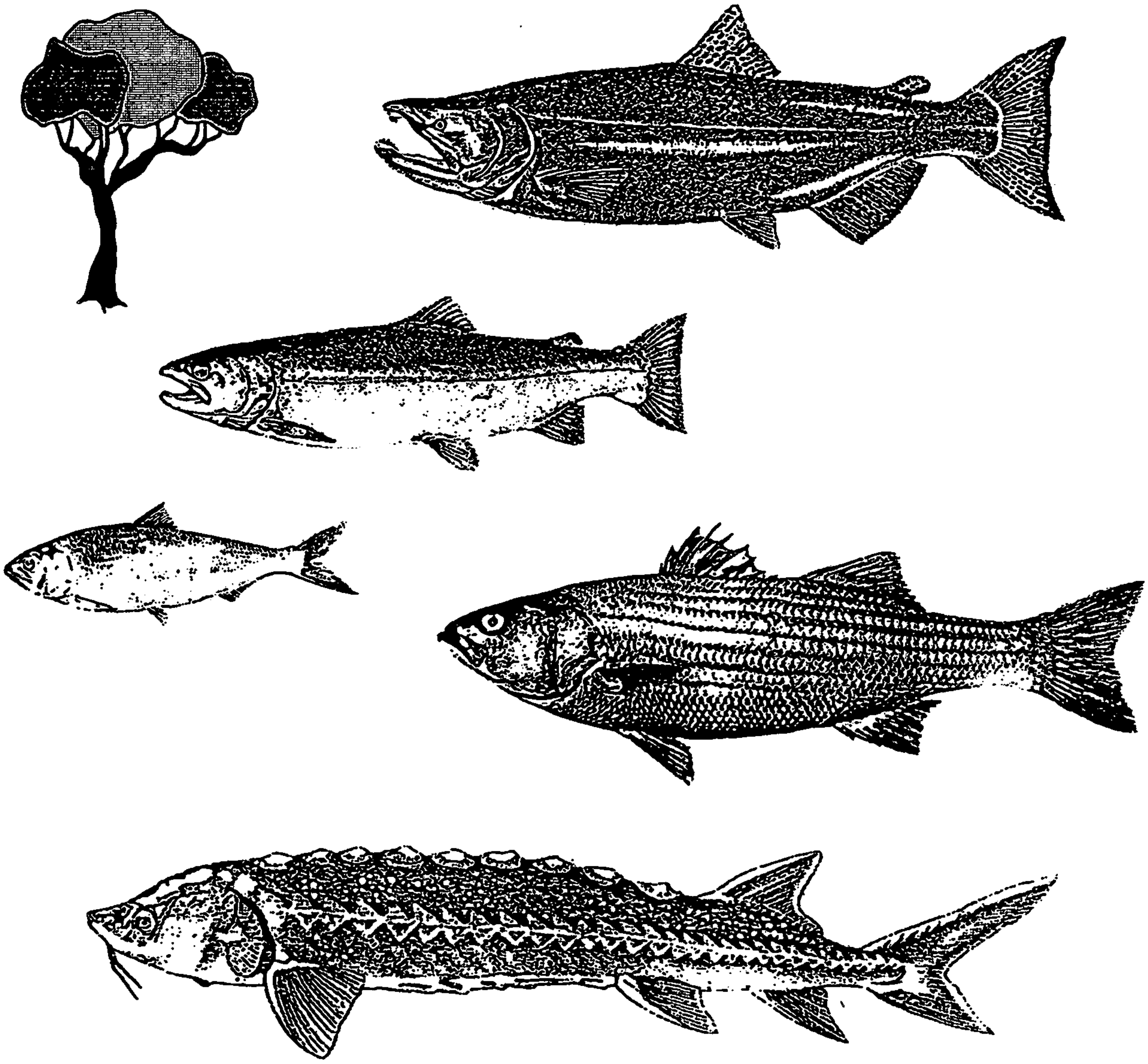
RESTORING CENTRAL VALLEY STREAMS:

A PLAN FOR ACTION



DEPARTMENT OF FISH AND GAME

NOVEMBER
1993

STATE OF CALIFORNIA—THE RESOURCES AGENCY PETE WILSON, *Governor*

DEPARTMENT OF FISH AND GAME
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November 10, 1993

To Whom It May Concern:

On behalf of the California Department of Fish and Game (DFG), I am pleased to present our report, *Restoring Central Valley Streams: A Plan for Action*, which will serve as the foundation for restoring Central Valley anadromous fish habitat and riparian communities. In this action plan, the DFG assesses the present conditions and needs of Central Valley anadromous fish habitat, the associated riparian wetlands, and sets priorities for taking action.

As presented in Governor Pete Wilson's April 1992, water policy statement, the specific goals of this plan are to restore and protect California's aquatic ecosystems that support fish and wildlife and to protect threatened and endangered species. This would implement the State-legislated policy to double populations of anadromous fish in California.

We Californians must begin restoring the Central Valley's premier anadromous fishes: the various runs of salmon, steelhead, striped bass, sturgeon, and American shad. This effort, however, will be costly. Just to restore those fish habitats for which we have an estimated cost will likely require more than $500 million. The economic benefits accruing from restoration of these valuable habitats and fisheries, however, should outweigh the costs.

The DFG and other State and Federal agencies, such as the California Department of Water Resources and the U.S. Bureau of Reclamation, have active, ongoing habitat restoration and fishery protection programs within the Central Valley. For example, using funds provided by the State Water Contractors, the Department of Water Resources and the DFG have renovated spawning gravel in areas of the Tuolumne and Merced rivers for the benefit of fall-run chinook salmon, exchanged water in Mill Creek (a tributary of the Sacramento River) to benefit spring-run chinook salmon, and placed over 100,000 cubic yards of spawning gravel into the upper Sacramento River near Redding for the benefit of all runs of salmon and steelhead. The U.S. Bureau of Reclamation is providing funding to the DFG to accomplish similar habitat restoration actions.

The DFG has been restoring fish habitat for many years. On the north coast, for example, we have approved and supervised the expenditure of $26 million to implement over 1,200 individual habitat restoration projects since 1981. Many of the north coast projects have included stream bank protection, stabilization, and revegetation. Other instream habitat improvement projects include the installation of structures to provide cover, scour holding and rearing pools, and removing barriers to upstream migration. These projects have benefited the fisheries, provided many opportunities for employing area residents, and established strong partnerships with action groups, timber companies, county and local governmental agencies, and individuals. We are now ready to increase our efforts in similar ways in the Central Valley.

The priorities in this "Plan for Action" will guide our future efforts toward restoration. As the plan is dynamic, we are prepared to adjust our priorities as we identify additional needs for habitat restoration. Our solutions are not cast in stone; consequently, if more suitable alternatives are brought to our attention, they will be incorporated in the plan. I directed the development of this plan and requested that it be done quickly - in a manner not typical of governmental agencies - to capitalize on immediate opportunities for implementation and restoration. I would welcome any comments directed at implementing the many restoration actions presented in the plan.

We want to get things done for these fish, and the DFG now needs your participation. Many of the largest and most expensive solutions have been in the planning and design stage for several years, and, with the passage of the Central Valley Project Improvement Act (Public Law 102-575), are likely to be implemented within the next several years. But the success of the overall program will require open partnerships between the DFG and private interests for the numerous smaller-scale restoration actions. If you can help restore anadromous fish in the Central Valley, please contact Mr. Tim Farley, Department of Fish and Game, Inland Fisheries Division, 1416 Ninth Street, Sacramento, California 95814, telephone (916) 653-6194.

Sincerely,

Boyd Gibbons
Director

State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

RESTORING CENTRAL VALLEY STREAMS: A PLAN FOR ACTION

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November 1993

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RESTORING CENTRAL VALLEY STREAMS: A PLAN FOR ACTION

EXECUTIVE SUMMARY

The specific goals of this plan, as presented in Governor Pete Wilson's April 1992 water policy statement, are to restore and protect California's aquatic ecosystems that support fish and wildlife, and to protect threatened and endangered species. The goals of this plan also incorporate the State-legislated mandate and policy to double populations of anadromous fish in California.

This plan encompasses all Central Valley waters accessible to anadromous fish, excluding the Sacramento-San Joaquin Delta. The descriptions, analyses, conclusions, and action recommendations constitute the California Department of Fish and Game's assessment of the present conditions and needs of Central Valley anadromous fish habitat and of the associated riparian wetlands. The two overriding precepts that guided development and priority rating of all action recommendations are: (1) those fish or wildlife populations in jeopardy of extinction should be restored to a healthy stable condition, and (2) all anadromous populations should be significantly increased with the long-term goal of doubling their 1988 population numbers. The doubling goal for anadromous fish was established by the State legislature in 1988 with the passage of the Salmon, Steelhead Trout, and Anadromous Fisheries Program Act (Chapter 1545/88).

Central Valley salmon and steelhead spawning habitat has been greatly reduced from approximately 6,000 miles that existed prior to the construction of dams to less than 300 miles that exists today. Riparian wetland habitat has been reduced by about the same proportion. Some fish and wildlife species have been irretrievably lost as a result of this drastic decline in habitat. The populations of many other species have also declined to alarmingly low levels. When implemented, the actions recommended in this plan will result in significant recovery of all anadromous fish populations, and create a solid base of riparian wetland habitat to recover and maintain the associated fish and wildlife communities.

The plan is organized to allow maximum flexibility in its application for solving fish and wildlife habitat restoration and management problems. A unique set of fishery habitat recommendations is made for each major tributary. Each action recommendation and the sets of recommendations can be used separately or in combination. Agencies and organizations with basin-wide authorities or interests can use the plan in its entirety, or local agencies and organizations can make independent or coordinated use of individual stream action plans to meet the specific fish and wildlife planning or restoration needs in their area of concern.

Riparian wetland preservation and restoration action recommendations are generic to the entire Central Valley.

This plan relies heavily on the presumption that the major fish and wildlife habitat problems in the Delta will be corrected. Further, the maximum fish and wildlife benefit will be achieved only through the integrated implementation of all proposed actions. Priority or urgency of any of these actions for a specific restoration program will depend on the specified, or mandated goal of that program. For example, a program focused specifically on recovering the Sacramento River winter-run chinook salmon will have a different list of action priorities from one designed to double all anadromous fish populations, or from a program to restore riparian wetland habitats.

The list of highest priority actions necessary to restore anadromous fish habitat in the Central Valley is led by actions to recover and restore habitat of the State-designated endangered Sacramento River winter-run chinook salmon, and riparian areas vital to other threatened or endangered species. These are closely followed by actions to restore habitat of species in immediate jeopardy of being threatened with extinction. Finally, the list contains actions vital to restoring habitat of all Central Valley anadromous fish populations to allow those populations to double.

Priority of Actions

Each stream plan identifies the principal actions required to restore anadromous fish habitat in that particular stream. Some of the proposed actions are more important than others, and some streams are more important to the overall health or abundance of fish populations than others. Success of this action plan and rapid recovery of the fisheries requires that agencies and responsible parties address the most urgent and important actions first.

The activities proposed in each stream action plan fall into three general categories: habitat restoration, administrative, and evaluation. Habitat restoration actions are defined as those activities involving direct manipulation and modification of habitat or physical instream structures through the use of construction tools or heavy equipment. Administrative activities include negotiating streamflow agreements, developing and enforcing existing laws and regulations, coordinating water management operations in tributaries and in the main stem rivers above the Delta as they pertain to the aquatic environment and the associated resources, and participating in legal or administrative proceedings to obtain improved water quality or increased streamflow. Evaluation activities include developing and refining resource information necessary to implement habitat restoration or administrative actions. They also include evaluating completed habitat restoration or administrative actions.

All recommended actions have been ranked according to an alpha-numeric rating system. The alpha designator indicates whether the action is for the benefit of special status fish, for multiple species, or for minor populations. The numeric designator indicates the anticipated permanence or significance of the action. The alpha rating criteria are as follows: (A) The action principally benefits the habitat of threatened or endangered anadromous fish species or habitat of anadromous fish species and races in decline that may become threatened. These species include the State endangered and federally threatened winter-run chinook salmon, or species of special concern such as the spring-run and San Joaquin fall-run chinook salmon. (B) The action principally benefits habitat for aquatic communities which can produce large numbers of anadromous fish or provide benefits for multiple species (species diversity). The American and lower Sacramento rivers would be included in this classification. (C) The action principally benefits habitat of relatively small populations of anadromous fish species in categories other than in A or B, but which are of sufficient merit to receive consideration. Therefore, according to these criteria, all actions are classified as A, B, or C in descending order of importance.

Habitat restoration and administrative activities are further rated according to their permanence or significance and their anticipated benefit to habitat of the target resource. Within each priority level, individual habitat restoration and administrative actions are placed into one of three numeric categories. The numeric rating criteria are as follows: (1) Actions having significant long-term or permanent benefits, (2) Actions having significant short-term benefits, or a moderate long-term benefits, and (3) Actions having relatively minor benefits, but are required to complete the restoration program.

Evaluation recommendations are similarly assigned numeric rankings, but with somewhat different criteria. Category 1 evaluation actions are needed prior to implementing a specific habitat restoration or administrative action. Category 2 evaluation actions follow the implementation of a habitat restoration or administrative action.

The rating and category for each recommendation were combined to determine a priority for each recommended action (Table 1). Highest priority, A-1, was given to those actions which would result in long-term benefits to an endangered or threatened species or species of special concern. Actions which did not affect listed species or species of special concern and did not result in long-term benefits to these species, were assigned lesser priorities.

TABLE 1. Criteria Used for Developing Priority Ratings for Recommended Action Items in the Central Valley Stream Action Plans.

Priority	Criteria
A-1	Actions to improve habitat of species that are threatened, endangered, or of special concern. Restoration or administrative actions having significant long-term benefits or evaluations needed prior to implementing restoration or administrative actions.
A-2	Actions to improve habitat of species that are threatened, endangered, or of special concern. Restoration or administrative actions having moderate long-term or significant short-term benefits or evaluations needed after completing restoration or administrative actions.
A-3	Actions to improve habitat of species that are threatened, endangered, or of special concern. Restoration or administrative actions resulting in incremental improvements to the habitat for these species at a level less than for priority A-2.
B-1	Actions to improve habitat that supports large populations of anadromous fish or for rivers with multiple species of anadromous fish. Restoration or administrative actions resulting in significant long-term benefits or evaluations needed prior to implementing restoration or administrative actions.
B-2	Actions to improve habitat that supports large populations of anadromous fish or for rivers with multiple species of anadromous fish. Restoration or administrative actions resulting in moderate long-term or significant short-term benefits or evaluations needed after completing restoration or administrative actions.
B-3	Actions to improve habitat that supports large populations of anadromous fish or for rivers with multiple species of anadromous fish. Restoration or administrative actions resulting in incremental habitat improvements at a level less than for priority B-2.
C-1	All other actions that improve habitat for anadromous fish. Restoration or administrative actions resulting in significant long-term benefits or evaluations needed prior to implementing restoration or administrative actions.
C-2	All other actions that improve habitat for anadromous fish. Restoration or administrative actions resulting in moderate long-term or significant short-term benefits or evaluations needed after completing restoration or administrative actions.
C-3	All other actions that improve habitat for anadromous fish. Restoration or administrative actions resulting in incremental habitat improvements at a level less than for priority C-2.

