program, the first of its kind, was implemented in February 1991 against a backdrop of projected severe water shortages. Water was developed through reservoir storage purchases, ground water substitution arrangements, and fallowing farm land. The basic water balance of the 1991 Water Bank is shown in Table 1–1.

In addition, substantial measures were taken to protect and provide additional benefits to fish and wildlife. Some 50,000 acre–feet of water was acquired by DFG through water transfers related to the Water Bank. In addition, substantial reregulation of Shasta, Oroville, Folsom, and Bullards Bar reservoirs resulted in improved streamflow conditions for fish. Specific measures were taken in the Delta to mitigate for impacts to the Delta fishery or to avoid impacts to the endangered winter run chinook salmon. Such measures included reregulating reservoirs and Delta pumping to shift transfers of most of the water through the Delta to the period from August to October. Some 300,000 striped bass fingerlings were acquired and planted to mitigate for incremental increases in projected losses at the SWP Delta Pumping Plant.

Some 160,000 to 170,000 acres of land were part of the fallowing component of the 1991 Water Bank. Of this total, some 130,000 acres were not planted. The remaining acreage represented crops already planted but denied further irrigation. Due to record rainfall in March 1991, substantial crop production was realized from much of this acreage.

Delta water requirements are termed *carriage water*, which is the incremental amount of Delta outflow needed to prevent reverse stream flows and resulting impacts on water quality. Economic and environmental effects of Delta carriage water are determined independently of the Drought Water Bank, and, in fact, are completely independent determinations that will continue to be made with or without the proposed program. The 1991 and 1992 Water Banks treated carriage water as a requirement under the SWP and CVP Coordinated Operation Agreement. None of the actions contemplated for this program would have any impact on possible redetermination of carriage water amounts by the SWP and CVP.

Table 1–1. Water Balance of 1991 and 1992 Drought Water Banks (numbers rounded)

	1991 Water Bank Amount	1992 Water Bank Amount
Water Source	**(acre–feet)**	**(acre–feet)**
Fallowing[1]	390,000	0
Ground water[1]	285,000	150,000
Surface water	145,000	35,000
Total	**820,000**	**185,000**
Delta Requirements[2]	–165,000	–31,000
Net available	655,000	154,000
Allocations		
Urban uses	307,000	39,000
Agricultural uses	83,000	95,000
Wildlife uses[2]	0[3]	20,000
Carryover storage	265,000	0
Total allocated	655,000	154,000

[1]The amounts for fallowing and ground water shown in the table for 1991 are those used in the analyses in this report, and agreed to by the SWP and CVP as part of the Coordinated Operation Agreement. One large purchase, included entirely in the groundwater category, also included some fallowed acreage. If this had been accounted for in the fallowing category, the fallowing amount would be about 25,000 acre–feet greater and the groundwater amount would be about 25,000 acre–feet less. There would be no change in the availability of the water at the Delta, however,since this was a transfer from a water supply contractor of the federal Central Valley Project and was provided by the CVP in the Delta when it was needed.

[2]water required to remain in Sacramento-San Joaquin Delta for water quality protection and miscellaneous technical corrections

[3]more than 40,000 acre–feet of water was provided in bank–related transactions

1992 Drought Water Bank. The 1992 Drought Water Bank was implemented under less severe conditions than 1991 with substantially lower demand for critical–needs water. While this report was being prepared, the 1992 Drought Water Bank was still in progress. Current statistics for sources and allocations of water are indicated in Table 1–1. No land was fallowed by DWR under the 1992 program.

Local Coordination

The 1991 and 1992 Water Banks included substantial coordination in several cases with local interests and local government. Two key examples were Water Bank transfers in Yolo and Butte counties. In February 1991, the Yolo County Board of Supervisors adopted a memorandum of understanding (MOU) with a large water user who proposed to transfer water during 1991. This MOU set forth monitoring requirements, a coordination process, and payments to the county to reimburse costs and contribute to an update of the County Water Plan. That water user eventually participated in the Water Bank and DWR agreed to the terms and conditions of the MOU. That process, including a 2 percent payment to the county, became the foundation of subsequent Water Bank contracts in the county involving ground water substitutions. In addition, DWR staff met frequently with local officials to keep them up to date on water transfer activities.

A Technical Advisory Committee of local water officials was formed to review the results of a comprehensive ground water monitoring program established to measure impacts of water sales. The monitoring program itself was established with substantial involvement by the county's water consultant. Coordination in Yolo County increased in 1992 and the Technical Advisory Committee became an active forum to discuss a wide range of local water resources concerns.

A similar approach to local coordination occurred in Butte County. In 1991, Butte County and DWR negotiated a contract that provided direct 2 percent payments to the county for ground water related contracts. A ground water monitoring program was established by DWR's Northern District in coordination with local water districts. Substantial local coordination, involving farmers, duck clubs, DFG, and the U.S. Fish and Wildlife Service (USFWS), occurred in 1991 regarding potential impacts of upstream Water Bank purchases on waterfowl areas in the Butte Sink. Butte Creek flow issues were resolved in a five–way agreement among these parties. Early in 1992, local water users formed the Butte Basin Water Users Association. The Association was formed to develop technical knowledge regarding the local ground water basin and to develop policies concerning water use and water transfers. In addition to providing a 2–percent payment to Butte

County in 1992, DWR agreed to provide an additional payment to the Association in relation to another water purchase, to support their ground water data collection and modeling efforts.

Two other transfers in 1992 resulted in substantial local benefits as a result of the transfers. The first was a transfer of water from South San Joaquin Irrigation District and Oakdale Irrigation District. Both districts divert water from the Stanislaus River. The boards of these districts required that local benefits to the fishery and Delta agriculture be a part of the transfers. The districts initiated discussions with DFG, the U.S. Bureau of Reclamation (USBR), Western Area Power Administration (concerning potential impacts to New Melones reservoir power generation), and the South Delta Water Agency. The resulting transfers provided additional benefits to the Stanislaus River fishery and Delta agriculture and transferred about 50,000 acre–feet to the Water Bank.

The second such transfer involved a sale of 15,000 acre–feet of water from Merced Irrigation District to the Water Bank. The District took a similar position to the one taken by the districts on the Stanislaus River. The Merced Irrigation District worked closely with DFG to release the transferred water on a schedule that would benefit migrating salmon on the Merced and San Joaquin rivers.

CEQA Process

DWR prepared this program environmental impact report (EIR) to comply with the requirements of the California Environmental Quality Act (CEQA) as set forth in Public Resources Code Section 21000, et seq. DWR decided to prepare a program EIR for the proposed Drought Water Bank program because the program is characterized as a series of similar actions that may occur in different years.

The proposed program is intended to be implemented quickly and reflects the short decision–making timeframes involved in meeting water needs on a real–time basis. While this EIR is intended to be a program document, it will not be practical to prepare a supplemental EIR each time the proposed program must be implemented. Consequently, implementation of the proposed program would proceed within the range and scope of effects set forth in this document. As conditions and knowledge change, it may be necessary to update information through preparation of a supplemental EIR or negative declaration.

The program EIR includes discussion of environmental effects as well as socioeconomic effects of the proposed Drought Water Bank program. However, CEQA specifies that any adverse socioeconomic effects are not considered as significant effects on the environment, unless such effects cause a physical change in the environment. The program EIR discusses potential significant environmental effects and mitigation incorporated into the program.

Legal Constraints

The California Legislature has established State policy to facilitate voluntary water transfers, and directed DWR, the SWRCB, and all other State agencies to encourage voluntary water transfers (Sections 109 and 475 of the California Water Code (CWC)). Water rights of those transferring water are not impaired or forfeited as a result of water transfers (CWC Sections 475, 1011, 1244, and 11961).

The Legislature declared temporary water transfers approved under a certain process by the SWRCB to be exempt from provisions of CEQA. Further, the SWRCB was authorized to approve temporary water transfers without a hearing if legal water users are not injured and fish, wildlife, or other instream beneficial uses are not unreasonably affected (CWC Section 1725). However, the SWRCB determined that at some point water transfers resulting in increased Delta exports could have significant adverse environmental effects and, therefore, projects would not be approved that involve increased Delta exports unless an adequate environmental assessment has been prepared that addresses potential fishery impacts and other environmental effects of a project. Environmental analyses essentially meeting the requirements of CEQA may be necessary to allow the SWRCB to make the required finding of no injury to any legal user of water nor unreasonable effect on fish, wildlife, or other beneficial uses (CWC Section 1727).

The SWRCB can issue four major types of transfer approvals. If the SWRCB finds an urgent need, a temporary *urgency permit* limited to a duration of 6 months may be granted for a new diversion (CWC Section 1425). An urgency permit may also be granted for a change to an existing diversion (CWC Sections 1435). The SWRCB may approve a *temporary change for transfer* that lasts 1 year or less involving water that is consumptively used or stored (CWC Section 1725). Such transfers must not injure any legal user of water nor unreasonably affect fish, wildlife, or other instream beneficial uses. *Long–term transfers* in excess of 1 year may be approved provided that no injury to any legal user and no unreasonable effect on fish, wildlife, or other beneficial uses would occur (CWC Section 1735). Long–term transfers are not exempt from CEQA requirements.

Statutes limiting interbasin water transfers to protect areas of origin have been enacted by the Legislature. Counties and watersheds of origin and immediately adjacent areas that can be conveniently supplied receive priority over SWP and CVP water users (CWC Section 10505 and 11460). Additional protections against exports pursuant to appropriations initiated after January 1, 1985, apply to the Sacramento, Mokelumne, Calaveras, and San Joaquin river systems and the Sacramento–San Joaquin Delta (CWC Section 1215). Reasonable consumptive uses in the Sacramento–San Joaquin Delta also receive priority under the Delta Protection Act of 1959. In addition, legislation creating water districts often restricts the sale or transfer of district water outside certain boundaries unless the water is surplus to the needs of the district. However, this surplus water restriction was modified in 1992 by AB 2897, Chapter 481 of the Statutes of 1992 (CWC Sections 1745 to 1745.11). Ground water is prohibited from being pumped for export from the Sacramento and Delta–Central Sierra basins unless pumping is in compliance with a ground water management plan adopted by ordinance approved by the county board of supervisors (CWC Section 1220).

Several recent State and federal laws affect the proposed project. AB 2897, Chapter 481 of the Statutes of 1992, was signed into law by Governor Wilson in August 1992. The bill makes a number of changes to existing law. First, it makes permanent the earlier temporary change to allow water suppliers to transfer water out of their service areas without making a finding that the water is surplus to their needs. Second, it protects the water rights of the transferor by reaffirming that a water transfer made pursuant to provisions of the bill is deemed to be a beneficial use of water. Third, it limits transfer of water from a water supplier to 20 percent of the supplier's water supplies for the year of the transfer, unless the supplier holds a public hearing. Finally, the bill places new restrictions on transfers involving ground water. It provides:

1745.10. A water user that transfers surface water pursuant to this article may not replace that water with ground water unless the ground water use is either of the following: (a) consistent with a ground water management plan adopted pursuant to State law for the affected area; (b) approved by the water supplier from whose service area the water is to be transferred and that water supplier, if a ground water management plan has not been adopted, determines that the transfer will not create, or contribute to, conditions of long–term overdraft in the affected ground water basin.

These new changes in State law are intended to reduce potential impacts of water transfers to the local economy, as well as reduce potential impacts to regional ground water resources. Future State drought water banks (and, in fact, many or all future water transfers) will operate to these reaffirmed or new conditions.

AB 3030 (Costa), Chapter 947 of the Statutes of 1992, provides new authority to water districts and other water suppliers to develop a ground water management plan within their service area. The law is permissive, and does not require that a plan be developed. However, ground water management plans developed pursuant to this new law fit into the requirements of AB 2897 (in particular, Water Code Section1745.10 cited above). Since no local ground water management plans have yet been adopted in areas from which Drought Water Bank purchases have come in 1991 and 1992, it is likely that the provisions of Water Code Section 1745.10 will lead surface water suppliers to develop ground water management plans to increase their control over transfers. This statute now appears in Water Code Sections 10750 to10755.4.

PL 102–575 (H. R. 429), a new federal law signed by President Bush in October 1992, is expected to have far reaching implications with regard to water transfers in California. The law, which includes separate sections applying to federal water facilities in other states, includes a major revision to federal law as it applies to the Central Valley Project (identified in the bill as Title XXXIV, Central Valley Project Improvement Act). A major portion of the Act deals specifically with water transfers. The Act encourages transfers and allows transfers of CVP water out of a service area. As this Draft EIR was being prepared, USBR began to develop proposed regulations and guidelines to carry out provisions of the law. The water transfer provisions apply to "... all individuals or districts who receive Central Valley Project water under water service or repayment contracts, water rights settlement contracts or exchange contracts ..." (Section 3405(a)). There are many uncertainties with the Act, including its applicability to so called "base supply" (that component of a CVP water right settlement contract which represents the quantity of water associated with a pre existing water right held by the water user). Water purchased for the Water Bank from CVP contractors in 1991 and 1992 was limited to base supply. It is not clear when the uncertainty of applicability of the new rules to base supply amounts will be clarified.

In any event, specific rules apply to transfers that are deemed to fall within the definition of the Act. The rules that have relevance to this Draft EIR include requirements that:

- All transfers made pursuant to the Act comply with State law, including CEQA.
- Transfers are subject to a right of first refusal for 90 days (from the date of intent to transfer) by other water users within the CVP service area.
- The Secretary of Interior should review and approve all transfers for compliance with the Act and that action be taken within 90 days of receipt of a completed application for a transfer; if the Secretary does not take action within 90 days, the transfer is deemed approved.
- The Secretary shall not approve any transfer unless the Secretary determines that it would have no significant long–term adverse impact on ground water conditions in the seller's area.
- The Secretary shall not approve any transfer that "... would result in a significant reduction in the quantity or decrease in the quality of water supplies currently used for fish and wildlife purposes, unless the Secretary determines pursuant to findings setting forth the basis for such determination that such adverse effects would be more than offset by the benefits of the proposed transfer; in the event of such a determination, the Secretary shall develop and implement alternative measures and mitigation activities as integral and concurrent elements of any such transfer to provide fish and wildlife benefits substantially equivalent to those lost as a consequence of such transfer ..." (Section 3405(a)(1)(L)).
- The Secretary shall not approve any transfer that might otherwise limit the Secretary's ability to meet CVP contractual or fish and wildlife obligations by displacing canal conveyance and/or pumping capacity.
- Transfers involving more than 20 percent of a selling district's water supply shall be subject to review and approval by the district via public notice and hearing.

Other provisions are less relevant to this document, but include increased payments to the federal government depending on the buyer of the transferred water, and additional protections to sellers similar to those contained in State law. It is unclear how the Act would affect purchases and operations of a drought water bank. First,there is some uncertainty as to whether it applies to *base supply*, the only type of water purchased from CVP contractors. Second, it is difficult to imagine how a drought water bank process could function successfully in a timing environment where a 90–day right of first refusal is required.

At the time this document was being completed, the SWRCB had just released on December 10, 1992 its draft Water Right Decision 1630 regarding interim protection standards for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary. The SWRCB's draft decision contains specific requirements to be met by water users totally on water supplies from the estuary. There are specific water conservation program requirements for both urban and agricultural water users. Urban water use requirements are tied to specific measures set forth in the urban water users MOU discussed in this report. Agricultural water use requirements also specify required water conservation programs. In addition to provisions regarding urban and agricultural water conservation, there are provisions in the draft decision providing greater protection to fish and wildlife public trust resources in the Estuary, and setting up a fish and wildlife mitigation fund supported by required payments to in–basin and export water users. The SWRCB proposed to adopt Water Right Decision1630 in late January, 1993. The program proposed in this Draft EIR will be further modified as necessary to comply with the requirements in that forthcoming decision.

The proposed Drought Water Bank will comply with all applicable regulations, including those enacted by the Legislature or contained in the California Water Code and Fish and Game Code, the federal and State Endangered Species Acts, the Clean Water Act, all appropriate State and federal laws, and agreements entered into by DWR. The program does not conflict with existing zoning, plans, or land use controls of any local or State governmental agency.

Intended Uses of the EIR

This EIR would be used as a guideline for actual implementation. Specific actions involved in implementing the proposed program depend on actual conditions, such as the level of demand of critical water needs, prevailing conditions and restrictions for protecting threatened and endangered species, and current hydrologic and reservoir storage conditions.

Agencies expected to use this EIR as part of implementation include DWR, DFG, SWRCB, and a number of local agencies and water districts. This EIR will be used to support action taken before the SWRCB in approving water transfers under their jurisdiction. In addition, this EIR will be used to secure approval from DFG for any changes in reservoir flow release schedules, as well as any changes in Delta pumping conditions that might need to be addressed by the Two-Agency Fish Agreement. Finally, this EIR will support decisions by boards of appropriate water agencies and districts in approving water sales and purchases.

Because this document is characterized as program EIR, later activities implementing a water bank will be examined in light of the EIR to determine whether an additional document will need to be prepared. If the examination shows that no new effects would occur or that no new mitigation measures would be required, DWR can approve the activity as being within the scope of the project covered by the program EIR and no new environmental document will be required. However, if the examination shows that there would be significant environmental effects not examined in the program EIR, an additional decision will be necessary. DWR will need to decide whether to prepare a new initial study leading to a negative declaration or a supplement to this EIR or to modify the activity to avoid the new effects. If the activity is modified, it may then be within the scope of this EIR so that no additional environmental documentation would be required.

Chapter 2. Environmental Setting

This section describes the environment in the vicinity of the proposed Drought Water Bank program. Since the proposed program may operate throughout the State, with the exception of the North Coast and Lahontan areas, the environmental setting description is quite detailed. However, specific areas where the proposed water bank may obtain and deliver water may vary widely from year to year depending on hydrologic conditions in local areas. Therefore, other areas not discussed may become sources of drought water bank water or have need for such water in the future. Areas that may provide or use drought water bank supplies in the future that are not discussed in this document, will be analyzed prior to incorporation into the water bank program for any unique environmental features that may differ from those of areas discussed in this document.

Overview

The Drought Water Bank will operate in much of the service areas for the CVP and SWP (Figure 2–1). The CVP service area extends for about 430 miles through much of the Central Valley from Shasta Reservoirs in the north to Bakersfield in the south (USBR, 1988). The CVP service area also includes the San Felipe Unit, which is located in the adjacent coastal valley. Major facilities of the CVP that may be affected by operation of the drought water bank include Shasta Dam on the Sacramento River, Folsom Dam on the American River, New Melones Dam on the Stanislaus River, and Millerton Dam on the San Joaquin River. All these rivers are tributary to the Sacramento–San Joaquin Delta.

The existing facilities of the CVP provide full, supplemental, or temporary water supply to about 3 million acres of agricultural land throughout the Sacramento and San Joaquin valleys (USBR/DWR, 1985). At present, the U.S. Bureau of Reclamation (USBR) has contracted to deliver 8.6 million acre–feet of CVP water annually (DWR, 1991a), including the sale of an additional 250,000 acre–feet of interim water to the Westlands Water District (USBR/DWR, 1985). CVP water supply contracts contain buildup provisions identifying periods during which the contractors may use less than their full entitlements. Crops grown on California lands irrigated by the CVP had a gross value of about $2.4 billion in 1981 (DWR, 1991a).

The CVP facilities also provide 536,000 acre–feet of water for domestic, municipal, and industrial use, and generate over 3.5 billion kilowatt–hours of electricity annually in addition to supplying the energy needs of project facilities (USBR, 1988). The largest share of water was delivered through the Contra Costa Canal to the cities of Martinez, Antioch, and Pittsburg and to a large industrial complex composed of steel, oil, rubber, paper, and chemical plants. The cities of Redding, Roseville, Placerville, Sacramento, Fresno, and Coalinga also receive all or a portion of their water from the CVP. East Bay Municipal Utility District and Sacramento Municipal Utility District have entered into long–term contracts for CVP water.

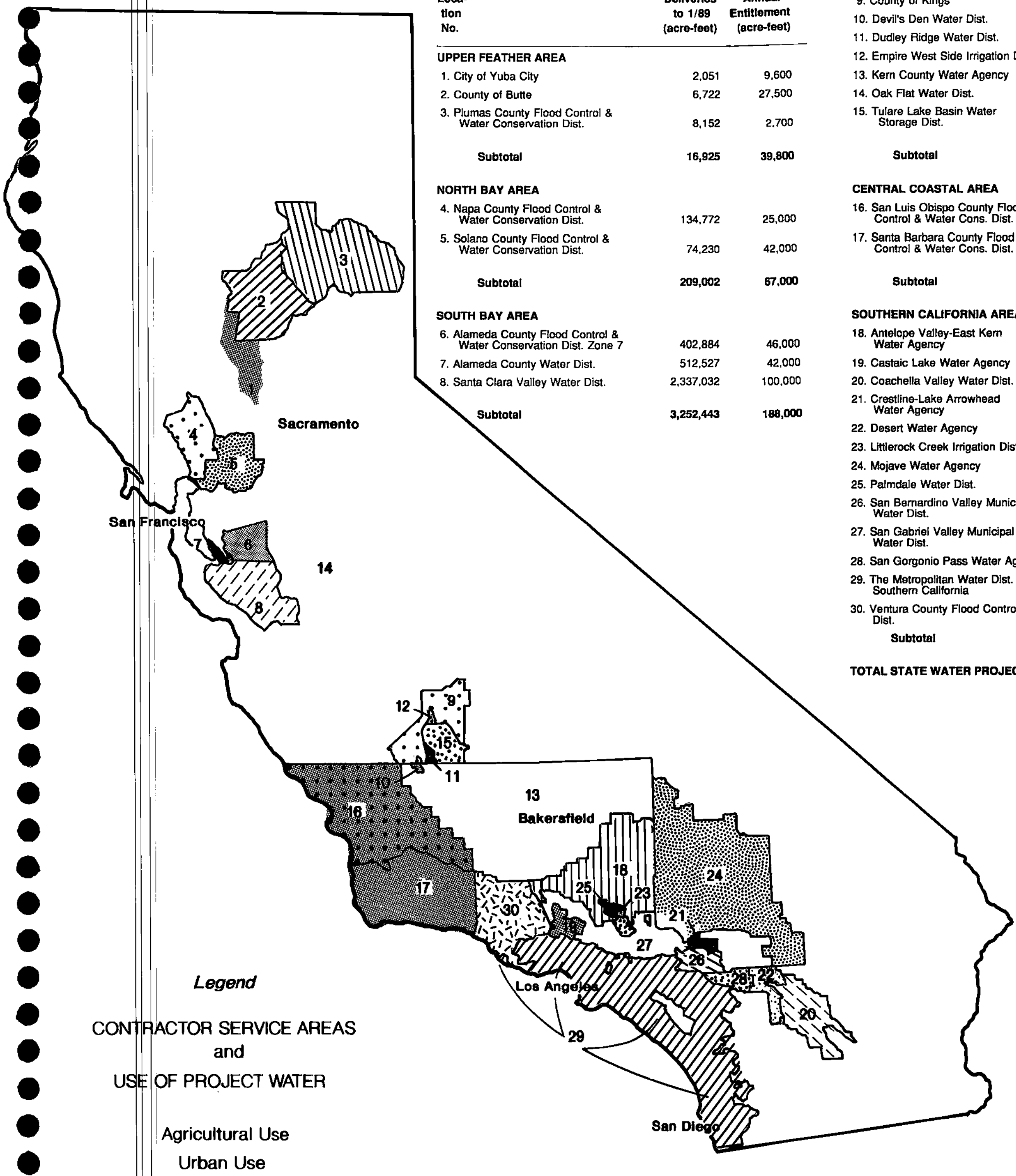
The SWP system consists of 22 reservoirs, 17 pumping plants, 8 hydroelectric power plants, and 550 miles of aqueducts and pipelines (DWR, 1991a). The primary storage facilities are located at Oroville on the Feather River, which is tributary to the Sacramento River. Additional supplies are developed from surplus flows in the Sacramento–San Joaquin Delta (DWR, 1987). Water from the SWP is transported through natural rivers and a system of canals and pipelines to the Bay Area, San Joaquin Valley, and Southern California for agricultural and municipal uses. Some water from the program is also delivered to the Feather River region, which has area of origin priorities for SWP supplies (USBR/DWR, 1985).

The State Water Project has water supply contracts with 29 public agencies whose jurisdictions encompass a fourth California's land area and two–thirds of the population (Figure 2–2). Most SWP water delivered in Southern California and the San Francisco Bay area is for urban use, while most delivered in the San Joaquin Valley is for agricultural use. The agricultural areas served by the SWP are mainly in Kings and Kern counties, and mainly in the western portions of these counties. The one exception is the Oak Flat Water District in western Stanislaus County. These areas relied on the SWP for 71 percent of their irrigation water supply in 1981, when the estimated value of crops grown with SWP water was $474 million. Cotton accounted for 41 percent of this total; almonds, oranges, pistachios, grapes, cantaloupes, lettuce, onions, alfalfa seed and hay, and wheat together accounted for another 41 percent, and about 40 other crops accounted for the remainder.

Figure 2-1. Major Features of the SWP and CVP

Figure 2-2. SWP Service Areas and Contracting Agencies

CONTRACTING AGENCY Location No.	Cumulative Deliveries to 1/89 (acre-feet)	Maximum Annual Entitlement (acre-feet)
UPPER FEATHER AREA		
1. City of Yuba City	2,051	9,600
2. County of Butte	6,722	27,500
3. Plumas County Flood Control & Water Conservation Dist.	8,152	2,700
Subtotal	**16,925**	**39,800**
NORTH BAY AREA		
4. Napa County Flood Control & Water Conservation Dist.	134,772	25,000
5. Solano County Flood Control & Water Conservation Dist.	74,230	42,000
Subtotal	**209,002**	**67,000**
SOUTH BAY AREA		
6. Alameda County Flood Control & Water Conservation Dist. Zone 7	402,884	46,000
7. Alameda County Water Dist.	512,527	42,000
8. Santa Clara Valley Water Dist.	2,337,032	100,000
Subtotal	**3,252,443**	**188,000**
SAN JOAQUIN VALLEY AREA		
9. County of Kings	51,900	4,000
10. Devil's Den Water Dist.	339,947	12,700
11. Dudley Ridge Water Dist.	1,235,791	57,700
12. Empire West Side Irrigation Dist.	79,315	3,000
13. Kern County Water Agency	17,661,891	1,153,400
14. Oak Flat Water Dist.	129,890	5,700
15. Tulare Lake Basin Water Storage Dist.	2,615,822	118,500
Subtotal	**22,114,556**	**1,355,000**
CENTRAL COASTAL AREA		
16. San Luis Obispo County Flood Control & Water Cons. Dist.	0	25,000
17. Santa Barbara County Flood Control & Water Cons. Dist.	1,240	45,486
Subtotal	**1,240**	**70,486**
SOUTHERN CALIFORNIA AREA		
18. Antelope Valley-East Kern Water Agency	681,539	138,400
19. Castaic Lake Water Agency	150,052	41,500
20. Coachella Valley Water Dist.	240,762	23,100
21. Crestline-Lake Arrowhead Water Agency	25,227	5,800
22. Desert Water Agency	384,830	38,100
23. Littlerock Creek Irrigation Dist.	9,746	2,300
24. Mojave Water Agency	59,847	50,800
25. Palmdale Water Dist.	33,334	17,300
26. San Bernardino Valley Municipal Water Dist.	238,430	102,600
27. San Gabriel Valley Municipal Water Dist.	118,431	28,800
28. San Gorgonio Pass Water Agency	0	17,300
29. The Metropolitan Water Dist. of Southern California	11,949,034	2,011,500
30. Ventura County Flood Control Dist.	5,824	20,000
Subtotal	**13,897,056**	**2,497,500**
TOTAL STATE WATER PROJECT	**39,491,222**	**4,217,786**



The urban areas served by the SWP include the most heavily populated parts of the State (USBR/DWR, 1985). The SWP is a major water supplier for the south coastal area where a little over half of all Californians live. In 1975, this area relied on the SWP for 15 percent of its water requirement of 3.4 million acre-feet. By the year 2000, this fast growing area is expected to require more than 4 million acre-feet of total water supply, with the SWP expected to supply about a third. In the San Francisco Bay area, the State's other major population center, the SWP supplies a lesser but still crucial portion of the area's total.

Various canals, aqueducts, and storage facilities transport and store water from the source areas of the two projects. The CVP pumps water from the Tracy Pumping Plant in the Delta to the San Joaquin Valley through the Delta-Mendota and San Luis canals, and from the Contra Costa Pumping Plant to Contra Costa County through the Contra Costa Canal. The CVP also supplies water upstream of the Delta from facilities that include the Tehama-Colusa, Corning, Folsom South, Madera, and Friant-Kern canals. The SWP transports water from the Delta from the Harvey O. Banks Delta Pumping Plant to the San Joaquin Valley and Southern California in the California Aqueduct, and to parts of the San Francisco Bay in the North and South Bay Aqueducts. Storage facilities of the SWP south of the Delta include Pyramid Lake, Castaic Lake, Silverwood Lake, and Lake Perris. San Luis Reservoir near Los Banos is a joint CVP-SWP facility.

The CVP and SWP differs in the ratio of urban to agricultural water users served by each project and yields and storage capacities of the projects (USBR/DWR, 1985). Of the water now being delivered, 95 percent of CVP water goes to agricultural users, while SWP water goes about equally to agricultural and urban use. The CVP's storage capacity in Clair Engle, Shasta, and Folsom Reservoirs totals 8 million acre-feet, while the capacity of the SWP's single significant upstream storage facility at Oroville is 3.5 million acre-feet. Due to its lesser upstream storage, the SWP relies more than the CVP on exporting surplus unstored flows available in the Delta during winter and spring.

Appropriative and riparian rights of water users along streams supplying water to the CVP and SWP determine water amounts available for export. However, water development facilities of other agencies, such as New Bullards Bar belonging to the Yuba County Water Agency on the Yuba River, provide additional opportunities to meet the critical water supply needs of California.

Central Valley Basin

The Central Valley Basin includes two major river basins, that of the Sacramento River on the north and the San Joaquin River on the south, plus the Tulare Lake Basin (USBR, 1970, 1975). The combined watersheds extend nearly 500 miles in a northwest-southeast direction, and average about 120 miles in width. The watersheds contain about 38 million acres of land, which is more than one-third the area of California (USBR, 1975a). The basin is entirely surrounded by mountains except for a narrow gap on the western edge at the Carquinez Straits. The Sacramento River and tributaries flow southward draining the northern part of the basin. The San Joaquin River and tributaries flow northward, draining the central southern portion. The two river systems join at the Sacramento-San Joaquin Delta, flow through Suisun Bay and Carquinez Straits into San Francisco Bay, and out the Golden Gate to the Pacific Ocean.

The valley floor is a gently sloping, practically unbroken alluvial plain which occupies about one-third of the basin; the other two-thirds are mountainous. The valley floor is about 400 miles long and averages about 45 miles in width. The Cascade Range and Sierra Nevada on the north and east rise in elevation to about 14,000 feet. The Coast Range on the west generally rises to less than 4,000 feet, but rises to as high as 8,000 feet at the northern end.

Water supply for the Central Valley is chiefly derived from runoff of the mountains and foothills of the Sierra Nevada, with minor amounts from Coast Range streams entering the west side of the valley (USBR, 1970). Rainfall contributions on the floor of the basin add to the supply. About four-fifths of the annual precipitation occurs during the winter between the last of October and the first of April, but snow storage in the high Sierra delays the runoff from that area until April, May, and June, in which months half the normal annual runoff occurs. Annual rainfall averages more than 10 inches in the Sacramento Valley, and rain or snowfall on surrounding mountains averages more than 60 inches annually over large areas (USBR/DWR, 1985). Averages are lower in the San Joaquin Valley and surrounding mountains. Precipitation varies widely, however, from year to year. Since a significant portion of precipitation in the basin occurs as winter snowfall in the mountains, runoff may lag precipitation, and the season of runoff often extends into late spring and summer as the winter snows melt. The average annual natural runoff of the Central Valley Basin for the 60 year period beginning in water year 1903 was about 33 million acre–feet, and for the critical 7–year dry period of 1928 to 1934 was about 18 million acre–feet.

Flood control or water storage works exist on all major streams in the basin, which alters the natural flow patterns (USBR/DWR, 1985). These facilities store water for the dry season and protect against the winter floods that were common before water development. They also produce hydroelectric power, enhance recreation opportunities, and serve other purposes.

A complex aquifer system underlies the Central Valley. The maximum depth to water is more than 900 feet. However, ground water may occur near ground surface. Usable storage capacity in a depth zone of 200 feet below ground surface has been estimated as between 80 to 93 million acre–feet in the San Joaquin Basin and 22 to 33 million acre–feet in the Sacramento Basin (DWR, 1975a; USBR, 1970). Low yield in some areas is considered a limiting factor. Ground water temperatures average about 65°F, but range from about 45 to 105°F. The dissolved solids content of the water averages about 500 parts per million (ppm), but ranges from 64 to 10,700 ppm. The predominant water type varies with location in the aquifer, but calcium, magnesium, sodium, bicarbonates, sulfate, and chloride are all present in significant quantities.

The primary use of water in the Central Basin is for the production of agricultural crops. However, water is also used by urban communities, industrial plants, and for other uses (USBR, 1970). Surface water supplies have been developed by local irrigation districts, municipal utility districts, county agencies, private companies or corporations, and State and federal agencies.

Water quality throughout the Central Valley is adequate to sustain beneficial uses, with certain exceptions (USBR, 1970). Quality problems are almost absent in the mountainous areas. On the valley floor, streamflow and water quality during the late summer months are dependent upon operation of upstream reservoirs.

Sacramento River Basin

The Sacramento River Basin contains some 16,714,000 acres and includes the McCloud and Pit River Basins, and the Goose Lake Basin in the northeastern extremity of California. The Sacramento River Basin is about 280 miles long and up to 150 miles wide. The area extends from the crests of the Coast Range and Klamath Mountains on the west to the crest of the Sierra Nevada and Cascade Range on the east, south to and including the American River and Putah Creek basins. In addition, the basin includes the Feather, Yuba, and Bear rivers that flow from the Sierra Nevada into the Sacramento River, and Cottonwood, Stony, and Cache creeks that drain the Coast Range west of the Sacramento Valley.

The Sacramento River Basin has about two–thirds of the surface water supply of the Central Valley. Average runoff from the basin is estimated at 21.3 million acre–feet per year (USCE, 1977). Water resources in the basin have been extensively developed for a wide range of purposes. The area has a total of about 16 million acre–feet of surface storage capacity—over 10.5 million in four major reservoirs Lake Shasta on the Sacramento River (4.552 million acre–feet), Oroville Reservoir on the Feather River (3.538 million acre–feet), Folsom Lake on the American River (1.01 million acre–feet), and Lake Berryessa on Putah Creek (1.6 million acre–feet). Water is also imported into the region from the Truckee and Cosumnes rivers and from the Trinity River Division of the CVP.

In addition to the major reservoirs built for flood control, there are other flood control measures consisting of more than 2.2 million acre–feet of potential flood control storage (DFG, 1987). These are a highly developed system of flood control basins, levees, channels and bypasses. Sacramento Valley levees and bypasses extend over 150 miles from Red Bluff on the north to Suisun Bay on the south, and include the Butte, Colusa, Sutter, American, and Yolo basins. The basins are composed of a series of natural and man–made bypass overflow areas that act as auxiliary channels to the Sacramento River during floodwater times. The bypass areas are used for agriculture during the summer and fall months and are valuable wetlands during the flood season.

Total storage capacity of the 22 ground water basins in the Sacramento River Basin has been estimated as 139 million acre–feet. Of these basins, only 8 have sufficient data available to estimate usable ground water storage. The total usable storage for these basins is 22.1 million acre–feet with 22 million acre–feet in the Sacramento Valley (DWR, 1975a). The safe ground water yield is about 1.6 million acre–feet per year, and the annual overdraft is about 140,000 acre–feet (DWR, 1991a).

The climate of the valley floor areas of the basin is characterized by hot, dry summers and mild winters with relatively light precipitation. Warm, dry summers and cold winters with heavy rain and snow prevail in the mountainous areas. The average annual precipitation varies with elevation and ranges from less than 10 inches in the valley to over 95 inches in the Sierra Nevada and Cascade ranges. Valley temperatures normally range from winter lows near freezing to summer highs of about 110°F. In the mountains, winter temperatures average about 30°F, and occasionally fall below zero.

The economy of the Sacramento Basin is based primarily on production of livestock and diversified crops. Related industries include food packing and processing, agricultural services and the farm equipment industry. Another important segment of the economy in the Sacramento Basin consists of military and other federal government establishments, the State government, and the aerospace industry. Lumber industries are centered in the Sierra Nevada, Cascade Range, Modoc Plateau, and a portion of the Coast Range. Industries engaged in timber byproducts were once located throughout the valley. Other industries are engaged in extraction or mining and production of natural gas, clay, limestone, sand, gravel, and other minerals. The basin is served by a highly developed transportation system including federal and State highways, airlines, railroads, and waterways.

The 1985 population for the Sacramento Valley region exceeded 1.8 million people (DWR, 1991a). Major urban areas include Sacramento, West Sacramento, Redding, Chico, Davis, Placerville, Woodland, Roseville, Yuba City, Auburn, Marysville, Oroville, Willows, Red Bluff, Quincy, Nevada City, and Alturas. Population growth has given rise to many service industries.

Water quality problems associated with irrigated agriculture and municipal and industrial discharges are relatively minor compared with other parts of the Central Valley (USBR, 1970). This has resulted in part from the use of the Sacramento River to convey increasing quantities of water developed within the Sacramento Basin or imported from the North Coastal Basin. Drainage from abandoned mines and tailings has upon occasion caused severe local losses of fish in the upper watershed.

The Sacramento River Basin supports a large variety of game and non–game species (Appendix A–1). Big game animals include blacktailed deer, black bear, and mountain lion. Valley quail, mountain quail, mourning dove, bandtailed pigeon, pheasant, turkey, sooty grouse, gray squirrel, Douglas squirrel, blacktailed jack rabbit, and brush rabbit are the common species of upland game (DWR, 1975b). Furbearers include badger, beaver, bobcat, coyote, ermine, fisher, gray fox, red fox, marten, mink, muskrat, opossum, river otter, raccoon, ringtailed cat, striped skunk, spotted skunk, and weasel. The Sacramento Valley also supports millions of wintering waterfowl. Fish supported by rivers and streams in the basin include chinook salmon, steelhead trout, rainbow trout, brown trout, striped bass, American shad, sturgeon, black bass, catfish, and non–game species such as carp, suckers, and squawfish.

Over 2 million visitors participate in recreational activities along the Sacramento River annually (USBR, 1991). Fishing and relaxation are the most popular recreational activities. Other types of recreation include boating, swimming, camping, picnicking, hiking, and outdoor sports. Between Shasta Dam to the Red Bluff Diversion Dam, total annual recreation participation has been estimated at 1,076,000 hours. Winter–run salmon fishing was very popular prior to the severe decline in the population and current State restrictions. Steelhead trout and spring, fall, and late fall salmon runs remain popular among recreational anglers along the river. Ocean sport fishing also accounts for a large percentage of the Sacramento River anadromous fish catch.

Upper Sacramento River. The drainage area of the Sacramento River above Shasta Dam encompasses 6,649 square miles, producing a mean unimpaired annual flow of 5.7 million acre–feet (USBR/DWR, 1985). Runoff from the upper Sacramento River watershed of the northern Sierra and southern Cascade mountains is stored in Shasta Reservoir near Redding. Major tributaries above Shasta Dam are the Sacramento, Pit, and McCloud rivers.

The climate in the Shasta Lake drainage basin is of the dry summer subtropical (Mediterranean) type (USGS, 1983). Precipitation is highly variable both temporally and spatially in the basin. Average annual precipitation at Shasta Dam is about 60 inches. Rainfall dominates the type of precipitation at Shasta Lake, while snow is the principal form of precipitation in the northern part of the basin at higher elevations. The normal monthly air temperatures at Shasta Lake vary from 46°F in January to 83°F in July.

Sacramento River. The Sacramento River originates as the north, middle, and south forks on the east slopes of the Trinity Divide in Siskiyou County (DFG, 1991). A few miles downstream from the confluence of the three forks, water is impounded behind Box Canyon Dam forming Lake Siskiyou with a storage capacity of 26,100 acre–feet. A minimum flow of 40 cubic feet per second (cfs) is maintained below the dam. From Box Canyon Dam, the river flows about 47 miles to Shasta Lake. Numerous small tributaries enter the Sacramento River between Box Canyon Dam and Shasta Lake. The drainage area of the Sacramento River above Shasta Lake is 425 square miles, and produces an average annual yield of 868,700 acre–feet (USGS, 1988). The Sacramento River contributes about 13.9 percent of the total average annual surface inflow to Shasta Lake.

Elevations range from about 6,500 feet in the headwaters to 3,000 feet at Box Canyon Dam and 1,065 feet at Shasta Reservoir. The drainage consists of mountains and foothills, with the river flowing through a steep canyon downstream from Box Canyon Dam.

The upper reach of this portion of the Sacramento River is a highly productive, cold–water mountain stream for most of its length due to cold, nutrient rich and well oxygenated water from Lake Siskiyou and numerous springs (DFG, 1991). Environmental conditions vary along the length of the river. Late summer temperatures range from the low 50s°F in the river immediately below Box Canyon Dam to the high 60s°F above Shasta Lake. The upper portion of the river is generally swifter with a steeper gradient, longer riffles, and shorter shallower pools than the lower portion of the river.

Before July 1991, the river below Box Canyon Dam was planted with catchable trout, while the lower portion was managed as a wild trout stream. Rainbow trout was the dominant salmonid in the river, with some brown trout also present. Other species included hardhead, Sacramento squawfish, California roach, speckled dace, Sacramento sucker, and riffle sculpin. Also found in the lower reaches of the river were smallmouth bass, Alabama spotted bass, and channel catfish. On July 14, 1991, a boxcar from a Southern Pacific train derailed while crossing the Sacramento River just north of Dunsmuir at the Cantara Loop. The chemical metam sodium was released into the river, destroying downstream aquatic life. Fish and other aquatic life are gradually reappearing from upstream and tributary sources, as well as migration from Shasta Lake.

Pit River. The Pit River is the most extensive tributary to Shasta Reservoir. The North Fork originates in the northeastern portion of Modoc County, while the South Fork originates in northeastern Lassen County. The two forks join at Alturas in eastern Modoc County. The Pit River then flows about 160 miles to Shasta Reservoir (CVRWPCB, 1953). Principal tributaries to the Pit River are Fall River and Hat Creek. The drainage area of the Pit River above Shasta Reservoir, excluding the Goose Lake Basin, is 4,952 square miles, with an average annual discharge of 2.7 million acre–feet (USGS, 1988). The Pit River contributes about 59.5 percent of the average annual surface inflow to Shasta Lake (USGS, 1983).

About two–thirds of the drainage consists of mountains and foothills, with the remainder as valley and mesa lands. Elevations vary from about 7,500 feet in the headwaters to about 1,065 feet at Shasta Reservoir.

The Pit River drainage has been extensively developed with impoundments, diversions, and hydroelectric facilities. Fifteen major impoundments have been constructed in the drainage, with the most significant being West Valley Reservoir (21, 700 acre–feet), Big Sage Reservoir (77,000 acre–feet), Lake Britton (40,600 acre–feet), Iron Canyon Reservoir (24,200 acre–feet), Pit Reservoir No. 6 (15,890 acre–feet), and Pit Reservoir No.7 (34,600 acre–feet). Intensive use is also made of water for agricultural production, with meadow pasture, alfalfa, and grain as the major crops (DWR, 1982). Consumptive use during the summer depletes the flow of the Pit River in Big Valley, but effluent ground water and irrigation return flows usually reestablish flow in the river channel near Fall River Valley.

Nutrient and mineral levels in the Pit River are high due to intensive agricultural uses of the water. However, other significant water quality impairment is not known.

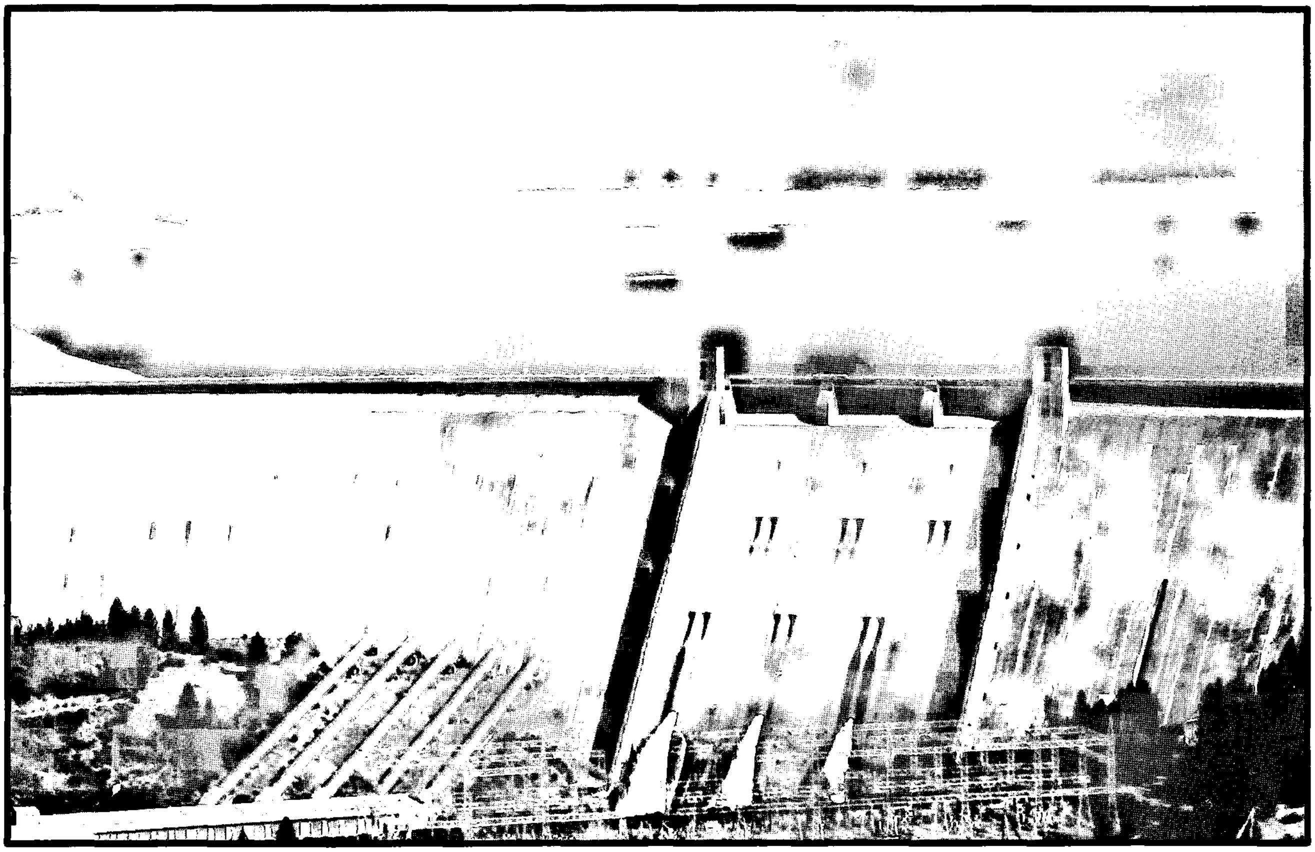
Streams of the Pit River system above Fall River generally do not support significant fish populations due to poor mineral quality and intermittent flows, with the exception of the South Fork above Likely. Principal streams from the standpoint of sport fishing are Fall River, Hat Creek, Pit River below Fall River, and headwater streams of the South Fork.

Recreation is an important activity in the region, with Hat Creek, Burney Creek, and Fall River areas well patronized by vacationers, campers, fishermen, and sightseers. Hunting is also a major activity due to significant game and wild fowl populations.

McCloud River. The McCloud River originates in southeastern Siskiyou County at an elevation of about 4,900 feet. The drainage area is 604 square miles with an average annual discharge of 1.23 million acre–feet prior to completion in 1965 of McCloud Dam 16.5 miles upstream from Shasta Lake (USGS, 1988). Lake McCloud has a storage capacity of 35,200 acre–feet. Water is diverted from Lake McCloud to Iron Canyon Reservoir in the Pit River drainage for power production. Since 1965, annual average discharge from the McCloud River has been reduced to 592,600 acre–feet, representing about 9.3 percent of the average annual surface inflow to Shasta Lake.

The McCloud River is a clear mountainous stream of excellent water quality. The McCloud River supports an excellent sport fishery, with rainbow trout the dominant species. Access is limited and difficult along much of the lower portion of the river.

Shasta Dam and Related Facilities. Shasta Dam in Shasta County was completed in 1945 as part of the CVP. Principal purposes of the project are flood control, water supply, and hydroelectric power generation (USGS, 1983). Additional beneficial uses include streamflow regulation for navigation and water quality enhancement, irrigation, improvement of fisheries and wildlife, and contact and non–contact forms of recreation. The reservoir has a drainage area of 6,665 square miles and storage capacity of 4.552 million acre–feet (USBR, 1975b). Average annual inflow is about 5.7 million acre–feet.



Major CVP facilities that may be included in operation of the drought water bank include Shasta Dam on the Sacramento River. This photograph was taken before the current drought.

The Shasta Powerplant is just below Shasta Dam. Water from the dam is released through five 15 foot diameter penstocks leading to the five main generating units and two station service units. The total capacity of these units is 570,000 kilowatts (USBR, 1991).

Water quality in Shasta Lake reflects the high quality of the tributary streams. Mineral and nutrient quality is excellent. However, mine and mine tailing contaminated runoff from Squaw and Backbone creeks causes localized copper pollution and fish kills (USBR, 1978).

Shasta Lake thermally stratifies, producing significant differences between surface and bottom water temperatures. Surface water temperatures have ranged to a maximum of 88°F, during the summer of 1976, with bottom temperatures of 47.5°F for the same period (USBR, 1991). Typically, however, surface water temperatures during the summer range from 70 to 75°F, with bottom temperatures ranging from 40 to 45°F.

Minimum dissolved oxygen levels in Shasta Lake have been found near the thermocline during summer thermal stratification. During the drought year of 1977, dissolved oxygen levels at the thermocline decreased to about 3 parts per million (ppm), but in the more normal year of 1983 only decreased to about 6 ppm.

Turbidity in Shasta Lake follows a seasonal pattern in which greatest levels occur in the winter when storm runoff enters the reservoir. During the summer, turbidity in Shasta Lake increases with depth (USBR, 1991). Turbidity in the upper 100 feet of the reservoir generally ranges between 1 and 2 NTU's. Between 100 and 400 feet in depth, turbidity usually ranges from 4 to 7 NTU's. Below 400 feet, turbidity ranges between 7 and 14 NTU's.

Shasta Lake supports a wide variety of cold and warm water fish species (USBR, 1991). Resident species include rainbow trout, brown trout, kokanee and land–locked chinook salmon, large and smallmouth bass, spotted bass, black crappie, green sunfish, bluegill, brown bullhead, channel catfish, white catfish, threadfin shad, Sacramento sucker, squawfish, and carp.

Keswick Reservoir. Keswick Dam, located 8 miles downstream from Shasta Dam, impounds a reservoir with a storage capacity of 23,800 acre–feet which regulates reservoir releases from Spring Creek and Shasta Powerplants. Hydroelectric facilities at Keswick Dam consists of three generators with a total output of more than 90,000 kilowatts (USBR, 1991).

The reservoir supports both rainbow and brown trout (USBR, 1991). Some warmwater fish, including large and smallmouth bass and crappie, from Shasta Dam releases are also present. The dam forms a complete barrier to upstream migration of fish, which are primarily chinook salmon and steelhead. Migratory fish trapping facilities at the dam are operated in conjunction with the Coleman National Fish Hatchery on Battle Creek, 25 miles downstream (USBR, 1975b).

Whiskeytown Lake. Whiskeytown Lake is a 241,100 acre–foot reservoir on Clear Creek, which is tributary to the Sacramento River downstream from Keswick Dam. The reservoir regulates diversions from Lewiston Lake on the Trinity River. Diverted water is released into the Clear Creek Tunnel to the Judge Francis Carr Powerhouse, which discharges to Whiskeytown Reservoir. The powerhouse has two hydroelectric generators with a total output of 154,000 kilowatts. Water from Whiskeytown Lake is released through a three mile long tunnel to the Spring Creek Powerplant and discharged to Keswick Reservoir. The Spring Creek Powerplant has two hydroelectric generators with a total output of 192,000 kilowatts (USBR, 1991).

Water in Whiskeytown Lake is of excellent mineral quality and suitable for domestic, agricultural, and recreational use. All reported water quality criteria are within recommended limits.

Spring Creek Debris Dam. The Spring Creek Debris Dam is located on Spring Creek above the tailrace of the Spring Creek Powerplant. The reservoir has a capacity of 5,900 acre–feet, and was constructed to control sediment and debris above Spring Creek Powerplant and to regulate acid mine drainage from Iron Mountain Mine. Releases from Spring Creek Debris Dam are made into Keswick Reservoir.

Keswick Dam to Red Bluff. The Sacramento River winds about 56 miles from Keswick Dam to Red Bluff. The river in this reach is largely contained by steep hills and bluffs. River flows in the upper part of this reach are highly controlled by releases from Shasta Reservoir, but become more influenced by tributary inflow downstream toward Red Bluff.

Topography. From Keswick Dam to Redding, the Sacramento River flows through steep, rugged foothills and high bluffs made up primarily of volcanic and sedimentary rocks, some of which have been strongly metamorphosed (USCE, 1975). From Redding to Anderson the river winds through gravelly sediment originating from the Klamath Mountains and northern Coast Range, and generally encounters less resistance to erosion than above Redding, forming a wider flood plain characterized by agricultural flatland. Below Anderson, the terrain is characterized by hills and dissected uplands, and the river in several locations encounters high bluffs. The most prominent land features below Anderson are Table Mountain and Iron Canyon, both of which contain steep slopes rising about 250 feet above the river channel.

Land Use. Along the Sacramento River, soils are deep and fine textured and are suitable for a wide variety of field and orchard crops (DWR, 1965). Crops presently grown are corn, milo, sugar beets, safflower, strawberry plants, alfalfa, and hay. Orchards are planted to apples, olives, walnuts, almonds, prunes, and peaches. In addition, large farming areas are devoted to the raising of beef and dairy cattle.

West of the Sacramento River, the land rises in parallel, narrow, alluvial valleys separated by moderately high granitic ridges. Through these valleys, many streams empty into the Sacramento River. In the valleys along the watercourses of the Cottonwood Creek area, agriculture is highly developed. Toward the foothills, where the soil thins and becomes rocky, cattle raising is almost the only use made of the land. In the extreme western sections of the area at the higher elevations, pines grow in profusion. In the central section at the lower elevations, the natural forest consists of sparse cottonwood, scrub oak, and manzanita.

Ground water may be either abundant or sparse. The lack of water has precluded major development in the upper areas. However, in the few areas along the higher ridges and terraces where water is available, one-half to five acre homesites are rapidly being developed.

Clear Creek, the second largest tributary on the west side of the basin, drains into the Sacramento River between Redding and Anderson. The only developed agricultural areas within the Clear Creek area are concentrated in Happy Valley about 2 miles west of Anderson and 4 miles northwest of Cottonwood. The Happy Valley area has formed a public water district and contracted with USBR for water from Whiskeytown Reservoir.

The lower foothill lands of the eastside are largely devoted to cattle raising with spots of irrigated meadow supplied by ground water. Forested areas of Douglas fir and pine lie in scattered parcels along the higher foothill elevations, usually along intermittent or ephemeral streams which interlace the area. The upper edge of the area is heavily forested with pine and fir. Lumbering is one of the major activities in this area, and many small mills dot the landscape.

Agriculture in the eastside area consists largely of pasture, but also includes small acreages of walnuts and strawberry plants. Much of the pasture is grown on irrigated lands adjacent to the creeks running through the area. Most of the irrigation is done by direct diversion from the creeks, although limited use is made of ground water in some areas. Very little irrigable land exists in the northeastern portion of the area. In this area, the land is hilly and rocky, leaving only scattered patches of irrigable land. For a part of the year, cattle can be grazed in the mountains, but as the soil moisture is depleted and the grasses die, the cattle are moved to better pasturage.

Climate. Precipitation averages about 31 inches annually, occurring mostly as low intensity winter rains. Amounts of average annual precipitation vary considerably, ranging from about 22 inches near Red Bluff to 50 inches near Keswick Dam.

Annual precipitation in the mountainous areas to the west and east averages 42 inches, occurring mostly in the form of low intensity winter and spring rains, or snow where elevations exceed 5,000 feet. Amounts of annual precipitation vary considerably, ranging to about 90 inches at Lassen Peak. Runoff is very responsive to rainfall and the pattern of runoff follows the seasonal distribution of precipitation.

Surface Water Hydrology. Major tributaries to the Sacramento River between Keswick Dam and Red Bluff include Cow, Stillwater, Bear, Battle, Paynes, Cottonwood, and Clear creeks. Surface water development within the drainage has been minor, with the exception of Whiskeytown Dam on Clear Creek. Minimum releases from the 241,000 acre-foot Whiskeytown Lake flow to the Sacramento River between Redding and Anderson.

The Wintu Pumping Plant in Shasta County delivers about 23,000 acre-feet from the Sacramento River for agricultural, municipal, and industrial use on land east of Redding in the Belle Vista Water District (USBR, 1975a). The pumping plant, with a capacity of about 100 cfs, lifts water 295 feet into the 8 mile long Bella Vista Conduit.

The Anderson-Cottonwood Irrigation District (ACID) maintains a flashboard and buttress dam across the Sacramento River near Redding with a storage capacity of about 100 acre-feet. Water is diverted from the Sacramento River for irrigation of about 17,000 acres. The District has rights to divert about 165,000 acre-feet from the Sacramento River, and has contracted with USBR for an additional 10,000 acre-feet (DWR, 1981). Water use by ACID between the months of April and October comprises about 80 to 85 percent of the approximate 200,000 acre-feet diverted from the river annually between Redding and Red Bluff. The remaining percentage is diverted by the City of Redding, industry, private farms, and small towns.

Misselbeck Dam supplies water to the Igo-Ono Community Services District, encompassing about 8,500 acres along the North Fork of Cottonwood Creek, of which about 4,800 acres are arable (DWR, 1990a). The Clear Creek Community Services District, encompassing about 5,000 acres further south, receives up to 15,000 acre-feet of water from Whiskeytown Lake through the Muletown Conduit. Additional supplies in these areas are obtained from diversions from the North Fork of Cottonwood Creek and its tributaries. Irrigated lands along the Middle and South Fork of Cottonwood Creek obtain water by diversion of streamflow and ground water pumping (DWR, 1965).

Several small storage reservoirs are maintained along Battle Creek. Coleman Forebay impounds 73 acre-feet, while Macumber and North Battle reservoirs store 425 and 1,016 acre-feet, respectively. Numerous other smaller reservoirs and ponds provide additional storage.

Ground Water Hydrology. The Redding Ground Water Basin contains most of the usable ground water in this portion of the Sacramento River drainage (DWR, 1965). This basin lies partly in south central Shasta County and partly in north central Tehama County. It is bounded on the north by the Klamath mountains, on the west by the foothills of the Klamath Mountains and the northern Coast Range, and on the south by the Red Bluff arch, a structural uplift which trends northeasterly across the Sacramento Valley in the vicinity of Red Bluff. The eastern boundary is arbitrarily defined as being at the foothills of the Cascade Range although it is recognized that a small part of the basin extends further to the east.

Important freshwater bearing geologic formations in the basin are alluvium, the Red Bluff formation, and the Tehama and Tuscan formations. The Tuscan and Tehama formations comprise the principal water bearing deposits in the basin. The ground water basin in the Cottonwood Creek area is composed of Continental and Marine sediments. The Marine sediments consist of a thick succession of sandstones and shales which are either impervious, or contain saline waters of unusable quality. The Continental sediments comprise the ground water reservoir and consist of a heterogeneous mass of clays, silts, sands, gravels, or mixtures. Most of the Cottonwood area is underlain by several hundred feet of water–bearing materials. Even though these materials are mostly fine grained and have relatively low specific yields, the large volume of materials provides considerable storage capacity.

Recharge of the ground water is accomplished mainly by percolation of water at higher elevations followed by slow subsurface movement to the valley. Some direct recharge occurs in the valley areas from infiltration of rainfall, and deep percolation of stream and applied water. The recharge has been sufficient in the past to allow only minor seasonal fluctuations in the level of the water table. No determination of the safe ground water yield has been made, though the basin may be reaching a safe yield threshold. Total storage in the basin is about 5.5 million acre–feet. About 290 thousand acre–feet was pumped for water supplies during 1990, resulting in a reduction of storage of about 41.5 thousand acre–feet from the spring to the fall. Water imported from the Trinity River to the Happy Valley area and the Bella Vista Water District provides additional recharge to the Redding ground water basin.

Irrigation wells in the Redding Ground Water Basin generally range in depth between 100 and 500 feet, though in portions of the basin ground water can be found as near as 9 feet from the ground surface. Most of the area is underlain by several hundred feet of water bearing materials.

Most ground water development has occurred south of the Redding Municipal Airport. However, good irrigation wells have been drilled to the north, and the Enterprise Public Utility District recently completed an excellent municipal well in the northwest portion of the area. Wells in this area produce up to 1,600 gallons per minute and often yield over 100 gallons per minute per foot of drawdown.

Surface Water Quality. Surface waters in the Sacramento River area between Keswick Dam and Red Bluff are an excellent mineral quality suitable for most beneficial uses. Most of the water can be classed as calcium–magnesium bicarbonate in type. Exceptions to this classification include waters in the upper reaches of Churn and Stillwater Creeks, which are classed as magnesium–sodium bicarbonate, and Clear Creek, which is classed as calcium–sodium bicarbonate. Detrimental concentrations of minerals have not been detected in any of the major streams or their tributaries. River water is soft to slightly hard, and varies only slightly in mineral content as indicated by electrical conductivity values that range from 93 to 146 μmhos at Keswick and increase slightly up to 160 μmhos at Red Bluff. Water in this area is considered class 1 (excellent to good) for irrigation purposes. This water is slightly hard, but would generally require no softening. The water would also generally be of satisfactory mineral quality for domestic and municipal uses.

Many tributaries drain into the river and water quality does not deteriorate, indicating the excellent quality of the tributary waters. Turbidity is generally less than 10 NTU's the entire river length from Keswick to Red Bluff. Turbidity levels occasionally become elevated in the river primarily as a result of high flows in Cottonwood Creek. This tributary is in a drainage basin that is highly susceptible to sediment loading during periods of high runoff. Turbidity during such periods have reached 838 NTU's. As flows recede and stabilize, the creek becomes quite clear with turbidity values generally less than 5 NTU's.

Waste discharges originating from industrial and municipal developments enter the Sacramento River along the entire length from Keswick to Red Bluff. Lumber by–product industries, cities and towns, light industries, food product plants, and a considerable volume of irrigation return flow all contribute a significant waste load to the Sacramento River.

A few miles northwest of Redding lies the Iron Mountain region containing metallic ore deposits, some of which are presently being mined. Water draining from this area, especially via Spring Creek, is frequently acidic and has undesirable concentrations of copper, zinc, iron, aluminum, and other toxic salts which are leached from tailings of both operating and abandoned mines. Water from this area is at times lethal to fish, and adversely affects animal and plant organisms on which fish feed. To alleviate this problem, USBR constructed the Spring Creek debris dam near the mouth of Spring Creek, which drains to Keswick Reservoir. Since high flows cause frequent uncontrolled releases of toxic laden water to Keswick Reservoir, USEPA has declared the Iron Mountain complex a Superfund site and has initiated actions to reduce the output of toxic materials.

Dioxins, which are a closely related group of highly toxic compounds produced as byproducts of various industrial processes, were discovered as a byproduct of the pulp bleaching process of paper mills in 1987. High levels of dioxins are discharged with mill wastes into the Sacramento River near Anderson. The Department of Health Services has issued an advisory not to eat resident fish from the Sacramento River between Keswick and Red Bluff. The Central Valley Regional Water Quality Control Board has ordered the paper company to reduce dioxins concentrations in the discharge.

Conversion to regional sewer plants rather than individual septic systems, while alleviating much of the concern for ground water contamination, has resulted in effluent with concentrated nutrient loads. This concentrated effluent is discharged to the Sacramento River by the cities of Redding south of Clear Creek, Red Bluff upstream from the diversion dam, and Chico. Coliform bacteria levels have occasionally exceeded a monthly average of 5,000 mean probable number per 100 milliliters, indicating that Sacramento River water requires treatment prior to use for drinking. Sewer treatment plant failure, due to overloading of capacity or malfunction, creates a health hazard from the discharge of raw sewage. Sewer treatment plant failure has occurred at the Red Bluff facility, resulting in the discharge to the Sacramento River of untreated domestic and municipal effluent.

The Sacramento River downstream from Keswick Dam has been designated as spawning waters for anadromous fish, with a minimum allowable dissolved oxygen level of 7 mg/L (USBR, 1991). The Sacramento River, measured at the Red Bluff Diversion Dam, maintains oxygen levels near saturation. Data collected since 1977 show a range between 90 and 110 percent of saturation the vast majority of the time. Dissolved oxygen concentrations have ranged from slightly below 10 mg/L to over 12 mg/L. Overall, the river remains well oxygenated throughout the reach from Keswick Dam to the Red Bluff Diversion Dam.

Warm water temperatures in the Sacramento River downstream from Shasta Dam have affected upstream salmon migration and caused egg mortalities (USBR, 1978). Temperatures are generally too warm for optimum spawning and rearing in the late summer and fall, and too cold for optimum juvenile growth in the spring (USBR, 1991). The problem is most severe in the early fall during dry years when low flows of relatively warm water are further influenced by high ambient air temperatures. Although high water temperatures occur naturally in the river, operation of Shasta Dam has aggravated the problem. Fall release temperatures from Shasta Dam are too warm for salmon spawning during dry years. Temperatures are partially controlled by modifying operations and importing colder water from Clair Engle Lake. Operations modifications include release of colder water through lower dam outlets, which result in loss of power generation through hydroelectric facilities at the dam. The SWRCB has established a temperature objective of 56°F to be attained to the extent controllable throughout the spawning area between Keswick Dam and Hamilton City. The current interim bypass operation at Shasta Dam is expected to meet the 56°F temperature objective most of the time immediately below Keswick Dam (USBR, 1991). Temperatures below the upper lethal temperature of 62°F are maintained between Keswick Dam and Red Bluff except during the months of August, September, and October, when temperatures may exceed this level on occasion. Temperatures remain below 62°F at Red Bluff in 75 percent of the years during September.

Effects of Shasta Dam releases on upper Sacramento River water temperatures decrease with downstream distance. River temperatures are greatly affected by ambient air temperature between the point of release and the Red Bluff Diversion Dam, particularly during the summer months (USBR, 1991). Ambient air temperature and tributary accretions combine to produce high summer river temperatures detrimental to some fishery resources in the river between Keswick Dam and the Red Bluff Diversion Dam. The effects of high summer water temperatures are compounded in minimal water years.

Elevated river temperatures during late summer and early fall is a primary factor limiting winter–run chinook salmon survival, which has been listed as an endangered species by the State and a threatened species by the National Marine Fisheries Service (USBR, 1991).

Ground Water Quality. Ground water is generally of excellent mineral quality and is considered class 1 for irrigation purposes. This water is generally suitable for domestic and industrial uses. Poor quality water, however, does exist in the basin fringe area near the base of the foothills where the salt water bearing Chico formation rises near the surface.

Wildlife and Fish. The wildlife resources in the vicinity are associated with riparian, oak woodland, marsh, and grassland habitat in addition to agricultural lands. The riparian corridor along the river below Keswick Dam is characterized by willow, cottonwood, sycamore, elderberry, coyote bush, poison oak, tule, cattail, smartweed, dock, watergrass, Johnson grass, Bermuda grass, and Baltic rush. This area is inhabited by passerine bird species including flycatchers, wrens, sparrows, swallows, finches, and blackbirds. Waterfowl (mallard, wood duck, common merganser, geese, and coots), shore and wading birds (herons, egrets, and kingfishers), upland game birds (ring-necked pheasant, turkey, mourning dove, and valley quail), and raptors (wintering bald eagles, osprey, red-shouldered hawk, red-tailed hawk, kestrel, and great-horned owl) may also be present.

River otter, beaver, and muskrat utilize the riverine and riparian habitat extensively. Riparian areas are also valuable habitat for blacktail and mule deer, feral hogs, coyote, striped and spotted skunk, raccoon, opossum, bobcat, mink, weasel, badger, red and grey foxes, cottontail and brush rabbit, blacktail hare, grey squirrel, and small rodents.

Anadromous fish species migrating to the Sacramento River between Red Bluff and Keswick Dam include steelhead trout, American shad, white sturgeon, and four races of chinook salmon (USBR, 1991). Resident species include rainbow and brown trout, largemouth and smallmouth bass, channel catfish, riffle sculpin, western and Sacramento sucker, hardhead, and carp.

Steelhead Trout – Steelhead trout comprise an important recreational fishery within the Sacramento River system. Approximately 15 percent of the annual steelhead runs in the Sacramento River are the result of stocked fish released as smolts and fingerlings (JSA, 1987).

American Shad – American shad were introduced into the Sacramento River system from the East Coast through a series of plantings between 1871 and 1880. The population expanded rapidly to levels that supported a commercial fishery from 1879 to 1957. A probable population decline began in the mid-1940s. In 1957, the commercial fishery was eliminated. A popular sport fishing effort is still present in the Feather, American and Yuba rivers. However, indications are that in recent years the number of adults entering these streams has declined.

American shad migrate up their natal rivers to spawn. In the Sacramento River system, adult migration occurs during April, May, and June. Spawning in the Sacramento River and its tributaries is usually completed by June. The distribution of first time spawning shad among tributaries appears to be related to the magnitude of the tributary flow relative to the mainstem flow. Higher numbers of first time spawners are attracted to tributaries when the proportion of tributary flow to mainstem flow is higher (Richard Painter, DFG, pers. comm.). Temperature is likely to be a factor in initiating migration spawning.

Shad spawn in schools in the main channels of rivers in depths of 3 to 30 feet or more. They are broadcast spawners with spawning intensity related to water temperature. Most American shad die after spawning, though a few survive to move downstream to the Bay and ocean and make the return spawning journey the following year.

Although shad eggs are semibuoyant and drift downstream after spawning, they gradually sink to the bottom. In water with temperature in the low 60s°F, incubation is about 3 to 6 days. Juvenile shad often spend considerable rearing time in their natal streams, but many may rear in the Delta as well. Juveniles may remain in the Delta from several weeks to several months, but gradually move toward the ocean. Little is known of their life history between the juvenile and spawning stages.

Chinook Salmon – The chinook salmon has the broadest geographic range of any of the Pacific salmon species and is an important recreational and commercial species throughout most of its range. Runs of chinook salmon are found along the northern Pacific Ocean and tributary drainages and around the Pacific Rim from northern Japan to souther California. In spite of its wide distribution, the chinook salmon is the least abundant of Pacific salmon species. As a species, the chinook salmon is distinguished by its highly variable life history, and many rivers have more than one distinct stock identifiable by their life history patterns.

The chinook salmon has the broadest geographic range of any of the Pacific salmon species and is an important recreational and commercial species throughout most of its range. The 1991 and 1992 Drought Water Bank operations were designed to reduce impacts to this and other fishery species as well as increase stream flows.

The life span of chinook salmon may range from 2 to 7 years. Although chinook salmon can spend from 1.5 to 5 years in the ocean before maturing and returning to natal streams to spawn, most return to fresh water 2.5 years after entering the ocean.

Chinook salmon eggs are laid in nests, referred to as redds, excavated by the female in loose gravel. Appropriate gravel beds selected by female chinook salmon consist mainly of gravel ranging from 1 to 6 inches in diameter. Optimal survival of eggs and pre–emergent fry occurs when the largest portion of the redd is composed of smaller gravel. The female seeks out gravel beds with water depths and velocities sufficient for spawning activities and egg incubation. Depths range from shallow riffle areas (0.5 to 2 feet) to deep runs or glides (5 feet to over 20 feet). Spawning depth is a function of physiological requirements, available habitat, and specific differences between stocks of salmon. For instance, some winter run chinook salmon have been observed to spawn on gravel in deeper water than the other three Sacramento River salmon runs. Preferred spawning velocities are generally in the range of 1.5 to 2.5 feet per second just above the surface of the gravel bed. As the female lays the eggs in the redd, one or more male salmon fertilize the eggs. The female subsequently buries the eggs in the redd by displacing gravel upstream of the redd onto the eggs.

Eggs hatch generally in about 40 to 60 days after an incubation period that is dependent on water temperature. Maximum survival of incubating eggs and pre–emergent fry occurs at water temperatures between 40 and 56°F. The newly hatched larvae, or pre–emergent fry, remain in the redd and absorb the yolk stored in their yolk sacs to grow into fry. Larval incubation lasts about 2 to 4 weeks depending on water temperatures. The fry then wiggle out of the redds into the water above. The fry seek out shallow areas near shore with slow current and vegetative or boulder cover nearby, where they begin to feed on insects and crustaceans drifting in the currents. As they grow, the juvenile salmon move out into the deeper, swifter water for rearing, but continue to remain near boulders, fallen trees, and other such cover to reduce chances of being preyed upon and to minimize energy expenditure.

Juvenile salmon may emigrate downstream toward the estuary at any time from immediately after emerging from the redd to after spending more than a year in fresh water. The length of juvenile residence time in fresh water and estuaries varies between salmon runs and depends on a variety of factors, including season of emergence, streamflow, turbidity, water temperature, and interactions with other species. There are two general types of chinook salmon life history strategies, the *stream* and *ocean* types. Stream type juveniles remain in the river for one or more years before migrating to the ocean. Ocean type juveniles typically move to the ocean during their first few months of life. In general, stream types are found north of the Columbia River and have long stream migratory routes such as the Snake River in Idaho. Although California races more typically follow the *ocean* pattern, some fall, late fall, and spring run juveniles may emigrate as age one smolts. Apparently all winter run salmon migrate during the first few months after emergence (Frank Fisher, DFG, pers. comm.).

Sacramento River chinook salmon runs are designated by the season during which they enter the river to begin their upstream spawning migration. The four runs of chinook salmon in the Sacramento River are the fall, late fall, winter, and spring runs. Each of the freshwater life stages may be found in the same portion of the upper river every month of the year. The actual timing of each life stage varies somewhat from year to year and is primarily a function of weather, streamflow, and water temperature.

The population sizes of all four runs in the upper Sacramento River system have shown declines in recent years. These declines are due to natural conditions (such as drought and El Nino) and human causes (water development, pollution, and harvest). In the San Joaquin River, run size has declined dramatically during the drought. Escapement of fall run salmon to the American, Yuba, and Feather rivers have been somewhat more stable probably due to hatchery production.

The presence of four races of chinook salmon in Central Valley streams results in an extended period of emigration. However, during the summer months of July, August, and September, this emigration is minimal, probably because of low water levels and high temperatures. This lull in emigration provides a potential window for Water Bank transfers.

Adult fall run chinook salmon migrate from the ocean to the river system from July to December at three to four years of age. Spawning occurs between October and December, depending upon specific streamflows and temperatures. Incubation occurs from October through March. Juvenile rearing and emigration occur from January through June. Most of the juveniles migrate to the ocean within a few months following emergence. A small number will remain in freshwater and migrate as yearlings. Most of the historic spawning grounds of the fall run were downstream from current dam sites, which lends this run to hatchery production. Presently the fall run is by far the dominant run in the Central Valley.

The late fall run adult immigration occurs from October to April. Spawning occurs between January and April, and incubation occurs from January through June. Rearing and emigration occurs from April to October.

Adult winter run salmon migrants enter the Sacramento River from December through July, with spawning taking place in the mainstem near Redding. A possible remnant of winter run spawners migrate to the Calaveras River. Spawning occurs from April through July, peaking typically in May and June. Eggs incubate through August. Although juveniles begin to move out of the upper river as early as August, the main migration through the Delta occurs in January through April. Cool water temperatures during the summer (56°F in July and August, 60°F in September, and 62°F in October) are necessary to insure the survival of eggs and fry. Historically, this race spawned in the McCloud River but access was blocked by construction of Shasta Dam. However, through the 1940s and 1950s, cool water releases from the dam enabled the winter run to survive in the Redding area just downstream from the dam.

Like the winter run, the spring run traditionally spawned in the upper reaches of the Central Valley rivers and their tributaries, which are areas now blocked by dams. Although at one time the spring run was probably dominant in the San Joaquin River, it is now extirpated from that system. The run in the Sacramento River system generally enters freshwater between March and June. The distinguishing feature of this run is that the adults hold over during the summer months in colder pools in the upper river areas and do not spawn until the fall, sometime between late August and October.

Spring and fall run spawning periods overlap in the upper Sacramento and Feather rivers. Historically, the runs were geographically separated and did not interbreed. There is general agreement among fishery scientists that there has been sufficient crossbreeding between the fall and spring runs to result in one protracted late summer through fall spawning run in the mainstem of the Sacramento River and the Feather River. The exception to this may be spring run stocks utilizing small tributaries, such as Mill and Deer creeks. Spring run are also produced at the Feather River Hatchery, and this production may have resulted in additional loss of the spring run's genetic integrity.

Of the four runs of chinook salmon (fall, late fall, winter, and spring) that inhabit the river, the greatest concern is for the winter run. In recent years, the winter run has declined from an average escapement (fish returning to spawn) of 80,000 adult fish to 191 fish in 1991. This precipitous decline has prompted listings by the State as endangered and by federal agencies as threatened. While the majority of the winter run spawn upstream from Red Bluff, all four runs use the river as far down as Colusa for rearing young.

Recreation. Numerous public and private facilities provide recreational access along the Sacramento River. Fishing is excellent in the river between Keswick Dam and Red Bluff. Rafting, kayaking, and canoeing are also popular because the river is fast flowing and there are a number of riffle areas. Picnicking, camping, and sightseeing are other important recreation activities.

Fishing and hiking occur throughout the year, while picnicking and camping are limited to the spring through fall months. Water contact sports, such as swimming, kayaking, and canoeing, are generally restricted to the summer months where the daytime temperatures are often over 100°F. The Anderson–Cottonwood Irrigation District Diversion Dam, located about 3.7 miles downstream from Keswick Dam, is a barrier to boat traffic. However, there are boat launching ramps above and below the dam. Some recreation activities, in particular hiking, are impeded by private development along the river frontage.

With the possible exception of fishing, most of the recreation use originates locally, particularly from the surrounding communities of Redding, Enterprise, and Anderson.

Red Bluff to the Delta. The Sacramento River enters the Sacramento Valley about 5 miles north of Red Bluff. The 98 miles of river between Red Bluff and Colusa is a meandering stream, migrating through alluvial deposits between widely spaced levees. From about Colusa to the Delta, the Sacramento River is regulated by the Sacramento River Flood Control Project system of levees, weirs, and bypasses. The flood control system includes Moulton Weir at River Mile 158, Colusa Weir at River Mile 146, and Tisdale Weir at River Mile 118, which divert floodwaters in the Sacramento River into the Sutter Bypass (USCE, 1975). Sutter Bypass, running roughly parallel and between the Sacramento and Feather Rivers, receives additional flow from the Feather River, and the combined flow enters the Yolo Bypass at Fremont Weir near Verona. American River floodflows enter the Yolo Bypass through the Sacramento Weir at River Mile 63. The Yolo Bypass returns the entire excess flood flow to the Sacramento River about 10 miles above Collinsville. The system provides flood protection to about 800,000 acres of agricultural lands and many communities, including the cities of Sacramento, Yuba City, and Marysville.

Topography. Located in the middle of the Sacramento Valley, this area along the valley floor is relatively flat with elevations from about 60 to 300 feet (USFWS, 1987). The mountainous areas bordering the valley to the west and east range in elevation to over 5,000 feet, with long steep ridges and narrow valleys.

The action of the Sacramento River (e.g., meandering, flooding and overbank flow, erosion, cutoffs) within the floodplain plays a key role in shaping the topography and determining land uses within the valley (WCC, 1986). The lands within the floodplain are generally low and flat, and are characterized by meandering channels, natural levee terraces, swales, and associated wetlands, swamps, and ponds.

Soil types in the flood basin correspond to flow and inundation patterns of the river. As the river moves laterally back and forth, silt, sand, and gravel are deposited adjacent to the river to form gravel points and bars. The river banks, or natural levees, consist of deposits of sandy loams. Beyond the levees, fine clays and alkaline soils are carried into the floodplain. While flooding occurs across much of the overflow area, deposition of clays and soils on the floodplain primarily affects lands adjacent to the river. Waterways within the floodplain, such as sloughs and oxbows, provide valuable wetland areas and wildlife habitat.

Climate. The area is characterized by hot dry summers and mild wet winters. Precipitation is heaviest from November through March, when 80 percent of the annual rainfall occurs. Normal annual precipitation varies from about 22 inches near Red Bluff to about 15.7 inches at Colusa and 17 inches near Sacramento. The increase near Sacramento is due primarily to topography and proximity of the Sacramento–San Joaquin Delta and San Francisco Bay systems. These factors tend to superimpose a milder, Mediterranean–type climate, particularly below Verona. Precipitation increases in the mountainous areas, with average annual precipitation ranging up to about 40 inches to the east and west of the valley floor. Snow comprises much of the precipitation in the eastern mountains where elevations exceed 5,000 feet.

Average temperatures range from about 38°F in the winter to 95°F in the summer. During the summer, daytime temperatures occasionally exceed 100°F.

Land Use. Many individual residences and small communities exist along the upper river, such as Tehama, Los Molinos, Hamilton City, Princeton, and Butte City. Further from the river, larger towns and cities include Chico, Willows, and Colusa. Along the lower river, major urban development from the City of Sacramento fronts the river, with minor residential and commercial development at Knights Landing, Rio Vista, Isleton, Walnut Grove, Locke, Hood, Clarksburg, and Freeport. Marinas are common along the river in this reach, especially between Clarksburg and just upstream of Discovery Park.

Alluvial soils eroded from the surrounding mountains are well suited for a variety of agricultural uses, and historically supported extensive riparian forests. Riparian woodland and grass lands have largely been converted to agricultural uses, with orchards predominating in the upper portion of this reach and row crops dominating in the lower portion. Typical agricultural crops include almonds, pears, peaches, rice, tomatoes, sugar beets, wheat, corn, and seed crops such as melons and sunflowers (USCE, 1985). Thousands of acres of wetlands and refuges also occur in the area.

Agriculture is the most important segment of the economy for the smaller communities, while manufacturing and services form a larger portion of the economy of the larger towns.

Surface Water Hydrology. Streamflow in the Sacramento River is modified well upstream by Shasta Dam and several diversion structures, especially the Sacramento River Flood Control Project. Major streams entering the Sacramento River include Thomes, Elder, Stony, and Putah creeks from the west, and Antelope, Mill, Deer, and Big Chico creeks and the Feather and American rivers from the east. Numerous small tributaries drain the low foothills on either side of the valley.

Reservoirs on Stony Creek include Black Butte (144,000 acre–feet), East Park (51,000 acre–feet), and Stony Gorge (50,055 acre–feet) (USCE, 1977, 1987). Black Butte Reservoir provides flood protection to 64,000 acres of farmland lying along the lower reaches of Stony Creek, to the towns of Hamilton City and Orland, and to the Interstate 5 Freeway. The reservoir also helps to reduce floodflows along the Sacramento River. The reservoir provides about 57,000 acre–feet of water annually for irrigation.

Over 200,000 acres in the Sacramento Valley in Tehama, Glenn, Colusa, and Yolo counties are served by the Sacramento Canals Unit of the Central Valley Project, which consists of the Red Bluff Diversion Dam, Corning Pumping Plant, and several canals (USBR, 1975a). The Red Bluff Diversion Dam, which creates a 3,900 acre–foot lake on the Sacramento River, diverts water from the river at Red Bluff to the Tehama–Colusa Canal service areas. The Corning Pumping Plant, in the canal about half a mile downstream from the Diversion Dam, lifts water 56 feet from the Tehama–Colusa Canal into the 21 mile long Corning Canal. The capacity of the Corning Canal varies from 500 cfs at the Pumping Plant to 88 cfs at the terminus 4 miles southwest of Corning. The 122 mile long Tehama–Colusa Canal, which terminates in the northern part of Yolo County, has an initial diversion capacity of 2,300 cfs.

The Glenn Colusa Irrigation District (GCID) supplies water from the Sacramento River near Hamilton City to about 175,000 acres of land, including 25,000 acres of three federal wildlife refuges (GCID, 1989). The GCID diverts a maximum seasonal total of 825,000 acre–feet from April through October. The diversion has a capacity to pump 3,000 cfs with a 9 foot lift.

Butte Creek, originating in the Sierra Nevada and dropping through a steep canyon to the Sacramento Valley near Chico, flows southwesterly in the valley paralleling the Sacramento River. The creek flows into Butte Slough south of Colusa where it is either released to the Sacramento River or diverted to the Sutter Bypass. Most often the water flows to the Sutter Bypass, and is discharged through Sacramento Slough to the Sacramento River just above the confluence of the Feather River.

During the peak irrigation season, most of the flow of Butte Creek is diverted above the City of Durham. The Western Canal, which is a major agricultural diversion carrying irrigation and duck club water into the Butte Basin from the Feather River, flows into and across Butte Creek below Durham. Consequently, most of the flow in Butte Creek below Western Canal during the irrigation season is Feather River water. The lower portion of the Butte Basin is known as the Butte Sink. This area is one of five major flood basins in the Sacramento Valley and often floods during the winter with high flows from Butte Creek and the Sacramento River.

The Colusa Basin drainage area consists of 1,619 square miles of watershed west of the Sacramento River, extending from Orland to Knights Landing (Figure 2–3). The basin contains some 350,000 acres of rolling foothills intersected by several stream channels located along the eastern slopes of the Coast Range, and about 650,000 acres lying in the flat agricultural lands of the Sacramento Valley. A multi–purpose drain (Colusa Basin Drain) flows southerly along the eastern boundary of the basin, and is used both as an irrigation supply canal and as an agricultural return flow facility. The canal eventually discharges into the Sacramento River through the regulated outfall gates at Knights Landing or into the Yolo Bypass through the Knights Landing Ridge Cut (DWR, 1990b).

During the irrigation season, Sacramento River water is diverted through Glenn–Colusa Canal, Tehama–Colusa Canal, and other small diversions including westside streams and ground water. During 1988, total water imports were about 1,800,000 acre–feet. The resultant surface water outflow at Knights Landing was 273,000 acre–feet, which represents only 15 percent of the total applied. During the winter months, high precipitation levels have caused flooding for as many as 100,000 acres. These floods cause the Colusa Basin Drain to become inundated and the majority of outflow is through the ungauged Knights Landing Ridge Cut.

The Yolo Bypass, a low lying area of about 40,000 acres bordered by flood control levees (Figure 2–4), is part of the Sacramento River Flood Control Project (USCE, 1991). The flood control project consists of about 1,000 miles of levees plus overflow weirs, pumping plants and bypass channels that provide flood protection to urban areas, communities, and agricultural lands in the Sacramento Valley and Sacramento–San Joaquin Delta. A deep channel, the Toe Drain, borders the east levee. Water enters the Yolo Bypass from the Sacramento River flood flows, local and regional stormwater runoff, tidal action, wastewater discharge, and direct diversion for agriculture. Water is present in the Bypass throughout the year, with peak flows occurring during the winter in response to storm events.

During high flows, water is diverted into the Yolo Bypass from the Sacramento River via the Fremont and Sacramento Weirs near Knights Landing and West Sacramento, respectively. When the Yolo Bypass floods, large areas of seasonal wetlands, seasonal mud flats, and deep, open water cover types are created. Several private duck clubs with wetlands are located in the Yolo Bypass. In the summer, agricultural return flows enter the area primarily along the west side bypass levee. Additional water enters the Yolo Bypass through the Willow Slough Bypass, Putah Creek, Cache Creek (by way of the Cache Creek Settling Basin), and the Knights Landing Ridgecut. The El Macero drain carries storm water runoff from the City of Sacramento and agricultural return flows. Water in this drain is pumped through the west bypass levee and then conveyed to the Toe Drain on the east side of the bypass. The Toe Drain flows south to Prospect Slough in the Delta.

The Lisbon Weir is a weir and culvert structure in the Toe Drain. Incoming tides from the Delta pass over the weir and are trapped by flap gates on the subsequent culverts. Water stored behind the weir recharges the Toe Drain, assuring virtually year round availability of water. Canals convey water laterally across the area from the Toe Drain. Irrigation return waters are discharged into South Putah Creek, are used to irrigate land south of Putah Creek, and eventually drain southeast to the Toe Drain.

On the Feather River, Oroville Reservoir controls potential floodwaters, conserves water for release downstream, stores water for power generation, and provides recreation opportunities. The reservoir has a capacity of over 3.5 million acre–feet. Electrical power is generated in the Hyatt–Thermalito complex at the base of the dam. The intake structure to the powerplant is designed so water can be drawn from various depths in the reservoir pool, thus allowing adjustments in the temperature of released water. Water released through the powerplant enters the Thermalito Diversion Pool created by the Thermalito Diversion Dam about 4,000 feet downstream from Oroville Dam.

A portion of the fish maintenance is released directly to the Feather River from the Diversion Pool, but greater volumes of water are diverted to two irrigation canals, the Feather River Fish Hatchery, and the Thermalito Powerplant. Four canals divert from the Afterbay of the Thermalito Powerplant. Return flows from the fish hatchery and Thermalito Afterbay releases for fish and the Delta make up river flow below the Afterbay outlet. The Feather River then flows south for 65 miles before emptying into the Sacramento River near Verona, about 21 river miles above Sacramento.

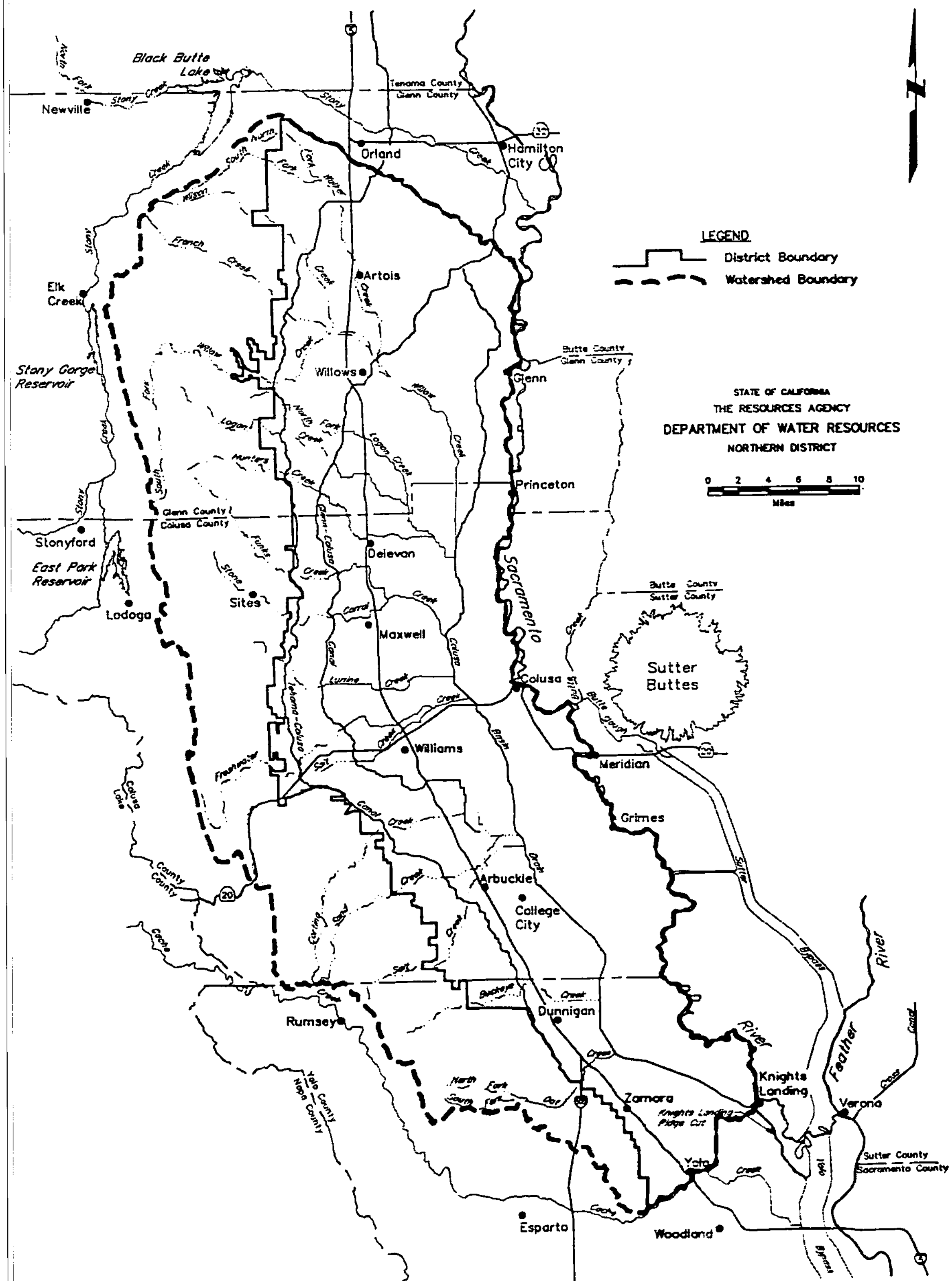
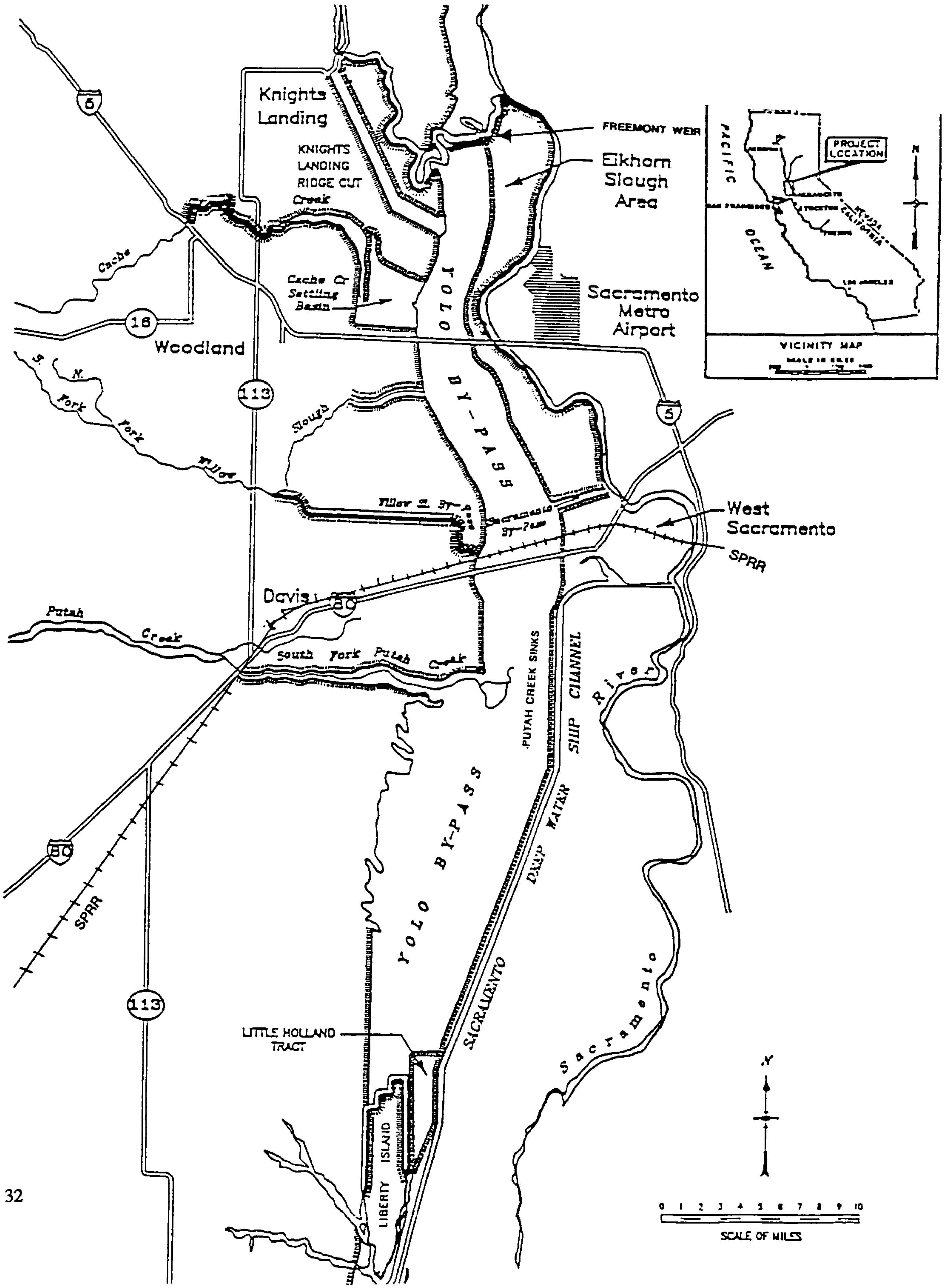
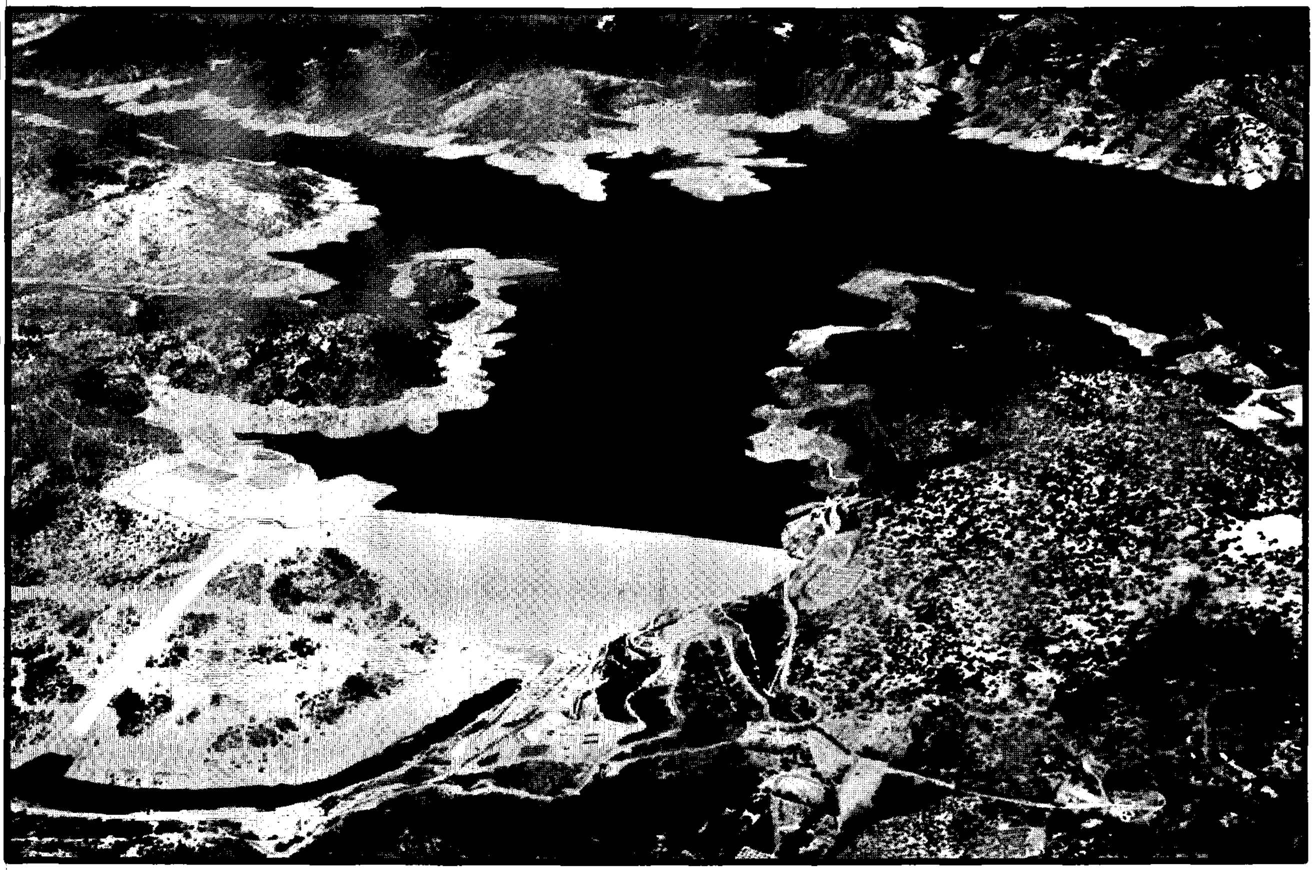


Figure 2–3. Colusa Basin and Colusa Basin Drainage District

Figure 2-4. Yolo Bypass Flood Control System





Storage at Shasta, Oroville, and Folsom reservoirs was significantly less than normal during the drought. This photograph shows Oroville under normal conditions

Above Oroville Dam, the Feather River drains 3,634 square miles of watershed with an average annual runoff of 4.2 million acre–feet (USBR/DWR, 1985). Three small reservoirs (Davis, Frenchman, and Antelope) on separate forks of the Feather River have a combined storage capacity of 162,414 acre–feet and provide local irrigation, recreation, and incidental flood control (USBR/DWR, 1985). All three reservoirs are stocked with trout, and water releases are regulated to improve downstream fish habitat. Below Oroville Dam, an additional 2,297 square miles of watershed contributes 1.5 million acre–feet annually, principally by two large tributaries, the Yuba River and the Bear River.