Habitat restoration actions, ranked in priority order, are presented in Table 2. Administrative actions necessary to restore stream habitat, ranked in priority order, are listed in Table 3, and evaluation actions, also ranked in priority order, are listed in Table 4. Recommendations to protect and restore riparian habitat within the Central Valley follow Table 4.

TABLE 2. Anadromous Fish Habitat Restoration Actions Listed in Priority Order.

Priority	Anadromous Fish Habitat Restoration Action	Cost
A-1	Install and operate permanent structural temperature control devices at Shasta and Whiskeytown dams and develop and implement modifications in Central Valley Project operations as needed to assist in the Secretary of the Interior's efforts to control water temperatures in the upper Sacramento River.	$105,000,000
A-1	Develop and implement permanent measures to minimize fish passage problems for adult and juvenile anadromous fish at the Red Bluff Diversion Dam in a manner that provides for the use of associated Central Valley Project conveyance facilities for delivery of water to the Sacramento Valley National Wildlife Refuge complex.	$52,000,000
A-1	Resolve entrainment problems at the Glenn-Colusa Irrigation District's Hamilton City Pumping Plant on the Sacramento River.	$45,000,000
A-1	Control effluent from Iron Mt. Mine Superfund site until Basin Plan objectives are met.	No Estimate
A-1	Remove Clough Dam on Mill Creek and move the existing diversion to allow salmon and steelhead unimpaired access to spawning areas.	No Estimate
A-1	Relocate the M&T diversion in Big Chico Creek to the Sacramento River and install fish screens.	$2,500,000
A-1	Establish and maintain a Sacramento River meander belt and limit future bank protection to preserve instream and riparian habitat.	No Estimate
A-1	Acquire Butte Creek water rights from willing sellers.	$500,000
A-1	Identify and correct fish passage problems at diversions in Butte Creek through dam removal or improvements to existing fish ladders.	$475,000
A-1	Install fish screens on 11 agricultural diversions in Butte Creek that range in capacity from 70 to 1,100 cfs.	$14,589,000
A-1	Provide flows from Whiskeytown Dam on Clear Creek to allow provide adequate spawning, incubation, rearing, and emigration habitat for salmon and steelhead.	No Estimate
A-1	Restore spawning gravel in Clear Creek for salmon and steelhead.	$500,000
A-1	Repair or rebuild the water control structures in Big Chico Creek at Five Mile Dam and Lindo Channel following completion of the hydrologic study.	$100,000
A-1	Inspect and repair existing fish ladders in Big Chico Creek.	$100,000

TABLE 2. Habitat Restoration Actions (Continued).

Priority	Anadromous Fish Habitat Restoration Action	Cost
A-1	Install a fish screen in the Yuba River on Browns Valley Irrigation District diversion.	No Estimate
A-1	Replace screens in the Yuba River on South Yuba-Brophy and the Hallwood-Cordua diversions.	No Estimate
A-1	Install and operate a temporary fish barrier on the San Joaquin River at the Merced River confluence each fall to prevent adult salmon from straying into irrigation canals. The barrier should be operated until a decision is made regarding restoration of chinook salmon in the upper San Joaquin River below Friant Dam.	$50,000 per year
A-1	Install a fish protective device in the San Joaquin River at Banta-Carbona Irrigation District diversion, or provide alternative water supplies to the district.	$1,245,000
A-1	Install a fish protective device in the San Joaquin River at West Stanislaus Irrigation District diversion, or provide alternate water supplies to the district.	$1,245,000
A-1	Install a fish protective device in the San Joaquin River at Patterson Irrigation District diversion, or provide alternate water supplies to the district.	$1,245,000
A-1	Install a fish protective device in the San Joaquin River at El Solyo Irrigation District diversion.	$400,000
A-1	Upgrade screens on four medium-sized riparian diversions in the Merced River (diversion capacities [cfs]: 20, 25, 27, 52), and upgrade fish bypasses on two additional diversions.	$620,000
A-1	Restore habitat for salmon migration, spawning, and rearing in the Merced River by rehabilitating riffle areas, repairing or constructing levees and channels, and isolating mining pit areas from the active channel.	$4,000,000
A-1	Restore habitat for spawning, rearing, and migration on the Tuolumne River at 17 sites by renovating spawning gravel and riffle areas, increasing side channel diversity, recontouring channels, and isolating predator habitat.	$2,000,000
A-1	Restore habitat for spawning, rearing, and migration on the Stanislaus River by renovating approximately 11,400 square yards of spawning and rearing habitat and modify approximately 14,600 linear feet of channel.	$1,925,000
A-1	Construct an effective escape channel in the west corner of the Keswick Dam stilling basin to protect salmon and steelhead.	No Estimate
A-1	Remove Sacramento River bank rip-rap and restore anadromous fish habitat.	No Estimate

TABLE 2. Habitat Restoration Actions (Continued).

Priority	Anadromous Fish Habitat Restoration Action	Cost
A-1	Continue acquisition of land and conservation easements to protect the riparian corridor along the Sacramento River.	No Estimate
A-1	Continue planting riparian vegetation along the banks of the Sacramento River.	No Estimate
A-1	In the absence of a water exchange program, install fish screens on the agricultural diversion in Battle Creek.	$110,000
A-1	Improve fish passage at Eagle Canyon in Battle Creek.	$5,000
A-1	Screen all unscreened hydropower diversions in Battle Creek.	$900,000
A-2	Correct fish passage and flow fluctuation problems at Anderson-Cottonwood Irrigation District's diversion dam on the Sacramento River.	No Estimate
A-2	Screen the larger diversions along the Sacramento River.	No Estimate
A-2	Purchase land adjacent to Clear Creek to preserve remaining sources of spawning gravel.	$1,000,000
A-2	Manage agricultural return flows from Colusa Drain and Sutter Slough to control water temperatures in the Sacramento River, and install barriers to upstream migration.	No Estimate
A-2	Improve spawning and rearing habitat in Butte Creek.	$200,000
A-2	Improve spawning and rearing habitat in the Yuba River.	$1,000,000
A-2	Avoid peaking power operations at Oroville Reservoir when storage is at or below 1.7 million AF.	No Estimate
B-1	Upgrade existing fish screens in the Mokelumne River at Woodbridge Irrigation District's diversion.	$2,000,000
B-1	Improve upstream fish passage in the Mokelumne River at Woodbridge Irrigation District Dam.	$100,000 to $700,000
B-1	Install fish screens in the Mokelumne River at North San Joaquin Water Conservation District diversions (north and south).	$300,000
B-1	Improve spawning habitat on the Mokelumne River by addition of approximately 23,000 cubic yards of gravel.	$500,000
B-2	Require stockpiling of spawning gravel from existing mining operations in Cottonwood Creek for subsequent placement in the Sacramento River.	$100,000

TABLE 2. Habitat Restoration Actions (Continued).

Priority	Anadromous Fish Habitat Restoration Action	Cost
B-3	Assist the City of Chico in eliminating siltation problems at One Mile Dam on Big Chico Creek.	$50,000
B-3	Protect and manage riparian habitat along the Yuba River.	$100,000/yr
C-1	Screen, as needed, any diversion on Cow Creek (each diversion < 5 cfs) that entrains juvenile salmon or steelhead.	$180,000
C-1	Install fish screens on all major water diversions in Bear Creek.	No Estimate
C-1	Construct fish passage facilities in the Calaveras River at Bellota Weir (Mormon Slough Diversion), Clements Dam (Clements Road Bridge), and Cherryland Dam, unless sufficient flow is obtained for adult salmon passage.	$150,000
C-2	Fence riparian corridors to exclude livestock from Cow Creek.	$800,000
C-2	Construct a fish passage structure over the Corning Canal siphon in Elder Creek.	$250,000
C-2	Replenish gravel on reconstructed spawning riffles in Paynes Creek on an as-needed basis.	$3,000/yr
C-2	Renovate existing spawning gravel in Mill Creek.	$100,000
C-2	Construct gravel detention structures in Mill Creek to provide new or additional spawning areas.	$500,000
C-2	Restore spawning gravel in the North Fork of Battle Creek.	$50,000
C-2	Construct a barrier at the mouth of Crowley Gulch on Cottonwood Creek to prevent entry of adult fish.	$50,000
C-3	Restore spawning gravel in the lower reach of Deer Creek.	$100,000
C-3	Dredge behind Saeltzer Dam on Clear Creek to provide a sediment trap.	$50,000
Total	Total does not include actions where "No Estimate" is listed. Inclusion of these "No Estimate" actions will add substantially to the overall total.	$343,292,000

TABLE 3. Administrative Actions Required for Full Restoration of Anadromous Fish Habitat Listed in Priority Order.

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
A-1	Meet flow standards, objectives, and diversion limits set forth in all laws and judicial decisions that apply to Central Valley Project facilities.	USBR
A-1	Adopt instream flow, seasonal fluctuations, and ramping rates for the Sacramento River as recommended by DFG: <u>Shasta Reservoir carryover storage < 2.8 million AF</u> October 1 - April 30 3,500 cfs May 1 - September 30 4,000 cfs <u>Shasta Reservoir carryover storage > 2.8 million AF</u> All Year 4,500 cfs Ramping rate should not exceed 15% in a 12-hour period for flows above 6,000 cfs, 200 cfs per 24-hour period for flows between 4,500 and 6,000 cfs, and 100 cfs per night for flows less than 4,500	SWRCB EPA
A-1	Implement Basin Plan objectives for the Sacramento River for all water quality parameters.	RWQCB
A-1	Through negotiations, obtain instream flows for salmon and steelhead in the lower reach of Deer Creek.	DFG Water Districts
A-1	Continue to provide recommendations to the USFS for developing land use policies to protect spring-run chinook salmon habitat in Mill Creek.	DFG USFS
A-1	Obtain increased flow in Mill Creek to allow adult and juvenile salmon and steelhead unimpaired up- and downstream passage.	DFG/SWRCB Water Agencies
A-1	Prepare a multi-agency Comprehensive Resource Management Plan for Clear Creek to address excessive erosion in the watershed.	multi-agency
A-1	Obtain increased streamflow below Whiskeytown Dam on Clear Creek to improve migration, spawning, and rearing habitat.	DFG/USBR FERC/SWRCB
A-1	Prepare a salmon and steelhead management and habitat restoration plan for Butte Creek.	DFG
A-1	Seek amendments to existing water rights and power licenses to provide additional Butte Creek flow for salmon and steelhead.	FERC SWRCB
A-1	Through the FERC and water rights processes, obtain increase releases from PG&E power plant diversions in Battle Creek to provide for anadromous fish.	FERC SWRCB

TABLE 3. Administrative Actions (Continued).

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
A-1	Negotiate with the Los Molinos Mutual Water Company for additional flow in Antelope Creek for salmon and steelhead.	DFG Water District
A-1	Establish a program to exchange Antelope Creek surface water for ground water with landowners with existing wells.	DFG
A-1	Evaluate the benefit of drilling new wells to establish a water exchange program with private landowners who divert Antelope Creek water.	DFG
A-1	Consider administrative or legal remedies to obtain streamflows in Antelope Creek to ensure restoration of habitat for salmon and steelhead.	DFG SWRCB
A-1	Develop a comprehensive plan to address fish and wildlife on the San Joaquin River, including streamflow, channel, and riparian habitat, and water quality improvements needed to re-establish naturally reproducing anadromous fisheries on the San Joaquin River below Friant Dam.	USFWS/DFG NMFS/USBR DWR/COE
A-1	Establish interim basin outflow objectives, criteria, or standards to protect juvenile salmon and steelhead during April 15 - May 15. The following minimum flow objectives should be adopted for Vernalis on the San Joaquin River for the April 15 through May 15 period during a defined interim period: Water Year type — Flow (cfs) Wet — 10,000 Above Normal — 8,000 Below Normal — 6,000 Dry — 4,000 Critical — 2,000	SWRCB EPA FERC
A-1	Establish interim basin outflow objectives, criteria, or standards to protect the upstream migration of adult salmon in the San Joaquin River.	SWRCB EPA
A-1	Establish water temperature protection objectives for the San Joaquin River at Vernalis (fall and spring).	SWRCB EPA
A-1	Require the following interim total annual instream flow releases (AF) on the Merced River for fisheries: Water Year Type — Total Release (AF) Wet water year - 355,956 Above-normal water year - 320,514 Below-normal water year - 267,252 Dry water year - 218,445 Critical water year - 181,716.	SWRCB EPA FERC

TABLE 3. Administrative Actions (Continued).

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
A-1	Require measurement of instream flow requirements at the Crocker-Huffman and Snelling stream gauges on the Merced River.	DWR
A-1	Establish the following water quality objectives on the Merced River for the protection of salmon spawning, rearing, and emigration: 56°F maximum from October 15-February 15 to protect incubating eggs throughout the designated spawning reach from Crocker-Huffman Dam to Cressey. 65°F maximum surface water temperature from April 1 - May 31 to protect emigrating salmon throughout the lower Merced River.	SWRCB RWQCB EPA
A-1	Require adequate instream flow releases for the protection of salmon spawning, rearing, and emigration on the Tuolumne River.	SWRCB FERC
A-1	Establish water quality objectives for the protection of salmon spawning, rearing, and emigration on the Tuolumne River: 56°F maximum from October 15 - February 15 to protect spawning and egg incubation throughout the designated spawning reach from LaGrange Dam to Waterford. 65°F maximum surface water temperature from April 1 - May 31 throughout the lower Tuolumne River to protect emigrating smolts.	SWRCB RWQCB EPA
A-1	Require the following interim total annual instream flow releases on the Stanislaus River for fisheries (AF): Water Year Type — Total Release (AF) Wet water year - 381,498 Above-normal water year - 325,959 Below-normal water year - 269,034 Dry water year - 221,811 Critical water year - 185,280.	SWRCB EPA FERC
A-1	Establish the following water quality objectives on the Stanislaus River for the protection of salmon spawning, rearing, and emigration: 56°F maximum water temperature from October 15 - February 15 throughout the designated spawning reach from Goodwin Dam to Riverbank to protect spawning and egg incubation. 65°F maximum surface water temperature from April 1 - May 31 throughout the lower Stanislaus River to protect emigrating smolts.	SWRCB RWQCB EPA

TABLE 3. Administrative Actions (Continued).