The Yuba River, on the western slope of the Sierra Nevada mountains, has a watershed of about 1,300 square miles. Flows in the North Yuba River are impounded in the Yuba County Water Agency's New Bullards Bar Reservoir about 29 miles northeast of Marysville. The reservoir has a storage capacity of 966,000 acre–feet, with a usable capacity of 727,380 acre–feet (DWR, 1988a).Releases from New Bullards Bar Reservoir join the Middle Yuba River and flow into Englebright Reservoir (Figure 2–5), which stores 70,000 acre–feet. The South Yuba River also flows into Englebright Reservoir. Releases from Englebright Dam flow westerly 12.7 miles to Daguerra Point Dam and then 11.4 miles to join the Feather River at Marysville. Daguerra Point Dam serves both as a barrier to impair downstream movement of mining debris and the point of diversion for the major water irrigation districts utilizing Yuba River flows. Operation of the facilities for power production, fisheries maintenance, water supply, recreation, and flood control are presently beneficial uses.

Minimum releases to the North Fork Yuba River downstream from New Bullards Bar Reservoir are 5 cfs. However, releases through the Colgate Powerplant, downstream from the dam, for power generation increase flows by about 550 to over 1,000 cfs (DWR, 1988a). Minimum flow requirements downstream from Englebright Dam are variable, ranging from 1,000 to 1,850 cfs from January 1 to January 15, 600 cfs from January 16 through March 31, 70 cfs from July 1 to September 30, and 400 cfs from October 1 to December 31.

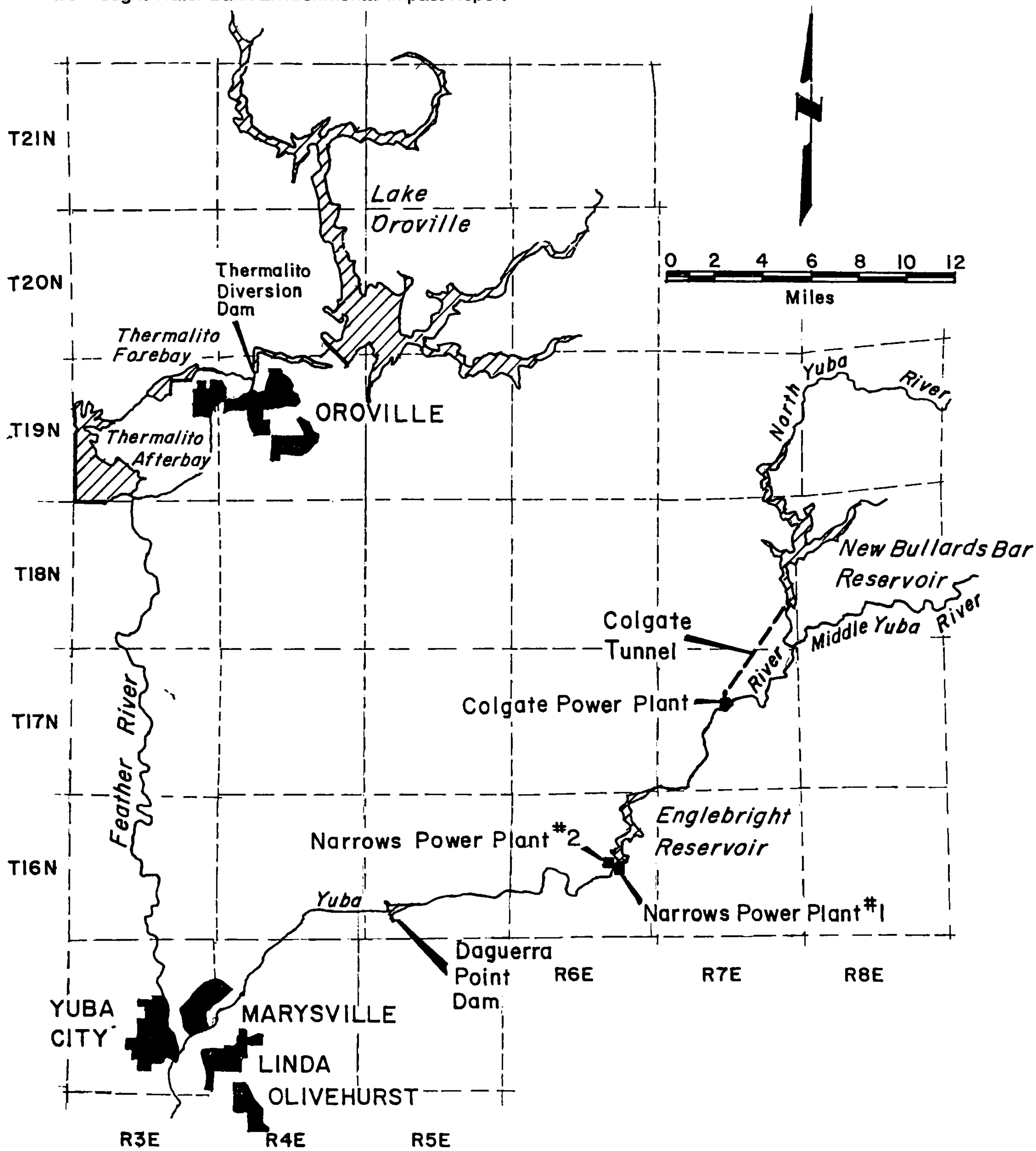


Figure 2-5. Water Resources Developments on the Yuba and Feather Rivers

Flows in the Yuba River are reduced by diversions at Daguerra Point Dam. Minimum flow requirements downstream from Daguerra Point Dam are 245 cfs from January 1 through June 30, 70 cfs from July 1 to September 30, and 400 cfs from October 1 through December 31. Releases may be reduced during critical dry years.

The American River drains a 1,921 square mile area in the north–central portion of the Sierra Nevada (USBR/DWR, 1985), with mean annual unimpaired runoff estimated at 2.6 million acre–feet (at Fair Oaks). CVP facilities on the American River include Folsom Dam and reservoir, with 1,010,000 acre–feet of storage capacity, and Nimbus Dam which impounds Lake Natoma as an afterbay for Folsom Dam. These facilities regulate river flow for irrigation, power, flood control, municipal and industrial use, and other purposes. The project provides about 500,000 acre–feet annually for irrigation and municipal water supplies. The American River joins the Sacramento River about 25 miles downstream from Nimbus Dam.

Numerous small diversions along the Sacramento River provide irrigation to riparian lands. Some of the larger diverters include the Provident Irrigation District at River Mile 9, Princeton–Cordora–Glenn Irrigation District at River Mile 177.6 and 165.0, and Reclamation District 1004 at River Mile 164.8 (USCE, 1975).

Ground Water Hydrology. The Sacramento Valley ground water basin encompasses about 5,000 square miles, extending from Red Bluff to the Sacramento–San Joaquin Delta (DWR, 1978). The basin includes all Sutter County and portions of Yuba, Tehama, Glenn, Butte, Colusa, Yolo, Solano, Placer, and Sacramento counties. Large quantities of water are stored in thick sedimentary deposits in this area. The total ground water in storage to a depth of 600 feet is estimated to be 113.6 million acre–feet.

Ground water is used intensively in some areas and only slightly in others where surface water supplies are abundant. However, overall consumption has been increasing steadily since the early 1900s. In 1990, ground water accounted for about 29 percent of all agricultural water in the valley. The total amount of Sacramento Valley ground water pumped represents about 12 percent of the 15 million acre–feet pumped annually from all basins in the State.

About 7.77 million acre–feet of applied water were used by farms and cities in the Sacramento Valley north of the Rio Vista area during 1990. Of this, about 29 percent, or 2.27 million acre–feet, came from wells, and the remainder, 5.5 million acre–feet, from surface sources. Crops irrigated by ground water used an average of 3.2 acre–feet per acre, as compared to 4.2 acre–feet per acre for those using surface sources. The lower use is attributed to a tendency for ground water irrigators to apply water more efficiently and to grow crops with a higher economic return and smaller water requirement.

Geology. Beneath the Sacramento Valley floor is a thick sequence of sedimentary materials deposited in both marine and nonmarine environments. The upper, nonmarine portion attains a maximum thickness of about 3,000 feet. Materials in this portion consist of volcanics transported to the valley as mudflows and fragmental rock eroded from the surrounding mountains and transported by stream action. As these were deposited, the structural trough gradually downwarped or subsided. As a result, a large volume of material accumulated without significant changes in surface elevation. Fresh ground water occurs in the void spaces between these granular materials to a maximum depth of about 3,000 feet in the south valley. Throughout the basin, saline water underlies the fresh water.

Several formations of post–Eocene age present in the valley are important sources of ground water. They include the Tuscan, Mehrten, Tehama, Laguna, and Victor Formations and several unnamed alluvial units, principally alluvial fans and flood plain deposits. The Tuscan Formation in the northeastern portion of the valley contains fresh water to depths of 1,500 feet in moderately permeable sand aquifers. Also present are beds of tuff breccia (volcanic mudflows) of low permeability which act as confining beds and restrict the upward movement of water from the underlying aquifers. Wells drilled through these beds may encounter water under sufficient pressure to force it to the surface.

South of Oroville, along the east side of the valley, the Mehrten Formation is particularly important, especially in Sacramento County. Permeability of this formation is quite variable due to the presence of permeable sediments and impermeable tuff breccia. The upper part of the formation may have a higher percentage of clay and fine grained sediments than the middle or lower portions, tending to confine ground water in the more permeable underlying sand and creating the pressure conditions found throughout much of the formation. The sand and gravel strata are generally moderately to highly permeable and yield large quantities of good quality water to irrigation and industrial wells.

The Tehama Formation is a source of ground water for irrigation in most areas along the west side of the valley. Although this formation is mostly fine grained, it contains sufficient sand or gravel zones in many areas to provide large quantities of ground water. In certain areas along the west side of the valley, this formation is predominantly clayey, particularly in the area between Willows and Williams. Wells in these areas generally will not yield large quantities of water, and those which penetrate the entire thickness of the formation may yield water of poor quality because some of the basal sands contain connate water derived from underlying marine sediments.

Along the east side of the valley, the Laguna Formation is a wedge shaped deposit that thins toward the foothills and thickens to more than 9,800 feet along the valley axis. Fine grained materials seem to predominate in the Laguna, with lenticular sands and gravels occurring sporadically. Gravels are more common toward the east but they may be clayey or cemented. This formation is tapped by domestic, irrigation, and industrial wells throughout much of the east valley area. Most wells in this area do not draw all their water from the Laguna Formation, but are perforated or gravel packed so that they may also receive part of their yield from underlying and overlying formations.

The Victor Formation is an assemblage of old alluvial deposits which include lenticular bodies of silt, sand, and gravel. The formation occupies the low alluvial plain on the east side of the valley. Together with the underlying Laguna Formation, the Victor constitutes the most important source of ground water on the east side of the valley south from the vicinity of Gridley.

The fanglomerate unit (not given a formation name) is an assemblage of partially cemented layers of sand and gravel with thick layers of clay and silt. The sediments were derived from large areas of Tuscan rock in the Cascades and now overlie the Tuscan Formation in the northeast margin of the valley. This unit is similar to the Tuscan Formation from which it was derived except that it does not contain tuff breccia. It supplies moderate quantities of water to moderately deep wells on the east side of the valley north of Chico.

Along the east margin, near Oroville and in small isolated areas south to Sacramento County and west of Red Bluff, Corning, and Orland, are gravelly deposits belonging to the Red Bluff Formation. In Sacramento County, similar deposits are known as the Arroyo Seco and South Fork gravels. These are all surficial deposits that occur mostly above the zone of saturation and have little importance as sources of ground water. Collectively they are known as the Pleistocene gravels.

Alluvial fans, stream channel deposits, flood plain, and flood basin deposits are the most recently deposited materials and represent important water sources. Alluvial fans occur mostly on the west side adjacent to the Coast Range, around the Sutter Buttes, and at Chico. They are relatively thin, but most contain highly permeable materials. Stream channel and flood plain deposits consist of well sorted sand, gravel, and silt adjacent to the major streams. The deposits are up to 8 miles wide and 200 feet thick in the north valley area. Flood basin deposits are the finest grained materials, consisting mostly of clay and silt. Five major flood basins occupy large areas adjacent to the Sacramento River. Their deposits are thin and poorly permeable and therefore unimportant for ground water development, but the older alluvium underlying the basin sediments often contain highly productive aquifers, particularly in the north valley.

Seven major structural features influence the occurrence and movement of ground water in the Sacramento Valley:

1) The Chico monocline, extending from the vicinity of Red Bluff southeast to Chico, tends to facilitate ground water inflow to the valley from areas outside the basin;

2) The Red Bluff arch, forming the northern boundary of the basin is a series of paralleling faults and gentle folds which tend to restrict movement of water between the Redding ground water basin and the Sacramento Valley ground water basin;

3) The Corning anticline impedes the eastward movement of ground water between Red Bluff and Corning;

4) The Sutter Buttes, northwest of Yuba City, are the surface expression of coalescing domes that were thrust from below, tilting, faulting, folding, and exposing at the surface the intruded Cretaceous to Pliocene sediments. The Buttes divert ground water around their flanks. Marine sediments surrounding them have been flushed of their saline water by meteoric water to great depths. This flushing action may be related to the shallow connate water found in the Sutter Basin to the south;

5) The Dunnigan anticline, which has folded the Tehama and Red Bluff Formations, diverts ground water southeast into Hungry Hollow;

6) The Plainfield Ridge, possibly a southern continuation of the Dunnigan anticline, impedes the flow of

ground water toward the east, causing it to flow through notches in the anticline and southeast toward Putah Creek; and

7) The Willows Arch, located just west of Artois and extending northward toward Orland, is probably the northern extension of an anticlinal structure which occurs in the Beehive Bend gas field to the southeast. It appears to be a partial barrier to southwesterly movement of ground water from Stony Creek.

Geohydrology. Ground water occurs in both confined and unconfined conditions through most of the Sacramento Valley Basin. Generally unconfined in the relatively shallow alluvial fan, flood plain, and stream channel deposits, ground water appears partially confined in and under the flood basin deposits. In the older Pleistocene and Pliocene formations, especially at deeper levels, water is confined beneath impervious thick clay and mudflow strata.

In the low lying central portion of the basin, from the Delta north to Glenn and Butte counties, depth to water in wells is 10 feet or less. Depth to water increases to 80 to 100 feet and more toward the basin margins.

Elevation contours of the upper surface of the ground water body in the north valley indicate that the general direction of movement is toward the Sacramento River. In the valley floor south of Sutter Buttes, the upper surface of the zone of saturation is virtually flat, so there is no marked movement toward the river under present conditions. Under natural conditions ground water moved from the margins of the valley to its floor with a nearly flat gradient, sloping toward the lower Sacramento River or the Delta, but intensive development of ground water since 1914 created three pumping depressions along the east side from Marysville to Sacramento County and one on the west side in Solano County. By 1971, these depressions were modified in size and depth, increasing or decreasing according to changes in withdrawal rates. In 1971, they were located in Sacramento County south of the State capitol, in southwestern Placer County, in Yuba County at Marysville, and in Solano County south of Davis. Ground water moves toward these areas of heavy pumping rather than toward the central part of the valley or the Delta as it did in the early 1900s.

Ground water levels fluctuate according to supply and demand on daily, seasonal, annual, and even longer bases. Short term and long term water level changes have been recorded for wells since the first documented measurements in 1929. In the north valley, there have been no consistent downward trends but at the southern representative wells show long term declines in nearly all counties since early measurements were made.

Well yields and specific capacities of wells generally increase toward the center of the valley. Areas of high yield and capacity correspond to areas of coarse grained alluvial fans and floodplain deposits. Along the margins of the valley, where older more compact formations occur, yields and capacities are low. The greatest incidence of wells with high specific capacity and potentially high yields occur in the north central portion of the valley, where there is a concentration of coarse materials deposited by the Sacramento River and its main tributaries.

Transmissivity values range from 4,300 to 64,500 square feet per day. The area of highest values extends north of Sutter Buttes along the Sacramento River and west into the Stony Creek alluvial fan area. They are slightly lower toward the east basin boundary. Except for small areas along the Sacramento River, the lowest values are found in the south Sacramento Valley.

Storage coefficient was found to vary from 0.04 to 0.12, when averaged over specific areas. In an unconfined system, these values are related to specific yields of 4 to 12 percent. Areas of highest specific yield (8 to 12 percent) occur where streams have deposited coarse alluvial materials on flood plains and alluvial fans. Examples are found along the Feather River near Oroville, at Cache and Putah Creeks near the edge of the valley, the lower portion of the Stony Creek alluvial fan, Yuba River, American River, and Sacramento River between Stony Creek and Sutter Buttes. Gravels carried downstream along the Sacramento River from Stony and Chico creeks have resulted in high specific yields in the flood plain north of Sutter Buttes. Most other areas in the valley have specific yields in the 4 to 8 percent range.

Replenishing ground water occurs through deep percolation of streamflow, precipitation, and applied irrigation water. Stream percolation and deep percolation of rainfall combine to provide a greater amount of recharge than does applied irrigation water. Recharge by subsurface inflow is considered negligible compared to other sources. Approximately two–thirds of the basin's total recharge under natural conditions occurs north of the Sutter Buttes, with the remainder in the south valley.

Average annual recharge from deep percolation of applied irrigation water was estimated for the period of 1961 through 1970 at nearly 600,000 acre–feet, and from streams and precipitation at nearly 1.2 million acre–feet, for a total of nearly 1.8 million acre–feet annually. During this 10 year period, accumulated water in storage increased about 320,000 acre–feet, or an average of about 32,000 acre–feet annually, indicating a greater amount of recharge than discharge. Most of this increase occurred in the north valley.

Discharge exceeded recharge in three areas over the 10 year period from 1961 to 1970. These areas were Sacramento County, a portion of Yolo County, and a portion of Glenn County near the west basin boundary. In three other areas recharge about equalled discharge, and in the remaining areas, recharge exceeded discharge.

Average annual ground water pumpage, the principal method of discharge, was about 1.8 million acre–feet for the years 1961 and 1970. Approximately two–thirds of this pumpage was in the south valley, with the remaining one–third in the north valley.

Butte Basin. The Butte Basin comprises the low, poorly drained lands south of Durham and between the Thermalito Afterbay and Feather River on the east side, to the Sutter Buttes on the south and the Sacramento River on the west. The area is about 15 miles in an east–west direction by 20 miles north to south and encompasses about 170,000 acres. Elevations vary from 120 feet at the north to 60 feet at the south, giving a low gradient to streams flowing through the area. Drainage from this almost featureless plain is provided by Butte Creek and Cherokee Canal to the west of the Sutter Buttes and by Morrison Creek to the east. With the nearly flat land, high water table, and abundant supply of water, the area is ideal for the growing of rice.

Ground water occurs at depths of 10 feet or less throughout most of the Butte Basin area. Ground water occurs under unconfined to partially confined conditions in the shallow zones. At depths of more than 200 feet, confined conditions are prevalent. However, there are extensive clay layers at shallow depths which would also cause confined conditions. Shallow ground water in the flood basins can be considered as being confined, but the hydrostatic head is so low that water in the shallow zone can be considered to be unconfined. Nearly 4 million acre–feet of ground water are stored from a depth of 20 feet to 500 feet.

Ground water moves in a southwest direction toward the Sacramento River on a low gradient of about 3 feet per mile.. The Sacramento River, therefore, acts as a drain and does not recharge the basin unless pumping near the river lowers water levels and establishes a gradient from the river to the pumping depression.

Ground water is recharged primarily by subsurface inflow from the northeast under present water level conditions. No water is contributed from the Feather River except farther south in the Marysville area. However, ground water may discharge to the Feather River under normal conditions. Recharge by subsurface inflow has been calculated as 6,000 acre–feet per year. Additional recharge from applied water and precipitation is estimated at 13,000 acre–feet. Total recharge, therefore, is about 19,000 acre–feet per year. Ground water discharge from the area should be of the same magnitude since annual change in storage is small.

Colusa Basin. The Colusa Basin is a shallow trough lower in elevation than the Sacramento River that borders it on the east. In its natural state, the basin was subjected to overflow from the Sacramento River whenever the capacity of the river channel was exceeded during winter storms and spring snowmelt. Annual flooding was common. Precipitation within the area, as well as runoff from the western foothills, added to the flooding. Many of the flood control works protecting the basin from floods have been constructed as part of the extensive Sacramento River Flood Control Project.

There is an estimated 5 million acre–feet of ground water stored in the top 200 feet of sedimentary deposits of the Sacramento Valley beneath the Colusa Basin watershed (DWR, 1990b). Ground water also occurs in more limited amounts in the foothill regions in the sedimentary "hard rocks." There was an estimated 200,000 acre–feet of ground water extracted from this area in 1989.

Ground water flows in a southeasterly direction north of Maxwell and in an easterly direction south of Maxwell. The flow is toward the Sacramento River except during high river stages (flood flows) when the ground water flow direction is locally away from the river (a phenomenon called seepage).

Many areas in the basin experienced gradual declines in ground water levels prior to the importation of surface water, with some areas exhibiting spring to fall ground water level fluctuations of from 15 to 20 feet. Ground water in these areas has since risen because pumpage was reduced and recharge increased from applied surface water obtained from the Glenn–Colusa Irrigation District and Tehama–Colusa Canal. Presently, ground water level fluctuations have been reduced to less than 10 feet as a result of reduced pumpage. In other areas, wells show almost no seasonal fluctuation and the ground water table is near the surface due to little use of the ground water. Deep percolation from surface water irrigation keeps the ground water basin full.

Most of the Colusa Basin has less than 5 feet of change in ground water level from spring to fall. This lack of ground water storage space increases surface runoff because the ground water basin quickly fills and rejects any rain, which then must run off.

Southern Sacramento Valley Ground Water Basin. The southern portion of the Sacramento Valley ground water basin occupies the area generally south of the Sutter Buttes and north of the Sacramento–San Joaquin Delta. This area includes the Yolo Bypass, Feather River, Yuba River, and American River areas.

The base of the useable ground water basin is near the base of the continental rocks and occurs at a depth of 1000 to 3000 feet. The rocks below this depth contain saline water and are not suitable as a source of agricultural or domestic water supplies. Ground water is present throughout this area although its use may be limited by localized areas of poor quality and by poor productive capability. Ground water levels are relatively near the surface in much of the basin although some regional pumping depressions are present. Overall, about 57 million acre–feet of ground water is in storage to a depth of 600 feet. Extensive ground water development has occurred to support irrigated agriculture and ground water provides the principal source of municipal water in much of the area.

Ground water in the basin occurs under conditions that range from confined, particularly in the flood basins that have thick sequences of clayey sediments near the surface, to nearly completely unconfined in parts of Yuba and Placer Counties. In general, the aquifer system can be thought of as being semi–confined and exhibiting greater degrees of confinement with depth. This means that for short term stresses, like seasonal or water bank pumping, water levels will initially respond as though confined and may decline rapidly but will change to a slower unconfined response as water begins to drain down from shallower levels. This can be seen in the significantly different water level measurements taken from production wells as opposed to monitoring wells that measure water levels in specific horizons.

While ground water is present throughout the basin, its development is uneven. This is partly a response to the availability of surface supplies and partly to conditions within the ground water basin. Ground water development has been limited in areas near the Sacramento and Feather rivers which have provided an inexpensive and readily available water supply to these areas. In addition, ground water conditions west of the Sacramento River tend to be of lesser than desired quality and wells often have limited production capability. The portions of the basin in much of Yuba, part of Sutter, and western Yolo counties have historically relied heavily on ground water for irrigation and have experienced declining ground water levels. These declines have largely been eliminated and water levels have risen as a result of the importation of new surface water supplies into these areas. In very dry years, these areas can revert to substantial reliance on ground water. Other areas, like central Yolo County continue to rely on ground water as the soul source of irrigation supply and most of the urban areas rely completely on ground water.

In the north part of this area, ground water flows to the south and away from the valley walls. The Sacramento River is a gaining stream north of Colusa and is a major ground water discharge zone. South of Colusa, the Sacramento River becomes a losing stream, contributing water to the adjacent sediments. In the east–central part of the valley from Oroville to Marysville, the Feather and Yuba Rivers recharge the ground water near the valley margin. Once on the valley floor, the Feather River becomes a gaining stream east of Sutter Buttes, but below Marysville it begins to lose water to pumping depressions to the east and west. A large pumping depression in the southeast draws water from the American and Sacramento rivers in the vicinity of Sacramento. Depressions in the water level caused by pumping also appear between Marysville and Wheatland and in the Pleasant Grove area.

An additional potential limit on ground water development in the basin is the potential for inducing land subsidence when ground water levels decline. The only area with documented land subsidence in the valley is the Yolo–Zamora area extending southward to Davis in Yolo County. However, the potential for land subsidence is present elsewhere in the valley. In areas where conditions susceptible to subsidence occur (confined aquifers and thick fine grained deposits) additional development will require careful evaluation.

Surface Water Quality. The Sacramento River between Red Bluff and the Delta is generally good quality. Although the river appears suitable for beneficial uses, periodic degradation occurs from the discharge of toxins, untreated sewage, and other nonpoint source contaminants. In the lower Sacramento River, water quality is affected by intrusion of saline sea water, which is of increasing concern as consumptive uses of freshwater continue to increase statewide.

The upper reaches of major tributaries, including the Feather, Yuba, and American rivers, all have excellent water quality characteristics. Downstream from storage reservoirs, however, some degradation occurs due to various discharges. Downstream water temperature is a concern on the Yuba and American rivers.

Agricultural drainage is the major source of waste water, and contributes to lower water quality during low flow periods in the Sacramento River and lower reaches of the major tributaries. Rice field herbicides cause the most significant degradation, but recent efforts by the State Department of Food and Agriculture and Central Valley Regional Water Quality Control Board are reducing levels of these contaminants.

Water quality concerns in tributaries include low dissolved oxygen levels in Butte Slough, Sutter Bypass, and Colusa Basin Drain; high water temperatures below diversion structures on Butte Creek; concentrations of minor elements (chromium, copper, iron, lead, manganese, selenium, and zinc) that exceed beneficial use criteria in the Sutter Bypass; and pesticide residues in the Sutter and Yolo bypasses and Colusa Basin Drain; Additional concern exists for effects of tributary discharges to the Sacramento River, including elevated temperature, dissolved solids, minor elements, pesticides, and turbidity, especially from the Sutter and Yolo bypasses and Colusa Basin Drain.

Ground Water Quality. Quality of ground water is generally excellent throughout the Sacramento Valley and is suitable for most uses. Concentration of total dissolved solids (TDS) is normally less than 300 mg/L, although water in some areas may contain solids to 500 mg/L. Ground water beneath the eastern basin is commonly a magnesium–calcium or calcium–magnesium bicarbonate water. In portions of the area, calcium, magnesium, and sodium are present in equal amounts as the dominant cations, while bicarbonate is nearly always the dominant anion. High concentrations of sodium chloride waters are found at Robbins, Clarksburg, and several areas near the edge of the basin where Cretaceous–age rocks are nearby. There are also some areas where iron, manganese, and boron are present in undesirable amounts, but the water generally remains suitable for most purposes.

In terms of mineral content, ground water in the west half of the valley is significantly poorer than that in the east half. This is a reflection of the rock types in the Coast Range, which contain more soluble minerals and saline connate waters than do the igneous and metamorphic rocks in the Cascade Range and Sierra Nevada. Calcium–magnesium and magnesium–calcium bicarbonate types are common here as well, but there are areas near Maxwell, Williams, and Arbuckle where high concentrations of sodium, chloride, and sulfate waters occur with TDS concentrations of 500 mg/L or more. Some of these waters are unsuitable for irrigation and drinking.

At a considerable depth beneath the valley, nearly all ground water contains sodium chloride. Depth to the base of fresh water is about 1,100 feet beneath most of the north valley and commonly over 1,500 feet in the south valley. Two exceptions are in the Robbins area south of Sutter Buttes, and the Colusa area where saline water occurs at shallow depths. Depth of saline water may be similarly shallow at the valley margins on both sides.

Butte Basin – Ground water quality is generally good for domestic and agricultural purposes along the eastern Sacramento Valley comprising the Butte Basin. Most of the ground water recharge for this area comes from surface infiltration through volcanic and metamorphic rock in the Sierra Nevada and Cascade mountain ranges. Ground water generally moves from the northeast to the southwest, but may be more westerly in the shallower zones.

Most ground waters in both the Butte and contiguous Sutter basins are magnesium and calcium bicarbonate in type. Some areas in the Sutter Basin are sodium bicarbonate in nature and often have elevated concentrations of sodium, chloride, sulfate, and total dissolved solids. Ground water use in these areas could be limited in the future for irrigation of sensitive crops.

Many wells in both the Butte and Sutter basins have shown an increase in electrical conductivity over their periods of record. The conductivity of Butte Basin wells have not deteriorated to the point of posing a hazard to beneficial uses. Some Sutter Basin wells are at or nearing levels that could present problems for irrigation of sensitive crops. If the use of ground water for irrigation increases, there may be a potential for increasing salt loading to soils, ground water, and surface water, since ground water supplies are usually higher in mineral concentrations than are surface water supplies.

Nitrogen and phosphorus levels are usually higher in ground water than surface water in the Butte and Sutter basins. Since the bulk of ground water use is for irrigation of crops, these higher nutrient concentrations are probably more of a benefit than a detriment. Nitrate concentrations have at times exceeded drinking water standards to protect infants from the temporary blood disorder, methemoglobinemia. Nitrate contamination does not appear to be a widespread problem and is usually associated with shallow domestic wells.

There are generally negligible amounts of toxic trace elements in ground water from the Butte and Sutter basins. Iron and manganese do exceed secondary drinking water standards in some wells. Exceeding secondary standards does not present a health hazard but means the consumer may experience objectionable tastes, odors, staining of plumbing fixtures, or accumulation of deposits in pipes. Arsenic, chromium, barium, copper, selenium, and zinc have all been detected in ground water from the basins, but not at levels detrimental to beneficial uses.

Pesticides in ground water have received a great deal of attention in recent years. Contamination of ground water with organic pesticides is not a widespread problem in the Butte Basin. Atrazine, bentazon, 2,4–D, dichloroprop, and DDE have all been detected. Bentazon is the only compound that showed relatively widespread contamination. Its use as a rice herbicide was discontinued in 1989 because management practices could not be developed to prevent its movement into ground water.

Widespread contamination of ground water in Sutter County was limited to bentazon and dibromochloropropane (DBCP). DBCP use was suspended in 1977 due to widespread detection in California ground water. Bromacil and 1,2–D have also been detected in Sutter County ground water. The use of 1,2–D as an active ingredient has not been allowed since 1984, and bromacil use is restricted in certain areas that were found to be sensitive to ground water contamination.

Colusa Basin – Ground water quality is generally good for domestic and agricultural purposes in the Colusa Basin. North of Colusa the ground waters are calcium bicarbonate in type. The ground water around the Colusa area is sodium–calcium bicarbonate in nature with the ground water turning to sodium bicarbonate in type below Colusa. Some areas south of Colusa often have elevated concentrations of boron, chloride, and sodium. Ground water use in these areas could be limited in the future for irrigation of sensitive crops.

Many wells in the Colusa Basin have shown an increase in electrical conductivity over their periods of record. The conductivity of a few wells pose a hazard to beneficial uses. Some Colusa Basin wells are at or near levels that could present problems for irrigation of sensitive crops. The use of ground water for irrigation may be increasing the salt loading to soils, ground water, and surface water, since ground water supplies are higher in mineral concentrations than are surface water supplies in the Colusa Basin. The pumping depressions increase the electrical conductivity due to the decrease of water moving out of the basin which would flush salts out of the soils.

Nitrogen and phosphorus levels are usually higher in ground waters than surface waters in the Colusa Basin. A few of the domestic wells contain levels of nitrate exceeding the recommended drinking water standards. Nitrate appears to be a point source contamination in a few wells and does not appear to be a widespread problem.

Trace elements are found in Colusa Basin ground water at levels below recommended limits for drinking and agricultural use. Manganese has been detected at levels above the drinking water standards in one well but does not present a health hazard.

Pesticide sampling in ground water has revealed a widespread problem in the Colusa Basin. Pesticides have been found in several wells throughout the basin at levels above water quality standards. Dacthal, dalapon, dithiocarbamates, dichloromethane, bentazon, ethylene dibromide, and dibromochloropropane have been detected in the Colusa Basin. Dithiocarbamates is a group of fungicides used on fruits and vegetables. Bentazon, dacthal, dalapon, and dichlorprop are herbicides with most reported use from treating landscape and rights of way. The soil fumigants DBCP and ethylene dibromide were reported from a few wells in Colusa Basin but did not show widespread contamination.

Southern Sacramento Valley Ground Water Basin – The overall quality of ground water in the lower Sacramento Valley Basin is considered good for irrigation and domestic uses. Ground water is predominantly calcium–magnesium bicarbonate in type, but in the area from Gridley to north of Marysville changes to a magnesium–calcium bicarbonate characteristic. The sodium ion increases in areas north of Sacramento to produce sodium bicarbonate characteristics. South of Sacramento, the water is magnesium–bicarbonate with high sodium and chloride levels, which causes fluctuations of water types in localized areas to magnesium–sodium bicarbonate, sodium chloride, or sodium–magnesium chloride.

Electrical conductivity measurements tend to increase from north to south in the basin, and indicate water that is excellent to good for all beneficial uses. Hardness is attributable principally to calcium and magnesium ions. Hardness values range from moderately hard to very hard water (80 to 334 mg/L) in the Feather River basin, moderately hard to very hard (80 to 600 mg/L) in the Yuba River basin, and soft to very hard (23 to 200 mg/L) in the American River basin.

Nitrate levels are higher in ground water than surface water with most wells at concentrations below the recommended drinking level. Water samples from scattered wells contained concentrations as high as 60 mg/L. For most agricultural purposes, nitrate in irrigation water is considered an asset because of its fertilizing value. No limits for nitrate in irrigation water have been established. Nitrate contamination does not appear to be a widespread problem since most wells are well below drinking water quality limits.

Small amounts of trace elements in the ground water have been detected. Iron and manganese have exceeded recommended drinking water limits in some wells. Iron and manganese are both essential mineral elements for human beings, and are considered relatively non–toxic to man and not a public health hazard because, before toxic concentrations are reached in water, the taste becomes quite unpleasant. Iron and manganese tend to precipitate as hydroxides, stain laundry and porcelain fixtures, accumulate as deposits in pipes, and have objectionable odors. Chromium, barium, copper, selenium, and zinc have been detected in ground water from the basin at levels not detrimental to beneficial uses. Elevated levels of arsenic have been detected in localized ground water areas, such as in the area surrounding Robbins, and are largely thought to be the result of past agricultural practices. However, elevated concentrations of arsenic near the Sutter Buttes are likely from previous volcanic activity in this area.

There is a potential for water quality problems in the Yolo Bypass area and the southern part of the Feather River basin, particularly in the area west of the Feather River, south of Yuba City, and extending southward into the Sutter Basin where concentrations of chloride and sulfate are higher than in any other part of the area. Some wells exceed the limit for chloride and sulfate in drinking water. These higher concentrations could limit future agricultural activities for chloride and sulfate sensitive crops.

Results from water samples indicate that a boron hazard generally does not exist in the ground water. Two wells in the northeastern area of the basin were found with boron concentrations of 5.3 and 6.5 mg/L. These two wells are in the foothill area of the eastern Sacramento Valley and tap aquifers that contain water of high dissolved solids concentration. These wells do not represent all wells tapping foothill ground water sources and are probably small isolated aquifers. Near the Sutter Buttes, recent monitoring has found boron concentrations ranging to 4.2 mg/L. High boron levels occur in much of eastern Yolo County.

South of Oroville, ground water contamination has been detected at Koppers and Louisiana Pacific lumber companies. Polynuclear aromatic hydrocarbon compounds (naphthalene, phenanthrene, benzo(a)anthiaene, and fluorene), fluoranthene, pyrene, chrysene, and benzo(a)pyrene have been detected. Cleanup of soils is in progress, with ground water monitoring continuing.

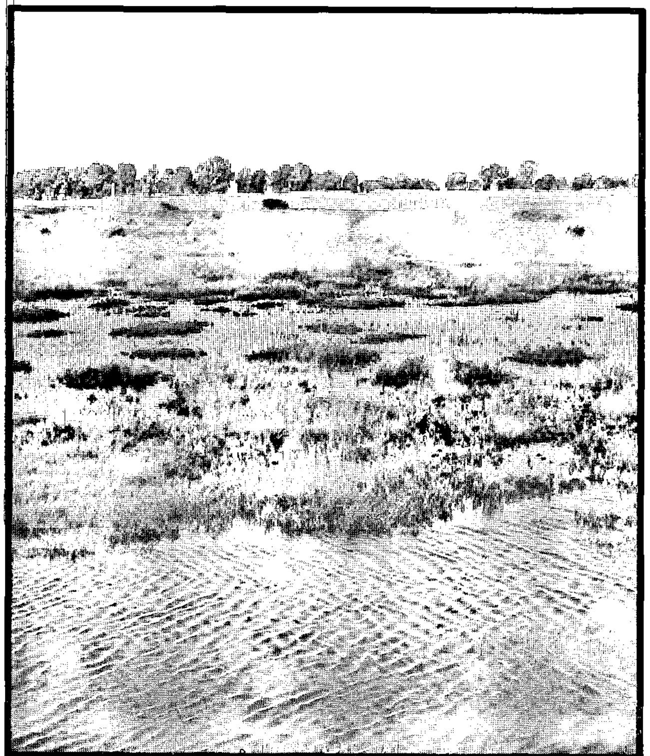
Contamination of ground water with organic pesticides is not known to be a widespread problem in the area. In 1979, four wells supplying McClellan Air Force Base and one well supplying the City of Sacramento were found to be contaminated with TCE. All five wells exceeded the action level for TCE and were taken out of service. Further studies have determined ground water contamination at a few localized spots. The Sacramento Army Depot has ground water contaminated with diazinon, dursban, and lindane. Water analyses of wells at McClellan and Mather Air Force bases have detected aldrin, alpha–BHC, beta–BHC, delta–BHC, lindane, 4,4–DDD, 4,4,DDE, 4,4,DDT, dieldrin, alpha–endosulfan, endosulfan sulfate, heptachlor, heptachlor epoxide, 2,4–D, 2,4,5–T, and 2,4,5,TP. Ground water cleanup is underway at these sites.

Bentazon has been found throughout the Feather River Basin in Butte, Yuba, Placer, and Sutter counties and isolated wells in the Yuba and American River basins.

The area west of the Yolo Bypass has four locations with ground water contamination. Ethylene dibromide was detected at a fertilizer company in Davis and in one municipal well which also contained 1,2–dichloroethane (1,2–D). The DOW Elanco Davis Agricultural Research well had picloram, dinoseb, and 1,2–D. Chlorpyrifos, dicamba, atrazine, and aldrin were detected in the ground water at the University of California at Davis. All sites are involved in cleanup and continued ground water monitoring.

Vegetation. The Sacramento River between Red Bluff and Colusa contains most of the river's remaining natural riparian vegetation, with only a small fraction of the original acreage of woody riparian vegetation still intact and relatively undisturbed in the reach of the Sacramento River between Colusa and the Delta (JSA, 1987). Riparian trees and shrubs occur along the Sacramento River in widths ranging from a few yards where the levee is the riverbank, to a flood plain riparian forest several hundred yards wide (USCE, 1985). The riparian community is a combination of multilayered and single layer vegetation. The overstory is dominated by cottonwood, box elder, California sycamore, valley oak, and black walnut. The midstory is composed primarily of elderberry, Oregon ash, black locust, various willow species, and smaller individuals of the overstory. The understory contains the largest number of species, dominated by blackberry, poison oak, wild grape, wild rose, and numerous grass, forb, and shrub species

The primary wetland types along this portion of the Sacramento River are defined in USFWS' National Wetlands Inventory as: 1) palustrine forested, scrub–shrub, or emergent wetlands, which are freshwater wetlands dominated by trees, shrubs and emergent vegetation, and 2) riverine wetlands, which are freshwater wetlands contained within a channel. These wetlands types are in decline according to USFWS's National Wetlands Priority Conservation Plan. USFWS is committed to protecting these wetlands according to the emergency Wetlands Resources Act of 1986..



Historically, freshwater marshes were widespread throughout the Delta and backwaters of the upper Sacramento River. Many wetlands and their inhabitants have disappeared. Water transfers can provide additional supplies to managed wetland areas during drought conditions.

Special Status Plant Species – Four special status plant species may occur within habitats along this portion of the Sacramento River. These include the Suisun Marsh aster, California hibiscus, Mason's lilaeopsis, and Delta tule pea.

The Suisun Marsh aster is known from 14 sites in the Sacramento–San Joaquin River Delta in the region from Suisun Marsh east to Jersey Island on the San Joaquin River, and southeast to the Discovery Bay area. No populations are reported upstream of River Mile 6 along the Sacramento River. Based upon its restriction to tidally influenced estuarine and freshwater marsh habitat in the Delta, the Suisun Marsh aster is not expected to occur upstream of Walnut Grove (River Mile 27) along the Sacramento River or upstream of Howard Landing on Steamboat Slough. Tidal fluctuation upstream of these sites is minimal and the emergent marsh vegetation associated with tidally influenced areas in the Delta is absent.

DFG's Natural Diversity Data Base (NDDB) records 69 California hibiscus sitings from Butte to San Joaquin counties. Populations are not known to occur in river channels with strong currents, intense flood forces, or steep banks. Typically, the California hibiscus occurs along quiet backwaters with emergent marsh vegetation, such as along sloughs, oxbows, irrigation canals, and related wetlands. This plant is known to occur in nearby wetlands in Butte, Glenn, and Colusa counties. In 1891, a population was recorded in the lower river and slough reaches near Rio Vista, but a search in 1974 failed to relocate the population. The urban, agricultural, and flood control projects in this area probably eliminated the population.

Currently, 32 populations of Mason's lilaeopsis are recorded by the NDDB. Most of these are located south and west of the area at the Delta mouth and along the lower San Joaquin River and tributaries. Five populations are known from the lower Sacramento River, between Horseshoe Bend (River Mile 7) and Grand Island (River Mile 15). It is highly probable that other populations occur in this vicinity because of the abundance of unsearched, suitable habitat. Mason's lilaeopsis requires tidally inundated habitats with emergent marsh vegetation and a specific type of rooting substrate. These habitat requirements and the species present range indicate that it does not occur north of Walnut Grove (River Mile 27) on the Sacramento River or Howard Landing on Steamboat Slough.

The Delta tule pea is reported from 16 locations within a wide geographic area from the Sacramento–San Joaquin Delta south and southeast to the San Joaquin Valley and southern Sierra Nevada. Originally, the species was believed to be restricted to the Delta, but several populations from inland areas have recently been identified. Most of the known local populations are in the region from the Delta mouth, east to near Stockton. Two populations on Grand Island (Sacramento River Mile 7.8 and 8.0) have been noted. Based upon the Delta tule pea's reported distribution along the Sacramento River, it would not have been expected to occur north of Walnut Grove. However, the wide distribution of this species in the San Joaquin Valley, its rather general habitat requirements, and the discovery of a new site near Butte City indicate that this species could potentially occur throughout the area.

Wildlife and Fish. Populations of most species dependent on riparian, oak woodland, marsh, and grassland habitats have declined with the conversion of these habitats to agriculture and urban areas. Populations of some Sacramento Valley species have declined so greatly that they have been listed as threatened or endangered, or are under study for future listing. In many cases, most of the remaining habitat for these species in the Sacramento Valley occurs along the Sacramento River.

DFG's Wildlife Habitat Relationship Program indicate a total of 249 species of wildlife using the valley foothill/riparian habitat of the Sacramento Valley (USFWS 1989). Included in this total are 151 species of birds, 65 species of mammals, and 33 reptile and amphibian species. Riparian zones also provide food and cover to other wildlife species more typical of adjacent upland areas and provide migratory corridors for many others.

Many bird species are common year-round or seasonal residents of the Sacramento Valley, while others are migrants or only occasional visitors (USCE, 1985). Wetland areas of the basin are important as prime waterfowl wintering areas in the Pacific Flyway, and the wintering waterfowl population often exceeds three million birds. Waterfowl in the valley include the mallard, pintail, widgeon, whistling swan, Canada goose, snow goose, and other less common species. Shorebird species such as the great blue heron, great egret, and spotted sandpiper utilize riverbanks, sandbars, riparian vegetation, and emergent or submerged aquatic vegetation and forage on small mollusks, fish, and crustaceans. Passerine (songbirds) are found in great numbers in the riparian vegetative cover along the Sacramento River and tributaries because of the excellent food and habitat value. The American goldfinch, song sparrow, rufous sided towhee, and American robin use the tree, shrub, and herbaceous plant species of the riparian habitat, while others such as the western meadowlark, loggerhead shrike, and common crow are found in the grassland and agricultural areas. Raptor species such as hawks and owls nest within the larger trees of the riparian and grassland habitat and feed on small animals that also inhabit the area. The most commonly observed raptors are the red-tailed hawk, marsh hawk, American kestrel, and burrowing owl. Game birds found in the area include the ring-necked pheasant, mourning dove, and quail.

Typical mammals of the Sacramento River basin riparian habitats include the mule deer (blacktailed subspecies), opossum, ringtail, raccoon, red fox, striped skunk, river otter, beaver, muskrat, western gray squirrel, ground squirrel, cottontail, and many small rodents (USFWS 1989). DFG conducted a field study of furbearers inhabiting the riparian vegetation of the Sacramento River and recorded 14 species. Thirteen species were found in climax, high terrace vegetation which included dense stands of large sycamore, black walnut, cottonwood, and oak trees. The study concluded that much of the Sacramento River riparian vegetation provides high quality habitat for furbearers.

Reptile and amphibian species are associated with both grasslands and riparian vegetation (WCC 1986). The western lizard, common king snake, and gopher snake inhabit grasslands, while amphibians such as the common bullfrog, Pacific treefrog, western toad, and other less common species are found in riparian habitat.

The Sacramento River and tributaries between Keswick Dam and the Delta provide important habitats for a diverse assemblage of fish, both anadromous and resident species. Anadromous fish include chinook salmon (four races), steelhead trout, striped bass, American shad, green and white sturgeon, and Pacific lamprey. Resident fish can be separated into warmwater game fish (such as largemouth bass, white crappie, black crappie, channel catfish, white catfish, brown bullhead, yellow bullhead, bluegill, and green sunfish), coldwater game fish (such as rainbow and brown trout), and non-game fish (such as Sacramento squawfish, Sacramento sucker, and golden shiner). Native non-game fish such as the Sacramento perch (California's only native sunfish) and the viviparous tule perch still persist in the Sacramento River. Remnant populations of the Sacramento perch occur in the Sacramento River system. Although the species is thought to be threatened with extinction in the Sacramento River, it is presently listed as status undetermined pending collection of additional information. Baseline resource information on this species is lacking.

The river upstream from Colusa produces about half of the Central Valley chinook salmon population. About one third of the river's naturally spawning salmon (mainly the fall run) spawn directly in the reach from

Colusa to Red Bluff (mainly above Chico Landing), and all the salmon use the river for rearing and migration. Most salmon spawning occurs where bank erosion and meandering processes are active and gravel is available.

Approximately two–thirds of the striped bass population in the State spawn in the Sacramento River system, while the remainder spawn in the lower San Joaquin River. Juvenile and adult striped bass abundance has declined over the last 15 to 20 years, and intensive studies have been conducted to determine the causes. DFG recently testified before the SWRCB that the striped bass decline has been due to cumulative impacts, changes in outflow, and losses of larval and juvenile striped bass at the CVP and SWP export facilities. Other possible contributors to the decline may be toxicants (specifically agricultural pesticides) and decreased food availability for juvenile striped bass.

Spawning in the Sacramento–San Joaquin Delta usually occurs during April and May. Further up the Sacramento River, spawning occurs from about mid–May though mid–June. The difference in timing is due to temperatures rising more slowly in the Sacramento River than the lower San Joaquin River. Eggs drift with river currents and are carried downstream. Larvae hatch two to three days after spawning. Initially, the larvae receive nourishment from the yolk sac, which is absorbed in five to ten days. As they move downstream toward the Delta, larvae begin feeding on small zooplankton. Upon reaching the western Delta, which is presently their primary rearing area, larvae are large enough to begin feeding on larger organisms such as the opossum shrimp (*Neomysis*). *Neomysis* remains the main food source until the stripers reach their second year when they become large enough to feed on bay shrimp and small forage fish.

Striped bass in the Sacramento–San Joaquin Delta system spend most of their time in the estuary, with only limited migration north and south of the Golden Gate. They reach maturity at 3 to 4 years of age and may live to 20 to 30 years of age. In recent years, most of the adult striped bass in the Bay–Delta system are in the 4 to 7 year age classes. The older, more fecund fish, are no longer present in great numbers.

Butte Basin – Butte Creek supports a small anadromous fishery that includes steelhead and spring and fall run chinook salmon. The anadromous fish runs in Butte Creek face many problems, including inadequate instream flow to allow both upstream and downstream passage of migrants, many diversion structures with inadequate or nonexistent ladders to allow passage, numerous unscreened diversions that result in the loss of fish due to stranding, high water temperatures that can stress and at times kill fish, high sediment loads, lack of adequate spawning gravels in some reaches, and unknown water quality effects of agricultural return flows.

Butte Basin is best known for its waterfowl, but also provides excellent habitat for mammals, song birds, raptors, shore birds, reptiles, and amphibians. Four community types are present, including riparian, permanently flooded lowlands, intermittently flooded lowlands, and uplands. Uplands are subdivided into grasslands and oak woodland. The upper portion of the basin has been extensively altered in the past for agricultural use and contains very little native vegetation. The lower section of the basin, known as the Butte Sink, still has extensive marshland and riparian habitat. The basin is probably one of the least developed floodplains in the Sacramento Valley and is one of the finest wetland wintering complexes in North America. The Butte Basin lies in the heart of the Pacific Flyway and over 50 percent of the ducks and geese that overwinter in California use the basin. Thirty–seven species of waterfowl, including one swan, seven geese, and 22 duck species, occur in the basin. Pintail, mallard, gadwall, widgeon, and green–winged teal are the most common species. Mallard, gadwall, cinnamon teal, shoveller, ruddy duck, pintail, redhead, and wood duck all nest in the area. Goose species are almost exclusively Snow and Ross's geese, with the lower Butte Basin recognized as an important wintering ground for Ross's geese. Much of the land in the basin is owned by private duck clubs devoted to waterfowl habitat and maintenance of natural wetlands. Additionally, DFG owns and operates Gray Lodge State Wildlife Refuge and the Upper Butte Basin Wildlife Area. USFWS operates the Sutter National Wildlife Refuge within the Sutter Bypass.

Human alterations, mostly in the form of flood control, have reduced the intensity and duration of flooding in the Butte Basin. The maintenance of wetlands requires artificial flooding with the greatest water use between August and December. Water sources include irrigation return flows, Sacramento River flood flows, Butte Creek, Feather River imports, rainfall, and ground water.

Colusa Basin Drainage Area – The basin has valuable wildlife habitat for waterfowl and pheasants that include three National Wildlife Refuges (Sacramento, Colusa, and Delevan), several private gun clubs, and other wetland areas. The basin is an important wintering ground for Pacific flyway waterfowl.

Another important resource in the Colusa Basin is the warmwater fishery. Catfish, bluegill, sunfish, and bass are fished extensively in the drains, channels, and ponds throughout the basin.

Yolo Bypass. Birds, such as Swainson's hawks, red-tailed hawks, northern harriers, great egrets, cinnamon teal, mallards, coots, white pelicans, and greater yellowlegs, are currently the dominant vertebrates (Appendix A–3), largely because they are mobile enough to use the area without being dependent on it. The non–native Eucalyptus stand provides forage for wintering hummingbirds. It also provides low to moderate habitat value for passerine birds, raptors, and small mammals. Mammal numbers are low, while reptiles and amphibians are generally confined to the ditches, drains, and remnant riparian areas. The frequency of flood inundation adversely affects these less mobile resident species. Agricultural land in the area provides low to moderate habitat value to wildlife species, including small mammals, game birds, songbirds, blackbirds, crows, gulls, and raptorial birds.

The seasonal wetlands and, at certain times, the unflooded agricultural lands, provide important feeding and resting areas for a wide range of migratory and resident birds, including waterfowl, shorebirds, and other water birds. Aerial surveys conducted by DFG show an average of about 320,000 wintering waterfowl have used the Yolo Basin during a recent 10 year period (1978–1987). During drier winters, however, the Yolo Bypass and Basin provide rather limited wetland habitat, and migrating waterfowl must generally bypass this critical area and use the wetlands, mainly State and federal refuges, located to the north and south.

Most of the Yolo Bypass is dry and cultivated during much of the year, and does not provide fisheries habitat. There are, however, irrigation and drainage canals, and borrow ditches which support warmwater fish. Resident species of the Sacramento River may also occupy the bypass during flooding, or from one of the west side tributaries (Cache Creek, Willow Slough, Willow Slough Bypass, and South Fork Putah Creek). Common game fish species caught in the area include largemouth bass, black and white crappie, bluegill, redear and green sunfish, white and channel catfish, and black bullhead. Several non–game fish such as carp, goldfish, inland silverside, mosquitofish, bigscale logperch, and other minnows are also present. Sacramento sucker and Sacramento squawfish may also be found in the bypass. Anadromous fish, such as striped bass, steelhead trout, American shad, Pacific lamprey, and the four races of chinook salmon may be present in the Bypass when it is flooded.

Feather River – Construction of Oroville Dam eliminated spawning areas for salmon and steelhead upstream of the dam. To compensate for this loss, the DWR built the Feather River Fish Hatchery downstream from Oroville Dam on the northern bank of the Feather River. The Feather River Fish Barrier Dam, about a half mile downstream from Thermalito Diversion Dam, diverts migrating salmon and steelhead into the Feather River Fish Hatchery for artificial spawning.

Most of the 40 mile reach of the Feather River below the Fish Barrier Dam is available for natural spawning. Minimum flows are maintained in the 5 mile "low flow section" between the Fish Barrier Dam and the river outlet from Thermalito Afterbay. About 80 percent of the natural spawning occurs within this reach.

The 36–mile reach of the Feather River below the Thermalito Afterbay river outlet, known as the "high flow section", receives a minimum flow of about 1,700 cfs and accommodates about 20 percent of the naturally spawning salmon. The entire 40 mile reach below the Fish Barrier Dam is used for juvenile salmon rearing. Spawning escapement totals about 50,000 chinook salmon, mostly fall run with some spring run, of which from 3,000 to 5,000 enter the hatchery. Other species include American shad, striped bass, steelhead trout, and many resident warmwater and coldwater species (Appendix A–4).

Yuba River – Yuba River instream flows are governed by a 1965 agreement between the Yuba County Water Agency and DFG. Provisions include minimum flows for maintenance of fish at various points of the Yuba River drainage and controls aimed at minimizing fluctuations in streamflows. The status of Yuba River flow requirements is currently being reviewed by SWRCB as part of the Yuba County Water Agency's water rights hearings. These hearings were held at the request of a coalition of angler groups who filed a complaint in 1988 that existing instream flow requirements and screening facilities do not adequately protect fishery resources. DFG has developed the lower Yuba River Fisheries Management Plan which is being reviewed as part of the process. The plan includes recommendations on instream flow, water temperature, and flow fluctuations.

New Bullards Bar Reservoir is considered good potential environment for nesting bald eagles, but there are currently no nesting pairs at the reservoir (DWR, 1988a). As many as eleven bald eagles, however, have been observed at the reservoir during one day, mid–January surveys. One pair of osprey, a federally sensitive species and DFG species of special concern, began nesting at New Bullards Bar in 1986 and 1987.

Surveys conducted in 1976 identified twenty–eight species of resident and anadromous fish in the Yuba River system (Appendix A–5). Anadromous fish of special concern include chinook salmon, steelhead trout, and American shad. New Bullards Bar Reservoir supports both warmwater and coldwater fisheries. Common and abundant coldwater species include rainbow and brown trout, while warmwater species include smallmouth and largemouth bass, crappie, bluegill, catfish, carp, Sacramento squawfish, Sacramento sucker, and threadfin shad. No rare or endangered species are known to occur in the reservoir.

The fall run chinook salmon is the most important and abundant anadromous fish in the lower Yuba River system. Historically, the Yuba River supported up to 15 percent of the fall run of the Sacramento River. In surveys from 1953 to 1989, the total number of adult fish ranged from a low of 1,000 in 1957 to a high of 39,000 in 1982. Fall run chinook salmon typically begin the migration into the Yuba River in late September. Low river flows and high water temperatures may delay migration into the river, resulting in late spawning (Wooster and Wickwire, 1970). Peak spawning occurs in October and November but has been known to last into January. Fry emerge from the gravel between December and March. Some emigrate within a few weeks of emergence while others rear in the river until June (Moyle, 1976).

The original spring run population had disappeared from the Yuba River by 1959. The remnant spring run present today is the result of strays from the Feather River or the infrequent stocking of hatchery reared fish by DFG. Spring run chinook salmon migrate into the Yuba River as early as March and as late as August. Generally, the majority of the run occurs in May and June. The adults spend the summer in deep pools in the Narrows reach of river, where water temperatures seldom exceed 60°F. Spawning can begin in August but the peak is between September and October. Fry emergence begins in November and extends through January. Emigration can occur within a few weeks of emergence or the juveniles can rear in the area until June.

The adult winter run steelhead trout enter the Yuba River to spawn as early as August. Peak arrivals occur between October and February and can extend through March. Spawning takes place from January to April. Incubation and emergence is completed by May or June.

The American shad population has declined in the Yuba River. Sport fishing still occurs between Daguerra Point Dam and the confluence of the Feather River from April through July. American Shad migrate up their natal river drainage to spawn. In the Sacramento River, the distribution of first time spawning shad appear to be related to the magnitude of the tributary flow relative to the mainstem flow. The greater the tributary flow, the greater the attraction for first time spawners. Preliminary investigations show that to maintain historic distributions of first time spawning shad, May through June flow in the Yuba River should not be less than 33 percent of the Feather River flow and the Feather River flow should not be less than 34 percent of the Sacramento River flow (Painter, 1979).

Adult shad arrive at the Yuba River between April and June. Spawning can begin as early as April, but usually does not begin until May and can be completed as late as July. The shad eggs hatch in about 3 to 6 days, and larvae are washed downstream to the Sacramento–San Joaquin Delta nursery area.

A small run of striped bass reaches the lower Yuba River, but have not been found upstream of Daguerra Point Dam. Adults and juveniles are found in the river in May and June. This corresponds to the spawning period in the rest of the Sacramento River system. However, eggs and larvae have never been found in the Yuba River, leading to the possibility that the river is utilized as a feeding and rearing area for those stripers spawning and hatching in the Feather River.

American River – Large and smallmouth bass, white catfish, brown bullhead, channel catfish and several sunfishes are among the fish species found in Folsom Reservoir. During normal water years, DFG plants hatchery–spawned rainbow trout and manages for previously planted kokanee salmon.

Downstream from Folsom Dam and 30 miles upstream from the mouth of the American River is the Lake Natoma–Nimbus Dam afterbay complex. The daily 4–to–7–foot lake level fluctuations, cold water temperatures, and limited food production support few fish. Anadromous fish cannot pass Nimbus Dam.

The Nimbus Salmon and Steelhead Hatchery is located on the downstream side of Nimbus Dam. For the period 1969 to 1981, the spawning escapement of salmon to the river and Nimbus Salmon and Steelhead Hatchery averaged 47,500 fish. Of these, about 60 percent were produced from fish spawning naturally in the river and 40 percent from hatchery operations. During prolonged drought conditions, low water levels at Folsom Dam have resulted in warmer water releases which range from marginal to lethal temperature thresholds for salmon eggs spawned both in the river and the hatchery.

Steelhead trout escapement, supported entirely by the hatchery, runs as high as 15,000 to 20,000 annually. Natural production of steelhead in the lower American River is negligible because of the lack of cold water during spring and summer months.

The lower American River aquatic habitat includes a meandering streambed in a broad flood plain which is delineated from surrounding urban areas by 30 foot levees. The waters' edge is bordered by native riparian vegetation, backwaters, dredge ponds, and urban recreational areas such as parks and golf courses. The river and backwater areas support at least 41 species of fish, including chinook salmon, steelhead trout, striped bass, and American shad. Common resident fish include the Sacramento sucker, black bass, carp, squawfish, and hardhead.

SWRCB Decision 893 currently governs releases from the Folsom–Nimbus complex. The requirements are 500 cfs flow between September 15 and January 1, and a minimum of 250 cfs during the remainder of the year. However, because of other recreational restrictions on flow and overall CVP operations, flows have almost always exceeded those levels. The exception occurred during the 1976–77 drought.

Species occurring in the basin that are either federally or State listed as threatened or endangered include the greater sandhill crane, bank swallow, least Bell's vireo, Swainson's hawk, western yellow billed cuckoo, California black rail, willow flycatcher, bald eagle, American peregrine falcon, Aleutian Canada goose, giant garter snake, valley elderberry longhorn beetle, and winter run chinook salmon. Five candidate species occur in the area (California tiger salamander, tricolored blackbird, white–faced ibis, snowy plover, Sacramento anthicid beetle, and Sacramento splittail), as well as five species recommended for candidate species (western spadefoot toad, vernal pool fairy shrimp, California linderiella, conservancy fairy shrimp, and vernal pool shrimp).The California hibiscus is a species of special concern that occurs in the area.

Bank swallows, designated as threatened by the State, are generally considered a riverine riparian species. Swallows nest colonially in earthen banks and bluffs, and in sand and gravel pits. Intensive surveys of the Sacramento River from Shasta Dam to the Delta identified 60 colonies which supported an estimated 16,149 breeding pairs. This represents about 70 to 80 percent of the total population in California.

The vireo was formerly considered common or abundant in lowland riparian habitats throughout California, but its population is now limited to a few areas in Southern California. This bird no longer occurs within the Central Valley of California, though formerly occurring at least as far north as Red Bluff in Tehama County. USFWS has identified the riparian zone of the Sacramento River as a prime reintroduction site for this species, which is listed as endangered by both the State and federal governments.

The Swainson's hawk, listed as a threatened species by the State, is closely associated with valley riparian systems. The hawk is limited to the Central Valley and portions of the extreme northeastern part of the State. The species occupies nesting habitat in California from April until August and spends the remaining 7 months in wintering habitat in South America and in migration (JSA, 1987). The Central Valley is estimated to support 280 (75 percent) of the remaining pairs in California. The distribution of Swainson's hawk nest sites ranges from Chico in the northern Sacramento Valley, south to near Fresno in the San Joaquin Valley. Most Central Valley territories are in Yolo, Sacramento, and San Joaquin Counties.

The western yellow–billed cuckoo, a State listed endangered species, specifically requires riparian habitat. The management plan developed by USFWS for this species recommends the protection of existing riparian habitat and the establishment of a protected riparian corridor along the Sacramento River.

The endangered bald eagle and peregrine falcon also occur within the riparian zone. About 20 to 30 eagles use the area during the wintering period, with a few individuals observed throughout the year. Peregrine falcons are being seen with increasing frequency during the winter months.

The giant garter snake, a subspecies of the western aquatic garter snake, is designated as threatened by the State. The giant garter snake formerly ranged from the Sacramento Valley south to Buena Vista Lake in Kern County. Agricultural development has caused it to be extirpated from the southern San Joaquin Valley. Its present range extends from Fresno County north through the Central Valley to the vicinity of Gridley in Butte County, but has not been observed along the Sacramento River.

The valley elderberry longhorn beetle, a federally listed threatened species, is a pith borer upon its host plant (elderberry) which occurs on floodplains of the Sacramento and San Joaquin Valleys. The actual distribution and abundance of the species is little known. The beetle has been collected at locations along the Sacramento River in Sutter, Colusa, Glenn, Butte, and Tehama counties; the American and Cosumnes rivers in Sacramento County; and Putah Creek in Solano and Yolo counties. Surveys suggest that the beetle is widespread above Colusa along the Sacramento River and less common downstream.

Two additional candidate species for federal listing in this reach of the river are the Sacramento anthicid beetle and Sacramento splittail fish. The Sacramento anthicid beetle was only recently described and relatively little is known about its distribution and life history. The Sacramento anthicid beetle was probably more widely distributed before human activities altered or eliminated many sand dunes in the Central Valley and Delta areas. This beetle is currently found at several sites along the Sacramento River, including sand dunes under the Ord Ferry Road bridge at River Mile 184.

The Sacramento splittail was at one time widely distributed in lakes and rivers on the floor of the Central Valley (Moyle 1976). The fish now appears to be confined to the Delta region and from the lower reaches of the Sacramento River to the Red Bluff Diversion Dam, where they prefer the slow moving stretches of water. The splittail require dead end sloughs with beds of submerged vegetation for spawning. Bank protection and channelization of the Sacramento River and Delta may be disruptive to splittail spawning requirements.

Recreation. Little recreational land is available in the Sacramento Valley floor outside of riparian corridors. The Sacramento River environment is the primary remnant riparian corridor in the valley, providing the most important recreational resource for local residents. Public access to the river for recreational use is limited by the amount of public lands along the river. About 65 percent of the total recreational use on the river at and above Sacramento is by people living in counties adjacent to the river. Ninety percent of the summer day use activity is by local residents.

Recreational use of the Sacramento River is diverse. Recreationists spent an estimated 2 million user days on the river in 1980, and present use is probably higher. Popular uses include fishing, boating, water skiing, picnicking, camping, and bird watching. Shore and boat fishing represents 39 percent of the annual recreational hours. Nearly 1.9 million recreation hours involved fishing in 1980, primarily for anadromous fish.

Recreational activities are limited in the Yolo Bypass due to private ownership of the land. Off road vehicle use, target practice, camping, hunting, and fishing activities do take place, however.

Recreational opportunities at the Oroville complex include boating, fishing, swimming, waterskiing, camping, picnicking, and hunting primarily for waterfowl. The Lake Oroville State Recreation Area is operated by the California Department of Parks and Recreation.

Current recreational facilities at New Bullards Bar Reservoir include a marina operated by a private concession, the Yuba County Water Agency's Cottage Creek Boat Ramp and a related picnic area, and the U.S. Forest Service's Dark Day Boat Ramp and a related picnic area. In addition, the U.S. Forest Service operates three drive–to campgrounds (Burnt Bridge, Schoolhouse, and Hornswoggle) and three boating campgrounds (Garden Point, Madrone Cove, and Frenchy Point) around the reservoir. Recreational opportunities include camping, picnicking, boating, fishing, waterskiing, and swimming. Some funding for the New Bullards Bar Reservoir was provided for recreation under California's Davis–Grunsky Act.

Englebright Reservoir also receives recreational use. Most of the recreation is in the form of day use including boating, waterskiing, fishing, and picnicking. The reservoir is served by Skipper's Cove Marina.

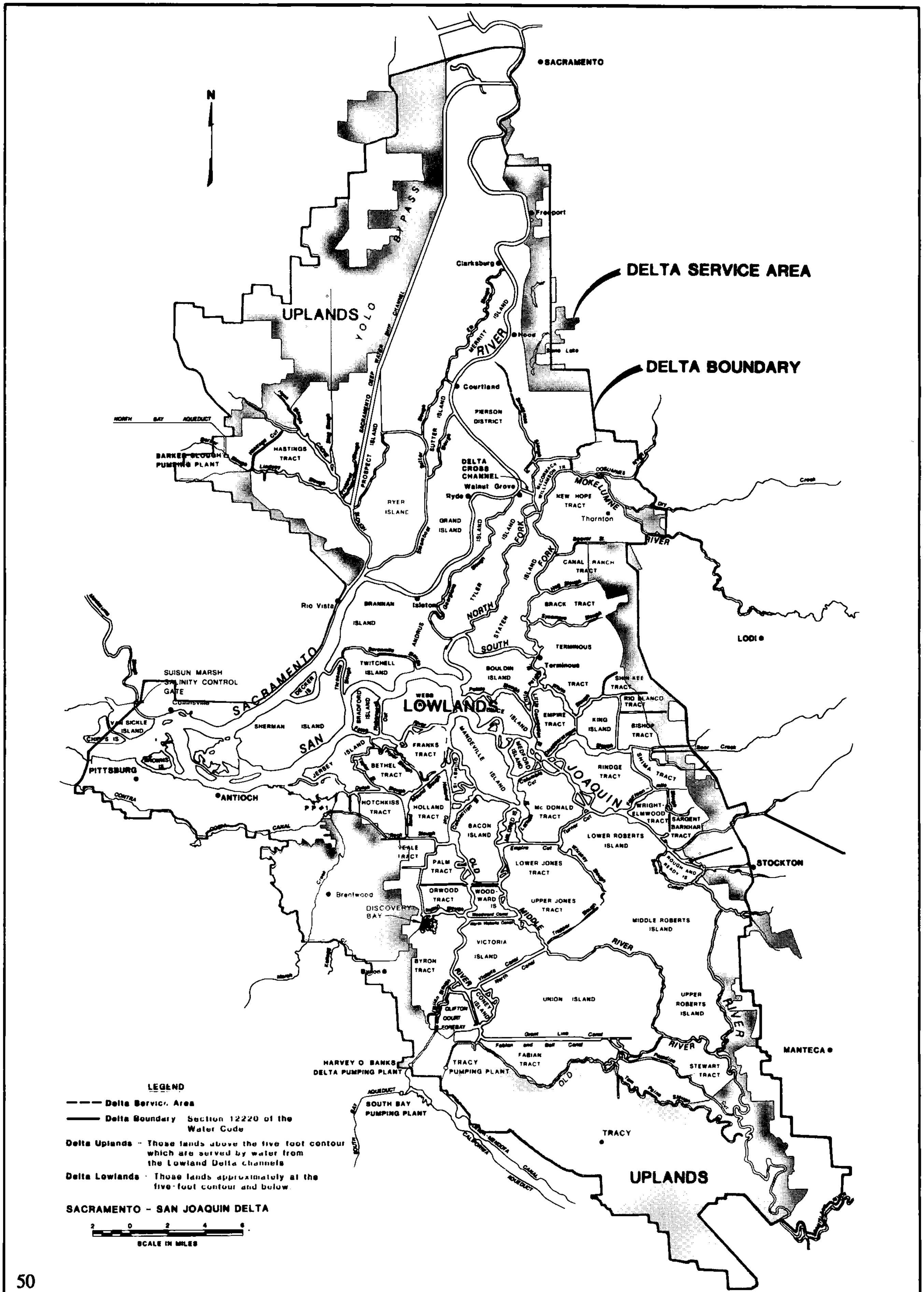
Recreation in the Yuba River from Englebright Dam to the Feather River is primarily in the form of fishing, swimming, and rafting.

Folsom Lake is heavily used for recreation, with an 18,000 acre park that is the most popular unit of the California State Park System. Recreation use of Folsom Lake and Lake Natoma runs about 2 million visitor days annually. Fishing, swimming, and waterskiing are the main attractions.

Delta-Central Sierra Area

The Delta–Central Sierra area includes the Cosumnes, Mokelumne, Calaveras River Basins and the Sacramento–San Joaquin Delta, totaling 3,109,000 acres (USBR, 1970). The Delta area forms the lowest part of the Central Valley bordering and lying between the Sacramento and San Joaquin Rivers and extending from the confluence of these rivers inland as far as Sacramento and Stockton (Figure 2–6).

Figure 2-6. Statutory Delta Service Area



The Sacramento–San Joaquin Delta, a 738,000 acre region of low lying land and waterways at the landward end of the estuary, is mainly farmland (USBR/DWR, 1985). Prior to development, which began in the mid–19th century, the Delta was mainly tule marsh and grassland, with some high spots rising to a maximum of about 10 to 15 feet above mean sea level. The low dikes of early Delta farmers became a system of levees that now protect about 520,000 acres of farmland on 60 major islands and tracts (DWR, 1991a). There are now about 1,100 miles of levees, some standing 25 feet high and reaching 200 feet across at the base.

Behind the levees, peat soils have subsided over the years due to oxidation, shrinkage, and soil loss by wind erosion. As a result, some of the island surfaces now lie more than 20 feet below mean sea level and as much as 30 feet below high tide water levels in surrounding channels. All the major tracts and islands have been flooded at least once since their original reclamation, and a few have been allowed to remain flooded. Delta lands in the areas of deep peat soil, where subsidence has been greatest, are expensive both to protect from inundation and to reclaim from inundation once flooded.

The Delta is an important agricultural area. Historically, the area was noted for its truck crops, such as asparagus, potatoes, and celery, but since the 1920s, there has been a shift toward lower valued field crops. Corn, grain, hay, and pasture currently account for more than 75 percent of the region's total production. The change has been attributed mainly to market conditions, although technological change and changes in growing conditions have also played a role. Delta farming produces an average gross income of about $375 million (DWR, 1991a).

The Delta is generally bordered by the cities of Sacramento, Stockton, Tracy, and Pittsburg (DWR, 1991a). The small cities of Antioch, Brentwood, Isleton, Pittsburg, and Tracy, plus about 14 unincorporated towns and villages also lie within the Delta area. The population of the Delta is about 200,000 people, most of which is in upland areas on the eastern and western fringes. Most Delta islands are sparsely populated, though some, including Byron Tract and Bethel Island, have large urban communities.

Hydrology. The Sacramento and San Joaquin rivers unite at the western end of the Sacramento–San Joaquin Delta at Suisun Bay. The Sacramento River contributes roughly 85 percent of the Delta inflow in most years, while the San Joaquin River contributes about 10 to 15 percent. The minor flows of the Mokelumne, Cosumnes, and Calaveras rivers, which enter into the east side of the Delta, contribute the remainder. The rivers flow through the Delta and into Suisun Bay. From Suisun Bay water flows through the Carquinez Strait into San Pablo Bay, which is the northern half of San Francisco Bay and then out to sea through the Golden Gate.

Tidal influence is important throughout the Delta. Historically, during summers when mountain runoff diminished, ocean water intruded into the Delta as far as Sacramento. During the winter and spring, fresh water from heavy rains pushed the salt water back, sometimes past the mouth of San Francisco Bay.

With the addition of Shasta, Folsom, and Oroville dams, salt water intrusion into the Delta during summer months has been controlled by reservoir releases during what were traditionally the dry months. Typically, peaks in winter and spring flows have been dampened and summer and fall flows have been increased. In very wet years, such as 1969, 1982, 1983, and 1986, reservoirs are unable to control runoff so that during the winter and spring the upper bays become fresh and even at the Golden Gate the upper several feet consists of fresh water.

On the average, about 21 million acre–feet of water reaches the Delta annually, but actual inflow varies widely from year to year and within the year (USBR/DWR, 1985). In 1977, a year of extraordinary drought, Delta inflow totaled only 5.9 million acre–feet, while inflow for 1983, an exceptionally wet year, was about 70 million acre–feet. On a seasonal basis, average natural flow to the Delta varies by a factor of more than 10 between the highest month in winter or spring and the lowest month in fall. During normal water years, about 10 percent of the water reaching the Delta would be withdrawn for local use, 30 percent would be withdrawn for export by the CVP and SWP, 20 percent would be needed for salinity control, and the remaining 40 percent would become Delta outflow in excess of minimum requirements. The excess outflow would occur almost entirely during the season of high inflow.

Hydraulics of the estuary system are complex. The influence of tide is combined with freshwater outflow resulting in flow patterns that vary daily. Delta hydraulics is further complicated by a multitude of agricultural, industrial, and municipal diversions for use within the Delta itself and export by the SWP and CVP.

Climate. The Delta area has a Mediterranean climate with warm, rainless summers and cool, moist winters (DWR, 1991a). The annual rainfall varies from about 18 inches in the eastern and central parts to about 12 inches in the southern part. Ocean winds enter the Delta through the Carquinez Strait and are very strong at times in the western Delta.

Water Supply Developments. The Delta–Central Sierra area is the hub of the major State and federal water development facilities, and numerous local water supply projects. Water projects divert water from Delta channels to meet the needs of about two–thirds of the State's population and to irrigate 4.5 million acres (DWR, 1988b). Delta agricultural water users divert directly from the channels, using more than 1,800 unscreened pumps and siphons, which vary from 4 to 30 inches in diameter, and with flow rates of 4 to about 200 cfs. Total diversions vary between 2,500 and 5,000 cfs during April through August, with maximum rates in July.

The federal Delta Cross Channel near Walnut Grove diverts water from the Sacramento River into the Mokelumne River. Channel flows can be controlled by two radial gates. Since the Mokelumne River is about 5 feet lower in elevation than the Sacramento River, water flows by gravity from the Sacramento River into the North and South Forks of the Mokelumne River. Sacramento River water moves down these channels through the central Delta and into the San Joaquin River. Flows in the Cross Channel reverse as the tide changes, and at certain stages there is considerable flow from the Cross Channel into the Sacramento River. The Delta Cross Channel is closed for flood control purposes when river flows exceed about 25,000 cfs. Other channels that convey water across the Delta include Georgiana Slough, North Fork Mokelumne River, San Joaquin River, Old River, and Middle River.

North Bay Service Area. The SWP's North Bay Aqueduct supplies water to Napa and Solano counties, encompassing 1.1 million acres of which about 64,000 acres were in urban use in 1980 (DWR, 1991a). An estimated 95,000 people live in Napa County, primarily in the Napa Valley communities. The population of Solano County is about 303,500 and is distributed among seven cities and scattered rural areas.

Napa County is well known for production of wines and brandies. There is also a substantial livestock and dairy industry (DWR, 1991a). Solano County agriculture centers on field crops, with substantial values of fruit and nut crops and a significant livestock industry. Heavy water using industries include two meat packing companies and a cannery in Dixon, a refinery in Benicia, a brewery in Fairfield, and two food processors in Vacaville. Two major defense facilities located in the region are Mare Island Naval Shipyard and Travis Air Force Base.

Hydrologic features in the North Bay Service Area include perennial and intermittent streams and lakes, sloughs, marshlands, and two major ground water basins. The majority of streams in the area are intermittent. Tidal sloughs are located along the east central and south central portions of the area. Prior to completion of the North Bay Aqueduct, the City of Vallejo diverted water for domestic use from Cache Slough. Currently, there are numerous private agricultural withdrawals and returns from both Cache and Lindsey sloughs. During peak usage periods (summer months), the net flow in both channels is upstream.

Sources of water for Solano County include the North Bay Aqueduct, surface water from Lake Berryessa (the principal storage facility of the federal Solano Project), Lake Solano, and several small reservoir and stream projects, plus ground water, agricultural return flows, and reclaimed waste water. Deliveries to Solano County supply municipal and industrial uses in Benicia, Fairfield, Suisun City, and Vacaville.

The federal Solano Project, built in the 1950s, includes Monticello Dam, Lake Berryessa, Putah South Canal, and other related facilities. USBR supplies water to Solano County through the Solano County Water Agency, which sells the water to member agencies and agricultural water users. Minimum contract entitlements are 14,200 acre–feet per year for municipal water use and 161,200 acre–feet per year for agricultural use.

Solano County contains two major ground water basins (Putah Plain and Suisun–Fairfield Valley) and several smaller basins. Ground water supplies are primarily used for agricultural irrigation, although some local municipalities (e.g., Vacaville, Dixon, and Rio Vista) also rely on ground water for domestic supply. Ground water is used primarily during the summer months when water demand is high and surface supplies are reduced.

Napa County's water supply comes from the North Bay Aqueduct, several small reservoirs, a number of springs and wells, and some ground water. The North Bay Aqueduct, which begins at Barker Slough south of Dixon and ends at the Napa Turnout Reservoir, delivers water to Napa County for use in the city of Napa and by exchange in American Canyon, Yountville, and Calistoga. Usable ground water storage capacity is restricted to the area between Napa and St. Helena.

Contra Costa Water District Service Area. The western Delta includes some important industrial areas in eastern Contra Costa County (USBR/DWR, 1985). The Delta also supplies water to a number of cities within the region, including the City of Antioch. Western Delta municipal and industrial water users obtain water supplies either directly from channels or from the Contra Costa Canal, which is a CVP facility that diverts from Rock Slough. The Contra Costa Water District is the water distribution authority for the Contra Costa Canal. Direct diverters obtain supplies from the San Joaquin River and adjacent channels off the Contra Costa County shoreline in the Antioch–Pittsburg area, but can also take water from the Contra Costa Canal if offshore water is unsuitable.

The extensive industrial complex adjacent to the San Joaquin River in the Antioch–Pittsburg area depends on the availability of large quantities of water for processing and cooling. The industries have three possible Delta water sources: 1) water diverted directly from the San Joaquin River or New York Slough; 2) raw water purchased from Contra Costa Water District conveyed from Rock Slough via the Contra Costa Canal or, in the Pittsburg area, pumped from Mallard Slough at the District's pumping plant; and 3) treated water purchased from municipal purveyors who obtain their raw water from the Contra Costa Canal or a San Joaquin River diversion.

A diversity of industry is located in the county. With its miles of waterfront linking ocean, river, and overland transportation facilities, the area offers many advantages to heavy industries requiring large supplies of cooling and processing water, large land areas, and access to a deep water ship channel. Major industry groups in the county requiring the greatest amounts of water are petroleum and coal products, paper and allied products, chemicals and allied products, primary metal industries, and food and related products. Presently, the exceptionally high water needs of the petroleum refineries are largely met with brackish supplies from the south shores of San Pablo and Suisun Bays.

The Contra Costa Water District provides the municipal water needs of about 300,000 county residents. Of the nine bay area counties, Contra Costa is projected to experience the most rapid future population growth. The growing trend toward municipal water use increases the need for both improved water quality to meet State and federal standards and improved system reliability to meet peak water demands.

Clifton Court Forebay. In the south Delta near Byron, the 31,000 acre–foot capacity Clifton Court Forebay regulates water for distribution to other areas (Figure 2–7). The reservoir is operated to minimize water level fluctuation in the intake along Old River by taking water in through gates at high tides and closing the gates at low tides (DWR, 1992a). This operation provides a more constant head for pumps and allows DWR to maintain channel and screen velocities at fish protection facilities near the optimum range for either striped bass or chinook salmon, depending on the season. Even with the Forebay, however, net flows are toward the pumps.

The SWP's Harvey O. Banks Delta Pumping Plant lifts water from the Clifton Court Forebay into the Edmund G. Brown California Aqueduct, which carries flows to Bethany Reservoir. Between the Forebay and pumping plant, the John E. Skinner Fish Protective Facility removes fish from the intake channel for return to the Delta. The fish protection facility consists of primary and secondary louver systems to divert fish into holding tanks, from which they are returned to Delta water by special tank trucks (DWR, 1989a, 1990). Generally, the behavioral screens (louvers) are designed to salvage fish larger than 1 inch. Consequently, most eggs and small larvae are lost down the aqueduct where some of them grow in the canal and reservoirs to provide an important recreational fishery. Most of the water from Bethany Reservoir flows south into the California Aqueduct, which winds along the west side of the San Joaquin Valley to San Luis Reservoir.

In contrast to the SWP, the CVP draws water directly from the channels over the entire tidal cycle, resulting in a continuous flow toward the Tracy Pumping Plant whenever operating. A combination of ever changing water surface elevations and constant pumping makes it more difficult for the CVP to maintain required velocities at its fish protection facilities. Fish inadvertently drawn to the pumping plant are salvaged at the Tracy Fish Collecting Facility. The CVP provides water to the Delta–Mendota Canal, which conveys water to agricultural users in the San Joaquin Valley and to facilities of the CVP's San Luis Unit. Some of the water provided in the San Joaquin Valley is delivered on an exchange basis to areas that used water from the San Joaquin River prior to construction of the CVP.

Changes in operations of the SWP and CVP can affect flows in the lower San Joaquin River along Sherman Island. At low outflows, increases in export and internal Delta demand results in net reverse flows in this portion of the river. During flow reversal, the net movement of water is upstream toward the pumps. Although net reverse flows are small in relation to tidal flow, there is concern that they may harm fish, especially the planktonic eggs and larvae of striped bass.

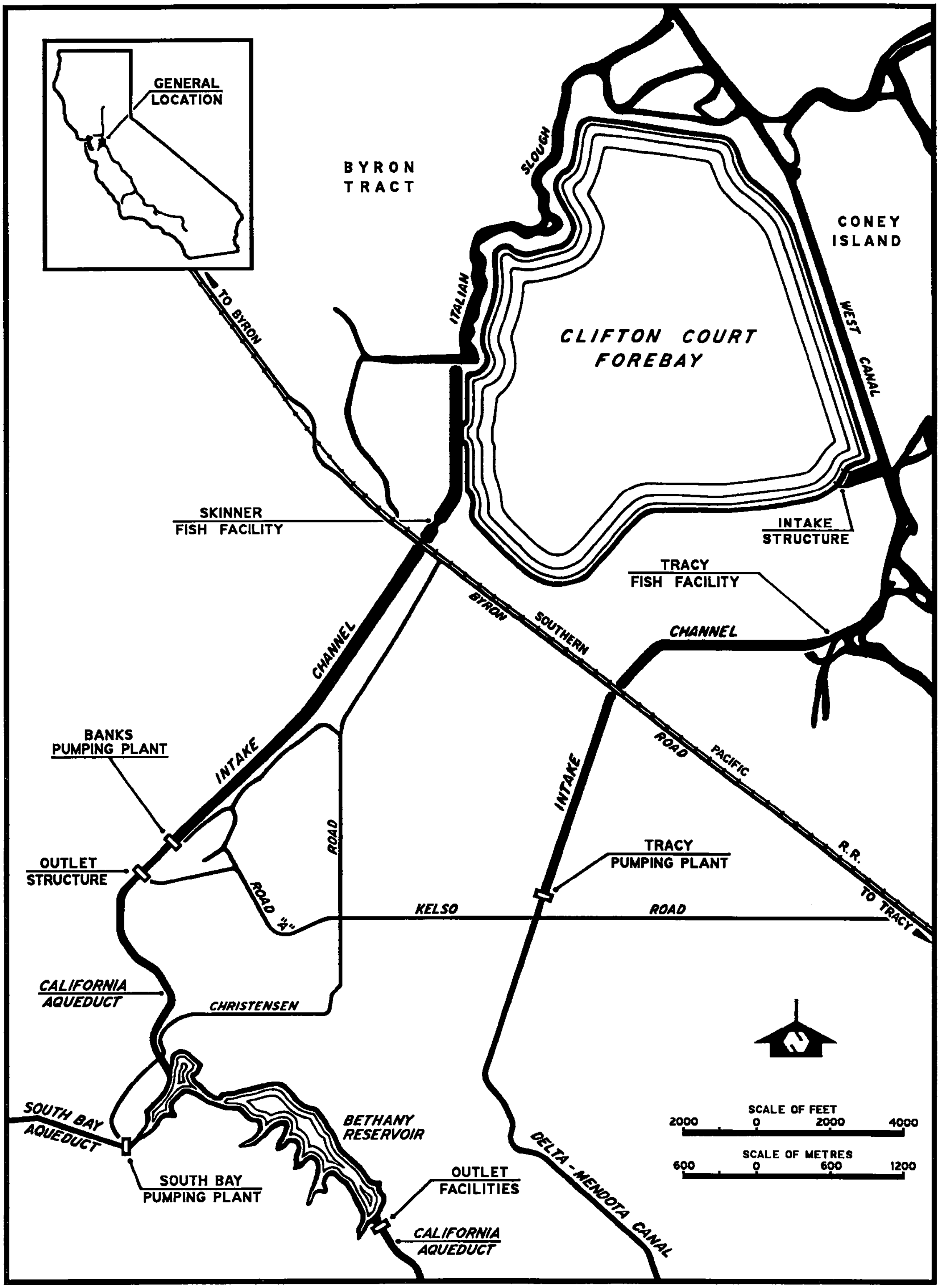


Figure 2–7. Clifton Court Forebay Facilities

The CVP can pump a maximum of 4,600 cfs into the Delta–Mendota Canal. Adding the Contra Costa Canal brings CVP export capacity to 4,900 cfs. The SWP can pump 10,300 cfs at the Banks Pumping Plant, but is limited by regulation of the SWRCB to 6,400 cfs except during the period from mid–December to mid–March when San Joaquin River flows are greater than 1,000 cfs. With its greater export capacity, the SWP is in a better position to take advantage of surplus flows when they are available in the Delta.

South Bay Service Area. From Bethany Reservoir, up to 300 cfs of Delta water is lifted by the South Bay Pumping Plant into the South Bay Aqueduct, which serves Alameda and Santa Clara Counties around the southern half of San Francisco Bay (Figure 2–8). Along the South Bay Aqueduct near Livermore, water is pumped into Lake Del Valle on Alameda Creek, which provides aqueduct flow regulation and flood protection. The 74,000 acre–foot lake also provides recreational opportunities for picnicking, swimming, boating, fishing, and camping. Facilities are operated by the East Bay Regional Parks District. Beyond Livermore Valley, water flows via pipeline to a 2.5 million gallon holding tank at the Santa Clara Terminal Facilities.

Alameda County has some natural runoff from Alameda Creek, but only Santa Clara County has significant surface water supplies (DWR, 1991a). Water is imported from the Tuolumne River via the Hetch Hetchy Aqueduct, and from the Delta via the South Bay Aqueduct and the San Felipe Project.

Ground water basins have been intensively developed for domestic, industrial, and irrigation uses and have been overdrawn, with resultant seawater intrusion and land subsidence problems. Extensive recharge programs using local and imported water supplies have allowed substantial recovery of the ground water basins.

Historically, Santa Clara County's economy was dominated by agriculture. However, the rapid urban development of the county has displaced much of the farming, which is now carried out in the less populated southern part of the county. The South Bay is northern California's leading business center. The economy of the area is diversified, with manufacturing, commerce, services, and government sectors employing significant numbers of people.

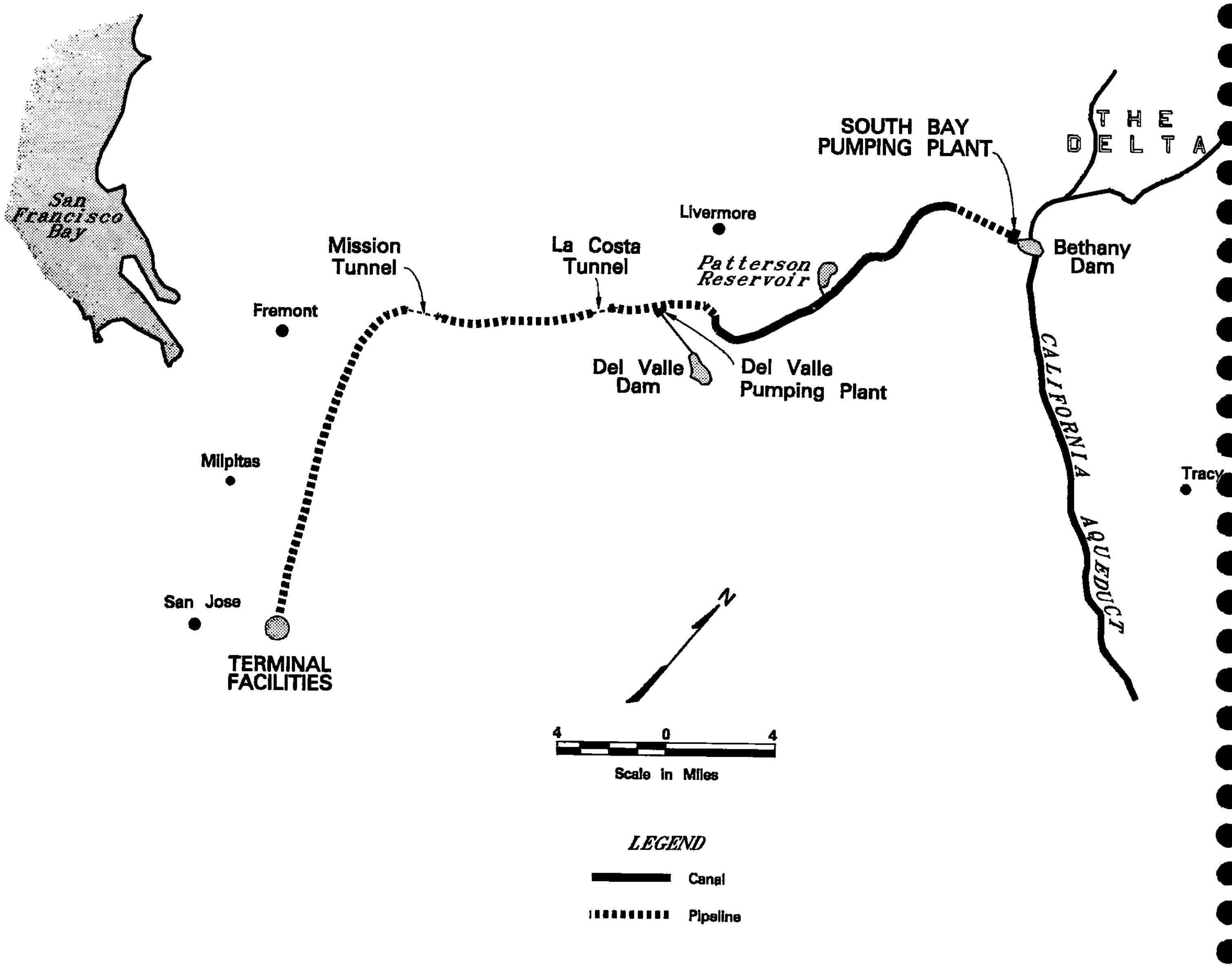
Surface Water Quality. Streams tributary to the Delta are generally of excellent water quality. However, in the North Bay, quality of local surface water has deteriorated since the 1960s (USCE/DWR, 1981). Both chloride and total dissolved solids (TDS) have increased, which may be due to changing agricultural practices in the region. Chloride and TDS concentrations are generally higher during the spring runoff period and decrease during the summer months when better quality Sacramento River water is being drawn. Both seepage of poor quality ground water and irrigation return flows contribute to the poor quality.

The quality of the Delta waters is generally adequate in most respects to support all beneficial uses (USBR, 1970). While evidence of gross pollution has been largely eliminated, the recent extremely rapid growth in the tributary area population and industrial activity has left some problems unsolved and created new ones. The existing water quality problems of the Delta system may be categorized by eutrophication and associated dissolved oxygen fluctuations, suspended sediments and turbidity, salinity, toxic materials, and bacteria.

The most serious enrichment problems in the Delta are found along the lower San Joaquin River and in certain localized areas receiving waste discharges but having little or no net freshwater flow. These problems occur mainly in the late summer and coincide with low river flows, high temperatures, and the harvesting season when fruit and vegetable canneries are in full operation. Dissolved oxygen problems are further aggravated by channel deepening for navigational purposes. The resulting depressed dissolved oxygen levels have not been sufficient to support fish life and, therefore, prevent fish from moving through the area. In the autumn these conditions, together with reversal of natural flow patterns by export pumping, have created environmental conditions unsuitable for the passage of anadromous fish (salmon) from the Delta to spawning areas in the San Joaquin Valley.

Warm, shallow, dead end sloughs of the eastern Delta support objectionable populations of planktonic blue–green algae during summer months. Floating and semi–attached aquatic plants, such as water primrose and water hyacinths, frequently clog waterways in the lower San Joaquin River system during the summer. Extensive growths of these plants have also been observed in localized waterways of the Delta. These plants interfere with the passage of small boat traffic and contribute to the total organic load in the Delta–Bay system as they break loose and move downstream in the fall and winter months.

Figure 2-8. South Bay Aqueduct



Much of the water in the Delta system is turbid as a result of an abundance of suspended silts, clays, and organic matter. Most of these sediments enter the tidal system with the flow of the major tributary rivers. Some enriched areas are turbid as a result of planktonic algal populations, but inorganic turbidity tends to suppress nuisance algal populations in much of the Delta. Continuous dredging operations to maintain deep channels for shipping has contributed to turbidity of Delta waters and has been a significant factor in the temporary destruction of bottom organisms through displacement and suffocation.

Salinity control is necessary because the Delta is contiguous with the ocean, and its channels are at or below sea level. Unless repelled by continuous seaward flow of freshwater, sea water will advance up the estuary into the Delta and degrade water quality. During winter and early spring, flows through the Delta are usually above the minimum required to control salinity (described as *excess water conditions*). At least for a few months in summer and fall most years, however, salinity must be carefully monitored and controlled for "balanced water conditions." The monitoring and control is provided by the CVP and SWP and regulated by the SWRCB under its water rights authority.

At present salinity problems occur mainly during years of below normal runoff, and in the eastern Delta are largely associated with the high concentration of salts carried by the San Joaquin River into the Delta. Operation of the State and federal export pumping plants near Tracy draws high quality Sacramento River water across the Delta and restricts the low quality area to the southeast corner. Localized problems resulting from irrigation returns occur elsewhere such as in dead end sloughs. Salinity problems in the western Delta result primarily from the incursion of saline waters from the San Francisco Bay system. The extent of incursion is determined by the freshwater flow from the Delta to the Bay.

Industrial wastes have killed large numbers of fish in localized areas, and agricultural pesticides have been responsible for fish kills in the Delta and other areas of the Central Valley. The majority of these kills were the result of accidental spills or discharges. There has been some mortality among striped bass and other fishes during late spring and early summer for many years. The causes are as yet unknown but seasonal changes in water quality and toxic pollutants are suspected.

Pesticides are found throughout the waters and bottom sediments of the Delta. The more persistent chlorinated hydrocarbon pesticides are consistently found throughout the system at a higher level than the less persistent organophosphate compounds. The sediments having the highest pesticide content are found in the western Delta. Pesticides have concentrated in aquatic life of the Delta. The long–term effects of pesticide concentrations found in aquatic life of the Delta are not known. The effects of intermittent exposure to toxic pesticide levels in water and of long–term exposure to these compounds and combinations of them are likewise unknown.

Bacteriological quality of Delta waters, as measured by the presence of coliform bacteria, varies depending upon proximity of waste discharges and significant land runoff. The highest concentration of coliform organisms are generally found in the western Delta. Local exceptions to this can be found in the vicinity of major municipal waste discharges.

Another concern is that Delta water contains precursors of trihalomethanes (THMs), which are suspected carcinogens produced when chlorine used for disinfection reacts with natural substances during the water treatment process. Dissolved organic compounds that originate from decayed vegetation act as precursors by providing a source of carbon in THM formation reactions. During periods of reverse flow, bromides from the ocean intermix with Delta water at the western edge of Sherman Island. When bromides are present in water along with organic THM precursors, THMs are formed that contain bromine as well as chlorine. Drinking water supplies taken from the Delta are treated to meet current THM standards. However, more restrictive standards are being considered, which, if adopted, will increase the cost and difficulty of treating present Delta water sources.

Ground Water Quality. A major restriction on the use of ground water, particularly for municipal and industrial needs, is the variable and uncertain quality. Ground water salinity levels in the Suisun–Fairfield area typically range from 300 to 6,000 mg/L TDS, with average values generally exceeding 900 mg/L TDS. Putah Plain ground water is of somewhat better quality, with average TDS levels generally under 600 mg/L. However, the Putah Plain aquifer is distant from municipal and industrial water demand centers, so water transport facilities would have to be incorporated into any project developing ground water on a major scale.

Ground water quality is generally poor north of St. Helena and south of Napa, where it is frequently degraded by brackish water from San Francisco Bay. Because most of any additional demand for water would be for municipal and industrial use, where both quality and quantity are crucial, ground water will probably continue to be used as a supplemental local source, mainly for agriculture.

Wildlife and Fish. Many wildlife and fish species are found in the Delta area. Important groups of wildlife dependent on the Delta and Bay estuarine environment are waterfowl and other migratory waterbirds, game birds such as pheasant and quail, furbearers, and numerous nongame birds and mammals. Fish dependent on the Delta as a migration corridor, nursery, or permanent residence include striped bass, American shad, sturgeon, chinook salmon, steelhead trout, catfish, largemouth bass, and numerous other less known marine and freshwater species (USBR, 1978).

The wildlife and fish diversity is high due to the extensive mudflats and riparian vegetation and gradation of aquatic habitats from freshwater in the upper reaches of the Delta to brackish in the Suisun Bay region, and to saline in portions of San Francisco Bay. The three aquatic habitat zones historically graded gradually into one another. The zones move up or downstream, depending on the amount of freshwater outflow.

The complex interface between land and water in the Delta–Bay estuary provides rich and varied habitat for wildlife, especially birds. Habitat or cover types in the Delta are agriculture, forest, riparian forest, riparian scrub–shrub, emergent freshwater marsh, and heavily shaded riverine aquatic (DWR, 1991a).

The Delta is particularly important to waterfowl migrating via the Pacific Flyway. The principal attraction for waterfowl is winter flooded agricultural fields, mainly cereal crops, which provide food and extensive seasonal wetlands. The Delta, along with other principal wetlands that support Central Valley waterfowl, is winter habitat for 60 percent of the waterfowl on the Pacific Flyway, and for 91 percent of all waterfowl that winter in California. More than a million waterfowl are frequently in the Delta at one time.

Small mammals also find suitable habitat in the Delta and upland areas. Vegetated levees, remnants of riparian forest, and undeveloped islands provide some of the best mammalian habitats in the region. Species include muskrat, mink, river otter, beaver, raccoon, gray fox, and skunks.

The area also supports a variety of non–game wildlife, including songbirds, hawks, owls, reptiles, and amphibians.

The Delta has a large number of fishery habitat types, including estuary, freshwater, and marine water environments. The amount of habitat in each component depends on part upon outflow regimes and water year hydrology. Habitat varies from dead end sloughs to deep open water areas of the lower Sacramento and San Joaquin rivers and Suisun Bay. There are also a scattering of flooded islands offering submerged vegetative shelter. The banks of the channels are varied, and include riprap, tules, emergent marshes, and native riparian habitats. Water temperatures generally reflect ambient air temperatures. However, riverine shading may moderate summer temperatures in some areas.

Food supplies for Delta fish communities consist of phytoplankton, zooplankton, benthic invertebrates, insects, and forage fish. General productivity in the Delta is in constant flux and an evaluation of the interrelationships of the food web is now underway by the Interagency Ecological Studies Program. There are indications that overall productivity at the lower food chain levels has decreased during the past 15 or so years.

Biological productivity in the estuary is highest in the zone where freshwater Delta outflows meet and mix with more saline waters of the bay. This *entrapment zone* concentrates sediments, nutrients, phytoplankton, striped bass larvae, and fish food organisms. It is considered advantageous that outflows be sufficient to keep the entrapment zone in the upper reaches of Suisun Bay, where it can spread out over a large area, rather than in the narrower Delta channels upstream from Suisun Bay.

The estuary supports about 90 species of fish, of which the most important are the chinook salmon, striped bass, sturgeon, American shad, and steelhead trout (USBR/DWR, 1985). All these anadromous fish spend most of their adult lives either in the lower bays of the estuary or in the ocean. The Delta is a major nursery area for most of these species. Other fish in the estuary include catfish, black bass, crappie, and bluegill.

Apart from salinity control, flows caused, provided, or controlled by the CVP and SWP affect fish in numerous ways. Flows toward the project pumps draw both fish and fish food organisms into the export facilities. Larger fish are screened out, but smaller fish and fish food pass through and leave the Delta. Many of the larger fish do not survive screening and subsequent handling. The draw of the pumps may cause water to flow too fast for optimal fish food production in some channels, and the reverse flows in some channels may confuse migrating fish. Flows carry outmigrant anadromous fish downstream to the ocean.

Factors other than CVP and SWP operations that affect fish dependent on the Delta–Bay ecosystem include water diversions within the Delta, diversions upstream, water pollution, agricultural return flows, fishing, and natural predator–prey interactions.

Striped Bass. Operation of the projects, and the resulting water qualities at various places in the Delta, affects abundance and distribution of striped bass in all phases of their life history (USBR/DWR, 1985). The number of adult striped bass in the estuary is partially determined by CVP and SWP exports from the southern Delta, salinity in certain Delta channels, outflows, and direction and velocity of flow through the Delta.

Striped bass, frequently used as an indicator of the health of the ecosystem, have been in decline since the early 1960s. Various hypotheses have been advanced to explain this decline. Some of the hypotheses link the decline to operation of the CVP and SWP, particularly to the increase in total diversion from the Delta since the beginning of SWP operation and effects associated with that increase. Project operations have an important role in controlling key factors that affect the ecosystem, particularly water quality and flows in the Delta. The rate at which the projects are exporting water from the southern Delta affects Delta outflow, which in turn affects the amount of ocean salinity that may advance up the estuary. The export rate can also affect the direction of flow in many Delta channels.

Delta outflow is important for young striped bass and *Neomysis* shrimp, an important bass food source. Although information is lacking for a complete understanding of the factors controlling the young striped bass population, Delta outflow in the spring and early summer is believed significant. Maintenance of the entrapment zone in the Suisun Bay area (at outflows of about 4,000 to 6,000 cfs) is one beneficial function of outflow. At lower levels, the entrapment zone moves upstream into the less productive area around Antioch, while at extremely low levels, it moves into the western Delta.

Level and timing of exports from the southern Delta affect the number of striped bass eggs, larvae, and juveniles exposed to removal from the Delta with export water. Eggs and larvae, abundant from May through July, cannot be screened from export water, and the screening efficiency for small striped bass, abundant in July and August, is low at the present fish protective facilities. Higher exports at these times, therefore, impact striped bass to a higher degree than exports made in the fall and winter, when striped bass are less abundant in the southern Delta and can be screened fairly efficiently.

Flow patterns in the Delta affect the abundance of juvenile striped bass and their food supply. The most harmful project induced flows are the reverse flows in the lower San Joaquin River, which draw young fish out of the western Delta toward the export pumps.

Salmon. Operation of the SWP and CVP in the Delta affects immigrating adult and emigrating juvenile chinook salmon on their way to and from spawning and nursery areas in the Sacramento and San Joaquin river systems. Flow direction and velocity in Delta channels, operation of the Delta Cross Channel, and exposure of fish to the export pumps are the major project related factors affecting salmon survival (USBR/DWR, 1985).

Adult salmon require the presence of home–stream water to guide them to their spawning grounds. Salmon using the San Joaquin River are seriously affected by SWP and CVP operation, since at many times virtually all San Joaquin River water is being exported.

Salmon from the Sacramento River system, migrating through the Delta as juveniles on their way to the ocean in the spring and early summer, are sometimes affected by reverse flows in the lower San Joaquin River. They are also affected by diversion into the interior Delta through the Delta Cross Channel, where survival is lower than if they continued downstream in the Sacramento River.

The exposure of chinook salmon to the SWP and CVP fish screens causes losses due to predation by larger fish in front of the screens, screen inefficiencies, and attrition in the process of handling and hauling screened fish.

Delta Smelt. The Delta smelt does not exist outside the Sacramento–San Joaquin Delta. Adult Delta smelt spawn in freshwater between February and June, with peak spawning commonly occurring in April and May. Depending upon outflow, the spawning areas are deadend sloughs and the edges of shallow channels between the upper Delta sloughs near Rio Vista and Suisun Marsh. The eggs are demersal and adhesive, sticking to substrate material such as vegetation, gravel, and tree roots. Incubation takes 12 to 14 days.

The larvae are buoyant and rise to the surface upon hatching. They then follow the currents downstream to the freshwater–saltwater interface. The larvae grow to about 2 inches in length by the end of summer. Adults reach nearly 3 inches in length (Moyle 1976). Past studies have noted an abrupt change from single age adults to juveniles. This suggests that the majority of adults die after they spawn (Radtke, 1966).

The population declined in the early 1980s and has remained at low, but stable, numbers since then. The 1990 DFG review of the status of Delta smelt was unable to determine factors causing the observed decline. However, Delta smelt larvae, juveniles, and adults are entrained in CVP and SWP Delta diversions. USFWS will soon be announcing its decision on listing the Delta smelt as threatened under the federal Endangered Species Act.

Numerous listed or candidate rare, threatened, or endangered vertebrate species are known to live in the Delta (Appendix A–6), but none is confined exclusively to that area. Seven listed species are birds (bald eagle, American peregrine falcon, Swainson's hawk, California black rail, Aleutian Canada goose, tricolored blackbird, and California yellow–billed cuckoo), two are mammals (salt marsh harvest mouse and San Joaquin kit fox), four are reptiles (giant garter snake, southwestern pond turtle, California tiger salamander, and California red–legged frog), and four are fish (winter run chinook salmon, Delta smelt, Sacramento splittail, and Sacramento perch). There are five listed or candidate endangered or threatened invertebrate species in the Delta (valley elderberry longhorn beetle, Lange's metalmark butterfly, Delta green ground beetle, Sacramento anthicid beetle, and curve–foot hygrotus diving beetle). Twelve rare or endangered plant species, most of which are associated with freshwater marshes, can also be found in the Delta.

Several active Swainson's hawk nests have been found in trees along Snodgrass Slough, Steamboat Slough, the Mokelumne River, and along Old River (DWR, 1990c, 1990d, 1991). While nesting habitat is absent from most of the South Fork Mokelumne and North Fork Mokelumne, the area does contain a significant portion of remaining riparian woodland preferred by this species.

The bald eagle, peregrine falcon, yellow–billed cuckoo, and Aleutian Canada goose have been observed in the Delta, but none are confined exclusively to the Delta.

Two black rail calls were heard at one location in Little Potato Slough at its confluence with White Slough, and were also heard from two islands in the Middle River area north of Woodward Ferry. The habitat along the island is dominated by emergent bulrush and cattails in the tidal zone and by shrub and tree willow, cottonwood, and dogwood in upland areas. Suitable black rail habitat throughout the remainder of the area is limited. The few areas of marsh vegetation that form suitable habitat are either growing from inundated substrates or are dominated by willows.

The nearest known nesting colony of tricolored blackbirds was reported as about 8 miles east of the area. Habitat which may be suitable for nesting is found in cattail/tule stands along water courses and in scattered areas of mustard bordering agricultural fields. With the possible exception of Snodgrass Slough and Lost Slough, the amount of emergent marsh vegetation in the area is probably not large enough for winter roosting.

Spotlighting and track plates were used to search for San Joaquin kit fox in the proposed forebay expansion area north and west of Clifton Court Forebay. No kit fox were observed in the area, nor did the track plates reveal any canid tracks. One kit fox was observed about 2 miles south of Byron Tract near Bethany Reservoir, an area occupied by kit fox in 1982. The San Joaquin kit fox and salt marsh harvest mouse are known to live in the Delta, but are not confined exclusively to the area.

Only one giant garter snake was observed during surveys. The snake, a large pregnant female, was found west of Snodgrass Slough about 0.75 miles north–northeast of Locke. However, suitable habitat consisting of marsh and streambed riparian vegetation is widespread in the area. Areas of suitable habitat include vegetated levees, vegetated islands and mid–channel berms, and vegetated irrigation canals and drains within agricultural lands. Virtually all islands and channels in the area contain some suitable habitat.

Suitable habitat for western pond turtles occurs along all water courses in the area. Several large, adult western pond turtles were observed during field surveys in Lost Slough, Snodgrass Slough, South Fork Mokelumne River, and Old and Middle Rivers. Since no small turtles were observed, it is not known whether a viable breeding population exists in these areas.

California tiger salamanders and California red–legged frogs require quiet, still water for breeding. The major waterways in the area are too deep, swift, and subject to frequent inundation to provide suitable habitat. Many of the irrigation ditches are kept clear of aquatic vegetation, while the surrounding lands are intensively cultivated, further reducing suitable habitat.

Winter run chinook salmon, Sacramento perch, Delta smelt, and Sacramento splittail are present in the area, and regularly appear in fish diversion facilities at Clifton Court Forebay. DFG electrofishing studies in the Mokelumne River and South Fork Mokelumne River in the early 1980s found no Sacramento perch. The species has not been seen in the Delta since the 1970s. DFG biologists regard the species as possibly extirpated from the Delta.

Little is known of Delta smelt occurrence. Suitable habitat may be present, but due to the large population decline, this habitat may not be occupied.

DFG electrofishing surveys in 1981 found over 20 splittail in the Mokelumne River near the Interstate 5 bridge, indicating the species probably spawns in that portion of the river. A few individuals were also found at scattered locations in the South Fork Mokelumne River and Snodgrass Slough.

Elderberry is widely distributed and is a common component of the mixed riparian woodland community of the Delta. These plants are considered potential habitat for the valley elderberry longhorn beetle.

Suisun Marsh aster plants have been found in Little Potato and Little Connection sloughs and Burns Reach of the San Joaquin River, either growing on instream islands or above rock revetment on the water side of levees. Mason's lilaeopsis have been found growing mainly on eroded mud banks, with greatest densities on islands in Little Potato Slough and Middle River. An extensive colony has also been found on a tule island at the north end of West Canal. All other populations have been isolated patches intermixed with other mud bank species. California hibiscus has been found at scattered locations, with the greatest concentration in the Snodgrass Slough area and large continuous populations in Middle River. Individual plants have been found in other locations. Delta tule pea have been found in Snodgrass Slough and in Middle River on tule islands. Sanford's arrowhead has been found on a point bar in Steamboat Slough and the North Fork Mokelumne River, which was estimated to contain thousands of individuals. Other listed species that may be found in the area include the Delta button celery and slough thistle (DWR, 1992b).

Recreation. Although the Delta environment has been extensively altered over the past 125 years by reclamation and development, natural and aesthetic values remain that make it a valuable and unique recreational asset (DWR, 1991a). Waterfowl and wildlife are still abundant, sport fishing is still popular, and vegetation lining the channels and islands are still attractive. As a result, the miles of channels and sloughs that interlace the area attract a diverse and growing number of people seeking recreation. Recreational use of the natural resources of the Bay–Delta estuary is probably much higher than for any other area of similar size in the State.

With its unique and numerous recreational opportunities, the Delta will continue to support large numbers of recreationists. Motor boating and fishing are the leading activities. The extensive riparian vegetation of the Delta area is conducive to sight seeing, bird watching, and relaxing. Overnight camping, picnicking, swimming, and waterskiing, are enjoyed by many people. Photography, bicycling, hunting, and sailing are participated in less frequently.

There are about 20 public and more than 100 commercial recreational facilities in the Delta (DWR, 1990c). These facilities provide rentals, services, camping, guest docks, fuel, supplies and food. Demand for and use of these facilities continue to grow.

San Francisco Bay

The San Francisco Bay, though not part of the Central Valley, is an integral part of the Central Valley ecosystem. Runoff from the northern and southern Central Valley converges in the Delta prior to discharging to the ocean through the Bay, and anadromous fish traveling to Central Valley streams to spawn or returning to the ocean travel through the Bay.

Nine counties surround the San Francisco Bay: Marin, San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Solano, Napa, and Sonoma. In 1987, the Bay area became the fourth largest metropolitan area in the United States. The total 1988 population was about 5.8 million and is projected to reach 6.2 million by 1995 and 6.7 million by 2005.

Water requirements in the Bay area are met by local surface and ground water supplies, and imported surface water. The conveyance systems that bring the area the majority of its water are Hetch Hetchy, South Bay, North Bay, Mokelumne, Petaluma, and Santa Rosa–Sonoma aqueducts; Contra Costa and Putah South canals; Cache Slough Conduit; and the San Felipe Project. More than 60 percent of the water is imported from Delta supplies.

The San Francisco Bay area contains some 3,650,000 acres and includes the Russian River Basin and several smaller basins tributary to the Pacific Ocean as well as the San Francisco Bay system itself (USBR, 1970). The

San Francisco Bay system is composed of Suisun, San Pablo, and San Francisco bays (Figure 2–9). San Francisco Bay is the largest bay on the California coast, with a water surface area of about 420 square miles at mean high water, 274 miles of shoreline (not including islands), and about 130 square miles of adjacent tidal flats and marshes.

Suisun Marsh, one of the few major marshes remaining in California, is at the northern edge of Suisun Bay, just west of the confluence of the Sacramento and San Joaquin rivers. The area contains 58,600 acres of marsh, managed wetlands, and adjacent grasslands, plus 29,500 acres of bays and waterways. Most of the managed wetlands are enclosed within levee systems, and about 70 percent are privately owned by more than 150 duck clubs. DFG owns and manages 14,000 acres. Another 1,400 acres on the channel islands is owned by the federal government.

Waterfowl are the marsh's major wildlife. Ducks, geese, swans, and other migrant waterfowl use the marsh as feeding and resting areas. Species of ducks wintering in the area include pintail, shoveler, mallard, widgeon, greenwinged teal, ruddy duck, canvasback, scaups, gadwall, bufflehead, and scoter. Geese, though much less common than ducks, are represented by Canada, snow, and white–fronted species. As many as 25 percent of California's wintering waterfowl inhabit the marsh in dry winters. Waterfowl are attracted to the marsh by water and the abundance of natural food plants, most valuable of which are alkali bulrush, fat hen, and brass buttons. Growth of such plants depends on proper soil salinity, which is affected by salinity of applied water. Freshwater flows from the Delta into Suisun Bay and Marsh channels from October through May affect marsh salinities and waterfowl food production.

The marsh also supports 45 species of mammals, 15 species of reptiles and amphibians, and 230 species of birds. Two endangered species (salt marsh harvest mouse and California clapper rail), one threatened species (California black rail), and one species being proposed for protection (Suisun song sparrow) probably occur in Suisun Marsh.

Most fish in marsh channels are striped bass, for which the marsh is an important nursery area. Other anadromous species sometimes found in the marsh include chinook salmon, sturgeon, American shad, and steelhead trout. Catfish also support a sport fishery.

The Suisun Marsh is protected by several standards, agreements, and facilities (DWR, 1991a). Among them is Water Rights Decision 1485, which requires the SWP and CVP to mitigate their impacts on the marsh by meeting specific standards for the Sacramento River at Collinsville and seven other stations in the marsh. As allowed by Decision 1485, facilities have been constructed to provide water from internal channels to certain wetland areas. In addition, DWR, USBR, DFG, and the Suisun Resource Conservation District signed a Suisun Marsh Preservation Agreement in 1987 to assure that a dependable water supply will be maintained in the marsh to produce duck food and to preserve other habitat.

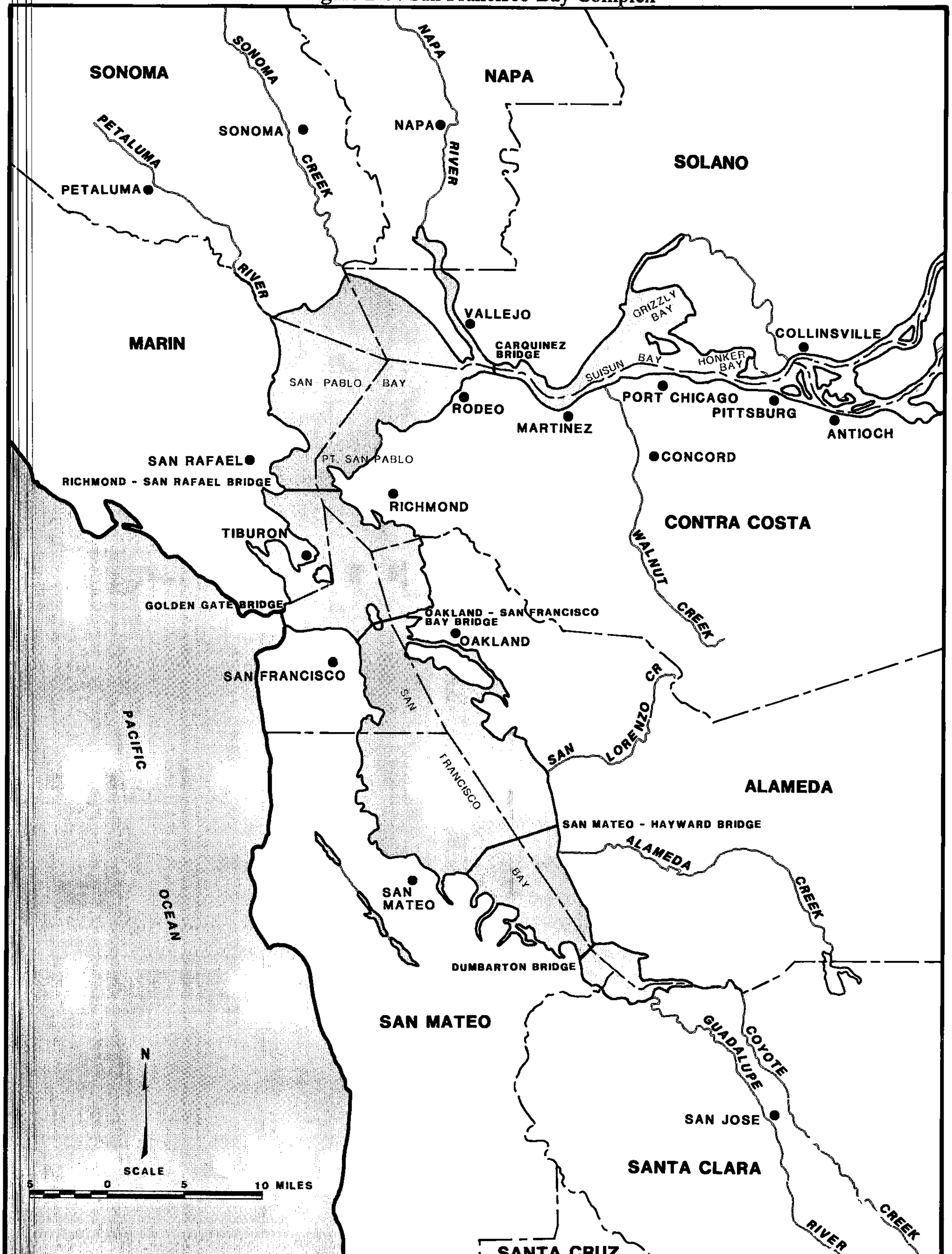
Hydrology. The surface hydrology of the San Francisco Bay can be divided into two distinct patterns. The northern bay, including San Pablo and Suisun bays, receives freshwater outflow from the Sacramento–San Joaquin Delta, and functions as part of the Delta–Bay estuary (USBR/DWR, 1985). The southern bay receives scant runoff, and behaves like a lagoon. Circulation in and flushing of the Bay depends on tides and Delta outflow. Circulation is primarily a tidal process, while flushing is believed to depend on tidal action supplemented by periodic Delta outflow surges following winter storms.

Freshwater outflow from the Delta to San Francisco Bay is believed to be important to maintaining desired environmental conditions in the bay, but no standards govern such outflow (USBR/DWR, 1985). High volume, uncontrolled outflow surges during the winter cause freshwater to penetrate well into the central bay, from which it can enter the southern bay by tidal exchange. Such events cause salinity stratification in much of the South Bay that can persist for several weeks or months following the initial appearance of freshwater.

Delta outflows vary greatly according to month and hydrologic year (DWR, 1991a). No Delta outflow has occurred during critically dry periods such as 1928 and 1934. Present summer Delta outflows are maintained by upstream reservoir releases. Delta outflow has averaged 24 million acre–feet over the period from 1977 to 1986, ranging from less than 2.5 million acre–feet in 1977 to more than 64 million acre–feet in 1983.

Other significant sources of freshwater inflow to San Francisco Bay are Alameda Creek, Napa River, Petaluma River, Coyote Creek, Guadalupe River, Walnut Creek, and Sonoma Creek. These tributaries have a total average annual inflow of about 350,000 acre–feet. Streamflow is highly seasonal, with more than 90 percent of the annual runoff occurring during November through April and very little flow during mid or late summer.

Figure 2-9. San Francisco Bay Complex



Water Quality. Depressed levels of dissolved oxygen in the extreme portions of South San Francisco Bay occur during the late summer and early fall months due to municipal waste discharges. Dissolved oxygen deficiencies also occur in the Petaluma and Napa Rivers. Algal growths have caused complete lack of dissolved oxygen in the extreme reaches of some tidal sloughs, creeks, and rivers. Recent years have brought red water discoloration caused by marine ciliates, a phenomenon probably aggravated by high nutrient concentrations.

Fish kills have occurred in the Bay system as the result of accidental spills of toxic materials and inadequately treated sewage and industrial waste discharges. Localized fish kills involving large numbers of striped bass have occurred in Suisun Bay from unknown causes.

Pesticides in the Bay system originate from municipal storm sewer and sanitary sewerage systems, urban runoff, and drainage from the vast agricultural lands in the Central Valley. The presence of these pesticides is a threat of unknown magnitude to the fisheries and wildlife resources.

The San Francisco Bay area has experienced oil pollution problems mainly localized at refinery docks, ports, marinas, and near storm sewer outlets attributable to accidental spills, deliberate discharges, pipeline leaks, and pumping of oil bilge or ballast water.

Much of the Bay contains coliform bacteria levels greater than those recommended for water contact sports. Substantial improvement has been reported since initiation of chlorination of the discharge from a large municipal sewerage system.

Wildlife and Fish. The bays and surrounding lands support a wide variety of migratory birds, mammals, and fish. Habitat types in the bay include open water, tidal mudflats, and marshland. These habitats are used by various species, especially shorebirds and waterfowl. The anadromous species of fish include chinook salmon, striped bass, sturgeon, American shad, and steelhead trout (DWR, 1991a). Marine fish, found mainly in the lower bays, include flatfish, sharks, and surf perch. Other popular sport fish include jacksmelt and topsmelt. Shellfish in the San Francisco bays include mussels, oysters, clams, crabs, and shrimp.

Seasonal variations in salinity in the bays, due to varying Delta outflows, affect the seasonal distribution of fish and invertebrates. Benthic invertebrates, such as clams, are limited to areas where conditions are favorable year-round. There is no commercial oyster industry in San Francisco Bay although it was a thriving business at one time (USBR, 1970). There is sport clamming, although coliform bacteria concentrations are higher than the Public Health Service and State allowable limits.

CVP and SWP operations have little observable effect on wildlife of the bay, except in Suisun Marsh (USBR/DWR, 1985). Seeds of the alkali bulrush plant constitute the bulk of the winter food supply for waterfowl using the marsh. Production of alkali bulrush seeds is related to salinity of water in the marsh, which is determined in part by project operations. Coordinated operation of the CVP and SWP maintains high alkali bulrush seed production and germination throughout the marsh.

Rare, threatened, or endangered animal species found in the area include the Alameda striped racer, salt marsh harvest mouse, San Francisco garter snake, California clapper rail, California black rail, and California yellow-billed cuckoo.

Recreation. Mild temperatures and brisk winds make San Francisco Bay a favorite recreational boating area. More than 150,000 recreational boats were registered in the Bay Area in 1987. Other water oriented recreation includes sight seeing, picnicking, fishing, nature walking, and camping.

San Joaquin River Basin

The San Joaquin Valley, extending from the Tehachapi Mountains in the south to the Sacramento-San Joaquin Delta in the north and from the crest of the Sierra Nevada to the Coast Ranges, comprises two hydrologic regions: the San Joaquin River and Tulare Lake. The San Joaquin River Basin comprises the northern part of the San Joaquin Valley (DWR, 1991a). The basin encompasses about 7,017,000 acres (USBR, 1970).

The San Joaquin Valley area is a rich agricultural region. The valley's long growing season, mild and semi-arid climate, good soils, and available water provide conditions suitable for a wide variety of crops. Major crops include cotton, grapes, tomatoes, hay, sugar beets, and various orchard and vegetable crops (DWR, 1991a). Agriculture and closely related industries provide the economic base that supports a large and growing population, which increased from 1.7 million in 1970 to 2.5 million in 1985. Urban areas include Fresno, Bakersfield, Visalia, and Modesto.

CVP and SWP Operations. Local water supplies are unable to meet demands in the San Joaquin Valley. Supplemental water is imported to the San Joaquin basin from the Delta. Deliveries of SWP and CVP water pumped from Clifton Court Forebay in the Delta flow south in the California Aqueduct and Delta–Mendota Canal to the San Luis facilities.

San Luis Facilities. The primary goal of the CVP portion of the San Luis facilities is to furnish supplemental irrigation supplies for fertile farmland in the arid western portions of Merced, Fresno, and Kings counties, which contain a gross area of about 600,000 acres on the west side of the San Joaquin Valley (USBR, 1972). Most of the area drains to the sea by way of the lower San Joaquin River through waterways of the Delta and into San Francisco Bay, but the southern portion drains southward to the closed Tulare Lake basin.

The SWP portion of the San Luis facilities links the California Aqueduct from O'Neill Forebay to Kettleman City. This link serves water requirements in the San Joaquin Valley service area primarily in Kern and Kings counties and a very small area in Stanislaus County (DWR, 1991a). (Water is also imported to the southern San Joaquin Valley via the CVP's Friant–Kern Canal, and CVP water is transported through the California Aqueduct to Kern County under an agreement between USBR and the State). This service area is in one of the most productive agricultural regions in California. In part of the area on the west side of the valley, the quantity and quality of ground water supplies are poor, and local surface streams are practically nonexistent. With water, however, and the favorable climate, much of the area is conducive to production of a wide variety of orchard, vineyard, and truck and field crops. The two major river drainages in the service area are the Kings and Kern rivers.

Surplus flows from the Delta during the winter and spring flow about 70 miles to O'Neill Forebay in the SWP California Aqueduct or are pumped from the Delta–Mendota Canal at the CVP's O'Neill Pumping Plant. Water is pumped into San Luis Reservoir from the O'Neill Forebay by the San Luis Pumping–Generating Plant. The O'Neill Dam and Forebay provides storage necessary to permit off–peak pumping and on–peak electrical power generation.

When Delta flows cannot supply the State and federal water projects, water is released back into the forebay to flow southward in the San Luis Canal or Delta–Mendota Canal. The reservoir can store a total of 2,038,771 acre–feet; 1,067,908 acre–feet is the State's share. O'Neill Forebay stores 56,426 acre–feet.

The San Luis Canal carries both CVP and SWP water 102 miles south to Kettleman City in the southern San Joaquin Valley (USBR, 1972). At mile 15.8 of the canal, the Dos Amigos Pumping Plant, with a capacity of 13,200 cfs, lifts water an average of about 125 feet permitting a gravity flow to the end of the canal. The initial San Luis Canal capacity is 13,100 cfs and reduces to 8,350 cfs in the last reach. The State's share of the canal is 7,000 cfs which is delivered into the southern portion of the SWP's California Aqueduct at Kettleman City.

Two detention dams control stream cross drainage and provide flood protection for the San Luis Canal. Los Banos Dam, on Los Banos Creek about 7 miles southwest of Los Banos, is an earthfill structure about 154 feet high and 1,370 feet long. The Los Banos Detention Reservoir has a storage capacity of about 34,500 acre–feet and a surface area of about 640 acres. Besides protecting the San Luis Canal, it provides flood protection to the town of Los Banos and vicinity. The Little Panoche Detention Dam and Reservoir are located on Little Panoche Creek south of Los Banos Creek. The dam is an earthfill structure with a height of 121 feet above streambed and a crest length of 1,440 feet. The storage capacity is 5,600 acre–feet with a surface area of 190 acres.

Before reaching Kettleman City, some CVP water is diverted into the Pleasant Valley Pumping Plant (USBR, 1972). The plant raises water 180 feet at the rate of 1,050 cfs into the 12 mile long Coalinga Canal, which serves farmland in the southwestern section of the San Luis service area and also delivers water to the city of Coalinga for municipal and industrial uses.

At Kettleman City, water is pumped by the SWP's Las Perillas and Badger Hill Pumping Plants into the Coastal Branch Aqueduct. This short aqueduct serves agricultural areas to the west of the California Aqueduct, and may eventually be extended to serve Santa Barbara and San Luis Obispo counties.

The Buena Vista, Wheeler Ridge, and Wind Gap Pumping Plants raise water another 944 feet in the California Aqueduct before reaching the foot of the Tehachapi Mountains. At the Tehachapis, the A. D. Edmonston Pumping Plant raises the water 1,926 feet in a single lift to enter 8.5 miles of tunnels and siphons. From this Tehachapi Crossing, the water flows into the Antelope Valley for use in Southern California.

CVP water released from the San Luis Canal is delivered throughout the 600,000–acre service area by an underground distribution system (USBR, 1971). Underground drainage collection systems had been constructed to convey irrigation subsurface drainage from individually owned on–farm drainage systems, predominantly along the eastern portion of the service area, to the San Luis Drain. The drain was planned to collect and transport drainage water from near Kettleman City to the western edge of the Delta near Antioch, but was not completed and terminates at the Kesterson Regulating Reservoir near Los Banos. The drain was plugged in 1986 due to toxic accumulations of selenium in the reservoir.

San Felipe Division. The San Felipe Division of the CVP is located in the central coastal area of California and includes the Santa Clara Valley in Santa Clara County, the northern part of San Benito county, the southern part of Santa Cruz County, and the northern edge of Monterey County (USBR, 1988). The principal facility associated with this unit is the Pacheco Tunnel, which connects the service area of this division to San Luis Reservoir. Other facilities include Coyote Afterbay Dam, San Justo Dam, Hollister Conduit, Pacheco Conduit, Santa Clara Tunnel and Conduit, and various pumping plants and switch yards.

New Melones Dam and Reservoir. New Melones Dam, on the Stanislaus River about 60 river miles upstream from the confluence with the San Joaquin River, is operated by USBR as part of the CVP. Capacity of the dam is 2,400,000 acre–feet.

About 450,000 acre–feet of storage space in New Melones Reservoir is used for flood control. By year 2020, 131,000 acre–feet of water per year from New Melones may supplement existing water supplies within the Stanislaus River basin and 49,000 acre–feet will be allocated to the Central San Joaquin Water Conservation District. Up to 70,000 acre–feet are used to maintain water quality in the Stanislaus and San Joaquin rivers and 98,000 to 148,000 acre–feet are allocated for fish.

Friant Dam. Friant Dam is a CVP facility on the San Joaquin River, about 25 miles northeast of Fresno. It impounds Millerton Lake, which has a capacity of 520,000 acre–feet. The 150 mile Friant–Kern Canal diverts water southerly from Friant Dam to the southern San Joaquin Valley. The Madera Canal, about 36 miles long, diverts water northerly from the dam.

Before the Friant Dam was built, the water captured in Millerton Lake was used downstream by diverters along the San Joaquin River. These San Joaquin River flows have been replaced by Sacramento River water imported from the Delta and delivered to the San Joaquin Valley through the Delta–Mendota Canal.

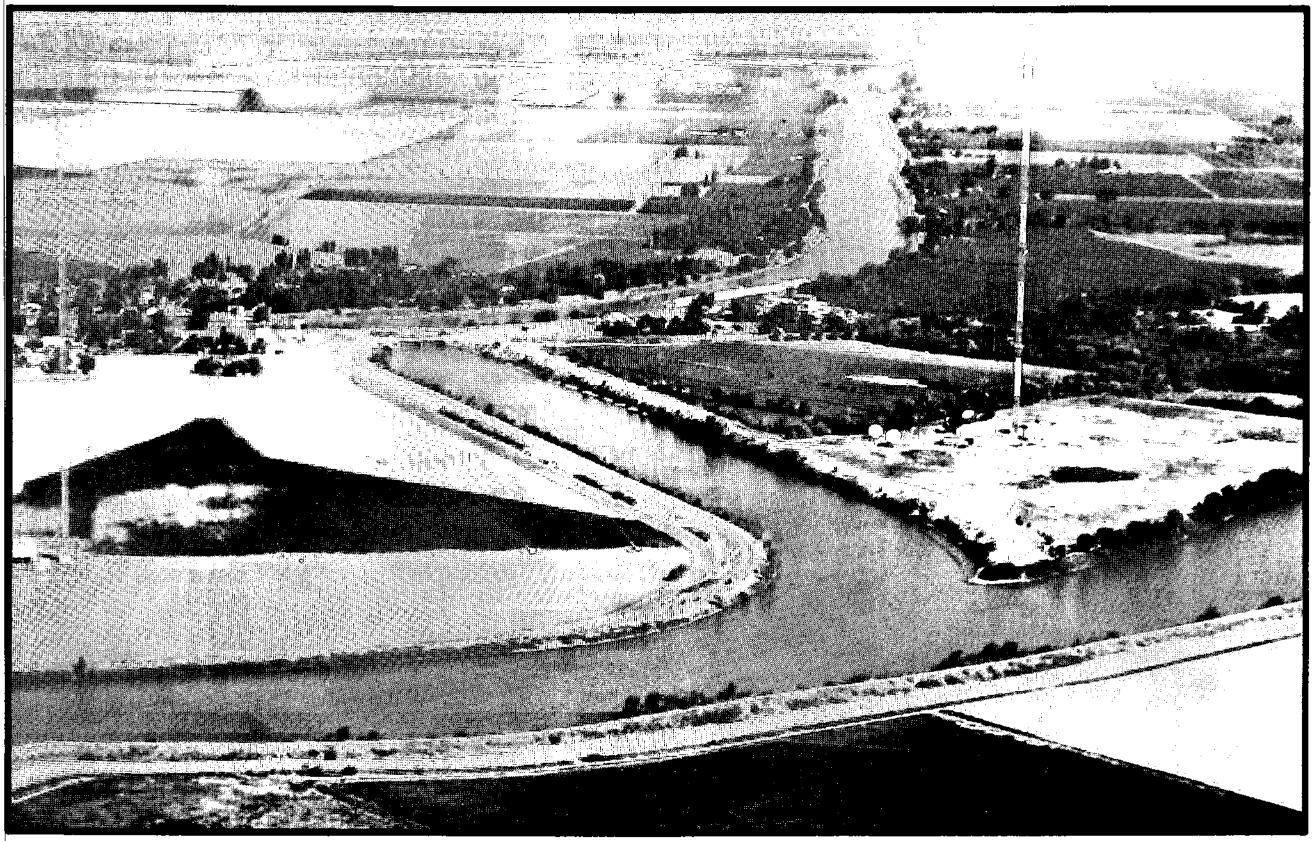
Cross Valley Canal. Kern County Water Agency's Cross Valley Canal is part of a delivery system used to supply CVP water from the Delta to agricultural users near Bakersfield. CVP water delivered to these customers is water from Millerton Lake, delivered through the Friant–Kern Canal, that would otherwise be delivered to the Arvin–Edison Water District, south of Bakersfield. By delivering Delta water to the Arvin–Edison Water District through the Cross Valley Canal, the Friant–Kern water is released for use north of Bakersfield.

Water for the Cross Valley Canal is captured in federal reservoirs north of the Delta and delivered down the Sacramento River system for diversion from the Delta. However, the CVP's Delta–Mendota Canal is too small to carry the extra water from the Delta to O'Neill Forebay, and the San Luis Canal (the federal–State segment of the California Aqueduct) ends at Kettleman City. The Cross Valley Canal intercepts the California Aqueduct 65.7 miles south of Kettleman City, at Tupman. CVP water must be wheeled 63.4 miles through the California Aqueduct from the Banks Pumping Plant to O'Neill Forebay and 65.7 miles from Kettleman City to Tupman.

Climate. The San Joaquin Valley is semiarid, characterized by hot, dry summers and mild winters except for the highest altitudes (CVRWPCB, 1957). In the mountains, summer days are warm and nights cool but winter temperatures are often severe with heavy snowfall.

The summer droughts are the result of a subtropical high pressure belt located off the coast which prevents summer rainfall. In winter, the high pressure area moves to the south and allows Pacific storms to move inland and deposit moisture on the watershed. The storm centers generally pass well to the north so that the extreme southern end of the valley receives little moisture. The mild winter climate is due to the moderating effects of the Pacific Ocean on the one side and of the high barrier of the Sierra Nevada which protects the basin from the cold air masses of the interior on the other side.

The valley floor is free of frost during the growing season, with the average frost–free period being from eight to nine months. A frost–free belt extends along the Sierra Nevada foothills from Fresno County southward, providing a suitable area for citrus and other frost sensitive crops. Maximum summer temperatures are in the neighborhood of 110°F and minimum winter temperatures may fall below 25°F. Relative humidities are low in summer.



Water from the 1991 and 1992 Drought Water Bank was transported through Delta channels to water users.

The year is divided into two distinct seasons: wet and dry. The major portion of the precipitation occurs in the winter season from November to April with rain at the lower elevations and snow in the higher regions. Topography and latitude are the major factors controlling precipitation in the basin. Heaviest precipitation occurs on the west slope of the Sierra Nevada and in general increases with altitude up to about 7,000 feet and then tends to decrease with increased elevation. Precipitation also decreases from north to south with lower means in the southern portion of the watershed areas. Precipitation is scanty on the valley floor with means ranging from 14 inches at Stockton to 4 inches at Buttonwillow.

Land Use. Most of the lands of the San Luis service area occupy the gently sloping coalescing alluvial fans laid down by creeks emerging from the Coast Range (USBR, 1972). These soils rank among the highest in the San Joaquin Valley in potential productivity and adaptability to a wide variety of high valued crops. Over 70 percent of the acreage has been classified by USBR as highly productive class 1 and 2 lands, 15 percent as moderately productive class 3, 12 percent as marginally productive class 4, and only about 3 percent as poor or unproductive class 6. In general the higher portions of the area have permeable medium–textured soils which are class 1 and 2. In the lower portions, the soils become finer textured, slowly permeable and have increasing accumulations of water soluble salts, and shallow water tables. The excellent soils coupled with a long, hot growing season make the area ideal for farming operations.

Agriculture is the major economic activity in the San Luis service area. The predominant crops are irrigated grain, cotton, alfalfa seed, field crops, melons, and small but increasing acreages of deciduous orchards. Some of the nonirrigated lands are used for dry farm grain and native pasture. Most of the area is in large landholdings, and large scale farming prevails. Except for packing sheds, cotton gins, auction yards, and similar activities directly related to the marketing of agricultural products, there are no industrial or commercial enterprises of significance. The Lemoore Naval Air Station occupies about 18,000 acres of which 14,000 are used for agricultural production. South of the service area several oil fields have been developed. The communities of Avenal and Coalinga exist chiefly to support the oil operations in the immediate vicinity.

Oil production has been relatively stable in this area and the known reserves are considered sufficient to maintain such level of activity for many years.

Agriculture and the oil industry are the primary economic activities in the San Joaquin Valley service area. Crops raised in the region include alfalfa, barley, safflower, sugar beets, fruits, vegetables, nuts, cotton, sweet potatoes, cantaloupe, and grapes. Beef cattle, dairy products, and poultry are also significant. Other sources of income include manufacturing, trade, services, and government. Despite substantial variations in annual SWP deliveries, total irrigated acreage in the San Joaquin service area does not normally fluctuate. Farmers rely heavily on ground water pumping in dry years and local surface water diversions in wet years to maintain the same irrigated acreage.

Surface Water Hydrology. Surface water serves about two–thirds of the region and ground water the remainder. Water to the valley from the Sierra Nevada is limited and there is an annual overdraft of ground water.

The main stem of the San Joaquin River rises on the western slope of the Sierra Nevada at elevations in excess of 10,000 feet (CVRWPCB, 1957). From its source, the river flows southwesterly until it emerges onto the valley floor at Friant. The river then flows westerly to the center of the valley near Mendota, where it turns northwesterly to join the Sacramento River at the head of Suisun Bay. The main stream has a length of about 300 miles, one–third of which lies above Friant Dam.

Principal tributaries to the San Joaquin River on the east side of the basin include the Stanislaus, Tuolumne, Merced, Chowchilla, and Fresno rivers. In the Delta, the Cosumnes, Mokelumne, and Calaveras rivers become part of the San Joaquin River. These Sierra streams provide the northern part of the San Joaquin Valley with high quality water and most of its surface water supplies (DWR, 1991a). Most of this water is regulated by reservoirs and used on the east side of the valley, but some is diverted across the valley to the Bay area via the Mokelumne and Hetch Hetchy aqueducts. The New Don Pedro Dam impounds flows on the Tuolumne River, while the New Exchequer Dam impounds those of the Merced River. On the west side of the basin, streams include Hospital, Del Puerto, Orestimba, San Luis, and Los Banos creeks. Streams flowing into the valley from the west are intermittent, often highly mineralized, and contribute little to water supplies.

Runoff from the watersheds of both the major and minor streams in the San Joaquin River basin show wide seasonal, monthly, and daily variations modified by the effects of storage, releases from storage, diversions, and return flows. Flows on the main stem of the San Joaquin River are regulated by operations of Friant Dam.

Partial stream regulation of tributary streams is afforded by Pardee Dam on the Mokelumne, Melones, Donnells, and Beardsley dams on the Stanislaus, Hetch Hetchy and Don Pedro dams on the Tuolumne, and Exchequer Dam on the Merced. In addition, there are a number of power and irrigation developments on these streams which serve to regulate and modify the natural runoff.

Streamflows are depleted by diversions and increased by drainage and return irrigation flows along the stream courses. Streamflows in the Delta are influenced by tidal action and diversion to the Delta–Mendota Canal. During the long dry season, the smaller streams often have no flows, and no flows may occur below diversion points on the larger streams at times. Lowest flow conditions usually occur just prior to the advent of the rainy season which generally gets underway in late November.

Ground Water Hydrology. In the San Joaquin River basin, 26 ground water basins and areas of potential ground water storage have been identified (DWR, 1975a). Nine basins have been identified as significant sources of ground water. The total area of these nine basins is about 13,700 square miles, of which the San Joaquin Valley alone occupies 13,500 square miles and is the largest ground water basin in the State.

The maximum thickness of fresh water bearing deposits (4,400 feet) occurs at the southern end of the San Joaquin Valley just north of Wheeler Ridge. Estimated storage capacity between depths of 0 and 1,000 feet is over 570 million acre–feet. The estimated usable storage capacity exceeds 80 million acre–feet. The principal factors limiting development are water quality and the high cost of pumping. Estimated storage capacity in three of the smaller basins is about 475,000 acre–feet.

Ground water temperatures range from about 45 to 105°F. TDS content of the water varies from 64 to more than 10,000 mg/L. Significant portions of the ground water in the basin exceed the recommended TDS concentrations in the Public Health Service Drinking Water Standards. The predominant water type varies from aquifer to aquifer and the source of recharge. The character of the water on the east side of the valley is predominantly sodium–calcium bicarbonate. Water on the west side principally contains sodium sulfate. Some areas also have excessive boron concentrations.

Subsidence in the San Joaquin Valley due to ground water extraction began in the mid–1920s. In 1942, 3 million acre–feet were pumped for irrigation, but by 1970, pumping for irrigation exceeded 10 million acre–feet. As a result, water levels in the western and southern portions of the valley declined at an increased rate during the 1950s and 1960s. By 1970, 5,200 square miles of valley land had been affected, and maximum subsidence exceeded 28 feet in an area west of Mendota.

Total annual net water use was projected to increase by about 680,000 acre–feet by the year 2010, including 480,000 acre–feet in agricultural use and about 170,000 acre–feet in urban use (DWR, 1983). Delivery of CVP supplies from New Melones and Folsom reservoirs and the Sacramento–San Joaquin Delta would provide about 440,000 acre–feet of the increased demand. The remaining net use is expected to be supplied from increased ground water overdraft of about 290,000 acre–feet annually.

Much of the Los Banos–Kettleman City subsidence area is now served by the San Luis Unit of the CVP. Since 1968, as more State and federal water has been used for irrigation, water levels have been recovering. In one instance, the rise in piezometric level exceeded 200 feet, and in about three–fourths of the area the rise has been over 100 feet. In the future, if full contractual CVP deliveries are made, subsidence in this area is expected to cease. Since 1971, SWP deliveries to some parts of the Wheeler Ridge–Maricopa Water Storage District in Kern County have resulted in a ground water level recovery of as much as 75 feet.

Since the area will continue to rely on ground water as a source for irrigated agriculture, water agencies are attempting to alleviate the overdraft conditions through artificial recharge and conjunctive use programs. Immediate problems caused by overdrafting are localized land subsidence, water quality degradation near Stockton from salt water intrusion, and higher pumping costs.

Water Quality. The major water quality problems of streams on the valley floor are large salt loads associated with irrigation and nutrients from municipal, industrial, and agricultural sources (USBR, 1970). Major portions of basin streams are reaching an undesirable state of nutrient enrichment. Prolific aquatic plant and algal growths are causing detriments to beneficial water uses. Aquatic plants have on occasion nearly blocked reaches of the lower Stanislaus River and have interfered with recreational uses. Diurnal fluctuation of dissolved oxygen due to the presence of large algal concentrations and partially treated municipal and industrial wastes have contributed to fish kills in the Stanislaus, Tuolumne, and San Joaquin Rivers. Other water quality problems include excessive coliform levels, pesticide concentrations, and turbidity.

Generally, water quality in the mainstem of the San Joaquin River is degraded downstream from Friant Dam during summer and fall months of all water years. High salt concentrations in the lower reaches of the San Joaquin River and its major tributaries arise from upstream diversion of natural flow and the large volumes of drainage, waste waters, and return flows which, directly or indirectly, find their way into the surface drainage. At times, the entire flow under certain conditions is comprised of used waters. The agricultural return water is estimated to carry a total annual salt load of 740,000 tons to the Sacramento–San Joaquin Delta. Although the water in the lower San Joaquin River is still usable for agriculture, severe crop damage has been occasionally experienced. Moreover, greater volume of applied water is needed to leach the greater amount of accumulated salts in the soil system. Increasing drainage problems have been associated with the increase in salt concentration.

Conductivity, boron, and other mineral concentrations are higher in dry or critical years due to a lack of dilution flows. This situation has imposed a slight to moderate degree of restriction on use of river water for irrigation (Westcot et al. 1992). Water quality characteristics present during the 1991 water year are typical of critical year conditions. Electrical conductivity ranged to 3,420 μmhos/cm in the upper reaches downstream from Friant Dam. Conditions improved somewhat at the downstream end, where conductivity ranged to 1,680 μmhos/cm. Water quality improves somewhat during a wet year, as in 1986 when conductivity ranged to 930 μmhos/cm in the upper portion and to 980 μmhos/cm in the lower portion of the river.

Boron concentrations during 1991 ranged to 0.75 mg/L in the upper area and to 1.2 mg/L in the lower reach.

Among the trace elements analyzed during 1991, median selenium values frequently exceeded EPA ambient water quality criteria of 5 μg/L for the protection of aquatic life in the middle portions of the river, and routinely exceeded the primary drinking water standard of 10 μg/L. Elevated molybdenum concentrations in the upper river have been consistently found during the previous five critically dry years. The molybdenum is apparently derived from ground water seepage entering the river since the site where this element has been found is upstream from the discharge of tile drainage (Westcot et al. 1992).

Generally, water quality in the Merced and Stanislaus rivers is good. Typically, water quality decreases somewhat during the late summer as natural flows to the river decrease and poorer quality flows such as agricultural return flows increase. The Merced and Stanislaus rivers, though contributing freshwater flows year round, do not have sufficient flows during summer and fall months to dilute the poor quality of the mainstem San Joaquin River.

The Tuolumne River generally has good quality through much of the year. However, in late summer and fall, when natural flows to the river decrease and lesser quality water such as agricultural return flows increase, water quality conditions are less than optimum. A contributor to the salt load of the basin is the saline water from abandoned gas wells on the Tuolumne River. The impact of this waste is such that the Tuolumne River at its mouth has about four times the salt concentration of similar adjacent rivers.

Vegetation. A major portion of the San Luis service area has been developed for some type of cropping (USBR, 1972). On the undisturbed portions, native vegetation consists of sagebrush, saltbrush, Russian thistle, and similar cover common to semiarid regions. In years of average or better rainfall, some wild oats, brome grass, and other native grasses prevail near the foothills. Native wildflowers which previously grew within the San Luis Reservoir area were transplanted to areas above the water surface.

Much of the native vegetation in the San Joaquin Valley service area has been replaced by introduced species or disturbed by cultivation or grazing. Major natural vegetation classes found within the valley include grassland, sagebrush shrub, coastal shrub, and hardwood forest–woodland.

Wildlife and Fish. Food and cover for native wildlife are limited (USBR, 1972). The hot, dry climate of the west side of the San Joaquin Valley limits vegetation on the valley floor mostly to sagebrush, tumbleweed, and some grasses, except in a few draws and creek channels. The foothills of the Coast Range are also dry and mostly treeless except in a few creek bottoms. Some wildlife cover plantings along the San Luis Canal have provided additional wildlife habitat.

Irrigated farming for several decades throughout the area has provided habitat for pheasants, while doves do well in the drier areas. Some quail live in and near the draws. Chuckar partridges have been introduced in the foothills above the service area and are thriving in the Panoche Creek area. They also occur in small numbers in Little Panoche and Los Banos Creek areas, as well as elsewhere where seeps provide water and atriplex herbs provide cover. A few badgers, skunks, and kit foxes survive on a diet of rodents and insects. Coyotes are present and so are jack rabbits. While deer inhabit the higher elevations, few ever visit the valley floor.

In the trough of the San Joaquin Valley between Mendota and Gustine are tens of thousands of acres of excellent waterfowl land. These constitute an important station along the Pacific Flyway, providing about 50 million waterfowl use–days per year (USBR, 1972). Drainage flows are an appreciable percentage of the water supply for this area and are used to grow feed and cover crops and provide resting ponds for the heavy waterfowl usage of this area. Additional feed and resting ponds had been provided by the construction of the Kesterson Regulating Reservoir. However, selenium concentrations that have increased to toxic levels have resulted in abandonment of the Kesterson Regulating Reservoir as a waterfowl refuge.

Despite the conversion of much of the San Joaquin Valley service area to agricultural uses, the wildlife populations of the service area remain extremely diversified. Sizable populations of wildlife can be found in the fringe areas of the service area. Most native fish populations, however, have been eliminated by drainage projects and modifications of natural watercourses. They are now confined to farm ponds, drainage canals, and aqueducts. A good warmwater and striped bass fishery has developed in San Luis Reservoir, O'Neill Forebay, Los Banos Reservoir, and the San Luis Canal since operation of the San Luis Unit started in 1967.

Anadromous fish species, including salmon, striped bass, and shad, occupy the Delta at the height of the pumping season and are affected by pumping to the San Joaquin Valley facilities. Resident fish species, including black bass, crappies, bluegill, and catfish, are not affected to any great extent since they do not have the migratory instinct and do not move downstream as part of their life cycle. With year–round pumping from the Delta, the hazard to Delta fishery is no longer merely seasonal as it was prior to operation of the San Luis Unit. Losses of anadromous fish, particularly striped bass and shad, occur in the Delta because their young are so small when first hatched that it is virtually impossible to screen them out of the pumping plants. The CVP's Tracy Fish Collecting Facility achieves an efficiency of up to 90 percent in salvaging salmon and striped bass over an inch in length by use of a louver-type fish diversion and collector. The SWP's Delta Pumping Plant uses a similar collection system. Fish screens are not needed at the O'Neill Forebay or at the lift into San Luis Reservoir since it is desirable that fish be diverted into them for restocking the forebay, reservoir, and San Luis Canal.

The only anadromous fishery in the San Joaquin River is a fall run of chinook salmon to tributary streams; no spawning occurs on the mainstem. Fall run populations in the Merced, Tuolumne, and Stanislaus river tributaries are now at dangerously low levels. The cumulative effects of six years of drought, poor water quality, habitat deterioration, water diversion, and ocean harvest have caused greatly reduced population levels. However, these low levels have occurred previously. The population rebounded in the 1980s in response to high flows.

Adult salmon migrating to spawning grounds face high temperatures, low dissolved oxygen in sections of rivers, and lack of attractant flows in the mainstem and tributaries. A temporary barrier is installed each fall by DWR at the head of Old River to improve water quality and help adult salmon migration in the lower reaches. Inadequate conditions for spawning, egg incubation, emergence, and juvenile rearing include high water temperatures, water diversion entrainments, deteriorated spawning habitat, low flows, and high predation rates. Emigrating smolt losses can be attributed to high water temperatures, low flows, high predation losses, unscreened water diversions, and SWP and CVP diversions.

Based on observations that high spring flows result in large spawning runs two and a half years later and that low spring flows are accompanied by warmer water temperatures, DFG believes that the emigrating salmon smolts in the San Joaquin River are subject to high chronic thermal stress. Temperatures in the river increase from April to June, which is the period of smolt emigration. Adults migrating up the San Joaquin River in September through December must also deal with warm water temperatures which can range in the mid-70s in September and October.

There are no minimum flow requirements for the mainstem of the San Joaquin River. There are often no flows in the mainstem itself beyond those flows originating in the three major tributaries (Merced, Tuolumne, and Stanislaus rivers) plus agricultural and municipal drainage. Prior to the construction of New Melones Dam on the Stanislaus River, agricultural drainage was such a large percentage of the flow that salinity increased in the mainstem above the Delta.

Minimum flows are maintained on the Merced River below Exchequer Dam and the Tuolumne River below New Don Pedro Dam by Federal Energy Regulatory Commission licensing requirements. On the Stanislaus River, SWRCB permits require that 98,000 acre-feet from New Melones Dam be released on a fisheries schedule. An agreement between DFG and USBR, which operates New Melones Dam, requires an interim streamflow on schedules determined by DFG on a sliding scale based on water year type using between 98,000 and 302,000 acre-feet per year.

The only rare or endangered species known to be in the general area affected by the San Luis Unit are the San Joaquin kit fox, California condor, blunt-nosed leopard lizard, and giant garter snake. The current range of the San Joaquin kit fox has been delimited as extending from the Tehachapi Mountain foothills surrounding the southern end of the San Joaquin Valley, north along the foothills of the western San Joaquin Valley almost to the Delta, and on the eastern edge of the valley north to about 20 miles south of Porterville. The only extensive occurrence on the valley floor proper is in the southwestern portion wherever native vegetation remains. The range contains about 3,000 square miles of appropriate habitat skirting along the southwestern edge of the San Luis service area. The San Luis service area overlaps the kit fox range on about 150 square miles, or about 5 percent of the total range.

Several years ago, all remaining wild California condors were captured and transferred to zoos for captive breeding. In 1991, the first pair of condors was released back into the wild, where they spent most of their time in remote areas of the Los Padres National Forest north of Los Angeles. During early October 1992, one of the birds had died. Six additional condors raised in captivity were released to the National Forest in December 1992. The Los Padres National Forest is near the southern boundary of the San Joaquin Valley. The former feeding range of the California condor extended along the Diablo Range (western rim of the San Joaquin Valley) north to the headwaters of Los Banos Creek, about 10 miles south of the latitude of the town of Los Banos. At no location does the San Luis service area overlap the former feeding range of this endangered species.

The blunt-nosed leopard lizard occurs in scattered locations in the San Joaquin Valley, in the foothills of

Tulare and Kern Counties, and up the eastern portions of the Coast Range foothills, over an area of about 16,200 square miles. It inhabits sparsely vegetated plains, alkali flats, low foothills, grasslands, canyon floors, large washes, and arroyos. It is absent or scarce in areas of heavy vegetation or tall grass. The San Luis service area falls within the range of this reptile but comprises less than 6 percent of its total range. This lizard is classified as endangered by both State and federal agencies.

The giant garter snake is classified as threatened by the State. This snake lives on the floor of the Central Valley from Sacramento and Antioch southward to Buena Vista Lake. It is one of the most aquatic of garter snakes and is confined to areas around permanent freshwater. Its range is about 11,300 square miles. The San Luis service area occupies about 8 percent of the total area inhabited by this snake.

Recreation. San Luis Reservoir, O'Neill Forebay, and Los Banos Reservoir offer good boating and fishing most of the year. Beach developments, particularly on the forebay, have been popular. Picnicking, swimming, waterskiing, hunting, and camping are activities afforded by the reservoirs. Recreational development is jointly funded by the federal and State governments, but is managed by the Department of Parks and Recreation.

Along the California Aqueduct, many miles of walk–in fishing sites have been provided, and a stock of many kinds of fish has developed from fish and eggs surviving the CVP and SWP pumps. There are also 170 miles of bikeways along the Aqueduct.

Tulare Basin

The Tulare Basin is one of the richest agricultural regions in the United States. The highly developed agricultural economy of the basin is dependent upon runoff from the Sierra Nevada, import from basins to the north, and ground water to supply its water needs.

Total annual net water use in the Tulare Basin is projected to increase about 840,000 acre–feet by the year 2010, including 700,000 acre–feet of agricultural use and 110,000 acre–feet of urban use (DWR, 1983). The additional needs are expected to be met by a small increase in CVP supplies, additional waste water reuse, and a substantial increase in ground water overdraft.

Surface Water Hydrology. The Tulare Basin hydrologic area, which has a land area of 11,076,000 acres, includes all San Joaquin Valley stream basins between Fresno and Bakersfield that drain into Tulare Lake rather than northward into the San Joaquin River (USBR, 1970).

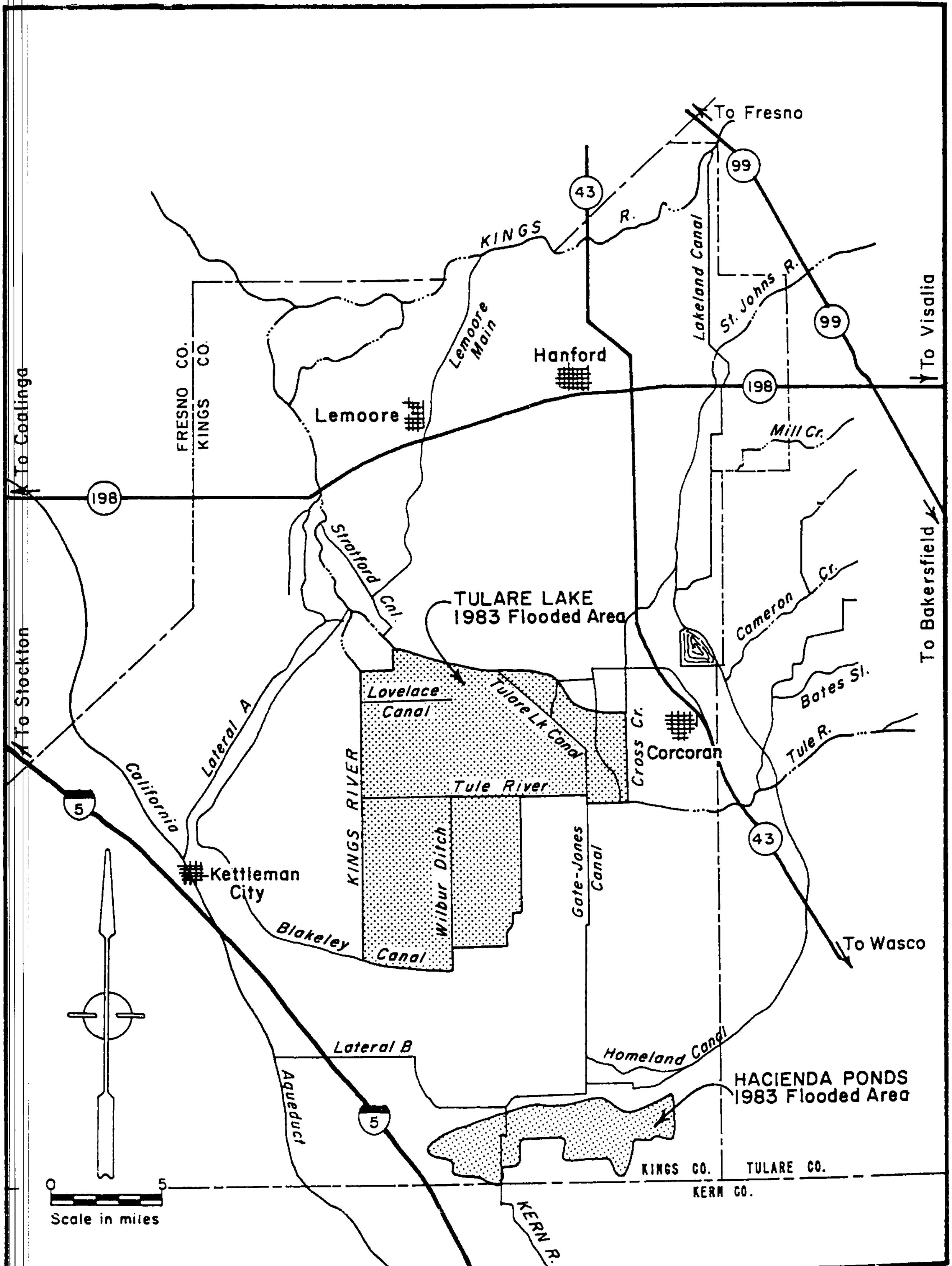
Part of the flood flow of the Kings River is tributary to the San Joaquin River by way of Fresno Slough. Before irrigation development, Tulare Lake also overflowed into the San Joaquin River during periods of extreme flood. The Kings River, which carries eroded material from the Sierra Nevada, has built up a low, broad ridge across the trough of the valley so that the Tulare Basin has essentially no surface water outlet. Principal streams flowing into the Tulare Basin in addition to the Kings River include Kaweah, Tule, and Kern rivers, which drain from the Sierra Nevada (Figure 2–10). Dams on all these rivers provide flood control and water supply for ground water recharge and urban and agricultural uses. No large streams enter the basin from the coastal ranges or the Tehachapi Mountains.

Tulare Lake tributaries are heavily used for irrigation, with little water reaching the lake. Water entering Tulare Lake Basin that forms Tulare Lake is from excess flood water from the Kings, Kaweah, Tule, and to some extent, the Kern River. Floods are not an uncommon occurrence, but are variable in intensity and frequency (DFG, 1987). Levees have been built to contain the water in cells to maximize farming possibilities in the basin. Flood waters collected in the basin are used for irrigation. Other means of disposal include evaporation, some ground water recharge, and recently by pumping out of the basin. In extreme flood conditions, water can flow out of the basin through the Kings River to the San Joaquin River.

Headwaters for the Kaweah River are in the Sequoia National Park in northeastern Tulare County. Just downstream from the park boundary and about 17 miles east of Visalia, the Kaweah River is impounded by Terminus Dam to form 143,000 acre Lake Kaweah (Figure 2–11). The reservoir provides flood control, irrigation water, and ground water recharge, and is also heavily used for recreation.

The Kaweah Delta Water Conservation District distributes water from the reservoir to the service area encompassing almost 340,000 acres of which 256,000 acres are used for agriculture. Most industrial, municipal, and domestic water in the service area is supplied from ground water. All water in the Kaweah drainage is utilized within the basin except during heavy flood years. When flood releases are made from Kaweah Reservoir, all possible water is diverted for irrigation use; any excess water flows into Tulare Lake.

Figure 2-10. Tulare Lake Basin



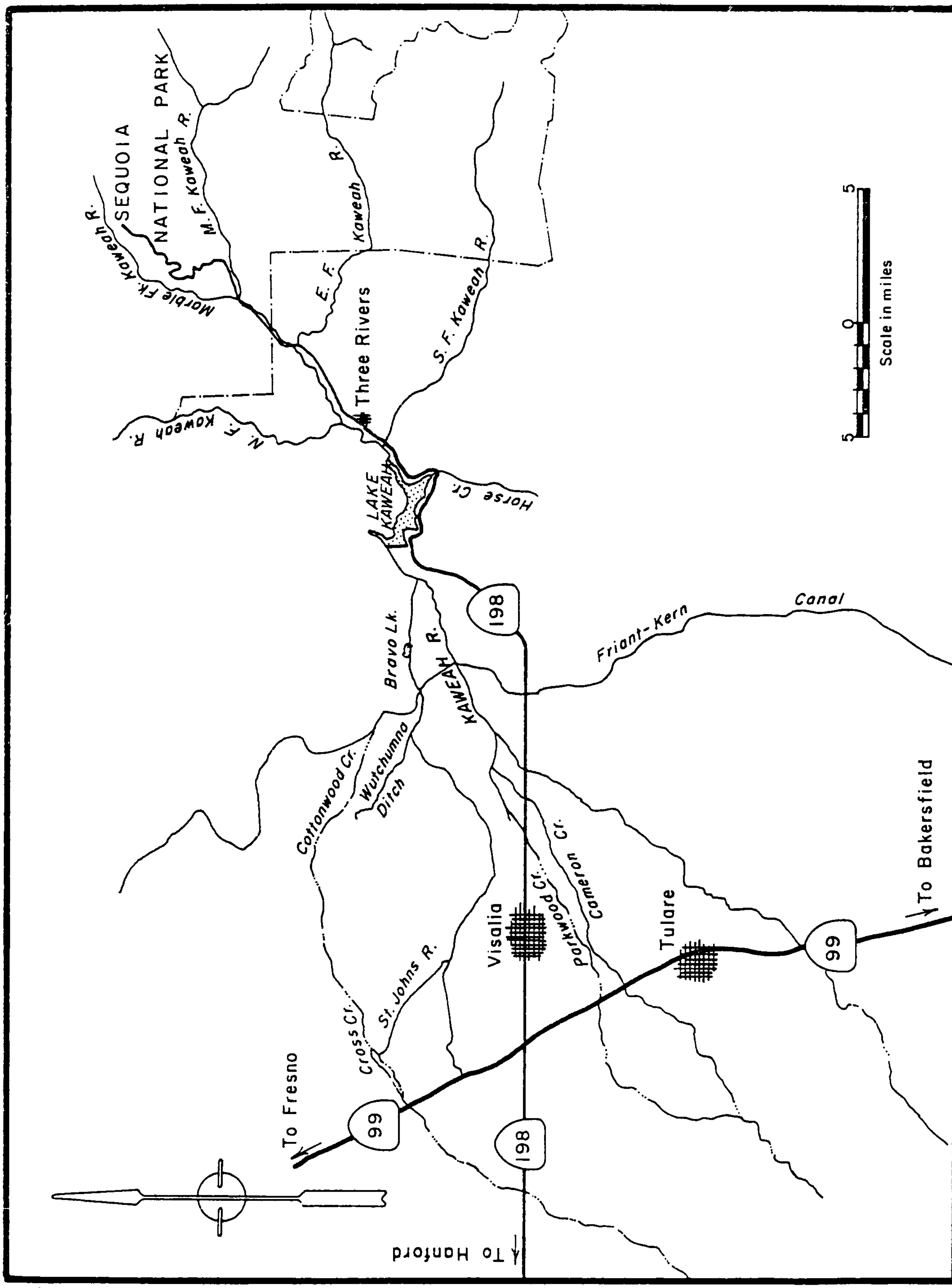


Figure 2-11. Kaweah Reservoir and River

Kaweah River flows downstream from Terminus Dam are controlled for irrigation purposes. During late spring, summer, and early fall, most water is diverted for irrigation with little flow left in the river. Wutchumna Ditch diverts water to Bravo Lake. Interconnection with the Friant–Kern Canal allows water from Bravo Lake to be transported to the Lindsay–Strathmore Irrigation District and the town of Lindsay. The St. Johns River diverts water from the Kaweah River into Cottonwood Creek to form Cross Creek. Cross Creek flows southward into Tule River. Other major diversions from Kaweah River include Mill, Cameron, and Packwood creeks, Elk Bayou, and Bates sloughs. Numerous small creeks and sloughs spread Kaweah River water across the valley floor.

The Kings River, which drains the Sierra Nevada mountains in eastern Fresno County, is impounded by Pine Flat Reservoir. The reservoir can store about 1,000,000 acre–feet (USBR, 1975b). The reservoir regulates water for irrigation and flood control.

The Kings River interconnects with the Friant–Kern Canal east of Fresno, where it divides into the South Fork and Kings River North. The South Fork flows into the Tulare Lake Basin. Kings River North flows in a northwesterly direction and can connect with the San Joaquin River through Fresno Slough. Historically, the Kings and San Joaquin rivers connected in most years during heavy runoff. More recently, this event occurs only during extreme flooding, but is more commonly hydraulically connected by virtue of irrigation practices.

The Tule River drainage serves over 400,000 acres of agricultural land (DFG, 1987). About six miles east of Porterville in Tulare County, Success Dam impounds the Tule River to form 82,000 acre–foot Lake Success (USBR, 1975b). The reservoir regulates flows for flood control and irrigation.

About half the agricultural lands in the Tule River basin are upstream from Success Dam and are served by local irrigation districts. The Lower Tule River Irrigation District and Tulare Irrigation District control most diversions downstream from the dam. Numerous ponding and ground water recharge basins controlled by local irrigation districts and non–public entities also occur along the river. The numerous diversions downstream from the dam and percolation into the river bed and flood plain result in discontinuous flow and intermittent pools throughout the lower river. The river interconnects with the Friant–Kern Canal. During extremely wet years, water in the Tule River flows to Tulare Lake.

Lake Isabella, in northeastern Kern County east of Bakersfield, impounds water from the Kern and South Fork Kern rivers draining eastern Tulare County. The reservoir has a storage capacity of 570,000 acre–feet (USBR, 1975b). As a result of numerous diversions and regulation of flow at Isabella Dam, the natural river flow is virtually nonexistent and most flows are depleted before reaching Tulare Lake in all but exceptionally large runoff years (DFG, 1987).

At the *first point of measurement,* 32 miles downstream from Isabella Dam, Beardsley Weir diverts water from the Kern River north into Beardsley Canal for delivery to the Cawelo Water District and North Kern Water Storage District, and south to Carrier Canal for delivery to the Kern–Delta Water District and Arvin–Edison Water Storage District. Calloway Weir diverts water north into the Calloway Canal to the North Kern Water Storage District. The City of Bakersfield pumps water for municipal and industrial uses from the pools above Calloway Weir. The Pioneer Canal, which is used only intermittently, diverts water to pump stations to the Cross Valley Canal, where water can be moved east or west between the Friant–Kern Canal terminus and the California Aqueduct. Water can also be diverted from the Friant–Kern Canal into the Kern River.

At the *second measuring point* in the Kern River, water is diverted south into the Alejandro Canal for use by the Buena Vista Water Storage District and Buena Vista Aquatic Recreation Area. At the Kern River–California Aqueduct Intertie, water can either be diverted into the aqueduct or flow over the Outlet Weir into Outlet Canal. At the end of Outlet Canal, water is diverted into the Eastside and Westside Canals for use by the Buena Vista Water Storage District. Downstream from this diversion, the Kern River is usually dry, except during high water years.

An earthen dam known as the *3–mile dam* backs water up for several miles during wet years for use by adjacent agriculture. Below this dam, the Hacienda Ponds complex uses the river bed mainly for drain and percolation. The Kern River ends at Sand Ridge Canal which is part of the Tulare Lake Basin Water Storage District's canal system.

Ground Water Hydrology. The immense ground water overdraft in the Tulare Basin is one of the most significant unresolved water resource problems in California (DWR, 1983). The rate of overdraft has been calculated to be about 860,000 acre–feet per year. The importation of SWP water and the availability of 741,000 acre–feet of surplus supplies (1979 to 1981 average) reduced average ground water overdraft from about

1,300,000 acre–feet in 1972 to 860,000 acre–feet in 1980. This was achieved despite an increase in irrigated crop acreage of about 300,000 acres.

SWP surplus supplies will diminish as the requirements for water exceed available supplies. Shortages in dependable water supplies could reach 660,000 acre–feet per year. About 90 percent of this shortage can be made up from ground water, which would result in a total overdraft in 2010 as high as 2,400,000 acre–feet per year. However, in wetter than normal years, some surplus surface supplies will continue to be available for ground water recharge, to the extent the California Aqueduct has capacity available to deliver the water. Also, if additions to SWP yield can be provided before 2010, ground water overdraft may not reach the level indicated.

The proposed Mid–Valley Canal addition to the CVP would also reduce the rate of ground water overdrafting by providing replacement water to irrigated areas. Preliminary studies indicate an average of about 450,000 acre–feet per year would be provided to the Tulare Basin. (A north branch would provide about 160,000 acre–feet per year to the San Joaquin basin).

Recently, large increases in electrical energy costs have given water agencies added incentive to intensify ground water recharge efforts in an attempt to reduce pumping lifts. The availability of SWP surplus supplies and the completion of the Cross Valley Canal in 1975 have enabled Kern County Water Agency to implement a large scale program aimed at mitigating overdraft. This program is in addition to all other recharge programs and other projects using surface water in lieu of pumping in the area.

Numerous public and private water agencies are engaged in the acquisition, distribution, and sale of surface water to growers in the Tulare Basin. Since most of the agencies overlie usable ground water and use ground water conjunctively with surface water, some of their operational practices, such as artificial recharge and use of "nonfirm" surface supplies in lieu of ground water, can be viewed as elements of a ground water management program. The agencies do not, however, have the power to control ground water extractions. Such authority is a requisite to comprehensive ground water management.

Water Quality. Major surface water quality problems have not generally been experienced in the Tulare Basin (USBR, 1970). The perennial streams which arise in isolated parts of the Sierra Nevada are not subject to major manmade waste loads since most discharges are applied to the land. Irrigation return water forms a major portion of the summer base flow in the lower reaches of the larger streams. Saline water from oil wells is a contributor to the basin salt load.

Ground water near Tulare Lake has experienced an increase in dissolved solids concentrations over the years. In some locations, ground water has been abandoned as a water source as a result of quality degradation from salt loading. Suitable salt levels in the root zone have been maintained by the practice of leaching dissolved solids downward. Significant portions of the ground water exceed the recommended total dissolved solids concentration in the USPHS Drinking Water Standard.

Nitrate concentrations in some ground water in the Tulare Basin approach or exceed the levels recommended by the Drinking Water Standards. High nitrogen concentrations are usually attributed to sewage effluent and leaching of naturally occurring nitrogen and fertilizers.

The salt content of Tulare Lake (about 570 mg/L TDS) is due mainly to soil salts historically in the basin and introduced fertilizers (DFG, 1987). Poso Creek also contributes salt to the southern portion of the basin, but the proportional quantity of water from this drainage is small.

Vegetation. Plant species along the tributaries to the basin are typical of those found on the west slope of the Sierra Nevada foothills (DFG, 1987). Grassland–oak savannah and oak woodland communities are typical of this region. Valley oak savannah dominates in the valley area, but in the foothills it is replaced by live oaks in progressively denser stands. Around streams and lakes, riparian habitats that occur include various willows, western sycamore, cottonwood, alder, and California buckeye, as well as shrubs and herbaceous species. Plants found outside the riparian area are mainly grasses and wildflowers. Some of the more common grasses include nutgrasses and fescues, bluegrass, wild oats, California needlegrass, and foxtails. Common wildflowers include California poppy, lupine, Mariposa lily, daisies, popcorn flower, fiddleneck, and larkspur.

A large part of the natural plant life including riparian areas below the reservoirs have been lost due to extensive agricultural encroachment and other development. However, there is a mature riparian forest on both sides of the Kaweah River immediately below Terminus Dam. Most natural vegetation below the reservoirs only remains in small disjunct patches. Further downstream, plant life becomes more similar to that of the Tulare Lake Basin. Plant life of the lower Kern River is characterized as valley mesquite habitat, which is uniquely found in southwestern Kern County.

Typical native plants in the Tulare Basin that might still occur on the undisturbed areas outside the riparian zones include those of the lower Sonoran Grassland Association and the Alkali Sink Association (DFG, 1987). However, these plants occur only in isolated areas or relatively small remaining natural areas since most of the land is extensively farmed.

There are four plants within the general area that are listed by California as either rare or endangered (DFG, 1987). The one rare species listed is Greene's Orcutt grass. Endangered species include the Kaweah brodiaea and Springville clarkia, and San Joaquin Valley Orcutt grass which is presumed to be extirpated from the recorded site. A species of special concern, the Kecks checkermallow, has also been recorded from this area.

Wildlife and Fish. A wide variety of wildlife species inhabit the tributary drainages (Appendix A–7). Many of these species are found throughout the drainages regardless of elevation. The more common and better known of those found throughout the drainages include California mule deer, mountain lion, golden eagle, coyote, and bobcat. Generally restricted to the higher elevations are species such as red fox, bear, marten, fisher, chickaree, mountain quail, and blue grouse. Further downstream, wildlife typical of the low Sierra Nevada foothills become less prevalent while those more typical of the valley floor become more numerous. Species common in the lower elevations include valley quail, band–tailed pigeon, dove, osprey, and red–tailed hawk. In addition to these common species, bald eagles frequently winter along the lower reaches, and wild turkeys have recently been established in the general area near the boundary of Sequoia National Park. The endangered California condor was also known to occasionally range over the drainage during the late summer months. Several rare or endangered species are known to occur in the Kern River drainage.

A majority of the native wildlife has been extirpated from the Tulare Lake basin. The land historically was marshland and swamp or a lake. Many species that occurred historically in the lake basin have been greatly reduced in number due to habitat deterioration and destruction from farming and urban development in the area. Birds known to inhabit the area, at least seasonally or when the lake exists, include most species of waterfowl, wading birds, and many types of gulls. Birds that are not water oriented occur in riparian areas adjacent to the lake in rivers or canals with riparian zones. Raptors can commonly be seen soaring over the farmlands in search of food.

The principal game fish species in the tributaries upstream of dams are rainbow and brown trout, smallmouth bass, bluegill, and green sunfish. The sport fishery in reservoirs is comprised mainly of two types of fish. Rainbow trout comprise the majority of the coldwater fishery maintained primarily by DFG's stocking program during the winter and early spring. The warmwater fishery is dominated by a more diverse group of fish including largemouth bass, bluegill, redear sunfish, black crappie, and white catfish.

Fish habitat downstream from tributary reservoirs is primarily warmwater. A fishery for trout exists immediately below some of the dams during the fall and winter seasons and is supported by trout moving out of the lakes. Summer water temperatures in these reaches of the rivers are too warm to sustain coldwater fish species on a year–round basis. The rivers are commonly dewatered when there is no irrigation or flood control needs, so that fish are only found seasonally and are usually from upstream areas. When intermittent pools do exist, then the more hearty and well adapted species such as carp, Sacramento blackfish, bullhead, green sunfish, bluegill, mosquitofish, hitch, golden shiner, log perch, and Mississippi silverside can usually be found. During irrigation deliveries, many game and non–game fish migrate up from the Tulare Lake basin through ditches and canals emanating from the river .

Water diversions, channelization, and construction of canals and levees have dramatically altered aquatic and riparian habitats in the Tulare Lake area. The vast lake bottom and marsh areas of Tulare Lake and much of its native flora and fauna have also been lost. Normal irrigation and farming practices dictate that these canals often dry up seasonally. In spite of this, several species of fish occur (seasonally or perennially) in Tulare Lake. Native fish species include rainbow trout (found only infrequently as they are incidentally transported from upstream areas), tule perch, Sacramento sucker, riffle sculpin, and endemic minnows. Most of these still exist in the area, though Sacramento perch and tule perch have not been reported recently from the drainage and the extent and diversity of native minnow populations has been diminished. Non–native species of both game and non–game fish have been introduced throughout the basin.

At least 10 endangered or threatened species may occur within the area, including the Sierra red fox, wolverine, San Joaquin kit fox, San Joaquin antelope squirrel, blunt–nosed leopard lizard, giant kangaroo rat, giant garter snake, bald eagle, California condor, peregrine falcon, Tipton kangaroo rat, black shouldered kite, great blue heron, and spotted owl.

The yellow–billed cuckoo has not been reported in this area for a number of years though it was formerly widespread in San Joaquin Valley riparian areas. Its disappearance from the area is probably due to the lack of adequate habitat since it requires relatively large areas of undisturbed riparian areas.

No rare or endangered fish species are known to be present in the drainages.

Central Coast Service Area

The Central Coast service area, consisting of San Luis Obispo and Santa Barbara counties, encompasses about 3.9 million acres (DWR, 1991a). Service to this area involves construction of Phase II of the Coastal Branch of the California Aqueduct (Figure 2–12). The Phase II facilities will transport 52,723 acre–feet of water to the area, though full SWP entitlement is 70,486 acre–feet per year for these areas. Santa Barbara County has the option to buy back an additional 12,214 acre–feet per year of SWP water.

Project Areas. The proposed Coastal Branch Phase II, and local pipeline projects such as the Mission Hills Extension, would transect western Kern, San Luis Obispo, and Santa Barbara counties. An environmental impact report and an advance planning study were completion in May 1991 (DWR, 1991b).

Phase II of the Coastal Aqueduct in Kern County would be located in the northeastern portion of Antelope Valley and eastern foothill regions of the Coast Range. The area is relatively barren with few streams or other drainages. Elevation of the valley floor is about 500 feet while hills near the project area range from 1,000 to 2,500 feet at Bluestone Ridge.

San Luis Obispo County consists of three broad physiographic regions: a coastal plain, coastal mountains and valleys, and interior mountains and valleys. Elevations range from sea level along the coastal plain to 5,106 feet at the summit of Caliente Mountain in the southeast corner of the county. The seven cities in the county are Arroyo Grande, Atascadero, Grover City, Morro Bay, Paso Robles, Pismo Beach, and San Luis Obispo.