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
A-1	Ensure compliance with fish screening requirements in Fish and Game Code Section 6100 for diversions in the Yuba River.	DFG
A-1	Require the following temperatures and streamflows to protect salmon and steelhead in the Lower Yuba River: Maximum Temperature (°F) Period / @Daguerre / @Marysville Oct 1 - Mar 31 / 56 / 57 April / 60 / 60 May / NR / 60 June / NR / 65 Jul - Aug / 65 / NR Sept / NR / 65 Streamflow (cfs) Period / @Marysville Oct - Mar / 700 April / 1,000 May / 2,000 June / 1,500 Jul - Sept / 450	SWRCB FERC Local Agencies
A-1	Maintain 1.5 million AF of carryover storage in Oroville Reservoir on October 1 of each year to preserve cold water for later release into the Feather River.	DWR
A-1	Adopt new flow release criteria for the Feather River following completion of the DWR instream flow study.	SWRCB

TABLE 3. Administrative Actions (Continued).

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
A-1	Require the following streamflow and temperature standards for the Feather River at the specified locations: At the riffle one mile below Thermolito Afterbay outlet: Period / Streamflow (cfs) / Temperature (°F) Jan - Apr / 2,000 / 56 May 1 - 15 / 3,000 / 60 May 16 - Jun 15 / 4,000 / 60 June 16 - Oct 15 / 1,000 / NR Oct 16 - Dec 31 / 1,700 / 56 At Shanghi Bend: Jan - Mar / 2,700 / 56 Apr / 3,000 / 60 May 1 - 15 / 5,000 / 60 May 16 - Jun 15 / 6,000 / 65 June 16 - Oct 15 / 1,500 / NR Oct 16 - Dec 31 / 2,200 / 56	SWRCB FERC DWR
A-1	Prepare and implement a comprehensive plan to restore habitat in Battle Creek for winter- and spring-run chinook salmon and steelhead.	DFG USFWS
A-1	Develop and implement a mechanism for real-time water projects operations coordination between the CVP and SWP in the Sacramento River Basin.	USBR DWR DFG
A-1	Seek general plan amendments to establish protection zones for riparian vegetation throughout the Sacramento River Basin.	Local Govt's
A-2	Prepare a watershed management and restoration plan for Big Chico Creek.	DFG/DWR RWQCB/Chico
A-2	Develop and implement a continuing program for the purpose of restoring and replenishing, as needed, spawning gravel lost due to the construction and operation of Central Valley Project dams, bank protection projects, and other actions that have reduced the availability of spawning gravel and rearing habitat in the Stanislaus River downstream from Goodwin Dam.	USBR DWR DFG USCOE
A-2	Develop and implement a continuing program for the purpose of restoring and replenishing, as needed, spawning gravel lost due to the construction and operation of Central Valley Project dams, bank protection projects, and other actions that have reduced the availability of spawning gravel and rearing habitat in the upper Sacramento River from Keswick Dam to Red Bluff Diversion Dam.	USBR DWR DFG USCOE

TABLE 3. Administrative Actions (Continued).

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
A-2	Prohibit dredging operations during late summer and fall in the Stockton Ship Channel to protect water quality for anadromous fish.	USACOE RWQCB
A-2	Develop a plan to increase rearing habitat for juvenile salmon and steelhead in the Yuba River.	DFG
A-2	Provide additional law enforcement to protect Stanislaus River salmon habitat through diligent enforcement of screening, water pollution, and streambed alteration Fish and Game Code sections.	DFG
A-2	Provide additional law enforcement to protect Tuolumne River salmon habitat through diligent enforcement of screening, water pollution, and streambed alteration Fish and Game Code sections.	DFG
A-2	Provide additional law enforcement to protect Merced River salmon habitat through diligent enforcement of screening, water pollution, and streambed alteration Fish and Game Code sections.	DFG
B-1	Implement RWQCB waste discharge requirements for operation of the One Mile Recreation Area in Big Chico Creek.	Chico DFG/RWQCB
B-1	Regulate gravel extraction to protect salmon and steelhead spawning areas in the Yuba River.	DFG County
B-1	After installation of an effective water treatment system at CNFH, allow fall-run salmon to migrate past the hatchery to spawn naturally in Battle Creek.	USFWS
B-1	Require the following instream flow releases to the American River below Nimbus Dam: Period — Flow (cfs) Oct 15 - Feb 28 — 1,750 - 4,000 Mar 1 - Jun 30 — 3,000 - 6,000 Jul 1 - Oct 14 — 1,500	Court SWRCB DFG USBR
B-1	Establish minimum fall carryover storage at Folsom Reservoir to maintain suitable year-round temperatures in the American River.	SWRCB
B-1	Adopt ramping rate criteria to protect eggs and fry of anadromous fish in the American River.	DFG USBR
B-1	Develop a coordinated multi-agency management plan for the Lower American River.	DFG/USFWS NMFS/COE USBR/County

TABLE 3. Administrative Actions (Continued).

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
B-1	Require the following total annual instream flow releases from the Mokelumne River (AF): Water Year Type — Total Release (AF) Wet water year - 284,628 Normal water year - 236,217 Dry water year - 161,124	SWRCB FERC
B-1	Establish water quality objectives on the Mokelumne River for the protection of salmon spawning, rearing, and emigration.	SWRCB
B-1	Develop and implement a gravel management program for Cottonwood Creek.	Shasta Co. DFG
B-1	Complete an instream flow study for the lower Bear River.	DFG
B-1	Evaluate the existing water rights throughout the Bear River watershed and, if warranted, petition the SWRCB for increased instream flow.	DFG SWRCB
B-2	Develop and implement a continuing program for the purpose of restoring and replenishing, as needed, spawning gravel lost due to the construction and operation of Central Valley Project dams, bank protection projects, and other actions that have reduced the availability of spawning gravel and rearing habitat in the American River downstream from Nimbus Dam.	USBR DWR DFG
B-2	Restrict gravel extraction within the Mokelumne River floodplain.	County
B-3	Prepare a gravel management plan for Big Chico Creek.	DFG/DWR/Chico
C-1	Establish a riparian corridor protection zone for Cow Creek.	County/DFG Private Property Owners
C-1	Obtain 50 cfs for fish migration in Cow Creek through an agreement with private water right holders.	DFG/Water Right Holders
C-1	Require adequate instream flows in the Calaveras River for chinook salmon spawning, rearing, and emigration.	SWRCB
C-1	Require removal of all temporary flashboard dams in the Calaveras River, Mormon Slough, and Stockton Diverting Canal during the upstream migration period, or require provision of adequate fish passage facilities at these sites.	SWRCB DFG USACOE USBR
C-1	Negotiate for increased instream flows in Bear Creek.	DFG

TABLE 3. Administrative Actions (Continued).

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
C-1	Coordinate and implement an agreement with Anderson-Cottonwood Irrigation District for future canal operations affecting Westside streams.	DFG ACID
C-1	Continue to coordinate with local agencies to develop and implement sediment control measures for Westside streams.	DFG Local Govt
C-1	Coordinate with local agencies to develop a program to improve water quality of runoff into Westside streams from urban areas.	DFG/RWQCB Local Govt
C-2	Require fish passage when issuing permits for the Tehama-Colusa and Corning Canal siphon crossing on Thomes Creek.	COE
C-2	Require all gravel extraction permit applications to provide protection for fish passage in Thomes Creek.	DFG Tehama County
C-2	Institute an erosion control ordinance to protect salmon habitat in Thomes Creek.	Tehama County
C-2	Reduce sewage discharge into Churn Creek.	RWQCB DFG
C-2	Institute an erosion control ordinance to minimize sediment input into Elder Creek.	Tehama County
C-2	Obtain increased flow in Paynes Creek to allow adult and juvenile salmon and steelhead unimpaired up- and downstream passage.	DFG/SWRCB Water Users
C-2	Coordinate with local agencies to develop stream overflow areas to attenuate storm water runoff into Westside streams from urban areas.	Local Govt

TABLE 4. Evaluation Actions Required for Full Restoration of Anadromous Fish Habitat Listed in Priority Order.

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
A-1	Evaluate the performance of all structural remedies implemented to protect and restore the anadromous fish within the Sacramento River.	No Estimate
A-1	Reevaluate carryover storage and operational criteria for the Shasta-Trinity Division of the Central Valley Project.	No Estimate
A-1	Complete the Sacramento River instream flow study.	No Estimate
A-1	Continue monitoring upper Sacramento River spawning gravel restoration.	No Estimate
A-1	Monitor metal, dioxin, and nutrient contaminants in the Sacramento River.	No Estimate
A-1	Install an electronic fish counter on one of the diversion dams on Deer Creek.	$20,000
A-1	Conduct an instream flow study on the lower reach of Deer Creek.	$50,000
A-1	Conduct a stream flow study on Mill Creek.	$25,000
A-1	Install a stage recorder to monitor flows in Mill Creek.	$20,000
A-1	Conduct instream flow, stream temperature modeling, and related studies on the Merced River.	$350,000
A-1	Evaluate effects of fluctuating flows due to power peaking on salmon spawning and rearing in the Tuolumne River. Develop appropriate flow fluctuation criteria.	$100,000
A-1	Evaluate the benefits of interim increases in outflow in the spring and fall months for the migration of juvenile and adult salmon in the San Joaquin River.	$25,000
A-1	Develop a water temperature model for the San Joaquin River.	$100,000
A-1	Develop a dissolved oxygen model for the San Joaquin River near Stockton area to evaluate all options to decrease or avoid adult migration delays.	$100,000
A-1	In the course of preparing the Stanislaus River Basin and Calaveras River Water Use Program EIS, evaluate and determine existing and anticipate future needs in the Stanislaus River basin.	No Estimate

TABLE 4. Evaluation Actions (Continued).

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
A-1	Evaluate opportunities to re-establish spring-run salmon and increase late fall-run salmon and steelhead populations in the Stanislaus River basin.	$100,000
A-1	Complete water temperature modeling study on the Stanislaus River.	$50,000
A-1	Evaluate screening needs and set priorities in the San Joaquin River existing small- (< 10 cfs) and medium-size (15 - 250 cfs) diversions.	$25,000
A-1	Evaluate fish screening needs at 44 small riparian pump irrigation diversions on the Stanislaus River. Set priorities for installation of screens.	$15,000
A-1	Evaluate fish screening needs at 36 small riparian pump irrigation diversions on the Tuolumne River. Set priorities for installation of screens.	$15,000
A-1	Evaluate fish screening needs at 68 small riparian pump irrigation diversions on the Merced River. Set priorities for installation of screens.	$15,000
A-1	Complete evaluation of spawning, rearing, and migration habitat restoration needs on the Stanislaus River.	$33,000
A-1	Complete evaluation of spawning, rearing, and migration habitat restoration needs on the Tuolumne River.	$33,000
A-1	Complete evaluation of spawning, rearing, and migration habitat restoration needs on the Merced River.	$33,000
A-1	Inventory all water diversions in the Yuba River drainage from Englebright Dam to the Feather River.	$25,000
A-1	Conduct an instream flow study on Clear Creek.	$300,000
A-1	Conduct a Butte Creek water quality study.	$100,000
A-1	Complete the instream flow study on the Feather River.	$10,000
A-1	Complete the instream flow study on Battle Creek.	No Estimate
A-1	Monitor flow and temperatures at the hatchery to insure Feather River temperature compliance from the Fish Barrier Dam to the Thermalito Afterbay Outlet.	$10,000
A-1	Investigate developing a disease-free water supply for Coleman National Fish Hatchery on Battle Creek.	No Estimate
A-2	Evaluate fish passage problems throughout the Deer Creek drainage.	$25,000

TABLE 4. Evaluation Actions (Continued).

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
A-2	Monitor adult salmon and steelhead passage at Saeltzer Dam on Clear Creek.	$10,000
A-2	Monitor fish passage on Butte Creek.	$50,000
A-2	Conduct instream flow study on Butte Creek.	$150,000
A-2	Develop hydrologic model for Butte Creek.	No Estimate
A-2	Monitor salmon and steelhead passage on Big Chico Creek.	$50,000
A-2	Investigate flow-temperature relationship in Mill Creek.	$25,000
A-2	Evaluate existing spring-run chinook salmon and steelhead holding, spawning, and rearing habitat in Antelope Creek to identify opportunities for habitat restoration.	No Estimate
A-2	Conduct a fish passage problem survey in lower Antelope Creek.	$15,000
A-2	Reestablish the abandoned USGS gauging station upstream of the existing agricultural diversion dam on Antelope Creek.	$25,000
A-2	Conduct annual spring-run chinook salmon snorkel surveys in Antelope Creek.	$10,000
A-2	Continue to install and monitor thermographs in the headwaters of Antelope Creek to record summer water temperatures in spring-run chinook salmon holding area.	$5,000
A-2	Install and operate a thermograph and streamflow gauge near the mouth of Antelope Creek to determine flow-temperature relationships.	No Estimate
A-2	Conduct surveys in Antelope Creek for fall-run and late-fall-run chinook spawning habitat.	$5,000
A-2	Reestablish the Upper Bidwell Park USGS streamflow gauge in Big Chico Creek.	$25,000
A-2	Complete a sediment transport and hydrologic study for Big Chico Creek.	$100,000
A-2	Install and monitor thermographs in Big Chico Creek.	$10,000
A-2	Monitor flow and temperatures in the Feather River at the riffle one mile below the Thermalito Afterbay Outlet.	$10,000
B-1	Evaluate opportunities for alternative methods of providing temperature control at New Melones Reservoir on the Stanislaus River (e.g. installation of a temperature curtain, removal of Old Melones Dam).	$50,000

TABLE 4. Evaluation Actions (Continued).