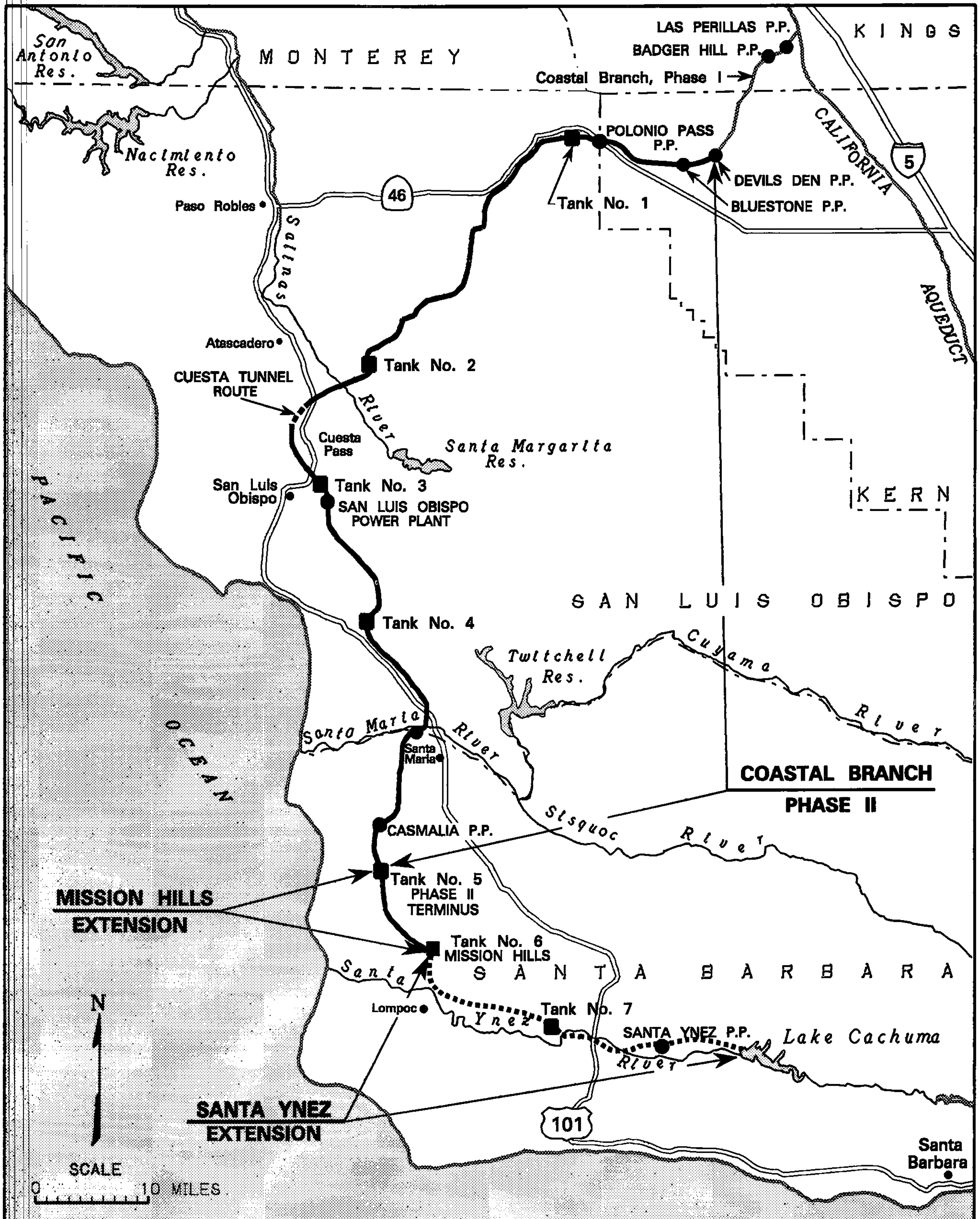
Like San Luis Obispo County, Santa Barbara County has the same three broad physiographic regions. The topography of Santa Barbara County is dominated by the Sierra Madre, San Rafael, and Santa Ynez mountain ranges. Elevations within the county vary from sea level to 6,828 feet at the summit of Big Pine Mountain. The six cities of Santa Barbara County are Santa Barbara, Santa Maria, Lompoc, Carpinteria, Solvang, and Guadalupe. Unincorporated communities include Goleta, Buellton, Mission Hills, Montecito, Orcutt, Santa Ynez, and Vandenberg Village. Vandenberg Air Force Base dominates the western coastal area of the county.

Climate. The climate of the area, like much of coastal Southern California, is Mediterranean (DWR, 1991b). Typically, winters are mild and moist, and summers are warm and dry. Mountain ranges intercept much of the rain, producing drier climates, and even deserts, in eastern San Luis Obispo and western Kern counties. The wettest areas occur in the Santa Lucia and Sierra Madre ranges, with an average rainfall of 40 inches per year. The Antelope Valley in Kern County is one of the driest areas, with an average rainfall of 7 inches per year. Average rainfall of the coastal plains of San Luis Obispo County and Santa Barbara County is 14 to 20 inches. Precipitation varies considerably from year to year, with most occurring during November through April. Fog occurs frequently along a 2– to 15–mile–wide coastal strip.

Land Use. The economy of this area depends on agriculture and related activities. In the coastal lowlands, there is considerable high value fruit and vegetable farming. In the drier lowlands, inland from the coast, livestock and dry farmed grains are produced. Manufacturing is limited, but heavy water using industries, such as petroleum production, food processing, and stone, clay, and glass products are present. Some mining and military installations also contribute to the region's economy. Recreation and retirement activities are increasing in the coastal communities.

The agricultural preserve program, under the Williamson Act, has helped limit urbanization of agricultural lands in Santa Barbara County. Land committed to public purposes includes Vandenberg Air Force Base, Los Padres National Forest, and other U.S. Forest Service land.

Figure 2-12. Coastal Branch, Phase II, and Mission Hills Extension



Surface Water Hydrology. Major streams in San Luis Obispo County include the Cuyama, Salinas, Nacimiento, and Santa Maria rivers. Lesser streams include Santa Rosa, Chorro, San Luis Obispo, and Arroyo Grande creeks. Major streams in Santa Barbara County include the Cuyama, Santa Maria, Santa Ynez, and Sisquoc rivers, while lesser streams include San Antonio Creek, Atascadero Creek in Goleta, Mission and Sycamore creeks in the city of Santa Barbara, and Santa Monica, Steer, and Rincon creeks in the Carpinteria area. Salsipuedes Creek is a major creek in the Santa Ynez Valley. Others include Alisal, Alamo Pintado, and Santa Aqueda. The Carrizo Plain, located in southeastern San Luis Obispo County, is an entirely enclosed interior drainage basin. All drainage terminates in Soda Lake, a highly mineralized body of water.

The Santa Ynez, Santa Maria, and Salinas rivers constitute the major drainages of the Central Coastal service area. The Salinas River is the largest single watershed in the Central Coast area and flows northward into Monterey County and discharges into Monterey Bay. Dams and canals have been constructed on these rivers to conserve runoff. No water is imported into the area.

Ground Water Hydrology. Ground water is the main source of water supply. Over use of ground water resources has led to overdrafting and water quality problems in some locations, such as the Santa Maria Valley and southern coastal Santa Barbara County.

Vegetation. Much of the natural vegetation in the two counties remains relatively undisturbed. Those areas that have been developed have mainly been the valleys, alluvial fans and plains, and terraces. Plant communities found in the area include grasslands, chaparral, scrub, riparian, marsh, woodland, and forest (DWR, 1991b). Numerous sensitive plant species occur in these communities (Appendix A–8).

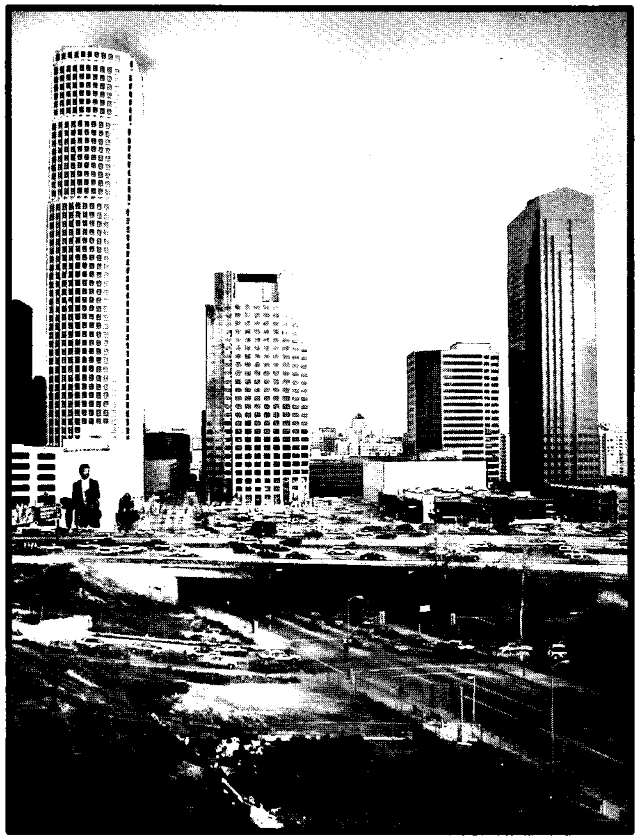
Wildlife and Fish. Due to the wide variety of plant communities in the area, animal populations are extremely diversified. Some of the more common animal species which occur in most communities throughout the service area include the mourning dove, red–tailed hawk, white–crowned sparrow, side–blotched lizard, and western rattlesnake.

Rare and Endangered Species. Because of the overlap between the northern and southern floristic elements, many rare and endangered species inhabit the Central Coastal service area (Appendix A–8). Sixty–six sensitive wildlife species potentially occur in the area (DWR, 1991b). These include federal or State listed, candidate or sensitive bird, mammal, reptile, amphibian, fish, and insect species.

Southern California

The Southern California service area of the SWP includes Ventura, Los Angeles, and Orange counties and parts of San Diego, Riverside, Imperial, San Bernardino, and Kern counties.

Since the 1940s, Southern California has changed from a largely rural lifestyle with an agricultural economy to a highly urban–industrial society. The estimated population in 1986 was over 15 million (DWR, 1991a). Los Angeles County, the most populous county in the State, has experienced the largest increase.



More than 300,000 acre–feet of water from the 1991 Drought Water Bank went to urban areas.

Water service contractors in Southern California have entitlement to 2,497,500 acre–feet, which is 59 percent of the ultimate minimum SWP yield (DWR, 1984). Water is delivered to these contractors through both the East and West Branches of the California Aqueduct. Increased conveyance capacity, along with construction of additional conservation facilities and a Delta transfer system, would make possible the delivery of the full Metropolitan Water District (MWD) entitlement. This would result in the transfer of additional water from the Sacramento–San Joaquin Delta, but no more than originally planned under normal operations of the SWP.

State Water Project. Once over the Tehachapi Mountains and in Antelope Valley, the California Aqueduct divides into two branches. Both branches of the Aqueduct take SWP water to the project's predominantly urban customers in parts of Southern California. Thirteen water contractors in Southern California are served from the East and West Branches of the California Aqueduct (DWR, 1984).

East Branch. The East Branch carries water through Antelope Valley into Silverwood Lake in the San Bernardino Mountains. Formed by Cedar Springs Dam, Silverwood Lake has a storage capacity of 74,970 acre–feet.

From Silverwood Lake, water enters the San Bernardino Tunnel and drops 1,418 feet into the Devil Canyon Powerplant. Water then flows in a buried pipeline to Lake Perris, which is the southernmost reservoir of the SWP, southeast of Riverside, and 444 miles from the Delta. Water from Lake Perris supplies San Bernardino, Los Angeles, Orange, Riverside, and San Diego counties. The lake, about 25 miles southeast of Riverside, has a capacity of 131,452 acre–feet.

The East Branch serves Antelope Valley, East Kern Water Agency, Palmdale Water District, Littlerock Creek Irrigation District, and Mojave Water Agency in the Antelope and Mojave Basins (DWR, 1984). The East Branch also conveys water to the Crestline–Lake Arrowhead Water Agency in the San Bernardino Mountains, and to MWD, San Gabriel Valley Municipal Water District, San Bernardino Valley Municipal Water District, San Gorgonio Pass Water Agency, Desert Water Agency, and Coachella Valley Water District downstream of the Devil Canyon Powerplant Afterbay. The last two agencies now exchange SWP water with MWD for Colorado River water, because they do not have facilities to convey SWP water from the East Branch to their service areas. San Gorgonio Pass Water Agency has not yet taken delivery of SWP water because it also lacks the necessary facilities, but it may enter into a similar exchange agreement with MWD.

In Ventura and Los Angeles counties, some SWP supplies are released into natural stream channels from the East Branch (DWR, 1991a). Piru Creek, a tributary to the Santa Clara River, serves as a conveyance to Ventura County users. In Los Angeles County, SWP water is released into Gorman Creek for recreational use as part of the Hungry Valley recreational area. Additional opportunities exist for streamflow augmentation where the East Branch of the California Aqueduct crosses natural streams.

The existing East Branch can convey up to 760,000 acre–feet per year through the Devil Canyon Powerplant below Silverwood Lake. Its capacity is sufficient to meet most long range requirements of all contractors served from the East Branch, except MWD due to rapid population increase and loss of Colorado River water to the Central Arizona Project. Expansion of the East Branch is nearly complete, which will increase the yield by about 63,000 acre–feet per year.

West Branch. Water in the West Branch flows through the William E. Warne Powerplant into Pyramid Lake in northwestern Los Angeles County. The lake, which stores 171,196 acre–feet, supplies water for Los Angeles and other southern coastal cities, and provides regulated storage for the Castaic Powerplant downstream.

Releases from Pyramid Lake flow through the Angeles Tunnel and Castaic Powerplant, and into Castaic Lake, which is the terminus of the West Branch of the Aqueduct. Energy produced from the 1,250 megawatt Castaic Powerplant is used by the city of Los Angeles and the SWP. Castaic Lake, storing 323,702 acre–feet, is a major water source for Los Angeles, Ventura, and Orange counties.

The West Branch serves the Castaic Lake Water Agency, Ventura County Flood Control District, and MWD. Ventura County Flood Control District has not yet taken delivery of water from the SWP (DWR, 1989b).

Topography. The aqueduct borders the high Antelope Valley and Mojave Desert, which forms a broad basin with remnants of eroded mountains and ridges (DWR, 1984). The San Gabriel Mountains are the dominant mountain range, extending from the Quail Lake area on the west to the Cajon area on the east. Average elevation exceeds 4,000 feet, with many peaks well over 8,000 feet high.

The southern boundary of the Antelope and Mojave Basins includes a portion of the San Andreas fault rift zone, which consists of a series of long, narrow valleys separated from Antelope Valley by narrow ridges. Most prominent of these fault valleys and ridges is Leona Valley, which contains Elizabeth Lake, Lake Hughes, and Portal Ridge, west of Palmdale. From Portal Ridge, the southern boundary follows the northern slope of the San Gabriel Mountains to Cedar Springs Dam. An extensive alluvial fan that spreads out into the valley from this boundary is characterized by a series of mesas, low hills, and playa lakes. The largest of these playas are Rosamond, Rogers, and Buckhorn Lakes. These are dry lake beds that are the terminuses of drainages and washes formed by intermittent streams draining the east slope of the Tehachapis and the north slope of the San Gabriel Mountains.

Cedar Springs Dam, on the West Fork of the Mojave River, is located on the southeastern boundary of the area within the Antelope and Mojave Basins. Below Cedar Springs Dam, the Mojave River joins Deep Creek and other tributaries from the San Bernardino Mountains and follows a course northward into the Mojave sink, where it terminates in several playas, including the dry Soda, Silver, and East Cronese Lakes.

The Mojave Valley located northeast of Cedar Springs Dam, consists of a large alluvial plain interspersed with numerous mountains, mesas, valleys, playas, and the lowlands bordering the Mojave River.

Climate. The East Branch of the Governor Edmund G. Brown California Aqueduct extends through an area that is characteristically hot and dry in the summer, with temperatures exceeding 100°F (DWR, 1984). Winters are fairly cold, and freezing is frequent. The average length of the growing season is about 260 days.

Precipitation in the Antelope and Mojave Basins occurs primarily in the winter and spring. Average annual precipitation ranges from 5 to 8 inches on the valley floor to 12 to 16 inches in the foothills bordering the basins.

Land Use. The rapid economic growth that Southern California experienced during the 1950s and 1960s has slowed, but diversification of the economy continues. This region is the State's leading center of business activity. Southern California contains the State's largest concentration of manufacturing activity, particularly the aerospace industry. Other major industries include petroleum, fabricated metals, chemical production, food processing, and paper production.

In the coastal areas of Southern California, agriculture remains important economically, despite urbanization. Farms generally produce high value crops on small irrigated parcels. Agriculture is also important in the Colorado Desert, especially in the Coachella and Imperial valleys. Livestock, field crops, truck crops, sugar beets, and cotton are important. Poultry, livestock, and field crops are produced in the Mojave Desert. On the agricultural lands in the Antelope and Mojave Basins, the principal crops are alfalfa and grain products. Almond, apple, apricot, pear, irrigated pasture, and some truck crops are also grown.

Land use in the Southern California service area has changed dramatical since the early part of the century, when the citrus industry dominated the economy. Several factors have led to changes in land use, including the discovery of oil, construction of the Los Angeles and Colorado Aqueducts, increase of port facilities to accommodate the shipping and trade brought about by the Panama Canal, location of the 11th Naval District in San Diego, development of the movie entertainment industry, and location of heavy industry (especially aircraft and ship building). These factors have caused a shift from agricultural to urban and suburban development.

Surface Water Hydrology. Streams rising in the bordering mountains carry drainage across the aqueduct route. These streams enter the valley floor, some in defined watercourses but most in channels that shift from storm to storm (DWR, 1984). Rainfall often is so intense that the watercourses overflow, covering large areas of the valley floor with sheet flow. These conditions result in changing patterns of erosion and deposition. The streams have intermittent flow and for the most part percolate into ground water basins in the Antelope Valley and Mojave areas. The largest stream is the Mojave River, which has an average annual runoff of about 59,000 acre–feet.

Due to the highly seasonal precipitation, there are no major rivers in the desert plateau region of the Southern California service area. The intermittent streams that flow from the mountains percolate primarily in ground water basins. A limited surface water supply has been developed, and most local water supplies have been fully developed for flood control, ground water recharge, and water supply.

Because local water supplies are limited, imported water has played a significant role in meeting the area's growing water demands. Imported water was first brought into the area from Owens Valley in the Los Angeles Aqueduct by the City of Los Angeles in 1913 (DWR, 1984). As development on the coastal plain increased, the Colorado River was tapped as a second imported supply in 1941 by MWD, which constructed the Colorado River Aqueduct to carry this water. Both of these import facilities have been operating at or near capacity. A third major source of imported water, the

SWP, first made deliveries to the Southern California area in 1972.

Ground Water Hydrology. Ground water supplies a significant portion of the water in this service area. The South Coastal hydrologic basin, which encompasses this service area, has at least 44 major ground water basins (DWR, 1991a). Although further development is possible in a few local areas, some of the basins have been over used. In 1974, an annual ground water overdraft of 160,000 acre–feet led to seawater intrusion problems in some areas along the coast. Seawater barrier and artificial recharge programs have been developed to correct these situations.

The Antelope Valley Ground Water Basin and several minor basins in the Lake Hughes and Acton areas underlie the aqueduct area. The Antelope Valley Basin, situated southeast of the Tehachapi Mountains and north of the San Gabriel Mountains, covers about 600 square miles. The basin is also located between the Garlock and San Andreas faults, two major geological features of Southern California. Surface elevation of the basin ranges from 2,300 to 3,500 feet. Replenishment of this basin is supplied by runoff from the surrounding mountains.

The principal water bearing formation in the Antelope Valley Basin is alluvial fill that underlies most of the valley. These alluvial deposits are porous and permeable and yield large amounts of water. Estimates are that there are nearly 2 million acre–feet of ground water storage capacity per 100 feet of sediment, or 10 million acre–feet in the entire basin to the depth of 500 feet. Only a portion of the ground water supply can be pumped economically. The estimated average annual recharge to the Antelope Valley Ground Water Basin is about 58,000 acre–feet.

Antelope Valley ground water is used by the overlying Antelope Valley–East Kern Water Agency, which receives up to 138,400 acre–feet of imported water from the SWP. Without imported water, the overdraft of ground water by the water agency would be about 150,000 acre–feet annually by the year 2000.

Some SWP supplies are used for local ground water recharge programs.

Water Quality. Many water quality problems exist in this service area. In the coastal area, thermal discharges from electrical generation plants and nutrient overloading of streams cause local problems. In the desert areas, the problems are more general and relate to increasing salinity of both ground water and lakes such as the Salton Sea (DWR, 1991a).

The quality of imported water ranges from less than 220 mg/L TDS for SWP supplies to 750 mg/L for Colorado River water (DWR, 1991a). In some areas, SWP water is blended with imported Colorado River water to provide a better overall quality.

The quality of streams in the Antelope Valley area is good to excellent (DWR, 1984). TDS content is usually less than 300 mg/L and ranges from about 50 to 450 mg/L. The water is moderately hard, but ranges from soft to very hard, and is calcium bicarbonate in character.

Ground water quality in the immediate vicinity of the aqueduct in the Antelope Valley is excellent. TDS concentrations of about 150 to 300 mg/L dominate, with a few smaller areas around the communities of Littlerock and Pearblossom having TDS concentrations of about 300 to 500 mg/L.

The quality of water from the intermittent streams of the Mojave River area near the aqueduct is also generally good to excellent. The water is soft to moderately hard and suitable for most uses. Stormwater flow in the Mojave River is calcium bicarbonate in character and has a TDS level of less than 300 mg/L.

The ground water quality in the Mojave River area is fair. TDS concentrations range from about 300 to 1,000 mg/L and are predominantly calcium or sodium bicarbonate in character, with calcium predominating in the recharge area of the foothills and sodium in the middle and lower discharge areas of the playas

Vegetation. While some of the naturally occurring vegetation in the Southern California service area has been altered significantly by urban and agricultural development, a large part of the region (mostly uplands) retains its native cover. The dominant natural vegetation type in the non–urbanized portion of the Southern California service area is a mixture of coastal sage scrub and chaparral communities (DWR, 1984). This vegetation type covers 46 percent of the land area. Chaparral is composed of various species of manzanita, wild lilac, ceanothus, oak, sage, mountain mahogany, and chamise, which grow in the foothills and on lower mountain slopes. Chaparral has little commercial value, but it forms a valuable watershed cover and wildlife habitat. The second most abundant vegetation type in this basin is that covering agricultural lands, which form 15 percent of the land area.

An extensive band of agricultural lands borders the aqueduct area on the north, from the Alamo Powerplant to the Pearblossom Pumping Plant near Littlerock (DWR, 1984). A narrower agricultural band, along with some chamise and piñon–juniper communities, borders the area on the south. Piñon–juniper communities, which consist of open stands of low needle–leaf evergreen trees with various mixtures of shrubs and herbs, are dominated by California juniper, western juniper, and singleleaf piñon. From the Pearblossom Plant to Silverwood Lake, the area is surrounded almost exclusively by Mojave creosote communities, characterized by open stands of low to medium shrubs and dominated by creosote bush and yucca.

Major drainages traversed by the aqueduct, which are Cottonwood, Little Rock, Big Rock, and Amargosa creeks and the West Fork of the Mojave River, support typical riparian species such as western sycamore, white alder, Fremont cottonwood, and willow.

DFG has also planted some wildlife habitat sites along the East Branch with a mixture of shrubs and herbs. These sites, located predominantly between Alamo Powerplant and Pearblossom Pumping Plant, were established under authorization of the Recreation and Fish and Wildlife Enhancement Bond Act of 1970 (Proposition 20). Additional sites are planned for development in the future.

The vegetation within the aqueduct right–of–way has been previously disturbed by human activity. Despite this disturbance, some vegetation, such as creosote bush, saltbush, and blackbush shrubs, can be found on the aqueduct berms. Along with these shrubs, some stands of Joshua tree can also be found.

Four rare or endangered plant species and three plants of special concern may occur adjacent to or near the aqueduct. Although these plant species are found in habitat conditions similar to those in the aqueduct area, none of these species has actually been found adjacent to the aqueduct. Further, because the area has previously been disturbed, precise habitat requirements do not appear to occur in the area.

Natural Areas. Seven natural areas occur along the aqueduct alignment (Figure 2–13). Three of the areas are either immediately adjacent to or within the aqueduct right–of–way. The Wetland Marsh Area, enhanced by DFG as part of its Wildlife Habitat Enhancement program, is within the aqueduct right–of–way adjacent to the aqueduct. This 25 acre area is in a region of permanent seepage from Anaverde Creek. The freshwater wetland and marsh habitat is important for providing a greater habitat base for the associated flora and fauna.

The Ritter Ridge Area, bordering the aqueduct to the north and west, displays some of Antelope Valley's finest mixed stands of Joshua trees and California juniper. Wildlife is abundant, with more than 90 species of mammals, birds (not including migrants), and reptiles recorded.

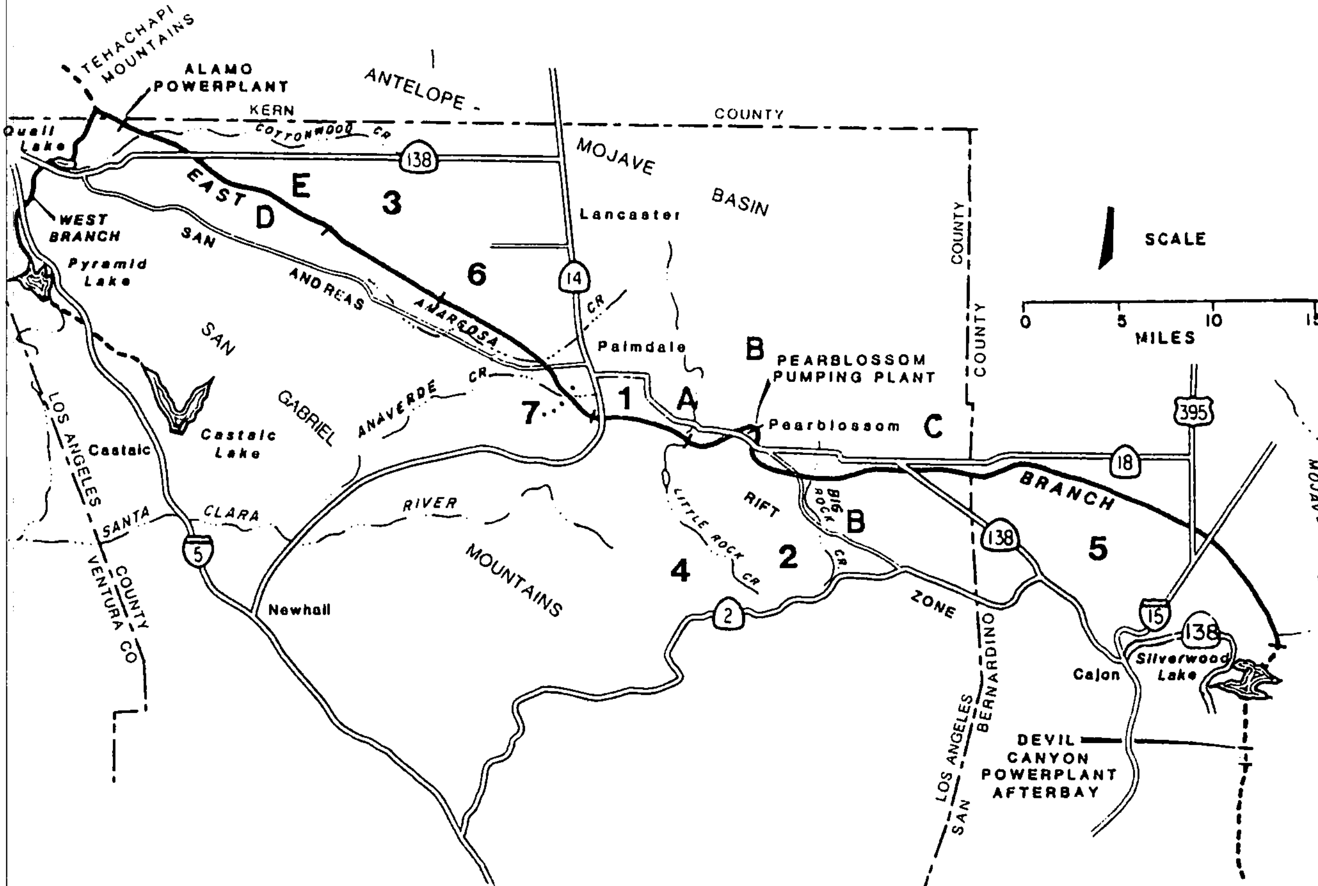
The Mescal County Wildlife Sanctuary, which is contiguous to the aqueduct right–of–way on the south, displays some of the most diversified plant communities in the Antelope Valley. Creosote bush shrub and Joshua tree woodland each occupy about 40 percent of the area. The remainder of the area is a desert wash. Wash plants include scalebroom and box–thorn. Gambel's quail and the long–nosed leopard lizard are among the desert animals found here.

Significant Ecological Areas. The aqueduct traverses four areas designated by Los Angeles County as significant ecological areas: Little Rock Wash, Big Rock Wash, Joshua Tree Woodland, and Desert–Montane Transect. It also borders two other such designated areas: Ritter Ridge, which is also one of the natural areas, and Portal Ridge/Liebre Mountain.

Big Rock and Little Rock Washes are considered important wildlife habitat and migration corridors and provide a means of seed dispersal for many desert plants. The Joshua Tree Woodland area, as its name indicates, supports a Joshua tree woodland habitat. This habitat type is becoming increasingly scarce, especially in western Antelope Valley. The Desert–Montane Transect area is one of the largest undisturbed areas outside the Angeles National Forest. It possesses vegetation types that provide an example of the transition between the Mojave Desert and the northern slopes of the San Gabriel Mountains. The Portal Ridge/Liebre Mountain area contains 10 distinct plant communities, representing the transition between desert, foothill, and montane environments.

Wildlife and Fish. The Southern California service area supports a great diversity of wildlife. The diversity of habitats available in the area, combined with the impacts of a rapidly developing human population, has resulted in a large number of rare and endangered plant and wildlife species (Appendix A–9).

Figure 2-13. Natural Areas and Significant Ecological Areas



NATURAL AREAS

1 – ANTELOPE VALLEY FREEWAY CUT

2 – BOB'S GAP

3 – CALIFORNIA POPPY RESERVE

4 – DEVIL'S PUNCH BOWL

5 – MESCAL COUNTY WILDLIFE SANCTUARY

6 – RITTER RIDGE

7 WETLAND MARSH AREA

SIGNIFICANT ECOLOGICAL AREAS

A – LITTLE ROCK WASH

B – BIG ROCK WASH

C – DESERT–MONTANE TRANSECT

D – PORTAL RIDGE/LIEBRE MOUNTAIN

E – JOSHUA TREE WOODLAND HABITAT

Carnivores, such as coyote, badger, gray fox, bobcat, and spotted and striped skunk, are found in the upper Antelope Valley areas (DWR, 1984). Raccoons are locally abundant along the permanent watercourses where suitable food and dens can be found. A few beaver inhabit the riparian areas along the West Fork of the Mojave River.

Limited numbers of mule deer are found in the more productive yucca–juniper and juniper–Joshua tree plant communities. Typical arid–adapted species such as the desert night lizard and the desert kangaroo rat also are found here.

Upland game species, including desert cottontail, brush rabbit, black–tailed jackrabbit, and mountain quail, occur where suitable habitat is available.

Populations of mourning dove are found in the upper Antelope Valley. The dry–land cereal grains provide an abundant food supply. The orchards and the Joshua and juniper trees provide nesting sites for dove.

Most of the wildlife in this area are birds. The raven, horned lark, loggerhead shrike, roadrunner, scrub jay, and western meadowlark are the most commonly observed species. Also, the cactus wren, Scott's oriole, California thrasher, and Say's phoebe are often seen in areas where the juniper–Joshua tree plant community joins the chaparral or the foothills. Birds of prey, such as the golden eagle, red–tailed hawk, Cooper's hawk, sparrow hawk, marsh hawk, and prairie falcon, are found in the area. The agricultural lands provide habitat for the burrowing owl, which is locally abundant.

Reservoirs along the aqueduct provide habitat for numerous geese, ducks, and shore birds, including several hundred Canada geese that winter in the upper Antelope Valley.

Fish found in the aqueduct include largemouth bass, striped bass, green sunfish, bluegill, and catfish. In addition to these species, rainbow trout are stocked in Silverwood Lake.

Steps have been taken in Southern California to preserve habitats that have unique biological significance (coastal wetlands, for example). One measure, the California Coastal Act of 1976, requires development in areas adjacent to environmentally sensitive habitat to be sited and designed to prevent impacts that would significantly degrade such habitat, and to be compatible with the continuance of such habitat.

The threatened Mohave ground squirrel and the endangered bald eagle may potentially occur near the aqueduct (DWR, 1984). The range of the Mohave ground squirrel is limited to the western portion of the Mojave Desert, extending from Olancha in Inyo County south to Victorville in San Bernardino County and from the Tehachapi Mountains in Kern County east to the Granite Mountains in San Bernardino County. Information on this species is limited. One study conducted in 1977 reported trapping a Mohave ground squirrel about 4 miles north of the aqueduct between Hesperia and Victorville in San Bernardino County. However, other traps set closer to the aqueduct in this same area produced no other Mohave ground squirrels. The only other area in proximity to the aqueduct known to support this species lies about 10 miles southwest of Pearblossom Pumping Plant (at the intersection of Bob's Gap Road and 165th Street). This area supported a significant population in the early 1960s. However, when this area was live trapped in the early 1970s, no Mohave ground squirrels were found. The NDDB does not list the squirrel as occurring along the aqueduct.

One endangered fish, the unarmored three–spine stickleback, occurs in the service area but is no longer found in the Los Angeles, San Gabriel, and Santa Ana rivers (DWR, 1991a). The fish population in the Santa Clara River is threatened by increased recreational use and development.

Recreation. Recreational facilities along the aqueduct include a bicycle trail with attendant rest facilities and fishing sites (DWR, 1984). The bikeway extends 105 miles from Quail Lake near Interstate Highway 5 to a point near Silverwood Lake in the San Bernardino National Forest. It is available to bicycle riders, hikers, and anglers. Rest stops with toilets, picnic tables, drinking water, and shade ramadas are placed along the bikeway about every 10 miles. Use of the Southern California portion of the California Aqueduct Bikeway exceeded 3,600 recreation days in 1982.

The U.S. Forest Service anticipates routing a portion of the Pacific Crest National Scenic Trail along the aqueduct. This would establish a hiking and equestrian route that would intersect the aqueduct, move east for 1 mile along the East Branch right–of–way to the Los Angeles Aqueduct, then north along that aqueduct, eventually connecting with the Sequoia National Forest portion of the trail. Along the East Branch, the trail would be routed as far from the water as possible but within the right–of–way limits. It would traverse the East Branch at its crossing with the Los Angeles Aqueduct. The crossing would require no special facilities, such as bridges or tunnels, because, at this point, the East Branch passes through an underground siphon. At present, the trail temporarily crosses the East Branch at the Mojave Siphon below Silverwood Lake.

Five fishing access sites are available along the East Branch. All sites have toilets, picnic tables, drinking water, and parking facilities. Use of the fishing access sites and walk–in fishing along the California Aqueduct was about 5,200 recreation days in 1982.

The four Southern California reservoirs receive heavy year–round recreation use, with Castaic Lake seeing as many as a million visitor–days per year, while Lake Perris receives more than 800,000. Castaic offers boating, swimming, fishing, waterskiing, and picnicking, and camping facilities are available in the adjoining Angeles National Forest. Facilities at Castaic Lake and Lagoon are operated by the Los Angeles County Department of Parks and Recreation. Lake Perris, where recreation facilities are run by the Department of Parks and Recreation, offers swimming, boating, waterskiing, picnicking, camping, fishing, hiking, hunting, scuba diving, and rock climbing.

The other two Southern California reservoirs are farther from population centers but by no means remote. Pyramid Lake, in northwestern Los Angeles County, has facilities operated by the U.S. Forest Service. It offers boating, fishing, picnic sites, waterskiing, and swimming. Campsites are 20 miles away in the Angeles National Forest. Silverwood Lake, in the San Bernardino Mountains, has a State Recreation Area run by the Department of Parks and Recreation. Recreation possibilities are fishing, picnicking, camping, hiking, swimming, bicycling, waterskiing, and boating. Use at Silverwood Lake approached 610,000 recreation–days in 1982.

Chapter 3. Environmental Impact

This section analyzes potentially significant environmental effects of the proposed Drought Water Bank program, including short-term direct and indirect effects on surface water sources, ground water sources, instream fisheries, the Delta, wildlife, sensitive plant communities, recreation and socioeconomics. This section also discusses growth-inducing impacts of the proposed program and effects found not to be significant.

Significant Environmental Effects of Proposed Program

The proposed Drought Water Bank can obtain water from several sources. Using the 1991 and 1992 banks as examples, the sources are surface water storage, ground water substitution, Delta fallowing, and non-Delta fallowing. The availability of water varies depending on the source (Tables 3–1 and 3–2). Impacts from the proposed program also vary with source of water.

Surface Water Sources

The period when water is available from source areas is not always when the water is actually pumped at the Delta for delivery to Water Bank buyers. To minimize fishery impacts of pumping Bank Water in the Delta, as much pumping as possible is done in August, September, and October. This shift is accomplished by using CVP and SWP upstream storage reservoirs. When Water Bank sources are providing water to the Delta, releases at the upstream reservoirs are adjusted so that water can be saved in storage and released later for Delta export during the desired months. Water Bank deliveries to buyers south of the Delta are supported, when necessary, by loaning water from San Luis Reservoir in the spring and early summer. Water in San Luis Reservoir is then replaced in the late summer and fall months when Water Bank water can be pumped at the Delta.

Maximum Drought Bank Description. The maximum size for the proposed Drought Water Bank program is similar to the 1991 Water Bank.

The 1991 Bank involved purchases and transfers of a total of 820,000 acre–feet. A summary of the sources and disposition of this was shown in the introduction to this draft EIR. The numbers for the 1991 Bank are broken down differently for this analysis to show impacts on stream flows and additional pumping out of the Delta.

Of the 820,000 acre–feet of water purchased, 58,000 acre–feet was initially subtracted due to technical corrections (associated primarily with differences in crop consumptive use amounts and corrected for actual 1991 rainfall). This leaves a balance of 762,000 acre–feet. Of this amount, 732,000 acre–feet was provided to the Bank in 1991. The remaining 30,000 acre–feet was a deferred delivery from the Yuba County Water Agency in May and June, 1992, which was accounted for as part of the carryover storage for the SWP. The analysis shown on Table 3–1 uses the 732,000 acre–feet amount. The numbers in Table 3–1 show a more definitive breakdown of the sources of water, both by location and actions taken to provide the water.

Table 3–1 indicates that a total of 329,000 acre–feet came from fallowing farm land, 286,000 acre–feet came from ground water substitution programs, and 117,000 acre–feet came from storage releases. The fallowing number already accounts for the technical corrections of crop water use and actual rainfall. The storage release number, as mentioned earlier, does not include the 30,000 acre–feet of delayed release from Yuba County Water Agency, since that water was released to the SWP in 1992. The Delta carriage water amount of 65,000 acre–feet is associated with the 400,000 acre–feet of water pumped from the Delta.

Table 3–1 also displays a carryover amount for the SWP, labeled *SWP/CVP Storage Change*. This amount (267,000 acre–feet), combined with the 30,000 acre–feet of Yuba water and reduced by the Delta carriage water factor for the total amount, resulted in a net carryover of about 265,000 acre–feet for the SWP.

Water Bank supplies were pumped at the Banks Pumping Plant from April through November, with the majority of the water pumped during August and October. Carriage water (the extra Delta outflow needed to maintain Delta salinity requirements when Delta exports increase) was determined to be 14 percent of the water available for export. The amount of Water Bank supplies exported in 1991 were 400,000 acre–feet, as used in this analysis. The actual amount of water pumped was about 390,000 acre–feet (10,000 acre–feet less), which matches the *critical needs* demands of the purchasers of water from the 1991 Bank. This minor correction has no significant impact on the results of the analyses made in this document.

To compare the effects of the Water Bank on streamflows and reservoir storage, median year flows and storages were estimated from operation studies that assumed SWP deliveries of 3.66 million acre–feet and current full CVP contractual deliveries.

Streamflows from the 1991 Water Bank were significantly less than those of median hydrologic years (Figures 3–1 through 3–12). Water Bank streamflows were not significantly different through the middle of the year than would have occurred during this drought period without the Water Bank. The Water Bank did, however, result in higher stream flows during the late summer and fall than would have occurred, except in the Feather River. From spring through fall, streamflows in the Feather River were slightly less due to operation of the Water Bank than those that would have occurred under drought conditions (Figure 3–4).

Storage at Shasta, Oroville, and Folsom reservoirs was significantly less than median conditions during the drought (Figures 3–13 through 3–15). The 1991 Water Bank created more storage at these reservoirs than would have occurred otherwise. Storage at New Bullards Bar Reservoir was also less than median conditions (Figure 3–16). The Water Bank resulted in a slight increase in storage from spring through mid summer, but less storage after late summer. At San Luis Reservoir, storage through late spring was much less than median conditions (Figure 3–17). The Water Bank resulted in less storage than under drought conditions from mid–spring to mid–fall, although the storage was not significantly different.

Minimum Drought Bank Description. The minimum size of the proposed Drought Water Bank program is similar to the 1992 Water Bank, at the time this environmental analysis was being conducted, was estimated to be able to provide 187,000 acre–feet. Of this amount, 154,000 acre–feet is to be pumped in the Delta from the Banks Pumping Plant, USBR's Tracy Pumping Plant, and the Contra Costa Canal Pumping Plant. The amount of 30,000 acre–feet is to be used as carriage water and to cover San Joaquin River losses.

Table 3–2 indicates that 97,000 acre–feet came from ground water substitution, and 90,000 acre–feet came from surface water. While the numbers and the specific source areas in the table are correct, the water from Browns Valley Irrigation District, Oakdale Irrigation District, and South San Joaquin Irrigation District was generated from water conservation and ground water substitution. Water from these three districts was reregulated in their respective reservoirs to match instream fishery and delivery needs. The SWP purchased no water for carryover use in 1992, so there is no storage change at the end of the year's operation.

As occurred in 1991, streamflows are projected to be significantly less than median conditions during 1992 due to the lingering drought (Figures 3–18 through 3–29). Streamflows as a result of the 1992 Water Bank are essentially what they would have been without the Water Bank at all these representative streams. Sacramento River flows at Freeport (Figure 3–20) are only slightly greater during late summer and slightly less in late fall than under drought conditions without the Water Bank. Similarly, flows in the Feather River below Thermalito (Figure 3–21) and the Banks Pumping Plant (Figure 3–26) are slightly greater in late summer, while flows in the Yuba River at Marysville (Figure 3–23) are slightly greater in late spring than under drought conditions without the Water Bank. This increased flow is due to a release of 30,000 acre–feet of water from New Bullards Bar Reservoir, which is the remainder of Yuba County Water Agency's sale to the 1991 Drought Water Bank. This water became a component of the carryover for the SWP. Delta flows (Figure 3–28) are unchanged from drought flow conditions due to the Water Bank.

During 1992, all reservoir storage was less than median conditions due to the prolonged drought (Figures 3–30 through 3–34). The 1992 Water Bank resulted in essentially no changes in storage at Shasta, Oroville, and Folsom reservoirs compared to storage levels that would have occurred during the drought without the Water Bank (Figures 3–30 through 3–32). Storage in New Bullards Bar Reservoir was slightly less due to the Water Bank than under drought conditions without the bank (Figure 3–33). Storage at San Luis Reservoir was only slightly less due to the Water Bank during the summer than under drought conditions without the bank. Storage at San Luis Reservoir was only slightly less due to the Water Bank during the summer than under drought conditions without the Bank (Figure 3–34).

Table 3–1. Water Distribution for the 1991 Drought Water Bank (in 1,000's of acre–feet)

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Water Supply													
Delta Fallowing	0	0	0	29	42	55	82	55	15	7	0	0	285
Ground Water Exchange													
Sacramento River	0	0	0	7	15	17	26	17	18	4	0	0	104
Feather River	0	0	0	28	21	14	23	8	2	4	0	0	100
Yuba River	0	0	0	0	0	0	29	53	0	0	0	0	82
Non–Delta Fallowing													
Above Shasta reservoir	0	0	0	0	2	1	2	2	0	0	0	0	7
Below Shasta Reservoir	0	0	0	1	11	9	10	7	–2	1	0	0	37
Storage Releases													
Yuba County Water Agency	0	0	0	0	0	0	0	0	84	15	0	0	99
Browns Valley I.D.	0	0	0	0	0	0	5	0	0	0	0	0	5
Oroville–Wyndotte I.D.	0	0	0	0	0	0	0	0	0	0	10	0	10
Little Holland	0	0	0	0	0	0	0	0	0	1	1	0	2
Wilson & McCall Inc.	0	0	0	0	1	0	0	0	0	0	0	0	1
Total Water Supply	**0**	**0**	**0**	**65**	**92**	**96**	**172**	**147**	**117**	**32**	**11**	**0**	**732**
Water Disposal													
Delta Exports													
H.O. Banks Pumping Plant	0	0	0	2	6	9	40	80	116	133	14	0	400
Carriage Water	0	0	0	0	1	1	7	13	19	22	2	0	65
Total Water Disposal	**0**	**0**	**0**	**2**	**7**	**10**	**47**	**96**	**135**	**155**	**16**	**0**	**465**
SWP/CVP Storage Change	**0**	**0**	**0**	**63**	**85**	**86**	**125**	**54**	**–18**	**–123**	**–5**	**0**	**267**

Table 3–2. Water Distribution for the 1992 Drought Water Bank (in 1,000's of acre–feet)

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Water Supply													
Ground Water Exchange													
Sacramento River	0	0	0	0	0	7	12	12	12	2	0	0	45
Feather River	0	0	0	0	0	1	12	14	13	10	0	0	50
Delta (East Contra Costa)	0	0	0	0	0	0	0	1	1				2
Storage Releases													
Browns Valley I.D.	0	0	0	0	0	0	0	2	3	0	0	0	5
Oroville–Wyndotte I.D.	0	0	0	0	0	0	0	0	0	0	10	0	10
Placer County Water Agency	0	0	0	0	0	0	0	0	6	4	0	0	10
Oakdale I.D./So. San Joaquin I.D.	0	0	0	0	0	0	0	15	14	21	0	0	50
Merced I.D.	0	0	0	0	0	0	0	0	0	9	6	0	15
Total Water Supply	**0**	**0**	**0**	**0**	**0**	**8**	**24**	**44**	**49**	**46**	**16**	**0**	**187**
Water Disposal													
Delta Exports													
H.O. Banks Pumping Plant	0	0	0	0	0	0	0	28	28	13	0	0	69
Tracy Pumping Plant	0	0	0	0	0	0	31	14	8	14	5	0	75
Contra Costa Canal Pumping Plant	0	0	0	0	0	0	0	0	2	8	0	0	10
Carriage Water	0	0	0	0	0	0	6	10	9	7	1	0	33
Total Water Disposal	**0**	**0**	**0**	**0**	**0**	**0**	**37**	**52**	**47**	**42**	**6**	**0**	**187**
SWP/CVP Storage Change	**0**	**0**	**0**	**0**	**0**	**8**	**–13**	**–8**	**2**	**1**	**10**	**0**	**0**

Figure 3-1. Flows at the Sacramento River below Keswick under 1991 Water Bank, drought, and median conditions.

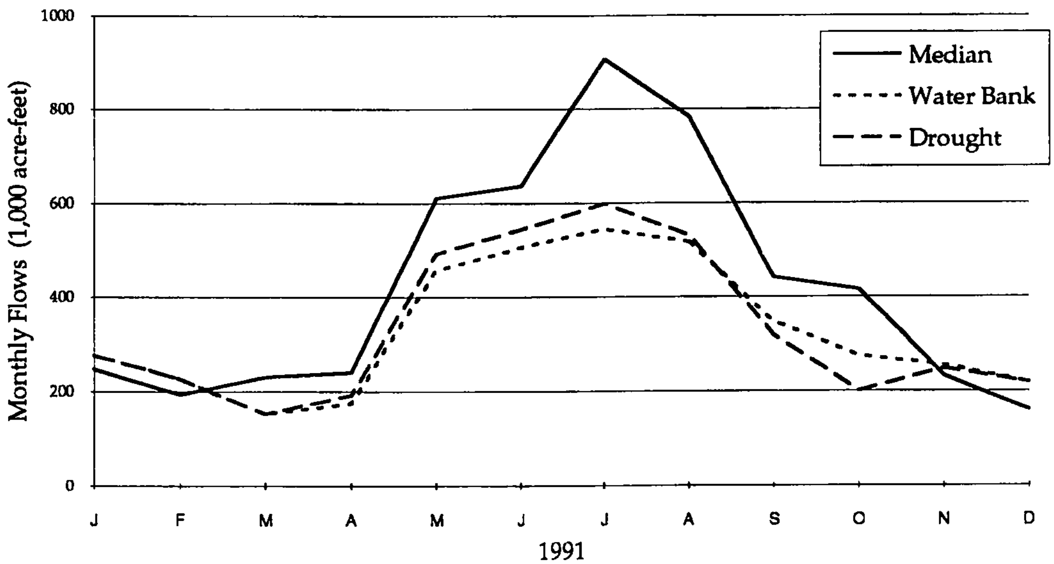


Figure 3-2. Flows at the Sacramento River at Wilkins Slough under 1991 Water Bank, drought, and median conditions.

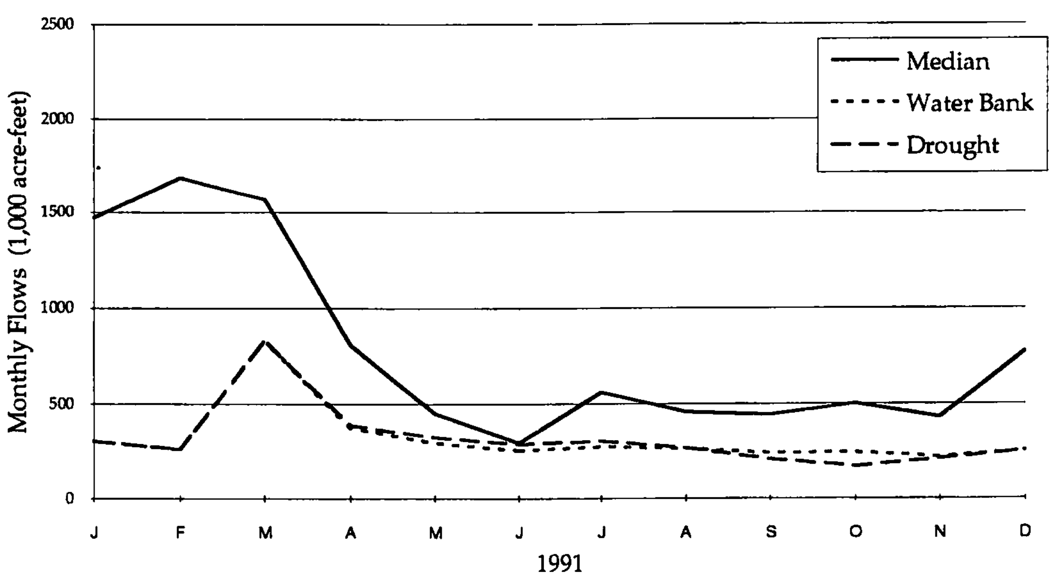


Figure 3-3. Flows at the Sacramento River at Freeport under 1991 Water Bank, drought, and median conditions.

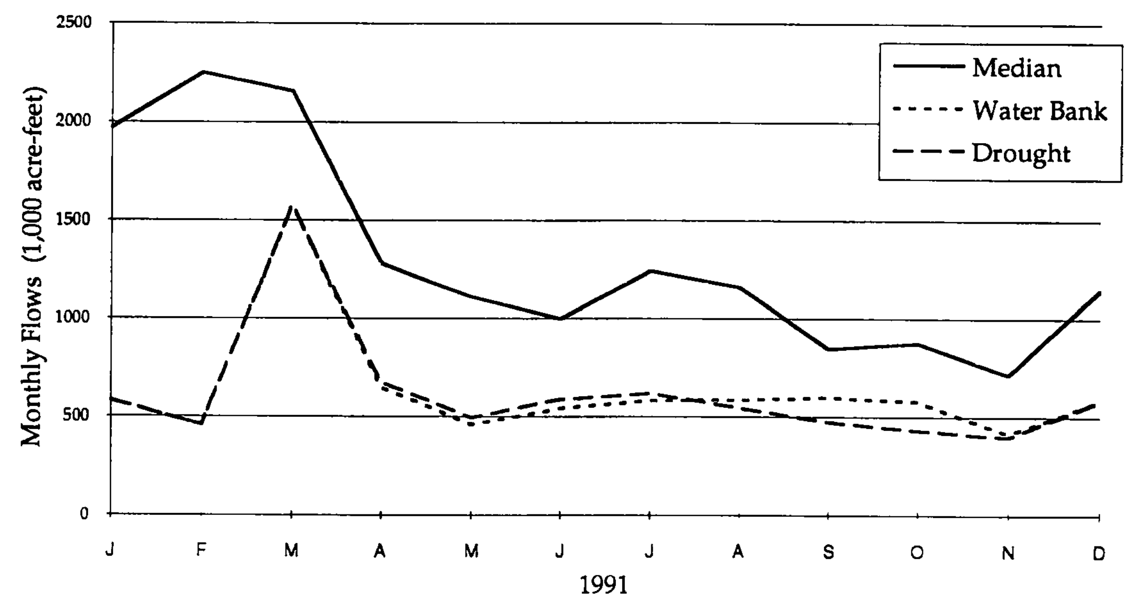


Figure 3-4. Flows at the Feather River below Thermalito under 1991 Water Bank, drought, and median conditions.

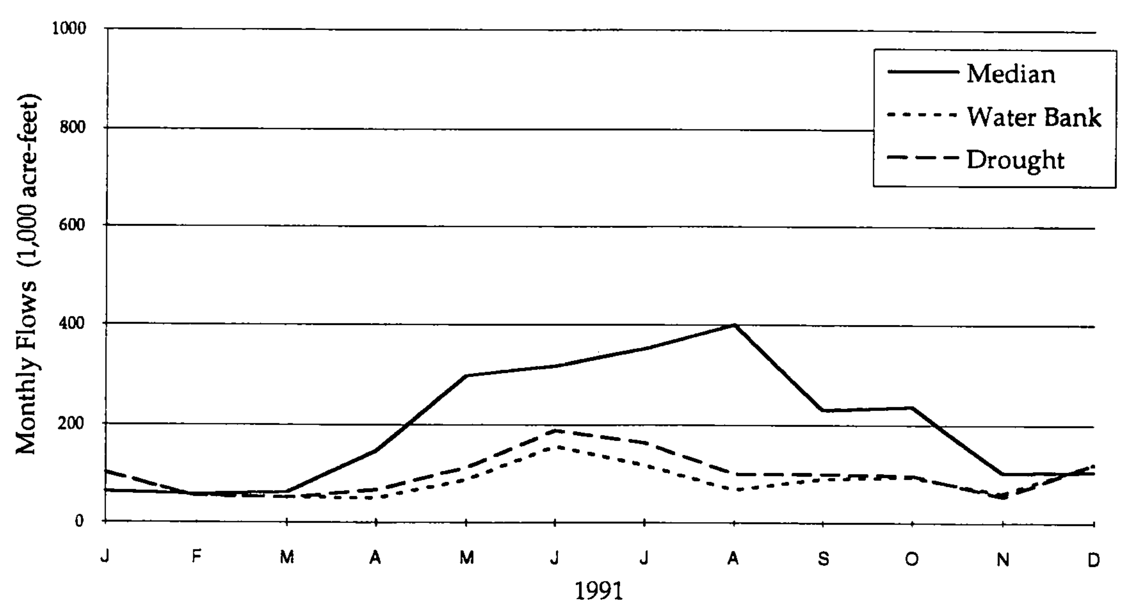


Figure 3-5. Flows at the Yuba River below New Bullards Bar Reservoir under 1991 Water Bank, drought, and median conditions.

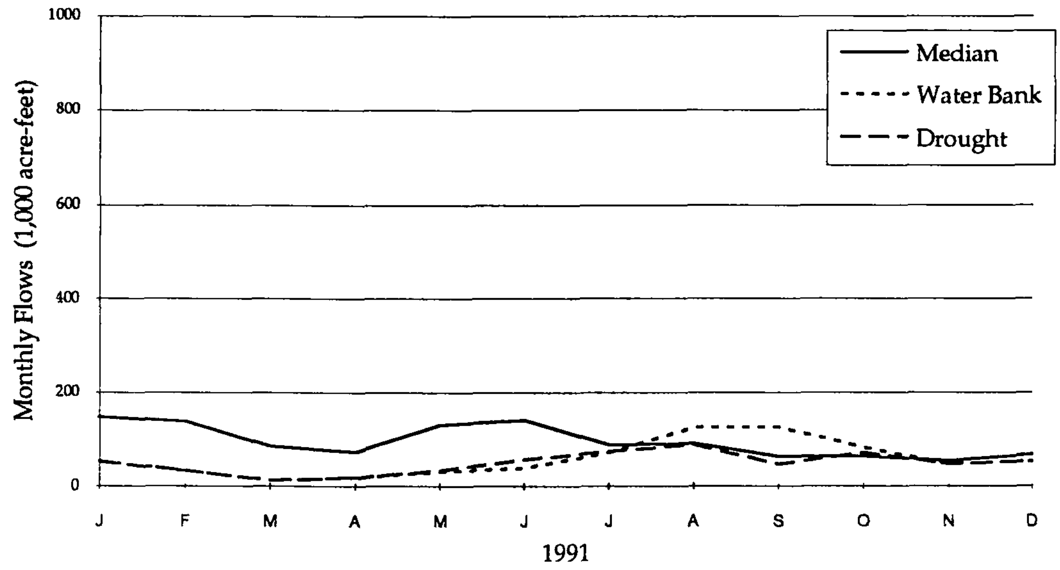


Figure 3-6. Flows at the Yuba River at Marysville under 1991 Water Bank, drought, and median conditions.

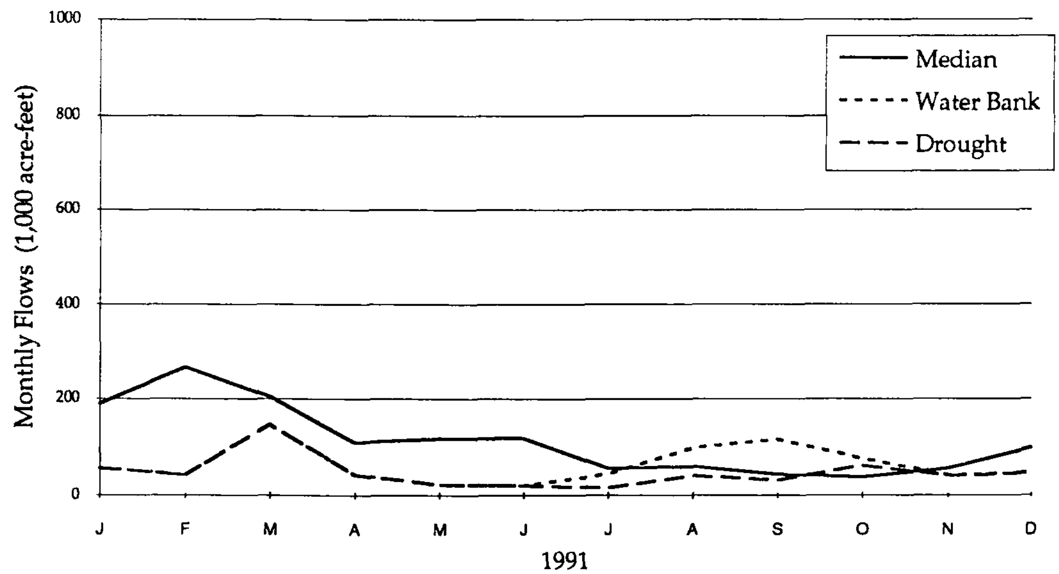


Figure 3-7. Flows at the Feather River below the Yuba River under 1991 Water Bank, drought, and median conditions.

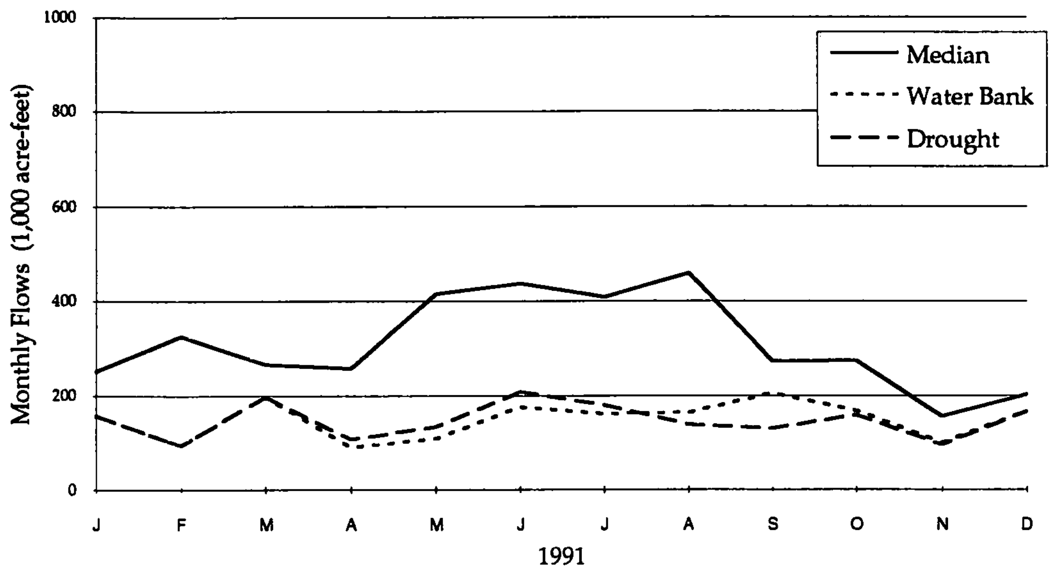


Figure 3-8. Flows at the American River below Nimbus under 1991 Water Bank, drought, and median conditions.

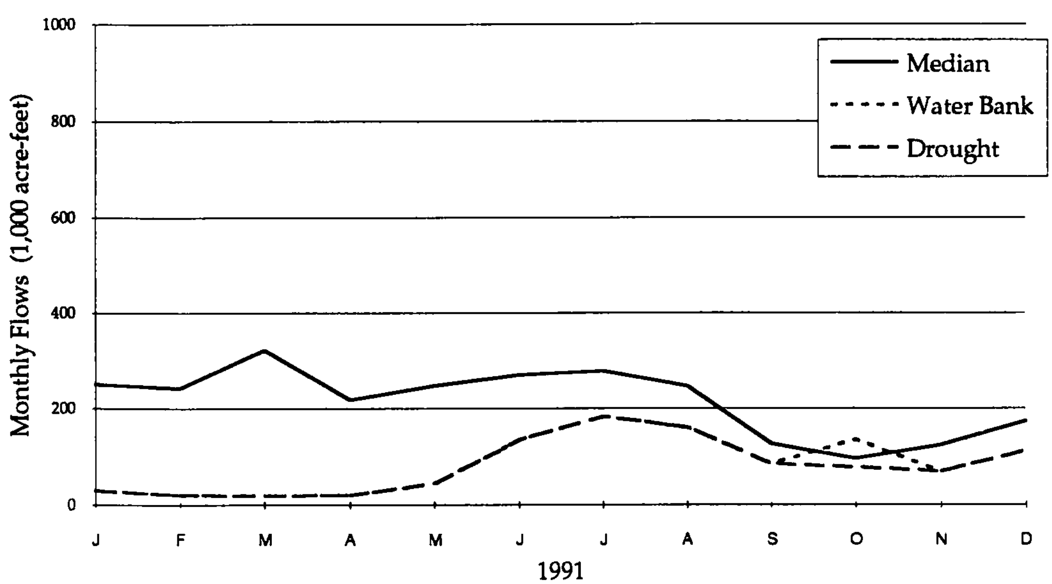


Figure 3-9. Flows at SWP H. O. Banks Pumping Plant under 1991 Water Bank, drought, and median conditions.

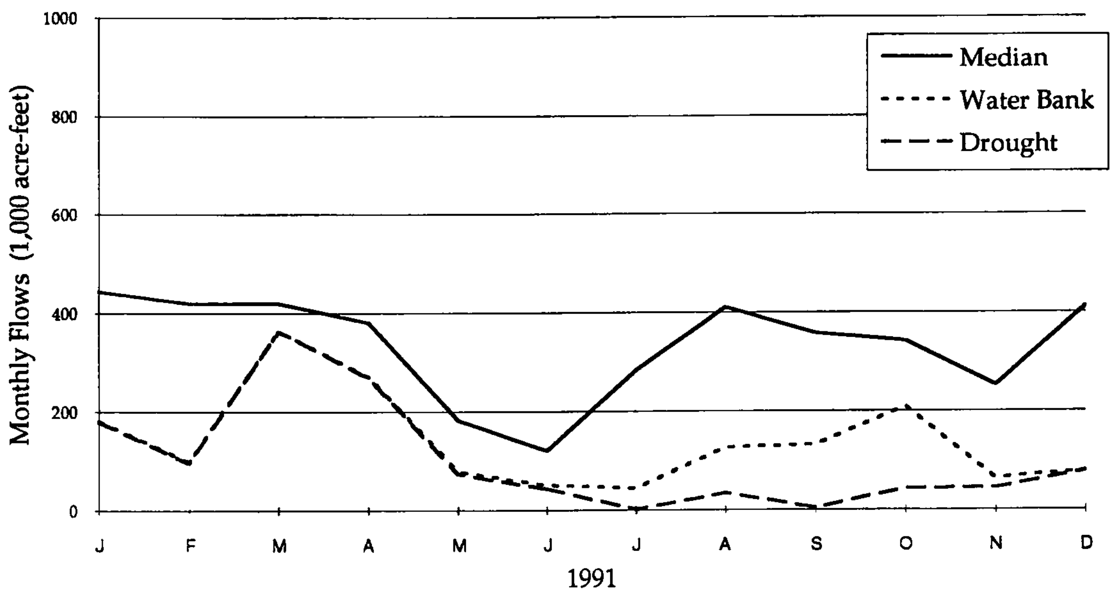


Figure 3-10. Flows at the CVP Tracy Pumping Plant under 1991 Water Bank, drought, and median conditions.

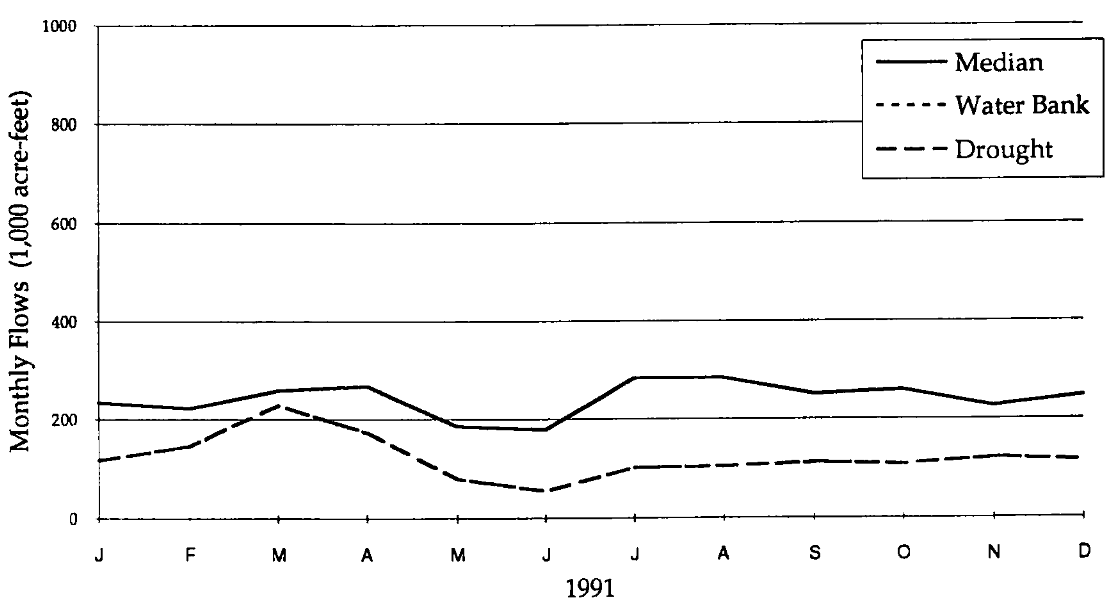


Figure 3-11. Delta Outflow Index under 1991 Water Bank, drought, and median conditions.

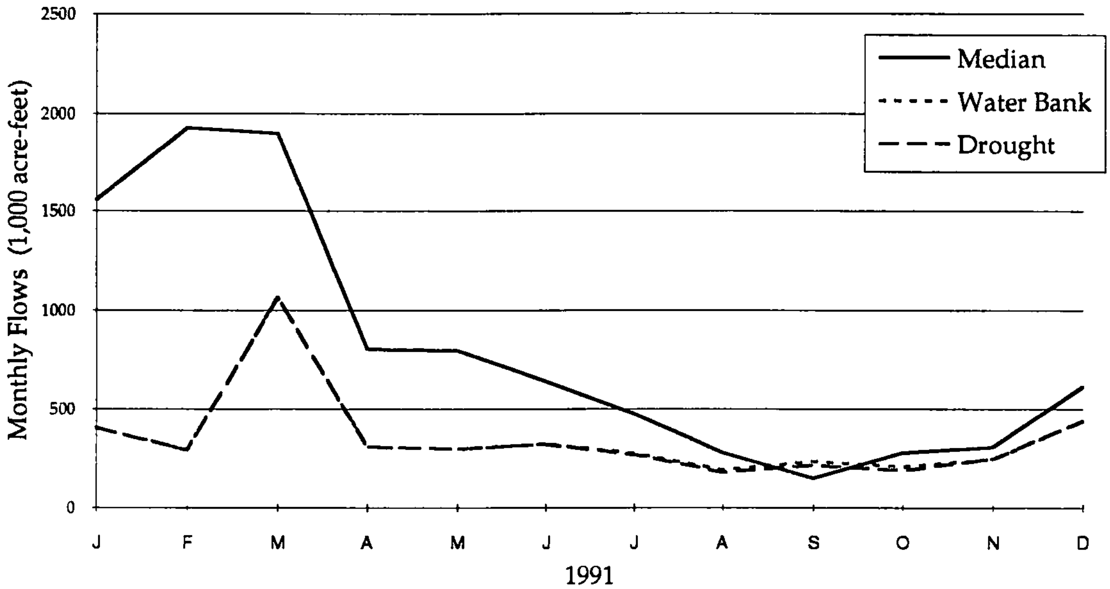


Figure 3-12. Flows at the San Joaquin River at Vernalis under 1991 Water Bank, drought, and median conditions.

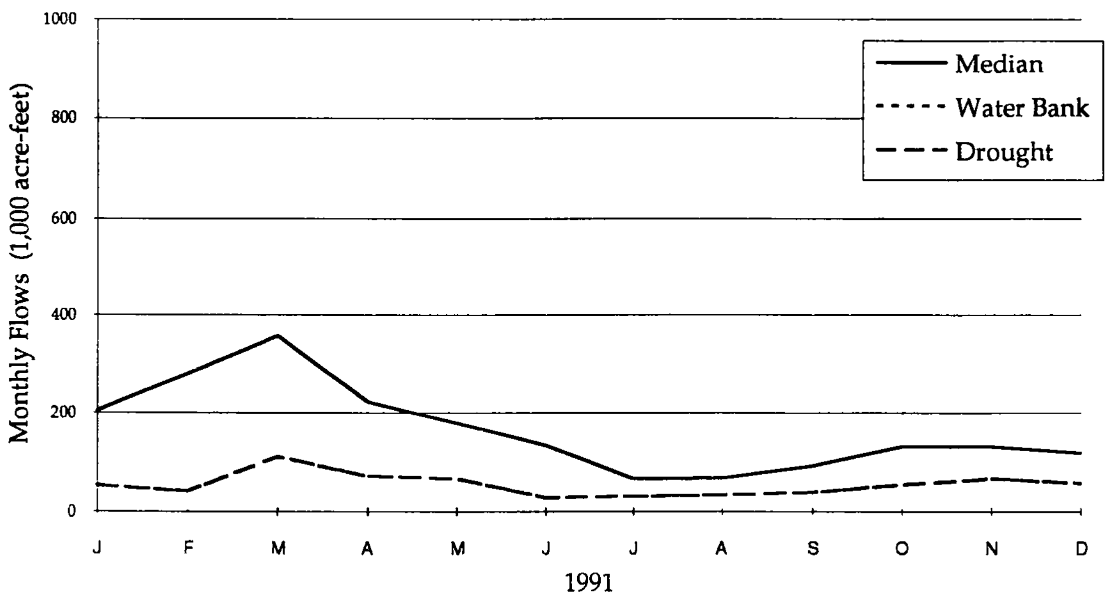


Figure 3-13. End of month storage at Shasta Reservoir under 1991 Water Bank, drought, and median conditions.

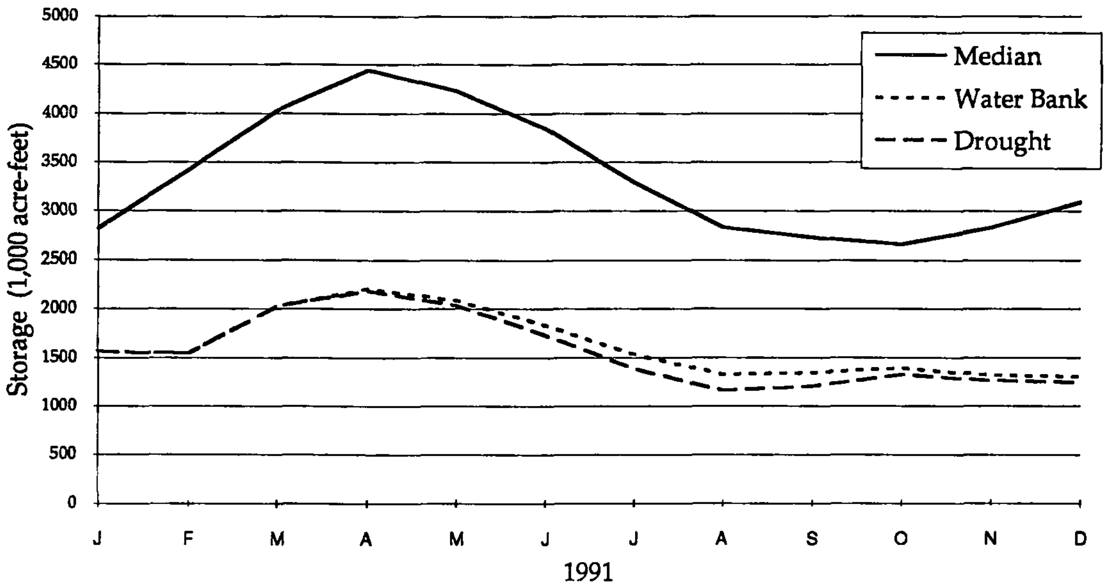


Figure 3-14. End of month storage at Oroville Reservoir under 1991 Water Bank, drought, and median conditions.

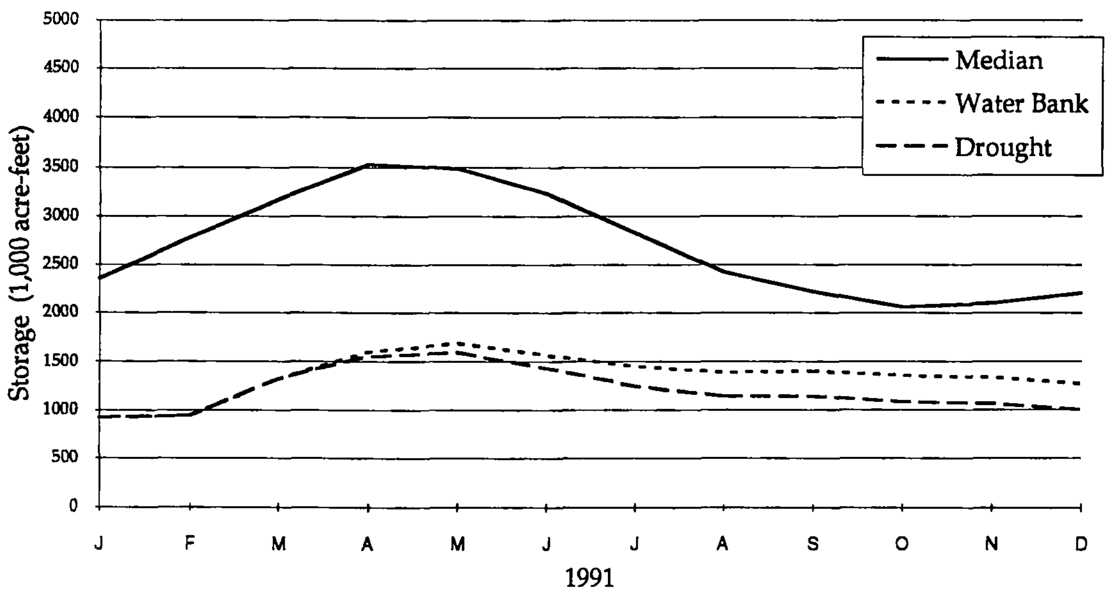


Figure 3-15. End of month storage at Folsom Reservoir under 1991 Water Bank, drought, and median conditions.

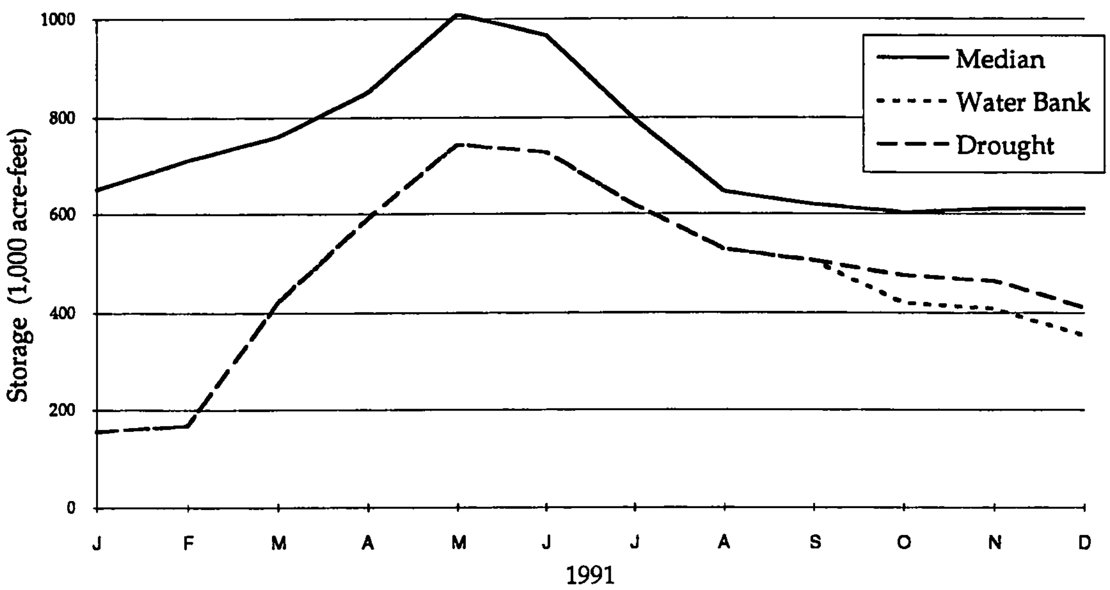


Figure 3-16. End of month storage at New Bullards Bar Reservoir under 1991 Water Bank, drought, and median conditions.

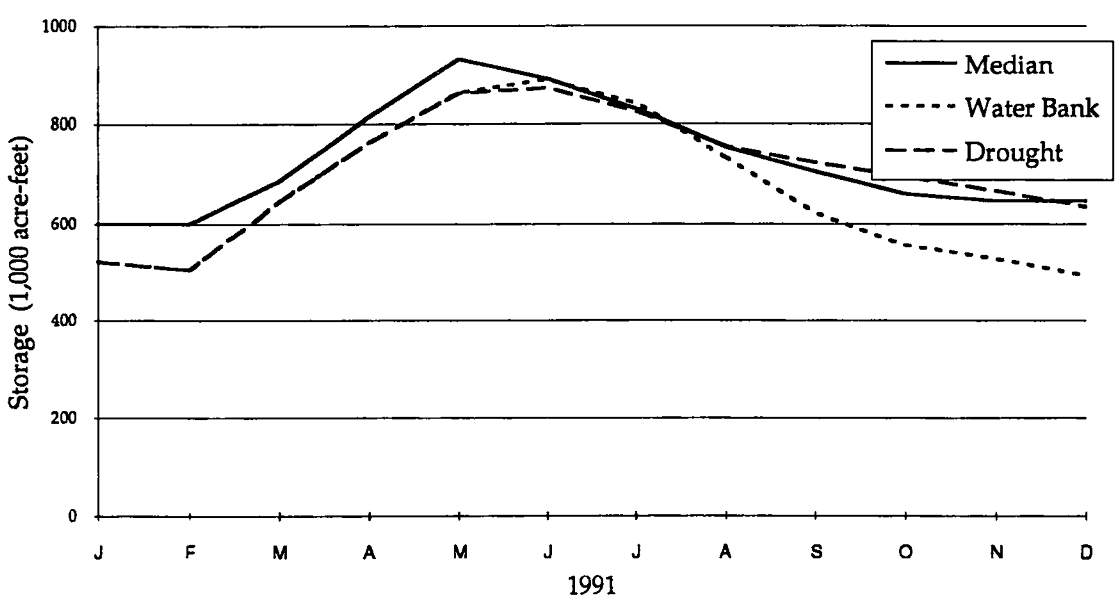


Figure 3-17. End of month storage at San Luis Reservoir under 1991 Water Bank, drought, and median conditions.

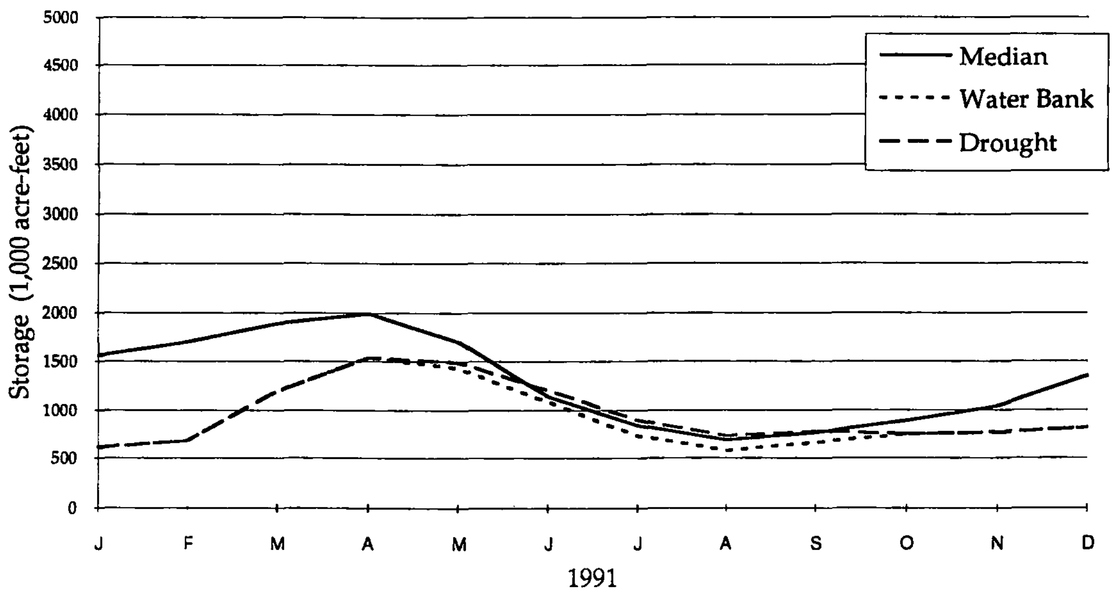


Figure 3-18. Flows at the Sacramento River below Keswick under 1992 Water Bank, drought, and median conditions.

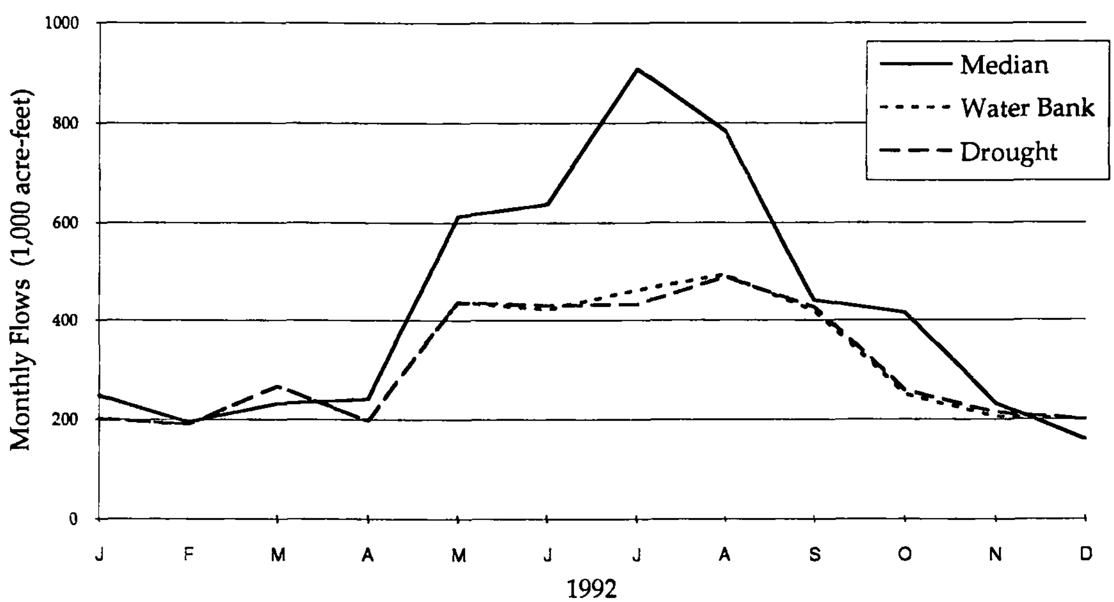


Figure 3-19. Flows at the Sacramento River at Wilkins Slough under 1992 Water Bank, drought, and median conditions.

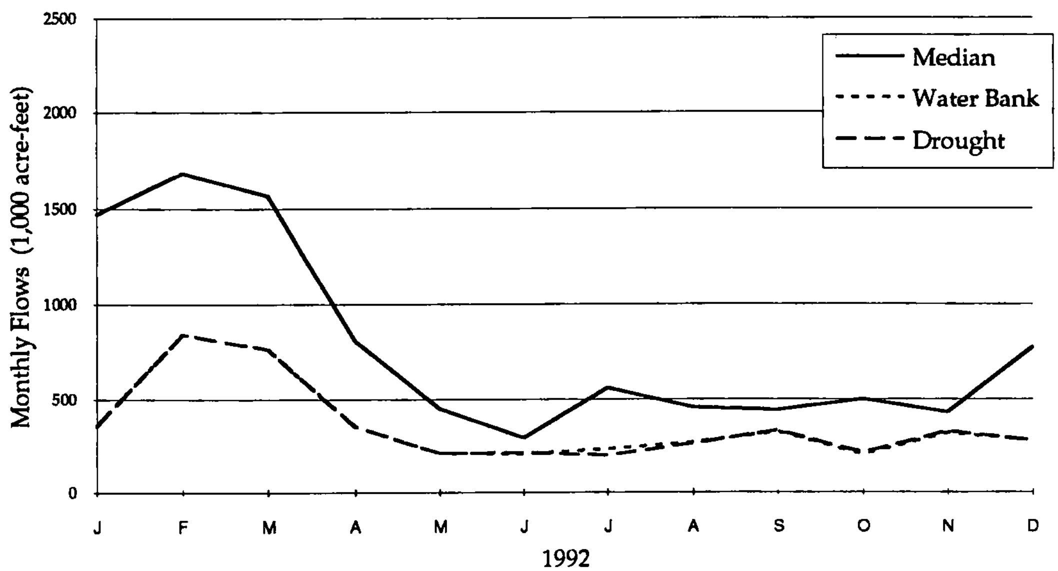


Figure 3-20. Flows at the Sacramento River at Freeport under 1992 Water Bank, drought, and median conditions.

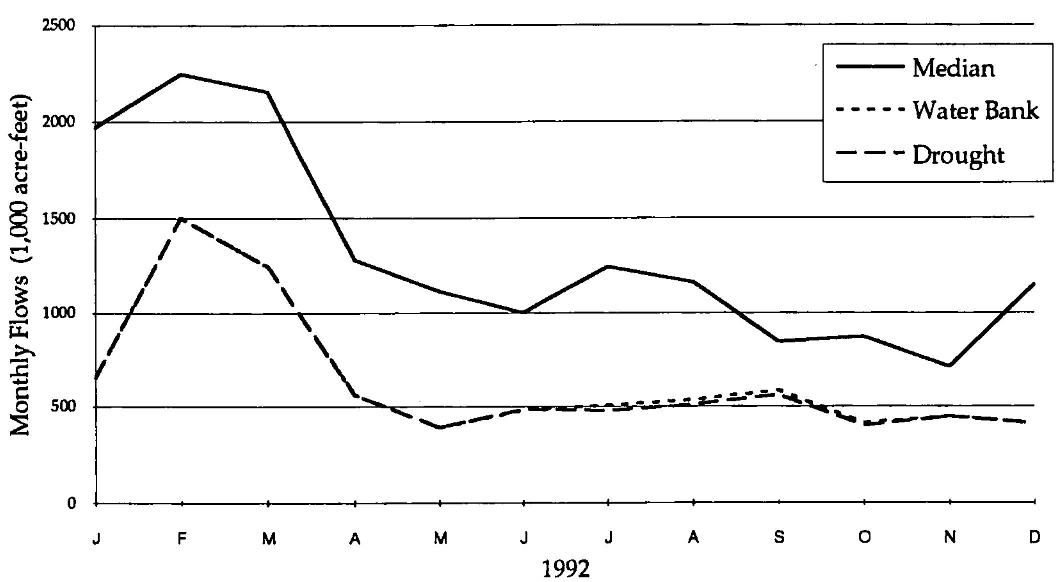


Figure 3-21. Flows at the Feather River below Thermalito under 1992 Water Bank, drought, and median conditions.

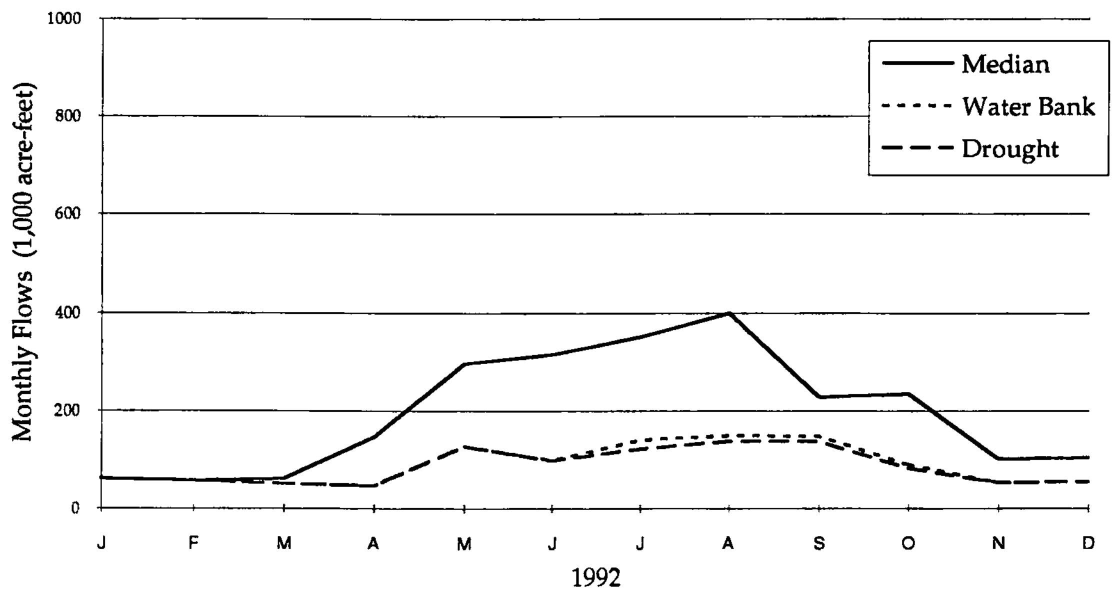


Figure 3-22. Flows at the Yuba River below New Bullards Bar Reservoir under 1992 Water Bank, drought, and median conditions.

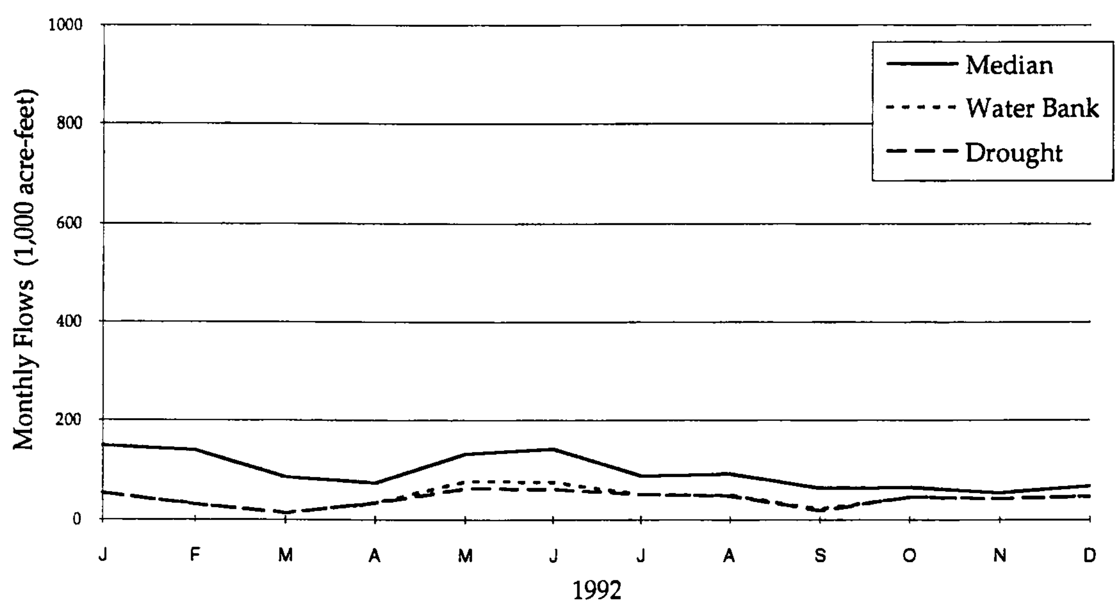


Figure 3-23. Flows at the Yuba River at Marysville under 1992 Water Bank, drought, and median conditions.

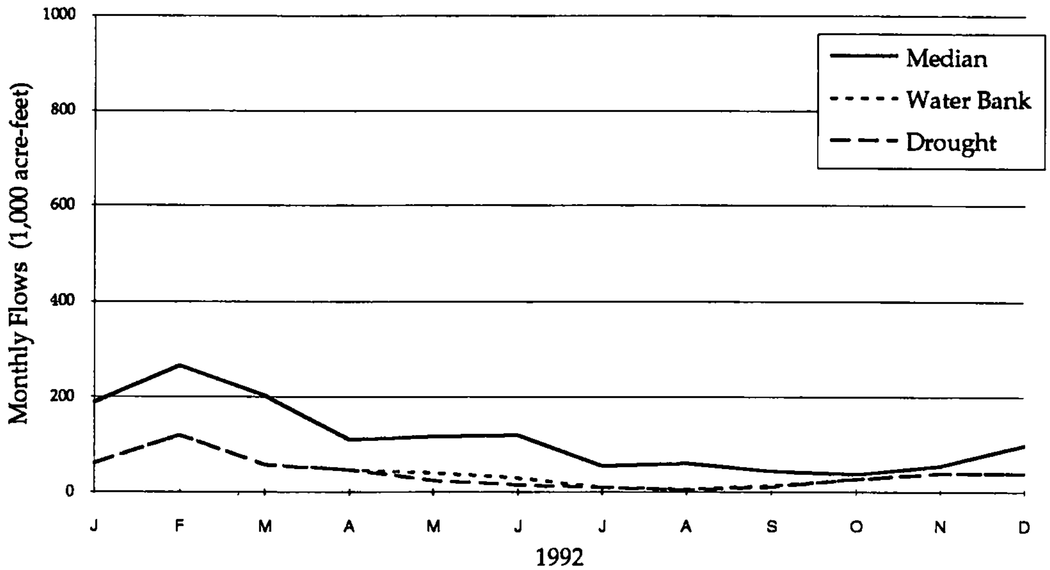


Figure 3-24. Flows at the Feather River below the Yuba River under 1992 Water Bank, drought, and median conditions.