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
B-1	Complete instream flow studies on the lower American River and conduct monitoring as required by court order.	$250,000
B-1	Evaluate screening needs at small riparian diversions in the Mokelumne River.	$15,000
B-1	Evaluate establishing vegetative cover along the banks of the American River.	No Estimate
B-1	Evaluate the need for gravel restoration in the American River.	$100,000
B-2	Monitor and evaluate spawning gravel quality and quantity in Clear Creek.	$75,000
B-2	Conduct a temperature modeling study in Deer Creek below existing diversions.	$20,000
B-2	Identify spawning gravel restoration sites in Big Chico Creek.	$10,000
B-2	Conduct an inventory of diversions on the Bear River and identify those needing fish screens.	$10,000
C-1	Conduct instream flow and stream temperature modeling studies to determine flow needs for spawning and rearing on the Calaveras River.	$300,000
C-1	Determine the number and capacity of unscreened water diversions on the Calaveras River. Establish a priority for installing screens.	$25,000
C-1	Conduct an instream flow study in Cow Creek to determine migration, spawning, and rearing needs for fall- and late-fall-run chinook salmon and steelhead.	No Estimate
C-2	Evaluate the effectiveness of Sacramento River spring pulse flows on the survival of juvenile anadromous fish.	No Estimate
C-2	Develop predictive methodology for Sacramento River hydrology, temperature, fish populations, fish harvest, water development, and wetlands.	No Estimate
C-2	Conduct an annual review of gravel operations to ensure unimpaired fish migration in Thomes Creek.	$25,000
C-2	Conduct a fish passage study in Thomes Creek.	$10,000
C-2	Investigate the feasibility of developing alternative water supplies for diverters in Paynes Creek drainage.	$25,000
C-2	Investigate the feasibility of obtaining adequate stream flows for salmon in Stony Creek.	No Estimate

TABLE 4. Evaluation Actions (Continued).

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
C-2	Investigate the feasibility of constructing a siphon at the Glenn-Colusa Irrigation District canal crossing on Stony Creek.	No Estimate
C-2	Determine adequacy of fish screen at Granlees Diversion Dam on the Cosumnes River.	$15,000
C-2	Conduct annual salmon spawning surveys in Bear Creek.	No Estimate
Total	Total does not include actions where "No Estimate" is listed. Inclusion of these "No Estimate" actions will add substantially to the overall total.	$2,999,000

Riparian Habitat Action Recommendations

All State lands should be examined and existing or potential riparian habitats enhanced and permanently preserved. Federal and local agencies should be strongly encouraged to retain or acquire riparian lands for permanent preservation. Riparian lands suitable for maintenance and restoration should be acquired by fee purchase, easement, or deed restriction throughout the Central Valley.

Accelerated regeneration of riparian plant communities should be undertaken on public lands and private lands, under long-term lease, to establish corridors along streams and wetlands to link riparian plant communities. Acquisition programs for protection or regeneration of riparian lands should target development of corridors to establish linkages between existing valley riparian tracts.

Specific actions recommended for immediate implementation to protect and restore riparian habitat include:

1. Examine all State-owned Central Valley lands and establish riparian areas for permanent restoration and preservation by the Department of Fish and Game for fish and wildlife.

2. Conduct a fish and wildlife oriented survey of Central Valley streams to identify existing riparian wildlands and areas of high potential for restoration of riparian woodlands.

3. Allocate surface and ground water for restoration and maintenance of key riparian tracts and corridors.

4. Establish a State policy for preservation and restoration of riparian wildland communities as a high priority for all State agencies.

5. Develop and adopt a comprehensive State riparian habitat restoration, preservation, and management policy and plan for the Central Valley administered by the Department of Fish and Game under the authority of the Secretary of Resources. Request the Legislature to enact the comprehensive policy.

6. Fully fund an accelerated riparian habitat acquisition program for lands to be administered for fish and wildlife by the Department of Fish and Game.

7. Maximize preservation and restoration of riparian habitats and streamside corridors to meet open space, greenbelt, and other wildland and parkland objectives through mandated State and local land use planning and zoning programs.

8. Recognize plants, fish, wildlife, and invertebrates with equal emphasis in riparian habitat acquisition, restoration, and management programs.

9. Incorporate riparian habitat restoration into all State fish, wildlife, recreation, and other land management and environmental restoration programs.

10. Amend the Forest Practices Act to include greater protection for riparian hardwoods through harvest, regeneration, and conversion regulations similar to, or more restrictive than, those provided for other commercial species.

RESTORING CENTRAL VALLEY STREAMS: A PLAN FOR ACTION

I. INTRODUCTION

This action plan identifies known and correctable habitat problems impairing anadromous fish production in the Central Valley upstream of the Sacramento-San Joaquin Delta and describes the present conditions of riparian wildlife habitat. It also provides guidance regarding the additional fish habitat data collection, administrative, and regulatory actions needed to successfully achieve full habitat restoration for the various species. The action plan does not describe the measures needed in the Delta and Estuary to complement actions proposed for streams elsewhere in the Central Valley; restoration of anadromous fish, however, is highly dependent on actions taken in the Delta and Estuary.

Fish and wildlife of the Central Valley are unique and valuable natural resources contributing significantly to the State's recreation, tourist, and commercial fisheries economies. The diverse assemblage of riparian, wetland, and stream habitats support countless birds, mammals, fish, and other aquatic organisms. The Central Valley is world renowned for its concentration of waterfowl and serves as a winter haven for numerous other bird species. Anadromous fish are broadly distributed throughout the Central Valley and are highly valued for their beauty, sporting qualities, historic and educational resource values, and as food. The principal anadromous fishes in the Central Valley are chinook salmon, steelhead trout, white sturgeon, striped bass, and American shad. Striped bass and American shad were introduced from the East Coast during the late 1800's.

The ability of the Central Valley aquatic ecosystems to sustain large populations of anadromous fish and riparian dependent wildlife has been impaired by water development and management strategies, streamside and instream commercialization of natural resources, and by the magnitude of population growth in the Central Valley since the mid-1800's. Population growth is stimulating further water development and changing management strategies for both water and fisheries. Virtually all species and races of anadromous fish have declined to record low levels in recent years. Some have become extirpated from areas in which they evolved and others are on the verge of extinction. Reversal of the downward trend is requiring tremendous efforts by Federal, State, and local agencies, and concerned citizens to identify and resolve critical factors contributing to the decline.

In the evolution of California's biological communities, variability in streamflow and water temperature patterns helped shape the existing differences in Central Valley salmon and steelhead populations. Salmon with the strength to travel far upstream early in the year to the cool headwaters could survive and reproduce successfully even in drought years or when the rains arrived late. Young fish sensitive to rising springtime temperatures might perish in early-season droughts while those with keener responses would move safely downstream to complete their life cycle or move upstream to cool habitat and migrate to the sea when conditions improved. In this manner, each region of the Central Valley evolved distinct "races" of fish which entered the streams at different times to spawn. A catastrophe might eliminate one spawning run, but nature had prepared another run, days or weeks behind it, to fill that special niche.

The survival of salmon and steelhead is necessary for the continued balance of their ecosystem. Aquatic insects and larvae provide food for young fish, and these young in turn may become sustenance for other animal life ranging from insects to large mammals. If a fish population is threatened by deteriorating habitat, then the health of all other species endemic to that ecosystem are also likely in peril.

The first great threats to the native anadromous fishes came shortly after the discovery of gold. Panning for the precious metal gave way to hydraulic mining which destroyed hundreds of miles of critical spawning and rearing grounds. As California approached the 1900's, anadromous fish began to face new problems.

By 1881, increasing numbers of fish were being harvested to feed the State's burgeoning population and to supply an exportable product for the salmon canneries and salteries along the north coast and in the San Francisco Bay area. State officials grew concerned that too few salmon and steelhead were returning to their historic spawning grounds. In response, they banned commercial netting on Saturdays and Sundays so that some fish might reach their homestream spawning grounds. The ensuing confrontations between fishermen and the State fish patrols characterized early conservation efforts for salmon and steelhead.

Striped bass were introduced in 1879 from the New Jersey coast to Martinez, California. The population quickly expanded to several million fish. By the 1900's, the annual commercial catch was averaging over 1 million pounds.

During the 1930's and 1940's, efforts to conserve fish through harvest regulations were overwhelmed by the devastating effects of economic growth and development. Californians tamed and cultivated the countryside, harnessed rivers for crop irrigation and hydroelectric power, and developed land for roads and recreation.

Today, Central Valley salmon and steelhead populations are at risk and the striped bass resource is severely depleted. Virtually all salmon and steelhead rivers have been blocked by dams. This has reduced the amount of river and stream spawning habitat available to salmon and steelhead from 6,000 miles to a scant 300 miles -- a 95% reduction from historic levels. Although anadromous fish were extirpated from much of their former range, these species were resilient enough that sufficient numbers survived and adapted to new environmental conditions below the dams. Fish that spawned late in the year did better, however, than races or runs that spawned earlier. Modern water project operations during the early post-construction years were apparently less stressful on the surviving fish because surplus water was available and adequate flow and water temperatures were provided for successful spawning and egg incubation. But as the water projects grew to completion and additional projects were constructed, conditions again changed for the worse. The quality and quantity of the streamflow, after storage or diversion, has declined and is frequently lethal or nearly lethal to salmon and steelhead.

Shasta Dam on the upper Sacramento River near Redding blocked enormous upriver runs of hundreds of thousands of salmon and steelhead. Friant Dam dried up sections of the San Joaquin River and an annual production of 300,000 spring-run chinook salmon was lost without regard for mitigation or replacement of the losses.

The Shasta Fish Salvage Plan was initially developed to mitigate for the construction of Shasta Dam and contained many other features in addition to the construction of Coleman National Fish Hatchery. Virtually all of the other "mitigation" features of the Salvage Plan either failed or were never implemented. The fish ladders in the Sacramento River at the Red Bluff Diversion Dam, for example, have not worked well and prevent some fish from reaching their spawning grounds. Downstream migrating juveniles become disoriented as they pass the dam and become easy prey for squawfish and other predators.

The rivers of the Central Valley are now essentially managed as canals, except for the San Joaquin River which is managed as a drain. They are operated conservatively for beneficial uses such as water deliveries to irrigation districts, power production, municipal water supplies, and other authorized project purposes. The water developments on the rivers of the Central Valley clearly have not been operated to sustain fish and wildlife and their habitats.

In December 1990, representatives from the three major user groups (urban, agricultural, and environmental) recognized the necessity for mutual accommodation to achieve progress toward an acceptable solution to their dilemma. They agreed that a phased approach in water allocation and additional water development must be followed to insure simultaneous benefits for all. Urban and agricultural leaders recognized environmental needs by accepting mitigation responsibility; embracing the goal of restoration; and supporting environmental guarantees as new facilities are developed. Environmentalists, in turn, recognized that California needs improved water management facilities.

A New Initiative

A new water policy for the State was called for by Governor Pete Wilson in April 1992. In his policy statement, the Governor pointed out that while there was a need to implement short-term solutions regarding water allocations and deliveries, there was an urgent need for a long-term comprehensive water policy. Past water warfare among agricultural, urban, and environmental water users has not been to the benefit of the State. The water wars have produced polarization and paralysis as the users have been unable to resolve this most basic resource issue.

The Governor stressed his objectives for the new water policy. They are:

For cities: Safe, reliable water supplies for domestic, municipal, and industrial uses.

For agriculture: Adequate long-term water supplies at a reasonable cost, with dry-year groundwater reserves where feasible.

And for the environment: Restoration and protection of fish and wildlife resources and aquatic habitat; and protection of threatened and endangered species.

The Governor stated in his water policy that the Delta "is broken" and initiated a 3-year comprehensive planning effort to prepare a program "to protect and enhance the San Francisco Bay/Sacramento-San Joaquin Delta Estuary by addressing water quality concerns, effective design and operation of water export systems, maintenance of Delta levees and channels, and guarantees for protection of the Bay-Delta Estuary and its fish and wildlife resources." The Department of Fish and Game is actively participating in that effort and expects it to define the actions needed in the Estuary to complement the measures described in this report for the Central Valley.

The Governor also stated in his water policy that California needs to develop an action program to restore and enhance the aquatic ecosystems in the Central Valley that support fish and wildlife populations. This action plan addresses that need and sets forth a listing of known and identified aquatic and riparian habitat problems that require correction.

This report emphasizes salmon and steelhead. The measures needed to restore certain anadromous fish, such as striped bass, pertain primarily to the Estuary. While the report includes some upstream measures for other anadromous fish, restoration measures for these species are left largely to the planning efforts for the Delta and bays.

Several approaches are integrated to rank restoration activities for action. Foremost among action priorities are those measures that will restore or enhance habitats of threatened and endangered species, or depleted species -- those fish that are at risk, though not yet protected through listing. The next level of priority includes actions to restore and enhance habitats of those species and races that are maintaining stable populations or continue to make substantial contributions to the ocean sport and commercial, and in-river sport fisheries. The final level of protection focuses on maintenance or restoration of habitat in minor streams that provide for small populations of anadromous fish. While each of the smaller streams can provide only a small benefit on their own, cumulatively, these streams can provide significant benefits in the overall restoration of anadromous fish in the Central Valley. Generally, the higher priority habitat restoration actions will also benefit aquatic habitats in the lower priority rankings.

Streamflow, water quality, water diversions, and gravel quantity and quality are the primary habitat factors requiring restoration and enhancement. Other essential factors of the aquatic ecosystem include riparian lands and corridors, and associated wetland areas. The keystone of an effective strategy to correct past and present habitat problems affecting Central Valley fish and wildlife is the integration of watershed, riparian, wetland, and instream habitat restoration and protection actions.

The riparian zone comprises many of the important natural elements contributing to a valley system rich in species diversity. These include water access, maximum habitat edge, a complex productive food web, and rich vegetative diversity.

Riparian lands provide a highly suitable and often critical habitat for a wide array of birds, mammals, and other wildlife. State and Federal threatened or endangered species include the bald eagle, bank swallow, western yellow-billed cuckoo, Swainson's hawk, and the valley elderberry longhorn beetle, which is endemic to the Central Valley of California. The area also provides habitat for many other raptors, migratory birds, amphibians, and mammals.

Historically, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with bands of vegetation spreading four to five miles wide. In the last 150 years, agricultural conversion has been the primary factor eliminating riparian habitat. Other land use activities such as timber and fuel harvesting, channelization, dam and levee construction, bank protection, and streamflow regulation have altered the riparian system and contributed to vegetation loss. Conversion of riparian woodlands by agriculture and urbanization has reduced the present habitat to less than five percent of the original acreage. In addition, less than one-half of the original river edge vegetation beneficial to resident and anadromous fisheries production remains.

Several water development and flood control projects have dramatically altered the rivers' natural flow regimes and sediment transport characteristics. These projects have also had a major influence on the lower reaches of the river and its associated riparian habitat. For example, federally funded structures in the Sacramento Valley include Shasta, Keswick, Folsom and Whiskeytown dams, and the Red Bluff Diversion Dam; and in the San Joaquin Valley include New Melones, Friant, Hidden, and Buchanan dams. State-funded structures are less numerous but include Oroville Dam on the Feather River. The Sacramento River Flood Control Project extends south from Chico Landing and includes a series of levees, weirs, and overflow areas. The Sacramento River Bank Protection Project was designed to protect the flood control system between Chico Landing and Collinsville. The Chico Landing to Red Bluff Comprehensive Bank Stabilization Project, designed to control lateral migration (meandering) in this reach, is about 54 percent complete but has not been expanded since 1984.

Relationship of this Plan to Management and Restoration of the Sacramento-San Joaquin Delta and San Francisco Bay

This plan addresses anadromous fish habitat restoration and protection in all areas upstream of the Sacramento-San Joaquin Delta and Estuary. However, full restoration of salmon and the other anadromous species cannot be achieved without consideration of the Delta ecosystem and integration of protective measures to restore fish habitat.

The San Francisco Bay/Sacramento-San Joaquin Delta Estuary is at the center of California's water dilemma. Although millions of people rely on the water exported from the Delta for municipal, industrial, and agricultural purposes, the detrimental effects of these exports on fish and wildlife living in or migrating through the Delta has been clearly established.

To achieve a balance among the various competing water uses, the State Water Resources Control Board is expected to amend existing terms and conditions in the water right permits already issued to the Department of Water Resources (DWR) for the State

Water Project and to the U.S. Bureau of Reclamation (USBR) for the Federal Central Valley Project. That process is ongoing and expected to be completed within five years.

Other near-term actions intended to help ensure that the reasonable and beneficial uses of Delta water are protected include the following:

1) The Governor's Bay/Delta Oversight Committee is preparing environmental documentation that will serve as a planning framework to consider facilities for "fixing" the Delta. The environmental documentation process is expected to be completed within three years.

2) The DWR is developing water management programs in the central and southern Delta to assist in improving water quality and supply, including construction of flow control barriers, channel enlargements, and project operational changes.

3) The National Marine Fisheries Service has completed a consultation with the USBR and the DWR pursuant to Section 7 of the Federal Endangered Species Act regarding long-term project operations of the SWP and CVP for the protection of the Sacramento River winter-run chinook salmon.

4) The U.S. Fish and Wildlife Service is conducting a similar consultation with the USBR and DWR regarding Delta smelt, recently listed as a threatened species by both the State and Federal governments.

5) Implementation of Title 34 (Central Valley Project Improvement Act) of Public Law 102-575 should alleviate some of the Delta problems associated with water quantity and flow patterns and correct problems associated with structures that impair fish survival.

overseeing programs of agency departments including DWR and DFG. The agency evaluates CEQA documents for consideration of existing State policy, programs, and plans and coordinates all State agency comments regarding permit applications administered by the U.S. Corps of Engineers for compliance with the Federal Clean Water Act.

The Department of Parks and Recreation (DPR) administers the California Wildlife Protection Act of 1990, one provision provides $2 million in annual funding for grants to acquire, restore, or enhance aquatic habitat for spawning and rearing of anadromous salmonids and trout.

Local Agency Role

Resource Conservation Districts are authorized to assist the State in conserving soil and water on farm, range, urban, and timber lands. The districts provide assistance to landowners and government agencies to prevent soil erosion, control runoff, stabilize soils, and protect water quality.

Local water districts serve the water supply needs of users within specific geographic areas. Many are responsible for making instream flow releases or maintain habitat or fish and wildlife related facilities on the streams of the Central Valley used by anadromous fish.

Reclamation Districts are responsible for levee maintenance. These special districts are formed and supported by the landowners of the area protected by the levees.

Local governments are required to have a general plan with mandated elements including open space/conservation, safety, land use, and circulation. The conservation element addresses the conservation, development, and utilization of natural resources, including water, forests, soils, rivers, and other waters, harbors, fisheries, wildlife, minerals, and other natural resources.

III. HISTORICAL PERSPECTIVE

Habitat of Anadromous Fish

Ninety-five percent of the historic Central Valley salmon habitat has been lost. The streams have either been dammed, blocking migration, or they have been so severely degraded that they are no longer usable by salmon. The most severe damage and loss of habitat began with the discovery of gold in 1849 and culminated in the 1970's with completion of the major water diversion and conveyance facilities.

Hydraulic mining caused sedimentation of spawning grounds, water diversions blocked migrating fish and depleted stream flows, and the sudden human population explosion during the gold rush resulted in significant development and disturbance all along the Central Valley streams and rivers. Then, the need for building materials created a logging industry that added further to the decline in available habitat.

The unrestricted use of hydraulic mining in the river drainages along the eastern edge of the Central Valley was extremely damaging to the stability of the stream systems and habitat for anadromous fish. This belt of hydraulic mining transversed most of the Sierra Nevada west side drainages to the Sacramento and upper San Joaquin valleys. Between 1850 and 1885, hydraulic mining washed tons of silt, sand, and gravel into the Sacramento, Feather, American, San Joaquin, Merced, and Tuolumne rivers. The most intensive hydraulic mining occurred on the Feather, Yuba, and Bear rivers. The mining debris, composed of clay, sand, gravel, and cobbles, rapidly washed downstream during high flows. As early as 1860, a sand bar had formed in the Sacramento River across the mouth of the American River. By 1866, the larger steamboats could no longer reach Sacramento, and by 1876, the channels of the Bear and Yuba rivers had been completely filled resulting in adjacent agricultural lands becoming covered by sand and gravel. The State Supreme Court, in 1884, upheld a suit against the hydraulic mining interests filed on behalf of agricultural interests. That decision was the beginning of the end for hydraulic mining. However, extensive damage had already occurred.

Prior to the construction of levees for reclamation and flood control, the Sacramento River was confined, at normal flows, between its natural river banks. During periods of flood, large areas of the Central Valley were inundated. Flood control in Sacramento Valley had its inception with low levees constructed on the rimlands along streambanks by farmers endeavoring to protect their crops. Until 1850, ownership of the tule, swamp, and overflow lands was vested in the United States government. With the passage of the "Arkansas Act" in 1859, these lands were transferred to the State of California and made available to private ownership in 1865. By 1868, nearly all the land had been sold with the provision that the owners reclaim the land through the formation of reclamation districts.

By 1894, many miles of levees had been constructed along the stream channels and some of the favorably located lands had been formed into districts with levees of sufficient height to afford some degree of flood protection. By the 1930's only 25% of the land of the Sacramento Valley floor was subject to periodic inundation.

In 1893, the Congress established the California Debris Commission to deal with the loss of navigable river channels and to provide a plan to control flooding in the Valley. The flood control plan was adopted by the State Legislature in 1911 and by Congress in 1917. Adoption of the plan brought together a large number of reclamation districts and allowed reclamation of the greater part of the remaining swamps. Flood control was accomplished using a system of levees to protect farmlands, by establishing areas to bypass flows of flood water, and by constructing dams on the rivers to capture flow. The flood control plan proposed by the Debris Commission was essentially complete in the late 1960's.

Logging was not significantly regulated in California until the second half of the Twentieth Century. This hundred-year period of virtually uncontrolled harvest of trees resulted in streams being choked with sediment and debris making them inaccessible or useless for anadromous fish. During this same time the Central Valley was being developed for agriculture. Water storage and diversion projects were being built, denying anadromous fish access to historic spawning areas.

By 1960, salmon habitat in the Sacramento-San Joaquin river watersheds had been substantially reduced. Shasta Dam on the Sacramento River near Redding, constructed in 1938-44, became a barrier to all salmon in November 1942. This barrier prohibited salmon from reaching their historic spawning areas in the upper Sacramento, Pit, and McCloud rivers. The USFWS estimates that the Sacramento River historically supported an average salmon run of 600,000 fish and, at times, as many as a million salmon a year may have spawned in the river. Many of these fish would have spawned in the area above Shasta Dam. Friant Dam on the San Joaquin River, completed in 1949, resulted in the elimination of a run of spring-run chinook salmon that ranged from 2,000 - 56,000 between 1943-48. As demand for water grew, new dams were built until the Feather River was the only significant river in the Central Valley that was still relatively free-flowing. This changed in 1960 when California voters approved construction of the SWP.

Approval of the SWP resulted in the construction of the Oroville Dam on the Feather River near the town of Oroville, the Harvey O. Banks Pumping Plant in the Delta, the

California Aqueduct, and San Luis Reservoir. Oroville Dam and the other facilities were completed in 1965 which allowed the State to begin delivering water to the San Joaquin Valley and to the cities in southern California. The Oroville Dam blocked most salmon including all wild spring-run chinook salmon, changed the historic flow patterns in the river below the dam, and affected runs of anadromous fish throughout the Central Valley by reducing Delta inflow and outflow.

While the SWP was being completed, the Federal government constructed the Red Bluff Diversion Dam (RBDD) on the Sacramento River near the town of Red Bluff. This gravity diversion feeds the Corning and Tehama-Colusa canals and originally had the capacity to divert over 2,000 cubic feet of water per second (cfs). Since the enlargement of the Tehama-Colusa Canal headworks, diversion capacity at the RBDD is over 3,000 cfs.

During this same period, numerous other projects were constructed that indirectly or directly affected salmon habitat. Among these were New Bullards Bar Dam and New Scotts Flat Reservoir in the Yuba River drainage, New Melones Dam on the Stanislaus River, New Don Pedro Dam on the Tuolumne River, and New Exchequer Dam on the Merced River. The cumulative effect of these projects on anadromous fish populations was enormous. Prior to construction of these projects, flows in the rivers closely resembled historic patterns; even though the fish were blocked by the "old" dams. The new dams, however, provided cooler water during parts of the year due to reservoir stratification. Now the rivers are regulated to the point that high flows below the dams typically occur in late spring and summer during the irrigation season, and low flows occur in the fall, winter, and early spring during the storage season. This is completely inverse to the conditions in which the fish evolved. The natural channel of the San Joaquin River above the mouth of the Merced River cannot be used by salmon since it is no longer used to deliver irrigation water and there are no high flows during the summer.

The SWP's Harvey O. Banks Delta Pumping Plant and the California Aqueduct more than doubled the capacity to export water south. Prior to the installation and operation of the SWP Delta pumps, Delta water exports were limited to the quantities the Federal pumps could deliver. With the addition of the SWP export, the magnitude of reverse flows across the Delta increased, Delta outflow decreased, and the concomitant entrainment of salmon increased. The problems were exacerbated by the increased storage upstream, since less water reached the Delta and, therefore, a larger percentage of Delta inflow was exported.

Reduced instream flows below storage reservoirs affect salmon habitat in several ways. The most obvious impact is to migrating fish. Adult fish must be able to reach the spawning areas and juvenile fish must be able to emigrate to the ocean. Low flows do not flush the fine sediments from salmon spawning gravel, thus the gravel's suitability for spawning is reduced. Low streamflows also permit encroachment of riparian vegetation into spawning gravels which reduces available spawning area. Lower flows in the summer and fall result in higher water temperatures. When water temperatures exceeds 56°F, developing eggs begin to experience mortality. The rate of egg mortality greatly increases when temperatures exceed 57.5°F.

Historic Wetlands and Riparian Habitat

The lack of authentic records prevents determining the precise distribution and abundance of historic wetland and riparian habitat in California. For this reason, substantial differences exist in the estimates of the total wetland acreages in California prior to settlement by Europeans in the 19th Century. A report prepared by the USFWS in 1978 estimates the total historic wetland area at between 4.1 million and 5.0 million acres.

The State originally supported an estimated 500,000 acres of permanent freshwater marshes. The majority of this habitat occurred as tidal and nontidal marshes along the borders of Grizzly and Suisun bays and the Delta, Tulare and Kern lakes, and in basins along the Sacramento and San Joaquin rivers. These vast, permanently flooded marshes consisted primarily of cattails, several species of bulrushes, and pondweeds. These marshes, ponds, and stream channels were generally bordered by dense stands of riparian woodlands in various stages of transitional development from grasses to old growth hardwoods.

Each winter millions of additional acres of seasonal wetland were created as rivers and streams throughout the Central Valley and elsewhere in the State, swollen by rainfall and melting snow, overflowed and inundated adjacent grassland and wetland riparian forests. Vast flocks of waterfowl, which reportedly darkened the sky for several minutes as they passed, eagerly sought the temporary abundance of grass seed and terrestrial insects.

Most recently, there are an estimated 292,000 acres of seasonal or permanent wetland in the Central Valley. Approximately 70% of the existing wetlands, which are primarily duck clubs, are privately owned. State and Federal refuges comprise the other 30% of Central Valley wetlands. In addition to 292,000 acres of seasonal or permanent wetlands, post-harvest flooding of rice, corn, and wheat provides additional habitat for waterfowl and shorebirds. Though still impressive, California's great heritage of waterfowl and migratory water birds is greatly diminished and remains in jeopardy as wetlands continue to decline. Riparian woodlands have been diminished to a few isolated blocks within the flood plain and intermittent strips along the major stream courses.

IV. CENTRAL VALLEY FISH, WILDLIFE, AND RIPARIAN HABITATS

Anadromous Fish

Anadromous fish migrate to the ocean early in their life, mature in the ocean, and return inland as adults to spawn in freshwater streams and rivers. Chinook salmon and striped bass are the predominant anadromous fish using the waterways of the Central Valley. The habitat requirements of salmon and striped bass and the other anadromous fish in the freshwater environment vary by life stage, season of the year, species, and race.

Four distinct races of chinook salmon spawn in the upper Sacramento River, and they are named for the season during which the majority of the run enters freshwater as adults. Fall-run chinook usually spawn within a few weeks of their arrival in the fall. Late-fall-run chinook salmon spawn in the winter. Spring-run chinook spend the summer in deep, cool pools and spawn in early fall. Winter-run fish enter the river in the winter and spawn early the following summer. In addition to the four races, the DFG manages the fall-run chinook salmon within the San Joaquin basin as a distinct group, separate from the fall-run of the Sacramento River basin, pending clarification of its "uniqueness" or genetic status.