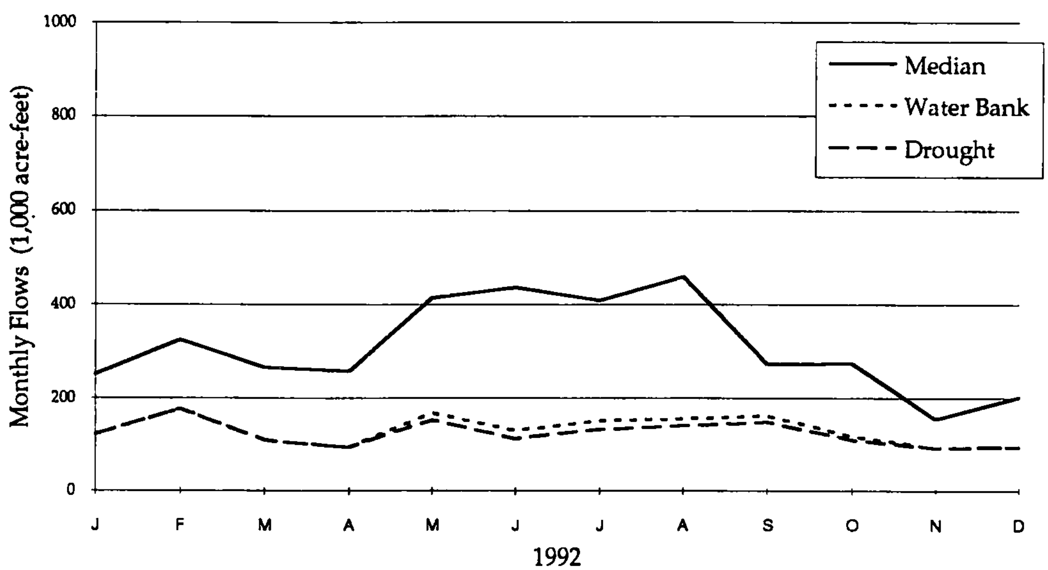


Figure 3-25. Flows at the American River below Nimbus under 1992 Water Bank, drought, and median conditions.

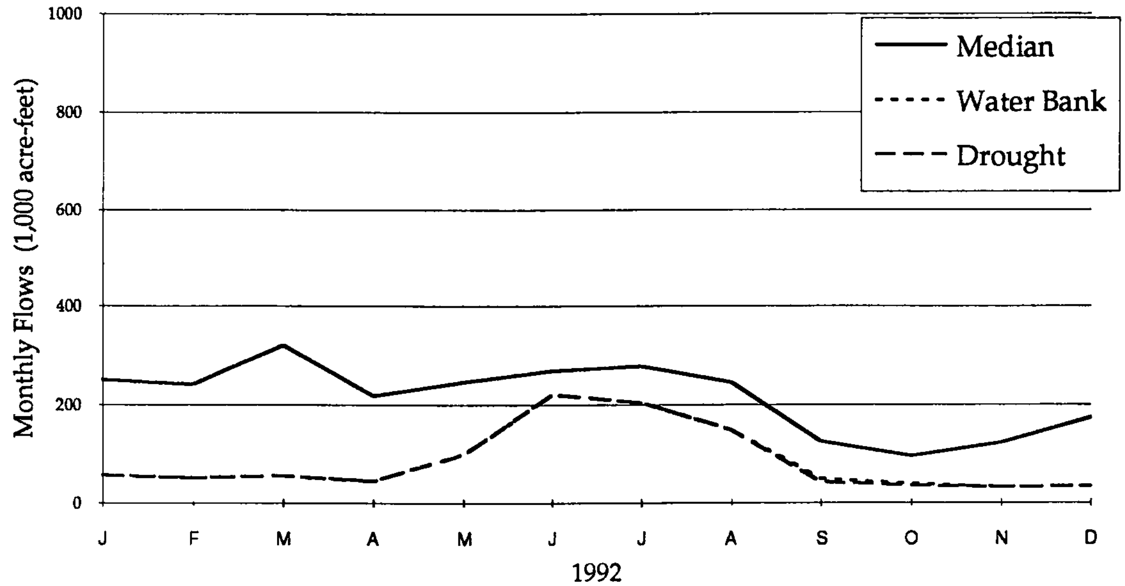


Figure 3-26. Flows at SWP H. O. Banks Pumping Plant under 1992 Water Bank, drought, and median conditions.

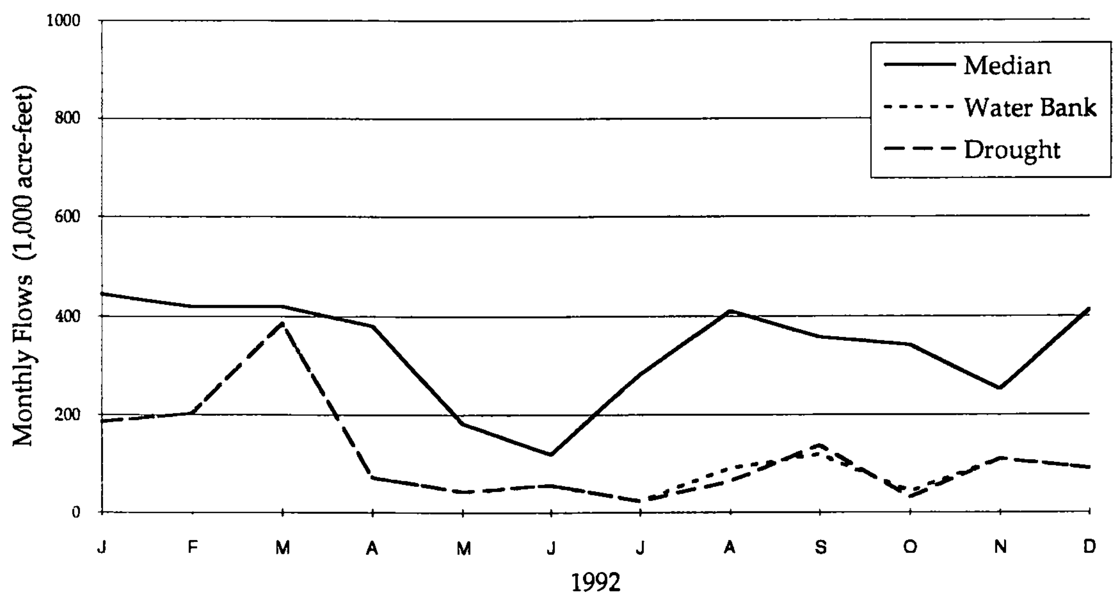


Figure 3-27. Flows at the CVP Tracy Pumping Plant under 1992 Water Bank, drought, and median conditions.

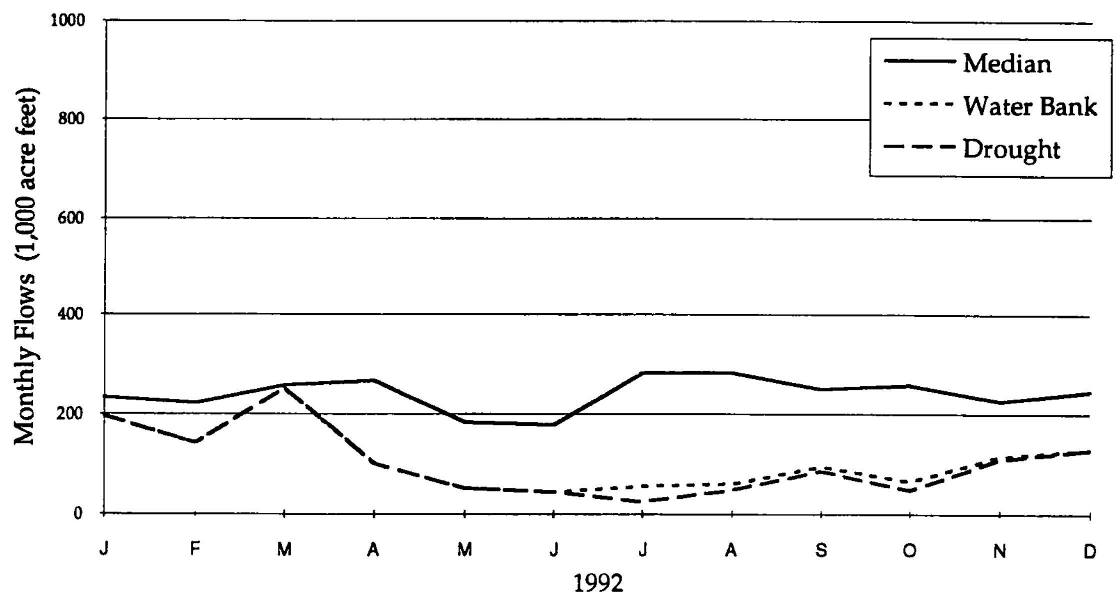


Figure 3-28. Delta Outflow Index under 1992 Water Bank, drought, and median conditions.

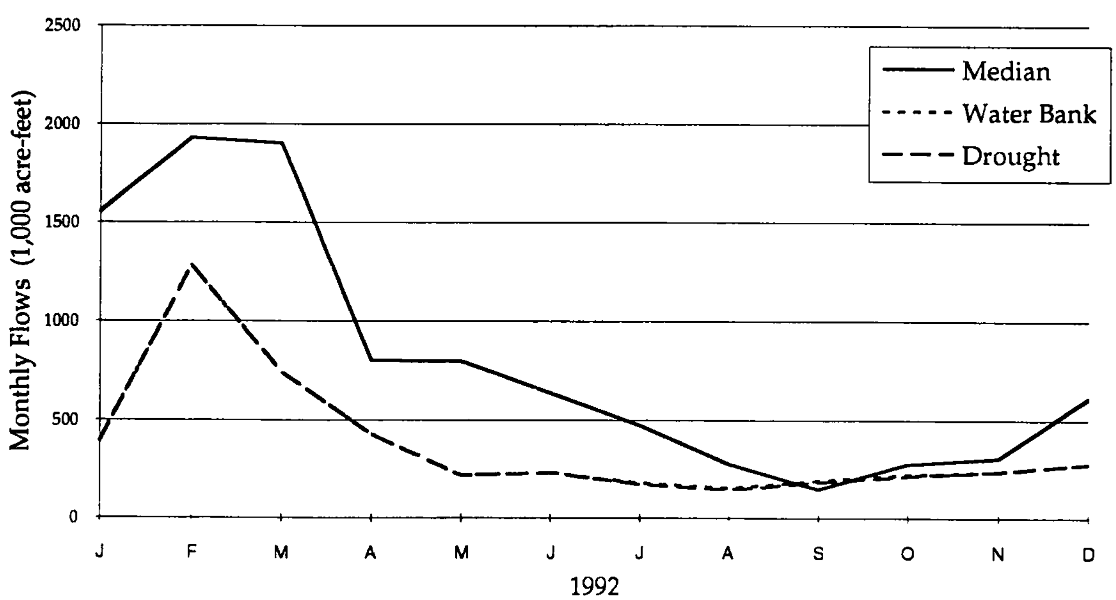


Figure 3-29. Flows at the San Joaquin River at Vernalis under 1992 Water Bank, drought, and median conditions.

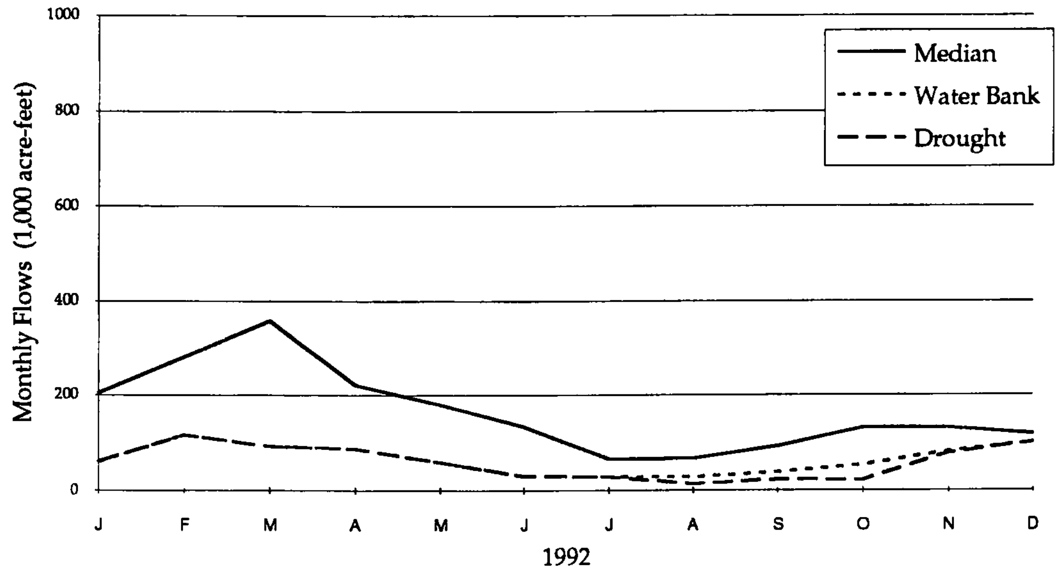


Figure 3-30. End of month storage at Shasta Reservoir under 1992 Water Bank, drought, and median conditions.

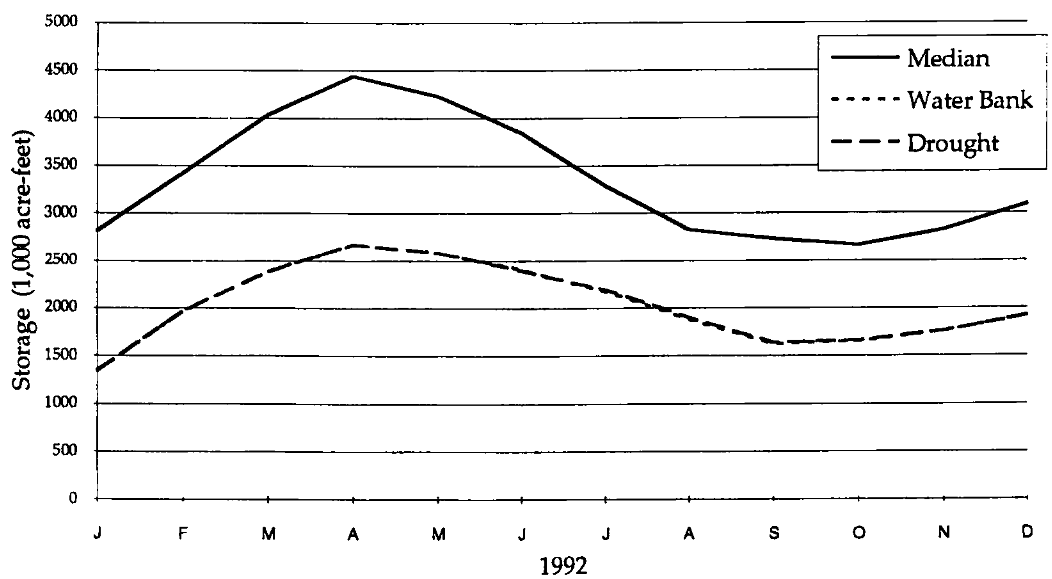


Figure 3-31. End of month storage at Oroville Reservoir under 1992 Water Bank, drought, and median conditions.

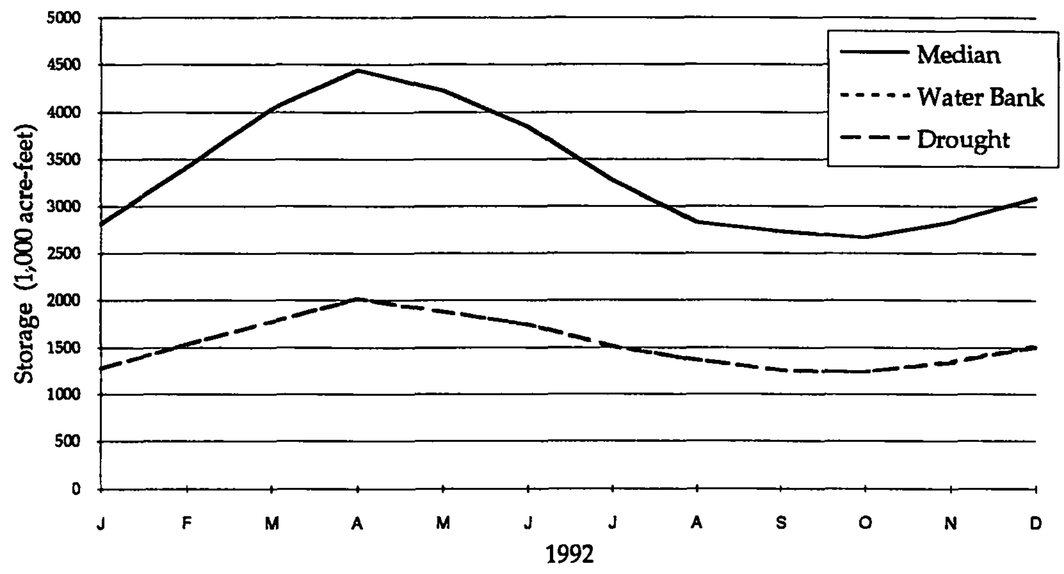


Figure 3-32. End of month storage at Folsom Reservoir under 1992 Water Bank, drought, and median conditions.

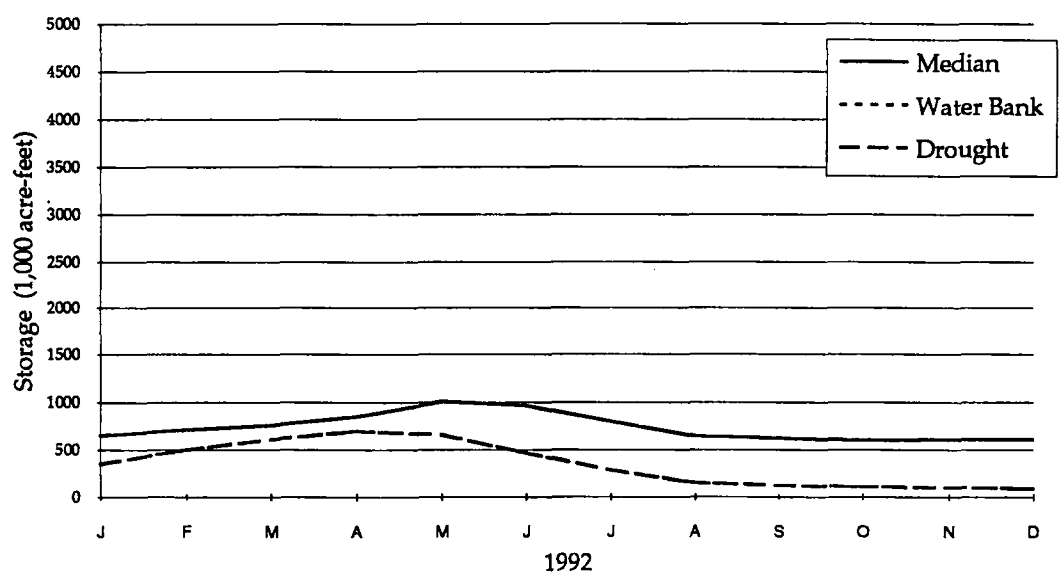


Figure 3-33. End of month storage at New Bullard's Bar Reservoir under 1992 Water Bank, drought, and median conditions.

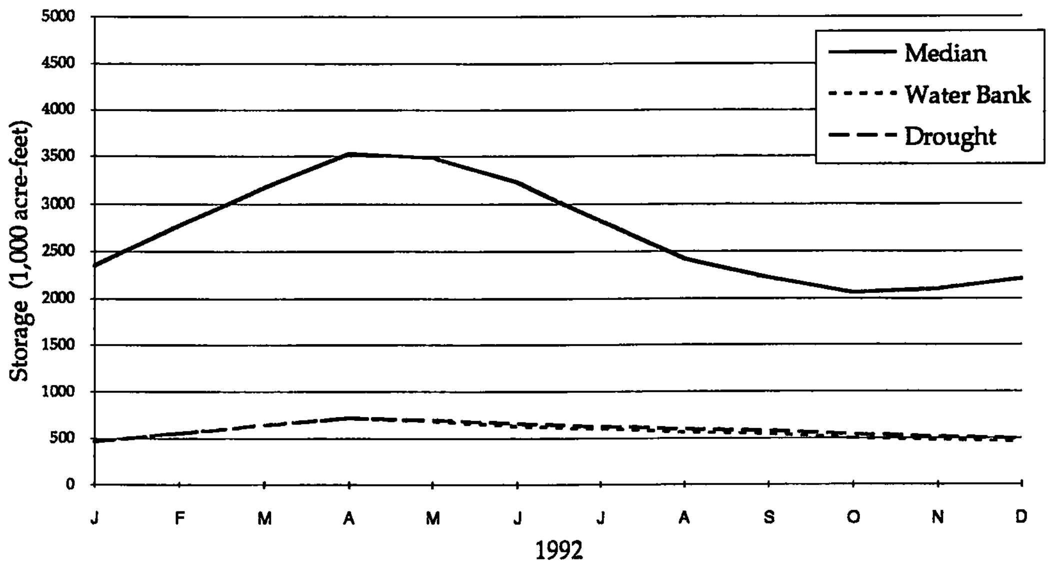
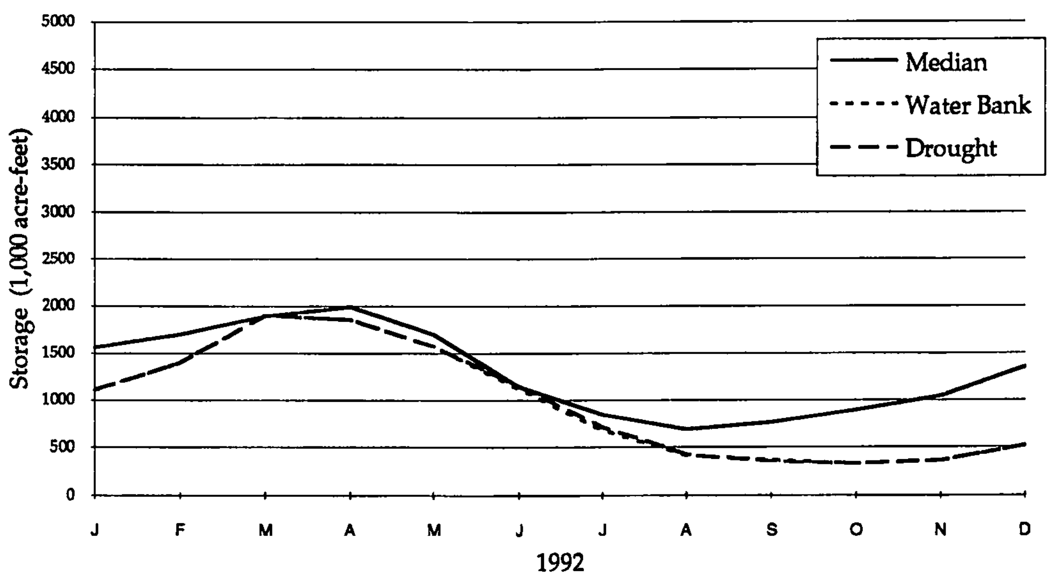


Figure 3-34. End of month storage at San Luis Reservoir under 1992 Water Bank, drought, and median conditions.



Environmental Effects. The 1991 and 1992 water banks produced relatively minor changes in streamflows and reservoir storage, which are not known to have resulted in any significant adverse environmental impact. Indeed, if these minor changes were to result in any discernable effect, such effects would likely be beneficial. Increased streamflows create increased habitat for aquatic life. Deeper reservoirs enhance recreational opportunities and create larger pools of cold water deep within the reservoirs to release for fishery benefits. Not all reservoirs benefited from increased storage, but the benefits produced in those that did should off-set any adverse effects from slightly lower levels at others.

Potential significant effects could occur from using a reservoir as a source of water for the proposed program for more than one year. Decreased carryover, as a result of the water bank, could affect local water needs in subsequent years if sufficient rains do not occur to refill the reservoir.

The proposed Drought Water Bank program is expected to result in similar effects as the 1991 and 1992 Water Banks, and therefore produce no significant adverse environmental impacts from use of surface water sources except for possible reduction in carryover storage.

Ground Water Sources

Potential environmental effects of using ground water sources, either directly or by exchange, for a drought water bank differ from effects associated with other water sources only as a result of changes in ground water levels. Therefore, only water level related impacts are evaluated in this section. These can be divided into four areas: 1) overdraft, 2) land subsidence, 3) effects on other pumpers, and 4) effects on flows in the surface water system. In addition, some areas currently experience poor ground water quality, while in other areas increased ground water extraction can result in degradation of water quality. The 1991 and 1992 Water Banks provided experience in evaluating and developing approaches to avoid or mitigate any significant impacts.

Ground Water Overdraft. Ground water overdraft occurs when the amount of water removed from a ground water basin exceeds the amount of replenishment over an extended period of time under average water supply and hydrologic conditions. Ground water overdraft applies to a long-term imbalance of supply and demand in an entire ground water basin. Overdraft is not synonymous with declining water levels. Neither the localized fall of water levels in response to pumping or the larger scale declines that occur in a dry period constitute overdraft. In turn, conjunctive use operations that coordinate the use of surface water and ground water resources to maximize the available water supply do not result in overdraft in and of themselves, although they may contain a component of temporary deliberate reduction in ground water storage. The water removed from storage is subsequently replaced by recharge.

Overdraft occurs in a number of basins in California. DWR lists 11 basins as subject to critical conditions of overdraft (Table 3-3, Figure 3-35). Currently, the total overdraft in California is about 2,000,000 acre-feet per year, the bulk of which occurs in the southern San Joaquin Valley. Drought Water Bank transfers involving ground water substitution are expected to occur in basins that are not overdrafted. Most ground water transfers are anticipated to originate in the Sacramento Valley or perhaps in the northern San Joaquin Valley. The amount of ground water involved (about 200,000 acre-feet) and the intermittent imposition of this demand will not result in overdraft in the ground water basins in these areas.

Table 3-3. Basins Subject to Critical Conditions of Overdraft

Santa Cruz at Pajaro Basin	Cuyama Valley Basin
Chowchilla Basin	Madera Basin
Kings Basin	Kaweah Basin
Tulare Lake Basin	Tule Basin
Kern County Basin	

Land Subsidence. Widespread land subsidence has occurred in California as a result of ground water development (Figure 3-36). The most extensive area of subsidence is in the central and southern San Joaquin Valley where the maximum reduction in elevation has exceeded 28 feet. In the Santa Clara Valley, as much as 14 feet of subsidence has occurred with the land surface in the lower end of the valley falling below sea level. In the Sacramento Valley, documented subsidence has occurred in the Zamora to Davis area in Yolo County with a maximum land surface decline of about 6 feet. Land subsidence related to ground water pumping may have occurred in other parts of California, but is thought to be less significant and is poorly documented. The Sacramento-San Joaquin Delta has also experienced significant subsidence. Here subsidence is not related to ground water pumping but rather to compaction, oxidation, erosion of peat soils, and, perhaps to a lesser extent the extraction of natural gas.

Figure 3-35. Basins Subject to Critical Conditions of Overdraft

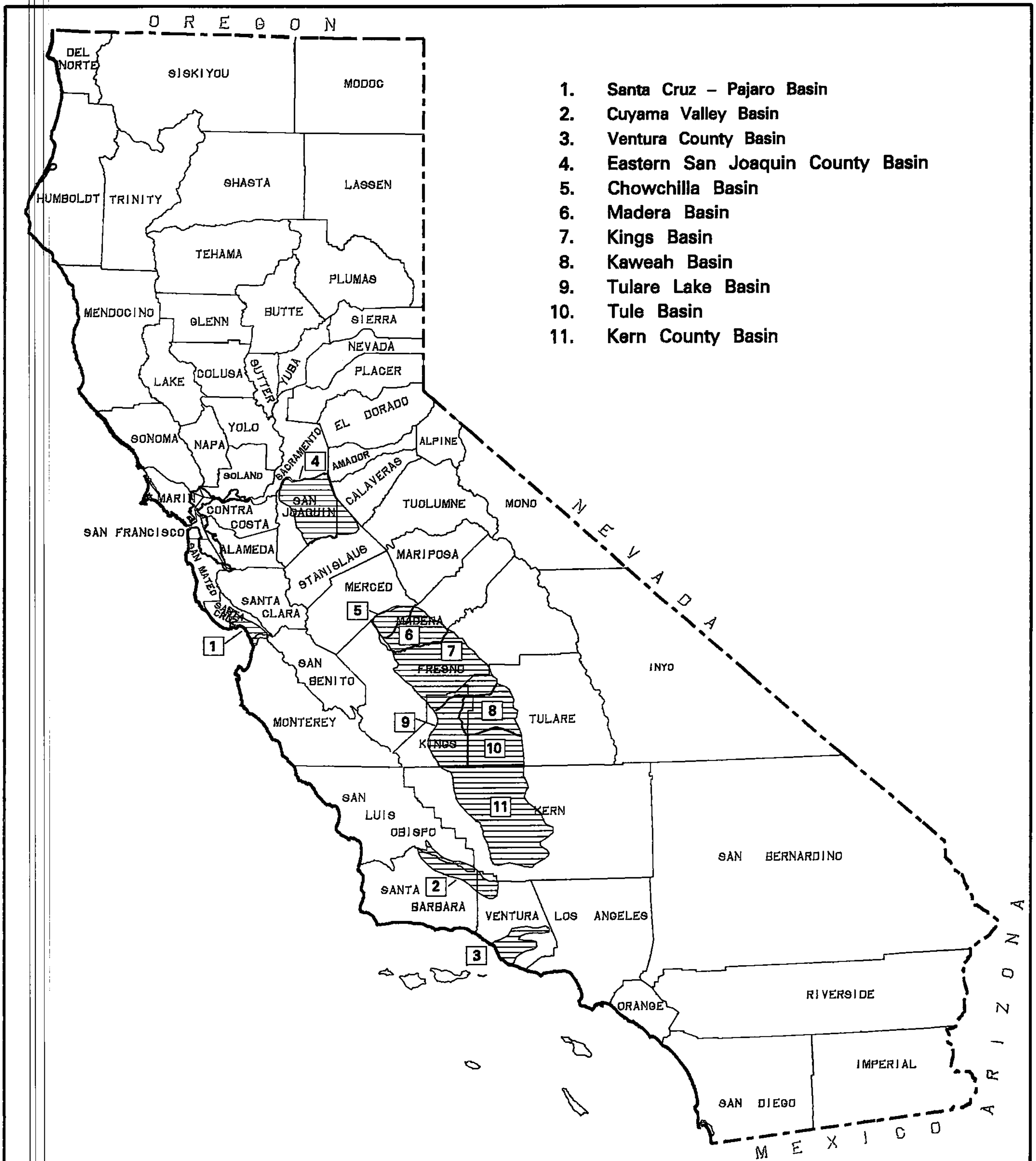


Figure 3-36. Areas with Significant Subsidence

Land subsidence occurs when declining water levels increase the effective stress on fine grained (generally clayey) materials contained in a ground water basin causing them to compact. It is a slow process because it takes time for the water contained in the clays to slowly drain away into the higher permeability aquifer materials where it becomes available for extraction. Therefore, dramatic impacts are not seen, but rather the slow accumulation of effects. Renewed pumping of a recovered aquifer results in very rapid declines in water levels until historic lows are reached, at which point subsidence will be renewed and the rate of decline will decrease significantly. Conversely, water levels will recover rapidly with recharge and cessation of pumping. The principal effect changes the way the aquifer system responds to pumping stress. Contrary to the popularly held belief, subsidence does not reduce the amount of useable storage space in the basins. Water removed from clays is so tightly held that it does not flow to a well and thus is not useable in terms of storage that could be drained and refilled.

The potential for land subsidence is a concern in those areas where ground water is exchanged for surface water used in water transfers. In recipient areas, transfers are likely to be neutral or beneficial from a land subsidence standpoint, since the amount of ground water pumping required to meet area needs would be reduced. The primary areas where potential land subsidence is a concern in potential water bank source areas are the northern San Joaquin Valley and the Sacramento Valley. In these areas, subsidence potential is least significant in the northern and eastern Sacramento Valley where much of the ground water pumping comes from semiconsolidated materials or areas that are unconfined with limited amounts of fine grained material.

Subsidence has two potential impacts within the aquifer system. The first is the possibility that wells will be destroyed as compaction crumples or shears off casings as has occasionally happened. This is not a universal occurrence, but depends on conditions at a given site and on well construction characteristics. The other impact within the aquifer system is on declining water levels that result in increased cost of pumping, deepening the well, or lowering the bowls in the pumps. This is probably not significant other than in areas with historic subsidence with recovered water levels.

The potentially most significant impacts of subsidence result from changes to the land surface elevation. These can disrupt conveyance in surface water facilities, both natural and man made, and result in increased maintenance requirements for surface facilities such as railroads, especially if subsidence is localized instead of regional. The most significant potential impact is on the network of levees that provide flood protection where the level of protection would be reduced by significant subsidence.

The actual lowering of water levels in the unconfined portion of a basin could have impacts on wetlands supported by high ground water levels, phreatophytic and riparian vegetation, and on the amount of water required to maintain rice production. However, surface water exchanged for ground water as part of a water transfer could be used, in some cases, to supply water to wetland areas otherwise being impacted by drought conditions. Also, lowering water levels could benefit areas where inadequate drainage adversely impacts agriculture.

During the 1991 and 1992 Water Banks, potential effects of each proposed transfer involving ground water were evaluated and only those transfers that were not expected to cause significant adverse effects were accepted. Extensive monitoring programs were established to identify any significant adverse effects associated with ground water extraction due to the Water Banks. Some insignificant local effects were identified from this monitoring dealing with lower ground water levels, but subsidence was not identified as a problem. The ground water substitution program was quickly modified to mitigate these insignificant effects to water levels.

Effects on Other Pumpers. The main effects of exchanging ground water for surface water in a drought water bank will be reduced ground water levels. As water levels decline in response to increased pumping, the amount of energy, and hence cost, required to lift water to the surface increases. In addition, there may be cases where water levels decline sufficiently to require deepening wells, constructing new wells, or lowering pump bowls in wells. This would result in increased costs to the well operator, or owner, and possibly other economic losses if an alternative water supply is not available in the interim. It is also possible that wells on the margins of basins could be completely dewatered as a result of regional water level declines.

DWR's extensive monitoring efforts during the 1991 and 1992 Water Banks were able to identify some adverse effects to neighboring land owners from ground water substitution for surface water supplies. Ground water extraction as a result of the Water Bank in 1991 resulted in lowering water levels in wells serving individual residences in a rural subdivision in Yuba County. DWR's monitoring program identified this problem before it became significant and modified ground water extraction activities to resolve the problem.

Effects on Flows in the Surface Water System. In most potential source areas for a drought water bank, the surface and ground water systems are hydraulically connected. As a result, additional ground water pumping could reduce the flow in the surface water system and impact other areas of discharge or areas from which additional recharge is induced. This can result from changes in the hydraulic gradients in the ground water system or from lowering ground water levels.

Additional ground water pumping can affect the amount of flow in surface streams in either of two ways depending on the relative elevation of water levels in the river and the adjacent basin. Normally water is either being recharged into the basin by seepage from a river or is being discharged to the river from ground water. As ground water levels decline, the gradient to the surface system increases and the amount of seepage from the river increases or the discharge to the river decreases, either of which reduces flows in the river system. This may result in the need to increase releases of stored water into the river system.

DWR is not aware of any changes in surface water sources due to the 1991 and 1992 Water Banks. Effects to surface water sources due to recharge to the ground water would likely not be able to be differentiated from short–term water transfers proposed by the Drought Water Bank. Although some surface water may be lost to ground water recharge, such effects are considered insignificant in relation to the duration of the proposed program.

Water Quality Effects. Known water quality problems are of concern in some areas of the Central Valley. Toxic elements such as selenium, arsenic, boron, and various salts have been detected in ground water. Accumulation of these potentially toxic constituents must be avoided. However, the quality of ground water in many areas of the State are poorly known.

Ground water extraction can induce poorer quality water to migrate to wells and the surrounding ground water. Nevertheless, in the worst case, water quality at a well could deteriorate to the point where it was no longer suitable for its intended use. This would necessitate abandoning that use, finding alternative uses, finding alternative supplies, or providing treatment to improve the water quality. All of these alternatives have potential economic impacts. In addition, portions of the basin may become unusable since it is very difficult to reclaim substantial areas where water quality has deteriorated to the point where it is unusable. Some areas where wells have not previously been developed may also contain poor quality water.

No adverse water quality effects were identified from operations of the 1991 and 1992 Water Banks.

Recent changes in the California Water Code that go into effect on January 1, 1993, include the following provisions regarding water transfer:

> 1745.10. A water user that transfers surface water pursuant to this article may not replace that water with ground water unless the ground water use is either of the following:
>
> (a) Consistent with a ground water management plan adopted pursuant to State law for the affected area.
>
> (b) Approved by the water supplier from whose service area the water is to be transferred and that water supplier, if a ground water management plan has not been adopted, determines that the transfer will not create, or contribute to, conditions of long–term overdraft in the affected ground water basin

The provisions of these new changes in State law are intended to reduce potential impacts of water transfers to the local economy, as well as reduce potential impacts to regional ground water resources. Future State drought water banks (and, in fact, many or all future water transfers) will operate to these provisions.

Identification and mitigation of any adverse effects will require careful consideration of data from existing ground water monitoring programs and the extension of Drought Water Bank monitoring beyond the annual time frame when each bank expects to operate. At a minimum, ground water monitoring should continue through the subsequent winter and spring recharge period to determine the extent of water level recovery following bank extractions. This information could be used to provide a baseline from which any possible residual effects of the Drought Water Bank can be assessed. This information can be used to determine possible effects of future Drought Water Banks and locations where banks should be avoided.

Evaluation of 1991 and 1992 Water Banks. During implementation of the 1991 and 1992 Water Banks, the potential impacts of each proposed transfer involving ground water were evaluated and only those transfers that were not expected to cause significant adverse impacts were accepted. These evaluations were cooperatively performed by hydrogeologists from DWR and the USBR. In addition, an appropriate monitoring program was developed for the transfers that became part of the bank. The results of the monitoring programs were used to identify the impacts of the transfers, evaluate claims of adverse impacts on third parties, and provide a basis for modifying the transfer where such impacts occurred. In general, problems were minor or nonexistent.

In the 1991 and 1992 Water Banks, transfers involving ground water were conceptually very similar. In essence, a surface water user would switch to a ground water supply and relinquish a portion of the surface water to the bank. However, each individual transfer differed in the intensity of ground water pumping, the degree that other ground water use occurred in the area, and the potential consequences of any adverse impacts that mighty occur. Consequently, individual monitoring programs were developed for the transfers and their degree of sophistication was tied to local conditions and concerns.

At a minimum, most transfers required installation of flow meters on the wells, evaluation of the construction characteristics of the wells in relation to aquifer properties, and periodic water level measurements of the pumping wells, where possible. In a situation where the transfer involved a single well or a few widely spaced wells in areas with little or no other ground water use, this could constitute the entire monitoring program as the potential for significant adverse impacts was expected to be inconsequential. As the intensity of pumping or development increased so did the degree of monitoring.

The monitoring of the participating districts within the Yuba County Water Agency, during the 1991 Water Bank, illustrates an intermediate level of monitoring. Yuba County is an area that at one time relied primarily on ground water for a source of agricultural supply, with a resultant long term decline in water levels. However, development of surface water resources allowed ground water levels to recover. In effect, pumping for the water bank constituted a partial return to former water supply conditions. As a result, stresses due to water bank pumping were not expected to result in significant adverse effects. The main concern focused on water level impacts on domestic wells that may have been installed during recent periods of relatively high water levels. Therefore, in addition to the minimum monitoring requirements, a network of wells suitable for monitoring water level responses in the area was identified. Water levels were measured monthly during the period of pumping for the Water Bank and during the subsequent water level recovery period. Ground water levels at the end of the pumping season were generally above historically low levels, thereby confirming the absence of new stresses on the aquifer system. Water quality was not monitored in this case because historic data did not identify a potential problem. The only significant problem identified was the lowering of water levels in wells serving individual residences in a rural subdivision. This problem was quickly resolved by redistributing pumping in the district making the transfer. The only other concern raised was the increased cost of pumping experienced by some users as water levels declined below those experienced in recent years.

The most intense level of monitoring is illustrated by the activities undertaken in Yolo County. The situation here was much more complex and the implications of potential adverse impacts more severe. The properties involved in water bank pumping were located in and adjacent to the Yolo Bypass (a major flood control feature) and normally rely on surface water as a source of agricultural supply. However, only limited ground water development has occurred and the area immediately to the west, including the cities of Davis and Woodland and the surrounding agricultural areas, relies heavily on ground water. In addition, lands west of the program area have experienced significant land subsidence as a result of ground water use. The area near Zamora has historically subsided about 6 feet, with less subsidence experienced as far south as Davis. All these factors demonstrate a need for intense monitoring to allow early detection of any adverse affects of pumping for the water bank.

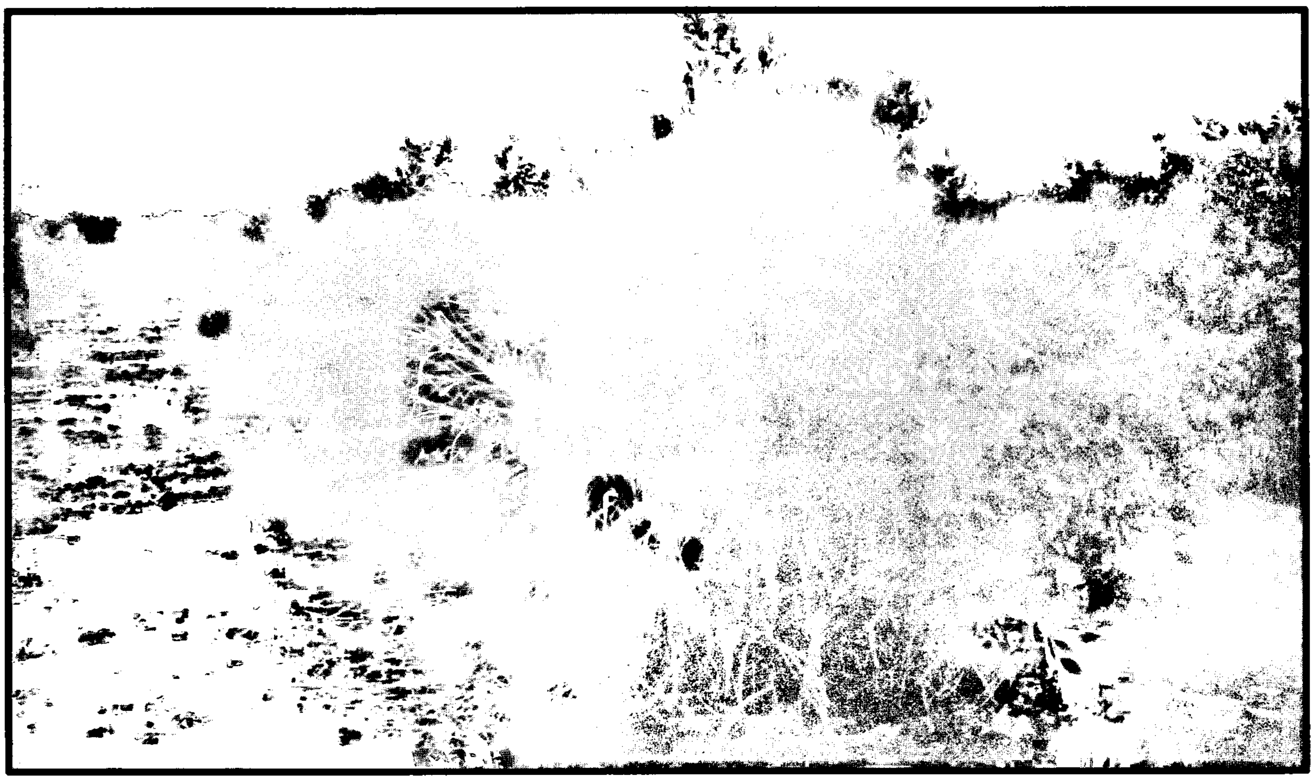
During 1991, pumping in this area was limited to the maximum that had been experienced historically since this was expected to minimize any risks. Monitoring was incorporated to determine actual conditions that occurred. To facilitate monitoring, a network of multiple completion monitoring wells was designed and constructed in the program area. These allowed the collection of water level and water quality data from 2 or 3 levels within the aquifer system subject to pumping. Water levels were measured weekly during the pumping season, and monthly during the recovery period. Water quality sampling was done periodically. In addition, testing was done during well construction to develop reliable information on the aquifer properties in the area. A network of ground surface elevation benchmarks was established in the area, and periodic elevation measurements were made using global positioning satellite technology to detect any subsidence occurring in the area. An extensometer was installed to measure aquifer compaction in the portion of the aquifer system subject to pumping and to determine whether any detected subsidence was related to pumping or had other non–bank related causes. Because of the lack of prior historic information on ground water conditions in the program area, the results of this monitoring program will provide the basis for evaluating the effects of future pumping in the area.

No significant adverse impacts were detected in Yolo County during 1991 as a result of pumping for the water bank. Monitoring in this area is continuing as part of the 1992 water bank to evaluate the effects of additional pumping in the area. In 1992, an aquifer performance test was conducted using wells near the Sacramento River in an attempt to estimate the amount of depletion of river flows as a result of nearby pumping for the water bank. This test suggested that about 30 percent of the water pumped from these wells may be derived from induced seepage from the river. This 30 percent seepage amount was accounted for in the transfer amounts. Most wells being used are located much further from the river and would have no or at most a negligible effect on river flow in the year of transfer. Impacts on river flow in future years is unknown due to generally unquantified relationships between ground water and surface water in the region. This subject is expected to be investigated in some detail in future years. Intensive monitoring in Yolo County was conducted due to the potential concerns to be addressed and the significance of potential impacts. Yolo County monitoring is considered close to maximum in terms of the potential concerns to be addressed and the significance of potential impacts. It should not be considered the norm.

In summary, the monitoring programs have shown that the 1991 and, to date, the 1992 water banks have operated without causing significant adverse impacts.

Agriculture

The proposed Drought Water Bank would acquire surplus stored water or surface water and replace it by pumping ground water. This practice would not alter agricultural activity. Agricultural crops would continue to be planted, harvested, and processed. No changes in land use would occur from these two alternative water sources for the proposed program.



High value fruit and vegetable farming depends heavily on irrigation. Photo shows an orchard being flood irrigated. This practice is gradually being replaced by drip irrigation. Agriculture was the major buyer of water from the 1992 Drought Water Bank.

Substituting crops that require less water would also have less impact than fallowing but, depending on agricultural practices, could produce various third–party impacts and, depending on labor intensiveness, could produce beneficial or detrimental third–party impacts.

Fallowing land to generate water for purchase by the proposed program has some potential environmental effects. Those lands on which fallowing consists of refraining from planting must be either clean tilled, treated with herbicide, or planted to a nonirrigated cover crop. Land that is tilled or remains barren is subject to increased wind erosion and contributes to air pollution from dust. Tilling will be discouraged to minimize these effects.

Soil organic matter levels would be expected to decrease in the absence of a vegetative cover. Peat soils become hydrophyllic if tilled when not irrigated, which causes a problem of slow water intake when irrigation is reestablished. However, normal agricultural practices allow lands to remain fallow during the growing season to give the soil a rest. Such practices help to recover soil nutrients through physical and microbial actions. Fallowing associated with the proposed program will pose no greater effects than those created during normal agricultural practices.

If not controlled, fallowed land may develop weeds that can affect future crops. However, fallowing is a time when certain weeds and other pests can be brought under control or eliminated. Land releveling, irrigation system improvements, and maintenance of capital investments can also be accomplished while fields are fallowed.

Fallowing benefits include less impact to roads from heavy machinery, decreased amounts of pesticides used, and decreased soil oxidation. Other agricultural benefits occur in areas purchasing water from the proposed program, including saving permanent crops, such as deciduous orchards and vineyards, and allowing growers of high value crops to continue farming.

Fisheries

Effects of Water Bank transfers on fish can occur in the streams conveying the transferred water to the Delta and in the Delta itself. In the streams, effects can be due to flow changes resulting from the transfers or, in the case of those transfers involving reservoir releases, due to changes in storage which may affect subsequent releases. Concerns in streams focus on chinook salmon. In the Delta, effects can be direct or indirect. Direct effects are associated with the losses of fish through entrainment, whereas indirect effects can be due to changes in hydrology and Delta flow patterns (e.g., reverse flow). Concerns in the Delta focus on six fish species: chinook salmon, striped bass, American shad, Delta smelt, longfin smelt, and splittail.

Water Bank transfers can provide benefits to fish if properly managed. For example, flow increases in streams and the Delta may improve habitat for some species. Decreased diversions from transfer of water within the Delta may reduce losses of fish through unscreened diversions that would otherwise occur. In 1991, ACID initiated a fallowing program which resulted in reduced Sacramento River diversions at the facility. Depending on the seasonality and magnitude of the diversion reduction, a corresponding reduction in fisheries losses caused by that diversion is expected. Based upon the findings by the National Marine Fisheries Service of the impacts of the ACID on the listed winter run salmon, reductions in diversions at this facility should benefit the threatened species. The overall effects of water banks are determined by weighing the benefits and detriments of transfers.

Information obtained from the 1991 and 1992 transfers is considered to be generally applicable to future water banks that would have about the same volumes of water being moved from similar sources.

Delta Effects. Delta effects are divided into entrainment losses, changes in outflow, and reverse flow. Also included is consideration of effects of Delta fallowing programs on fish.

Entrainment Losses. Losses of fish at the State and federal facilities in the Delta occur because of predation, velocity through the facility louvers (therefore louver screening efficiency), and handling and trucking. These factors are calculated into the losses and are reasonably well defined for chinook salmon and striped bass. For splittail, Delta smelt, American shad, and longfin smelt, changes in salvage caused by the Water Bank can only be estimated.In 1991, the Water Bank resulted in an additional 400,000 acre–feet of water being diverted through the John E. Skinner Fish Protective Facility. (No 1991 Water Bank water was diverted through the federal facility.) The estimated amount of Water Bank water transferred per month was as follows:

Month	Amount (acre–feet)
April	2,000
May	6,000
June	9,000
July	40,000
August	80,000
September	116,000
October	133,000
November	14,000
Total	**400,000**

As shown, about 92 percent of the additional diversions occurred during the July through October period. This schedule was selected to minimize impacts to winter run chinook salmon. Because of drought conditions, pumping was much lower than historic levels even with the Water Bank (Figure 3–9).

It should be noted that these loss and salvage calculations (Table 3–4) for the 1991Water Bank were determined with no rounding or error bars. All of the values used in the calculations are estimates. The numbers should be used as indicators of general trends, not as absolutes.

The 1992 the Water Bank was much smaller than 1991 and the water was pumped by both the State and federal pumps, according to the following schedule:

Water Bank Water Transferred from Delta (acre–feet)

Month	Facility: State	Facility: Federal	Total
July	0	31,500	31,500
August	28,200	13,900	42,100
September	28,200	7,800	36,000
October	12,300	7,200	19,500
November	0	5,100*	5,100
Total	68,700	65,500	134,200

*Anticipated amount at time Draft EIR was being prepared.

As in 1991, the prolonged drought resulted in much lower pumping than normal in 1992, even with the Water Bank in operation (Figure 3–26).

Table 3–4. Calculated Change in Loss or Salvage of Six Species of Fish Due to the 1991 Water Bank at the Harvey O. Banks Pumping Plant

With Project

Year	MO	SWP Rate	Loss: Striped Bass	Loss: Chinook	Salvage: American Shad	Salvage: Splittail	Salvage: Delta Smelt	Salvage: Longfin Smelt
1991	5	1,280	2,648	17,767	96	278	242	1,222
1991	6	869	57,385	3,656	1,888	10,510	6,238	216
1991	7	729	39,858	0	7,413	2,245	5,339	750
1991	8	2,051	23,756	0	119,348	0	1,164	0
1991	9	2,215	4,491	0	62,145	0	0	517
1991	10	3,388	991	382	44,488	353	381	0
1991	11	1,076	1,621	5,882	15,715	0	0	0
1991	12	1,278	34,260	12	37,108	0	0	0
1991		1,613	165,010	27,699	288,201	13,386	13,242	2,705

Without Project

Year	MO	SWP Rate	Loss: Striped Bass	Loss: Chinook	Salvage: American Shad	Salvage: Splittail	Salvage: Delta Smelt	Salvage: Longfin Smelt
1991	5	1,181	2,439	16,580	88	256	110	1,127
1991	6	718	45,973	3,072	1,559	8,683	5,152	178
1991	7	78	4,093	0	794	240	572	80
1991	8	753	8,653	0	43,821	0	427	0
1991	9	272	492	0	7,639	0	0	63
1991	10	1,228	330	140	16,125	127	138	0
1991	11	828	1,040	4,806	12,104	0	0	0
1991	12	1,278	34,260	12	37,108	0	0	0
1991		794	97,280	24,610	119,241	9,308	6,400	1,449
Net effect:			–67,730	–3,089	–168,960	–4,078	–6,842	–1,256

The 1992 estimates for loss and salvage (Table 3–5) are based on preliminary salvage information from DFG. Since fish length information was not available in the preliminary 1992 data set, 1991 lengths were used to calculate screen efficiencies in the chinook salmon and striped bass loss estimates. American shad salvage data were not available in the preliminary data set. Finally, CVP screen efficiencies were assumed to be the same as for the State project to calculate losses through Tracy facilities (Table 3–6).

Table 3–5. Calculated Change in Loss or Salvage of Five Species of Fish due to the 1992 Water Bank at the Harvey O. Banks Pumping Plant

Year	MO	SWP Rate	Loss		Salvage			
With Project								
			Striped Bass	Chinook	American Shad	Splittail	Delta Smelt	Longfin Smelt
1992	5	669	22,329	1,423	*	812	2,095	34
1992	6	943	62,182	0	*	972	1,893	142
1992	7	376	7,894	0	*	0	25	0
1992	8	1,482	2,216	0	*	0	0	6
1992	9	2,770	351	10	*	0	0	4
1992	10	*	*	*	*	*	*	*
1992	11	*	*	*	*	*	*	*
Without Project								
Year	MO	SWP Rate	Loss		Salvage			
			Striped Bass	Chinook	American Shad	Splittail	Delta Smelt	Longfin Smelt
1992	5	669	22,329	1,423	*	812	2,095	34
1992	6	943	62,182	0	*	972	1,893	142
1992	7	376	7,894	0	*	0	25	0
1992	8	1,023	1,537	0	*	0	0	4
1992	9	2,296	290	8	*	0	0	3
1992	10	*	*	*	*	*	*	*
1992	11	*	*	*	*	*	*	*
Net effect:			−740	−2	*	0	0	−3

* Data not available.

Comparison of direct entrainment losses for the 1991 and 1992 Water Banks indicates that losses per acre–foot pumped were much lower in 1992 than in 1991 (Table 3–7). Although it is not possible to determine the exact cause of this difference, much of it was probably due to the 1992 shift in pumping to later in the summer. The shift was intended to avoid impacts to winter run chinook salmon. However, it had the additional benefit of reducing losses of other species. When the American shad data become available, they will probably show that there were still significant numbers of shad entrained due to 1992 Water Bank.

Table 3–6. Calculated Change in Loss or Salvage of Five Species ofFish due to the 1992 Water Bank at the Tracy Pumping Plant								
With Project								
Year	MO	SWP Rate	Loss		Salvage			
			Striped Bass	Chinook	American Shad	Splittail	Delta Smelt	Longfin Smelt
1992	5	846	2,556	136	*	106	60	106
1992	6	739	1,910	0	*	1,726	0	0
1992	7	898	897	0	*	0	0	0
1992	8	989	302	0	*	0	0	0
1992	9	1,595	1,595	0	*	0	0	0
1992	10	1,057	*	*	*	*	*	*
1992	11	*	*	*	*	*	*	*
Without Project								
Year	MO	SWP Rate	Loss		Salvage			
			Striped Bass	Chinook	American Shad	Splittail	Delta Smelt	Longfin Smelt
1992	5	846	2,556	136	*	146	60	106
1992	6	739	1,910	0	*	1,726	0	0
1992	7	385	381	0	*		0	0
1992	8	763	223	0	*	0	0	0
1992	9	1,464	1,484	0	*	0	0	0
1992	10	777	*	*	*	*	*	*
1992	11	*	*	*	*	*	*	*
Net effect:			−626	0	*	0	0	0
Data not available.								

Table 3–7. Losses of Fish per Acre–Foot for the 1991 and 1992 Water Banks						
	Striped Bass	Chinook	American Shad	Splittail	Delta Smelt	Longfin Smelt
1991 (Banks PP)	0.169	0.008	0.422	0.010	0.017	0.003
1991 (Banks PP)	0.011	0.000	–	0	0	0.000
1991 (Tracy PP)	0.010	0	–	0	0	0

The impacts of entrainment losses on the adult populations of fish are difficult to assess. For striped bass, DFG has developed a model that indicates that entrainment losses are a major factor in causing the decline of striped bass in the Sacramento–San Joaquin estuary. The impacts of entrainment on striped bass should be somewhat mitigated by the planting program which resulted in several million yearling bass being planted in the estuary. A complete evaluation of this planting effort is not yet available from DFG. For other species, the impacts of losses of a relatively few individuals is even less clear. For example, in a 1991 analysis, DFG was unable to find a relationship between losses of Delta smelt at the pumps and the observed decline in abundance.

The water banks did cause more fish to be lost through entrainment than would have been lost had the banks not occurred. Although the actual losses were small in relation to total population sizes, the overall impact was undoubtedly negative. With the present physical system there is no way to move water across the Delta without incurring direct and indirect losses.

Changes in Delta Outflow. Carriage water released as part of the transfers resulted in slight increases in Delta outflow during the summers of 1991 and 1992 (Figures 3–11 and 3–28). These increases could have some fisheries benefit, although the benefit would be small and impossible to quantify. For those organisms showing positive flow–abundance relationships (e.g., longfin smelt, striped bass, splittail) the flow period of concern is winter and spring, not the summer or fall during which water bank transfers would occur.

Reverse Flow. As described earlier, during low inflow periods, CVP and SWP pumping, combined with other Delta diversion, can result in calculated net flow in the lower San Joaquin River being upriver towards the pumps. In this region, maximum tidal flows are in the range of 100,000 to 200,000 cfs, whereas reverse flows, when present, are generally in the 0 to 3,000–cfs range.

Reverse flows are calculated flows because they are so low relative to tidal flows that they cannot be measured. Model results (Figure 3–37) for February 1988 conditions conducted to evaluate the impacts of a Georgiana Slough barrier indicate a major change in reverse flows from −1,352 cfs to −6,341 cfs on the San Joaquin River at Antioch. This is a small portion of the tidal flow which ranges from approximately 100,000 cfs to 150,000 cfs over the tidal cycle at this site.

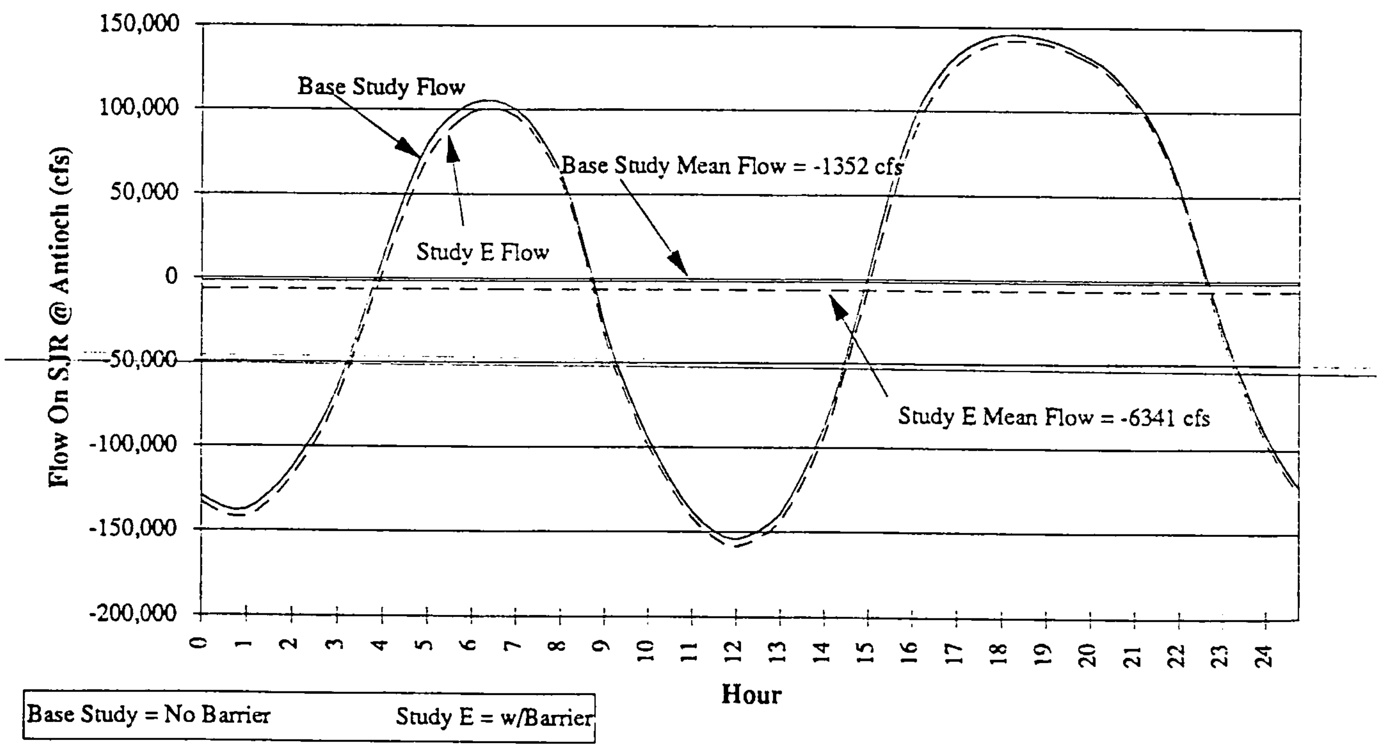
The 1991 Water Bank increased the magnitude and duration of flow reversals as compared to 1992 (Table 3–8) with maximum change in flow occurring during the months of July through October. In both 1991 and 1992, the general lack of pumping due to the drought caused the magnitude of flow reversal to be much lower than the −2,000 to −4,000 cfs seen during the same months in recent years.

Table 3–8. Calculated Effects of 1991 and 1992 Water Bank on Average Monthly Flows (cfs) in the San Joaquin River at Antioch

Month	1991			1992		
	Actual	Without Water Bank	Difference	Actual	Without Water Bank	Difference
January	1,091	1,091	0	388	388	0
February	936	936	0	612	612	0
March	−2,827	−2,827	0	−4,165	−4,165	0
April	−1,404	−1,271	−133	−61	−61	0
May	1,065	1,279	−214	−1,474	−1,474	0
June	948	1,251	−303	775	800	−25
July	−72	585	−657	476	777	−301
August	−956	−66	−890	−220	34	−254
September	−393	679	−1,072	−668	−451	−217
October	−669	485	−1,154	1,374	1,415	−41
November	1,136	1,265	−129	933	925	−8
December	2,002	2,002	0	1,563	1,563	0

Although it is not possible to quantify the impacts of Water–Bank–induced flow reversals on fish, they might be characterized as slightly negative. An empirical model of striped bass entrainment (Wendt 1987) contains a term for San Joaquin River flow, with higher flows toward the pumps resulting in increased entrainment of larval striped bass. However, the Water Bank flow reversals occurred mostly in months after striped bass had grown out of the larval stage, and the model may not apply to larger fish.

Figure 3-37. Georgiana Slough Barrier Study -- Comparison Between Tidal Cycle Flow and Mean Flow on the San Joaquin River at Antioch



The 1991 Water Bank did cause slight negative (100 to 300 cfs) changes in flows at Antioch during April, May, and June, which is the period when juvenile chinook salmon are migrating through the Delta. The majority of juvenile salmon migrating through the Delta during this time period are most probably part of the fall and late fall run outmigrants. The end of the winter run outmigrants may be present in April. It is unlikely that these small changes had any measurable impact on salmon survival.

Overall, the question of reverse flow impacts on fish is largely unanswered. From a physical standpoint, it is not clear how slight changes in net flow among tidal flows that are orders of magnitude greater are able to influence the movement of nonplanktonic fish. There is, however, empirical evidence that reverse flows have negative impacts on the life stages of some fish. It may be that calculated flows at Antioch are simply an index of Delta flow conditions and are not to be interpreted in a simplistic physical sense. Under this scenario, positive flows are desired and projects that detract from positive flows by definition have adverse impacts on fish.

Delta Land Fallowing. The 1991 Water Bank purchased about 285,000 acre-feet of water from Delta farmers. In this exchange, the farmers were basically paid not to divert water onto Delta lands, with their foregone water pumped at the Banks pumping plant.

The monthly distribution of the water made available through fallowing in 1991 was as follows:

Month	Amount – AF
Apr.	29,000
May	42,000
June	55,000
July	82,000
August	55,000
September	15,700
October	7,000

Since the Delta agricultural diversions are unscreened, the fallowing program probably resulted in a significant decrease during May and June in the numbers of fish lost onto Delta farmlands. This benefit is offset by losses of fish at the State fish protective facility. Although unquantifiable, the fallowing program probably resulted in somewhat fewer fish losses associated with the 285,000 acre-feet of water from this portion of the Water Bank.

Tributaries Upstream of Storage Reservoirs. The proposed program is not expected to have significant impacts on fishery resources of streams tributary to major storage reservoirs. By reducing diversions due to fallowing and water exchange, instream flows during operation of the proposed Drought Water Bank would be higher than flows that would be typical during critically dry years.

Analyses of the 1991 (Figures 3–38 through 3–40) and 1992 Drought Bank operations (Figures 3–41 through 3–43) show increased inflow to Shasta, Oroville, and Folsom Reservoirs occurred during certain months of the year. No reduction of inflow occurred. The timing and magnitude of increased instream flows vary, depending on magnitude of bank operation and location of sellers, but typically occur during one to four summer or fall months. Benefits will also vary, depending on the degree to which carriage streams are otherwise impacted by low flows during drought years.

Storage Reservoirs. Reservoir storage changes created by the proposed program would primarily affect downstream water temperatures. Reservoirs with streams tributary to the Sacramento–San Joaquin Delta generally support anadromous fish that require certain temperatures for successful reproduction. Reservoir storage levels affect the amount of water available with these suitable temperatures. Effects of the 1991 and 1992 Water Banks on reservoir temperatures were determined from temperature profiles and depth of water above reservoir outlet elevations.

Higher water levels at Shasta Reservoir during 1991 due to the Water Bank (Figure 3–13) increased the amount of cold water available for release to maintain fish reproduction downstream from the dam. During August and September 1991, this additional storage resulted in water temperatures near the power outlet (elevation 815 feet) in Shasta Reservoir about one degree Fahrenheit cooler than would have occurred without the Water Bank (Figure 3–44). In 1992, no discernable differences occurred in water temperatures (Figure 3–45) although there was slightly less storage than would have occurred without the Water Bank (Figure 3–30). These Water Banks were not detrimental to maintenance of cool water temperatures downstream from Shasta Dam.

Figure 3-38. Sacramento River flows to Shasta Reservoir under 1991 Water Bank, drought, and median conditions.

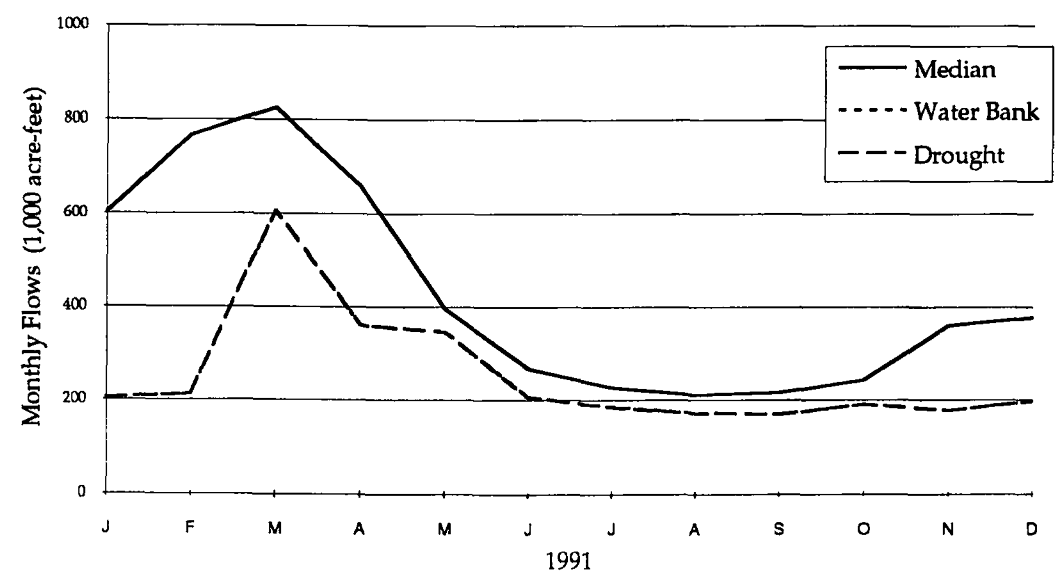


Figure 3-39. Feather River flows to Oroville Reservoir under 1991 Water Bank, drought, and median conditions.

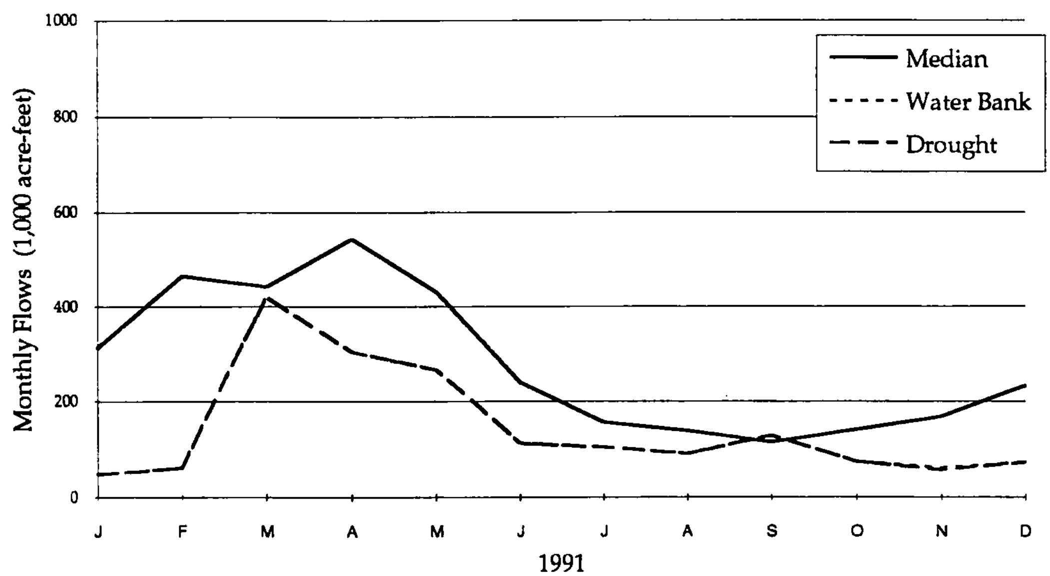


Figure 3-40. American River flows to Folsom Reservoir under 1991 Water Bank, drought, and median conditions.

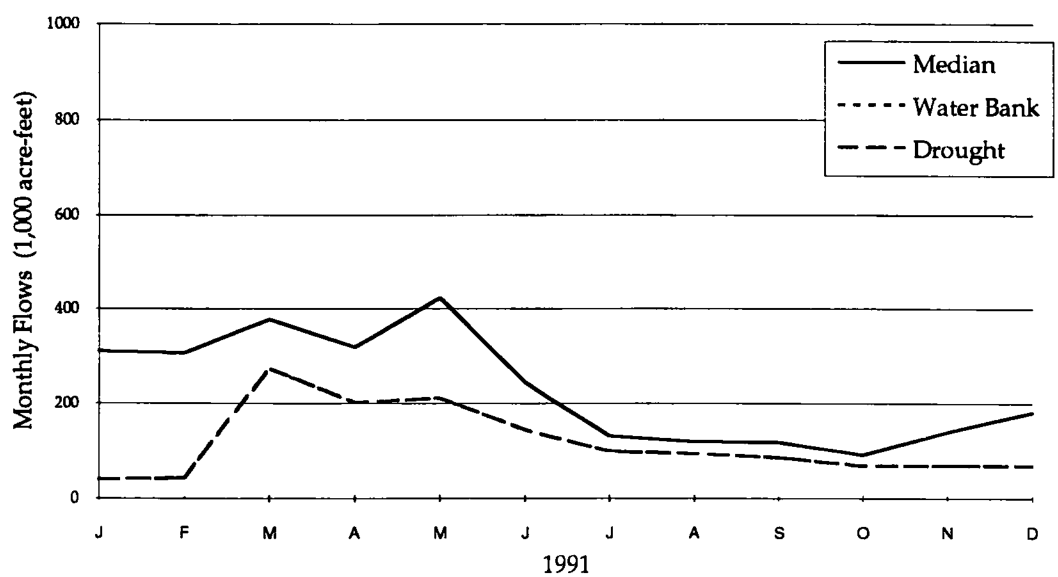


Figure 3-41. Sacramento River flows to Shasta Reservoir under 1992 Water Bank, drought, and median conditions.

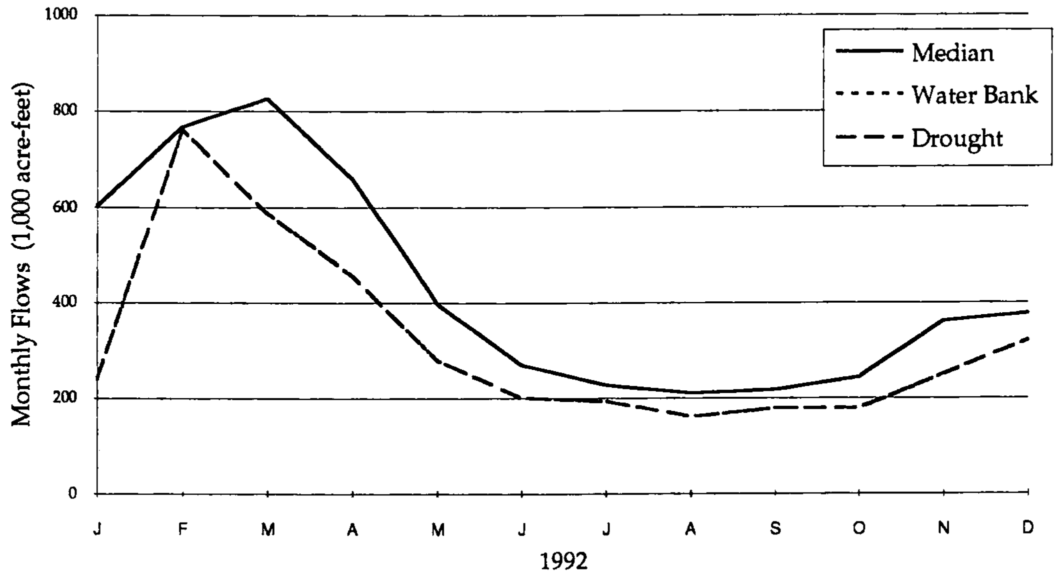


Figure 3-42. American River flows to Folsom Reservoir under 1992 Water Bank, drought, and median conditions.

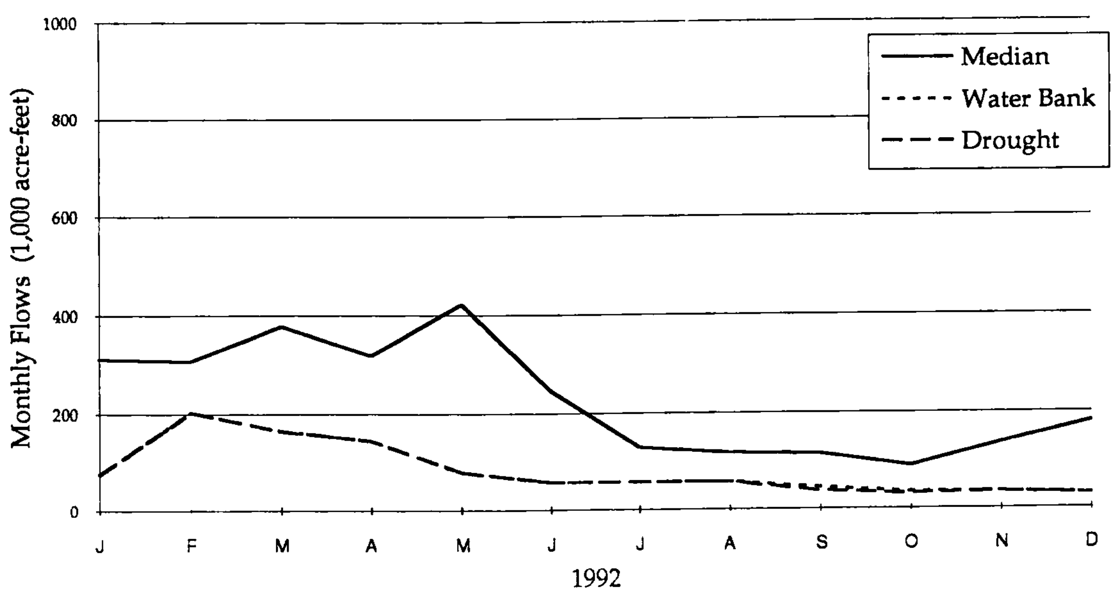


Figure 3-43 Feather River flows to Oroville Reservoir under 1992 Water Bank, drought, and median conditions.

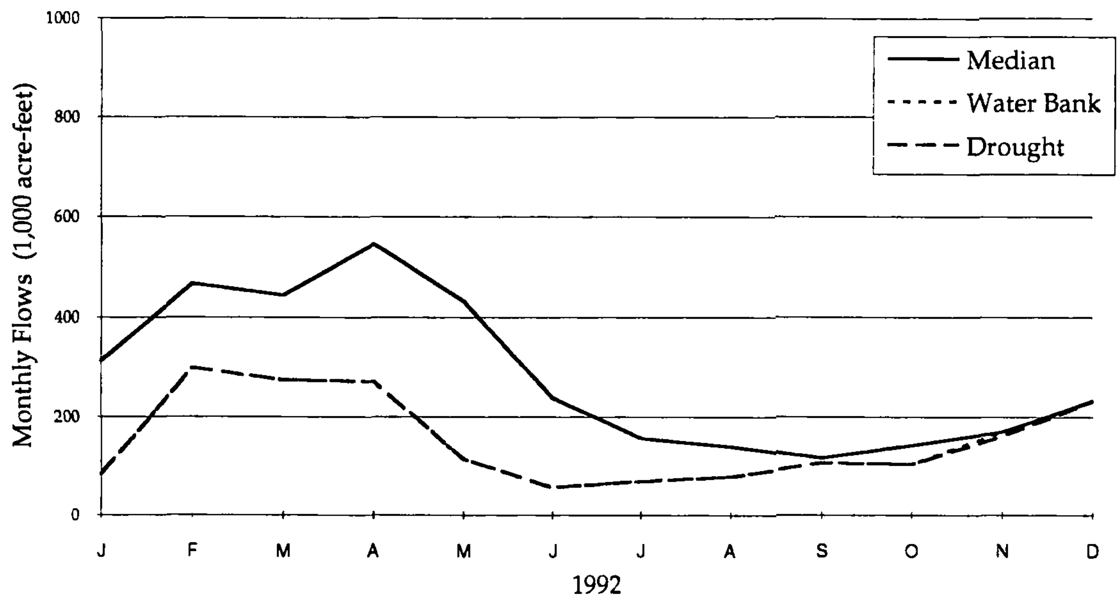


Figure 3-44. Water temperatures in Shasta Reservoir corresponding to depth of power outlet in 1991.

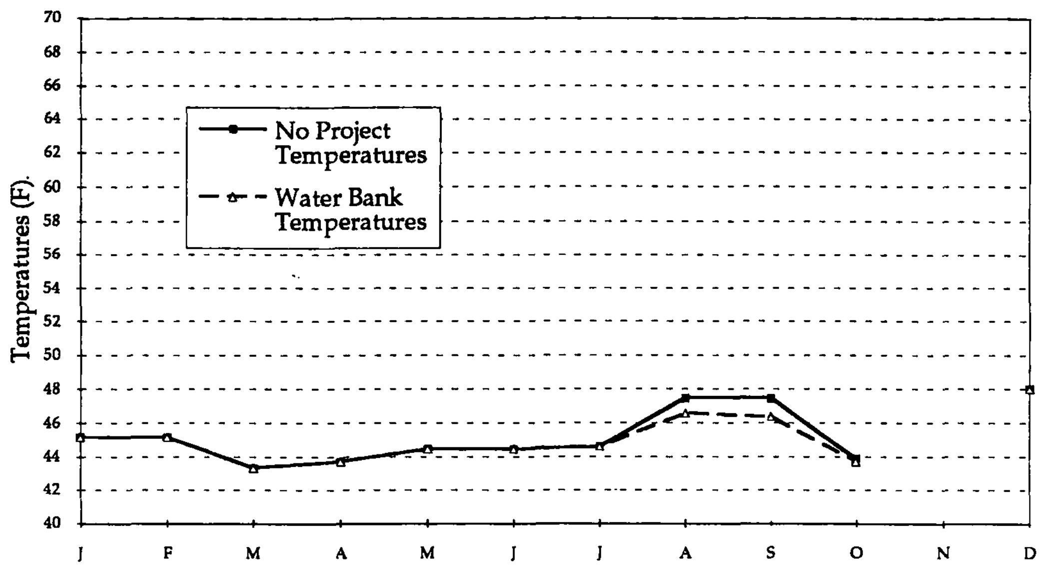
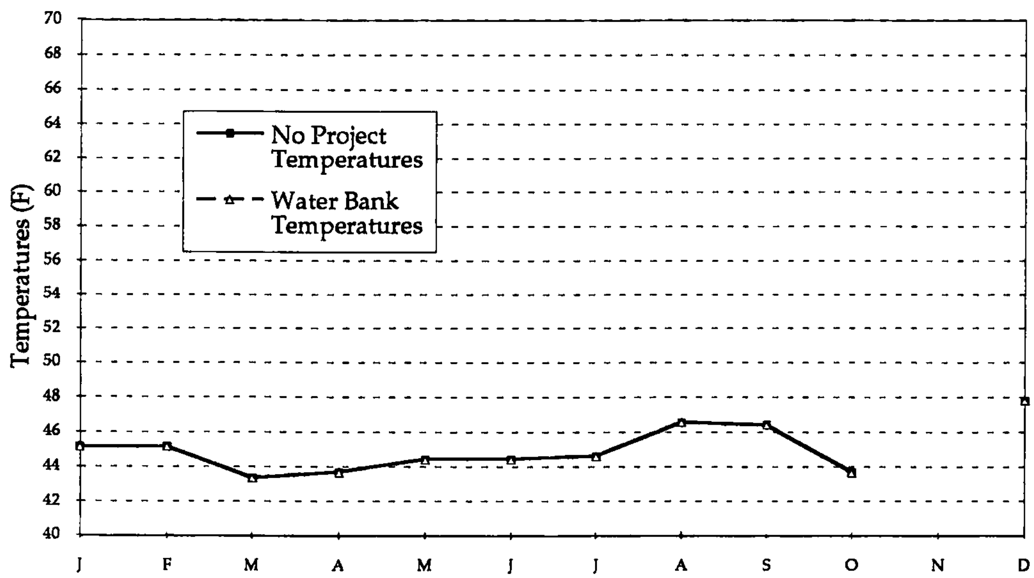


Figure 3-45. Water temperatures in Shasta Reservoir corresponding to depth of power outlet in 1992.



Temperatures of water in Oroville Reservoir were also cooler in 1991 and 1992 than would have occurred without the Water Banks. In 1991, water temperatures were over 16°F cooler than would have occurred without the Water Bank (Figure 3–46) due to higher reservoir storage levels (Figure 3–14). The cooler temperatures became most apparent after July, which is also the period during which cooler water releases are most important for the maintenance of immigrating chinook salmon and steelhead trout in the Feather River. No temperature differences (Figure 3–47) in 1992 were apparent either with or without the Water Bank due to the small change in storage (Figure 3–31). Neither the 1991 nor 1992 Water Banks adversely affected the temperature regime in the Feather River.

Although storage in Shasta and Oroville reservoirs generally increased because of the Water Banks in 1991 and 1992, storage in New Bullards Bar Reservoir decreased (Figures 3–16 and 3–33) except during early summer 1991. Increased storage during summer 1991 and slightly decreased storage during 1992 did not affect temperatures (Figures 3–48 and 3–49). The slightly decreased storage due to the banks resulted in slightly higher temperatures at the elevation of the withdrawal outlet beginning in late summer. However, temperature differences between those that would have occurred with and without the Water Banks ranged from only a half degree in late summer to 1.1°F in December. Such slight differences should have no significant effects on downstream release temperatures. Temperatures at the withdrawal elevation were less than 49°F throughout both 1991 and 1992.

The 1991 Water Bank resulted in a small decrease in carryover at Folsom Reservoir (Figure 3–15). This decrease could affect downstream fisheries in subsequent years by reducing water available for downstream release. The 1992 Water Bank resulted in indiscernible changes in storage (FIgure 3–32).

Tributaries Downstream From Storage Reservoirs. Operation of a water bank can affect flows in rivers downstream from storage reservoirs involved in water transfers. Changes in flows can subsequently affect temperatures and fish populations.

Sacramento River Below Keswick Dam. The Sacramento River below Keswick Dam supports all four races of chinook salmon, steelhead, American shad, and several other resident fish. The 1991 and 1992 Water Banks affected stream flows below Keswick Dam and at Wilkins Slough (Table 3–9).

Figure 3-46. Water temperatures in Oroville Reservoir corresponding to depth of minimum power pool in 1991.

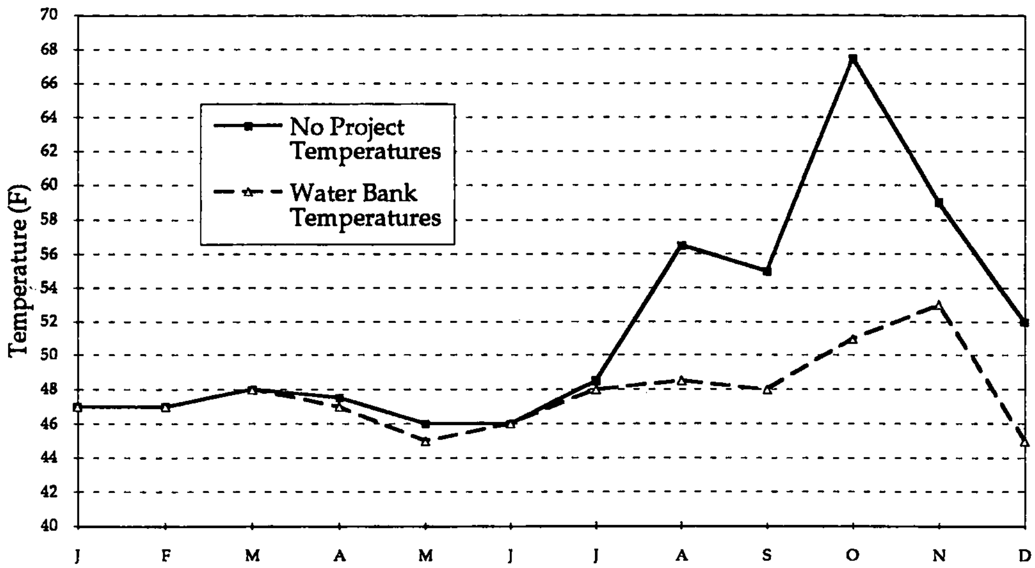


Figure 3-47. Water temperatures in Oroville Reservoir corresponding to depth of minimum power pool in 1992.

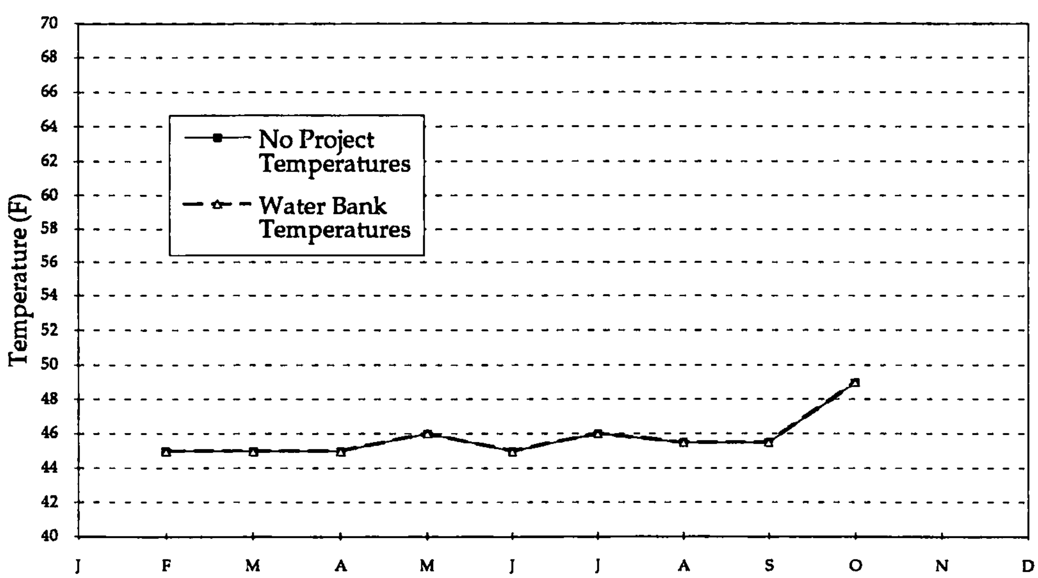


Figure 3-48. Water temperatures in New Bullards Bar Reservoir corresponding to depth of withdrawal in 1991.

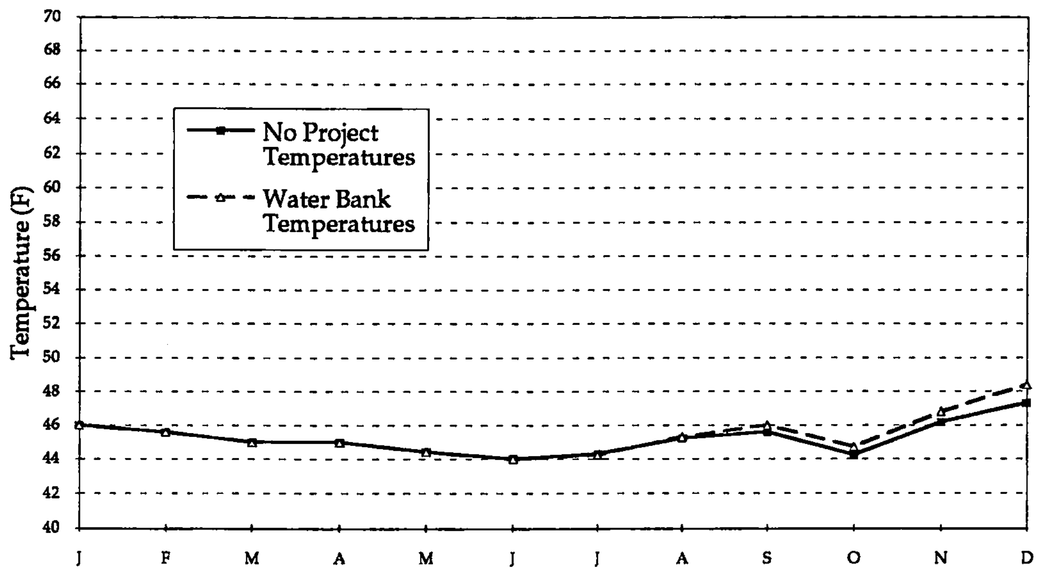


Figure 3-49. Water temperatures in New Bullards Bar Reservoir corresponding to depth of withdrawal in 1992.

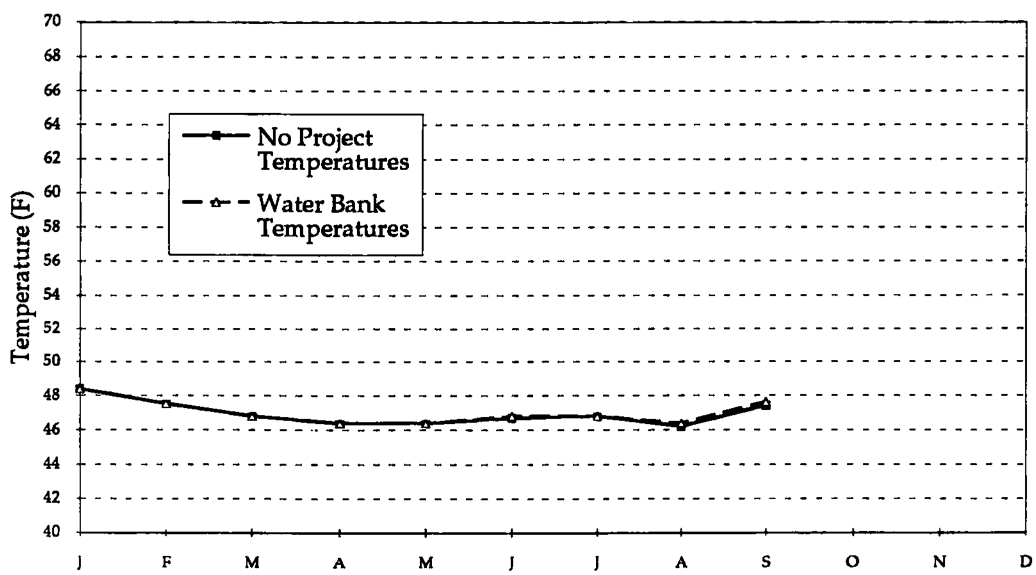


Table 3–9. Effects of the 1991 and 1992 Water Banks on Stream Flows in the Sacramento River								
	1991				1992			
	Below Keswick		Below Wilkins		Below Keswick		Below Wilkins	
Month	Actual	Without Project	Actual	Without Project	Actual	Without Project	Actual	Without Project
January	4,468	*	4,945	*	3,275	*	5,827	*
February	4,068	*	4,653	*	3,402	*	15,106	*
March	2,479	*	13,526	*	4,315	*	12,471	*
April	2,927	3,220	6,269	6,481	3,315	*	5,952	*
May	7,457	7,894	4,774	5,285	7,131	*	3,420	*
June	8,526	9,157	4,264	4,820	7,081	7,226	3,488	3,614
July	8,914	9,595	4,422	4,963	7,553	7,048	3,824	3,291
August	8,540	8,665	4,264	4,326	8,059	7,990	4,410	4,315
September	5,789	5,327	4,010	3,456	7,034	7,177	5,517	5,630
October	4,455	3,258	3,945	2,734	4,075	4,207	3,342	3,469
November	4,249	4,138	3,649	3,538	3,431**	3,599	5,381	5,549
December	3,542	*	4,088	*	3,258	*	4,566	*

* No change
** November and December 1992 flows are projected.

In general, the 1991 Water Bank resulted in somewhat lower flows in the Sacramento River during the months of April through August. Higher flows occurred from September through November. In all instances the increase or decrease was less than 10 percent of the projected without project flows.

In 1992, the Water Bank caused slight reductions in Sacramento River flows during June, September, October, and November, and increases in July and August. The changes in 1992 were much smaller than in 1991, being less than 5 percent in all months.

Flow changes of the magnitudes seen in the 1991 and 1992 Water Banks should have little or no impact on resident or migratory fish populations. In the past few years, summer water temperatures in the reach below Keswick Dam have been a particular concern for winter run chinook salmon, and have been controlled by releasing cold hypolimnetic water from Shasta Reservoir. Flow decreases of 300 to 600 cfs or increases in the same range will have little impact on water temperature. For example, from the October 1992 CVP Operation Criteria and Plan, a July flow change from 12,000 cfs to about 14,000 cfs resulted in a model predicted decrease of 0.3 °F in the river below Keswick.