Both spring- and fall-run chinook salmon were abundant in the upper Sacramento River prior to Federal, State, and private water development, although significant declines were noted by 1929. Causes of the declines were thought to include overharvest, blockage by irrigation dams, and habitat degradation. There is limited information on the magnitude of the salmon runs prior to the construction of the CVP. However, in 1905 the combined chinook salmon egg collection at three upper Sacramento River egg stations located off the main river represented the spawn of at least 30,000 adult salmon. This indicates that the total run in all other tributaries and main stem could easily have exceeded that number by more than tenfold. Based on gill-net catch data for the Sacramento-San Joaquin rivers, it has been estimated that the peak chinook salmon runs in the Sacramento River system may have been as large as 800,000 to 1 million fish, with an average run size of about 600,000 fish prior to 1915.

The San Joaquin River system supports an important population of fall-run chinook which is now only a remnant of its former size. Spawning populations and production varies widely from year to year, depending upon the timing and magnitude of flows available for upstream migration, spawning, rearing, and emigration. San Joaquin River basin salmon populations can be severely affected by pumping operations in the Delta which may capture all of the San Joaquin River outflow. Chinook salmon escapements have been monitored by the DFG and other agencies using various techniques on one or more San Joaquin tributary upper tributary watersheds also occurs in September through December. It is likely that some individual spring-run chinook have interbred with fall-run in the main stem Sacramento River, but the extent of the hybridization has not been quantified. A genetically uncontaminated strain of spring-run chinook may still exist in Deer and Mill creeks where they are geographically separated from fall-run. Spring-run chinook are also present in Antelope, Battle, Cottonwood, Big Chico, and Butte creeks, and the Feather River. The Feather River fish are thought to have interbred with fall-run chinook and their genetic status is uncertain. However, the earliest spawning Feather River spring-run chinook are thought to closely emulate true spring-run chinook salmon.

Chinook Salmon Natural History and Biological Requirements. Chinook salmon spawning generally occurs in swift, relatively shallow riffles or along the edges of fast runs where there is an abundance of loose gravel. The females dig spawning redds in the gravel and deposit their eggs in several "pockets". The eggs are fertilized by the male and buried in the gravel by the female. The adults die within a few days after spawning. Water percolates through the gravel and supplies oxygen to the developing embryos. An average female chinook salmon produces 3,000-6,000 eggs depending on size and race of the fish.

Salmon select spawning riffle areas within narrow ranges of water velocity and depth. Spawning requires well-oxygenated cool water. Velocity is generally regarded as a more important parameter than depth for determining the hydraulic suitability of a particular site for spawning. The velocity determines the amount of water which will pass over the incubating eggs. Depths under 6 inches can be physically prohibitive for spawning activities. In general, optimum spawning velocity is 1.5 feet per second (fps), ranging from 1.0-3.5 fps. Central Valley salmon probably exhibit differences in preferred depths for spawning based on race and watershed. Central Valley chinook typically spawn at depths ranging from 1-5 feet. Winter-run salmon have been observed spawning at depths exceeding 21 feet in Lake Redding, but this is much deeper than normally seen and may not be a consistent or significant phenomena within the Central Valley.

Substrate composition is the other critical factor in suitability of a section of river for spawning. For successful reproduction, chinook salmon require clean and loose gravel that will remain stable during incubation and emergence. The average size of chinook salmon redds is approximately 165 square feet. In areas of heavy activity, the redds dug by late spawners may overlap those dug by early spawners by more that 60%. The territory required for pre-mating (nuptial) activity has been estimated to be between 200 and 650 square feet for a pair of salmon but this varies widely according to population density. Where spawning occurs throughout a protracted spawning season, as many as three or four redds may be dug in the area equivalent to the territorial requirement of one pair. A conservative range for minimum spawning area per female is 75-100 square feet. Requirements also appear to vary according to the size of the fish and the characteristics of the stream. For example, the actual excavated redd areas in the San Joaquin basin range from 60 to 90 square feet.

Substrate composition must be low in sand and fines so that its permeability to water allows successful incubation and emergence of the juveniles. Also, oxygen requirements of developing eggs and sack fry or alevins increase with increasing temperature. For these reasons (temperature, dissolved oxygen), the minimum intra-gravel percolation rate needed to ensure good survival of incubating eggs and alevins can vary considerably according to stream flow rate, water depth, and water quality. Transported sediments deposited on redds can reduce percolation through the gravel and suffocate eggs or alevins.

Several authors have proposed "optimum" streambed composition. In general, the substrate chosen by chinook salmon for spawning is composed mostly of gravels from 0.75-4.0 inches in diameter with smaller percentages of coarser and finer materials with no more than about 5% fines. Although some spawning will occur in suboptimal substrates, incubation success will be lowered. Gravel is completely unsatisfactory when it has been cemented with clays and other fines, or when sediments settle out and cover eggs during the spawning and incubation period. Gravel deposited for enhancement purposes should be 80% 0.5-2.5 inch diameter, and 20% 2.5-4.0 inch diameter.

The preferred temperature for chinook salmon spawning is generally 52°F with lower and upper threshold temperatures of 42°F and 56°F. Temperatures above these ranges result in reduced viability of eggs or heavy mortality of developing juveniles. Holding adults prefer water temperatures less than 60°F, although, acceptable temperatures for upstream migration range from 57 to 67°F.

Within the appropriate temperature range, eggs usually hatch in 40-60 days, and the young "sac fry" usually remain in the gravel for an additional 4-6 weeks until the yolk sac is completely absorbed. The rate of development is faster at higher water temperatures. Significant egg mortalities occur at temperatures in excess of 57.5°F with total mortality normally occurring at 62°F. A useful method of estimating time of emergence is calculation of degree-days (commonly called "temperature units"). Chinook salmon eggs require approximately 750 degree-days for hatching and an approximate equal thermal period for resorption of the yolk sac for a total of 1,425 degree-days. A degree day is one degree (°F) above freezing (32°F) for 24 hours. Degree-days are computed by multiplying the incubation temperature (°F-32) by the number of elapsed 24-hour periods. Thus the total time from spawning to emergence at 50°F is approximately 79 days.

After emergence chinook salmon fry attempt to hold position in the water column and feed in low velocity slack water and back eddies. They move to somewhat higher velocity areas as they grow larger. Length of rearing and migration timing vary for the salmon runs. In California most young chinook salmon enter the ocean as 0-age smolts where they remain until their third or fourth year at which time they return to their home stream to spawn (2- and 5-year old fish also participate in the spawning run in small numbers).

While straying of naturally spawning adult salmon is probably not extensive, hatchery practices can result in substantial straying of some hatchery-produced fish. For example, when Feather River and Nimbus hatchery smolts are planted many miles downstream in or near the lower Delta, straying is substantial. At sites such as CNFH near Anderson, straying is much less if the fish are released near the hatchery.

Steelhead Trout. Steelhead trout are an anadromous strain of rainbow trout that migrate to sea and later return to inland rivers as adults to spawn. In contrast to all Pacific salmon, not all steelhead die after spawning. With natural spawning greatly reduced in the Sacramento-San Joaquin river system, steelhead populations are mostly dependent on hatcheries to maintain populations. Steelhead are highly prized by inland sport anglers.

Steelhead are generally distributed from southern California to the Aleutian Islands. Within California's Central Valley, a viable population of naturally produced steelhead is only found in the Sacramento River and its tributaries. No significant steelhead populations now occur in the San Joaquin River system.

In the Sacramento River, upstream migration occurs from early August through November with the peak occurring in mid-September. Some upper Sacramento River steelhead runs peak in mid-winter. Sacramento River system steelhead spawners are typically 2- or 3-year olds that weigh 2-12 pounds. The Eel River strain of steelhead introduced into the American River at Nimbus Fish Hatchery has interbred with the remnants of the American River and other Sacramento River strains; this seems to have resulted in steelhead larger than those found in the upper Sacramento River. Mad River steelhead were also introduced in the American River, but the results have been inconsequential. Spawning in the Sacramento River and its tributaries usually occurs from January through March, and individuals which survive the spawning run return to the sea between April and June. Females in the American River contain an average of 3,500 eggs, with a range of 1,500-4,500.

Like other salmonids, steelhead prefer to spawn in clean, loose gravel and swift, shallow water. Gravel from the redd excavation forms a mound or tail-spill on the downstream side of the pit. Eggs deposited along the downstream margin of the pit are buried in the gravel as excavation proceeds. An average of 550-1,300 eggs are deposited in each redd. The males fertilize the eggs as they are deposited. Water percolating through the gravel supplies oxygen to the developing embryos.

River depth-velocity criteria for spawning and rearing steelhead differ slightly from those for salmon. Velocity appears to be about the same as for chinook salmon, 1.5 fps, but depth is slightly less, to about 0.75 foot. Gravel particle sizes selected by steelhead vary from about 0.25-3.0 inches in diameter, somewhat smaller than those selected by chinook salmon.

Steelhead seem less tolerant of fines than chinook salmon, probably because eggs are smaller and oxygen requirements for developing embryos are higher. A positive correlation has been demonstrated between steelhead egg and embryo survival and the percolation rate of water through gravel. Oxygen content of the water has also been proven positively correlated with egg survival.

The average size of a steelhead redd is smaller than that of a chinook salmon. Redd sizes range from 22.5-121 square feet and average 56 square feet. Female steelhead dig six to seven pockets in each redd; however, some overlap may occur as several females may spawn in the same area. Since most races of steelhead in the Sacramento system are considerably smaller than in other California streams, their spawning area requirements are probably smaller.

All freshwater life stages of steelhead, except rearing, require lower temperatures than chinook salmon. The preferred temperatures for steelhead in the Sacramento River are between 50°F and 58°F, although they will tolerate temperatures as low as 45°F. Studies show that the upper preferred temperature limit for rainbow trout in Sierra Nevada streams is 65°F. The temperature range for spawning is somewhat lower, ranging from 39-55°F, and the preferred incubation and hatching temperature is 50°F. During the egg's "tender" stage, which may last for the first half of the incubation period, a sudden change in water temperature may result in excessive mortality.

Egg incubation in the Sacramento River system takes place from December through April. The rate of embryo development is a function of temperature with higher temperatures contributing to faster development. At 50°F, hatching occurs in 31 days; at 55°F hatching occurs in 24 days.

Newly hatched sac fry remain in the gravel until the yolk sac is completely absorbed, a period of 4-8 weeks. Emergence is followed by a period of active feeding and accelerated growth. The diet of newly emergent fry consists primarily of small insects and invertebrate drift. As they grow, fry move from the shallow, quiet margins of streams to deeper, faster water.

Unlike juvenile fall-run chinook salmon, which typically emigrate soon after emerging from the gravel, juvenile steelhead usually remain in fresh water for at least one year. Because rearing steelhead are present in fresh water all year, adequate flow and temperatures are important to the population at all times.

Generally, throughout their range in California, the most successful young steelhead spend from 1-2 years in fresh water before migrating downstream. In the Sacramento River, steelhead generally emigrate as l-year olds during spring and early summer months. Emigration appears to be more closely associated with size than age, 6-8 inches being the size of most downstream migrants. Downstream migration in unregulated streams has been correlated with spring freshets.

Adult steelhead generally return to their parent stream to spawn but exhibit a higher straying rate than naturally spawning salmon populations. A 2-3% yearly exchange of individuals in two neighboring coastal streams has been observed, demonstrating that population mixing occurs. Steelhead, like other anadromous fish, are probably attracted by high flows and tend to be diverted from their home streams by high flows elsewhere.

Declines in natural and hatchery-maintained steelhead stocks in the Central Valley are due mostly to water development, inadequate instream flows, rapid flow fluctuations, high summer water temperatures in streams immediately below reservoirs, diversion dams which block access, and entrainment of juveniles into unscreened or poorly screened diversions. The operations of the SWP and the CVP, particularly the Delta pumping plants, have had a detrimental effect on steelhead smolts emigrating through the Delta to the ocean. Reverse flows, entrainment of fish into the pumping facilities, and increased predation at water facilities are major problems.

Striped Bass. Striped bass are native to the Atlantic Coast from the Gulf of St. Lawrence to the eastern part of the Gulf of Mexico. Since being introduced into the San Francisco Bay complex in the latter part of the last century they have become one of the most popular sport fishes within the Central Valley. The bulk of the striped bass population is in the Sacramento-San Joaquin River system including the San Francisco Bay complex, the nearby ocean, the Delta, and the larger tributary streams downstream from the impassable dams.

Striped bass support one of the most important sport fisheries in the State. It is the most important sport fish in the San Francisco Bay region, the Delta, and the lower part of the Sacramento River.

Striped bass begin spawning in the spring when the water temperature reaches 58°F. Most spawning occurs from April to mid-June. They spawn in fresh water where there is moderate to swift current. Important spawning areas include the main stem Sacramento River from Courtland to Colusa and the San Joaquin River from the vicinity of the Mokelumne River to Santa Clara shoals.

Female striped bass usually spawn for the first time in their fourth or fifth year when they are about 18 to 22 inches long. Most males mature at age 3. A 5-lb female may release as many as 250,000 eggs in one season, and a 12-lb fish may release over a million eggs. The eggs are quite small but after being released and fertilized, they absorb water, triple their diameter, and become transparent and very hard to see. The eggs are only slightly heavier than water. With moderate current, many eggs sink to the bottom and most die. The larval bass are hatched in about two days, the length of time depending upon the temperature.

Estimates of the number of legal-sized adult striped bass in the Central Valley have ranged from 1,948,000 in 1967 to only 574,364 in 1990.

Sturgeon. Sturgeon include the largest fishes found in fresh water. Sturgeon are slow growing and very long-lived. There are two species of sturgeon in California: the white and the green. White sturgeon is the more abundant of the two in the Central Valley.

The commercial sturgeon fishery was short-lived and in 1901 the Legislature temporarily abolished the fishery. At the time, white sturgeon were claimed to be on the verge of extinction. The fishery remained closed until 1910, was re-opened for two years, and then closed until 1916. In 1917, the fishery was again abolished by the Legislature, and the taking or possession of sturgeon was completely prohibited until 1954, at which time the fishery was reopened for sport fishing only. At present, angling is heaviest in San Pablo Bay, but some sturgeon are taken upstream in the larger rivers. Some are taken far upstream in the Sacramento River past the mouth of the Feather River. Sturgeon are caught by anglers in the San Joaquin River between the Merced and Stanislaus rivers generally from February through April.

Studies by the DFG indicate that adult sturgeon migrate upstream in late winter and spring into the Delta, using both the Sacramento and San Joaquin channels. By summer most have moved downstream. White sturgeon were blocked by the Red Bluff Diversion Dam between 1966 and 1986, but are now able to ascend upstream during the non-irrigation season when the diversion gates are raised.

The actual spawning of either white or green sturgeon has not been well described. Other species of sturgeon are known to migrate upstream and spawn in areas of fast water and coarse gravel bottom. The eggs settle into the crack between rocks and are adhesive. Hatching time for some other species of sturgeon ranges from two to five days depending partly on water temperature. The habitat requirements of sturgeon offspring are largely unknown.

Abundance estimates of adult white sturgeon have ranged from 114,700 in 1967 to 20,700 in 1974. In 1990, white sturgeon abundance was estimated at 26,800. Green sturgeon are relatively uncommon and their abundance has ranged from an estimated 1,850 in 1967 to about 200 in 1975. The 1990 estimate was 540 fish.

American Shad. American shad are members of the herring family. American shad were first introduced into the Sacramento River in 1871, with several supplemental introductions later. Shad did exceptionally well and were being harvested in marketable quantities by 1879.

Shad spawning runs occur from late April to early July. In many of the spawning streams some shad go as far upstream as they are able, but unlike salmon, shad do very poorly at ascending fishways and are stopped even by relatively low dams. Formerly, shad ascended the Sacramento River to Redding in some years. Since the construction of Red Bluff Diversion Dam, most of the run stops at that point. American shad enter the San Joaquin River and its tributaries in years when May and June outflow is high.

Spawning takes place where there is good current in tidal fresh water or farther upstream. Most spawning occurs over gravel or sand bottoms and a female may release from 120,000 to 650,000 eggs. Many shad die after completion of spawning. The fertilized eggs are not adhesive and are slightly heavier than water. The eggs drift with the current near the bottom. Hatching is usually completed in 4 to 6 days depending on water temperature.

Some young shad move downstream into brackish water soon after hatching but large numbers remain in fresh water into November when they are 5 to 6 months old. By December most have left fresh water.

Riparian Systems

Riparian systems and their associated animal life, here collectively called "riparian systems", have their origins in a complex mix of geologic, climatic, hydraulic, and biogeographic interactions. They are closely related to, and often physical neighbors of, aquatic wetland systems--lakes, marshes, rivers, creeks, and springs. Described most generally, they are terrestrial sites where water accumulates sufficiently in the soil and other terrestrial substrates to permit the growth of mesic (requiring medium to high soil moisture) terrestrial plants and associated animals.

In the arid and semi-arid West, riparian systems are generally bounded on the upland side by drier soils and xeric (adapted to low soil moisture) vegetation. In this case, the water reaching the soil of the riparian zone comes from the water body, which may be a lake, pond, stream, or marsh. The riparian zone itself is bounded by the aquatic zone with its saturated soils and hydric plants, and by the drier soils and xeric plants of the upland zone.

Usually riparian zones experience periodic flooding. Hence part of the water reaching them comes from lateral movement into and through the soil, and part from the natural "irrigation" from overbank flooding which carries silt and nutrients. The combined effects of these two hydrologic functions cause most floodplain riparian zones to extend outward from the watercourse to about the 100-year flood line. A recent estimate based on watercourse lengths delineated on 1:24,000 USGS topographic maps indicates that there are between 600,000 and 1 million linear miles of riparian zone in California. No estimate of Central Valley riparian acreages has yet been developed.

Virtually all aquatic wetlands have riparian zones associated with them. The landward or terrestrial edges of all lakes, ponds, marshes, streams, rivers, and other open-water bodies are riparian zones (as are the lower elevations of islands within them). Many of the organisms associated with aquatic wetlands are, in one manner or another, dependent upon the adjacent riparian wetlands.

Traditionally, wetland boundaries for management or conservation purposes have been drawn at the water's edge or at the outer edge of emergent aquatic vegetation. "Wetland" has meant aquatic wetland. "Wetland conservation" has meant aquatic wetland conservation. This approach persists rather strongly in the more traditional wetland groups, with references being made to "the wetland edge" or to "palustrine wetlands", when what is really being addressed is the riparian zone.

In addition to those associated with permanent open water, riparian systems such as meadows may be created by high groundwater levels; others such as seeps and desert oases are created by surface-emergent aquifers. Still others are formed by intermittent streams and desert washes, where the intermittently supplied imported water is stored in the porous streambed substrate or flows below the surface of the streambed.

Riparian zones and their resulting riparian systems are determined by, and in turn themselves help shape, the landforms or physiography of the earth's surface. Watercourses develop between adjacent hills or mountains and along fault lines and other natural channels. Lakes and ponds occur in natural depressions caused by faults, glaciation, watercourses blocked by landslides, and other geologic events.

Where geologic forces have thrust the land up into mountain masses, the water flow is swift, with streams incised into the underlying rocks. The riparian zone may be limited in these areas to a very narrow streamside strip since very little soil can be deposited for roots to lodge in. Where geological processes have produced valleys and more gentle slopes, eroded soil is deposited, and the riparian zone substrates for meadows, streamside riparian woodlands, riverine bottomland forests, and other characteristic landforms are created.

Major landform patterns determine the structure of riparian zones in California. Each of these major landform provinces directly influences the formation of riparian zones in unique ways. The Sierra Nevada, for example, is largely an uplifted mass of granitic rock of great erosion resistance, while the Coast and Klamath ranges are composed of more easily weathered materials. The Basin and Ranges are yet different. Each of these major landforms responds differently to water and weathering, and their individual geological histories are uniquely different. The Central Valley and Mojave Desert are strikingly different from the mountain ranges, and from each other, even though both are largely depositional. This great diversity of landforms is one of the principal reasons for the variety of pattern in both aquatic and riparian wetland systems found throughout the State and in the Central Valley.

The amount of water delivered to and naturally carried by a watercourse is determined both by the size of the watershed (a function of landform) and the precipitation pattern (a function of climate). The watershed of the Sacramento Basin covers an area in excess of 22,000 square miles in central and northeastern California. This area also receives a significant amount of precipitation. In such a situation, a very large amount of water may be collected. This is reflected in the estimated average annual discharge of 17,870,000 AF for the lower Sacramento River, making it the largest river in the State.

The State's aridity is one of the central points in understanding the importance of riparian systems to regional ecology. In over two-thirds of California's land surface, watercourses and surface-emergent aquifers and their riparian systems provide the only permanent sites of high soil moisture and mesic broad-leaf vegetation. Otherwise this large portion of the State--some 110,000 square miles--is a region of arid uplands. The plant species of these uplands are by and large less palatable and nutritious to livestock and most wildlife species than riparian vegetation. These natural riparian gardens of highly productive, deciduous, broad-leaf trees and shrubs with their groundcovers of herbs and grasses are the State's only equivalent to the tens of millions of acres of bottomland hardwood forests and other riparian systems in the eastern half of the United States.

The ecological implications of this aridity can be further appreciated from an examination of national precipitation maps. Two-thirds of California has an annual precipitation rate of 20 inches or less. About two-thirds of that region receives less than 10 inches per year. In contrast, nearly the entire eastern half of the United States, from eastern Texas eastward, has annual precipitation rates exceeding 30 inches, with 70% of that region receiving 40-60 inches, much of it during the warm months of vigorous plant growth.

For those regions of the State with precipitation rates of less than about 40 inches per year, riparian systems are of exceptional ecological importance. The situation is made even more acute in that large part of California having a "Mediterranean" climate, characterized by winter rains and summer drought. As most of the precipitation falls during the cooler winter period when plants are dormant or very slow-growing, much water drains off the land without promoting significant vegetative growth. By the time spring arrives and plants are able to use the water, most of it is gone. By summer--with the conspicuous exceptions within the riparian zones--vegetation has dried up and largely ceased either to grow or to be palatable to wildlife or livestock. It is not surprising that many of California's riparian systems become linear or single-point oases. Scarcity makes them of great ecological value for the native wildlife.

Most bird and mammal species in California depend upon wetland or riparian habitat for at least some portion of their life history. Some have relatively small, localized distributions, while others may be found in isolated communities over many thousands of square miles, wherever the local circumstances are adequate. The actual distributional patterns of most riparian plants and animals are not understood and only now are the necessary data being gathered to permit such understanding.

However, it is recognized that the distributional ranges of major riparian plant species and communities do not coincide at all well with California floristic regions. Their present increased local air movement. The dependence of many of our native reptiles and amphibians upon riparian systems is in large part because of this special microclimate. The presence on the floor of a rich layer of duff and humus in the riparian woodland provides moist hiding and feeding places.

It is easy to see how linear riparian systems, with their shade, food supplies, cover, and water, can become important corridors for the migratory and dispersal movements of wildlife. In some parts of the country, elk and deer consistently use riparian zones as migration corridors between summer and winter ranges. Riparian corridors provide important migratory and dispersal routes for highly mobile species such as birds, bats, and other mammals, and even for some reptiles, amphibians, and insects. This phenomenon may have special significance in the Central Valley of California where linear riparian systems traverse the north-south length of the valley, a distance of 450 miles. Many species of land birds use riparian corridors as they are sometimes the only available woodland environment through which the birds may traverse a geographic region while on migrating flights. In the riparian zone, they find food and cover which may be unavailable in adjacent uplands a few feet away.

The strong ecological contrasts between riparian and adjacent upland systems add to the structural diversity of upland areas and promote wildlife utilization of those uplands. This is in part due to the linear configuration of most riparian systems, which maximizes ecotonal or edge effect.

The layered or stair-stepped configuration of riparian vegetation, often with contrasting forms (deciduous versus coniferous; shrubs versus trees), provides large numbers and varieties of feeding and nesting (denning) opportunities, especially for birds and bats. Deciduous riparian vegetation provides two seasonally contrasting structural conditions, a spring/summer full-leaf vegetation and a winter bare-branch one.

The presence of surface and near-surface water and the associated moist, often deep soils promote high species and structural diversities in riparian plant communities. This is especially important for both the terrestrial and aquatic arthropod fauna, which tends to be more host-specific than birds or mammals. These arthropods often in turn become food sources for fish, birds, and other wildlife.

A useful national perspective on the importance of riparian habitat is provided by the ninth annual report of the U.S. Council on Environmental Quality which reported in part:

No ecosystem is more essential to the survival of the nation's fish and wildlife. For example, western riparian ecosystems contain approximately 42 percent of the mammal species of North America, 38 percent of the reptiles, and 14 percent of the breeding birds and 75 species of fish of the Southwest are dependent upon riparian ecosystems.

California has a rich herpetofauna, including about 120 native species. Amphibians and reptiles represent important ecological components of riparian communities, where they may reach high densities. In California, it is estimated that riparian systems provide habitat for 83% of the amphibians and 40% of the reptiles. Many species are permanent residents of the riparian zone, while others are transient or temporal visitors.

Some of the figures for reptile and amphibian abundance in riparian systems are dramatic. In a review of this subject, some researchers reported that the riparian system of Corral Hollow Creek, San Joaquin County, supports seven species of amphibians and 21 species of reptiles, including 13 species of snakes. In certain streams, the Pacific giant salamander is the dominant vertebrate in both biomass and frequency of occurrence and makes up as much as 99% of the total predator biomass in some sites. The Pacific pond turtle may have reached densities as high as 172 per acre in California ponds and streams. These and other reported abundance levels far exceed most previous expectations and indicate that the riparian-dependent herpetofauna is ecologically more significant than has until now been appreciated (Tables IV-1 and IV-2). Very little is known of the ecology of California's herpetofauna within riparian systems. Due to our lack of knowledge, we can only guess at the effects of human-uses upon this group. Similarly, the densities and distribution of most species and subspecies are only partially known. We must recognize that in the absence of more definitive information, we are at risk of losing whole populations of this important group through inappropriate land use and development, without ever being aware of that loss. Those species with high dependencies upon riparian systems are at greatest risk.

Since birds are highly mobile, relatively abundant, and easily observed, they are the most visible and widely studied group of animals inhabiting riparian systems. Many bird species are dependent upon riparian vegetation for food, cover, nesting sites, singing and observation perches, migration corridors, and other requirements.

As migratory birds move northward in the spring they often pause for two to three days in riparian woodlands to rest and feed. Many species travel north from Central and South America to breed in the riparian vegetation of California's creeks and rivers. Similarly,

TABLE IV-1. Use Classification of Amphibians Occurring in California Riparian Systems.

Constant Use

Species occur in the riparian zone throughout their lives.

Northwestern salamander	Tailed frog	Cascades frog
Pacific giant salamander	Red-spotted toad	Foothill yellow-legged frog
Olympic salamander	Black toad	Mountain yellow-legged frog
Dunn's salamander	California treefrog	Leopard frog
Desert slender salamander	Red-legged frog	Inyo Mountains salamander
Spotted frog		

Breeding Use

Species utilize riparian systems primarily for breeding, but may leave the riparian zone as adults.

Long-toed salamander	Southwestern toad	Western toad
California newt	Pacific treefrog	Woodhouse's toad
Colorado River toad	Rough-skinned newt	Great Plains toad
Yosemite toad	Red-bellied newt	

General Use

Species utilize riparian systems as well as other systems throughout their range.

Del Norte salamander	Siskiyou Mountain salamander
Ensatina	Pacific slender salamander
California slender salamander	Black salamander
Clouded salamander	Arboreal salamander
Limestone salamander	Shasta salamander
Mount Lyell salamander	

TABLE IV-2. Use Classification of Reptiles Occurring in California Riparian Systems.

Constant Use

Species occur in the riparian zone throughout their lives.

Western pond turtle
Sonoran mud turtle
Checkered garter snake
Common garter snake
Western aquatic garter snake

Arid Use

Species depend on riparian systems in the arid parts of their range.

Western skink
Gilberts skink
Panamint alligator lizard
Northern alligator lizard
Ringneck snake
Sharp-tailed snake
Western terrestrial garter snake

General Use

Species utilize riparian systems as well as other systems throughout their range.

Western fence lizard
Sagebrush lizard
Long-tailed brush lizard
Western whiptail lizard
Southern alligator lizard
California legless lizard
Western blind snake
Rubber boa
Racer
Striped racer
Gopher snake
Common kingsnake
California mountain kingsnake
Northwestern garter snake
Western black-headed snake
Night snake
Western rattlesnake

there is a large complement of bird species which breeds further north and comes south in the fall to winter in the bottomland woods and forests of the State.Large winter-resident populations have been reported and studied in the mesquite and riverine woodlands along the lower Colorado River. A somewhat similar pattern has been observed in riparian vegetation along the Sacramento River. Some species, like the Red-shouldered Hawk and the Swainson's Hawk, seem to strongly prefer trees growing along the edges of streams and sloughs. At one time, the Swainson's Hawk was one of the more abundant hawks in California. With the progressive loss of nesting trees over the last century and other factors, the Swainson's Hawk population has dwindled until it is now officially listed as a threatened species in California.