Flow changes in the range seen in 1991 and 1992 may cause slight increases or decreases in spawning and nursery habitat, but are probably not significant. When the results are available, the DFG–DWR IFIM study of this area will provide an analytical tool which can be used to provide a more quantitative evaluation.

Feather River. Water Bank impacts on Feather River fish populations can be directly associated with changes in flow in the reach of the river between the Thermalito Afterbay and the river mouth. Flow changes can affect temperature and the amount and quality of fisheries habitat. Indirect effects can occur due to changes in reservoir storage with its possible changes in flows during future months. The actual impacts of changes in storage on fish depend on subsequent hydrology.

1991 Water Bank. The 1991 Water Bank resulted in flow changes in the Feather River below the Thermalito Afterbay and the mouth of the Yuba River (Table 3–10). The Water Bank resulted in lower flows between the Thermalito Afterbay and the mouth of the Yuba River from April through October. Below the mouth of the Yuba River, Feather River flows were lowered somewhat between April and July and increased from August through November. All flows in 1991, both actual and projected without project, were within the limits established in the 1983 DWR–DFG agreement to protect Feather River fishery resources. DWR and DFG are presently conducting an instream study to determine if these requirements should be modified.

Table 3–10. 1991 Water Bank Average Monthly Flow (cfs)				
	Below Thermalito		Below Mouth of Yuba River	
Month	Actual	Without Project	Actual	Without Project
January	1,653	*	1,548	*
February	949	*	1,692	*
March	821	*	3,224	*
April	823	1,107	1,524	1,808
May	1,427	1,822	1,778	2,178
June	2,626	3,155	2,942	3,487
July	1,896	2,674	2,633	2,932
August	1,074	1,600	2,673	2,,246
September	1,504	1,650	3,454	2,179
October	1,500	1,571	3,735	2,569
November	1,000	900	1,695	1,596
December	1,954	*	2,698	*
*No change				

1992 Water Bank. The 1992 Water Bank resulted in flow changes in Feather River below the Thermalito Afterbay and the mouth of the Yuba River (Table 3–11).

Table 3–11. 1992 Water Bank Average Monthly Flow (cfs)				
Month	Below Thermalito		Below Mouth of Yuba River	
	Actual	Without Project	Actual	Without Project
January	1,010	*	1,987	*
February	1,035	*	3,180	*
March	838	*	1,778	*
April	800	*	1,593	*
May	2,086	*	2,735	2,490
June	1,671	1,618	2,171	1,898
July	2,282	1,998	2,460	2,168
August	2,437	2,241	2,536	2,302
September	2,500	2,291	2,727	2,500
October	1,475	1,350	1,915	1,790
November	900**	*	1,559	*
December	901	*	1,545	*
*No change **November and December flows are projected				

Feather River flow changes below the Thermalito Afterbay due to the 1992 Water Bank occurred primarily during the months of July through October. Flows during this period were higher with the Water Bank than they would have been otherwise. All flows were within the limits contained in the 1983 agreement with DFG to protect Feather River fish populations. The relatively minor flow increases may have benefitted adult spring run chinook salmon, steelhead, American shad, and striped bass found in the river during this perio. Juvenile fall run chinook salmon had probably left the stream before the flows changed.

In summary, the 1991 and 1992 Water Banks probably had little impact on fish in the Feather River. This conclusion is based on the observation that flows generally were well in excess of the minimum flows required under the DWR–DFG Feather River fish agreement. Increased carryover storage due to Water Bank purchases may provide fish protection should the drought continue in a seventh year.

Following the same general operation schedule as seen in 1991 and 1992, future drought water bank impacts should also be minimal. The results of an instream flow incremental methodology (IFIM) study on the Feather (due in 1994) should provide additional information with which any impacts can be evaluated.

Yuba River. Yuba River instream flows are currently governed by a 1965 agreement between the Yuba

County Water Agency and DFG. Provisions include minimum flows for maintenance of fish life (Table 3–12) at various points of the Yuba River drainage, and controls aimed at minimizing fluctuations in streamflows. Water bank operations will not cause any of the conditions of the agreement to be breached.

On the Yuba River, flow standards are set at Marysville. Existing standards call for flows ranging from 400 cfs to 70 cfs, depending on the season. DFG has proposed significant increases in these flows, ranging from 2,000 cfs to 450 cfs, depending on the season. The SWRCB has not released the results of their findings on Yuba River flows.

Table 3–12. Critical Periods for Various Life Stages and Habitat Conditions for Fish in the Yuba River

Species	Life Stage	Habitat Function	Period
Fall run chinook salmon	adult adult egg juveniles	immigration spawning incubation rearing	September–October October October May–June
Spring run chinook salmon	adult adult adult egg juvenile	immigration summer holding spawning incubation rearing	May–July June–August September–October September–October May–June
Steelhead	adult egg fry fry juveniles	immigration incubation emergence rearing/emigration rearing	August–October May May–June May–October May–June
American shad	adult adult egg juvenile	immigration spawning incubation rearing	May–June May–July May–July May–October

The 1991 and 1992 Water Banks resulted in flow changes in the Yuba River during the months of May through October (Table 3–13). The Water Banks caused increased flows at Marysville. In all instances, flows with the Water Bank were higher than those required by existing minimum flow standards on the Yuba River. In June 1992, flows that would have occurred without the Water Bank were lower than existing standards. Flows with or without the Water Bank were almost always below DFG's proposed flows, the exceptions being July, August, and September 1991, when the flows with the Water Bank met DFG's recommendations.

Water Temperature. The water temperatures in the lower Yuba River during the potential period of operation of the Water Bank (May, June, July, August, September, and October) are a function of the temperature and flow of the water releases from Englebright and New Bullards Bar reservoirs. Because of the relatively small capacity of Englebright (70,000 acre–feet), water temperature manipulation would result from coordinated operations of both Englebright Reservoir and the larger capacity upstream reservoir, New Bullards Bar Reservoir (961,300 acre–feet).

Two USGS gauging stations located below Englebright Dam and near Marysville maintain the most consistent period of record for water temperature (1973 through 1978).

The USFWS' Stream Network Temperature Model (SNTEMP) was used for the lower Yuba River Fisheries Management Plan to model water temperatures for several streamflow conditions in the lower Yuba River. Results from these models indicate that the greatest temperature change from Englebright Dam to Marysville occurs during a warm June at a flow release of 245 cfs or less.

The Lower Yuba River Fisheries Management Plan found that, in all the years evaluated, water temperatures in the lower river were near the upper range or exceeded the preferred temperature ranges in September and October for upstream migration of fall run chinook salmon. This could delay the migration by as much as 1.5 months. Suitable spawning and incubation temperatures were not reached for this species until early to mid–November in most years evaluated. Suitable rearing temperatures ended by June in most years along the entire portion of the lower Yuba River. This would probably force juveniles to leave the river shortly after emergence.

Table 3–13. Effects of the 1991 and 1992 Water Banks on Stream Flows in the Yuba River								
Month	1991				1992			
	Below New Bullards Bar		At Marysville		Below New Bullards Bar		At Marysville	
	Actual	Without Project	Actual	Without Project	Actual	Without Project	Actual	Without Project
January	831	*	395	*	829	*	974	*
February	596	*	743	*	506	*	2,072	*
March	204	*	2,403	*	202	*	938	*
April	300	*	701	*	536	*	793	*
May	484	536	355	*	1,220	976	647	403
June	649	920	333	*	1,245	993	499	247
July	1,154	1,193	727	257	802	*	169	*
August	2,036	1,394	1,599	645	779	740	99	*
September	2,077	769	1,951	529	331	291	227	187
October	1,310	1,162	1,235	834	699	*	439	*
November	766	*	696	*	687**	*	659	*
December	848	*	743	*	720	*	641	*

* No change
** November and December 1992 flows are projected

During dry years, low flows and high temperatures can block the spring run chinook salmon from accessing the deep pool holding habitat in the Narrows section of the river. In September and October, water temperatures in the spring run spawning area just below Englebright Dam regularly exceed 55°F. The preferred spawning and incubation temperatures are assumed to be 40 to 55°F.

September and October temperature trends of the lower river generally exceed the range preferred by migrating steelhead adults. Preferred temperature ranges for egg incubation usually occur during the winter months. However, in May (the one month of the incubation period within the operation range of the water bank), temperatures frequently exceeded optimum temperatures. The rearing stages of fry and juveniles are found throughout the year in the lower Yuba River. With some variation from year to year with the beginning and ending month, temperature conditions regularly exceeded optimum temperatures for this life stage between May and October.

The timing and strength of spawning shad migrations are a function of flows and water temperature. In half of the years analyzed in the Lower Yuba River Fisheries Management Plan, the water temperature exceeded the preferred spawning and incubation range of American shad. Rearing temperatures in the midsummer months were also high, limiting rearing areas to the mouth of the Yuba River where water temperatures are influenced by the Feather River.

The SNTEMP model was used to evaluate flow changes to the Water Banks. May releases of 400 cfs at Englebright Dam of 53.6°F water results in water temperatures of about 60.8°F at Daguerra Point Dam (Table 3–14). Water temperatures reach approximately 68°F at the mouth of the Yuba River. When 53.6°F water is released from Englebright at 650 cfs, there is an approximately 3.6°F drop in water temperature at Daguerra Point Dam to 57.2°F. However, the temperature is again approximately 68°F at the mouth of the Yuba River.

The same model demonstrates that June releases at Englebright Dam of 57.2°F water at 250 cfs results in water temperature of 69.8°F at Daguerra Point Dam. The mouth of the Yuba River was predicted at 73.4°F. At 400 cfs of 57.2 °F water, Daguerra Point Dam water temperature is reduced to 66.2°F, and the mouth of the Yuba River,unlike in May, benefits with a lower temperature of approximately 3.6°F. The actual temperature of water released from Englebright Reservoir will be a function of weather conditions during that month.

Table 3–14. Effects of Releases on Water Temperatures in the Yuba River				
	Releases (cfs)	Temperatures (°F)		
		Englebright Dam	Daguerra Point Dam	Mouth of Yuba River
May	400	53.6	60.8	68.0
May	650	53.6	57.2	68.0
June	200	57.2	69.8	73.4
June	400	57.2	66.2	69.8

All life stages of the primary species found in May, June, July, August, September, and October in the lower Yuba River should benefit from the increased flow volume and the associated cooler water temperatures provided when the Drought Water Bank is operating.

Aquatic Habitat and Stream Discharge Relationships. The Lower Yuba River Fisheries Management Plan includes an analysis of aquatic habitat and stream discharge relationships. Information developed includes the types of habitats suitable for various life stages of species at various river flows at various reaches of the river. Based on life stage requirements, species life stage/discharge relationships, and river water temperatures, DFG developed minimum flow regimes to be maintained in the lower Yuba River during normal and wet water years. Flow requirements from the management plan are higher than those in the 1965 agreement.

The 1965 flow requirements were satisfied during all critical months (May through October) under conditions that would have occurred without operation of the 1991 or 1992 Water Banks. When the 1991 and 1992 Water Banks are considered, flows were greater than would have occurred without the project and also satisfy all flow requirements. During 1991, flow remained the same in May and June with or without the Water Bank. In July, August, September, and October, flows from the Water Bank exceeded the proposed management plan standards.

Effects of 1991 and 1992 Water Banks. In general, the impact of Water–Bank–induced flow changes in 1991 and 1992 was neutral or perhaps slightly positive. Compared to DFG's recommended flows, optimum habitat conditions were not present in the Yuba River during these two summers. However, flows were closer to the recommended flows due to the Water Banks than those which would have occurred otherwise.

American River. There was little effect of either the 1991 or 1992 Water Banks on flows in the lower American River (Table 3–15). Flows were affected only during September and October. The increased flows during these months may have had slight beneficial effects on fish.

Table 3–15. Effects of the 1991 and 1992 Water Banks on Stream Flows in the American River				
Month	1991		1992	
	Actual	Without Project	Actual	Without Project
January	491	*	942	*
February	339	*	904	*
March	314	*	906	*
April	341	*	761	*
May	707	*	1,625	*
June	2,262	*	3,711	*
July	2,976	*	3,319	*
August	2,604	*	2,422	*
September	1,440	719	827	*
October	2,204	576	634	1,269
November	1,160	*	550**	*
December	1,831	*	550**	*
*No change **November and December flows are projected				

San Joaquin River. The 1991 Water Bank did not affect flows in the San Joaquin River system. The 1992 bank, however, did result in flow changes at Vernalis (Table 3–16).

Table 3–16. Effects of the 1992 Water Bank on Stream Flows in the San Joaquin River		
Month	Flow (cfs)	
	Actual	Without Project
August	478	234
September	634	393
June	846*	358
June	1,365*	1,269
*Projected flows		

In early November 1992, winter run chinook salmon juveniles were found in the Delta. The Water Bank transfer between Merced Irrigation District and DFG (via the federal pumps) was stopped due to the presence of these fish.

The 1992 Water Bank provided small but significant benefits to chinook salmon in the San Joaquin River system. Early adult migrants had more attraction and passage flows, and the increased flows probably improved a significant dissolved oxygen problem on the San Joaquin River near Stockton.

Overall Assessment of Instream Impacts of the 1991 and 1992 Water Banks. In most cases, the Water Banks caused relatively minor flow changes during the summer months. The instream impacts of the 1991 and 1992 Water Banks in the American, Feather, Yuba, Sacramento, and San Joaquin rivers appeared to be minimal.

Water Quality. Increased stream flows are generally regarded as beneficial to water quality conditions. Increased flows result in a decreased rate of atmospheric warming, increased oxygenation, and dilution of naturally occurring minerals and waste discharges.

Northern California streams usually have excellent water quality. Increased flow effects caused by the Water Bank will benefit water quality, but will likely be undetectable in most streams. Benefits from increased flows due to the Water Bank will probably only detectable in seriously degraded streams such as the San Joaquin River.

Effects to water quality in the San Joaquin River system as a result of implementing the proposed Drought Water Bank will likely be beneficial. As a result of any proposed increase in flows during August,September, and October, water quality conditions could be substantially improved.

If all increased flows from the 1992 Water Bank (estimated at 15,000 acre–feet for August, 14,300 acre–feet for September, and 20,700 acre–feet for October) were released from one tributary (Merced, Tuolumne, or Stanislaus River) water quality conditions would likely improve significantly on that tributary as well as the mainstem downstream of where it joins. All these tributaries have experienced degraded water quality conditions throughout the three month period during each of the previous critically dry years, thus any increase in flows greater than what might be expected during a critical year would be beneficial.

If total increased flows for the three–month period were to be proportionately divided among the three tributaries, water quality conditions would probably improve, but improved water quality conditions on the mainstem would be less significant. For instance, if the three tributaries were divided proportionately by their unimpaired runoff contributions to the mainstem (the proposed increase of 15,000 acre–feet for the month of August) flows on the Stanislaus River would increase by 37 cfs and flows on the Tuolumne and Merced rivers would each increase by 88 cfs. The result would improve conditions on all three tributaries, but have less, though still beneficial, effect on the mainstem.

Wildlife. Wildlife impacts or benefits vary substantially as a function of geographic location, type of bank action, and the individual and cumulative acreage of wildlife habitat involved. Analysis of effects of the proposed Drought Water Bank on wildlife species is based on the assumption that none of the water sold will be used for additional *new* agricultural development of currently undeveloped wild land habitats.

Land Fallowing as Water Bank Source. Land or crop fallowing for water bank use includes simply not planting a crop; planting a crop, but not irrigating the plants; planting a crop and foregoing one or more irrigations; or planting a crop different and less water dependent than the preferred or intended crop. Fallowing agreements may or may not include a cover crop for soil protection or discing and weed control.

Crop lands are generally monotypic, containing low structural diversity and little plant species diversity. These factors limit the diversity of wildlife species present on intensively managed agricultural lands. However, some crop lands do provide valuable seasonal habitat. Fallowing of cereal grain crops (corn, rice, wheat, and barley) has a high potential for wildlife impacts. Waste grain in harvested fields provides a substantial portion of seasonal food requirements for both migrating and resident wildlife. Harvest efficiencies for grains seldom exceed 95 percent. In a corn field where the yield is 6,000 pounds per acre, 300 pounds of corn residual may be left for wildlife. Rice, a major crop in the northern Sacramento Valley, also generates residual grain for wildlife of approximately 300 pounds per acre. Wheat and barley yields are lower but significant. Fields that are not plowed, burned, or disced immediately after harvest are much more valuable as wildlife habitat. Removal of vegetative cover severely restricts the density and diversity of wildlife species present.

Row crops and cotton generally do not provide substantial or critical wildlife food supplies or habitat. Substitution of a low water use crop, such as winter wheat or fallowing with subsequent annual weed growth, could generate local wildlife benefits. Alfalfa provides cover for ground nesting birds and forage for grazing rodents and other mammals. Pioneering weedy plants can rapidly reclaim fallowed crop lands due to the relatively high soil productivity of these lands. Early successional weedy species are frequently heavy seed producers and can provide excellent wildlife cover as well.

Effects of Fallowing on Rare or Endangered Species. The Swainson's hawk, a State–listed threatened species, depends on rodents living in agricultural fields as a food supply. Fallowing and subsequent reductions in rodent populations could impact this species. Fallowing productive soils can also result in dense, tall weedy cover unsuitable for Swainson's hawk foraging even though the fallowed land may harbor high rodent densities.

The greater sandhill crane, a State listed threatened species, is dependant upon wet meadow and emergent wetlands for nesting in northeastern California. Irrigated pastures are also frequently used as nesting habitat. During the first few weeks of life, young cranes require the availability of moist soil where they forage for invertebrates. Foregoing irrigation or fallowing could adversely affect the quantity and quality on sandhill crane nesting habitat.

Surface Water as Water Bank Source. Water supplies can be augmented for the bank through the direct purchase of surplus stored water. A considerable number of water transfers or sales involving stored water from reservoirs have occurred during the current drought. Although concerns have been raised about observed and potential impacts to fisheries, few wildlife impacts have been projected or documented.

A few water supply reservoirs are maintained at stable enough levels to support riparian vegetation or aquatic emergent vegetation. Drawdown of these reservoirs related to water bank activities could result in damage or destruction of riparian or wetland habitat and loss of dependent wildlife species.

Ground Water Substitution as Water Bank Source. Foregone diversions of natural flow from streams are generally considered to be a benefit to wildlife occurring along the stream. During periods of drought and low flows, riparian and wetland habitats are significantly affected by diversions from streams. Where water right holders are paid to leave their entitlement in the stream for use or export elsewhere, local benefits to wildlife can be generated.

Ground water pumping, as a replacement supply for surface water, is unlikely to cause observable impacts to wildlife. Impacts to wildlife, with no changes in land use, would be expected.

Potential Impacts to Wetlands. Although the general discussion of wildlife impacts included several instances where wetland habitat could be impacted or enhanced, special circumstances require additional evaluation.

Many publicly and privately owned permanent and seasonal wetland areas in the Central Valley depend on drain water or class 2 type contracts for their basic water supply. The potential exists for water districts to sell water through conservation efforts, such as tailwater recovery operations and improved irrigation scheduling. However, this can result in reduced flows downstream of such water districts, where the water might be used by farms or waterfowl areas before it goes back into surface water streams.

Downstream farmers and duck clubs may not have legal rights to these irrigation return flows, but would be impacted by them nonetheless. Resulting impacts to wetland habitats and migratory waterfowl could be significant. Such impacts can be prevented or minimized through careful analysis of potential water sales to the water bank, disclosure by potential sellers, and implementation of specific measures by the water bank. DWR has dealt with these kinds of problems as part of the 1991 and 1992 Drought Water Banks, and it is anticipated that adverse impacts to wetlands and waterfowl will continue to be avoided.

Sensitive Plant Communities

Plant communities could be affected from operation of the proposed Drought Water Bank, depending on the source of water for the program.

Stored Surface Water. The proposed Drought Water Bank could obtain water from reservoirs. Use of this water source is not expected to produce significant adverse impacts to plant communities at reservoirs. Water levels normally fluctuate in reservoirs, which precludes the long term establishment of sensitive plant communities. The proposed program would not significantly increase reservoir fluctuations that have occurred during past water short periods, such as the 1976 to 1977 drought, and that occur as a result of normal reservoir operation.

Streamflow Alteration. Flows would be less in some streams than those that would have occurred without the Water Bank under drought conditions, but would be greater in others streams. However, flows in the summer and fall due to the Drought Water Bank would generally be much less than those occurring at corresponding periods in a normal year. This eliminates concern for erosion of stream banks that may contain sensitive plant communities. During the 1991 Water Bank, stream flow was greater during late summer in the Yuba River (measured at Marysville) than flows that occur in median hydrologic years (Figure 3–6). However, flow in the Yuba River due to the Water Bank was still much less than normal high flows and was contained within the normal channel.

Ground Water Substitution. Substitution of ground water for surface water, or of low water use crops for high water use crops, is not expected to produce impacts to natural plant communities. Agricultural practices would continue as they had without the Drought Water Bank, and therefore would not generate any new impacts.

Effects of Fallowing. Certain sensitive plant species may be present on some agricultural lands. Habitat possibly associated with irrigated pasture is the most likely to support sensitive species. Cessation of water diversion, typically arranged under a contract to fallow pasture land, may reduce habitat available to some sensitive wetland plants.

DFG's Natural Diversity Data Base can be utilized to reference known occurrences of sensitive species by geographic location. As an example, wet pastures in the vicinity of Fall River Mills may provide potential habitat for several sensitive species (Table 3–17). Fallowing may have a negative impact on these species if they are present on pasture included in the Drought Water Bank program.

During 1991 and 1992 Water Bank operation, fallowed pasture occurred only in relatively small geographic areas. The Anderson–Cottonwood Irrigation District and the Fall River Valley contained the only pasture fallowed north of the Delta. Other agricultural croplands, such as those under corn, rice, and row crop production, are not expected to impact sensitive plant species when fallowed.

Recreation

Reservoirs and streams throughout the State are widely used for recreational pursuits, including fishing, waterskiing, boating, swimming, camping, hiking, hunting, and rafting. Operation of the proposed Drought Water Bank may alter water levels in reservoirs and flows in streams.

Effect on Reservoirs. The influence of maximum (1991) and minimum (1992) Water Bank operations on reservoir storage was evaluated for five reservoirs integral to Bank operation: Shasta, Oroville, New Bullards Bar, Folsom, and San Luis (Figures 3–50 through 3–54). Compared to reservoir operations expected in the absence of the Water Bank, reservoir storage in most instances was increased. Increased reservoir storage typically improves conditions for reservoir recreation.

Table 3–17. Sensitive Plant Species Near Fall River Mills, Potentially Present on or Adjacent to Irrigated Pasture

Scientific Name	Common Name	Status*
Calochortus longebatustus var. *longebarbatus*	Long–haired star tulip	3C, 1B
Eryngium mathiasiae	Mathias' button celery	3C,4
Gratiola heterosepala	Bogg's lake hedge–hyssop	SE, 1B
Limnanthes floccosa ssp. *bellingeriana*	Bellinger's meadowfoam	2, 1B
Orcuttia tenuis	Slender Orcutt grass	SE, 1B

*SE – State Endangered;
1B, 4 – California Native Plant Society list, Species of Concern;
2, 3C – Federal Candidate Category

Improved recreational conditions can be considered program benefits at Shasta and Oroville reservoirs during the 1991 and 1992 Water Banks. These reservoirs received the greatest storage benefit from Water Bank operations. Higher reservoir levels occurred in all summer and fall months, except that levels dropped very slightly below those that would have occurred without the Water Bank during September of 1992.

New Bullards Bar Reservoir maintained lower reservoir levels than would have occurred without the Water Bank during the summer and fall of 1992. These lower levels ranged from 2 to 6 percent less storage. A volume of 30,000 acre–feet in New Bullard's Bar Reservoir represents a change in water level of 8 to 10 feet. Water levels during the summer were reduced about 5 feet in May to 14 feet by the end of summer. The 1991 Water Bank operation also reduced storage during the later half of the year, but increased summer storage. Water levels were increased from about 2 feet in May to 5 feet during July. Maximum fall water level reductions occurred by November, resulting in lowering the reservoir by about 30 feet more than had the Water Bank not been in operation in 1991 and 14 feet in 1992. Since most recreational activities occur during the summer, slight water level reductions such as occurred during the 1992 Water Bank should not produce significant adverse effects. Similarly, slightly higher summer water levels such as occurred with the 1991 Water Bank would produce slight but insignificant recreational benefits.

Figure 3-50. Change in storage at Shasta Reservoir due to the Water Bank in 1991 and 1992.

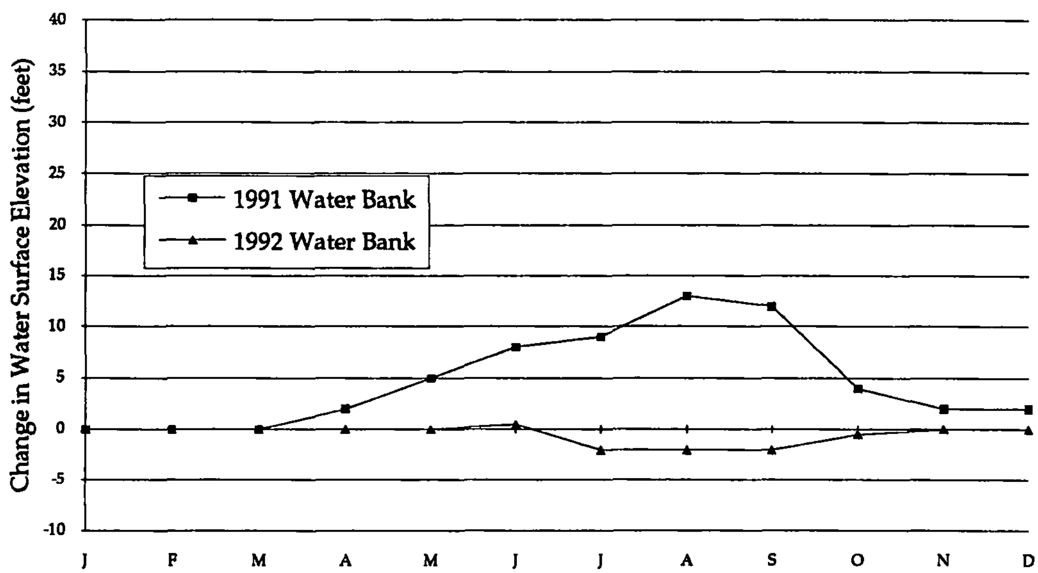


Figure 3-51. Change in storage at Oroville Reservoir due to the Water Bank in 1991 and 1992.

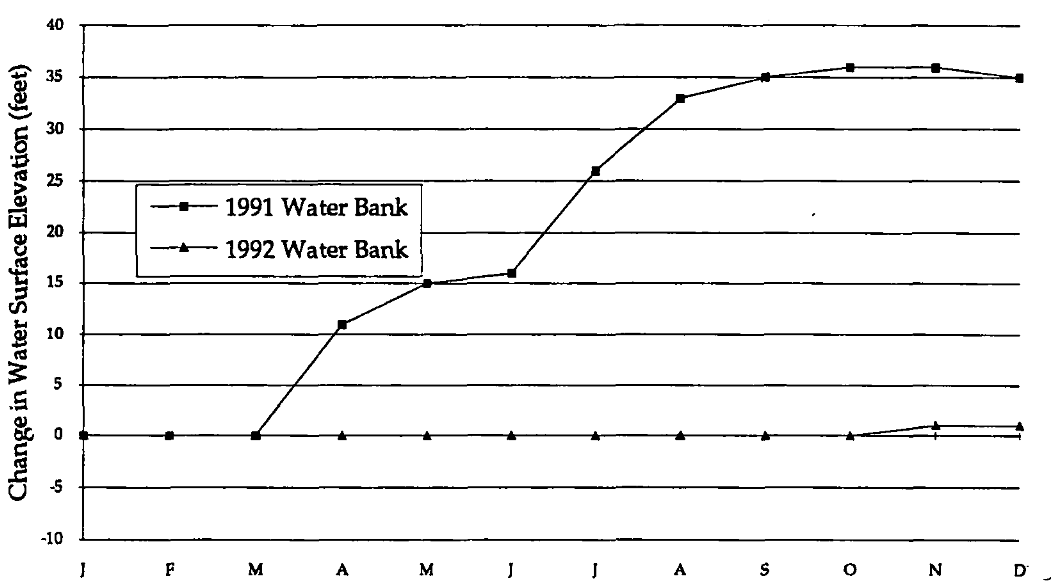


Figure 3-52. Change in storage at New Bullards Bar Reservoir due to the Water Bank in 1991 and 1992.

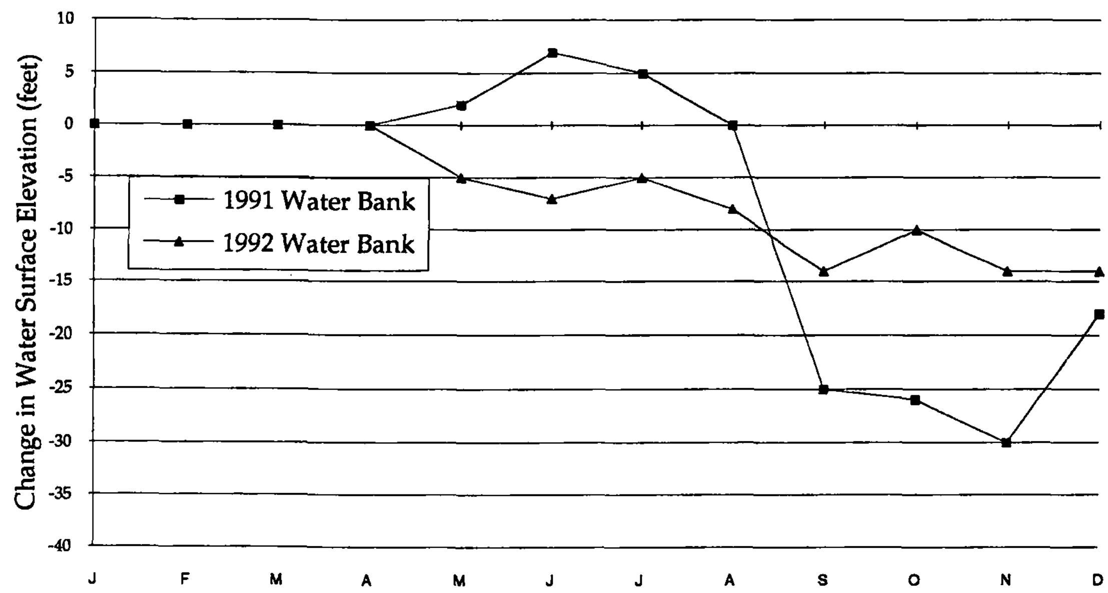


Figure 3-53. Change in storage at Folsom Reservoir due to the Water Bank in 1991 and 1992.

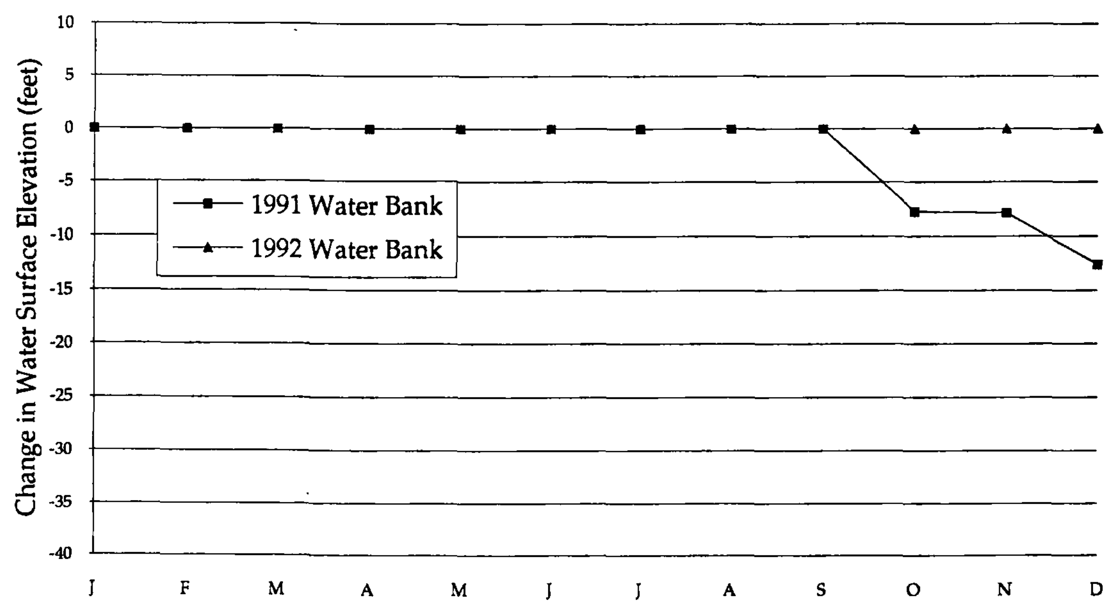
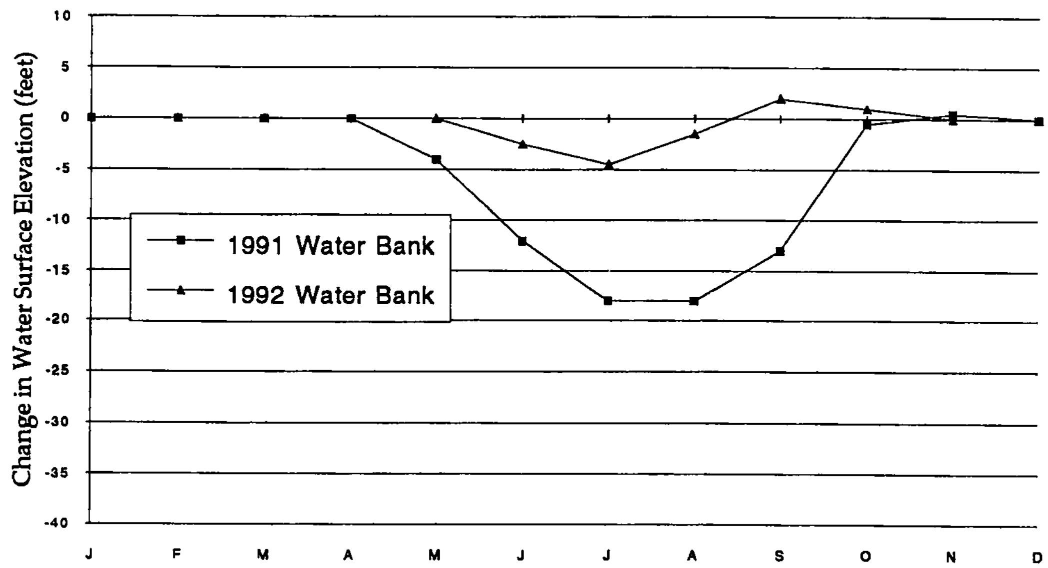


Figure 3-54. Change in storage at San Luis Reservoir due to the Water Bank in 1991 and 1992.



San Luis Reservoir storage was reduced significantly during the recreational season (April to September) under past Water Bank operation schedules. Although storage increased during some fall and winter months, recreational season storage ranged from 1 to 22 percent lower than storage that would have occurred without the Water Bank. Recreational impacts at San Luis Reservoir are the same magnitude as benefits incurred at Shasta and Oroville reservoirs. When annual attendance is considered (San Luis 200,000; Oroville 700,000; Shasta 1,000,000+ recreational days), the benefits at Shasta and Oroville reservoirs offset impacts at San Luis Reservoir.

In addition, the primary goal of San Luis Reservoir is to supply water when supplies cannot be pumped from the Delta. This goal coincides with operation of the Water Bank. Water Bank supplies could not be pumped through the Delta during the summer due to fishery concerns and were held in upstream reservoirs until fall. San Luis Reservoir supplies were used to meet critical water needs south of the Delta, which resulted in the drawdown of the reservoir in 1991 and 1992. This would have happened without the Water Bank during the summer when water could not be delivered through the Delta. Water in the reservoir was replaced in the fall when Water Bank supplies could be delivered through the Delta.

Compared to storage that would have occurred without the Water Bank, Folsom Reservoir storage was unaffected during the summer but reduced during the late fall by the 1991 Water Bank and was essentially unaffected by operations during the 1992 Water Bank. The reduction in storage after the recreational season should have had insignificant impacts on recreational use of the reservoir.

Effects on Rivers. Operation of the Drought Water Bank is not expected to have any discernable effect on river recreation. Flows in the Sacramento, Feather, Yuba, and American rivers during the 1991 and 1992 Water Banks were periodically either higher or lower than those that would have occurred without the Water Bank. Changes in river flows are within the ranges of variability typical of drought conditions. The variation is not expected to significantly affect potential recreational opportunities.

Effects on the Delta. Recreational activities in the Sacramento–San Joaquin Delta will be unaffected by the Drought Water Bank program. Comparisons of the Delta Outflow Index during operations of the 1991 and 1992 Water Banks with those which would have occurred without the Water Bank indicate that slightly increased fresh water outflow occurred during much of the recreational season when the Water Banks were in operation. While this may provide some water quality benefits, any recreational benefits are not expected to be measurable.

Growth-Inducing Impact of the Proposed Project

The proposed Drought Water Bank project is not growth inducing since it would operate in near–emergency conditions to augment statewide water supplies after all existing water supplies are utilized. The proposed project is designed to meet water needs under drought and similar conditions, and is not designed or expected to provide reliable, quantified water supplies as are needed to support increased growth. Accordingly, as new reliable water supplies are added, the demand for water transfers should be reduced.

Concern was expressed at public scoping sessions that the availability of water from water transfers (and particularly the availability of less expensive water from the 1992 Water Bank) takes away the incentive to develop additional water storage facilities. This concern is misplaced for several reasons. First, experience in the 1991 and 1992 Water Banks has shown that there is a limited supply of less expensive water available. If the actual demand is higher than the availability of potentially less expensive water, the price for all water purchased in any given year may be affected.

Second, the quantity of potentially less expensive water available is much less than the long–term (and current) need for additional water supplies. For the SWP alone, the contractual commitment and the long–term demand for water is more than 4 million acre–feet, while current facilities can supply no more than 2.5 million acre–feet during drought periods.

Third, DWR has an aggressive water development program in addition to increasingly successful ongoing water conservation and reclamation programs. The existence of the 1991 and 1992 Water Banks caused no decrease in these activities, which have accelerated in the last several years.

And fourth, the inability to bring new projects on line is not a function of the lack of need for the projects. Rather, these projects are subject to stringent and expanding regulatory control which have not allowed any major water resource development project to proceed in California for some time. DWR is gradually working proposed programs through environmental review and mitigation processes, but it takes more than double the time supported by past experience. Examples of environmental concerns and controls include water rights proceedings before the SWRCB, the full range of issues regarding the Sacramento–San Joaquin Delta, the wetlands issues regarding Section 404 of the federal Clean Water Act, the State and federal Endangered Species Acts, and acceptable mitigation solutions for wildlife habitat disruption (particularly for endangered species).

Effects Found Not To Be Significant

An Environmental Checklist (Appendix B) from the CEQA guidelines (Remy, et al., 1992) was used to aid and focus the environmental assessment. No adverse significant effects are anticipated to the earth, air, noise levels, light and glare, rate in use of natural resources, risk of upset, distribution of the human population, housing, transportation, public services, energy, utilities, human health, aesthetics, or cultural resources.

However, the proposed program was determined to affect water quantities and flows, and potentially affect plant life, animal life, land use, and recreation. The proposed program was also determined to have the potential to reduce the habitat of fish or wildlife species and contribute to cumulative effects.

Chapter 4. Unavoidable Significant Effects of Proposed Program and Proposed Mitigation

This section describes environmental effects of the proposed Drought Water Bank program that cannot be avoided, and mitigation for these effects that will be included as part of the program.

The proposed Drought Water Bank will be modeled after the successful Emergency Drought Water Banks of 1991 and 1992. These two water banks are examples of possible extremes of operation. The 1991 Water Bank is considered a maximum bank, while the 1992 is considered a minimum bank. Expected environmental effects of the proposed Drought Water Bank should be similar and within the same range as these two water banks.

Surface Water Sources

The 1991 and 1992 Emergency Drought Water Banks produced relatively minor changes in streamflows and reservoir storage. No significant environmental effects were discernable from operation of these two banks. The Water Banks may have produced environmental benefits from higher stream flows and reservoir storage levels. Similarly, no significant adverse environmental effects are expected to occur to surface water sources from operation of the Drought Water Bank.

However, potential significant effects could occur from using a reservoir as a source of water in successive years for Drought Water Banks. Decreased carryover could result in decreased water supply for local water needs in subsequent years if sufficient runoff does not occur to resupply a reservoir.

Mitigation. Prudent reservoir operation dictates maintaining sufficient reserves to meet supply needs in subsequent years, even though drought conditions may persist. Consideration of prudent reservoir reserves at the time of purchase will minimize the likelihood of insufficient carryover for subsequent years.

Ground Water Sources

Potential environmental effects from using ground water sources in exchange for surface water supplies include overdraft, land subsidence, effects on other pumpers, water quality degradation, and effects on flows in the surface water system.

Overdraft. Overdraft has not been identified as a problem as a result of the 1991 and 1992 Water Banks. Most areas where ground water was substituted for surface water supplies were in basins not subject to overdraft, such as the Sacramento Valley. The limited and intermittent imposition of ground water demand for substitution of surface water supplies should not lead to overdraft in these areas. In areas subject to overdraft, however, substitution of ground water for surface water supplies could incrementally increase overdraft.

Land Subsidence. Subsidence was not identified as a problem due to operation of the 1991 and 1992 Water Banks. However, subsidence has been identified as a problem in areas of California, including the northern San Joaquin Valley and Sacramento Valley in which ground water substitution for surface supplies could be part of the Drought Water Bank. Consistent with the Governor's water policy, no water will be transferred from a ground water basin that would result in unmanageable problems caused by overdraft or subsidence.

Effects on Other Pumpers. Ground water extraction due to the proposed Drought Water Bank program will result in decreased ground water levels. Reduced ground water levels could result in increased pumping costs, deepening of wells or lowering of pumps within wells, construction of new wells, and dewatering in basin margins.

Effects on Flows in the Surface Water System. Surface and ground water systems are hydraulically connected in most areas. Additional ground water extraction in an area reduces the flow in the adjacent surface water system. Short–term water transfers for the proposed Drought Water Bank program are not expected to produce significant detectable effects to surface water systems.

Water Quality Effects. Extraction of poor quality ground water can produce deleterious effects to crops or surface water. Aquifers in some areas of the State are known to contain poorer quality water, while in others poorer quality water may be lying beneath usable supplies. Increased ground water pumping for the proposed Drought Water Bank could result in the movement of this poorer quality ground water to extraction wells and surrounding ground water.

Mitigation. Ground water use in the expected source areas for future Drought Water Banks is essentially unregulated, largely unmanaged, and poorly understood. As such, DWR cannot control the activities of nonparticipants in a Drought Water Bank. Such regulation, if desired, could be established through implementation of local ground water management programs. This presents a difficult framework within which the potential impacts of a Drought Water Bank must be evaluated. In many cases, the cause of detected effects will remain uncertain. To minimize this uncertainty, DWR will consider the data available from existing ground water monitoring programs it operates and those of other agencies to identify overall changes in ground water conditions and to provide perspective for the possible effects of Drought Water Bank extractions. These existing programs are both limited and fragmented but can, when coupled with site-specific Water Bank monitoring, provide valuable information on which to base future management considerations.

The transfer specific approach to proposal evaluation and project monitoring will be continued in future Drought Water Banks. As additional experience is gained in project operation and the understanding of aquifer responses to pumping increases, the evaluation and monitoring programs may be adjusted accordingly to assure that potential adverse effects are minimized and detected early to allow appropriate modifications to the transfers to be made.

Similar to 1992 contracts, all contracts for future drought water banks will have a requirement that the seller avoid adverse impacts related to subsidence, water levels, and water quality. The seller and DWR will jointly investigate any identified or claimed adverse effect. If such investigation should determine that a significant adverse effect is occurring as a result of the water bank, pumping from wells contributing to the problem will be reduced, modified, or terminated as appropriate. Additional mitigation measures may be appropriate in some cases. These could include, but not necessarily be limited to, such measures as provision of alternative water supplies, replacement of wells, or compensation for additional costs. Due to the site specific nature of possible impacts and causes, it is not possible to specify in advance the exact mitigation measures that would be appropriate. Furthermore, additional contractual provisions may be required to bind both sellers and purchasers to residual effects that may occur after the Water Bank pumping period.

Potential depletion of surface water sources due to ground water extraction will be minimized through careful analyses of recharge where a conflict is suspected. In addition, in those cases where the degree of surface water depletion can be estimated, the net amount of water transferred can be restricted to offset the effects of depletion.

Water purchased as part of a Drought Water Bank is expected to be used for direct delivery to offset shortages being experienced of either surface or ground water supply. As such, the effects on ground water are expected to be nonexistent where no ground water resources in the purchasing area are involved or beneficial where ground water resources are involved.

In general, ground water levels would be expected to be higher with this program than in its absence and thus would mitigate any adverse effects of declining water levels in these areas. It is possible, though unlikely, that localized adverse effects, such as water logging or liquefaction, could occur. However, it is not possible to anticipate these effects as they are very site specific and future purchasers and their operations are unknown. Purchasers will be expected to develop appropriate monitoring programs when their use of water from a Drought Water Bank could adversely affect ground water conditions in their service area.

Agriculture

Ground water substitution for surface water and purchase of surplus stored water supplies for a water bank would not affect agricultural activity. Crop substitution could also have insignificant effects on agricultural activity. Potential effects to agriculture result when fallowing is a component of a water bank. Effects to soil from fallowing associated with a water bank are no greater than those associated with fallowing as a normal agricultural practice. Wind erosion of bare soil is one potential adverse effect. This effect will be minimized by discouraging tilling of unplanted land until necessary to prepare for planting of crops.

Although significant adverse effects have not been identified to agriculture from fallowing for the 1991 and 1992 Water Banks, DWR will minimize fallowing due to environmental considerations.

Fisheries

Impacts to fisheries due to Drought Water Bank activities may occur in streams below reservoirs, but occur most significantly in the Delta.

Delta. The fisheries resources in the Delta have been declining. The causes of the decline and their interrelationships are being debated. The more prominent possible factors include the export of water from the Sacramento River watershed and prolonged drought conditions. Water Banks occur during critical water shortage periods. It is possible that the impact of Water Banks on fisheries may be magnified during these critical times because changes occur under already stressed fisheries conditions. On the other hand, the magnitude of Water Bank operations may be insignificant compared to the impacts of the non–project operations on that same fisheries resource.

Most Water Bank transfers will entail transport of water through the Delta. Any pumping of water from the Delta to the San Joaquin Valley or southern California will result in loss of fish. The ideal project is designed to avoid or at least minimize fisheries impacts. However, it is often not possible to completely avoid impacts, thus mitigation and offsetting measures must be included in a project.

Avoidance and Minimization Measures. The first avoidance measure is to complete Delta transfers during those periods when fish impacts would be at their annual lowest. With over 40 species of fish present in the Delta, however, it is not possible to select a period which avoids impacts to all fish.

During the period from 1978 through 1991, seasonal salvage of fish at the State pumping plant has varied (Figure 4–1). For some species, such as chinook salmon, transfers during the summer months will minimize direct and indirect impacts in the Delta. On the other extreme is American shad, which is most abundant in the Delta during the summer.

Transfers during 1991 and 1992 were designed to avoid Delta impacts on winter run chinook salmon and were successful in achieving this goal. If other species, such as the Delta and longfin smelts and the splittail are listed or each remain at low levels, it will become increasingly difficult to find "fish friendly" periods in which Bank water can be transferred. This problem is particularly serious for a Water Bank which typically occurs during droughts when fish populations are often already stressed.

Delta impacts on many species can be minimized by physical improvements to the Delta and project intakes. Although changes in Delta plumbing, such as by dredging and creation of barriers, can be an important factor in future water banks, the extent of these changes and their benefits are not defined well enough to evaluate. The work of the Bay–Delta Oversight Council is to provide information relating to the benefits of changes in Delta facilities for environmental as well as water supply purposes.

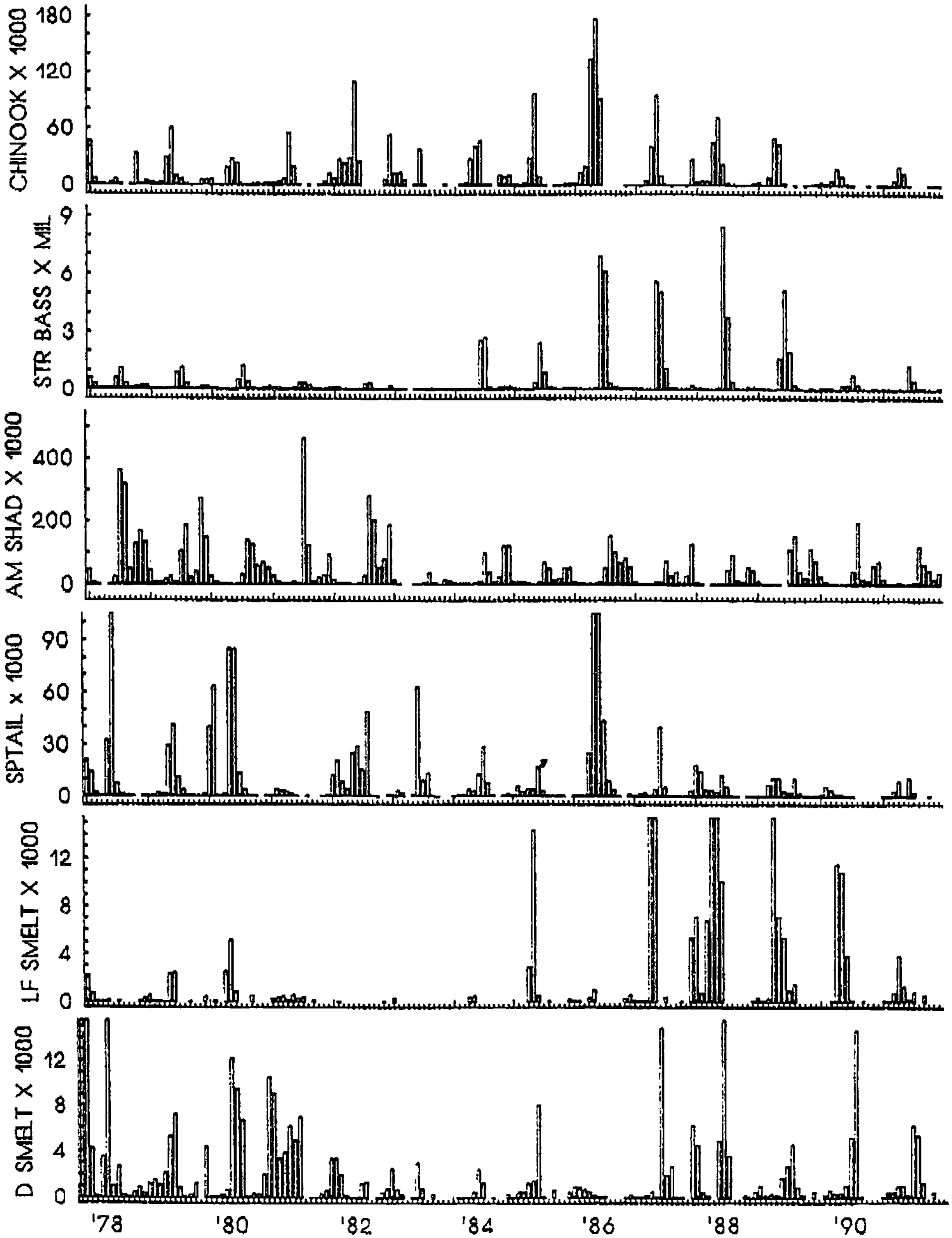
Some changes have been and are being made at the CVP and SWP intakes which should minimize losses of several species of fish. These changes include predator control programs to reduce prescreening losses, improvements in the facilities themselves, and changes in handling and hauling procedures to decrease mortality of those fish reaching the holding tanks after passing through the screening facilities.

Mitigation Measures. For the SWP, the primary means of mitigating or offsetting direct pumping impacts is through the DWR–DFG Delta Fish Protection Agreement("4–Pumps" Agreement). Signed in 1986, this agreement provides a mechanism for offsetting the direct losses of fish at the pumps. An accounting procedure has been developed by which calculated losses are balanced by fish production from projects approved by an advisory committee and the two agency directors. The agreement also provides $15 million for fishery projects which are not tied to annual losses and for which exact benefits are difficult to determine. (The $15 million account, for example, was used to fund placement of about 100,000 cubic yards of gravel in the Sacramento River near Redding to improve salmon spawning habitat.)

Although the 4–Pumps Agreement is to cover all species of fish lost at the pumps, during the first 6 years only striped bass, steelhead, and chinook salmon projects have been implemented. Presently, losses of other species cannot be calculated because information on screen efficiencies, predation, and other factors is not available.

Until 1992, striped bass obligations were offset by planting hatchery yearlings. In 1992, DFG stopped this program, at least temporarily, because of concerns about winter run chinook salmon. The annual obligation will remain, and other projects to provide mitigation for striped bass are being evaluated. Potential projects include screening other Delta diversions and rearing striped bass salvaged at the screens in pens floating in the Delta.

For chinook salmon mitigation, projects have focused on habitat improvement, mainly in the San Joaquin River system. Several projects have been approved which should, in total, provide sufficient production to offset the calculated salmon losses. However, escapements to the San Joaquin River tributaries in recent years has been so low that expected production levels have not been achieved.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The 4–pumps agreement also contains a provision (Article VII) that specifies that DWR and DFG must agree to measures to mitigate for the indirect impacts of Delta pumping before the present limit on Delta diversions can be lifted. DWR, DFG, and USBR are currently negotiating terms of this new agreement.

In 1992, USBR and DFG signed an agreement by which USBR can offset its direct pumping impacts. As yet, no specific actions have been taken pursuant to this agreement.

In the 1991 and 1992 water banks, DWR took measures beyond the 4–pumps agreement to mitigate indirect impacts of the transfer. In 1991, DWR agreed to purchase and stock an additional 300,000 striped bass yearlings. In 1992, with the stocking option not available, DWR agreed to pay DFG a mitigation cost of $1 per acre–foot transferred. DFG is to use these funds for mitigation projects and provide DWR with a record of the projects funded, including costs and expected benefits. Both of these measures are in addition to the normal 4–pumps annual mitigation obligation.

The existing 4–pumps and USBR–DFG agreements provide the mechanism for mitigating the direct impacts of future Drought Water Bank transfers. Projects will be developed which provide effective mitigation for the original three species of fish as well as the other more than 30 species for which no mitigation measures are available.

Tributary Streams. Increased streamflows are generally regarded as beneficial to fisheries. Streamflows in tributaries to reservoirs would increase as the result of decreased diversions for a Drought Water Bank. During the years when the project would operate (severe reductions in runoff), fishery benefits from increased streamflows would be most significant. No adverse effects to fisheries are expected from the proposed program.

Water storage levels in reservoirs affect downstream temperatures. Temperatures are critical for certain species, such as salmon and steelhead. Increasing the depth of water and stratification produced temperature benefits and availability of cooler water for downstream releases as a result of the 1991 and 1992 Water Banks in Shasta and Oroville reservoirs. Water levels were decreased in New Bullards Bar Reservoir due to purchases by the 1991 Water Bank, but sufficient reserves were available such that cold water availability at the elevation of the reservoir outlet was unaffected. Adverse effects to fisheries from purchase of surplus stored water were not apparent from the 1991 and 1992 Water Banks. Careful consideration of temperature and storage relationships in future Drought Water Banks will be used to minimize the potential for adverse effects associated with the proposed Drought Water Bank.

Flow changes resulting from the 1991 and 1992 Water Banks produced no discernible adverse effect to fisheries resources downstream from reservoirs. Transfers that are part of future water banks will be required to conform to instream flow needs, thus avoiding impacts in the streams. Short–term stream fluctuations resulting from natural storm events, hydroelectric power generation, diversion requirements, and similar activities can occur on a daily basis. Fisheries impacts would include dewatering of redds, stranding of juveniles, and loss of spawning habitat. On the Yuba River, operational procedures to minimize stream fluctuation impacts are outlined in the 1965 Yuba County Water Agency Agreement. More stringent procedures are described in the proposed Lower Yuba River Fisheries Management Plan. Operation of the proposed Drought Water Bank would employ procedures consistent with current requirements for the Yuba River, as well as other rivers included in any future project.

Until the winter run chinook salmon is delisted, summer salmon habitat conditions in the Sacramento River below Keswick Reservoir will be largely dictated by concerns related to maintaining water temperatures that do not adversely impact egg incubation and alevin survival. Operations of future Drought Water Banks involving changes in river flow, and perhaps carryover storage, will be required to meet conditions established in Biological Opinion(s) issued by the National Marine Fisheries Service.

Restrictions on the period in which water can be moved across the Delta will limit transfer flexibility and may preclude flow schedules which provide instream benefits. The 1992 experience with winter run chinook salmon provides an example of this problem. The transfer between Merced Irrigation District and DFG was stopped when winter run chinook salmon juveniles were found in the Delta. The transfer was providing improved habitat in the Merced River for fall run chinook salmon that is at dangerously low population levels. In addition, the transferred water was going to wetlands where development and the continued drought have caused severe problems.

Water Bank transfers in the range seen in 1991 and 1992 should not require additional mitigation measures in the streams themselves if they are conducted so that instream flow criteria are met.

Water Quality

Significant adverse effects to surface water quality were not identified during the 1991 and 1992 Water Banks. Any effects to water quality were considered beneficial due to increased flow. Similarly, the proposed Drought Water Bank program is not expected to adversely affect surface water quality.

Extensive water quality monitoring was not generally incorporated into the 1991 and 1992 Water Banks. An exception to this was Yolo County, where a network of monitoring wells was installed and a series of water quality analyses was conducted. Ground water extraction activities associated with the Drought Water Bank will incorporate sufficient monitoring to detect any significant adverse water quality effects. Ground water will not be used to substitute for surface water if beneficial uses would be impaired.

Wildlife

Effects to wildlife vary with geographic location, source of water for a water bank, and the acreage of habitat involved. Potential adverse effects to wildlife from the proposed Drought Water Bank may occur from fallowing and use of surface water sources.

Fallowing. Fallowing row crops produces little significant adverse effects to wildlife since such crops generally do not provide substantial habitat or food. Fallowing cereal grain crops, however, removes seasonal habitat for certain species, such as waterfowl, and decreases food supplies for both resident and seasonal wildlife by reducing waste grain availability. Fallowing may affect threatened or endangered species that forage on waste agricultural products or the species attracted to such areas. The greater sandhill crane, another threatened species, may also be adversely effected by fallowing because this species requires wetlands or irrigated pastures as nesting habitat.

A number of options exist which would lessen or mitigate the potential impacts to wildlife associated with agricultural fallowing for water bank purposes. Substitute waste grain could be provided, either as a limited planting (i. e., 5 percent of fallowed land) without harvest or reduced harvest efficiencies on nearby cropped lands. For example, if corn fallowing is the objective, 5 percent of the total acreage could be planted and left standing or mowed for wildlife use. If a landowner chooses, reduced harvest efficiencies can offset lost waste grain for wildlife.

In areas such as the peat soils of the Sacramento–San Joaquin Delta where cover crops are essential to soil protection and air quality considerations, planting of vetch or another soil building crop would provide excellent wildlife forage and cover. A combination of vetch and barley or wheat would be ideal. In all cases, wildlife impacts are reduced if the fallowed land is left undisked and weed control is deferred until planting is resumed. In the Delta, fallowed land is often rapidly invaded by watergrass. This valuable wildlife plant occurs naturally and grows well in peat soils with a high water table. Management of watergrass as a cover crop and wildlife habitat could include mowing in the fall to a height of 1 or 2 feet. This would afford access to the seeds by waterfowl and other birds and increase use by raptors, such as Swainson's hawk, seeking rodents.

Where a crop shift (i. e., from corn to winter wheat) is the means to generate bank water, the crop residue following harvest could be left unplowed or not disked until the land must be prepared for planting.

Although fallowing of row crops or cotton would not likely result in significant adverse impacts to wildlife, DWR will consider such effects prior to execution of a fallowing contract.

Of the methods of providing bank water (i.e., ground water substitution, surface water, and fallowing), fallowing has the greatest potential for impacts to wildlife habitat. Fallowing contracts requiring that carefully controlled vegetative removal or other weed control activities be conducted, in appropriate situations, would largely mitigate the potential for fallowing–related wildlife impacts. However, allowing significant vegetation to grow on some lands, particularly those in the Delta with subsurface water supplies or shallow ground water, could significantly reduce the water savings from fallowing. One means of accomplishing most water savings goals and reducing impacts to wildlife is to delay mowing or disking until mid–summer, after the nesting season is over for resident wildlife. Another alternative is to maintain border strips of vegetation and keep most of the fallowed land free from vegetation at the outset of the program through the next farming period.

Surface Water Sources. Wildlife habitat can also be adversely affected by loss of agricultural tail water that is currently used to maintain wetlands. In all water transfers, DWR carefully analyzed the source of bank water to determine if it really exists and where it comes from. DWR has been diligent in maintaining existing wetland supplies and would continue to do so with a Drought Water Bank.

Some reservoirs that do not experience significantly reduced levels on an annual basis may develop riparian or emergent vegetation important as wildlife habitat. However, no reservoirs involved in the 1991 and 1992 Water Banks contained such vegetation. Before including such reservoirs in a Drought Water Bank, DFG will be consulted to determine mitigation for any significant adverse effects.

Sensitive Plant Communities

Water bank supplies from surplus stored water are not expected to affect sensitive plants. The normal fluctuation of reservoirs precludes long-term establishment of sensitive plant species. The proposed program would not significantly increase reservoir fluctuations that have historically occurred.

Changes in streamflows as the result of a water bank also would have no effect on sensitive plant communities. Streamflows attributable to the 1991 and 1992 Water Banks were within the normal range of flows experienced by streams and precludes establishment of sensitive plants in stream channels and does not affect streambank erosion. The proposed Drought Water Bank would operate under similar constraints.

Substituting ground water for surface water would not produce significant adverse effects to plants since normal agricultural practices would still occur.

Certain sensitive plants may occur on some agricultural lands, with the most likely such lands to be irrigated pasture. Fallowing irrigated pasture may adversely affect a sensitive plant associated with that pasture. Fallowing other crops, such as corn, rice, and row crops, is not expected to affect sensitive plant species since such species are not usually found in such intensively managed agricultural lands. Adverse environmental effects to sensitive plant communities from fallowing will be minimized by only considering fallowing as a water source of last resort. DWR will coordinate with DFG to minimize effects to sensitive plants from fallowing

Recreation

Increased reservoir levels from the 1991 and 1992 Water Banks benefited recreational activities at Shasta and Oroville reservoirs. Water levels were slightly increased due to the 1991 Water Bank at New Bullards Bar Reservoir but slightly lower in 1992. No significant adverse effects to recreation are known to have occurred due to these slight water level differences. Significant water level reductions occurred at San Luis Reservoir in 1991, but only slight reductions occurred in 1992. The goal of San Luis Reservoir is to provide water when water cannot be pumped from the Delta. Severe level fluctuations are thus expected for this reservoir and those caused by water banks are not considered unusual. Reservoir storage at Folsom Reservoir was unaffected during the summer recreational season in 1991, although levels were reduced in the late fall. Reservoir levels were unaffected by the 1992 Water Bank.

Water bank operations are not expected to affect stream recreation. Stream flows due to the water bank are within the range of those normally experienced.

Slightly increased Delta outflow occurred during much of the recreational season due to the 1991 and 1992 Water Banks. Recreational benefits from such increases are probably unmeasurable.

The Drought Water Bank is expected to result in similar insignificant impacts to recreation.

Chapter 5. Significant Cumulative Impacts

Cumulative effects refers to two or more individual effects that may not be significant when considered individually but are significant when considered together. Closely related past, present, and reasonably anticipated future projects with related effects may produce cumulative effects.

The proposed Drought Water Bank will only be operated in years with significantly less than normal surface runoff that create near–emergency conditions in parts of the State due to lack of water. Water deliveries, even with the proposed program, would be less than those occurring in years of more normal runoff. Many impacts from water delivery projects are related to the quantity of water transported through the Delta. Although some adverse effects may still occur from operation of the Water Bank, such effects will be much less than during years of delivery of normal water quantities. Cumulative impacts from related projects will be reduced due to reduction in water deliveries during the periods when the project would operate.

Ground Water Extraction

Ground water use associated with a Drought Water Bank will be in addition to that otherwise expected to occur in a water–short year and, as such, may incrementally contribute to any adverse effects that would otherwise occur. Given the general absence of ground water management in the potential Drought Water Bank source areas, it is not realistic to expect local agency action in the near future to minimize adverse effects of pumping or to coordinate the overall use of surface and ground water to maximize usable water supplies. This situation is not expected to change significantly in the near future. However, to the extent that ground water management programs are established by local agencies, operations of Drought Water Bank ground water projects would have to conform. In addition, ground water extraction for a Drought Water Bank has the potential to affect ground water conditions in subsequent years. Effects due to the proposed Drought Water Bank will be extremely difficult to differentiate from the effects of other pumping.

One concern with ground water transfer programs (either direct transfer or ground water substitution) is back–to–back years of transfer. This has already occurred in 1991 and 1992 as part of the Governor's drought water banks. Such circumstances merit very careful monitoring of ground water characteristics, including water levels, subsidence, and water quality. Very little is known in many areas as to how the local ground water basin is recharged. Of course, the source of water is surface water. Key characteristics include which streams contribute to recharge, time lag, and annual recharge patterns. Recharge always occurs each year in some amounts.

Water Transfers

Statewide emphasis on several distinct types of water transfers has intensified during the 1980s. A number of new laws have been passed that express State policy, add to the existing water rights authority of the SWRCB, and authorize new programs for DWR. These include advocation of voluntary transfer of water and water rights where consistent with the public welfare of the place of export and the place of import; encouragement by DWR and SWRCB of voluntary transfers of water and water rights by offering technical assistance, if necessary, to identify and implement water conservation measures that will make additional water available for transfer; authorization for local and regional public agencies to sell, lease, exchange, or transfer surplus agency water for use outside the agency; and prohibition of State and local agencies from denying a bona fide transferrer of water the use of unused capacity in a water conveyance facility.

DWR is required to establish an ongoing program to facilitate the voluntary exchange or transfer of water; implement various State laws pertaining to water transfers; create and maintain a list of entities seeking to enter into transfers and a list of the physical facilities that may be available to carry out water transfers; and prepare a water transfer guide. In March 1986, DWR established an inhouse Water Transfers Committee to respond to the interest in water marketing and water transfers. The committee has published two draft documents to facilitate the voluntary exchange or transfer of water within California, titled *Catalog of Water Transfer Proposals and Questions to be Asked in the Case by Case Review of Water Transfer Proposals.* A *Water Transfer Guide*, authorized by Section 482 of the Water Code, was released in June 1989.

The COA between DWR and USBR provides for negotiating a contract for the sale of currently excess federal water to DWR and for conveyance of federal water through SWP aqueduct facilities. The SWRCB, DFG, and USFWS are involved in the negotiations, which are also open to the public. The negotiations are closely coordinated with periodic meetings with the State water contractors.

Several substantial water transfers have occurred during the past few years. DWR entered into an agreement with the Yuba County Water Agency (YCWA) to purchase water from New Bullards Bar Reservoir during the summer of 1988. The release of this water by YCWA allowed DWR to hold a corresponding amount of water in Lake Oroville, which had the effect of transferring water from New Bullards Bar Reservoir to Lake Oroville for the SWP. DWR and YCWA renegotiated a water transfer for 1989. Yuba County agreed to make 200,000 acre–feet of water available. Santa Clara Valley Water District paid the costs of transferring 90,000 acre–feet, and Tulare Lake Basin Water Storage District paid the costs of transferring the remaining 110,000 acre–feet.

The City of Napa purchased 7,000 acre–feet of water from the YCWA for use in 1989. The water was conveyed through the North Bay Aqueduct.

Water rationing was instituted by the East Bay Municipal Utilities District (EBMUD) in 1988, and had planned for 25 percent reductions in 1989. EBMUD purchased 60,000 acre–feet of water from the YCWA to avoid rationing at greater than 25 percent. As a result of additional rains, however, EBMUD did not use this water. In August 1989, EBMUD sold 30,000 acre–feet of the purchased water to DFG for use in the San Joaquin Valley for salmon enhancement and riparian benefits. The City of Napa and EBMUD negotiated directly with YCWA for their purchases.

Marin Municipal Water District (MMWD) is seeking a supplemental water supply of 10,000 acre–feet per year, with the North Bay Aqueduct (NBA) as a possible link in the delivery chain. Water purchased by MMWD somewhere in the Central Valley could be rediverted from the Delta into the NBA and delivered at NBA terminal facilities. MMWD would have to build a conduit from the NBA to its service area in Marin County. DWR has participated in meetings with MMWD and representatives of the Napa and Solano County agencies that have contracted for deliveries from the NBA.

Water transfers may occur in future years unrelated to the proposed Drought Water Bank. Whether such transfers occur, as well as location and magnitude of transfers, is not known at this time. Cumulative effects associated with future, but unknown, water transfers may include changes in ground water storage, reservoir storage, stream flow, Delta flow, and water quality. These effects may subsequently affect fish or wildlife populations. Cumulative environmental effects due to future non–Drought Water Bank transfers can only be evaluated once such transfers become known. The significance of cumulative effects will be evaluated prior to the beginning of any Drought Water Bank.

With transfers involving local use of ground water in exchange for surface water, DWR will fully evaluate cumulative effects of additional ground water substitutions that may be considered for the proposed Drought Water Bank. DWR will not enter into agreements for ground water substitution without monitoring to protect the ground water resource from overdrafting and possible subsidence.

Similar to precautions that will be used in the use of ground water in exchange for surface water transfers to the proposed Drought Water Bank, DWR will evaluate the possible cumulative effects that may exist when surplus surface water is purchased. Where other non–Drought Water Bank purchases are conducted, DWR will not purchase additional surplus supplies if it determines that adverse cumulative environmental effects may occur due to additional purchases for the Drought Water Bank.

Most non–Drought Water Bank transfers will have to use DWR conveyance systems, especially those that transfer water from the northern portion of the State to areas south of the Delta. This provides DWR the opportunity to ensure that other water transfers have considered cumulative effects, and that appropriate mitigation measures have been incorporated.

Water transfers can increase Delta inflow and outflow in drier years, increase exports when transfers occur from north to south of the Delta, and decrease exports when transfers involve supplies south of the Delta. Water quality may be improved with higher flows in the Delta, although fish screening losses may be increased from increased pumping.

Water Development Projects

Water development projects center on transferring water through the Delta. New surface water developments north of the Delta have not progressed beyond the preliminary planning stage and are too speculative to consider possible environmental effects. Projects that improve water delivery through the Delta and store surplus water south of the Delta may produce cumulative effects. Effects of such projects (Table 5–1) have been considered in numerous environmental studies (DWR 1990c, 1990d, 1990e, 1992a, 1992b; USBR/DWR, 1985).

Table 5–1. Potential Cumulative Effects of Water Development Projects (DWR, 1990c)	
Project Activity	**Potential Cumulative Effect**
State Water Project Additions to 2010 • Delta pumps • Interim CVP purchase • Kern Water Bank • Los Banos Facilities • South Delta Program • North Delta Program	Increase current dependable supply from 2.3 million acre–feet (MAF) to 3.6 MAF 90 percent of the time. Temporary 0.4 MAF shortage expected 10 percent of the time to be managed by extraordinary conservation and water management measures. Improvements in Delta flow patterns and operational flexibility can reduce fishery impacts and improve drinking water quality. Delta flood protection including protection of valuable wildlife habitat. Net decrease in Delta outflow
Water conservation Water reclamation Water transfer Water sharing Conjunctive use Desalination	Increase emphasis on these measures to meet future water needs. By 2010, conservation will reduce annual demands and Delta exports by 1.3 MAF. Waste water reuse will increase annually to further reduce diversions by 200,000 AF. Calaveras–Stanislaus Conjunctive Use Program could provide improved Delta inflow and water quality. Increasing population, loss of Mono Lake and Colorado River supplies, and ground water contamination will further accelerate acceptance of these measures.
West Delta Water Management Program	Improve up to 10,000 acres of wetlands and diverse habitat for wildlife, including rare, threatened, and endangered species. Protection against salinity intrusion resulting from flooding.
Suisun Marsh Agreement	Protect 116,000 acres of estuary wetlands providing habitat for 200 species of birds and 60 species of mammals, amphibians, and reptiles.
Harvey O. Banks Delta Pumping Plant Fish Agreement	Correct significant actions for striped bass, salmon, and steelhead. Specifically defines DWR mitigation commitment for increased pumping limits. Current actions include striped bass growing facility and upstream spawning restoration.
Delta Flood Protection Act	Increase protection of Delta waters from salinity intrusion due to flooding and protects valuable habitat including habitat for rare, threatened, and endangered species.
Delta Wetlands Project	Conduct project planning by private corporation. Provides added water supply and waterfowl habitat.
Storage north of the Delta	Conduct planning for Auburn Dam and Red Bank Project. Storage would reduce winter and spring Delta inflow and increase summer and fall inflow. Additional flood control and dry–year salinity protections would be provided.
Upper Sacramento and San Joaquin River Restoration Program	Improve fishery, wildlife, and riparian habitat to cumulatively add to estuary populations. Actions could include spawning restoration, water temperature improvements, hatchery improvements, and installation of fish screens.
Local upstream increased use	Protect by area of origin law; however, will cause cumulative reduction of inflow and Delta outflow.
Drinking water quality Wetland and waste discharge action	Continue further reduction of Bay pollutants and restrictions of reduced wetlands loss due to development. Continue studies and actions to protect drinking water standards.

The large number of existing water development projects in California resulted in flow changes in streams and the Delta with subsequent effects on water quality and fish and wildlife. The SWP and CVP are the largest water developments that have altered the natural regime. However, numerous other water projects have also altered the natural regime (the largest includes Pacific Gas and Electric Company's Canyon Dam (Lake Almanor) on the North Fork Feather River, Yuba County Water Agency's New Bullards Bar Reservoir on the Yuba River, San Francisco's Hetch Hetchy Reservoir and the Turlock and Modesto Irrigation District's Don Pedro Reservoir on the Tuolumne River, Merced Irrigation District's Exchequer Reservoir on the Merced River, and the Army Corps of Engineers' New Hogan Reservoir on the Calaveras River, Isabella Reservoir on the Kern River, New Melones on the Stanislaus River, and Pine Flat Reservoir on the Kings River (USBR, 1975; DWR, 1984b)). The SWP and CVP have been the only water projects with requirements for protection of beneficial uses in the Bay–Delta.

Proposed SWRCB Decision 1630 would impose requirements on other projects as well.

SWRCB Proceedings. In 1987, the SWRCB began a comprehensive program to protect the waters and associated biological resources of the Bay–Delta system (SWRCB, 1991). This program includes: 1) the California Water Quality Assessment, adopted in April 1990; 2) the Pollutant Policy Document, adopted in June 1990; 3) the Inland Waters Plan and the Enclosed Bays and Estuaries Plan, adopted in April 1991 but amended in November 1992; 4) the Water Quality Control Plan for Salinity for the Bay–Delta; and 5) the Water Rights Phases of the Bay–Delta proceedings. Publications providing detailed information about these assessments and plans are available from the SWRCB.

The intent of the Water Quality Control Plan for Salinity is to establish objectives to protect water quality and beneficial uses of the Bay–Delta waters, including salinity at municipal and industrial intakes; salinity levels to protect Delta agriculture; salinity levels to protect export agriculture; salinity for fish and wildlife resources in the estuary; expansion of the period to protect striped bass spawning; and temperature and dissolved oxygen levels for fisheries in the Delta.

In addition to determining reasonable protection for all uses, the SWRCB is determining responsibility for meeting water quality objectives, including flow requirements. Flow requirements will determine how much water can be exported for consumptive use and how much is needed to protect fish and wildlife. Currently, the SWP and CVP are responsible for meeting salinity objectives in the Bay–Delta. However, about 7,000 parties divert Delta water to use throughout the State. The SWRCB determined that these other diverters should also be required to meet water quality objectives in the Delta. The identification of appropriate requirements and the parties responsible for meeting water quality and quantity objectives continues under the Water Rights Phases.

The Bay–Delta proceedings will result in protecting of water quality and fish and wildlife resources in the Bay–Delta due to cumulative effects from water development projects. DWR participates in numerous other measures to protect water quality and fish and wildlife resources in the Delta.

General Effects of Past and Current Development in the Delta

Many factors affect the complex Bay–Delta estuary environment. Changes have occurred in six general areas: 1) Bay and Delta land changes, reclamation, and flooding; 2) population; 3) pollution and water quality; 4) recreation; 5) fish and wildlife; and 6) Delta and Bay hydrology.

Reclamation. In 1850, there were about 300 square miles of marshlands and more than 250 square miles of tidal and submerged lands in the San Francisco Bay area (DWR, 1990c, 1990d). Due to reclamation, little more than 75 square miles of marshland and only about 150 miles of tidal and submerged lands remained unchanged. Of this, almost half, mostly along the southern sections of San Francisco Bay, was originally reclaimed for salt ponds. Large areas in the north and south bays have been reclaimed for airports. Thus, reclamation has cumulatively reduced valuable riparian and wetland habitat for many Bay–Delta species.

Delta Flooding. In its natural environment about 140 years ago, the Delta consisted of tidal swamp, overflow lands, and grasslands covered with dense growths of tules and other water loving vegetation. The Delta was subject to intermittent intrusion of ocean salts during the dry summer months of lean water years and to uncontrolled flooding during winter and spring.

Over the years, the former swamp lands of the Delta have been transformed into some 50 man–made reclaimed islands and tracts, largely devoted to farming. By 1930, all swamp lands considered feasible for reclamation had been leveed and were being farmed.

The fertile Delta islands are defined by more than 1,000 miles of levees that protect nearly 500,000 acres of productive farmland. Maintaining this fragile levee system has been a continuous problem since the original reclamation began in the 1890s. More than 100 levee failures have occurred since then. Even with modern construction equipment and improved governmental assistance, there have been 24 levee failures since 1980. Reclamation of inundated islands has become so expensive that in some cases they have been left flooded (Franks Tract, lower Sherman, Little Franks Tract, Big Break, and Mildred Islands). As of 1990, State and federal disaster assistance have provided $65 million to repair levee breaks. Some adverse effects of levee failures include degradation of Delta water quality, loss of agricultural production, major disaster fund expenditures, loss of wildlife habitat and effects on fish, urban damage, and disruption of utilities, gas well production, and highway traffic.

Population. Population in the San Francisco Bay–Delta area has risen from 5.8 million in 1980 to 6.3 million in 1985, an 8 percent increase. An increase to 7.9 million in 2010 has been forecasted, which amounts to a growth of 26 percent. This population growth will affect water supply and demand, water quality, air quality, fects on fish, urban damage, and disruption of utilities, gas well production, and highway traffic.

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Pollution and Water Quality. Overall, the Interagency Delta Health Aspects Monitoring Program studies have shown the Delta to be an acceptable source of water, which, when treated, meets existing drinking water standards. In the future, however, water exported from the Delta may be more difficult and expensive to treat if expected new water quality standards are adopted. Also, export water quality could possibly be improved by certain proposed new construction, such as enlargement of Clifton Court Forebay, and by water project operations in the Delta (Table 5–1).

The major source of Delta inflow is the Sacramento River, which includes rice field drainage containing pesticide residues. During the rice growing season, up to one third of the Sacramento River inflow can consist of rice field drain water, and during very wet years, valley drainage can enter the Delta and Cache Slough via the Yolo Bypass system.

The San Joaquin River is the second major tributary providing Delta inflow. The river carries considerable salts from irrigation drainage and other sources in the San Joaquin Valley. The San Joaquin River has been the subject of recent concern regarding effect on Delta water supplies. Data collected by DWR and other sources indicate that San Joaquin River water is not higher in pesticide concentrations than that of other streams tributary to the Delta, such as the Sacramento River. Pesticide levels in water samples from all streams measured were far below established drinking water limits. Data collected by DWR and USGS demonstrate that the San Joaquin River is not now significantly degrading Delta water supplies with, although the possibility of future adverse impacts cannot be dismissed.

Near the Delta, more than 50 municipal and industrial waste dischargers release about 453,000 acre–feet of waste water annually. In addition, drainage from Delta agriculture totals over 1 million acre–feet annually. However, several times as much pollution enters San Francisco Bay via direct surface runoff which is the largest single source of pollution.

Sound water resources management requires comprehensive data collection to enable understanding of factors that can adversely affect water quality. Toward this goal, DWR, in cooperation with other agencies, initiated the Interagency Delta Health Aspects Monitoring Program in 1983. This program is vital to fulfillment of DWR's mission of water resource planning and drinking water protection in California. The program was developed in response to recommendations by a scientific panel appointed by DWR's Director to assess the quality of Delta water supplies as it affects human health. The program focuses on sodium, bromide, selenium, asbestos, trihalomethane precursors, and pesticides, all of which are important because of their potential effects on public health.

The interrelationship of water supply planning and the Delta as a source of drinking water is recognized by DWR and other water agencies. Numerous water resources programs and studies have been initiated to understand this relationship and implement projects that will improve both supply and quality of water (Table 5–1). These programs and studies are discussed in detail in numerous publications (DWR, 1988b, 1989c, 1990c, 1990d, 1990e, and 1991a).

The California Urban Water Agencies (CUWA) recently financed a study (BCCE, 1989) to determine changes in operation of the existing water facilities or construction of new facilities that will allow the Delta to remain as a viable future source of drinking water. The study outlines current water quality in the Delta with current water facilities, and possible water quality improvements if other previously and currently considered water resources facilities are implemented. This study shows that these Delta facilities could improve water quality in the Delta. Higher quality Delta water would reduce the cost and complexity of treating drinking water to meet standards and increase the possibility that treatment plants could reliably remove contaminants from the water.

In anticipation of EPA's probable further restrictions on drinking water quality standards, MWD initiated a 2–year study of three water treatment processes: 1) granular activated carbon (GAC), 2) ozone, and 3) peroxone, which is a combination of ozone and hydrogen peroxide. Preliminary results indicate that peroxone provides the best results in reducing THM levels to below 2 or 3 parts per billion.

DWR is upgrading water quality modeling to include simulation of the dynamics of TDS loading by Delta agriculture drainage returns. This effort will improve evaluation of salinity patterns in the interior Delta, particularly the south Delta.

Recreation. Along with population, water–oriented recreation in the Delta had increased to about 12 million visitor days by 1980 and is expected to reach almost 14 million in 2010. This will increase fishing and boating pressure.

Fish and Wildlife. During the past century, the estuary has undergone some dramatic changes. Land reclamation, dredging, water development projects, introduction of new species, water pollution, and excessive fishing have caused some resources to decline. Many of the commercial fisheries began to diminish before the turn of the century. Since 1970, a portion of the Interagency Ecological Studies Program's work in the San Francisco Bay–Delta has been to distinguish the impacts of State and federal water projects from the impacts of other natural and cultural factors, such as flood and drought, pollutants, and introduced species.

Introduced species fall into two categories, intentional and accidental. Many species were introduced in the late 1800s and early 1900s to provide fish that would be recognized by recent immigrants, and include striped bass, carp, goldfish, catfish, sunfish, largemouth bass, and American shad. In many cases, these fish displaced native species and are now accepted by most Californians. Project operations are often modified to protect them, particularly striped bass and American shad. Current DFG policy is to severely restrict the introduction of further new species into California. Still, accidental introductions of other various organisms are continuing in the estuary, possibly affecting the estuary's ability to provide suitable habitat for game fish.

Recently, large numbers of a small clam, a small fish called the chameleon goby, and two small fish food organisms (copepods) have been found in a portion of the upper estuary that has long been the nursery grounds for young striped bass. These new arrivals apparently came from the Orient by way of ballast water pumped from ships into the San Francisco Bay–Delta. The food chain of striped bass and other fish can be disrupted by competition from the clam and goby. The native copepod species, which has been the preferred food for newly hatched larval bass, may be displaced by the introduced copepod. The appearance of these new organisms may be one of a number of reasons why fewer young striped bass are produced now than during the 1960s and early 1970s.

The plant and animal community in the San Francisco Bay–Delta is constantly changing. Natural resource and regulatory agencies must be made aware of these changes when trying to assess project impacts and define reasonable levels of protection. If these introductions have caused changes in basic system productivity, it may be impossible to determine historic population levels.

In May 1989, the California Fish and Game Commission listed the winter run chinook salmon as endangered, based in part on estimates by the DFG that the population was under 600, down from what had appeared to be a stable 2,000 individuals. Under State law, after the Commission determines the basis for listing a species, it must adopt a regulation to that effect. The National Marine Fisheries Service (NMFS) listed the winter run salmon as threatened under an emergency listing in August 1989. The basic provisions of both sets of regulations prohibit taking listed species and require an agency involved in activities that could jeopardize the listed species to consult with the appropriate fishery agency. *Taking* is defined very broadly. Violations can lead to civil and criminal actions. DWR works closely with DFG and NMFS to determine exactly how the listings will affect various activities and programs.

During phase one of the SWRCB water quality hearings, considerable disagreement arose over the impact of water development on the health of San Francisco Bay–Delta fisheries. Declining striped bass populations received considerable attention.

Salmon populations have been relatively stable. Hatchery production has increased, and thus is compensating for the decline in natural production.

Some reports have concluded that changes in fresh water outflow cause significant biological changes in estuaries of all types. Biological changes result, in most cases, from responses by organisms to physical conditions, such as altered circulation patterns, increased salinities, and reduced nutrient input. The ecological significance of these changes is not completely defined in most systems. In some cases, the same flow change favors some organisms and affects others adversely. Biological responses to flow are difficult to document because the cause–and–effect relationship between flows and organism abundances generally operates through a chain of events rather than direct effects of flow alterations on abundance.

Delta Hydrology. Natural features of the San Francisco Bay–Delta estuary affecting the environment are ocean tides and salinities, inflows of fresh water, and interior Delta flow patterns. Ocean salinity intrusion varies with fresh water inflow rates. Tidal fluctuations occur in regular cycles throughout the year. Natural tributary inflow to the Delta is controlled by the climate and varies greatly from season to season and from year to year. Before major upstream regulation, low dry season inflow often allowed ocean salt water to intrude far into the estuary. In 1924, 1926, 1931, 1934, and 1939, chloride concentrations in nearly all Delta channels exceeded 1,000 mg/L.

Control and development of Central Valley streams to reclaim land and to produce power and water needed for California's farms, homes, and industries have altered the seasonal pattern of river flows and reduced the amount of water reaching the ocean by way of the Delta. Wet season flows are reduced principally by storage in upstream reservoirs and by exporting Delta inflows. Dry season flows are reduced by upstream uses, but releases from project reservoirs maintain Delta outflows at or above minimum protective levels specified by the SWRCB. In the Central Valley, local water uses and exports for use elsewhere have reduced the unimpaired runoff from a 57–year historical annual average of 28 million acre–feet to an annual Delta outflow of 13 million acre–feet per year, which is a reduction of 15 million acre–feet. Unimpaired runoff represents the natural water production of a river basin, unaltered by upstream diversions, storage and exports or imports, but assumes existing channelization. Delta outflow in an average year is 5 million acre–feet required to meet Decision 1485 requirements and to protect water quality at project export pumps, and 8 million acre–feet of unregulated Delta outflow in excess of minimum requirements. The 15 million acre–feet per year reduction in unimpaired runoff includes 1.6 million acre–feet of local Delta use, 5.9 million acre–feet of combined SWP and CVP water exported directly from the Delta for use both inside and outside the Central Valley, and 7.5 million acre–feet of upstream uses, including exports from the Central Valley via the Hetch Hetchy Aqueduct, Mokelumne River Aqueduct, Friant–Kern Canal, and other local projects.

Bay circulation is driven by three main factors: tides, estuarine circulation, and wind induced mixing. Most water motion in San Francisco Bay is the result of tides. Filling and diking along San Francisco Bay over the years have changed the tidal range, which in turn has affected tidal flushing of San Francisco Bay. The average volume of water passing the Golden Gate during a single flood or ebb tide is about 1.1 million acre–feet, which is about 20 percent of San Francisco Bay's total volume.

Estuarine circulation created by fresh water inflow from the Sacramento River system is also being studied as a factor affecting net transport into and out of San Francisco Bay. Estuarine circulation is driven by the difference in density between fresh water and salt water, which is related to Delta outflow. The importance of estuarine circulation, and its association with the effect of winter storms on salinity distribution in the southern reaches of San Francisco Bay, is being investigated in connection with flushing the South Bay and controlling long term buildup of toxic materials. Fresh water inflow to San Francisco Bay also provides large amounts of suspended sediments and nutrients, which contribute to San Francisco Bay's ecological balance.

Other Factors. Many factors contribute to changes in the San Francisco Bay–Delta estuary system. Some will continue to affect the estuary, with or without proposed projects. Others will be cumulatively impacted by incremental changes caused by the projects. Some incremental changes may be beneficial, such as reduced reverse flows in the lower San Joaquin River with implementation of the North Delta Program (NDP).

Past, current, and future factors which have impacted, or will impact, the estuary include land reclamation; sediment load from early hydraulic gold mining activities; waste water effluent and surface runoff from local and upstream urban development; oil spills; drainage and leaching water discharge from Delta and upstream agricultural water use; commercial, sport, and illegal fishing; construction and maintenance of deep water shipping channels; use of natural inflows by agricultural and urban development; changes in amount and variation of outflow; upstream storage and regulation of natural inflows by the CVP, SWP, Hetch Hetchy Aqueduct Project, Mokelumne Aqueduct Project, and local projects; Delta diversions by the CVP, SWP, local municipal and industrial water users, and Delta agricultural water users; levee failures in the Delta; and some positive beneficial effects due to improved environmental factors.

SWP Planning and Related Projects

A number of programs have been planned that affect the Delta and other aspects of the SWP.

Coordinated Operation Agreement. The essence of the Coordinated Operation Agreement (COA) is the sharing formula, which provides a CVP–SWP proportionate split of 75/25 for responsibility in meeting in–basin use from stored water releases, and a 55/45 responsibility for the capture and export of excess flow. Both parties also agreed to meet a specified set of Delta water quality standards from the SWRCB Decision 1485.

These standards provide more environmental protection than the USBR's water quality requirements, known as Tracy Standards, by adding about 100 new protective criteria at 15 additional Delta locations. This agreement also requires a commitment of about 2.3 million acre–feet from both projects during a critical water supply period to meet Delta outflow and quality protective needs.

The COA has the potential to increase Delta inflow and export, and decrease Delta outflow. Fish screening losses can potentially increase. The COA requires Delta protection, and there are possible mitigation alternatives.

H. O. Banks Delta Pumping Plant. The H. O. Banks Delta Pumping Plant was built to accommodate 11 units, but only 7 were initially installed. Four additional units, each with a design capacity of 1,067 cfs, have now been installed. Completion of the Banks Pumping Plant increases SWP delivery reliability and efficiency by increasing standby capacity for the existing units and by permitting a larger share of the pumping to be done with off–peak power. The new units also allow a small amount of additional pumping to be shifted to the winter months. The additional units only slightly change export, outflow, water quality, and fish and wildlife effects.

The last four units of the Banks Pumping Plant increase the total capacity of the pumping plant to 10,300 cfs, bringing the California Aqueduct up to its full design capacity between the Banks Pumping Plant and Bethany Reservoir. To protect the navigable capacity of the Delta waterways near the pumps, DWR limits diversions into Clifton Court Forebay to historical levels.

Installing the additional units also increases the reliability of SWP water supply deliveries. Under USCE constraints, the additional pumps could increase firm deliveries during critical water supply periods by about 60,000 acre–feet annually. This water, pumped during high flow winter months, will partially offset the frequency and severity of projected shortages.

Environmental concerns regarding the additional units at Banks Pumping Plant have been addressed. A fishery agreement was signed between DWR and DFG on December 30, 1987. DWR agreed to mitigate direct fish losses at the Banks Pumping Plant complex. The agreement specifies funding to be made available for projects which will help to increase the survival of chinook salmon, steelhead, and striped bass. The agreement requires two types of payment by DWR: 1) $15 million to initiate a program to quickly replenish fish populations depleted by SWP pumping, and 2) annual payments based on the calculated numbers of fish lost at the complex.

DWR is mitigating fish losses, in cooperation with DFG, through purchases of replacement fish, operation of a striped bass rearing facility, streambed improvements in upstream spawning areas, fish hatchery improvements, installation of screens on diversions, rearing of steelhead at hatcheries, instream flow augmentation, and barrier construction in the Delta to benefit fish.

On execution of the Banks Pumping Plant Fish Agreement, the parties began discussions of developing methods to offset the adverse fishery impacts of the SWP that are not covered by the agreement. Included are facilities needed to offset fishery impacts and more efficient conveyance of water.

DWR and the DFG are continuing to examine and evaluate potential striped bass and chinook salmon projects as they are developed. An advisory committee representing fishery, environmental, and water user interests has been established to assist in evaluating and selecting projects. The agencies are also evaluating the factors used to calculate mitigation losses and will make adjustments as needed.

Delta Flood Protection Act. Senate Bill 34, enacted in 1988, creates the Delta Flood Protection Fund from tidelands revenues currently designated by statute for the California Water Fund. The Bill authorizes $12 million per year for appropriation by the Legislature for a ten year period of flood protection in the Sacramento–San Joaquin Delta. Specifically, $6 million is allocated to the Delta Levee Maintenance Subventions Program, and the remaining $6 million is for special flood control projects for eight western Delta islands and the towns of Walnut Grove and Thornton.

The goal of the Delta Levee Maintenance Subventions Program is to rehabilitate the local Delta levees for flood protection. SB 34 has the potential to protect water quality in the Delta from salinity encroachment due to island flooding. It will also increase water supply reliability with no net loss of fish and wildlife habitat. All proposals for levee maintenance are reviewed by DFG to ensure no net long term loss of fisheries, riparian, or wildlife habitat. In addition to levee maintenance, $5 million was appropriated to mitigate specified adverse impacts in the Delta and San Francisco Bay and some other special areas.

Delta Wetlands Project. A unique wetlands management and water storage project for the Sacramento–San Joaquin Delta has been proposed by Bedford Properties (JSA, 1990). Four Delta islands (Bouldin, Webb, Holland, and Bacon) would be converted from agricultural use to provide waterfowl habitat and store water during winter and spring. The water for storage would be pumped from the islands in early summer to provide fishery benefits and for use by DWR.

The Bedford Properties proposal is being evaluated by DWR and DFG. Both agencies are working with the project sponsor to define issues and identify the types of information needed to make decisions about the project. Some of the issues are environmental documentation under CEQA and NEPA, required permits, Safety of Dams jurisdiction, operation, structural engineering, economic feasibility, liability, potential regulatory changes, control of the water in the reservoir, and water quality.

The project has the potential to increase Delta exports and decrease Delta outflows during the winter. The main benefit of the project is to provide operational flexibility, which can benefit fish, wildlife, and water quality.

Kern Water Bank. The Kern Water Bank (KWB) is a conjunctive use ground water program being developed by DWR, in cooperation with the Kern County Water Agency and local water districts, to augment the dependable water supply of the SWP. The KWB will store and extract water from the Kern County Ground Water Basin, in coordination with the operation of surface water storage and conveyance facilities. In general, water would be banked in the basin during years of above average water supply and withdrawn during drier years, when surface water supplies are below average.

During 1989, the Kern Fan Element of the KWB was restructured for staged development. Initial plans called for storage of 1 million acre–feet, with the first stage planned for maximum storage of 300,000 acre–feet beginning in 1991, and ultimate development following in 3 to 4 years. Local elements, as cooperative programs with surrounding water districts, will also be developed in stages.

The Kern Fan Element has the potential of increasing SWP firm dry period yield as much as 140,000 acre–feet. Initial studies indicate that local elements could more than double the contribution of the KWB to SWP supplies.

The KWB will increase exports and decrease outflow during wetter years, but will have no effect on inflow. The project will provide operational flexibility to reduce incremental fish screening losses and only slightly degrade water quality.

Folsom Dam and Reservoir. Whereas this is not a new project, there has been a resolution of a long standing problem involving a storage contract between East Bay Municipal Utility District (EBMUD) and USBR, versus a group of interested users of lower American River flows. EBMUD will be able to exercise its contract with USBR for 150,000 acre–feet of Folsom Reservoir storage annually and to take this water through the Folsom South Canal. A connection will be built by EBMUD between the end of the Folsom South Canal and the Mokelumne Aqueduct. In turn, EBMUD will be restricted by a diversion schedule that helps keep the lower American River in a healthy condition.

Conjunctive Use Programs. Conjunctive use is a planned use of both surface and ground water in a complementary manner to increase water yield or reliance. Conjunctive use programs will generally reduce pressure on Delta exports, manage resources more efficiently, and increase yield to existing projects.

New Melones Conjunctive Use Plan. Two San Joaquin County agencies (Stockton East Water District and Central San Joaquin Water Conservation District) made a proposal to DWR that could increase the yield of the SWP. The districts propose to use their USBR contract entitlements (106,000 acre–feet surplus and 49,000 acre–feet firm) from New Melones Reservoir in normal and above normal years, but forego diversions during dry and critical years for release down the Stanislaus River into the Sacramento–San Joaquin Delta. The districts would rely on ground water to meet their needs during dry and critical years, and then recharge their basins during normal to wet years. In turn, they would want financing for the necessary facilities to divert and convey the New Melones Project water to their service areas. The proposal has been discussed with USBR, San Joaquin County interests, and State water contractors.

In March of 1989, DWR and USBR signed a Memorandum of Understanding with 15 agencies in Calaveras, Tuolumne, Stanislaus, and San Joaquin counties to prepare a plan for the long term use of water supplies from the Stanislaus and Calaveras rivers. DWR and USBR developed and completed a Scope of Study for the program and proceeded with preparation of a

Draft EIR/EIS for the Stanislaus River Basin and the Calaveras River Water Use Program.

The proposal may provide many benefits, including water supplies for local use, increased fishery flows in the Stanislaus and San Joaquin rivers, improved water quality in the south Delta, and increased yield to the both the SWP and CVP.

Glenn–Colusa Irrigation District. In late 1988, DWR entered into a cooperative agreement with Glenn–Colusa Irrigation District (GCID) to determine the impacts and economic considerations of developing ground water in the area. GCID hopes to develop a conjunctive use program to ensure a reliable water supply for users in the district during water shortages. The district would like to develop a ground water capacity of about 100,000 acre–feet per year.

GCID completed a test well to determine the feasibility of supplementing the surface water supply with ground water. DWR funded 50 percent of this project. The district testing program has been successful, and a production well yielding some 3,000 gpm has been completed. Further direction of the cooperative study is uncertain at this time. However, GCID is discussing conjunctive use projects with other agencies.

Water Conservation. Recent legislation, the Urban Water Management Planning Act (UWMPA) of 1983 and the Agricultural Water Management Planning Act (AWMPA) of 1986, require larger water suppliers, under certain conditions, to prepare water management plans. Water management plans will benefit both project operations and contractors by reducing demand buildup schedules, thereby stretching available supplies and reducing risks of water shortages. The reduced demand buildup schedule would minimize potential Delta export impacts.

Urban Conservation. Some 300 urban water suppliers prepared water management plans under the UWMPA. These plans identify many current and future water conservation programs. They include low water use landscaping and improved irrigation efficiency on large turf areas, water audits and leak detection, industrial water conservation, residential retrofit with low flow and ultra low flow toilets and showerheads, waste water reclamation, capital outlay projects to replace old water mains and similar facilities, public education, and in–school education. DWR provided technical and financial assistance to urban water agencies and local governments in all these areas since 1980.

Agricultural Water Conservation. California's agricultural sector has for decades been developing and implementing ways to reduce on farm water use. This conservation effort has been broad based, involving various public institutions, private industries, and individual farmers. Many different irrigation techniques have been developed to reduce and tailor water use for the varied irrigation conditions encountered throughout the State.

DWR has had a multifaceted agricultural water conservation program since 1980. It focuses on assisting water districts and growers with irrigation scheduling based on crop water needs, education to improve the efficiency of various irrigation systems, support of research related to improved irrigation management and reductions in evapotranspiration rates of crops, and financial assistance to agricultural water districts to begin or expand their irrigation management programs.

The AWMPA required every agricultural water retailer supplying more than 50,000 acre–feet of water, if not covered by water conservation requirements of State and federal agencies, to report water management efforts to DWR. If the supplier finds that water can be conserved, or that the quantity of highly saline or toxic drainage water can be reduced, the supplier must adopt an agricultural water management plan.

Industrial Water Conservation. Under a contract with DWR, the MWD completed a literature search to identify industrial water conservation technologies. The best of the abstracts have been reprinted and made available to local water districts for distribution to industrial customers.

DWR is also cosponsoring a project with the City of San Jose to assess the potential for improving water use efficiency of various industries. Follow–up pilot projects will be undertaken for those industries showing potential.

USBR Water Contracting Programs. In 1979, USBR imposed a moratorium on new long term contracts for uncommitted water from the CVP because of concerns about environmental and water quality effects in the Delta. The COA requires the CVP, in conjunction with the SWP, to operate in conformity with State water quality standards with few exceptions. This action lifted the moratorium, and USBR was able to resume long term contracting of what was then determined to be available and uncommitted water from the CVP. An EIS is required, however, because entering into new long–term contracts is a major federal action that may have significant effects on the environment in such areas as fisheries and wildlife, energy, land use, population, housing, and related social effects.

USBR prepared an EIS for three distinct areas (the Sacramento River Service area, the American River Service area, and the Delta Export Service area) to be served under new water contracts. In late 1988, USBR distributed three draft EISs for public review. These drafts disclose probable impacts of selling additional water from the Sacramento and Trinity river divisions of the CVP. Revision of the documents is underway because of the overwhelmingly negative comments on the draft EISs received by USBR. Completion dates for the revised drafts are uncertain at this time. Recent federal legislature (House Resolution 429) may affect plans for allocation of additional water from the CVP.

Water Supply Reductions in Southern California. Southern California faces increasing dry year water deficiencies. The area gained an estimated 350,000 new residents during 1988–89, and contains five of the nation's 10 fastest growing counties. In addition to the problem of population growth, the area has to adjust to reduced water supplies from both the Colorado River and the eastern Sierra.

Priorities for use of Colorado River water in California are based on the 1931 Seven–Part Agreement as modified in 1964 by the U. S. Supreme Court's decree in Arizona vs. California. With the Central Arizona Project on line, California can no longer depend on receiving more than 4.4 million acre–feet of Colorado River water per year. As the junior appropriator, MWD is limited to 550,000 acre–feet per year of fourth priority water plus half of any surplus flows on the lower Colorado River. After deducting allotments for three Indian reservations, miscellaneous current perfected right holders, delivery system losses, and possible further rights for water to Indian tribes, MWD could be reduced to about 360,000 acre–feet per year, which is a significant reduction from recent use averaging 1.135 million acre–feet per year.

For several years, environmentalists had been attempting to overturn permits and licenses issued to the Los Angeles Department of Water and Power (LADWP) to divert water from Mono Lake. Finally, in August 1989, a Superior Court ruling mandated drastic cuts in the City's diversions and, later, a change in the way that LADWP was preparing to route the increased flow from Mono Lake. LADWP had been diverting up to 100,000 acre–feet per year from the Mono Lake Basin, which is about 17 percent of its annual needs. The recent ruling will reduce the diversion substantially, although a final determination has not been made. LADWP will probably have to rely more on its existing contracts with MWD.

The reduced water supplies from both the Mono Lake Basin and the Colorado River will mean that eventually MWD will have to obtain additional water supplies elsewhere. There are, however, several problems. MWD's largest source, the SWP, has not been completed, and environmental concerns in the Delta may impede additional deliveries. MWD relies on ground water for about one third of its supply, and expansion of this supply is limited while current supplies are threatened by contamination and more stringent health standards. A third source, large scale water projects, is either affected by environmental concerns or negative public sentiment.

Reduction of water supplies in Southern California will potentially increase Delta export and inflow, decrease outflow, reduce water quality protection, and increase fish screen losses.

Environmentalists suggest that current supplies be used more efficiently by water conservation, waste water reclamation, and re–allocation of water supplies from agriculture to urban use. In this regard, MWD has agreed with the Imperial Irrigation District to fund conservation measures in exchange for an estimated 100,000 acre–feet of water that would be saved. MWD is working on a similar project with USBR to line the All–American Canal in exchange for the water saved. MWD has offered to buy Colorado River water from Palo Verde Irrigation District in dry years and is exploring a contract with Arvin–Edison Water Storage District to store water underground during wet years for extraction in dry years.

Two recently signed legislative bills allocated $390.8 million to help resolve a number of the State's water–related issues. Together, the bills form the Environmental Water Act of 1989. Principally designed to protect the sensitive ecology of Mono Lake, the Act provides as much as $60 million to replace water and power supplies lost by LAWPD for preserving Mono Lake. However, the State's current budget problems will substantially reduce funds currently available for these efforts.

Upper Sacramento River Fisheries and Riparian Habitat Management Plan. Severe declines in salmon and steelhead populations and riparian habitat over the past four decades prompted the California Legislature to enact 1986 legislation calling for preparation of a fisheries and riparian habitat management plan for the Sacramento River from Keswick Dam to the mouth of the Feather River. The act, SB 1086, created an advisory council composed of 25 members from federal, State, and local agencies and environmental, fishery, and landowner groups. DWR has played a major role in formulating and contributing to the management plan.

Goals and policies identified by the advisory council include: 1) reestablish a continuous riparian ecosystem along the river between Chico and Redding and reestablish riparian vegetation along the river from Verona to Chico, consistent with the Sacramento River Flood Control Project; 2) give the highest priority to a fishery restoration plan that will protect, restore, and enhance wild strains of salmon and steelhead; 3) give second priority to maximizing habitat restoration for naturally spawning salmon and steelhead; natural production is intended to be limited only by the carrying capacity of the natural ecosystem; 4) artificial production will be limited to actions that will fully compensate for fish populations that existed at the time their historic habitat was permanently lost due to blockage by construction of dams or other human actions; and 5) minimize fish losses due to entrainment, predation, and other hazards associated with diversion of water from the upper Sacramento River and its tributaries; such measures may include installing fish screens, reducing diversions during critical periods, or relocating diversion points to avoid conflicts with fish populations.

A $185 million measure to restore fish populations in the Sacramento River over the next 10 years has been introduced in Congress. Part of the money would be used to build new fish ladders and more effective fish screens at the Red Bluff Diversion Dam and the Anderson–Cottonwood Irrigation District Dam. The funds would also be used to increase the quantity and quality of gravel used for fish spawning and rearing between Keswick and Red Bluff Diversion dams. Some of the funds would be used to update and expand the Coleman National Fish Hatchery near Redding, to construct new hatcheries, and to build a $50 million device at Shasta Dam to help control downstream water temperatures which have devastated the salmon run in recent years. The funds would also be used to reduce the level of toxic zinc and copper leaching from the Iron Mountain Mine complex into the Sacramento River and to improve fish screening at the Glenn–Colusa Irrigation District diversion headworks.

The various potential projects on the upper Sacramento River can decrease Delta outflow, increase Delta exports, reduce water quality protection, and significantly improve Delta fisheries.

San Joaquin River Management Program. Similar to the upper Sacramento River fisheries restoration efforts, DWR has been actively involved in the recently formed San Joaquin River Management Program (SJRMP). The SJRMP was created to address the needs of the San Joaquin River system. Existing conditions on the San Joaquin River are less than satisfactory for many uses of the system. Assembly Bill 3603, Chapter 1068, was signed into law on September 18, 1990 to stem further deterioration in the San Joaquin River system, and develop consensus on solutions to water use problems.

The legislation created the SJRMP to provide a forum where information can be developed and exchanged to provide for the orderly development and management of the water resources of the San Joaquin River system; identify actions which can be taken to benefit legitimate uses of the San Joaquin River system; and develop compatible solutions to water supply, water quality, flood protection, fisheries, wildlife habitat, and recreation needs.

The legislation identified specific tasks to be accomplished in developing the management program. Those tasks are:

- Identify ongoing studies concerning the San Joaquin River, including USBR's San Joaquin River Basin Resource Management Initiative and USCE's studies on the San Joaquin River Basin.
- Identify and describe issues and problems that are affecting the river system.
- Prepare a program scope consistent with the stated purpose of the management program.
- Establish a series of priority actions with specified time frames, estimated costs and benefits, and proposed funding sources.
- Propose local, State, and federal actions to solve some of the problems and conflicts on the river system.

Accomplishments to date include providing a forum for the development of ideas and the exchange of information, identifying ongoing studies concerning the San Joaquin River, identifying and describing issues and problems, and recommending actions.

San Joaquin Valley Agricultural Drainage Program. Current agricultural drainage conditions on the west side of the San Joaquin Valley present three basic problems: 1) salt balance, 2) water balance, and 3) toxic or potentially toxic trace elements in subsurface agricultural drainage, which, when discharged to streams, ponds, or wetlands, can adversely affect fish and wildlife.

The severity of the toxic problem became known about 1983, with the discovery of deaths and deformities of water birds, which were linked to high selenium levels in agricultural drainage water at Kesterson Reservoir. In mid–1984, USBR, USFWS, USGS, and DFG formed the San Joaquin Valley Drainage Program (SJVDP) to investigate drainage problems and identify possible solutions. The four goals of the SJVDP are to: 1) minimize potential health risks associated with subsurface agricultural drainage water; 2) protect existing and future reasonable and beneficial uses of surface and ground water from impacts associated with drainage water; 3) protect, restore, and, to the extent practicable, improve valley fish and wildlife resources; and 4) sustain the productivity of farm land on the west side of the San Joaquin Valley.

In 1987, the SJVDP narrowed its focus on planning alternatives for solving drainage problems to measures that could be taken within the valley itself. In 1989, the SJVDP published a report on preliminary planning alternatives, which would consist of combinations of drainage management strategies falling into seven categories: 1) source control to reduce drainage from individual farms; 2) manage shallow water tables by pumping; 3) treat drainage water; 4) reuse drainage water; 5) dispose of drainage water in the valley; 6) fish and wildlife measures; and 7) institutional changes.

Drainage water reduction and disposal methods include irrigation improvements, reuse of drainage water for propagation of eucalyptus trees and saltbush, and limited drainage water storage in ground water and disposal in evaporation ponds. Discharge to the San Joaquin River is included for selenium free areas or where drainage containing selenium can be safely assimilated by the river. The alternative also involves actions to protect public health and to protect and restore fish and wildlife, including provision of fresh water supplies conserved from irrigation improvements for use on existing wetlands and wildlife areas.

DWR is collecting data and preparing studies on reuse and disposal of agricultural drainage water in the State service area. Analyses emphasize trace elements, such as selenium and arsenic, because of their potential adverse effects on water supplies and the environment. Other water quality parameters, such as nutrients, do not appear to be a problem and are analyzed less frequently. DWR has increased selenium data collection and is working with USGS to investigate shallow ground water in the Tulare Lake Basin. Together with information on applied irrigation rates, cropping patterns, soil types, and precipitation, these data are being evaluated to identify possible trends in selenium leaching.

Suisun Marsh Planning and Implementation. Suisun Marsh in southern Solano County comprises about 116,000 acres. It supports as many as 200 species of wildlife. The brackish water in Suisun Marsh fosters plants and provides habitat for wildfowl.

The marsh's salinity affects the wildlife food chain, and the Sacramento–San Joaquin Delta outflow affects marsh salinity. Decision 1485 required DWR and USBR to develop a plan to meet specified water quality standards within the marsh. Initial facilities were completed in 1983, and a coordinated protection plan for Suisun Marsh water quality was developed. The protection plan includes a program to construct (as required) a major tidal pumping station, three conveyance channels, and one additional distribution system, and a system to monitor compliance with water quality standards and measure the performance of the facilities constructed. The monitoring plan has been implemented.

In March of 1987, DWR, USBR, DFG, and the Suisun Resource Conservation District signed the Suisun Marsh Preservation Agreement. The agreement includes definitions of marsh water quality standards and construction staging, as well as details for implementing the Plan of Protection.

DWR has evaluated the effectiveness of the Suisun Marsh salinity control gates facility in maintaining lower salinity levels in the marsh's interior channels since the gates began operating in October 1988. There was an immediate and dramatic reduction in salinity levels in the eastern and middle reaches of Montezuma Slough, and although less dramatic, lower salinities were observed in the western reach just above Grizzly Bay. This western reach did appear to be vulnerable to encroaching salts over extended periods of low outflows and strong tidal currents. Further evaluation will be necessary before DWR can determine the full impact of the operation on the entire western portion of Suisun Marsh.

DWR is conducting this evaluation in cooperation with the other parties of the Suisun Marsh Preservation Agreement. SWRCB has agreed that DWR and USBR can operate under the agreement's Interior Marsh Deficiency Standard through the test operation of the control gates and development of criteria for the most effective operation.

According to the agreement, DWR is to operate the gates for 3 years and monitor their impact on marsh salinities. The data, along with information gained from running an upgraded Suisun Marsh stage and salinity model, will be used to determine the need and potential effectiveness of additional marsh facilities. If DWR finds that additional facilities are needed to maintain marsh salinity, the next stage is to be in place by October 1, 1993.

General Obligation Grant and Loan Programs. Since 1976, DWR has been involved with two loan and grant programs to help counties upgrade their water systems—the Safe Drinking Water Bond Law and the Water Conservation Bond Law.

The Safe Drinking Water Bond Law provides loans and grants to bring domestic water systems up to drinking water standards. Substituting pipelines for open ditches is one method of improving water quality and has the additional effect of reducing conveyance losses. After Proposition 55 (Safe Drinking Water Bond Law of 1986) passed, 1,976 applications for funds were received and 237 applicants were invited to submit final applications. The bond funds are over–subscribed, however, and new applications are not being accepted.

Proposition 81 (November 1988 ballot) provided an additional $75 million to continue the Safe Drinking Water loan and grant program. The Department of Health Services, after public notice and hearing and with the advice of DWR, established a priority list of projects to consider for financing under this law.

The Water Conservation Bond Law (1984) provides funds to DWR to be loaned to irrigation districts, water agencies, and municipalities at low interest rates to use in cost–effective, capital outlay water conservation programs. The maximum loan has been $5 million for a single project, such as lining a distribution canal and replacing distribution mains. The Safe Drinking Water Bond Law of 1986 added ground water recharge projects and feasibility studies as qualifiers for loans. Funds provided under the 1984 law are committed and DWR adopted a priority list of applicants for funds provided under the 1986 law.

The Sand Trap Siphon Project,dedicated in June 1988, was the first water conservation project completed under the 1984 law. Georgetown Divide Public Utility District received $469,000 for this project. An inverted siphon was constructed to replace a section of unlined ditch. This project is expected to save 1,045 acre–feet of water each year.

The Water Conservation Bond Law of 1988 (Proposition 82) received voter approval in November 1988. The program provides for a bond issue of $60 million for local water project assistance, water conservation programs, and ground water recharge facilities.

Cumulative Effects on Bay-Delta Estuary of Projected Demands

Analysis of projected water demand and supply balance in the service areas (DWR, 1987) can be a measure of future cumulative impacts of new projects when combined with other projects (Table 5–2). Net water use is lower than applied water because it takes into consideration the substantial reuse that commonly occurs. Agricultural water use, which generally reflects population growth, is expected to increase. The increase in projected net water use is substantial in all regions.

Table 5–2. Regional Use of California's Developed Water Supplies, 1985 and 2010 (1,000s of acre–feet)

Regions	Applied Water			Net Water Use		
	1985	2010	Change	1985	2010	Change
San Francisco Bay and Central Coast	2,780	2,980	200	2,450	2,640	190
South Coast	4,040	4,700	660	3,760	4,360	600
Sacramento River	8,700	10,110	1,410	7,480	7,830	350
San Joaquin River and Tulare Lake	18,690	19,270	580	14,550	15,010	460
Colorado River	3,930	3,710	220	4,030	3,690	310
Remaining Regions	2,320	2,460	140	1,950	2,090	140
State Totals	**40,460**	**43,230**	**2,770**	**34,220**	**35,620**	**1,400**

DWR analyzed statewide recent and near future levels of water demands (Table 5–3) in 1987. Except for the CVP, developed but uncommitted supplies are relatively small. Some of the 1.4 million acre–foot deficit can be met from uncontracted CVP project supplies. The remainder can be satisfied from a variety of other sources.

For the SWP, the present dependable supply is about 2.4 million acre–feet. Near future water requirements for the SWP service area, projected in 1987, are about 3.6 million acre–feet, assuming 250,000 acre–feet of water conserved in the Colorado River Basin become available, an increase in waste water reuse of 200,000 acre–feet in the SWP service area, and continuing water conservation measures. Under those assumptions, existing SWP facilities would have a deficit of dependable supplies in the near future. Facilities adding up to about 900,000 acre–feet in new supplies are in the early implementation or planning stages, including South Delta facilities, North Delta facilities, Los Banos Grandes Reservoir, Kern Water Bank, and purchase of interim CVP supplies. With the additional facilities, dependable water supplies will increase about 900,000 acre–feet per year and will meet near future water requirements 90 percent of the time.

A need for dependable SWP supplies amounting to as much as 0.4 million acre–feet in a given year would remain after the major facilities and actions listed above are implemented. This would not be a chronic shortage, but a shortage that could occur in dry years. A temporary shortage of this magnitude may well be manageable with extraordinary conservation efforts (measures taken only during times of drought) and such actions as water marketing, water banking, or extra withdrawals from ground water storage.

Not all the water resources activities (Table 5–1) will be implemented in the near future; some will extend into the future beyond the scope of current statewide water resources planning. Just how all these activities interrelate is difficult to project. However, certain assumptions can be made to combine actions with mitigation and thus produce favorable effects on cumulative impacts of projects. Other assumptions could combine actions without mitigation, thereby producing adverse impacts.

Several events have occurred since DWR projected water supply demands (DWR, 1987) that place an additional burden on agencies attempting to keep pace with the increasing needs for water in California. These events will also accelerate the need to implement Delta water management plans, water banking programs, and conservation activities recommended in by DWR in 1987.

Table 5–3. Projected Water Demands Over the Next 20 Years (in millions of acre–feet)

Source of Supply	1985 Net Use	Projected 2010 Net Use	Change from 1985
Local surface water	9.2	9.2	–
Ground water safe yield	6.0	6.1	0.1
Federal Central Valley Project	7.0	7.8	0.8
Other federal sources	1.3	1.3	–
State Water Project	2.4	3.2	0.8
Colorado River	5.0	4.2	–0.8
Local agency imports (excluding the Colorado River)	1.0	1.1	0.1
Reclaimed waste water	0.3	0.5	0.2
Ground water overdraft	2.0	1.8	–0.2
Other sources	–	04	0.4
Totals	**34.2**	**35.6**	**1.4**

In 1985, the Department of Finance projected 36.3 million people in California by the year 2010. Interim projections in early 1990 increased the 2010 projections to 39.4 million. This number will be further revised by the results of the 1990 census. With the present population at 30 million, this latest projection means California will be adding an average of nearly 500,000 people per year for the next 20 years. Increases during the past 3 years have considerably exceeded that rate. Using the same assumptions as used previously (DWR, 1987), including implementation of extensive urban water conservation measures and transfer of agricultural water supply to urban uses where encroachment onto agricultural lands is projected, a one million increase in population in the SWP service area increases net water use by at least 120,000 acre–feet per year. With the 2010 population in the SWP service area projected to be 2.3 million people more than in 1987, water needs are expected to be 276,000 acre–feet greater than previously projected.

In 1987, no reduction in supply for Los Angeles from the Mono Lake–Owens Valley system was assumed due to uncertainty of the situation at that time. As a result of recent court decisions and agreements, it appears the average annual supply available to the South Coast region will be reduced by about 100,000 acre–feet per year.

No reduction in the 1985 level of ground water usage in the South Coast region due to contamination was assumed in 1987. Since then, several wells have been taken out of production in the San Fernando Valley, and widespread contamination from sewage and cow manure from dairy herds in the Santa Ana River watershed threaten the water supply for 1.5 million people. Even though programs for clean up of the contaminated water are planned or underway, a reduction in the usable annual supply averaging at least 50,000 acre-feet by the year 2010 appears to be a reasonable assumption.

In addition to SWP and CVP water planning actions, many factors have affected, and will continue to affect, the estuary cumulatively. Among these are land reclamation and bay fill; sediment load from early gold mining activity; toxic chemical, pesticide, and waste water pollution from cities, farms, and boats; concentrated salt loadings from irrigation and soil leaching agricultural activities; commercial, sport, and illegal fishing; construction and maintenance of ship channels; use of natural inflows by upstream and Delta agricultural and urban development; Delta diversions by the CVP, SWP, local Delta municipal and industrial water users, and Delta agricultural water users; levee failures in the Delta; wave wash erosion caused by boat traffic; direct diversions and thermal pollution from power plant operations; increased urbanization around the San Francisco Bay-Delta area, leading to loss of valuable wildlife habitat; agricultural practices and crop patterns that decrease the value of the Delta to wildlife; levee maintenance programs in which rip rap replaces riparian habitat; and upstream storage and regulation of natural inflows by the Hetch Hetchy Aqueduct, Mokelumne Aqueduct project, the CVP, the SWP, and others.

Cumulative Effects of SWP Deliveries

DWR has contracts with 30 water agencies throughout the State that require the SWP to deliver a maximum of 4.23 million acre-feet after the year 2020. Projected water deliveries for the SWP at the 2035 level total 4.217 million acre-feet (Table 5-4).

To meet the additional deliveries that will ultimately be requested by the SWP contractors, the H. O. Banks pumping diversions out of the Delta will need to increase. Additional deliveries and exports, along with reduced carriage water requirements will change the overall operation of the SWP system and its upstream release pattern.

Table 5-4. Projected SWP Water Entitlement Requests, Year 2035

Area	Acre-Feet (1,000s)
Feather River	40
North Bay	67
South Bay	188
San Joaquin Valley	1,355
Southern California	2,497
Central Coastal*	70
Total	4,217

The Central Coastal service area's entitlement has been reduced from 82,700 acre-feet to 70,000 acre-feet. However, it may be restored to full entitlement in the future.

Cumulative Effects of CVP Deliveries

The Coordinated Operation Agreement commits the parties to negotiate a separate contract specifying that excess capacity in the pumping and conveyance facilities of the SWP would be used to increase the amount of water the CVP can deliver from the Delta. This is a separate action, requiring a separate contract or agreement, and a separate environmental impact report. With its present Delta export facilities, the CVP lacks the pumping and conveyance capacity to deliver to existing and potential contractors south of the Delta all the potentially exportable CVP water available in the Delta at certain times.

The SWP has capacity in the California Aqueduct for transporting CVP supplies at the current level of SWP system development. If proposed storage projects south of the Delta are implemented, transporting capacity during the winter will be severely restricted. With transportation through SWP facilities, the effect of the CVP's capacity limitation would be lessened.

Transportation of this type could represent increased exports from the Delta. Such transportation is distinguishable from other transports covered under the COA by the fact that the other transports, for outages and to make up for the May-June pumping restrictions, are already established and serve only to maintain (not expand) the water supply services of the SWP and CVP. An increase in transport negotiated under the COA could cause increased project exports from the Delta, which could cause environmental impacts incremental to those associated with the existing level of project operations. However, any future transportation arrangement would have to be carried out within the protective flow and quality provisions of the SWRCB's Delta standards and would require a separate EIR/EIS and contract.

Any incremental impacts of negotiated transport arrangements cannot be quantified or specifically described until the details of these arrangements are known. Early indications from operational studies suggest that the SWP has little remaining pumping capacity and conveyance capacity available for transport with existing facilities and restrictions. The potential for transport of CVP supplies would increase if SWP conveyance facilities were expanded.

Further analysis of the environmental impacts of transporting CVP supplies may be found in the water conveyance and purchase contract EIR/EIS; the environmental statements prepared by USBR concerning proposed water service contracts; any environmental document prepared in connection with new Delta standards that succeed those of Decision 1485; and environmental impact studies for the NDP (DWR, 1990c) and SDP (DWR, 1990d), the results of which indicate that the impact of CVP supplies transport would increase only slightly with implementation of Delta projects because of other restrictions and limitations.

Other Cumulative Effects

Other cumulative effects associated with potential water development upstream from Delta probably would be similar to, and would increase the impacts of, past surface water development. Past projects on the Sacramento, San Joaquin, and Trinity river systems have had a variety of beneficial and adverse effects, including development of water supplies for local and statewide needs; development of hydroelectric power; increased power requirements; improved navigation on the Sacramento River; creation of reservoir recreation areas and fisheries; increased flood control; creation of jobs; displacement of people and wildlife; inundation of lands, archeological sites, and live streams; blockage of anadromous fish runs; and changed flow regimes, sediment regimes, water quality, erosion, and seepage conditions along affected streams.

Cumulative effects of offstream storage south of the Delta would include new recreation opportunities and reservoir fisheries; creation of jobs; displacement of people and wildlife; inundation of lands and archeological sites; improvement in quality of water delivered to service areas; a net increase in power requirements; and ground water programs south of the Delta, which would involve construction of wells and distribution systems, as well as local water quality and hydrologic impacts and increased power requirements.

Mitigation Measures for Cumulative Effects

Identification and mitigation of any adverse effects associated with ground water substitution will require careful consideration of data from existing ground water monitoring programs and extension of Drought Water Bank monitoring beyond the annual time frame in which each bank is expected to operate. At a minimum, ground water monitoring will continue through the subsequent winter and spring recharge period to determine the extent of water-level recovery following bank extractions. This information could be used to provide a baseline from which any possible residual effects of the Drought Water Bank can be assessed. This information can be used to determine possible effects of future Drought Water Banks, and locations where banks should be avoided.

Various actions such as Decision 1485, the Suisun Marsh facilities, and DFG stocking programs have benefitted fish and wildlife in the Delta. Studies by State, federal, and local agencies and private groups have provided much information from which laws protecting fish and wildlife have been enacted. At least 30 State and federal policies, as well as agency regulations, help protect the Delta's environment. Physical facilities, such as fish screens at the CVP and SWP pumping plants, have been relatively effective in salvaging fish from export water. Funds from State, federal, and local sources for protection of fish and wildlife resources are in the many millions of dollars for ecological studies and physical facilities.

Mitigation measures for cumulative impacts due to future State, federal, and local water development generally consist of safeguards by laws, regulations, and water rights standards; contracts; physical measures; and studies and water management programs.

State and federal laws and agreements provide safeguards and include:

- Area of Origin Provision of the Water Code
- County of Origin Provision of the Water Code
- South Delta Agreements
- Delta Water Contracts
- Davis–Dolwig Act
- Delta Protection Act
- Burns–Porter Act

- Porter–Cologne Water Quality Control Act
- Banks Pumping Plant Fish Agreement
- Suisun Marsh Protection Plan
- Delta Flood Protection Act
- Federal and State Endangered Species Acts
- California Environmental Quality Act
- National Environmental Policy Act
- Coordinated Operation Agreement
- Federal Fish Agreements for Tracy
- National Fish and Wildlife Coordination Act
- National Clean Water Act
- Provisions in Congressional Authorization of Federal Water Projects

State and federal regulatory agencies administering the laws include the SWRCB, Regional Water Quality Control Boards, EPA, and the USCE.

Binding contracts are negotiated between project operators and various interests. DWR executed contracts with several Delta water agencies that commit DWR to provide reliable water supplies and qualities under the Delta Protection Act. These contracts provide a further safeguard for Delta protection. DWR continues negotiations with other Delta interests. Contracts to manage fish and wildlife resources in the San Francisco Bay–Delta estuary can be broader in scope and the participating agencies. Such contracts would specify mitigation measures identified by studies and negotiations. The agreement for coordinated operation of the SWP and CVP allocates available supplies and shortages between both projects after meeting in–basin obligations, including Delta water quality objectives.

Several specific potential physical mitigation measures could be incorporated into contracts, including:

- Fish–hatchery construction
- Adjustment of reservoir releases, habitat modification, establishment of reservoir fishery, fish screens and return systems, export curtailments, and fish stocking programs
- Wildlife – purchase of replacement lands, capture and removal of species, control fencing, escape devices; mitigation in Suisun Marsh as specified in the Environmental Impact Report and Plan of Protection
- Socioeconomic – payment of increased public services caused by project work force
- Cultural – avoidance or removal of identified cultural resources where possible, purchase of private property where necessary
- Recreation – construction of recreational facilities
- Soils and vegetation – reestablishment of native vegetation, erosion control techniques, replacement of soil and topography where possible
- Transportation – relocation of roads and railroads
- Utilities – relocation of utilities

State legislation passed in 1986 created an advisory council composed of 25 members from federal, State, and local agencies, and environmental, fishery, and landowner groups. The Council's Upper Sacramento Fisheries and Riparian Management Plan proposed 20 action items for restoration of fisheries and riparian habitat along the upper Sacramento River and its tributaries. Federal legislation is progressing through Congress to provide money to restore fish populations in the upper Sacramento River according to this plan. Fish screens and ladders, gravel restoration, hatchery expansion, and toxic reduction would be eligible programs. Many of the specific needs for mitigation are uncertain. Potential impacts requiring mitigation can be identified during planned studies.

Objectives of the Interagency Ecological Study Program for the Sacramento–San Joaquin Estuary, funded in part by the SWP, are to improve understanding of the requirements of fish and wildlife in the estuary; develop design and operating criteria for the SWP and CVP for protection and enhancement of fish and wildlife; and monitor and evaluate project operations. These studies provide a sound basis for mitigation measures. For example, the predation control studies in Clifton Court Forebay may reduce losses of chinook salmon.

The court decision requiring monitoring of Delta channels with the additional pumps at the H. O. Banks Pumping Plant also provides mitigation. Mitigation for Delta agricultural needs are identified through studies of leaching practices and the salt tolerance of corn. Continuation of programs to improve water management would provide mitigation by reducing the buildup rate of future upstream diversions and Delta exports.

Primary objectives of the North and South Delta Water Management programs (DWR, 1990c, 1990d) are to reduce reverse flows in the lower San Joaquin River and to reduce fishery impacts. Such programs should add cumulatively to the Upper Sacramento River Fisheries and Riparian Habitat Management Plan, and could be considered links in the restoration of salmon and steelhead.

Chapter 6. Socioeconomic Impacts

The proposed Drought Water Bank involves the willing transfer of water supplies from regions with adequate supplies during a drought (or other near emergency) to areas experiencing critical reductions in water supplies. As a result, socioeconomic effects may occur in the regions exporting water supplies as well as in the regions importing the water supplies. For the exporting regions, there may be reduced economic activity depending on the method and extent of water purchases and the economic decisions made by the water sellers. This reduced economic activity may adversely affect community services. In contrast, regions importing these supplies should receive economic benefits because economic losses that would have otherwise occurred as a result of the drought can either be reduced or eliminated.

Types of Socioeconomic Effects

The project will result in direct and indirect economic (income and employment) effects in the regions exporting water supplies and in the regions importing those supplies. For example, in the exporting region, farmers will receive direct payments for relinquishing water supplies either through ground water exchange or by fallowing crops. Since this program is voluntary, it is assumed that the farmer would receive enough compensation to cover the increased ground water costs or lost crop revenues. Thus, at a minimum, the farmer should at least break even. In the importing region, those receiving project supplies will also be directly affected by the project. This may include farmers who would have otherwise suffered reduced crop revenues due to water shortages, or urban water users who would have otherwise experienced increased costs (or lost production) as a result of drought.

In addition to these direct effects, the project will also create indirect economic effects, or *third party effects*. For example, to produce crops, a farmer typically purchases equipment and other supplies (such as seed, fertilizers, pesticides, etc.) as well as the services of managers and laborers. Once the crops have been harvested,the products must either be transported to processing firms or delivered to markets. Farm products may be processed by many firms before a final product is ready for delivery to markets. This indirect economic activity creates income earned by households which in turn is spent for personal consumption, thereby generating additional economic activity (induced effects). If the project results in crop acres being fallowed in the exporting region, then all (or portions) of these other linked activities may also be adversely affected.

However, in the water importing region, the effect will be just the opposite. For example, the availability of water supplies may prevent the losses of these indirect activities that would have otherwise occurred as a result of the drought.

In addition to economic effects on income and employment, the project may also affect community services. For example, the fallowing program may result in decreased employment in a region because of idled farm workers and a potential net decline in general business activity (indirect effects). This could affect local governments two ways. First, there would be less income being generated from sales taxes and other sources to fund local government programs. At the same time, local government expenses may increase to fund additional social services that need to be provided as a result of the decreased employment. The effects of unemployment will be reduced depending on how well displaced workers can locate other employment.

Any socioeconomic effects that might occur from the project will be temporary because the project will be operated only during periods of droughts or other water shortage emergency. However, substantially different effects could be expected if the project were intended to be a long term substitute for water supply development, which it is not.

The direction (positive or negative) and magnitude of socioeconomic effects will vary depending on the project size (how much water is transferred), the source of water that is utilized (surface water transfers, ground water exchange, and fallowing), and the ultimate destination of the water supplies. Thus, quantitative estimates of potential project effects cannot be computed because each of these variables is subject to change depending on the severity of the drought or other emergency. However, the following discussion evaluates in general terms the potential socioeconomic effects that can result from the three different transfer mechanisms in both the exporting and importing regions. This discussion indicates whether the effect is likely to be positive or negative, or no effect is expected.

Exporting Region

Water supplies for the project are anticipated to be mostly obtained in the Sacramento Valley and the northern San Joaquin Valley—both agricultural regions. Of the three potential project water sources, surface water transfer should have the least effect on farmers and the regional economies, followed by ground water exchange and fallowing sources.

Surface Water Transfer. This source of water is from the sale of surplus surface water supplies, primarily from water districts. This program should not have any–short term direct economic effects on farmers if their water allocations are not reduced. If there are no direct economic effects on farmers, then no secondary economic effects would be expected. Similarly, there should be no significant negative effects on community services. However, the program could have some positive effects as capital can be used for purposes such as water system improvements and debt reduction.

Ground Water Exchange. With this source of supply, farmers are paid to relinquish surface water supplies and replace those supplies with an equivalent amount of ground water. Since this program is voluntary, it can be assumed that the revenues received from the sale of surface supplies would at least equal the costs of the replacement ground water, otherwise there would be no incentive for the farmers to participate. Hence, there should be a positive net income benefit to the farmers.

If crop acreages remain the same with this program compared to what would have occurred without the program, then there should be no secondary regional income or employment effects on farm suppliers and the processors and distributors of farm produce. However, if acreages decrease, then there could be decreases in regional income and employment associated with those industries. No significant adverse community effects are anticipated with this program, unless there is a notable decrease in crop acreages.

Potential exists for this program to negatively affect other farmers in the region not participating in the program if additional ground water pumping adversely affects ground water supplies. For example, possible adverse effects might include declining ground water levels and resultant increased pumping costs, decreased quality of ground water with potential negative effects on crop yields, and possible land subsidence. These potential negative effects can be minimized by careful monitoring of ground water conditions during the program.

Fallowing. Of the three sources of water, fallowing is likely to have the most significant effect on farmers and consequently secondary economic effects. The consequences will probably differ in magnitude among the three fallowing options.

The first option would pay farmers to withhold future irrigation to crops already planted. With this option, the farmer would directly receive revenues from selling the water that would have otherwise irrigated crops, a positive effect. In addition, the farmer would have reduced crop production costs. However, the farmer must accept either a reduction or total loss of crop revenue. Since this program is voluntary, it is assumed that the farmer would receive enough payment to at least cover the lost crop revenue. Thus, at a minimum, the farmer should at least break even.

However, this option could have regional economic effects, depending on at what time in the crop's season further irrigation is withheld and the pattern of expenditures the farmer continues to make after irrigation is terminated. The first is important because if irrigation is terminated relatively late in the crop's season,then most growing expenses (except harvesting) have already been incurred and the regional effects will be less. However, if irrigation is terminated relatively early in the season, then more expenses will be foregone, with more implications for regional income. The second item is also important because the farmer is likely to continue making some types of expenditures, such as equipment purchases, field maintenance, or perhaps some improvements (such as to irrigation systems). Thus, some farm suppliers may not be significantly effected. However, if the harvest is reduced or eliminated, then those firms (and labor) involved with processing and distributing would be affected more heavily.

The second option would require that the farmer substitute a lower water using crop for a higher water using crop. This option would be implemented before the planting decision is made, and the farmer would receive revenues from water savings that are sold. However, the farmer would probably incur decreased crop revenues. Again, since this is a voluntary program, it is anticipated that the farmer would at least break even from the transfer.

However, this option could have regional economic effects. Farm suppliers could be negatively or positively affected, depending on the new crop and inputs needed to bring that crop to harvest. For example, the new crop is likely to need seed, fertilizers, pesticides, and farm labor as would the original crop (although the pattern of expenditures is likely to differ). Effects on processors and distributors would also depend on the type of replacement crop and the requirements specific to that crop (as compared to what would have been planted without the project).

The final option of not planting any crop would have the most significant effect on the farmers and the regional economies. For the farmer, there would be revenues obtained from the water sales and less production costs. However, there would be a loss of crop revenues. As with the other two options, it is assumed that the farmer would estimate the net benefits of the program and only participate if those net benefits are positive. Generally only field crops would be included in a fallowing program.

Farm suppliers, processors, and distributors will be affected by this program, although the effects are likely to be complex. For example, the farm suppliers can be anticipated to be negatively affected by the program as farmers reduce (or eliminate) the purchase of inputs needed for crops being fallowed. However, some studies suggest that the farmers may still purchase some inputs and may continue to at least maintain the land. Thus, some suppliers may be more adversely affected than others. The distributors and processors of farm produce are likely to be the most adversely affected as the crop is removed from production. The extent of effects on distributors and processors depends on their ability to substitute crops grown in other areas, including from outside the State. The ability to do this depends on the type of crop fallowed.

Employment effects are also likely to be complex. Although the farmer is likely to hire less management and laborers as a result of fallowing land, some workers may still be needed to maintain the land and perhaps make improvements. Some studies suggest that farmers may tend to forego hiring part–time help, but retain full–time employees. To keep valued employees, farmers may continue to pay them high wages to do menial tasks in the interim.

Of the three fallowing options, the one of not planting crops would have the greatest potential community service effects. This option would have the most potential for creating unemployment among farm workers and related agricultural businesses in the community.

One concern that has been raised is how the fallowing program could affect local property taxes. Most farm land is protected by the Williamson Act, which lowers property taxes for farmers agreeing to maintain agricultural productivity on their land. If a farmer is paid not to grow crops, this could reduce local county property taxes. The Sacramento County Assessor's Office does not believe that a fallowing program would have a significant effect on property taxes within that county. A fallowing program would only apply to field crops, and these crops are assessed an "economic rent" according to what the land could produce. If a farmer chose not to grow crops during a particular year, property taxes would still be assessed as if the crops were grown. An exception to this would be if the Assessor's Office determines that no crops will be grown "in the foreseeable future," then it might reduce the assessment to apply to dry farmed crops. If this were to occur, then county revenues would be reduced. However, this would only occur if the fallowing program extended over a prolonged period of time (for example, over 5 consecutive years). Future drought water banks will only be conducted for 3 consecutive years at a maximum. Another exception might occur if the fallowing program applied to tree crops (in which the assessment is tied to annual production), but tree crops are incompatible with any fallowing program.

The option of withholding future irrigation from crops could also have some adverse community impacts as workers involved with harvesting and processing of farm produce could be affected. The option of substituting lower water use crops for higher water use crops is not anticipated to have significant effects on community services, as crops will still be brought to harvest. However, there may be slight effects depending on the labor requirements for harvesting and processing of the new crop compared to the crop that would have been planted without the program.

Importing Regions

In contrast to the exporting regions, socioeconomic effects will occur in the importing regions as a result of reducing water supply deficits caused by drought or other emergencies. The types of effects will be similar, with both direct and indirect economic effects on income and employment. However, the source of water supplies (surface water transfer, ground water exchange, or fallowing) is irrelevant to the importing regions. The important factors are the amount of water transferred, location of the transfer, and intended use (agricultural or urban) of the transfer.

At this time, it is impossible to determine the amount of water that will be transferred because the project will be utilized on an as needed basis, with project supplies depending on the magnitude of future droughts. Project supplies are anticipated to be used primarily in the southern San Joaquin Valley, San Francisco Bay area, and southern California. Supplies for the San Joaquin Valley would generally be used for agricultural purposes, whereas in the other two regions the supplies would be used for urban purposes. The project includes participant guidelines that dictate how project supplies are to be used. For both urban and agricultural areas, maximum use must be made of existing supplies.

Agricultural Effects. In agricultural areas, project supplies would be used to reduce drought caused damages to plants such as trees, vines, and other permanent and high value crops. At a minimum, such damages would include monetary losses associated with reduced yields. Drought–stressed perennials can also show reduced yields in following years. However, the maximum effect would be the loss of plants. If a loss of tree or vine crops is experienced, then the direct effect of the drought will be spread over a number of years as replacement plants would need as much as 5 years to become economically productive. Thus, the direct effect of the proposed Drought Water Bank project is the reduction of monetary losses to the farmer that would have otherwise occurred as a result of the drought or other emergency.

Positive indirect income and employment effects will also occur as the additional water supplies will enable the farmer to at least keep the plants alive until the next season. Reductions in farm employment may be partially avoided, and some farm input purchases from suppliers are likely to continue. If the plants can be harvested,then adverse effects on processors and distributors will be reduced. Finally, the avoidance of these adverse effects should benefit community services.

Urban Effects. In urban areas, project supplies will be used to avoid significant environmental, economic, or social losses and damage. Without the bank, urban agencies would have to develop more costly alternative water supplies, implement additional conservation measures, or impose more stringent cutbacks on residential, commercial or industrial customers. At a minimum, some of these options would result in increased costs to urban users for maintaining existing levels of service. However, if additional cutbacks are required, then the effects would be more severe, depending on how water shortages are allocated to residential, commercial, and industrial customers. For example, additional cutbacks to commercial and industrial users could result in direct and indirect losses in income and employment levels. Cutbacks to residential users can result in the loss of costly landscaping, which in turn translates into job and income losses in the landscape maintenance industry. These losses would have potential adverse effects on community services.

Finally, if the drought becomes severe enough, communities may impose construction moratoriums until the emergency eases. These moratoriums will have negative effects on jobs and income in the construction and related industries.

Estimated 1991 Drought Water Bank Economic Effects

The above discussion focused on potential socioeconomic effects that could result from future State drought water banks. Because timing and magnitude of these events cannot be forecast, no attempt was made to quantify expected effects to exporting and importing regions. However, Rand Corporation and U. C. Davis prepared an evaluation of the economic effects of the 1991 Water Bank. The economic effects of this bank are probably indicative of the effects that could be expected of future banks.

This bank purchased about 820,000 acre–feet of water at $125 per acre foot. These supplies were exported from Butte, Colusa, Contra Costa, Sacramento, San Joaquin, Shasta, Solano, Stanislaus, Sutter, Tehama, Yolo, and Yuba counties. Kern, Fresno, and Stanislaus counties imported supplies for agricultural uses (about 80,000 acre–feet). Alameda, Contra Costa, Los Angeles, San Francisco, and Santa Clara counties imported about 310,000 acre–feet for urban use. Imported supplies were purchased for $175 per acre–foot. The difference between supplies purchased and actually delivered is due to carryover to 1992 (about 265,000 acre–feet) and the remainder from carriage water requirements and technical corrections..

The Rand Corporation study evaluated income and employment effects (direct, indirect, and induced) in the exporting and importing regions. In the exporting region, it was estimated that the income lost from fallowing crops exceeded the income gained from water sales by about $12.8 million. However, in the importing regions, the project resulted in a net income gain to agriculture of $45.4 million and a savings to urban users of about $58.8 million from the avoidance of purchasing more expensive alternative water supplies, for a total gain of about $104.2 million. Thus, the net gain to the State was about $91.4 million.

Employment effects were similar to the income effects. In the exporting region,employment lost to fallowing exceeded employment created from water sales revenues by about 162 jobs. However, in the importing region, about 1,153 jobs were gained. Thus, there was a net employment benefit to the State of about 991 jobs.

Although there were net declines in income and employment in the exporting region, the study concludes that these losses were relatively minor compared to overall county income and employment levels.

In addition to this study, two other studies are currently in progress that will attempt to quantify the economic effects of the 1991 Water Bank. One study being conducted by Rand Corporation will focus on the effect of water sales on local farm economies. The second study is a joint effort between the California Urban Water Agencies, Rand Corporation and the Department of Water Resources. This study will identify the economic effects of the drought in urban areas, and the economic benefits of water supplied by the 1991 Water Bank in urban areas.

Cumulative Socioeconomic Effects

A critical condition for evaluating the socioeconomic impacts of drought water banks is that they are intended to be used on an as needed basis and are not intended to be used as a substitute for development of long–term water supplies or conservation programs. However, as the current drought indicates, drought periods can extend over several years, and the cumulative effect of implementing drought water banks several years in a row can be more severe than if implemented for 1 or 2 years at a time.

The cumulative effect of successive drought water banks over a number of years is particularly important for regions exporting project supplies. For the surface water transfer program, several years of transfers may adversely affect water users in the exporting region if remaining supplies are seriously depleted. With the groundwater exchange program, ground water levels and quality may also be seriously affected if the program is conducted several years in a row.

Adverse effects can also occur from land fallowing. In general, most crops are subject to year–to–year fluctuations depending on market conditions and the industries that provide supplies and services for those crops adjust to these changes. If a drought water bank is implemented for only 1 or 2 years at a time, any declines in agricultural–related business activities due to land fallowing may not be significantly different than expected fluctuations (depending on the size of water transfer). However, if the Drought Water Bank is implemented for 3 or more years, then the likelihood for more severe effects on these industries will increase.

The California Environmental Quality Act requires that economic impacts be addressed to the extent that they may cause physical changes in the environment. None of the potential impacts of the proposed project fall into this category. Nonetheless, good public policy requires that this issue be addressed. DWR is currently developing a policy to reduce or mitigate economic impacts to local economies resulting from water transfers. These impacts are most likely to come about as the result of fallowing land.

The following strategies are being considered in developing a policy for potential future drought water banks:

- Consider fallowing as a water transfer source of last resort
- Limit fallowing acreage by region and crop to lessen impacts to regions and specific crop support businesses
- Limit future drought water banks to a maximum of 3 years in a row; if it is necessary to extend the bank, additional evaluation will be conducted to determine if adverse socioeconomic effects will occur
- Reimburse local government for identified increased costs associated with unemployment due to water bank fallowing
- Coordinate as much as possible with fallowing elements of the federal farm program administered by the Agricultural Stabilization and Conservation Service
- Provide as much advance notice as possible regarding the possibility of a fallowing program, as well as the rules
- Fund a crop shift demonstration program in the Delta to demonstrate actual water savings resulting from substituting summer irrigated crops (such as corn and tomatoes) with non–irrigated wheat or barley; this program will include features to minimize potential adverse impacts to wildlife, including migratory waterfowl

Chapter 7. Program Alternatives

The objective of the proposed Drought Water Bank program is to augment water supplies that are deficient for critical needs during water-short periods due to drought or other unexpected conditions. Alternatives to the use of a water bank during these periods are discussed in this chapter.

No Program Alternative

The *no program* alternative would have no Drought Water Bank, although it might include some non–water bank transfers. SWP and CVP facilities would pump and convey less water under this alternative. With no Drought Water Bank transfers, there would be less flow in rivers tributary to the Delta. For example, no transfers from Feather River water users would result in reduced flows in the Feather River as well as the Sacramento River below the confluence with the Feather River. Similarly, there would be reduced flows on the Stanislaus River and perhaps other tributaries to the San Joaquin River above its entry to the Delta at Vernalis.

The no program alternative would have higher surface water diversions from rivers and streams upstream of the Delta than the proposed Drought Water Bank.

Operational flexibility of the SWP and CVP would be reduced under the no project alternative. The Water Banks in 1991 and 1992 provided operational flexibility in SWP and CVP operations. In both cases, additional amounts of water were stored behind Shasta Dam during critical portions of the year than would otherwise have occurred, resulting in water temperature benefits to winter run chinook salmon.

The Drought Water Bank is intended to reduce economic, environmental, and social impacts during drought periods to areas receiving the water. In such areas, the no project alternative is likely to have significant adverse environmental effects compared to the proposed program. Critical water supply needs would not be met, resulting in losses of permanent crops, high value crops, expensive landscaping, and industrial production. In addition, increased ground water overdraft would occur in areas with ground water supplies, while extensive land areas would be fallowed where ground water supplies do not exist.

The experience in Marin County in 1977 may provide an example of severe drought–related cutbacks in water deliveries. To prevent loss of jobs in the industrial sector, receiving areas are likely to impose the most severe water curtailments in residential areas. Lawns would go brown from lack of watering. Shrubbery would be stressed but barely kept alive by hand watering with buckets of "gray water" that would normally go down household drains. Severe job losses would be experienced in the "green industry." Showers would be shorter, and toilets would be flushed less often.

Wildlife and Fish Impacts. With reduced pumping in the Sacramento–San Joaquin Delta under the no program alternative, there would be less direct and indirect fish losses at the pumping plants than with other alternatives. However, greater water diversions from rivers and streams would likely result in greater fish losses at unscreened water intakes compared to the Drought Water Bank. Under the no project alternative, loss of operational flexibility, which allow increased storage behind certain reservoirs, could result in significant harm to fish species such as the winter run chinook salmon, which is listed under both the State and federal Endangered Species Acts.

The no program alternative would provide a slight benefit to resident wildlife species seasonally dependent on waste cereal grains (corn, wheat, barley, and rice). Wildlife and fish species that could benefit from the proposed Drought Water Bank by augmenting stream flow and associated maintenance of riparian vegetation and wetland habitat could experience short term localized impacts under the no program alternative. Wildlife and fish species dependent on salinity control from fresh water flow in the Bay–Delta estuary complex could also experience short term impacts under this alternative. Impacts to State or federally listed wildlife or fish species could occur under the no program, alternative, due to reduced habitat or decreased suitability of habitat as a result of reduced water supplies during drought conditions. Shortages of water supplies in wildlife refuges could lead to losses of habitat and losses of waterfowl and other wildlife. In 1991 and 1992, refuges received water bank water deliveries to minimize such losses.

Free Market Alternative

A variation on the No–Program alternative would be a free market approach. Based on the idea that market mechanisms can reallocate resources efficiently, this approach would allow buyers and sellers to negotiate and arrange their own transfers without working through a State drought water bank as an intermediary.

A free market in water transfers has been promoted by people for several reasons. Some people simply want government out of economic affairs. Others see the market as a more efficient mechanism for reallocating resources than is government regulation. Yet others see water transfers as a way of avoiding the environmental costs of new dams and reservoirs.

In terms of economic theory, the market assures that the resource goes to the buyer with the greatest need because that buyer would be willing to pay the highest price. Buyers with competing needs may bid up the price, but the higher price would induce more people to enter the market and sell water.

Past experience gives only an imperfect picture of how a free market approach to water transfers in a short-term, drought situation would work. The 1991 Drought Water Bank involved a constrained market. To avoid price gouging and bidding wars, the Governor required that all entities needing to transfer water from the Sacramento Valley to south of the Delta work through the water bank.

In 1992, transfers were allowed outside the framework of the bank, but few independent cross–Delta transfers occurred. Several purchasers tried to arrange their own transfers but finally went to the Bank to meet their needs. Several sellers negotiated with the Bank and with independent purchasers and decided to contract with the Bank. These sellers preferred the institutional certainty that came with working through the Bank.

A number of independent transfers were carried out where both the buyers and the sellers were located north of the Delta. In these cases, there was no need to delay release of the transferred water until pumping capacity would become available at the Delta Pumping Plant. Several of these transfers used the Department's North Bay Aqueduct Pumping Plant on Barker Slough in the north Delta, but that pumping plant is far less constrained in operation than the Delta Pumping Plant on the south side of the Delta.

Transfers south of the Delta proceeded independently of the Bank in both years. For example, many transfers were carried out among water districts in Kern County, but they were carried out within the framework of the Kern County Water Agency, its member water districts, and its water supply contracts. A few transfers were arranged between agencies that had not previously been contracting with each other.

These few independent transfers served to identify a number of problems that would be encountered with a short-term free market in drought year water transfers. Transfers take time to negotiate, as do analyses that determine the sources of transferred water. Buyers have found sellers willing to sell someone else's water or water for which there was no history of use. This is known as the "paper water" problem.

Determining whether the transfer would involve "real water" requires analysis of the history of past water use by the seller, the need for physical facilities to store or convey the water and their availability, the hydrology of the streams or the aquifer, and the water rights and contracts involved. Buyers must also obtain concurrence for cross–Delta transfers from either the Bureau of Reclamation or the Department of Water Resources to pump the water through CVP or SWP facilities respectively. These two agencies must be convinced that the transfer involves water that would not have flowed to the Delta in the absence of the transfer.

These two agencies are responsible under SWRCB Decision 1485 and under proposed Decision 1630 for maintaining water quality in the Delta. The agencies do this by adjusting their pumping rates and reservoir releases to maintain sufficient Delta outflow to meet required standards. If the water being transferred would flow through the Delta even in the absence of the transfer and the Department pumps that water for another agency, the Department would need to release more water from Lake Oroville to make up for the extra pumping. To protect their own supplies, the Bureau and the Department must have a role similar to an escrow agent to make sure that the entire transaction is legitimate before they will agree to pump the water.

Additional time will be required in developing a transfer if the transfer will be subject to the jurisdiction of the State Water Resources Control Board. If the transfer would involve any change in the place of use, purpose of use, or point of diversion as shown in the water rights permit for the water, SWRCB approval will be required. In deciding whether and how to approve a transfer, the SWRCB will examine the effects on other legal users of the water, fish, wildlife, other instream beneficial uses, and on the public interest generally. The SWRCB has normally imposed detailed conditions on its approvals of water transfers to minimize or avoid adverse effects on other water users or on the environment.

Not all transfers are subject to SWRCB jurisdiction, however. Pre–1914 appropriative rights are exempt from SWRCB control. If a transfer can be accomplished with the terms of an existing water rights permit, no SWRCB approval is needed. These transfers could be subject to the California Environmental Quality Act, but compliance might not be checked by any other agency.

After the contracts are signed and any necessary permit changes are obtained from the SWRCB, the buyer must still arrange for transportation of the water. Only two conveyance systems are available for transfers going south from the Delta. The first system consists of the Tracy Pumping Plant and Delta Mendota Canal of the federal Central Valley Project operated by the Bureau of Reclamation. The second system consists of the Banks Delta Pumping Plant and the California Aqueduct of the State Water Project operated by the Department of Water Resources. Pursuant to Water Code Section 1810, the buyer has a right to have its water transported, at least through the State Water Project facilities, in unused capacity upon payment of fair compensation for the use. In approving the use, however, the facility owner must determine that the water can be conveyed "without injuring any legal user of water and without unreasonably affecting fish, wildlife, or other instream beneficial uses and without unreasonably affecting the overall economy or the environment of the county from which the water is being transferred." WC 1810.

As this discussion indicates, even a "free market" in water transfers will include detailed involvement by a number of governmental agencies which are not a direct party to the transactions. Changes would be required in many statutes, regulations, and water rights decisions in order to create a truly free market for water transfers.

In a drought situation, the water supply is limited. The successful bidders with the greatest amount of money may buy all the water they need. Bidders without great resources may get nothing.

The drought water bank mechanism offers an approach with greater concern for fairness. If the available water supply does not meet all needs, the bank allocates the supply among all the bank purchasers with a sharing of the shortage while the bank seeks to increase the supply. Prices can be held within the reach of most participants. In 1991 and 1992, agricultural users and the Department of Fish and Game were able to participate in water purchases from the bank. With a free market, they might not have been able to purchase any water.

In terms of environmental analysis, a free market for temporary transfers would not lessen or avoid any of the potential adverse environmental effects of the drought water bank as identified in this document. A drought water bank and a free market have potentially the same effects. On the other hand, a free market would make it more difficult to mitigate or avoid the adverse environmental and economic effects of the transfers.

A drought water bank offers a better opportunity to select least environmentally sensitive transfers first, to spread out fallowing to minimize cumulative effects on wildlife and to minimize economic impacts on small communities. A bank can avoid buying from the same area too many years in a row to minimize impacts to ground water or wildlife. It can minimize farm labor impacts. During one year of fallowing, a farm owner may spend money on deferred maintenance and capital improvements such as laser levelling. In a second year of fallowing, these employment opportunities may not continue. A bank can develop a comprehensive monitoring network to detect potential cumulative impacts, such as subsidence, and to develop a better understanding of the storage and recharge potential of the aquifer.

A free market has no mechanism to address these environmental or broad economic impacts. In a theoretical free market, the interests of the buyer and the seller are represented and protected, but the economic, social, or environmental interests of affected third parties are not. The Department believes that in a short–term drought situation, a water bank operation offers a better opportunity than a free market to meet the needs of the buyers, the sellers, the public at large, and the environment.

While a voluntary market is expected to continue to co–exist with a drought water bank during drought conditions, market transactions will need to deal with the environmental, economic and social issues addressed above. This is particularly true with long-term water transfers, where free market transactions are expected to be the dominant or only mechanism.

New Water Storage Facilities

A substantial number of new water facilities are being planned to add to developed water supplies. These include Los Banos Grandes Facilities, Kern Water Bank, facilities in the Sacramento–San Joaquin Delta, Los

Vaqueros Reservoir, and Domenigoni Reservoir. Each proposed facilities is discussed separately below.

The Drought Water Bank would have no effect on the need and likelihood of new water–development facilities. Incentive to develop new water supply facilities would not be reduced even though water through water transfers may be purchased for as little as $50 per acre–foot. Experience so far with a drought water bank indicates that there is probably a limit to the amount of potentially less expensive water available. The reasons for this are two–fold. First, less costly water is a function of the cost of production and experience has shown that it is difficult to generate more than 200,000 to 400,000 acre–feet from additional ground water pumping and reservoir storage releases. Once fallowing is considered, the cost of producing the supply goes up and so does the purchase price. The second reason is that price is sensitive to the magnitude of the actual (as well as perceived) demand. In 1991, the demand was fairly high and the demand perception was even higher. Thus, while water from fallowing was purchased for the price of production plus profit, water from the other sources could only be purchased at the high fallowing price. In 1991, buyers paid $175 per acre–foot for the net price of the water and also had to pay actual transportation costs to get the water from the Delta to their place of use.

Based on past experience, therefore, significant quantities of water in excess of 200,000 to 400,000 acre–feet would most likely be at least as expensive as proposed new water development facilities. In addition, water transfers under a drought water bank would not have the dependable reliability with respect to both supply and price that is provided by water development facilities. The demand for additional supplies appears to be much greater than even the 1991 Drought Water Bank levels. A statewide drought water bank is not likely to compete with proposed new facilities, and there are no indications that facility planning and construction efforts have slowed in the past 2 years.

Los Banos Grandes Facilities. This is a planned 1.7 million acre–foot capacity offstream storage reservoir to be located on the west side of the San Joaquin Valley immediately south of the existing San Luis Reservoir. This specific project resulted from several years of evaluation of alternative offstream storage sites.

The project is integrally linked to the South Delta Water Management Program, which is designed to increase Delta pumping capacity to allow pumping large flows during winter months from the Delta to fill the reservoir. The project is designed to shift some Delta exports away from summer months into the winter, resulting in benefits to water quality and fisheries. The project will contribute some 260,000 acre–feet annually to the dry year supplies of the SWP.

While Los Banos Grandes Facilities were authorized by the California Legislature in 1984, it has not yet received all approvals for construction. At present, a combined EIR/EIS is being prepared on the environmental aspects of the project. Los Banos Grandes Facilities are not expected to be operational until after the year 2005, due to procedural requirements, design and construction, implementation of environmental mitigation features, and initial reservoir fill.

Kern Water Bank. This project is described as all opportunities to store and extract SWP water in the Kern County ground water basin. The project is expected to consist of a number of components or elements.

The Kern Fan Element is a direct recharge and extraction program located on 20,000 acres of land purchased by DWR in 1988. This land is located about 15 miles west of Bakersfield, adjacent to the Kern River and Interstate 5. The land consists of alluvial stream deposits, and has proven to be an ideal location for percolating water into the ground water basin. The Kern Fan Element is being developed in stages, with the First Stage expected to store up to 350,000 acre–feet underground and contribute approximately 50,000 acre–feet per year to firm supplies of the SWP. Subsequent development of the Kern Fan Element is planned to increase total storage to 1 million acre–feet, resulting in an increase in SWP firm annual supplies of about 150,000 acre–feet.

Other elements being planned are *local elements*, which are expected to be cooperative recharge and extraction programs with water districts overlying the ground water basin in Kern County. The potential benefits of such programs are currently being examined, but could more than double the contributions to the SWP water supplies from the Kern Fan Element.

Water supply benefits resulting from developing all Kern Water Bank elements are a function of the capabilities of the SWP to provide water for recharge in normal and wet years. This in turn is a function of the capabilities of the SWP to pump large volumes of water out of the Delta during such periods. The First Stage of the Kern Fan Element will be able to meet its projected water supply benefits with existing SWP facilities. However, most subsequent Kern Water Bank development will require additional pumping capacity at the Delta. Such capacity is expected to be developed as part of the

South Delta Water Management Program, discussed later in this section.

The First Stage of the Kern Fan Element is expected to be fully operational by 1995. The time frame for subsequent development of the Kern Fan Elements and the local elements is not yet certain, although it is expected that significant additions to the Kern Water Bank project would be added by the year 2000.

Delta Facilities. Several facilities are being planned for development in the Sacramento–San Joaquin Delta for a variety of uses. Such uses include greater flood protection, fisheries and water quality improvement, improved operational flexibility, and increased SWP water supplies. Such increased SWP supplies are expected to be made possible by more efficiently transporting water through the Delta to the export pumps, as well as the increased pumping capabilities to support offstream storage projects such as the Kern Water Bank and Los Banos Grandes Facilities. Each Delta program is summarized below.

South Delta Water Management Program. This program is directed at providing improved water quality, improved irrigation for local farmlands, fewer fish losses at SWP export pumps, better water supply reliability for the SWP in conjunction with Los Banos Grandes Facilities and the Kern Water Bank, enhanced Delta recreation, and better flood protection. The program would consist of: 1) enlarging the existing Clifton Court Forebay; 2) enlarging an existing channel (Middle River) to improve South Delta water circulation and flow; 3) using the full pumping capacity of the SWP Banks Delta Pumping Plant for winter storage at Los Banos Grandes Facilities and the Kern Water Bank; and 4) constructing up to four channel barriers to improve water levels and circulation for local irrigation withdrawals.

North Delta Program. This program is directed at providing better local flood protection, reducing reverse flow in several Delta channels, creating a more reliable water supply, improving drinking water quality, and enhancing fishery and wildlife. The North Delta Program will consist of levee rehabilitation, channel widening, and dredging along 35 miles of the Mokelumne River and tributaries in the Delta. Increases in water exports by the SWP of up to 140,000 acre–feet per year would be made possible by increased channel capacity, which would reduce the flows to the export pumps that would otherwise flow around the western edge of the Delta and contribute to reverse flows, adverse fishery impacts, and water quality degradation.

West Delta Water Management Program. This program is directed at providing additional wildlife and waterfowl habitat in the Delta, additional flood control protection, added protection for Delta water quality, recreation opportunities, and additional water supply reliability for all Delta water diversions such as the SWP, Contra Costa Canal, and the CVP. This program is in the planning and land acquisition stages, but will likely result in conversing land on several islands in the western Delta from farmland to managed wildlife habitat and major strengthening and reconstructing levees in the western Delta. Many levees in the western Delta are in jeopardy, as indicated by a prolonged history of periodic failure. Consequences of levee failures include seriously degraded water quality for all uses, as well as contributing to potential levee failures on interior Delta islands. From a water supply standpoint, the West Delta Water Management Program would provide more security to existing supplies, rather than develop additional supplies. It would prevent the reduction in existing supplies from future levee failures.

Los Vaqueros Reservoir. This is a proposed offstream storage reservoir planned by the Contra Costa Water District. Currently, neither specific capacity is known nor when this reservoir would be constructed. It is planned to improve water quality and add emergency storage.

The reservoir would be filled annually from Contra Costa Water District's diversion facilities at the intake to the Contra Costa Canal in the Sacramento–San Joaquin Delta. The district's Water Bank purchases were about 7,000 acre–feet in 1991 and 10,000 acre–feet in 1992. Since reservoir details are as yet uncertain, it is not clear how the reservoir might impact future drought year demands by Contra Costa Water District for Water Bank purchases. If there is any impact at all, it is expected to reduce the district's demands to no more than the maximum historical Water Bank purchases of 10,000 acre–feet, which would have a small–to–negligible impact on future Water Bank demands.

Eastside Reservoir Project. This is an offstream storage reservoir planned for construction by The Metropolitan Water District of Southern California (MWD). The project would involve constructing one of three reservoir alternatives in the eastern portion of MWD's service area (western Riverside County), near the junction of the Colorado River Aqueduct, San Diego Canal, and East Branch of the SWP's California Aqueduct. The three alternative sites are Domenigoni Valley, Potrero Creek, and Domenigoni Valley in conjunction with Vail Lake. Details are set forth in the October 1991 Final Environmental Impact Report for the Eastside Reservoir Project.

The reservoir would receive water from either the Colorado River Aqueduct or the California Aqueduct. MWD set forth five project goals: 1) provide emergency storage; 2) provide carryover (drought) storage; 3) provide seasonal storage; 4) preserve operating reliability; and 5) optimize ground water programs.

The Eastside Reservoir Project is intended to increase the long–term reliability of MWD's water supplies. To that end, and considering the drought carryover storage component of the project, it is expected that demand for water from drought water transfers would be less than if the Eastside Reservoir Project is not implemented. MWD has made it clear in public statements and presentations that even with the Eastside Reservoir Project and a number of demand–reducing strategies (e.g., expanded reclamation and conservation), it will need to rely on water transfers in normal and drier years to meet water demands in its service area. This is evidenced by recent programs implemented with Imperial Irrigation District and Palo Verde Irrigation District. In addition, MWD indicated that it will continue to reply on water transfers under drought–year circumstances.

Ability to Attain Objects of Proposed Program. The Los Banos Grandes Facilities, Kern Water Bank, Delta programs, Los Vaqueros Reservoir, and Domenigoni Reservoir are all in various stages of planning and approval. Major contributions of Delta facilities to SWP water supplies are tied to timing development of Los Banos Grandes Facilities and the Kern Water Bank. Major water supply benefits are not expected in the near future from any of these projects and do not contribute significantly to satisfying the goal of the proposed Drought Water Bank.

Wildlife and Fish Impacts. The potential for constructing new water storage facilities is limited. Wildlife and fish impacts associated with new development are generally site specific. Wildlife and fish benefits may occur for some species. However, inundation often results in significant wildlife, fish, and plant impacts over a large area and for a long time period. Relatively few areas in the State remain where a large surface water storage development will not impact a State or federally listed plant or animal species.

Demand Reduction Activities

Efficient use of existing water supplies can reduce the need for water that might be obtained through a water transfer. Efficiency can be achieved through urban water management, agricultural water management, and water recycling. Water shortage contingency measures are another way water users can reduce impacts.

As a means to mitigate the impact of water transfers made through the Drought Water Bank, these transfers will only be made to areas where the water supply agency has implemented reasonable and cost effective management and water recycling programs as described below.

This is consistent with the Governor's water policy of April 6, 1992, when he stated "entities receiving transferred water should be required to show that they are making efficient use of existing water supplies, including carrying out urban Best Management Plans or Agricultural Water Efficiency Practices."

The requirement that areas receiving transferred water implement appropriate management measures is also consistent with amendments made to the Urban Water Management Planning Act by Assembly Bill 11X, signed by the Governor on October 13, 1991. This legislation requires each urban water supplier to prepare an urban water shortage contingency plan as part of its urban water management plan. The law also specifies that an urban water supplier is ineligible to receive drought assistance from the state until the urban water management plan is submitted to DWR.

Urban Water Management. Water agencies and public advocacy groups in California worked together to establish an industry standard for urban water management. These organizations identified a series of management measures called Best Management Practices (BMP) that are either established and generally accepted practices, or measures that are technically and economically reasonable and environmentally and socially acceptable. Sixteen BMPs are described in a Memorandum of Understanding (MOU) Regarding Urban Water Conservation in California (Table 7–1). This MOU also defines a level of effort for the implementation of each BMP and establishes a timeline calling for implementation of specified BMPs to commence by 1992, 1993, and 1994, with all BMPs to be fully implemented throughout the suppliers' service areas by the year 2001. Finally, the MOU calls for the study of certain potential practices that may be added to the list of BMPs in the future.

The proposed Drought Water Bank will not make water available to any urban area unless the water supplier in that area is implementing BMPs according to the schedule in the MOU.

Table 7–1. Urban Best Management Practices
1. Interior and exterior water audits and incentive programs for single family residential, multi–family residential, and governmental/institutional customers.
2. Plumbing, new and retrofit. a. Enforcing water conserving plumbing fixture standards including requirement for ultra low flush (ULF) toilets in all new construction beginning January 1, 1992. b. Supporting State and federal legislation prohibiting sale of toilets using more than 1.6 gallons per flush. c. Plumbing retrofit.
3. Distribution system water audits, leak detection and repair.
4. Metering with commodity rates for all new connections and retrofit of existing connections.
5. Large landscape water audits and incentives.
6. Landscape water conservation requirements for new and existing commercial, industrial, institutional, governmental, and multi–family developments.
7. Public information.
8. School education.
9. Commercial and industrial water conservation.
10. New commercial and industrial water use review.
11. Conservation pricing.
12. Landscape water conservation for new and existing single family homes.
13. Water waste prohibition.
14. Water conservation coordinator.
15. Financial incentives.
16. Ultra low flush toilet replacement.

Pursuant to the California Water Code, every urban water supplier providing water for municipal use either directly or indirectly to more than 3,000 customers or normally supplying more than 3,000 acre–feet of water annually must prepare an urban water management plan containing specified elements, and update the plan at least once every 5 years. The proposed Drought Water Bank will not make water available to any urban area unless the water supplier in that area has prepared, adopted, and submitted an urban water management plan that addresses all elements contained in the law at the time the plan was adopted.

Agricultural Water Management. An advisory committee composed of representatives of irrigation districts, public advocacy groups, and others is working to establish a similar process to implement agricultural Efficient Water Management Practices (EWMP). Formation of this advisory committee was authorized by the Agricultural Water Suppliers Efficient Water Management Practices Act of 1990 (AB 3616). Committee members prepared a draft list of EWMPs (Table 7–2) and are negotiating a MOU that outlines a process and schedule for EWMP implementation.

The committee is developing consensus on the list of EWMPs, a schedule for their implementation, and a MOU or other document that establishes a process for EWMP implementation. DWR will use these as the standards of efficient agricultural water management.

If the committee is unable to reach consensus, DWR will establish a list of EWMPs and a schedule for their implementation that can be used as an efficiency standard by the proposed Drought Water Bank.

The proposed Drought Water Bank will not make water available to any agricultural area unless the water supplier in that area is implementing EWMPs according to the schedule that is established.

Water Shortage Contingency Planning. Best Management Practices are intended to reduce long term demands in urban areas. Urban water suppliers also need to carry out additional planning, coordination, and actions during occasional water supply shortages such as droughts. Pursuant to the California Water Code, Section 10631e, any water supplier providing water for municipal use either directly or indirectly to more than 3,000 customers or normally supplying more than 3,000 acre–feet of water annually must prepare a water shortage contingency plan (Table 7–3) before it is eligible to receive any drought assistance from the State. Agencies that are too small to meet these size criteria are encouraged to carry out such planning but will not be required to do so.

The proposed Drought Water Bank will not make water available to any urban area unless the urban water supplier in that area has prepared an urban water management plan including a water shortage contingency plan.

Water Recycling. Water recycling, which is the re–use of treated waste water, can significantly reduce the demand for potable water supplies. Recycled water can be used for any application where potability is not required. Some of these uses include agricultural irrigation where the water is not applied to edible portions of the plants, landscape irrigation, toilet flushing in nonresidential buildings, and ground water recharge.

Table 7–2. Efficient Water Management Practices
Irrigation Management
1. Improve water measurement and accounting.
2. Conduct irrigation efficiency studies.
3. Provide farmers with *normal–year* and *real time* irrigation scheduling and crop evapotranspiration information.
4. Monitor surface water qualities and quantities.
5. Monitor soil moisture.
6. Monitor soil salinity.
7. Promote efficient preirrigation techniques.
8. Provide on–farm irrigation system evaluations.
9. Monitor quantity and quality of drainage waters.
10. Monitor ground water elevations and qualities.
11. Evaluate and improve water user pump efficiencies.
12. Designate a water conservation coordinator.
Physical Improvements
13. Improve the condition and type of flow measuring devices.
14. Automate canal structures.
15. Line or pipe ditches and canals.
16. Modify distribution facilities to increase the flexibility of water deliveries.
17. Construct or line regulatory reservoirs.
18. Construct district tailwater reuse systems.
19. Develop recharge basins.
20. Improve on–farm irrigation and drainage systems.
21. Evaluate efficiencies of district pumps.
Institutional Adjustments
22. Improve communication and cooperative work among district, farmers, and other agencies.
23. Change the water fee structure in order to provide incentives for more efficient use of water and drainage reduction.
24. Increase flexibility in water ordering and delivery.
25. Conduct public information programs.
26. Facilitate the financing of capital improvements for district and on–farm irrigation systems.
27. Increase conjunctive use of ground water and surface water.
28. Facilitate, where appropriate, alternative land uses.

Table 7–3. Required Elements of Water Shortage Contingency Plans
1. Coordination of plan preparation with other urban water suppliers and public agencies in the area.
2. Past, current, and projected water use by sector.
3. An estimate of the minimum water supply available at the end of 12, 24, and 36 months assuming worst case water supply shortages.
4. Stages of action to be undertaken in response to water supply shortages as severe as 50 percent, and an outline of conditions applicable to each stage.
5. Mandatory provisions to reduce water use, such as prohibitions against gutter flooding.
6. Consumption limits in the most restrictive stages of the plan, such as percentage reductions or per capita allotments.
7. Penalties or charges for excessive use.
8. An analysis of the impacts of the plan on revenues and expenditures of the water supplier.
9. A draft ordinance or resolution to carry out the plan.
10. A mechanism for determining actual reductions in water use.
11. Public noticing and adoption of the plan.

More treated municipal waste water is now produced in California than is being reclaimed, yet water reclamation is increasing. In 1985, about 250,000 acre–feet was reclaimed. At present, hundreds of thousands of acre–feet of treated water are discharged to the ocean every year. By 2010, under favorable conditions, statewide use of reclaimed water could reach 500,000 acre–feet annually, as urban water managers continue to seek opportunities to use reclaimed water in lieu of water of drinking quality. The greatest incentives for expanded reuse occur where treated waste discharge is limited by regulation, treatment plant capacity is being exceeded, potable water supplies are being fully used, or potable water is expensive.

Because many potential sites for reuse are often located far from the point of supply, the need for separate storage facilities and dual distribution systems increases the costs of many reuse projects. Furthermore, users may be expected to pay the full cost of developing a reuse project.

The MOU Regarding Urban Water Conservation in California recognizes that urban water suppliers should prepare feasibility studies on water reclamation for their respective service areas. In addition, amendments made to the Water Code in 1991 (AB 1869) describe information on reclamation that should be included in urban water management plans and agricultural water management plans.

Wildlife and Fish Impacts. Water reclamation and reuse, such as the advanced treatment of domestic waste water, can result in diminished stream flows, lost riparian habitat, and decreased wetland acreage. Each potential impact could be lessened by the managed use of a portion of the reclaimed water for wildlife and fish.

Although very difficult to quantify, water conservation in most agricultural situations has the potential for wildlife and fish impacts. Tail water often supports small wetlands or pockets of riparian vegetation. These small areas receive disproportionately more wildlife use than the surrounding agricultural areas. In areas where agricultural water conservation is currently highly developed, especially where irrigation water is delivered via covered ditches or in pipes, tail water is an important source of wildlife drinking water. Reductions in drainage flows through reuse on fields can diminish instream flows and inflow to sinks and sumps that are important wildlife areas. Lining ditches, covering ditches, and piping water to fields can reduce annual and perennial vegetation along stream banks, with resultant losses in wildlife food, cover, and nesting habitat.

Moderation may be the key to mitigating wildlife impacts associated with agricultural water conservation. Short–term, moderate–scale conservation may not generate significant adverse impacts. Long–term or permanent reductions of water available to wildlife due to conservation may require mitigation. The most obvious mitigation technique is the allocating part of the conserved water to managing wildlife and fish habitat.

Urban water conservation also has the potential to impact wildlife habitat. Although urban wildlife habitats are often overlooked, they can be important refuges for many species. Storage basins for runoff, drainage facilities, recharge basins, and sewage treatment plants all serve a role in maintaining urban wildlife. Water conservation may decrease the availability of wildlife habitat from these sources.

Ability to Attain Objectives of Proposed Project. Water conservation, other than that already mandated by State regulations, has not been considered as a source of water during drought periods by the Drought Water Bank Program. During water–short periods, water users typically voluntarily conserve supplies, leaving little to be gained through additional conservation measures.

Desalination

Prompted by years of drought and the increased expense of developing new sources of imported water, interest in the possibility of finding an economical way to desalt ocean and brackish ground water has increased. Modern desalination methods make it possible to generate large volumes of water of suitable purity. In some parts of the world, desalting is an important source of water. Worldwide desalting capacity is about 3 billion gallons per day in 3,500 plants. In the United States, about 750 desalting plants have a combined capacity of 212 million gallons per day. In California, desalting is used to reclaim brackish ground water, desalt seawater, and treat water for industries that require process water of high purity (DWR 1990c, DWR 1991c). Water reclaimed through desalting offers potential to expand California's water supply. A program of desalting brackish agricultural drainage water would allow further local reuse of that water as a substitute for water imported from the Delta. As it becomes more difficult to obtain fresh water and as water demand increases, the necessity of conserving and recycling water becomes clear.

Cost. The principal limitation of desalting is its high cost, which is directly linked to its high energy requirements (40 to 60 percent of the operating costs). California has a very large potential water supply in certain brackish ground water basins that have not been developed in the past because of the high cost of desalination compared to the cost of alternative sources. Until recently, desalination was far more costly when compared to conventional water sources such as reservoirs. As these conventional water sources become more difficult and expensive to develop and desalination methods more efficient, the cost of desalination becomes more competitive.

The cost of desalination varies depending on the quality of water being treated. Raw water delivered to a desalination plant in California or elsewhere may be divided into broad categories, including seawater, brackish water, and wastewater. Seawater, with few exceptions, has a constant composition throughout the world and contains 35,100 mg/L of total dissolved solids. Seawater desalting can be achieved at costs of $1,200 to $3,000 per acre–foot. Brackish water is generally defined as having no more than 5,000 mg/L of dissolved impurities. Costs for desalting brackish ground water are about $300 to $500 per acre–foot.

Waste water, available from a variety of sources, has a varied concentration of impurities. Costs for desalination run from $400 to $3,000 per acre foot, depending on the quality of the waste water.

Much of the cost of producing product water results from problems associated with the quality of the feed water, pretreatment requirements, scale formation, storing and handling potentially dangerous chemicals, storing brine concentrate, skill of operators, and a reduction in the purity of product water related to age of the plant. Blending product water with untreated water may potentially reduce these costs. For example, if a well with 2,000 mg/L of TDS was blended with product water with a concentration of 10 mg/L of TDS , water with 500 mg/L of TDS may be achieved at a 25 percent reduction in cost (BGI, 1983).

Benefits. Protecting water quality, cleaning up ground water, and resolving problems posed by specific pollutants and contaminants are key objectives of this alternative. Reclaimed agricultural, municipal, and industrial effluent are reliable sources of water that could be utilized. Desalting ground water and waste water are both less costly than desalting sea water. Restoring the quality of water that could not otherwise be used has benefits, including restoration of abandoned aquifers and closed wells, enhancement of recharge operations, and additional flow to protect against seawater intrusion.

Ability to Attain Objectives of Proposed Project. Use of desalting methods to supplement water supplies will likely continue to expand as the costs of more conventional water supplies rise and the expense of desalting decreases. In addition, fresh water obtained from desalting methods can be tailored to meet the water requirements of many beneficial uses. Unfortunately, desalination is still too expensive for widespread use. Desalted water must also be transported from source areas to areas with critical water needs, adding additional costs for this potential water source. Construction of desalination plants require the same environmental review process as other water development projects and cannot be quickly constructed to alleviate drought effects.

Disposal of waste products from large scale desalination is a major concern. While some desalination techniques use various chemicals that must be handled and disposed to appropriate sites, creation of concentrated brine is common to all techniques. These brines contain high dissolved solids levels as well as concentrated levels of toxic materials such as heavy metals. Application to land, as is currently the case, can contaminate ground water as concentrated brines infiltrate the soils. Holding ponds for these brines also create an attractive nuisance that attracts waterfowl and other wildlife. Toxic compounds in these brine–holding ponds can cause direct mortality and reproductive deformities.

A few operational plants exist awaiting final permits (others are in the planning stages) that could potentially be called on line during times of water shortage, but their capacity, ability to transport product water to areas of need, and site–specific impact become an issue. The City of Santa Barbara has a plant capable of producing 7,500 acre–feet per year. The plant operated 60 days beginning in February 1992 and then went on indefinite standby when an adequate water supply was secured. The price of water produced was $1,925 per acre–foot. The facility can be expanded to a capacity of 10,000 acre–feet per year. Major water supply benefits are not expected in the near term from desalination projects and do not contribute significantly to satisfying the needs of the proposed Drought Water Bank.

Wildlife and Fish Impacts. During 1991, a seawater desalination plant was constructed at Santa Barbara. The project was developed in consultation with DFG to avoid significant environmental impacts. No wildlife impacts associated with operating the facility were identified. Sea water desalination, in general, is not likely to cause wildlife impacts with the possible exception of direct habitat loss due to plant site location. This potential impact can be avoided or mitigated through sensitive site selection. However, entrainment of aquatic organisms, including small fish or eggs, could occur at the pumps leading to a desalination plant. Careful design and maintenance of screens are necessary to minimize such losses.

Desalting agricultural drainage water could result in wildlife impacts. In the San Joaquin Valley, drainage water too saline for agricultural use contributes to the maintenance of wetland habitat and is used by migratory birds. Reductions in the volume of this brackish water available to wildlife habitats or increases in salinity or contaminants could result in wildlife impacts. Brine generated by desalting agricultural waste water could contain high levels of toxic materials and could be a threat to wildlife without proper disposal. Each individual project must be carefully evaluated, mitigated if necessary, and monitored.

Island Flooding (Delta Wetlands Project)

Island flooding in the Delta has been proposed to store seasonal diversions of unappropriated surface water. These islands then function as water supply reservoirs for later water sales, and as waterfowl habitats. Increasing the availability of quality water and the extent and value of wetland wildlife habitats are both potential beneficial qualities of this alternative. In addition, island flooding could provide operational flexibility for meeting export demands and Delta outflow requirements by capturing high quality winter flows and shifting them to the summer when Delta water quality is lower.

This alternative entails diverting and storing water on lowland islands within the Delta. Large siphons would be used to divert water onto the islands, which would later be pumped out in the spring and sold to the SWP. The timing and volume of diversions would depend on the availability of unregulated surplus Delta outflow as defined by D–1485. Surplus Delta outflows are assumed to begin in January as rainfall that produces significant runoff into the Delta, rather than controlled releases from upstream reservoirs. Surplus water could be diverted from January through May, and later discharged from May through July. The discharged water would mix with Delta inflows from the Sacramento River and other tributary rivers. This water could be pumped by the SWP or CVP, reducing pumping of Delta flows and creating reverse flows in channels, or could be used as export water.

From August through December, island land would be exposed and could be revegetated with wetland plants useful to wintering waterfowl as forage or cover. Islands with riparian water rights could then be flooded to a shallow depth from October through December to attract wintering waterfowl. This potential benefit responds to the extreme reduction in wetlands and riparian habitats in California and adds support to restoration and enhancement of this resource.

While this project attempts to respond to two general needs for action (to increase the availability of high quality water in the Delta and to increase the extent and value of wetland habitat), there are several technical issues that must be resolved to make it workable. These include water rights, seepage onto adjacent islands, fish screens, channel flow patterns, water quality, levee stability, and fish and wildlife losses.

Delta Wetlands Project. The proposed Delta Wetlands Project serves as an example to illustrate the effects of island flooding (JSA, 1990).

The Delta Wetlands Project proposes to use the Delta islands as storage reservoirs to store winter flows of water and develop seasonal wetland waterfowl habitat on Delta islands in the Sacramento–San Joaquin Delta. The project involves seasonally diverting and storing water on four Delta islands: Bacon Island, Bouldin Island, Holland Tract, and Webb Tract (Figure 7–1). Combined, the four islands encompass approximately 21,000 acres.

Diversions during January through May onto the four islands would be achieved through the use of large siphons with an aggregate maximum siphoning rate of approximately 13,000 cfs. This maximum diversion rate would only be accomplished when head differential between Delta channels and island interior water levels are the greatest. Fish screens, designed and operated to prevent entrainment and impingement of most life stages of fish in the Delta, would be constructed around the intakes of all siphons. Fish screen design characteristics would be negotiated with the DFG to ensure effective operation in Delta conditions.

The timing and volume of diversions would depend on the availability of unregulated Delta outflow as defined by D–1485. A procedure to coordinate project diversions with the SWP and CVP operations on a daily basis would have to be established to ensure that diversions captured were only unregulated Delta flow. Surplus Delta outflows are assumed to begin sometime in January. The maximum rate of proposed diversions would total 13,125 cfs on all four islands together. Approximately 312,000 acre–feet of diverted water would be allocated among the four islands. The project proponents predict that all four islands could be filled to planned storage levels from late January through March. Up to four weeks of diversion would be necessary to fill the project islands in most years.

Beginning in May, about 270,000 acre–feet of diverted water would be pumped at an average rate of 1,515 cfs and discharged uniformly over a 90–day period ending in July. Evaporation from the surface of the storage ponds accounts for the 42,000 acre–foot difference between diverted and discharged amounts.

From October through December, the islands would be flooded to shallow depths under riparian water rights to attract wintering waterfowl and to support operations of private hunting clubs. On primary hunting areas, water levels would be maintained at depths to make forage plants accessible to feeding waterfowl and to allow hunter access by small boat.

An accounting procedure would be developed to separate riparian and appropriative water without actual physical exchange being required. Energy would then be saved that would otherwise be required to pump riparian water from the project islands before seasonal storage diversions began. Discharge of riparian water prior to filling with appropriated storage water would also release a load of organic materials into Delta channels that would not be advantageous to water quality.

Use of the four islands for water storage would require substantial effort to maintain the reliability of the levees. Exterior levees of project islands would be buttressed to bear the additional stresses and erosion potential of water storage and rapid drawdown. Riverside slopes of the project levees would be maintained to the existing standards. Interior slopes of levees would be constructed to withstand damage from wind generated waves. Material for levee construction would be obtained from the interiors of the islands.

Significant Environmental Effects. Flooding Delta islands for later release as a water supply poses several significant environmental impacts.

Water Quality. Delta water uses include agriculture, municipal and industrial supply, fish and wildlife, and recreation. Each of these water uses has associated water quality requirements and concerns.

Island flooding may increase salinity in the south Delta and at export locations if reverse flows are caused or enhanced during diversion of water onto islands. Salinity intrusions occur in the Delta during periods of low Delta outflows, especially when export pumping is high.

Other concerns involve disinfection byproducts (DBP), a class of chemical variables important in judging the quality of drinking water sources. This alternative project may increase organic content and chloride and bromide concentrations that are the primary variables that influence the potential for DBPs and trihalomethane (THM) formation. THM levels above the standard of 100 ug/L pose a carcinogenic risk to humans. The increase in organics during water storage may lead to increased formation of THMs in drinking water supplies. A considerable amount of vegetative decay and possible peat soil leaching during flooded conditions increase the potential for THM formation.

Algal concentrations in export water may also increase as a result of nutrients being converted into algal biomass in the storage ponds. Chemicals associated with algal processes may cause taste and odor in water supplies, as well as contribute to THM formation.

Historic land practices, including domestic garbage dumps, pesticide storage areas, farm machinery repair areas, septic systems, pesticide and herbicide use, or other agricultural residues, may contaminate stored water. In addition, agricultural drainage from other agricultural islands that surround the project islands may influence water quality.

Water quality in the Bay may suffer as a result of cumulative effects associated with any increased diversions of water that periodically flushed the estuary. Captured high flows would reduce dilution of toxic chemicals and increase exposure time to those toxins.

Flood Control. The Delta levee system initially served to control island flooding during high water events. Today the levees are necessary to prevent inundation of island interiors during normal runoff and tidal cycles because island interiors have been lowered nearly 20 feet below sea level by extensive soil subsidence and peat deflation. Water storage operations would have a significant adverse impact on levee protection. Perimeter levees on islands would be susceptible to wind and wave erosion generated by the long wind fetch across the storage ponds.

Water seepage from waterways or adjacent islands is another major concern of Delta land users. All the islands included in the Delta Wetlands Project proposal and adjacent islands experience seepage problems of varying degrees under existing conditions. Due to continual subsidence effects associated with levee height and hydrostatic forces, seepage is expected to increase over time on these islands as a result of the project.

Fisheries Resources. The Delta–Bay region supports a wide variety of fish species. Because of their importance to sport and commercial fisheries, and their uniqueness to the Delta–Bay environment, factors that may affect their abundance, distribution, and production are extremely important.

Chinook Salmon. The Delta and Bay serve as immigration paths and holding areas for chinook salmon returning to their natal rivers to spawn. Four races of chinook salmon migrate up the Sacramento River. Run timing for each race is characterized by a modified response to river temperature and flow. Reduced chinook salmon populations are primarily attributed to upstream factors, including blockage of access to historic spawning areas, increased water temperatures below major reservoirs, increased predation and entrainment at water diversion facilities, and pollutant concentrations. Commercial ocean fishing practices also affect salmon populations.

Additional Sacramento River water would flow into the central Delta during the several week period in January through April when islands are proposed to be filled with water for storage. This increased flow could attract more adult salmon into the central Delta and delay their migration upstream. During island filling, the proportion of Sacramento River discharge that would be drawn into the central Delta may exceed 51 percent. The number of chinook salmon that could be affected by the proposed program diversions would be restricted to the proportion of each run migrating through the Delta during project filling. Winter run adults are the most likely run present during the project filling period. Delay of migrating adults in the Delta has not been shown to adversely affect spawning success, although the effect may be masked by other factors.

Additional flow into the central Delta during island filling could also transport more juveniles to this area as well. Juvenile chinook salmon drawn into the central Delta are believed to suffer from increased predation losses. About 25 to 50 percent of the smolts are present in the Delta during May and 25 percent are present in June. In July few juvenile chinook are present. The most affected races would be winter– and fall–run fish.

Project filling could also worsen reverse flow conditions in the central Delta, delay fish migration, and increase mortality of juvenile fish due to increased predation. Peak abundances of Sacramento squawfish and striped bass in the Delta coincide with filling of islands for the proposed Delta Wetlands Project. Any delay in migration may increase the vulnerability of juvenile salmon to predators. Chinook smolt emigration out of the Delta occurs from March through May, which overlaps both island filling and discharge.

The temperature of water discharged from project islands is expected to be higher than that of the receiving water by as much as 9°F. Proposed program discharges could adversely affect chinook salmon populations by increasing the overall water temperature, mostly in the central Delta, by approximately 2°F. Fall run chinook salmon would be the most likely affected populations. High water temperatures increase smolt mortality.

Striped Bass. Adult striped bass can be found in the Delta and Bay environment throughout the year. Over the past 20 years, their population in the Delta has declined. Direct and indirect entrainment by diversions, decreased food supply, toxics, and reduced egg production are all factors in their decline. About 50 percent of the stock spawn in the Sacramento River during May and June, and about 45 percent spawn in the San Joaquin River during April and May.

Striped bass are most vulnerable to entrainment mortality from April to mid–July, during their egg, larval, and juvenile stages. Depending on the Delta inflow during the 3 to 4 week diversion period of the proposed Delta Wetlands Project, filling the islands could worsen reverse flow conditions, and move striped bass eggs and larvae inland. Movement of eggs and larvae inland increases their entrainment by Delta diversions. In addition, spawning areas are limited by a salinity gradient, which is affected by reverse flow conditions. Striped bass would be adversely affected when spawning occurred during March and April.

Delta Smelt. The Delta smelt is a native to the estuary whose population has also declined. The population is more sensitive to short term environmental changes than other species because smelt do not live much beyond 1 year. Unsuccessful spawning for 2 successive years could eliminate the species. Delta smelt have a protracted spawning period, and larvae and juveniles may occur in the Delta from February through June. Timing of peak spawning is unknown, but salvage surveys indicate peak abundance in May and June. Larvae and juveniles are vulnerable to entrainment in March and April.

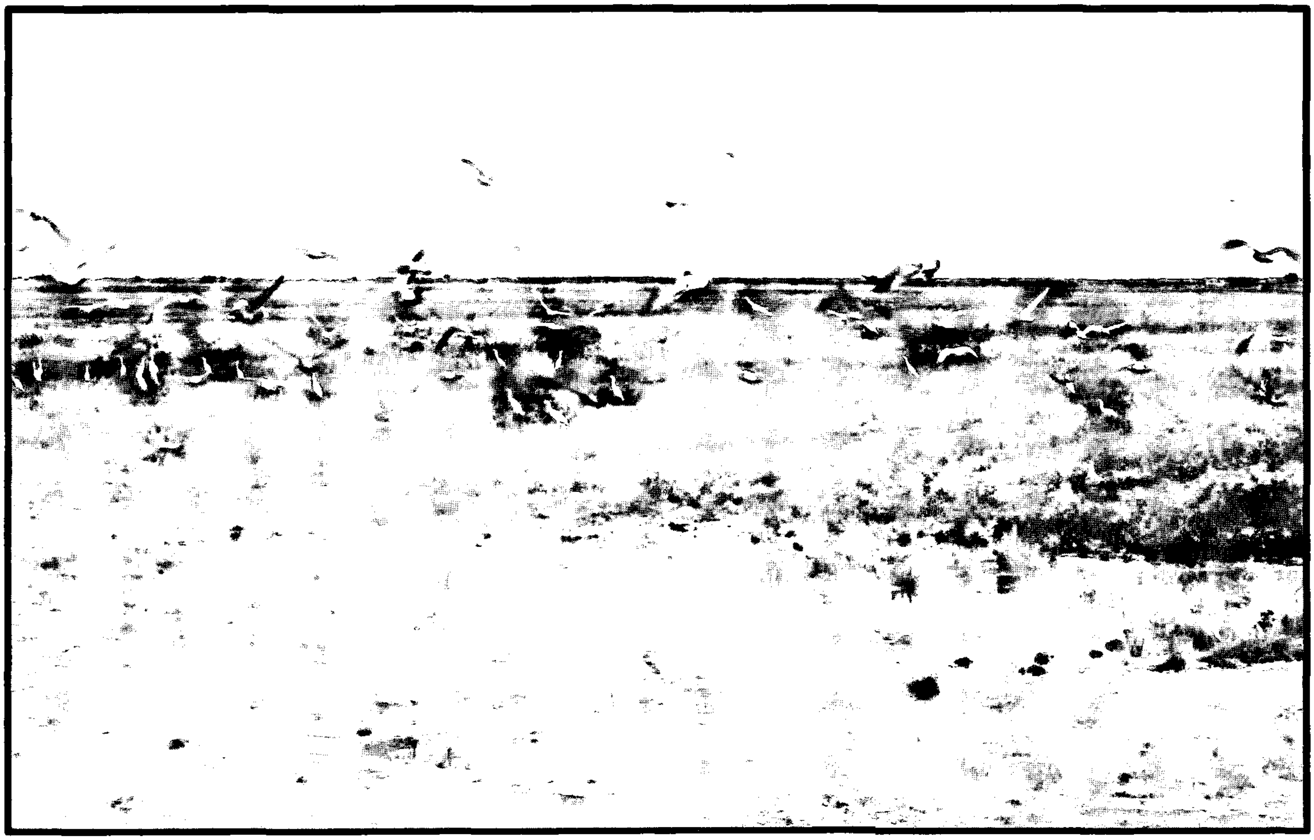
Diversion of unscreenable larvae and juveniles onto the islands would likely occur if diversions onto project islands extend into March. Considering the special status of the Delta smelt population and the importance of single year class survival, any effect associated with the project is significant.

Other Delta Species. Most Delta species, including American shad, Sacramento splittail, catfish, and sunfish, would not be significantly affected by the hydrodynamic changes resulting from project island filling. Those species that do not have eggs and larvae susceptible to transport by currents would not be significantly affected. In general, reduced Delta outflow may reduce recruitment of marine species that rely on estuarine circulation, increase entrainment caused by diversions, increase exposure to toxics caused by increased residence time, and reduce habitat.

Rice Wetlands Project

In early 1992, the Nature Conservancy, with the cooperation of the rice industry, U.S. Fish and Wildlife Service, DFG, DWR, and Ducks Unlimited, engaged a consultant to investigate the feasibility of flooding rice land after the crop is harvested in the fall to develop wetlands for migrating waterfowl. The plan is to use about 5,000 acres of an existing farm operation to ascertain the costs and benefits of such a project.

Some expected benefits would be restoration and expansion of California's once abundant wetlands. California's Pacific flyway is noted for its vital link in the life cycle of waterfowl. Estimates indicate there existed nearly 6,000,000 acres of wetlands that have dwindled to approximately 600,000 acres.



Wetland areas are important waterfowl wintering areas in the Pacific Flyway. The Sacramento Valley's wintering waterfowl population often exceeds three million birds.

Another anticipated benefit would be decomposition, rather than burning, to dispose of rice stubble. Indications are that burning rice straw will be prohibited by the year 2000. It is believed that the stubble could be rolled flat after harvest and would decompose when covered with water. Also, decomposed stubble is a source of food for waterfowl.

One facet of the project that remains unknown is whether water would be produced or would the project require water from existing supplies. Much depends on how long into the spring the water can be left to stand before being drained to a surface stream. Typical current farming operations would prefer to have the field drained by mid–March. Greater benefits, in terms of developing increased firm yield, would accrue if the water were held until mid–April or May, when demands for water from the river become greatest. Earlier in the year, excess water flow is usually available.

Most rice farming in the Sacramento Valley uses surface water as a supply. However, on a number of farms, wells were used prior to development of surface supplies. These wells can be used to meet a portion of the water needs for the Rice Wetlands Project. During the fall, when stream flows are low and are being maintained by releasing water from reservoir storage, ground water could be used for flooding fields rather than surface water, thereby allowing storage to be maintained in reservoirs. Once rains begin and excess stream flows occur, wells could be shut off and diversions could begin from streams. In this way, some of the excess river flow could be stored on the rice field for later release in the spring, possibly when diversion demands are high. However, rice must generally be planted by the first of May for fall harvest. Rice land must dry for a couple of weeks after water is removed to be tillable, which will require an additional period of time. Therefore, water would have to be released from fields by about the first of April in order to grow rice.

Water supply benefits of the project increase the longer water is held in the spring. Excess river flows generally occur in March, so draining the fields at that time would not be a gain in supply, but would only add to the already abundant Delta outflow. Changes in farming operations may allow the ponded water to be held until April or May. The ponded water could be collected in March and stored on a portion of the farm. The dewatered part could be tilled and planted in rice. The water storage portion could be drained back to the tilled field preparatory to planting rice. This would result in a direct saving of water by not diverting from the river. The ponded area last drained could be planted in a later crop, such as dry beans, late corn, or green tomatoes, or be used as set–aside land under the Agricultural Stabilization and Conservation Service if that program were in effect for rice. If the land was fallowed and there was no set–aside, the farmer could receive a payment from the proposed Drought Water Bank for fallowing land.

To better understand the feasibility of the Rice Wetlands Project, the USBR is requesting authorization and funding to conduct a large test program with willing farmers in the Sacramento Valley. Results will not be known for a year or so, but preliminary findings could lead to a few small water bank contracts depending on costs.

Presently, the viability of flooding rice fields for development of additional water supplies cannot be determined. Drought conditions may preclude surplus stream flows for flooding rice fields.

Wildlife and Fish Impacts. The principal environmental impact involves the diversion and loss of young fish, especially winter run chinook salmon. If fish loss can be prevented through screening, there is a potential for benefits to wetland dependent wildlife on temporarily flooded lands.

Waste grain, weed seeds, and invertebrates are the principal food sources that would be made available. However, temporary flooding or storage projects would have to limit water depth at peak storage to no more than two feet to ensure that grains and seeds would be accessible to birds. Returning the stored water to the rivers or the Delta could occur on an as needed basis without significant consequence to wildlife habitat.

Water quality concerns include the release of water high in organic content, which favors the formation of trihalomethanes in the Delta. Water applied to fields also may absorb toxic chemicals applied to control weed and vertebrate pests. Such toxic–laden water could have significant adverse impacts to aquatic life, including fish, in streams where the water was discharged. Large expanses of shallow water will warm readily during warm spring days. Temperatures of released water may be significantly higher than receiving water, which may impact aquatic life.

Weather Modification

Research has established that rain and snow from clouds with the right moisture and temperature characteristics can be increased by weather modification. Many investigators believe that average annual precipitation might be increased by about 10 percent. Weather modification has been conducted along the western slopes of the Sierra Nevada and some of the Coast Ranges for several years. However, precipitation will increase only when storm clouds are present, which means that the technique is more successful in years of near normal rainfall. Weather modification is most effective when combined with vegetation management to prevent shrubs and trees from using the additional precipitation.

In 1985, DWR awarded a contract to North American Weather Consultants to conduct a feasibility study of cloud seeding in the Feather River watershed. The results led to funding the design of an operational plan and preparation of environmental documentation for the Lake Oroville Runoff Enhancement Program.

The program emphasizes augmenting streamflow by increasing snowpack. It has been developed as a 5–year prototype project in a remote area of the Middle Fork Feather River near Johnsville. The final operational plan has been designed and implemented by a weather scientist. The prototype project is expected to furnish information to guide possible future design of a larger cloud seeding program in the Feather River watershed. The operational plan specifies the storms to be seeded, seeding agents to be used and rates of application, locations for ground based generators, suspension criteria, and proposed method of evaluation.

The program began in October 1988 with issuance of a negative declaration for the prototype runoff enhancement program. In November of 1988, two propane dispensers were installed to permit evaluation of the capabilities of the equipment control system and to provide information on the effectiveness of using propane to enhance precipitation. A five year prototype program began operation in November of 1991 which uses ten ground based propane dispensers. During a normal hydrologic year, this experimental program may be expected to increase precipitation by about 20,000 acre-feet, of which a portion would be lost to percolation. If the program proves to be feasible, the eventual average yield might approach 100,000 acre-feet for a 50 dispenser operation program.

Upstream weather modification can increase Delta inflow and increase drier year export and outflow. It can improve water quality protection in drier years and increase river flows while increasing screening losses of fish. However, the program is still experimental and, as such, is not a reasonable alternative to the proposed project. Even if fully operational, yields from weather modification would be greatly reduced during drought conditions that the proposed project would operate.

Regulatory Standards Relaxation

Regulatory standards that require withdrawal from storage generally represent a consumptive use of water. Suspension or relaxation of these requirements during periods of drought emergencies can produce water for other uses. The SWRCB and Federal Energy Regulatory Commission are the principal State and federal agencies with the authority to rule on emergency modification of standards.

Wildlife and Fish Impacts. The most likely wildlife and fish impact associated with a reduction in water allocated to maintain Bay-Delta standards is an increase in salinity in the Suisun Marsh or other Bay wetland habitats. Short term salinity increases during the fall or winter are not likely to be significant. Increases of a duration longer than 1 or 2 months, which affects soil salinities, could result in habitat loss and reduced productivity of marsh plants. The endangered salt marsh harvest mouse could then be impacted. Any proposal to relax existing standards or streamflow agreements would be subject to considerable evaluation and a public hearing process.

Chapter 8. Organizations and Persons Contacted

The Draft Environmental Impact Report was prepared in accordance with the California Environmental Quality Act (CEQA). Consultation and coordination with other agencies included reviewing comments submitted in response to the Notice of Preparation and obtaining input from agency personnel. Scoping Meetings were held in Chico on August 13, Sacramento on August 17, and Los Angeles on August 20, 1992, to obtain public input.

Organizations and agencies providing input to the Draft Environmental Impact Report include the U. S. Bureau of Reclamation, State Lands Commission, Department of Fish and Game, Regional Water Quality Control Board, Alameda County Water District, Butte County Office of County Counsel, Contra Costa County Community Development Department, County of Placer Office of County Executive, San Diego County Water Authority, Stanislaus County Chief Administrative Officer, Contra Costa Water District, Dudley Ridge Water District, The Metropolitan Water District of Southern California, Los Angeles Department of Water and Power, California Action Network, California Sportfishing Protection Alliance, The Bay Institute of San Francisco, and the Environmental Defense Fund.

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Appendixes

A–1	Wildlife in the Sacramento River Basin (from USFWS, 1989)
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B	Environmental Checklist

Appendix A-1. Wildlife in the Sacramento River Basin (from USFWS 1989)

Amphibians
- Tiger salamander
- Northwestern salamander
- Pacific giant salamander
- Rough-skinned newt
- California newt
- Red-bellied newt
- Ensatina
- California slender salamander
- Black salamander
- Western toad
- Pacific treefrog
- Foothill yellow-legged frog
- Bullfrog

Reptiles
- Western pond turtle
- Western fence lizard
- Coast horned lizard
- Western skink
- Gilbert's skink
- Western whiptail
- Southern alligator lizard
- Ringneck snake
- Sharp-tailed snake
- Racer
- Coachwhip
- Striped racer
- Gopher snake
- Common kingsnake
- California mountain kingsnake
- Common garter snake
- Western terrestrial garter snake
- Western aquatic garter snake
- Night snake
- Western rattlesnake

Birds
- Great blue heron
- Great egret
- Snowy egret
- Cattle egret
- Green-backed heron
- Black-crowned night heron
- Wood duck
- Mallard
- American wigeon

Birds (continued)
- Hooded merganser
- Common merganser
- Turkey vulture
- Osprey
- Black-shouldered kite
- Bald eagle
- Northern harrier
- Sharp-shinned hawk
- Cooper's hawk
- Northern goshawk
- Red-shouldered hawk
- Swainson's hawk
- Red-tailed hawk
- Ferruginous hawk
- Rough-legged hawk
- Golden eagle
- American kestrel
- Merlin
- Peregrine falcon
- Prairie falcon
- Ring-necked pheasant
- Turkey
- California quail
- Mountain quail
- Virginia rail
- Band-tailed pigeon
- Mourning dove
- Yellow-billed cuckoo
- Common barn-owl
- Flammulated owl
- Western screech-owl
- Great horned owl
- Northern pygmy-owl
- Long-eared owl
- Short-eared owl
- Northern saw-whet owl
- Common nighthawk
- Common poorwill
- Black swift
- White-throated swift
- Black-chinned hummingbird
- Anna's hummingbird
- Calliope hummingbird
- Belted kingfisher
- Lewis' woodpecker
- Acorn woodpecker

Birds (continued)

Yellow-breasted sapsucker
Red-breasted sapsucker
Nuttall's woodpecker
Downy woodpecker
Hairy woodpecker
Northern flicker
Western wood-pewee
Willow flycatcher
Hammond's flycatcher
Dusky flycatcher
Western flycatcher
Black phoebe
Ash-throated flycatcher
Western kingbird
Purple martin
Tree swallow
Violet-green swallow
Northern rough-winged swallow
Bank swallow
Cliff swallow
Barn swalllow
Steller's jay
Scrub jay
Black-billed magpie
Yellow-billed magpie
American crow
Common raven
Mountain chickadee
Chestnut-backed chickadee
Plain titmouse
Bushtit
Red-breasted nuthatch
White-breasted nuthatch
Brown creeper
Canyon wren
Bewick's wren
House wren
Winter wren
Marsh wren
American dipper
Golden-crowned kinglet
Ruby-crowned kinglet
Blue-gray gnatcatcher
Western bluebird
Swainson's thrush
Hermit thrush
American robin
Varied thrush
Wrentit

Birds (continued)

Northern mockingbird
California thrasher
Cedar waxwing
Phainopepla
Northern shrike
Loggerhead shrike
European starling
Solitary vireo
Hutton's vireo
Warbling vireo
Orange-crowned warbler
Nashville warbler
Yellow warbler
Yellow-rumped warbler
Black-throated gray warbler
Townsend's warbler
Hermit warbler
MacGillivray's warbler
Common yellowthroat
Wilson's warbler
Yellow-breasted chat
Western tanager
Black-headed grosbeak
Blue grosbeak
Lazuli bunting
Rufous-sided towhee
Brown towhee
Chipping sparrow
Lark sparrow
Savannah sparrow
Fox sparrow
Song sparrow
Lincoln's sparrow
Golden-crowned sparrow
White-crowned sparrow
Dark-eyed junco
Red-winged blackbird
Brewer's blackbird
Brown-headed cowbird
Northern oriole
Purple finch
House finch
Pine siskin
Lesser goldfinch
Lawrence's goldfinch
American goldfinch
Evening grosbeak

Mammals

Virginia opossum
Vagrant shrew
Ornate shrew
Broad-footed mole
Little brown myotis
Yuma myotis
Long-eared myotis
Fringed myotis
Long-legged myotis
California myotis
Small-footed myotis
Silver-haired bat
Western pipistrelle
Big brown bat
Red bat
Hoary bat
Spotted bat
Townsend's big-eared bat
Pallid bat
Brazilian free-tailed bat
Western mastiff bat
Brush rabbit
Desert cottontail
Black-tailed jack rabbit
Allen's chipmunk
Sonoma chipmunk
California ground squirrel
Golden-mantled ground squirrel
Gray squirrel
Western gray squirrel
Northern flying squirrel
Botta's pocket gopher
Northern pocket gopher

Mammals (continued)

Great basin pocket mouse
Beaver
Western harvest mouse
Deer mouse
Brush mouse
Pinyon mouse
Dusky-footed woodrat
Bushy-tailed woodrat
California vole
Creeping vole
Muskrat
Black rat
Norway rat
House mouse
Western jumping mouse
Porcupine
Coyote
Gray fox
Black bear
Ringtail
Raccoon
Long-tailed weasel
Badger
Western spotted skunk
Striped skunk
River otter
Mountain lion
Bobcat
Wild pig
Elk
Mule deer
Feral goat

Appendix A-2. Plants from the Butte Basin from WCC 1986

Plants	
Fremont cottonwood	*Populus Fremontii*
Box elder	*Acer Negundo*
Oregon ash	*Fraxinus latifolia*
Valley oak	*Quercus lobata*
Black walnut	*Juglans Hindsii*
Willow sp.	*Salix sp.*
Sycamore	*Platanus racemosa*
Blue elderberry	*Sambucus caerulea*
Poison oak	*Rhus diversiloba*
California wild rose	*Rosa californica*
California wild grape	*Vitis californica*
California blackberry	*Rubus vitifolius*
Buttonwillow	*Cephalanthus occidentalis*
Fig	*Ficus Carica*
Dutchman's pipe	*Aristolochia californica*
Bed straw	*Galium Aparine*
Mugwort	*Artemisia Douglasiana*
Wild cucumber	*Marah fabaceus*
Horseweed	*Conyza canadensis*
Cockelbur	*Xanthium strumarium*
Small-flowered nightshade	*Solanum nodiflorum*
Baltic rush	*Juncus balticus*
Gum plant	*Grindelia camporum*
Bird's foot trefoil	*Lotus corniculatus*
Common spikeweed	*Hemizonia pungena*
Bulrush	*Scirpus sp.*
Nettle	*Urtica holosericea*
Shepherd's purse	*Capsella sp.*
Old man of spring	*Senecio vulgaris*
Bermuda grass	*Cynodon Dactylon*
Foxtail	*Hordeum jubatum*
Italian ryegrass	*Lolium multiflorum*
Curly dock	*Rumex crisvus*
Blue wildrye	*Elymus glaucus*
Ripgut grass	*Bromus diandrus*
Horsetail	*Equisetum sp.*
Common chickweed	*Stellaria media*
Dog fennel	*Anthemis Cotula*
White sweet clover	*Melilotus albus*
Yellow sweet clover	*Melilotus indicus*
Rabbit's-foot grass	*Polypogon monspeliensis*
Star thistle	*Centaurea solstitialis*
Vetch	*Vicia sp.*
Johnson grass	*Sorghum halepense*
Wild oat	*Avena fatua*
Soft chess	*Bromus mollis*
Poison hemlock	*Conium maculatum*

A-3. Wildlife and Fish from the Yolo Basin
(from USCE 1991)

Birds

Common loon	*Gavia immer*
Arctic loon	*Gavia arctica*
Red-throated loon	*Gavia stellata*
Red-necked grebe	*Podiceps grisegena*
Horned grebe	*Podiceps auritus*
Eared grebe	*Podiceps nigricollis*
Western grebe	*Aechomophorus occidentalis*
Pied-billed grebe	*Popilymbus podiceps*
White pelican	*Pelecanus erythrorhynchos*
Double-crested cormorant	*Phalacrocorax auritus*
Great blue heron	*Ardea herodius*
Great egret	*Casmerodius albus*
Snowy egret	*Egretta thula*
Black-crowned night heron	*Nvcticorax nycticorax*
Least bittern	*Ixobrychus exilis*
American bittern	*Botaurus lentiginosus*
White-fronted goose	*Anser albifrons*
Snow goose	*Chen caerulescens*
Ross goose	*Chen rossi*
Mallard	*Anas platyrhynchos*
Gadwall	*Anas strepera*
Pintail	*Anas acuta*
Green-winged teal	*Anas crecca*
Blue-winged teal	*Anas discors*
Cinnamon teal	*Anas cyanoptera*
American widgeon	*Anas americana*
Northern shoveler	*Anas clypeata*
Wood duck	*Aix sponsa*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Canvasback	*Aythya valisineria*
Greater scaup	*Aythya marila*
Lesser scaup	*Aythya affinis*
Common goldeneye	*Bucephala clangula*
Barrow's goldeneye	*Bucephala islandica*
Bufflehead	*Bucephala albeola*
Ruddy duck	*Oxyura jamaicensis*
Hooded merganser	*Lophodytes cucullatus*
Common merganser	*Mergus merganser*
Turkey vulture	*Cathartes aura*
White-tailed kite	*Elanus leucurus*
Goshawk	*Accipiter gentilis*
Sharp-shinned hawk	*Accipiter striatus*
Cooper's hawk	*Accipiter cooperii*
Red-tailed hawk	*Buteo jamaicensis*
Red-shouldered hawk	*Buteo lineatus*
Swainson's hawk	*Buteo swainsoni*

<u>Birds (continued)</u>

Rough-legged hawk	*Buteo lagoous*
Ferruginous hawk	*Buteo regalis*
Golden eagle	*Aquila chrvsaetos*
Bald eagle	*Haliaeetus leucocephalus*
Northern harrier	*Circus cyaneus*
Osprey	*Pandion haliaetus*
Prarie falcon	*Falco mexicanus*
Peregrine falcon	*Falco peregrinus*
Merlin	*Falco columbarius*
American kestrel	*Falco sparuerius*
California quail	*Lophortyx californicus*
Ringnecked pheasant	*Phasianus colichicus*
Sandhill crane	*Grus canadensis*
Virginia rail	*Rallus limicola*
Sora	*Poranza carolina*
Common gallinule	*Callinula chloropus*
American coot	*Fulica americana*
Semipalmated plover	*Charadrius alexandrius*
Killdeer	*Charadrius vociferus*
Mountain plover	*Charadrius montanus*
American golden plover	*Pluvialis dominica*
Black-bellied plover	*Pluvialis squatorola*
Common snipe	*Capella gallinago*
Long-billed curlew	*Numenius americanus*
Whimbrel	*Numenius phaeopus*
Spotted sandpiper	*Actitis macularis*
Solitary sandpiper	*Tringa solitaria*
Willet	*Catoptrophorus semipalmatus*
Greater yellowlegs	*Trinea melanoleuca*
Lesser yellowlegs	*Trinea flavipes*
Baird's sandpiper	*Calidris bairdii*
Least sandpiper	*Calidris minutilla*
Dunlin	*Calidris alpina*
Long-billed dowitcher	*Limnodromous scolopaceus*
Western sandpiper	*Calidris mauri*
Marbled godwit	*Limosa fedoa*
American avocet	*Recurvirostra americana*
Black-necked stilt	*Himantopus mexicanus*
Herring gull	*Larus argentatus*
California gull	*Larus californicus*
Mew gull	*Larus canus*
Bonaparte's gull	*Larus philadelphia*
Forster's tern	*Sterna forsteri*
Caspian tern	*Hydroproene caspia*
Black tern	*Childonias niger*
Band-tailed pigeon	*Columba fasciata*
Rock dove	*Columba livia*
Mourning dove	*Zenaidura macroura*
Barn owl	*Tyto alba*

Birds (continued)

Screech owl	*Otus asio*
Great horned owl	*Bubo virginianus*
Burrowing owl	*Speotyto cunicularia*
Long-eared owl	*Asio otus*
Short-eared owl	*Asio flammeus*
Saw-whet owl	*Aegolius acadicus*
Poorwill	*Phalaenoptilus nuttallii*
Lesser nighthawk	*Chordeiles acutipennis*
Vaux's swift	*Chaetura vauxi*
White-throated swift	*Aeronautes saxatalis*
Black-chinned hummingbird	*Archilochus alexandri*
Anna's hummingbird	*Calypte anna*
Rufous hummingbird	*Selasphorus rufus*
Allen's hummingbird	*Selasphorus sasin*
Calliope hummingbird	*Stellula calliope*
Belted kingfisher	*Megaceryle alcyon*
Common flicker	*Colaptes auratus*
Acorn woodpecker	*Melanerpes formicivorus*
Lewis woodpecker	*Asyndemus lewis*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Hairy woodpecker	*Dendrocopos villosus*
Downy woodpecker	*Dendrocopus pubescens*
Nuttall's woodpecker	*Dendrocopus nuttalli*
Western kingbird	*Tyrannus verticalis*
Ash-throated flycatcher	*Myiarchus cinerascens*
Black phoebe	*Sayornis nigricans*
Say's phoebe	*Sayornis sava*
Willow flycatcher	*Empidonax traillii*
Western flycatcher	*Empidonax difficilis*
Western wood pewee	*Contopus sordidulus*
Olive-sided flycatcher	*Nuttallornis borealis*
Vermilion flycatcher	*Pyrocephalus rubinus*
Horned lark	*Eremophila alpestris*
Violet-green swallow	*Tachycineta thalassina*
Tree swallow	*Iridoprocne bicolor*
Bank swallow	*Riparia riparia*
Rough-winged swallow	*Stelgidopteryx ruficollis*
Barn swallow	*Hirundo rustica*
Cliff swallow	*Petrochelidon pyrrhonota*
Purple martin	*Progne subis*
Steller's jay	*Cyanocitta stelleri*
Scrub jay	*Aphelocoma coerulescens*
Yellow-billed magpie	*Pica nuttalli*
Common raven	*Corvus corax*
Common crow	*Corvus brachyrhynchos*
Black-capped chickadee	*Parus atricapillus*
Mountain chickadee	*Parus gambeli*
Plain titmouse	*Parus inornatus*
Bushtit	*Psaltriparus minimus*

Birds (continued)

Water pipit	*Anthus spinoletta*
Cedar waxwing	*Bombycilla cedrorum*
Phainopepla	*Phainopeple nitens*
Loggerhead shrike	*Lanius ludovicianus*
Starling	*Sturnus vulgaris*
Hutton's vireo	*Vireo huttoni*
Solitary vireo	*Vireo solitarius*
Orange-crowned warbler	*Vermivora celata*
Nashville warbler	*Vermivora ruficapilla*
Yellow warbler	*Dendroica petechia*
Yellow-rumped warbler	*Dendroica coronata*
Black-throated gray warbler	*Dendroica nigriscens*
Townsend's warbler	*Dendroica townsendi*
Black-throated blue warbler	*Dendroica caerulescens*
Black-throated green warbler	*Dendroica virens*
Hermit warbler	*Dendroica occidentalis*
MacGillivray's warbler	*Oporonis tolmiei*
Common yellowthroat	*Geothlypis trichas*
Yellow-breasted chat	*Icteria virens*
Wilson's warbler	*Wilsonia pusilla*
House sparrow	*Passer domesticus*
Western meadowlark	*Sturnella neglecta*
Yellow-headed blackbird	*X. xanthocephalus*
Red-winged blackbird	*Agelaius phoeniceus*
Tri-colored blackbird	*Agelaius tricolor*
Hooded oriole	*Icterus cucullatus*
Brewer's blackbird	*Euphagus cvanocephalus*
Brown-headed cowbird	*Molothrus ater*
Western tanager	*Piranga lucoviciana*
Black-headed grosbeak	*Pheucticus melanocephalus*
Blue grosbeak	*Guiraca caerulea*
Lazuli bunting	*Passerina amoena*
Purple finch	*Carpodacus purpureus*
House finch	*Carpodacus mexicanus*
Pine siskin	*Spinus pinus*
American goldfinch	*Spinus tristis*
Lesser goldfinch	*Spinus psaltria*
Lawrence's goldfinch	*Spinus lawrencei*
Rufous-sided towhee	*Pipilo erythrophthalmus*
Brown towhee	*Pipilo fuscus*
Savannah sparrow	*Passerculus sandwichensis*
Vesper sparrow	*Pooecetes gramineus*
Lark sparrow	*Chondestes grammacus*
Rufous-crowned sparrow	*Aimophila ruficeps*
Sage sparrow	*Amphispiza belli*
Dark-eyed junco	*Junco hyemalis*
Chipping sparrow	*Spizella passerina*
White-crowned sparrow	*Zonotrichia leucophrys*
Golden-crowned sparrow	*Zonotrichia atricapilla*

Birds (continued)	
White-throated sparrow	*Zonotrichia albicollis*
Fox sparrow	*Passerella iliaca*
Lincoln's sparrow	*Melospiza lincolnii*
Song sparrow	*Melospiza melodia*
Anadromous Fish	
Pacific lamprey	*Lampetra tridentata*
River lamprey	*Lampetra ayresi*
White sturgeon	*Acipenser transmontanus*
Green sturgeon	*Acipenser medirostris*
American shad	*Alosa sapidissima*
Pink salmon	*Oncorhynchus gorbuscha*
Chum salmon	*Oncorhynchus keta*
Silver salmon	*Oncorhynchus kisutch*
King salmon	*Oncorhynchus tschawytscha*
Sockeye salmon	*Oncorhynchus nerka*
Steelhead trout	*Oncorhynchus mykiss*
Striped bass	*Morone saxatilis*
Resident Fish	
Brook lamprey	*Lampetra pacifica*
Threadfin shad	*Dorosoma petenense*
Kokanee	*Oncorhynchus nerka*
Brook trout	*Salvelinus fontinalis*
Dolly Varden trout	*Salvelinus sp.*
Brown trout	*Salmo trutta*
Redband trout	*Salmo sp.*
Golden trout	*Salmo aquabonita*
Rainbow trout	*Oncorhynchus mykiss*
Arctic grayling	*Thymallus arcticus*
Carp	*Cyprinus carpio*
Goldfish	*Carassius auratus*
Golden shiner	*Notemigonus crysoleucas*
Sacramento blackfish	*Orthodon microlepidotus*
Hardhead	*Mylopharodon conocephalus*
Hitch	*Lavinia exicauda*
Sacramento squawfish	*Ptychocheilus grandis*
Tui chub	*Gila bicolor*
Thicktail chub	*Gila crassicauda*
Sacramento splittail	*Pogonichthys macrolepidotus*
California roach	*Hesperoleucus symmetricus*
Speckled dace	*Rhinichthys osculus*
Lahontan redside	*Richardsonius egregius*
Fathead minnow	*Pimephales promelas*
Mountain sucker	*Catostomus platyrhynchus*
Sacramento sucker	*Catostomus occidentalis*
Channel catfish	*Ictalurus punctatus*
White catfish	*Ictalurus catus*
Yellow Bullhead	*Ictalurus natalis*

Resident Fish (continued)	
Brown bullhead	*Ictalurus nebulosus*
Black Bullhead	*Ictalurus melas*
Mosquitofish	*Gambusia affinis*
Threespine Stickleback	*Gasterosteus aculeatus*
Sacramento Perch	*Archoplites interruptus*
Black Crappie	*Pomoxis nigromaculatus*
White Crappie	*Pomoxis annularis*
Warmouth	*Lepomis gulosus*
Green Sunfish	*Lepomis cyanellus*
Bluegill	*Lepomis macrochirus*
Pumpkinseed	*Lepomis gibbosus*
Redear Sunfish	*Lepomis microlophus*
Largemouth Bass	*Micropterus salmoides*
Spotted Bass	*Micropterus punctatus*
Smallmouth Bass	*Micropterus dolomieui*
Redeye Bass	*Micropterus coosae*
Yellow Perch	*Perca flavescens*
Bigscale Logperch	*Percina macrolepida*
Rough Sculpin	*Cottus asperrimus*
Coastrange Sculpin	*Cottus aleuticus*
Prickly Sculpin	*Cottus asper*
Pit Sculpin	*Cottus pitensis*
Marbled Sculpin	*Cottus klamathensis*
Riffle Sculpin	*Cottus gulosus*
Mammals	
Virginia opossum	*Didelphis virginiana*
Ornate shrew	*Sorex ornatus*
Broad-footed mole	*Scapanus latimanus*
Yuma myotis	*Myotis yumanensis*
Long-eared myotis	*Myotis evotis*
Fringed myotis	*Myotis thysanodes*
Long-legged myotis	*Myotis volans*
California myotis	*Myotis californicus*
Western pipistrelle	*Pipistrellus hesperus*
Big brown bat	*Eptesicus fuscus*
Red bat	*Lasiurus borealis*
Hoary bat	*Lasiurus cinereus*
Townsend's big-eared bat	*Plecotus townsendii*
Pallid bat	*Antrozous pallidus*
Brazilian free-tailed bat	*Tadarida brasiliens*
Brush rabbit	*Sylvilagus bachmani*
Desert cottontail	*Sylvilagus audubonii*
Black-tailed hare	*Lepus californicus*
Sonoma chipmunk	*Tamias sonomae*
California ground squirrel	*Spermophilus beecheyi*
Gray squirrel	*Sciurus carolinensis*
Western gray squirrel	*Sciurus griseus*
Botta's pocket gopher	*Thomomys bottae*

Mammals (continued)

San Joaquin pocket mouse	*Perognathus inornatus*
California kangaroo rat	*Dipodomys californicus*
Western harvest mouse	*Reithrodontomys megalotis*
Deer mouse	*Peromyscus maniculatus*
Brush mouse	*Peromyscus bovlii*
Dusky-footed woodrat	*Neotoma fuscipes*
California vole	*Microtus californicus*
Muskrat	*Ondatra zibethicus*
Black rat	*Rattus rattus*
Norway rat	*Rattus norvegicus*
House mouse	*Mus musculus*
Porcupine	*Erethizon dorsatus*
Coyote	*Canis latrans*
Red fox	*Vulpes vulpes*
Gray fox	*Urocyon cinereoargenteus*
Ringtail	*Bassariscus astutus*
Raccoon	*Procyon lotor*
Long-tailed weasel	*Mustela frenata*
Mink	*Mustela vison*
Badger	*Taxidea taxus*
Western spotted skunk	*Spilogale gracilis*
Striped skunk	*Mephitis mephitis*

Species of Special Concern

Listed Species

Birds	
American peregrine falcon[1]	*Falco peregrimus anatum*
Invertebrates	
Valley elderberry longhorn beetle[2]	*Desmocerus californicus dimorphus*

Candidate Species

Amphibians	
California tiger salamander	*Ambystoma tigrinum californiense*
Reptiles	
Giant garter snake	*Thamnophis gigas*
Birds	
Tricolored blackbird	*Agelaius tricolor*
White-faced ibis	*Plegadis chihi*
Invertebrates	
Vernal pool fairy shrimp	*Branchinecta lynchi*
California linderiella	*Linderiella occidentalis*
Conservancy fairy shrimp	*Branchinecta conservatio*
Vernal pool shrimp	*Lepidurus packardi*

1 State and federal endangered
2 federal threatened

A-4. Fish from the Feather River
(from DWR 1988)

Fish	
Pacific lamprey	*Entosphenus tridentatus*
Brook lamprey	*Lampetra planeri*
American shad	*Alosa sapidissima*
Threadfin shad	*Dorosoma petenense*
Chinook salmon	*Oncorhynchus tshawytscha*
Coho salmon	*0. kisutch*
Chum salmon	*0. keta*
Pink salmon	*0. gorbuscha*
Sockeye salmon	*0. nerka*
Steelhead trout	*O. mykiss*
Brown trout	*Salmo trutta*
Carp	*Cyprinus carPio*
Goldfish	*Carassius auratus*
Hitch	*Lavinia exilicauda*
Hardhead	*Mylopharodon conocephalus*
Golden shiner	*Notemigonus crysoleuces*
Splittail	*Pogonichthys macrolePidotus*
Sacramento squawfish	*Ptychocheilus grandis*
Sacramento western sucker	*Catostomus occidentalis occidentalis*
White catfish	*Ictalurus catus*
Black bullhead	*I. melas*
Brown bullhead	*I. nebulosus*
Channel catfish	*I. punctatus*
Green sunfish	*Lepomis cyanellus*
Warmouth	*Chaenobryttus gulosus*
Bluegill	*Lepomis macrochirus*
Smallmouth bass	*MicroPterus dolomieui*
Largemouth bass	*MicroPterus salmoides*
Black crappie	*Pomoxis nigromaculatus*
Logperch	*Percina macrolepida*
Tule perch	*Hysterocarpus traskii*
Riffle sculpin	*Cottus gulosus*
Mosquitofish	*Gambusia affinis*
Striped bass	*Morone saxatilis*
White sturgeon	*Acipenser transmontanus*

Appendix A-5. Fish from the Yuba River
(from Beak 1976)

Fish	
Pacific lamprey	*Lampetra tridentatus*
Green sturgeon	*Acipenser medirostris*
White sturgeon	*Acipenser transmontanus*
American shad	*Alosa sapidissima*
Chinook salmon	*Oncorhynchus tshawytscha*
Rainbow trout	*Oncorhynchus mykiss*
Carp	*Cyprinus carpio*
California roach	*Hesperoleucus symmetricus*
Hardhead	*Mylopharodon conocephalus*
Golden shiner	*Notemigonus crysoleucas*
Sacramento squawfish	*Ptychocheilus grandis*
Speckled dace	*Rhinichthys osculus*
Sacramento sucker	*Catostomus occidentalis*
White catfish	*Ictalurus catus*
Brown bullhead	*Ictalurus nebulosus*
Channel catfish	*Ictalurus punctatus*
Mosquitofish	*Gambusia affinis*
Threespine stickleback	*Gasterosteus aculeatus*
Striped bass	*Morone saxatilis*
Green sunfish	*Lepomis cyanellus*
Warmouth	*Lepomis gulosus*
Bluegill	*Lepomis macrochirus*
Smallmouth bass	*Micropterus dolomieui*
Largemouth bass	*Micropterus salmoides*
White crappie	*Pomoxis annularis*
Black crappie	*Pomoxis nigromaculatus*
Logperch	*Percina caprodes*
Riffle sculpin	*Cottus gulosus*

Appendix A-6. Rare, Threatened, and Endangered Species Occurring in the Delta Area (from DWR 1990, 1991, 1992, USBR/DWR 1985)

Common Name	Scientific Name	Status	Distribution	Habitat
Plants				
Suisun Marsh aster	*Aster chilensis lentus*	C2	San Pablo Bay, Suisun Marsh, Delta	Dense vegetation, stabilized substrate
Antioch Dunes evening pnmrose	*Oenothera deltoides*	SE, FE	Delta	Sand dunes
Sanford's arrowhead	*Sagittaria sanfordii*	C2	Butte, Fresno, Sacramento, and Del Norte counties	Tule marshes
Mason's lilaeopsis	*Lilaeopsis masonii*	C2,SR	Delta	Mudbanks
California hibiscus	*Hibiscus californicus*	C2	Delta, Central Valley up to Butte County	Freshwater marsh
Delta tule pea	*Lathyrus jepsonii jepsonii*	C2	Delta	Freshwater marsh
Contra Costa wallflower	*Erysimum capitatum var. angustatus*	FE,SE	Loose sand; Antioch sand dunes; Contra Costa County	Delta
Slough thistle	*Cirsium crassicaule*	C2	Delta; Kern and Kings counties	Upland areas
Delta button celery	*Aster chilensis lentus*	C2,SE	San Joaquin, Stanislaus, and Calaveras counties	Seasonal wetlands
Birds				
Aleutian Canada goose	*Branta canadensis leucophareia*	FE	Western Delta, Modesto	Fresh and salt water marshes and waterways
Greater sandhill crane	*Grus canadensis tabida*	ST	Central Valley	Fresh water marsh, riparian areas, corn fields, near trees for nesting
California black rail	*Laterallus jamaicensis*	C2, ST	Coast from Marin County to north Mexico; inland marshes	Fresh and salt water marshes
Tricolored blackbird	*Agelaius tricolor*	C2	Central Valley, Sierra Nevada foothills	Marshes, flooded lands, margins of ponds, grassy fields
Swainson's hawk	*Buteo swainsoni*	ST	Lower Sacramento and San Joaquin valleys, Klamath Basin, Siskiyou Co, winters in South America	Grasslands, irrigated pastures, and open fields near trees for nesting
Peregrine falcon	*Falco peregrinus*	FE,SE	Breeds on cliffs in mountains and near coast; feeds and winters near coastal and inland marshes and riparian areas	Sacramento, Feather, and American rivers; Delta
California clapper rail	*Rallus longirostris obsoletus*	FE,SE	Salt marshes; Sonoma to Santa Clara counties	Delta, San Francisco Bay
Saltmarsh yellowthroat	*Geothlypis trichas sinuosa*	FC	Fresh marshes for breeding, salt and brackish marshes in winter; breeds Sonoma to San Mateo counties	Delta, San Francisco Bay

Appendix A-6. Cont'd.

Reptiles				
Giant garter snake	*Thamnophis couchi gigas*	C2, ST	Fresno Co north through the Central Valley, east Delta	Freshwater marsh, ripanan areas, rice fields, canals
Western pond turtle	*Clemmys marmorata*	C2	Throughout California west of Cascade-Sierra crest	Ponds and waterways lined with emergent vegetation
Amphibians				
California tiger salamander	*Arnbystoma tigrinum califomiense*	C2	Sonoma to Santa Barbara counties	Reservoirs, ponds, pools, lakes, and slow-flowing streams in grasslands and open woodlands
California red-legged frog	*Rana aurora draytoni*	C2	Coast, Transverse, Cascade, and Sierra Nevada ranges	Quiet, permanent water in woods, forest clearings, riparian areas, grasslands
Insects				
Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*	FT	Lower Sacramento Valley north to Red Bluff	Elderberry bushes in riparian areas
Sacramento anthicid beetle	*Anthicus sacramento*	C2	Yolo, Solano, Butte, Sacramento counties	Sand dunes near rivers
Lange's metalmark butterfly	*Apodemia mormo langei*	FE	Antioch sand dunes; Contra Costa County	San Joaquin River in the Delta
Curved-footed hygrotus diving beetle	*Hygrotus curvipes*	C2	Contra Costa County	Shallow ponds
Fish				
Delta smelt	*Hypomesus transpacificus*	C1, SC	Suisun & San Pablo Bays in early fall; spawns in channels and dead-end sloughs December through April	Salinities usually less than 2 parts per thousand
Sacramento splittail	*Pogonichthys macrolepidotus*	C2	Suisun Bay from February to April; spawns in upstream deadend sloughs January to July	Slower currents; tolerates brackish water
Sacramento perch	*Archoplites interruptus*	C2	Sacramento-San Joaquin Delta; Russian River; Scattered lakes and reservoirs	Needs beds of rooted and emergent aquatic vegetation; tolerates alkaline water
Chinook salmon (winter-run)	*Oncorhynchus tshawytscha*	FT, SE	Sacramento River system	Cool fresh water with access to ocean
Crustaceans				
California freshwater shrimp	*Syncaris pacifica*	SE,FC	Streams; Marin, Napa, and Sonoma counties	Several miles from the Delta
Mammals				
Salt marsh harvest mouse	*Reithrodontomys raviventris*	FE,SE	Salt marshes; Sonoma to San Mateo counties	Delta, San Francisco Bay
San Joaquin kit fox	*Vulpes macrotis mutica*	FE,ST	South San Joaquin Valley foothills north into Contra Costa County	Grassland and alkali sinks

Status:
FT=federal threatened
FE=federal endangered
FC=federal candidate
C1=federal candidate with sufficient data to support federal listing
C2=federal candidate currently without sufficient data to support federal listing
ST=State threatened
SE=State endangered
SR State rare
SC=State candidate for protected status

Appendix A-7. Sensitive Fish, Wildlife, and Insect Species Potentially Occurring in the Coastal Aqueduct and Santa Barbara Areas (from DWR 1991b)

Birds	Scientific Name	Status
Peregrine falcon	*Falco peregrinus anaturn*	CE,FE
Bald eagle	*Haliaeetus leucocephalus*	CE,FE
California condor	*Gymnogyps californianus*	CE,FE
Least Bell's vireo	*Viveo bellii pusillus*	CE,FE
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	CE,FC2
Swainson's hawk	*Buteo swainsoni*	CT,FC2
Ferruginous hawk	*Buteo regalis*	FC2
Tricolored blackbird	*Agelaius tricolor*	SA,FC2
Long-billed curlew	*Numenius americanus*	FC2
Bank swallow	*Riparia riparia*	CCE
Golden eagle	*Aguila chrysaetos*	CSC
Prairie falcon	*Falco mexicanus*	CSC
Cooper's hawk	*Accipiter cooperii*	CSC
Sharp-shinned hawk	*Accipiter striatus*	CSC.W
Northern harrier	*Circus cyaneus*	CSC
Short-eared owl	*Asio flammeus*	CSC
Long-eared owl	*Asio otus*	CSC
Burrowing owl	*Athene cunicularia*	CSC
Black-shouldered kite	*Elanus caeruleus*	CF[
Purple rnartin	*Progne subis*	CSC.WC
Yellow warbler	*Dendroica perechia brewsteri*	SC
Yellow-breasted chat	*Icteria virens*	CSC
Willow flycatcher	*Empidonax traillii*	CSC
Cornrnon loon	*Gavia immer*	CSC
Western grebe	*Aechmophorus occidentalis*	W
Double-crested cormorant	*Phalacrocorax auritus*	CSC
Great blue heron	*Ardea herodias*	SA
Great egret	*Casmerodius albus*	SA
Snowy egret	*Egretta thula*	SA
Least bittern	*Ixobrychus exilis*	CSC
Black-crowned night heron	*Nycticorax nycticorax*	SA
Le Contes thrasher	*Toxostoma lecontei*	CSC
Mammals		
San Joaquin kit fox	*Vulpes macrotis mutica*	CT,FE
Giant kangaroo rat	*Dipodomys ingens*	CE,FE
S.J. antelope squirrel	*Ammospermophilus nelsoni*	CT,FC2
San Joaquin pocket mouse	*Perognathus inornatus inornatus*	SA,FC2
Salinas pocket mouse	*Perognathus inornatus psammophilus*	CSC,FC2
Short-nosed kangaroo rat	*Dipodomys nitratoides brevinasus*	CSC,FC2
Townsend's w. big-eared bat	*Plecotus townsendii townsendii*	CSC,FC2
Spotted bat	*Euderma maculatum*	SA,FC2
Pacific kangaroo rat	*Dipodomys agilisfuscus*	SA
Tulare grasshopper mouse	*Onochomys torridus tularensis*	SA

<u>Mammals (continued)</u>		
McKittrick pocket mouse	*Perognathus inornatus neglectus*	SA
Little pocket mouse	*Perognathus longimembris psammophilus*	SA
American badger	*Taxidea taxus*	CSC
<u>Reptiles</u>		
Blunt-nosed leopard lizard	*Gambelia silus*	CE,FE
Southwestern pond turtle	*Clemmys marmorata pallida*	CSC.FC2
California horned lizard	*Phrynosoma coronatum frontale*	CSC,W
<u>Amphibians</u>		
California tiger salamander	*Ambystoma tigrinum californiense*	CSC,FC2
Red-legged frog	*Rana aurora draytoni*	CSC,FC2
Arroyo toad	*Bufo microscaphus californicus*	CSC,FC2
Foothill yellow-legged frog	*Rana boylei*	CSC
<u>Fish</u>		
Unarrnored threespine stickleback	*Gasterosteus aculeatus williamsoni*	CE,FE
Tidewater goby	*Eucyclogobius newberryi*	CSC,FC2
Steelhead rainbow trout	*Oncorhynchus mykiss*	SLC
<u>Insects</u>		
Stanton's Trigonscuta dune weevil	*Trigonoscuta stantoni*	FC2
Doyen's Trigonscuta dune weevil	*Trigonoscuta doyeni*	FC1
White sand bear scarab beetle	*Lichnanthe albipilosa*	FC2
Rude's longhorn beetle	*Necydalis rudei*	FC2
Atascadero Polyphylian scarab beetle	*Polyphylla nubila*	FC2
Morro Bay blue butterfly	*Icaricia icarioides moroensis*	FC2
San Joaquin dune beetle	*Coelus gracilis*	FC2
Hopping blister beetle	*Lytta hoppingi*	FC2
Moestan blister beetle	*Lytta moesta*	FC2
Molestan blister beetle	*Lytta molesta*	FC2
Morrison blister beetle	*Lytta morrisoni*	FC2
<u>Plants</u>		
Amsinckia furcata		FC2
Antirrhinum ovatum		FC2
Arctostaphylos morroensis		FC1
Arctostaphylos pilosula		FC2
Arctostaphylos rudis		FC2
Atriplex vallicola		FC2
Calochortus clavatus spp. recurvifolius		FC2
Calochortus obispoensis		FC3

Plants (continued)

Calystegia collina spp. venusta	FC2
Calystegia subacaulis spp. episcopalis	FC2
Camissonia hardhamiae	FC2
Carex obispoensis	-
Castilleja mollis	FC2
Caulanthus californicus	CE,FE
Chloroqalum purpureum var. reductum	CR,FC1
Chorizanthe breweri	FC3
Chorizanthe rectispina	FC2
Cirsium fontinale var. obispoensis	FC2
Cirsium loncholepis	FC1
Cirsium rhothophilum	FC1
Clarkia speciosa spp. immaculata	CR,FC1
Cordylanthus rigidus ssp. littoralis	CE,FC1
Delphinium parryi ssp. blochmaniae	FC2
Delphinium recurvatum	FC2
Dithyrea maritima	FC2
Dudleya abramsii ssp. murina	FC3
Eremalche kernensis	FE
Eriastrum hooveri	FT
Erigeron foliosus var. blochmaniae	-
Eriodictyon altissimum	CE,FC1
Eriodictyon capitatum	CR,FC1
Eriogonum temblorense	FC2
Eryngium aristulatum var. hooveri	FC2
Fritillaria ojaiensis	FC2
Fritillaria viridea	FC2
Hollisteria lanata	FC2
Layia jonesii	FC2
Lembertia congdonii	FE
Lupinus ludovicianus	FC2
Monardella crispa	FC2
Monardella undulata var. frutescens	FC2
Rorippa gambelii	CT,FC1
Scrophularia atrata	FC2
Sidalcea hickmanii ssp. anomala	CR,FC2

Status

FE-federally listed, endangered
FT-federally listed, threatened
FC1-enough data are on file to support federal listing
FC2-threat and/or distributional data are insufficient to support federal listing (candidate species)
C3-too widespread and/or not threatened
CE-California endangered
CR-California rare
CT-California threatened
SA-California Natural Diversity Data Base Special Animals List
CCE-California candidate for listing as endanged
CSC-California species of special concern
W-California Natural Diversity Data Base Watchlist
CFP-California DFG fully protected species
SLC-California DFG subpopulation of local concern

Reptiles (continued)

- Common garter snake
- Western terrestrial garter snake
- Giant garter snake

Amphibians

- Tiger salamander
- Pacific tree frog
- Western spadefoot toad
- Bullfrog
- Western toad

Birds

- Great blue heron
- Green heron
- Black-shouldered kite
- Red-tailed hawk
- Swainson's hawk
- Golden eagle
- Marsh hawk
- Prairie falcon
- Peregrine falcon
- American kestrel
- California quail
- Gambel's quail
- Ring-necked pheasant
- Chukar
- Killdeer
- Long-billed curlew
- Rock dove
- Mourning dove
- Spotted dove
- Roadrunner
- Barn owl
- Great horned owl
- Burrowing owl
- Short-eared owl
- Lesser nighthawk
- Anna's hummingbird
- Western kingbird
- Say's phoebe
- Horned lark
- Rough-winged swallow
- Common raven
- Common crow
- Robin
- Western bluebird

Birds (continued)

- Loggerhead shrike
- House sparrow
- Western meadowlark
- Red-winged blackbird
- Tricolored blackbird
- Brewer's blackbird
- Lazuli bunting
- House finch
- American goldfinch
- Lawrence's goldfinch
- Grasshopper sparrow
- Lark sparrow
- Rufous-crowned sparrow
- Lincoln's sparrow

Fish

- Rainbow trout
- Brook lamprey
- Threadfin shad
- Carp
- Goldfish
- Golden shiner
- Sacramento blackfish
- Hardhead
- Hitch
- Sacramento squawfish
- California roach
- Sacramento splittail
- Sacramento sucker
- Channel catfish
- White catfish
- Brown bullhead
- Mosquitofish
- Mississippi silversides
- Threespine stickleback
- Striped bass
- White bass
- Sacramento perch
- Black crappie
- White crappie
- Green sunfish
- Bluegill
- Redear sunfish
- Largemouth bass
- Bigscale logperch
- Riffle sculpin

Appendix A–8a. Plant, Wildlife, and Fish Species in the Tulare Basin (from DFG 1987)

Plants
- Salt grass
- Low barley
- Bullrush
- Iodine bush
- Silver saltbush
- Crown saltbush
- Bracted saltbush
- Alkali pepper-grass
- Jackass-clover
- Sheep milk-vetch
- Mesquite
- Alkali mallow
- Alkali heath
- Annual lupine
- Red-stemmed filaree
- Parry's mallow
- Birdseye gilia
- Narrowflower flaxflower
- Allscale saltbush
- London-rocket
- California malacothrix
- Rusty molly kochia
- Western miterwort
- Common glasswort
- Alkali blight
- Mojave seablite
- Sea purslane
- Western larkspur
- Alkaliweed
- Popcornflower
- Salt heliotrope
- Shrubby alkali aster
- Small fescue
- Reflex fescue
- Kern mallow
- Wild onion
- Blue curls
- Tarplant
- Eatonella
- Diablo milk-vetch
- Black milk-vetch
- Rusty molly kochia
- Eatonella
- Black milk-vetch

Mammals
- Opossum
- Yuma myotis
- Long-eared myotis
- Fringed myotis
- California myotis
- Hoary-winged myotis
- Western pipistrel
- Big brown bat
- Western big-eared bat
- Pallid bat
- Mexican freetail bat
- Raccoon
- Spotted skunk
- Striped skunk
- Coyote
- San Joaquin kit fox
- California ground squirrel
- San Joaquin antelope squirrel
- Valley pocket gopher
- San Joaquin pocket mouse
- Heermann kangaroo rat
- Giant kangaroo rat
- Deer mouse
- Southern grasshopper mouse
- Blacktail jackrabbit
- Desert cottentail

Reptiles
- Western banded gecko
- Blunt-nosed leopard lizard
- Coast horned lizard
- Western fence lizard
- Western skink
- Gilberts skink
- Western whiptail
- California legless lizard
- Glossy snake
- Racer
- Western ring-necked snake
- Common king snake
- Common whip snake
- Gopher snake
- Western rattlesnake
- Western patch-nosed snake

Appendix A-8b. Tulare Basin Species of Special Concern (from DFG 1987)

Common Name	Scientific Name
Sierra red fox	*Vulpes vulpes necator* [1]
Wolverine	*Gulo qulo*[1]
San Joaquin kit fox	*Vulpes macrotis mutica*[1,2]
San Joaquin antelope squirrel	*Ammospermophilus nelsoni*[1]
Blunt-nosed leopard lizard	*Gambelia silus*[2,3]
Giant kangaroo rat	*Dipidomys ingens*[3]
Giant garter snake	*Thamnophis couchi giqas*[1]
Bald eagle	*Haliaeetus leucocephalus*[2,3]
California condor	*Gymnogyps californianus*[2,3]
Peregrine falcon	*Falco peregrinus anatum*[2,3]
Tipton kangaroo rat	*Dipodomys nitratoides nitratoides* [4]
Black shouldered kite	*Elanus leucurus*[4]
Great blue heron	*Apurdea herodias*[4]
Spotted owl	*Strix occidentalis*[4]
Plants	
Green's orcutt grass	*Orcuttia greenei*[5]
Kaweah brodiaea	*Brodiaea insignis*[6]
Springville clarkia	*Clarkia springvillensis*[6]
San Joaquin Valley orcutt grass	*Orcuttia inaequalis*[6]
Kecks checkermallow	*Sidalcea keckii* [4]

Appendix A-8c. Plant, Wildlife, and Fish Species in the Kaweah River and Reservoir Basin (from DFG 1987)

Plants

Arrowhead
Blue and white lupine
Blue dicks
Blue oak
Black cottonwood
Black willow
California black oak
California buckeye
California needlegrass
California poppy
Cocklebur
Cream cup
Foxtail brome
Valley oak
Yellow mariposa
Golden lupine

Plants (continued)

Pine bluegrass
Fiddleneck
Pinpoint clover
Popcorn flower
Royal lupine
Silky lupine
Sixweeks fescue
Snake lily
Soap plant
Sunshine flower
Storksbill
Tidy tips
Fremont cottonwood
Wild oat
White mariposa
White daisy

Plants (continued)

- Grass nut
- Hansen larkspur
- Harvest brodiaea
- Interior live oak
- Manzanita
- Milk thistle
- Mouse barley
- Varicolored lupine
- Variegated larkspur
- Western sycamore
- White alder
- White-centered lupine

Mammals

- Opossum
- Ornate shrew
- Badger
- California mole
- Valley pocket gopher
- Raccoon
- Spotted skunk
- Striped skunk
- Coyote
- Gray fox
- San Joaquin kit fox
- Bobcat
- California ground squirrel
- San Joaquin antelope squirrel
- Western gray squirrel

Reptiles

- Side-blotched lizard
- Western fence lizard
- Mountain kingsnake
- Western garter snake
- Gilbert's skink
- California legless lizard
- Coast horned lizard
- Common garter snake
- Common whipsnake
- Gopher snake
- Long-nosed snake
- Pacific pond-turtle
- Racer
- Ringneck snake
- Western whip-tail lizard
- Western black-headed snake
- Night snake

Reptiles (continued)

- Rubber boa

Mollusks

- Freshwater mussel
- Asian clam

Birds

- Prairie falcon
- Peregrine falcon
- American kestrel
- California quail
- Horned grebe
- Eared grebe
- Pied-billed grebe
- Red-shafted flicker
- Acorn woodpecker
- Trowbridge shrew
- Western grebe
- Great blue heron
- Green heron
- American bittern
- Canada goose
- Fulvous tree duck
- Mallard
- Gadwall
- Pintail
- Green-winged teal
- Blue-winged teal
- American widgeon
- Wood duck
- Ring-necked duck
- Ruddy duck
- Canvasback
- Lesser scaup
- Greater scaup
- Lewis woodpecker
- Common merganser
- California condor
- Black-shouldered kite
- Goshawk
- Sharp-shinned hawk
- Cooper's hawk
- Red-tailed hawk
- Swainson's hawk
- Golden eagle
- Bald eagle
- Marsh hawk
- Osprey

Birds (continued)

- Western bluebird
- Fox sparrow
- White-crowned sparrow
- Chipping sparrow
- Ring-necked pheasant
- American coot
- Killdeer
- Common snipe
- Spotted sandpiper
- Wilson's phalarope
- California gull
- Ring-billed gull
- Forster's tern
- Caspian tern
- Band-tailed pigeon
- Rock dove
- Mourning dove
- Roadrunner
- Yellow-bellied sapsucker
- Downy woodpecker
- Nuttall's woodpecker
- Western kingbird
- Ash-throated flycatcher
- Black phoebe
- Say's phoebe
- Olive-sided flycatcher
- Violet-green swallow
- Tree swallow
- Bank swallow
- Barn swallow
- Cliff swallow
- Scrub jay
- Yellow-billed magpie
- Common raven
- Common crow
- Plain titmouse
- Common bushtit
- White-breasted nuthatch
- Brown creeper
- Dipper
- House wren
- Bewick's wren
- Canyon wren
- Rock wren
- Mockingbird
- Robin
- Varied thrush
- Hermit thrush

Birds (continued)

- Mountain bluebird
- Ruby-crowned kinglet
- Water pipit
- Cedar waxwing
- Loggerhead shrike
- Starling
- Hutton's vireo
- Audubon's warbler
- Black-throated gray warbler
- Western meadowlark
- Red-winged blackbird
- Tri-colored blackbird
- Brewer's blackbird
- Western tanager
- Lazuli bunting
- House finch
- Lesser goldfinch
- Barn owl
- Screech owl
- Great-horned owl
- Saw-whet owl
- Pygmy owl
- White-throated swift
- Black-chinned hummingbird
- Anna's hummingbird
- Rufous hummingbird
- Calliope hummingbird
- Belted kingfisher
- Rufous-sided towhee
- Savannah sparrow
- Grasshopper sparrow
- Lark sparrow
- Rufous-crowned sparrow
- Slate-colored junco
- Oregon junco

Insects

- Baetis
- Simuliidae
- Micrasema
- Chironomidae
- Paraleptophlebia
- Hydropsyche
- Nemoura
- Rithrogena
- Eperorus
- Brachyptera

Fish
- Goldfish
- Green sunfish
- Golden shiner
- Bluegill
- Black crappie
- Rainbow trout
- Brown trout
- Hardhead
- Riffle sculpin
- Sacramento squawfish
- California roach
- Sacramento sucker
- Brown bullhead
- Carp
- White crappie
- Mosquitofish
- Sunshine bass

Fish (continued)
- Redear sunfish
- Largemouth bass
- Spotted bass
- Smallmouth bass
- Threadfin shad
- Brown bullhead
- White catfish
- Channel catfish

Amphibians
- Bullfrog
- California slender salamander
- Pacific tree frog
- Red-legged frog
- Western toad
- Yellow-legged frog

Appendix A–8d. Plant, Wildlife, and Fish Species in the Kern River Basin (from DFG 1987)

Plants
- Barley
- Chess grass
- Red brome grass
- Fescue
- Nodding fescue
- Foxtail grass
- Slender wild oat
- Arabian grass
- Red scale bush
- Tamarisk
- Bakersfield salt bush
- Lost Hills salt bush
- Wild onion
- Cotton erigonum
- Pacific fescue
- Foxtail fescue
- Alkali sacaton
- Salt grass
- Common tule
- Tule
- Orange fiddleneck
- Cheezeweed
- Russian thistle
- Dwarf locoweed
- Wild heliotrope

Plants (continued)
- Alkali weed
- Alkali blight
- Iodine bush
- Common black willow
- Alkali grass
- Pickleweed
- Sea purslane
- Seep weep
- Coastal alkali-mallow
- Honey mesquite
- Jackass clover
- Salt brush
- Quail bush
- Slough thistle
- Salt cedar
- Spikeweed
- Tessel flower
- Valley spurge
- California lotus
- Sand pygmy weed
- Alkali larkspur
- Pale golden bush
- Desert dandelion
- Goldfields
- Tarweed

Plants (continued)

- Mule fat
- Pale golden bush
- Pepper grass
- London-rocket
- Locoweed
- Diablo locoweed
- Lupine
- Filaree
- Parry mallow
- Kern mallow
- Beaver-tail cactus
- Birds eye gilia

Mammals

- Opossum
- Ornate shrew
- Yuma myotis
- California myotis
- Western pipistrel
- Big brown bat
- Red bat
- Hoary bat
- Gray fox
- Bobcat
- California ground squirrel
- San Joaquin antelope squirrel
- Valley pocket gopher
- Little pocket mouse
- San Joaquin pocket mouse
- Heermann's kangaroo rat
- Western big-eared bat
- Pallid bat
- Mexican free-tailed
- Western mastiff bat
- Long-tailed weasel
- Badger
- Spotted skunk
- Striped skunk
- Coyote
- San Joaquin kit fox
- Giant kangaroo rat
- Fresno kangaroo rat
- Deer mouse
- Muskrat
- Norway rat
- House mouse
- Black-tailed jackrabbit
- Desert cottontail

Mammals (continued)

- Mule deer

Amphibians

- Tiger salamander
- Western spadefoot toad
- Western toad
- Southwestern toad
- Pacific treefrog
- Bullfrog

Reptiles

- Western pond turtle
- Coast horned lizard
- Blunt-nosed leopard lizard
- Side-bloched lizard
- Desert horned lizard
- Western whiptail lizard
- Spotted night snake
- Glossy snake
- Coachwhip
- Gopher snake
- Common kingsnake
- Long-nosed snake
- Common garter snake
- Giant garter snake
- Western black-head snake
- Western patch-nosed snake
- Western rattlesnake

Birds

- White-fronted goose
- Mallard
- Pintail
- Blue-winged teal
- Cinnamon teal
- Turkey vulture
- Black-shouldered kite
- Sharp-shinned hawk
- Cooper's hawk
- Red-tailed hawk
- Swainson's hawk
- Rough-legged hawk
- Marsh hawk
- Peregrine falcon
- American kestrel
- Ring-necked pheasant
- Common gallinule
- American coot

Birds (continued)

- Killdeer
- Mountain plover
- Common snipe
- Long-billed curlew
- Whimbrel
- Greater yellowlegs
- Lesser yellowlegs
- Least sandpiper
- Western sandpiper
- Brewer's blackbird
- Long-billed dowitcn
- Black-necked stilt
- American avocet
- Band-tailed pigeon
- Mourning dove
- Roadrunner
- Barn owl
- Burrowing owl
- Short-eared owl
- Lesser nighthawk
- Common flicker
- Western kingbird
- Say's phoebe
- Horned lark
- Tree swallow
- Bank swallow
- Rough-winged swallow

Birds (continued)

- Chipping sparrow
- White-crowned sparrow
- Song sparrow
- Vesper sparrow
- Savannah sparrow
- Sage sparrow
- Lark sparrow
- Brown-headed cowbird
- Northern oriole
- Hooded oriole
- Tricolored blackbird
- Redwinged blackbird
- Yellow-headed blackbird
- Western meadowlark
- House sparrow
- Yellow-rumped warbler
- Starling
- Loggerhead shrike
- Water pipit
- American robin
- Long-billed marsh wren
- Common crow
- House finch
- Common raven
- Cliff swallow
- Barn swallow

Appendix A–8e. Kern River Basin Species of Special Concern (from DFG 1987)

Common Name	Scientific Name
Joaquin kit fox	*Vulpes vulpes necator*[1,2]
Fresno kangaroo rat	*Dipodomys nitratoides exilus*[2,3]
San Joaquin antelope squirrel	*Ammospermophilus nelsoni*[1]
Peregrine falcon	*Falco Pereqrinus anatum*[2,3]
California yellow-billed cuckoo	*Coccyaus amerlcanus occidentalis*[1]
California condor	*Gymnoqyps californianus*[1]
Bald eagle	*Haliaeetus leucocephalus*[2,3]
Blunt-nosed leopard lizard	*Gambelia silus*[2,3]
Giant garter snake	*Thamnophis couchi giqas*[3]
Bakersfield salt bush	*Atriplex tularensis*[3]
Lost Hills salt bush	*Atriplex nallicola*[3]
Slough thistle	*Cirsium crassicaule*[3]
Cotton eriogonum	*Eriogaoum*[3]

1-State Threatened; 2-Federal Endangered; 3-State Endangered; 4-Special Concern
5-State Rare; 6-State Endangered

Appendix A-9. Plant, Wildlife, and Fish Species of Special Concern in the Southern California Service Area (from DWR 1984)

Plants	Scientific Name
Blue elderberry	*Sambucus caerulea*
Ponderosa pine	*Pinus ponderosa*
Digger pine	*Pinus sabiniana*
Incense cedar	*Libocedrus decurrens*
Black oak	*Quercus kelloggii*
Scrub oak	*Quercus dumosa*
Dwarf interior live oak	*Quercus wislizenii*
Dwarf coast live oak	*Quercus agrifolia*
Western sycamore	*Plantanus racemosa*
White alder	*Alnus rhombifolia*
Fremont cottonwood	*Populus fremontii*
Willow	*Salix spp.*
California juniper	*Juniperus californica*
Western juniper	*Juniperus occidentalis*
Singleleaf pinyon	*Pinus monophylla*
Joshua	*Yucca brevifolia*
Douglas fir	*Pseudotsuga menziesii*
Almond	*Punus communis*
Horsetail tree	*Casuarina equisteifloia*
Smooth Arizona cypress	*Cupressus glabra*
Jerusalem thorn	*Parkinsonia aculeata*
Mesquite	*Prosopis juliflora*
Black locust	*Robinia pseudoacacia*
Tamarix	*Tamarix aphylla*
Acacia	*Acacia ssp.*
Eucalyptus	*Eucalyptus spp.*
California joint fir	*Ephedra californica*
Nevada joint fir	*Ephedra nevadensis*
Creosote bush	*Larrea divaricata*
Burro brush	*Franseria dumosa*
Cheese bush	*Hymenoclea salsola*
Spinescale	*Atriplex spinifera*
Spiny hop sage	*Grayia spinosa*
Buckwheat	*Eriogonum fasciculatum*
Winter fat	*Eurotia lanata*
Paper-bag bush	*Salazaria mexicana*
Thornbrush	*Lycium andersonii*
Peach thorn	*Lycium cooperi*
Desert almond	*Prunus fasciculata*
Thamnosma	*Thamnosma montana*
Wishbone bush	*Mirabilis laevis*
Desert alyssum	*Lepidium fremontii*
Bitter brush	*Purshia glandulosa*
Desert cassia	*Cassia armata*
Small four o'clock	*Allionia pumila*

Plants (continued)

Goldenhead	*Acamptopappus sphaerocephalus*
Deer brush	*Ceanothus integerrimus*
Rubber rabbitbrush	*Chrysothamnus nauseosus*
Acton encelia	*Encelia actoni*
Torrey's desert thorn	*Lycium torreyi*
Sage brush	*Artemisia tridentata*
Chamise	*Adenostoma fasciculatum*
Whipple yucca	*Cercocarpus betuloides*
Mountain mahogany	*Salvia carnosa*
Mint sage	*Yucca whipplei*
Desert ceanothus	*Ceanothus greggi*
Jumping cholla	*Opuntia bigelovii*
Beavertail-cactus	*Opuntia basilaris*
Brittle bush	*Encelia farinosa*
Coastal bush	*Artemisia californica*
Bebba	*Bebba juncea*
Brickellia	*Brickellia desertorum*
White sage	*Salvia apiana*
Black sage	*Salvia mellifera*
Mule fat	*Baccharis viminea*
Sugar bush	*Rhus ovata*
Matchweed	*Gutierrezia californica*
Poison oak	*Rhus diversiloba*
Southern monkey flower	*Diplacus longiflorus*
Hairy horsebrush	*Tetradvmia comosa*
Yellow penstemon	*Penstemon antirrhinoides*
Wedgeleaf golden bush	*Haplopappus cuneatus*
Deerweed	*Lotus scoparius*
Redberry	*Rhamnus crocea*
Golden yarrow	*Eriophyllum confertiflorum*
Oregon grape	*Berberis nervosa*
Mormon tea	*Ephedra sp.*
Big-berry manzanita	*Arctostaphylos glauca*
Buckbrush	*Ceanothus cuneatus*
Gooseberry	*Ribes sp.*
Coffeeberry	*Rhamnus californica*
Rose	*Roasa sp.*
Yerba santa	*Eriodictyon sp.*
Nevin brickellbush	*Brickellia nevinii*
California brickellbush	*Brickellia californica*
Purple sage	*Salvia leucophylla*
Horehound	*Marrubium vulgare*
Narrowleaf goldenbush	*Haplopappus linearifolius*
Sawtooth goldenbush	*Haplopappus squarrosus*
Scarlet bugler	*Penstemon centranthifolius*
Toyon	*Photinia arbutifolia*
Tree tobacco	*Nicotiana glauca*
Saltbush	*Atriplex canescens*
Quail brush	*Atriplex lentiformis*

Plants (continued)

Chaparral white thorn	*Ceanothus leurodermis*
Hollyleaf cherry	*Prunus iliclfolia*
Mojave chorizanthe[4,5]	*Chorizanthe spinosa*
Russian olive	*Elaeagnus augustifolia*
Bladder pod	*Isomeria arborea*
Spanish broom	*Spartium junceum*
Allscale	*Artiplex polycarpa*
Trefoil	*Lotus sp.*
Bottle brush	*Melaleuca spp.*
Bottle bush	*Calothamnus homalophyllus*
Common sunflower	*Helianthus annuus*
California sunflower	*Helianthus californicus*
Fiddle-neck	*Amsinckia interrnedia*
Aster	*Corethrogyne spp.*
Jimson weed	*Datura meteloides*
Cud weed	*Gnaphalium bicolor*
Snapdragon	*Antirrhinum nuttallianum*
Bee plant	*Scrophularia californica*
Night shade	*Solanum spp.*
Nettle	*Urtica gracilis*
Pulsey	*Heliotrophium curassavicum*
Silver buckwheat	*Eriogonum elongatum*
Larkspur	*Delphinium parryi*
Golden bloomeria	*Bloomeria crocea*
Blue dicks	*Brodiaea capitata*
Scapellote	*Perezia microcephala*
Phacelia	*Phacelia ramosissma*
Stillingia	*Stillingia linearfolia*
California fuchsia	*Zauschneria californica*
Spike rush	*Heleocharis sp.*
Bulle tule	*Scripus campestris*
Common cat-tail	*Typha latifolia*
Pierson's morning glory[2,3]	*Calystegia peirsonii*
Parish's onion[4,2]	*Allium parishii*
Calabazilla	*Cucurbita foetidissima*
Philibertia	*Philibertia heterophylla*
Wild cucumber	*Marah macrocarpus*
Virgins bower	*Clematis paucflora*
Coyote-melon	*Cucurbita palmata*
Pipe-stem	*Clematis lasiantha*
Chia	*Salvia columbariae*
Pilago	*Filago californica*
White pigweed	*Chenopodium album*
Dove weed	*Eremocarpus setigerus*
Tansy mustard	*Descurainia pinnata*
Common mustard	*Sisymbrium spp.*
Short-podded mustard	*Brassica geniculata*
Bur ragweed	*Franseria acanthicarpa*
Forest Camp sandwort[1,2]	*Arenaria macradenia var. kuschei*

Plants (continued)

Mojave paintbrush[4,2]	*Castilleja plagiotoma*
Lemmons syntrichopappus[4,2]	*Syntrichopappus lemmonii*
Russian thistle	*Salsola kali*
Tumble-weed	*Amaranthus graecizans*
Stephanomeria	*Stephanomeria virgata*
Bedstraw	*Galium spp.*
Lupine	*Lupinus spp.*
Rattlesnake weed	*Euphorbia polycarpa*
Morning glory	*Convolvulus fulcratus*
Small flowered blazing star	*Mentzelia albicaulis*
Apollo blazing star	*Mentzelia albicaulis heliophila*
Red-stem filaree	*Erodium cicutarium*
Gold fields	*Baeria platycarpha*
Gilia	*Gilia spp.*
Bridua	*Brodiaea pulchella*
Mariposa	*Calochortus spp.*
Indian paint brush	*Castilleja angustifolia*
California poppy	*Eschscholzia californica*
Popcorn flower	*Plagiobothrys arizonicus*
Owl's clover	*Orthocarpus purpurascens*
Evening primrose	*Oenothera spp.*
Wheat	*Triticum aestivum*
Barley	*Hordeum spp.*
Red brome	*Bromus rubens*
Soft chess	*Bromus mollis*
Squirrel tail	*Sitanion hystrix*
Wild oat	*Avena fatua*
Rip-gut	*Bromus rigidus*
Fescue	*Festuca sp.*
Cheatgrass	*Bromus tectorum*
Needlegrass	*Stipa spp.*
Giant rye	*Elymus condensatus*
Pampas grass	*Cortaderia selloana*
Viviparous foxtail cactus[3,5]	*Coryphantha vivipara var. rosea*

Mammals

Opossum	*Didelphis marsupialis*
California mole	*Scapanus latimanus*
Adorned shrew	*Sorex ornatus*
Desert shrew	*Notiosorex crawfordi*
Mexican free-tailed bat	*Tadarida mexicana*
Pallid bat	*Antrozous pallidus*
Hoary bat	*Lasiurus cinereus*
Long-eared bat	*Corynorthinus rafinesn*
Long-legged myotis	*Myotis velifer*
Fringed myotis	*Myotis thysanodes*
Small-footed bat	*Myotis subulatus*
Large brown bat	*Eptesicus fuscus*
Western red bat	*Lasiurus borealis*

Mammals (continued)

Western mastiff bat	*Eumops perotis*
Western pipistrelle	*Pipistrellus hesperus*
Yuma myotis	*Myotis yumanensis*
California myotis	*Myotis californicus*
Black-tailed hare	*Lepus californicus*
Audubon cottontail	*Sylvilagus audoboni*
Brush rabbit	*Sylvilagus bachmani*
Antelope ground squirrel	*Spermophilus leucurns*
Beechey ground squirrel	*Spermophilus beecheyi*
Mohave ground squirrel[6]	*Spermophilus mohavensis*
Nimble kangaroo rat	*Dipodmys agilis*
Stephens' kangaroo rat[6]	*Dipodmys stephensi*
Western harvest mouse	*Reithrodontomys megalotis*
Deer mouse	*Peromyscus maniculatus*
California mouse	*Peromyscus californicus*
California meadow mouse	*Microtus californicus*
Brush mouse	*Peromyscus boylei*
San Diego pocket mouse	*Perognathus fallax*
California pocket mouse	*Perognathus californicus*
White-eared pocket mouse	*Perognathus alticolus*
Desert wood rat	*Neotoma lepida*
Dusky-footed woodrat	*Neotoma fuscipes*
Merriam chipmunk	*Eutamias merriami*
Botta pocket gopher	*Thomomys bottae*
Western gray squirrel	*Sciurus griseus*
Northern flying squirrel	*Glaucomys sabrinus*
Golden beaver	*Castor canadensis*
Raccoon	*Procyon lotor*
Ring-tailed cat	*Bassariscus astutus*
Long-tailed weasel	*Mustela frenata*
Striped skunk	*Mephitis mephitis*
Spotted skunk	*Spilogale gracilis*
Badger	*Taxidea taxus*
Gray fox	*Urocyon cinereoargenteus*
Desert kit fox	*Vulpes macrotis*
Coyote	*Canis latrans*
Bobcat	*Lynx rufus*
Black bear	*Euarctos americanus*
Mountain lion	*Felis concolor var. californica*
California mule deer	*Odocoileus hemionus*

Birds

Turkey vulture	*Cathartes aura*
Golden eagle	*Aquila chrysaetos*
Bald eagle[7]	*Haliaeetus leucocephalus*
Sharp-shinned hawk	*Accipiter striatus*
Red-tailed hawk	*Buteo jamaicensis*
Ferruginous rough-legged hawk	*Buteo regalis*
Marsh hawk	*Circus cyaneus*

Birds (continued)

Sparrow hawk	*Falco sparverius*
Pigeon hawk	*Falco columbarius*
Prairie falcon	*Falco mexicanus*
American peregrine falcon[7]	*Falco peregrinus anatum*
Cooper's hawk	*Accipiter cooper*
White-tailed kite	*Elanus leucurus*
California condor[7]	*Gymnogyps californianus*
California valley quail	*Lophortyx californicus*
Mountain quail	*Oreortyx pictus*
Band-tailed pigeon	*Columba fasciata*
Mourning dove	*Zenaidura macroura*
Pygmy owl	*Glaucidium gnoma*
Saw-whet owl	*Aegolius acadicus*
Great horned owl	*Bubo virginianus*
Barn owl	*Tyto alba*
Burrowing owl	*Speotyto cunicularia*
Screech owl	*Otus asio*
Long-eared owl	*Asio otus*
Short-eared owl	*Asio flammeus*
Brown-head cowbird	*Molothrus ater*
Poor-will	*Phalaenoptilus nuttallii*
Lesser night hawk	*Chordeiles acutipennis*
Road runner	*Geococcyx californianus*
Costa's hummingbird	*Calypte costae*
Black-chinned hummingbird	*Archilochus alexandri*
Anna's hummingbird	*Calypte anna*
Common raven	*Corvus corax*
Common crow	*Corvus brachyrhynchos*
Brewer's blackbird	*Euphagus cyanocephalus*
Belding's savannah sparrow[7]	*Passerculus sandwichensis beldingi*
Chipping sparrow	*Spizella passerina*
Purple finch	*Carpodacus pupureus*
House finch	*Carpodacus mexicanus*
Western bluebird	*Sialia mexicana*
Oregon junco	*Junco oreganus*
Killdeer	*Charadrius vociferus*
Western kingbird	*Tyrannus verticalis*
Western flycatcher	*Empidonax difficilis*
Ash-throated flycatcher	*Myiarchus cinerascens*
Traill's flycatcher	*Empidonax traillii*
Says' phoebe	*Sayornais saya*
Blue-gray gnatcatcher	*Polioptila caerulea*
Black-tailed gnatcatcher	*Polioptila melanura*
Western meadowlark	*Sturnella neglecta*
Loggerhead shrike	*Lanius ludovicianus*
Starling	*Sturnus vulgaris*
Common bushtit	*Psaltriparus minimus*
Wrentit	*Chamea fasciata*
Bewick's wren	*Thryomanes bewickii*

Birds (continued)

Mockingbird	*Mimus polyglottos*
California thrasher	*Toxostoma redivivum*
Robin	*Turdus migratorius*
Black-headed grosbeak	*Pheucticus melanocephalus*
Lazuli bunting	*Pasarina amoena*
Rufous-sided towhee	*Pipilo erythrophthalmus*
Brown towhee	*Pipilo fuscus*
Red-shafted flicker	*Colaptes cafer*
White-breasted nuthatch	*Sitta carolinensis*
Bullock's oriole	*Icterus bullockii*
Hooded oriole	*Icterus cucuilatus*
Vesper sparrow	*Pooecetes gramineus*
Lark sparrow	*Chondestes grammacus*
Sage sparrow	*Amphispiza belli*
Brewer's sparrow	*Spizella breweri*
White-crowned sparrow	*Zonotrichia leucophrys*
Black-chinned sparrow	*Spizella atrogularis*
Song sparrow	*Melospiza melodia*
Fox sparrow	*Passerella iliaca*
Steller's jay	*Cvanocitta stelleri*
Scrub jay	*Aphelocoma coerulescens*
Western wood pewee	*Contopus sordidulus*
Black phoebe	*Sayornis nigricans*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Townsend's solitaire	*Myadestes townsendi*
Golden-crowned sparrow	*Zonotrichia atricapilla*
Western tanager	*Piranga ludoviciana*
Swainson's thrush	*Hylocichula ustulata*
Varied thrush	*Ixoreus naevlus*
Plain titmouse	*Parus inornatus*
Least Bell's vireo[7]	*Vireo bellii pusillus*
Gray vireo	*Vireo vicinior*
Hutton's vireo	*Vireo huttoni*
Solitary vireo	*Vireo solitarius*
Warbling vireo	*Vireo gilvus*
Audubon's warbler	*Dendroica audoboni*
Black-throated gray warbler	*Dendroica nigrescens*
Myrtle warbler	*Dendroica coronata*
Orange-crowned warbler	*Vermivora celata*
Townsend's warbler	*Dendroica townsendi*
Wilson's warbler	*Wilsonia pusilla*
Yellow warbler	*Dendroica petechia*
Cedar waxwing	*Bombycilla cedrorum*
Acorn woodpecker	*Melanerpes formicivorus*
Downy woodpecker	*Dendrocopos pubescens*
Hairy woodpecker	*Dendrocopos villosus*
Ladder-backed woodpecker	*Dendrocopos scalaris*
Lewis' woodpecker	*Asyndesmus lewis*
Nuttall's woodpecker	*Dendrocopos nuttallii*

Birds (continued)

Rock wren	*Salpinctes obsoletus*
Canyon wren	*Catherpes mexicanus*
House wren	*Troglodytes aedon*
Cactus wren	*Campylorhynchus brunneicarpillus*
Barn swallow	*Hirundo rustica*
Tree swallow	*Iridoprocne bicolor*
Bank swallow	*Riparla rlparla*
Violet-green swallow	*Tachycineta thalassina*
Cliff swallow	*Patrochelidon pyrrhonta*
Rough-winged swallow	*Stelgidopteryx ruficollis*
American goldfinch	*Spinus tristis*
Lawrence's goldfinch	*Spinus lawrencei*
Lesser goldfinch	*Spinus psaltria*
Red-winged blackbird	*Agelaius phoeniceus*
Great blue heron	*Ardea herodias*
Horned lark	*Ercmophila alpestris*
Canada goose	*Branta canadensis*
Mallard	*Anas platyrhynchos*
Pintail	*Anas acuta*
Shoveler	*Spatcula clypeata*
American widgeon	*Mareca americana*
Gadwall	*Anas strepera*
Cinnamon teal	*Anas cyanoptera*
Green-winged teal	*Anas carolinensis*
Bufflehead	*Bucephala albeola*
Ruddy duck	*Oxyura jamaicensis*
Redhead	*Aythya americana*
Canvasback	*Aythya valisineria*
American coot	*Fulica americana*
Eared grebe	*Podiceps caspicus*
Sora rail	*Porzana carolina*
California black rail[6]	*Laterallus jamaicensis*
Light-footed clapper rail[7]	*Rallus longirostris levipes*
Pied-billed grebe	*Podilymbus podiceps*
American avocet	*Recurvirostra americana*
Black-necked stilt	*Himantopus mexicanus*
Lesser yellowlegs	*Totanus flavipes*
Least sandpiper	*Erolia minutilla*
Western sandpiper	*Ereunetes mauri*
Wilson's phalarope	*Steganopus tricolor*
California brown pelican[7]	*Pelecanus occidentalis*
California least tern	*Sterna albinfrons browni*
California yellow-billed cuckoo[6]	*Coccyzus americanus occidentalis*

Reptiles

Sagebrush lizard	*Sceloporus graciosus*
Western fence lizard	*Sceloporus occidentalis*
Side-blotched lizard	*Uta stansburiana*
Coast horned lizard	*Phrynosoma coronatum*

Reptiles (Continued)

Desert horned lizard	*Phrynosoma platyrhinos*
Western skink	*Eumeces skiltonianus*
Gilbert's skink	*Eumeces gilberti*
Collared lizard	*Crotaphytus collaris*
Yucca night lizard	*Xantusia vigilis*
Western whiptail	*Cnemidophorus tigris*
Southern alligator lizard	*Gerrhonotus multicarinatus*
California legless lizard	*Anniella pulchra*
Leopard lizard	*Crotaphytus wislizenii*
Western blind snake	*Leptotyphlops humilis*
Western patch-nosed snake	*Salvadora*
Ring-necked snake	*Diadophis punctatus*
Western ring-neck snake	*Diadophis amabilis*
Striped racer	*Masticophis lateralis*
Common whipsnake	*Masticophis flagellum*
Garter snake	*Thamnophis spp.*
Gopher snake	*Pituophis catenifer*
Glossy snake	*Arizona elegans*
Mountain king snake	*Lampropeltis zonata*
Common king snake	*Lampropeltis getulus*
Long-nosed snake	*Rhinocheilus lecontei*
Night snake	*Hypsiglena torquata*
California lyre snake	*Trimorphodon vandenburghi*
Sidewinder	*Crotalus cerastes*
Mojave rattlesnake	*Crotalus scutulatus*
Western rattlesnake	*Crotalus viridis*
Pacific pond turtle	*Clemmys marmorata*
Desert tortoise	*Gopherus agassizii*
Southern rubber boa[6]	*Charina bottae umbratica*
Coachella fringe-toed lizard[7]	*Uma inornata*

Amphibians

Eschscholtz's salamander	*Ensatina eschscholtzi*
Desert slender salamander[7]	*Batrachoseps aridus*
California newt	*Taricha torosa*
Foothill yellow-legged frog	*Rana boylei*
Pacific tree frog	*Hyla regilla*
Canyon tree frog	*Hyla californiae*
Bullfrog	*Rana catesbeiana*
Arroyo toad	*Bufo microscaphus*
Western toad	*Bufo boreas*

Fish

Unarmored threespine stickeback[7]	*Gasterosteus aculeatus williamsoni*
Mojave chub[7]	*Gila bicolor mohavensis*

Status

1-occurrence limited to one or a few highly restricted populations or present in seldom reported small numbers

2-not endangered

3-occurrence confined to several populations or to one extended population

4-rare, but found in significant numbers and distributed widely enough that the potential for extinction is low

5-endangered in a portion of its range

6-rare

7-endangered

APPENDIX B. ENVIRONMENTAL CHECKLIST

	Yes	Maybe	No
1. Earth. Will the proposal result in:			
a. Unstable earth conditions or in changes in geologic substructures?			X
b. Disruptions, displacements, compaction, or overcovering of the soil?			X
c. Change in topography or ground surface relief features?			X
d. The destruction, covering, or modification of any unique geologic or physical features?			X
e. Any increase in wind or water erosion of soils, either on or off the site?			X
f. Changes in deposition or erosion of beach sands, or changes in siltation, deposition or erosion which may modify the channel of a river or stream or the bed of the ocean or any bay, inlet, or lake?			X
g. Exposure of people or property to geologic hazards such as earthquakes, landslides, mudslides, ground failure, or similar hazards?			X
2. Air. Will the proposal result in:			
a. Substantial air emissions or deterioration of ambient air quality?			X
b. The creation of objectionable odors?			X
c. Alteration of air movement, moisture, or temperature, or any change in climate, either locally or regionally?			X
3. Water. Will the proposal result in:			
a. Changes in currents, or the course of direction of water movements, in either marine or fresh waters?	X		
b. Changes in absorption rates, drainage patterns, or the rate and amount of surface runoff?	X		
c. Alterations to the course or flow of flood waters?			X
d. Change in the amount of surface water in any water body?	X		
e. Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen, or turbidity?		X	
f. Alteration of the direction or rate of flow of ground waters?		X	
g. Change in the quantity of ground waters, either through direct additions or withdrawals, or through interception of an aquifer by cuts or excavations?	X		

	Yes	Maybe	No
h. Substantial reduction in the amount of water otherwise available for public water supplies?			X
i. Exposure of people or property to water-related hazards such as flooding or tidal waves?			X
4. Plant Life. Will the proposal result in:			
a. Change in the diversity of species, or number of any species of plants (including trees, shrubs, grass, crops, and aquatic plants)?		X	
b. Reduction of the numbers of any unique, rare, or endangered species of plants?		X	
c. Introduction of new species of plants into an area, or in a barrier to the normal replenishment of existing species?			X
d. Reduction in acreage of any agricultural crop?	X		
5. Animal Life. Will the proposal result in:			
a. Change in the diversity of species, or numbers of any species of animals (birds, land animals including reptiles, fish, and shellfish, benthic organisms, or insects)?		X	
b. Reduction of the numbers of any unique, rare, or endangered species of animals?		X	
c. Introduction of new species of animals into an area, or result in a barrier to the migration or movement of animals?			X
d. Deterioration to existing fish or wildlife habitat?		X	
6. Noise. Will the proposal result in:			
a. Increases in existing noise levels?			X
b. Exposure of people to severe noise levels?			X
7. Light and Glare. Will the proposal produce new light or glare?			X
8. Land Use. Will the proposal result in a substantial alteration of the present or planned land use of an area?		X	
9. Natural Resources. Will the proposal result in:			
a. Increase in the rate of use of any natural resources?			X
b. Substantial depletion of any non- renewable natural resource?			X
10. Risk of Upset. Will the proposal involve:			
a. A risk of an explosion or the release of hazardous substances (including, but not limited to, oil, pesticides, chemicals, or radiation) in the event of an accident or upset conditions?			X
b. Possible interference with an emergency response plan or an emergency evacuation plan?			X

	Yes	Maybe	No
11. Population. Will the proposal alter the location, distribution, density, or growth rate of the human population of an area?			X
12. Housing. Will the proposal affect existing housing, or create a demand for additional housing?			X
13. Transportation/Circulation. Will the proposal result in:			
a. Generation of substantial additional vehicular movement?			X
b. Effects on existing parking facilities, or demand for new parking?			X
c. Substantial impact upon existing transportation systems?			X
d. Alterations to present patterns of circulation or movement of people and/or goods?			X
e. Alterations to waterborne, rail, or air traffic?			X
f. Increase in traffic hazards to motor vehicles, bicyclists, or pedestrians?			X
14. Public Services. Will the proposal have an effect upon, or result in a need for new or altered governmental services in any of the following areas:			
a. Fire protection?			X
b. Police protection?			X
c. Schools?			X
d. Parks or other recreational facilities?			X
e. Maintenance of public facilities, including roads?			X
f. Other governmental services?			X
15. Energy. Will the proposal result in:			
a. Use of substantial amounts of fuel or energy?			X
b. Substantial increase in demand upon existing sources of energy, or require the development of new sources of energy?			X
16. Utilities. Will the proposal result in a need for new systems, or substantial alterations to the following utilities:			
a. Power or natural gas?			X
b. Communications systems?			X
c. Water?			X
d. Sewer or septic tanks?			X
e. Storm water drainage?			X
f. Solid waste and disposal?			X
17. Human Health. Will the proposal result in:			
a. Creation of any health hazard or potential health hazard (excluding mental health)?			X
b. Exposure of people to potential health hazards?			X
18. Aesthetics. Will the proposal result in the obstruction of any scenic vista or view open to the public, or will the proposal result in the creation of an aesthetically offensive site open to public view?			X

	Yes	Maybe	No
19. Recreation. Will the proposal result in an impact upon the quality or quantity of existing recreational opportunities?		X	
20. Cultural Resources.			
a. Will the proposal result in the alteration of or the destruction of a prehistoric or historic archaeological site?			X
b. Will the proposal result in adverse physical or aesthetic effects to a prehistoric or historic building, structure, or object?			X
c. Does the proposal have the potential to cause a physical change which would affect unique ethnic cultural values?			X
d. Will the proposal restrict existing religious or sacred uses within the potential impact area?			X
21. Mandatory Findings of Significance.			
a. Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal, or eliminate important examples of the major periods of California history or prehistory?		X	
b. Does the project have the potential to achieve short-term, to the disadvantage of long-term, environmental goals? (A short-term impact on the environment is one which occurs in a relatively brief, definitive period of time, while long-term impacts will endure well into the future.)			X
c. Does the project have impacts which are individually limited, but cumulatively considerable? (A project may impact on two or more separate resources where the impact on each resource is relatively small, but where the effect of the total of those impacts on the environment is significant.)		X	
d. Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?			X

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