Over 135 species of California birds are either completely dependent upon riparian systems or use them preferentially at some stage of their life histories. Fourteen of these species are now officially listed as Endangered or Threatened on the California and/or Federal lists. These include the Bald Eagle, American Peregrine Falcon, California Clapper Rail, Light-footed Clapper Rail, Yuma Clapper Rail, California Black Rail, Greater Sandhill Crane, California Least Tern, Swainson's Hawk, Western Yellow-billed Cuckoo, Elf Owl, Least Bell's Vireo, Bank Swallow, and the Inyo Brown Towhee.

Another group of 26 riparian-dependent or riparian-preferring birds is now in sufficient decline that they have been placed on a Bird Species of Special Concern List by the DFG. In many instances, placement on the list indicates that while available data show the species is in decline or has a very limited range, insufficient field evidence has yet been gathered to determine if it should be officially listed as endangered or threatened. Many of these species also appear on the Blue List, a list published annually by American Birds of species showing signs of non-cyclical population declines or range contractions in North America.

Riparian-dependent or riparian-utilizing California birds sensitive to habitat loss include:

Highest Priority	Second Priority	Third Priority
White-faced Ibis	Double-crested Cormorant	Least Bittern
Fulvous Whistling-duck	Marsh Hawk	Harlequin Duck
Yellow Rail	Osprey	Goshawk
Gilded Northern Flicker	Snowy Plover	Sharp-shinned Hawk
Willow Flycatcher	Long-eared Own	Cooper's Hawk
Vermilion Flycatcher	Gila Woodpecker	Brown-crested Flycatcher
Arizona Bell's Vireo	Bank Swallow	Crissal Thrasher
	Yellow-breasted Chat	Hepatic Thrasher
	Summer Tanager	Northern Cardinal

A review of published and unpublished reports on these species indicates that in most cases reduction in extent or quality of the riparian environment due to human-uses is the major cause of decline. In some instances, causal factors have not been identified, primarily because studies have not yet been undertaken.

California has a rich and diverse native mammalian fauna. Some 502 species and subspecies are found within the state's borders. Of these, approximately 25% (133 taxa) are limited to or largely dependent upon riparian and aquatic wetland environments. No other type of environment in California approaches that of riparian wetlands in importance to mammals, and none has been so diminished in extent and degraded in quality.

Several investigators searched the published and unpublished literature on California mammals to determine which species are present in Central Valley riparian systems. Due to the paucity of technical information available, their analysis was by species rather than subspecies or geographical race, and no attempt was made to determine the relative dependence of the species on riparian environments. With respect to this lack of information they wrote:

"... We have found that the composition of the mammal fauna of the Central Valley's riparian communities is poorly documented. More research is also needed to improve our knowledge of life histories of riparian mammals, and the ecological relationships between them and the communities they inhabit in the Central Valley. Opportunities for conducting this research have been diminishing with the destruction of natural riparian communities, so we recommend that field biologists turn their attention without delay to the remaining opportunities for research in this poorly understood area."

Recent research has demonstrated that some riparian-utilizing species are more abundant than previously thought. For example, a researcher found the ringtail population in the Central Valley, with few exceptions, "... to be associated with remnant stands of riparian forests bordering waterways such as the American River, Sacramento River, Feather River, Butte Creek, and Butte Slough. No ringtails were captured or reported from open, park-like stands of valley oak woodland." They found this species to be surprisingly abundant in riverine riparian vegetation, with densities of 26.7 to 52.8 per square mile. These densities are the highest for that species recorded in the literature.

Yet there is a darker side to this picture. Of the 133 taxa of native California mammals limited to or largely dependent upon riparian wetlands, 21 species and subspecies are particularly vulnerable to loss of habitat and are facing potential threats of extinction, principally through destruction of habitat. These taxa are in addition to those described earlier which are extinct or formally listed as endangered or threatened.

It can be seen that rather similar patterns of: a) high species dependency on riparian systems; b) population decline; and c) instability and threat to the remaining populations exist for California's native amphibians, reptiles, birds, and mammals. Regrettably, our knowledge of riparian insects and plants is still so limited that no similar evaluation can be made for them. However, it has been shown serious population structure aberrations in Central Valley Fremont cottonwood, California sycamore, and valley oak have occurred. Riparian plants are probably threatened more by gross reduction in distribution and abundance, hence with reduction in ecological significance, than with extinction. However, one species, the rose-mallow or hibiscus, is now officially listed as Endangered. A riparian insect, the valley elderberry longhorn beetle has also been listed as Endangered. When one also takes into account the high level of primary productivity of California's riparian systems such as the rapid growth rates, luxuriance, and palatability of their vegetations, it is easy to understand why California's riparian systems play such a central role in the ecology of our native wildlife populations.

The stream and its living creatures are directly and inexorably linked to the adjacent riparian zone, and in reality should all be thought of as part of a larger interacting system or environment that includes both an aquatic instream portion and an adjacent, terrestrial riparian portion.

The shading effect of riparian vegetation provides significant temperature-moderating effects to adjacent watercourses. This cooling effect can determine the suitability of streams for important coldwater gamefish species such as trout and salmon. It has been demonstrated that lack of, or removal of, shading along streams can increase water temperature by 11.7-18°F. Shading also can significantly diminish daily temperature variations in streams, which has important ecological effects.

Riparian vegetation protects watercourse banks from erosion through reduction of water velocity, soil binding by root masses, and the presence of ground litter, which impedes the rate of surface runoff. It promotes deposition of silt as new soil during periods of flood, without which key riparian species such as willows and cottonwoods could not reproduce. It also provides important substrates for aquatic insects, and escape and resting cover for many fish species.

The dead organic matter or detritus (leaves, twigs, branches), and to a lesser extent live invertebrates, from riparian vegetation are important sources of nutrients, especially to headwater streams. Up to 99% of the annual energy input, the food base for entire aquatic communities, comes from streamside vegetation in these situations, especially where there is a dense forest canopy.

Riparian systems have recreational, scientific, and economic values. The contribute to recreation, commercial fish, wood products, and open space. The Central Valley's riparian systems provide thousands of linear miles of diverse recreational opportunities, including picnicking, hunting, fishing, camping, birdwatching, sightseeing, photography, nature study, and just loafing in the shade on the bank of a stream. Their widespread distribution renders them accessible to recreationists in all parts of the valley.

Many kinds of scientific research are now being undertaken in them, in part to address some of the questions identified in this report. Some of these scientific efforts are of the most urgent nature because of the degree of existing damage and threat to individual species and the systems. Important basic research into the ecology, physiology, and population dynamics of the riparian biota, and integrated analysis of entire systems, is underway, and our knowledge of their internal dynamics is growing.

Most of the values of riparian systems do not result in consumption of the basic resource; that is, they take place without the systems being harvested or destroyed. While recreational overuse has at times degraded local areas of special interest, management of human and riparian system interactions can reduce impacts to insignificance. Each year hundreds of thousands of Californians invest millions of user days in riparian-oriented recreational activity and scientific study.

V. SOURCES OF FUNDS FOR RESTORATION

The total funding required to implement the recommended actions in this plan for which costs have been estimated is nearly $350 million. The costs for many restoration actions have not been estimated and these items are not included in the total cost estimate. Several potential funding sources exist for restoration of anadromous fish habitats upstream of the Delta. Presently, these funding sources are not adequate to implement projects on the vast scale needed to restore our anadromous fish. We anticipate that additional funding will be made available so that we will be able to implement many of the restoration actions identified in this plan.

Fish and Game Preservation Fund. This fund receives the revenues generated from the sales of licenses, stamps, and permits issued by the DFG for hunting, sport, and commercial fishing privileges, and other resource-related activities over which the DFG has purview. This fund presently provides approximately one-half of the DFG's annual monetary support.

Functionally, the fund is divided into two parts: the non-dedicated portion and the dedicated portion. In general, non-dedicated monies are available for expenditure at the discretion of the DFG for support of programs beneficial to fish, wildlife, and native plants. Expenditures from dedicated accounts within the fund are constrained to specific activities defined by their enabling legislation. Dedicated Fish and Game Preservation Fund accounts that have the potential to assist in anadromous fish recovery efforts are described under separate subheadings.

Funding for anadromous fish habitat restoration from the non-dedicated portion of the fund is very limited. Non-dedicated funds provided just over $179,000 of the $8.5 million budget for the Salmon and Steelhead Program in State fiscal year 1992/93. The needs of anadromous fish must compete with the needs of other fish, wildlife, and native plants for the relatively small amount of money that is available.

Commercial Salmon Stamp Account. This dedicated account was created through 1980's legislation that imposed a stamp fee on commercial salmon fishers and crew as well as commercial passenger salmon fishing vessel operators and crew. The annual stamp fee ranges from $85 to $260 and is based on the total pounds of salmon landed during the previous year. Total annual revenue has varied from approximately $340,000 to just over $1 million. California's commercial fishing industry played an instrumental role in conceiving the legislation, which provides the only significant source of ongoing funding for restoration of salmon and their habitat in the State. The requirement for salmon stamps extends through December 1996.

Funds from stamp sales are deposited into two subaccounts, the Commercial Salmon Stamp Dedicated Account and the Augmented Salmon Stamp Dedicated Account, in compliance with legal requirements. The first of these accounts ($30 per stamp) is statutorily directed to salmon rearing. The program annually rears a total of 2 million chinook salmon in the Central Valley, at a cost of $120,000. Production is divided between Feather River Hatchery and the Mokelumne River Hatchery. Expenditures from the augmented account must be in accordance with the recommendations of the Commercial Salmon Trollers Advisory Committee. Projects recommended for funding in the Central Valley include habitat restoration, rearing, equipment for hatcheries and habitat restoration crews, construction projects for facilities to support salmon rearing and habitat activities, and educational programs.

Striped Bass Stamp Account. Like the Commercial Salmon Stamp Account, this account originated in the early 1980's from the efforts of constituent groups willing to work through the legislative process to impose a tax on themselves to provide a source of money for striped bass restoration. A stamp costing $3.50 is required of sport striped bass anglers. Annual stamp receipts are approximately $1.5 million. Funds are directed to striped bass restoration activities, and proposed expenditures are reviewed by the Striped Bass Stamp Advisory Committee. Expenditures have primarily been for rearing, hatchery evaluation, and for research into the causes of California's striped bass decline. Future expenditures may also include habitat restoration where appropriate. The striped bass stamp requirement extends through December 1994.

Steelhead Trout Catch-Restoration Card. Beginning January 1, 1993, California steelhead anglers are required to purchase a $3 catch-restoration card in addition to any other required licenses or stamps. Annual revenue generated from card sales is expected to be approximately $360,000. Funds are directed to steelhead monitoring, restoration, and enhancement activities. Up to one-third of the revenue may be expended for Central Valley steelhead.

Public Resources Account (Proposition 99). Through the initiative process in 1988, Californians levied a tax on tobacco products and created the Cigarette and Tobacco Products Surtax Fund. The tax generates annual revenue in excess of $500 million, of which 0.83 percent is directed to fish habitat restoration through the fund's Public Resources Account.

In addition to the Public Resources Account, the Unallocated Account, which receives 25% of the total revenue generated, also exists in the fund. By law, a portion of the funds in this account could be used for anadromous fish restoration through transfers from this account to the Habitat Conservation Fund, administered by the Wildlife Conservation Board.

Future funding prospects for anadromous fish restoration from Proposition 99 are extremely uncertain. Depending on the legislative and executive direction given, the Cigarette and Tobacco Products Surtax Fund could be either a major or minor contributor to restoration of Central Valley streams.

California Wildlife, Coastal, and Park Land Conservation Fund of 1988 (Proposition 70). This 1988 initiative approved by Californians provided $10 million for salmon stream restoration. Through fiscal year 1992/93, approximately one-half of these funds will have been expended for projects and equipment. Expenditures must be in accordance with the recommendations of the Commercial Salmon Trollers Advisory Committee and the California Advisory Committee on Salmon and Steelhead Trout. Spending authorization for these initiative funds expires in 1998.

Proposition 70 also provided $6 million for wild trout and native steelhead. Allowable uses of this fund included habitat restoration, acquisition of public access, and construction of an experimental propagation facility.

Bosco-Keene Renewable Resources Investment Fund. This fund, created by 1981 legislation, receives 30% of the revenue deposited into the Geothermal Resources Development Account. Under current law, salmon and steelhead hatchery expansion and fish habitat improvement appear as items in one of eight listed potential uses for these funds. This fund currently provides $280,000 to the Salmon and Steelhead Program, but future use of the fund is highly uncertain.

Keene-Nielsen Fisheries Restoration Account. This account, with the objective of remedying some of the more severe effects of water and other development activities on fishery resources, was established through 1985 legislation. Authorizations totaling just over $15 million were included in approved legislation, but only $11.25 million were appropriated. The account was reauthorized through fiscal year 1993/94 by 1990 legislation, but the legislation provided no appropriation. The reauthorization did reword expenditure control language, however, tying expenditures closely to Salmon, Steelhead Trout, and Anadromous Fisheries Program Act projects. In 1992, $1 million remained in the account.

Expenditure of these funds in fiscal year 1992/93 will exhaust this account unless additional appropriations are directed to it by the Legislature or through the initiative process.

Wildlife Conservation Board. The Wildlife Conservation Board, comprised of the directors of the DFG and the Department of Finance, and the President of the Fish and Game Commission, has authority for expenditure of funds from a variety of sources for purposes beneficial to fish and wildlife as well as recreational activities associated with them. Funding sources that fall entirely or partially under the purview of the Board include the Wildlife Restoration Fund and specified portions of both the California Wildlife, Coastal, and Park Land Conservation Fund of 1988 (Proposition 70) and the Habitat Conservation Fund (Proposition 117). Enabling legislation for the latter fund, created through voter approval of the California Wildlife Protection Act of 1990, specifically provides that expenditures for acquisition, restoration, or enhancement of aquatic habitat for spawning and rearing of anadromous salmonids and trout resources are specified purposes of the fund. The Board may grant funds for restoration activities to public agencies and to nonprofit groups.

Department of Parks and Recreation. The California Wildlife Protection Act of 1990 provides the Department of Parks and Recreation $2 million annually from the Habitat Conservation Fund for 50% matching grants to local agencies. Grant purposes, by law, include acquisition, restoration, or enhancement of aquatic habitat for spawning and rearing of anadromous salmonids and trout.

Environmental Enhancement and Mitigation Program. This program for mitigating negative effects of highways and vehicle operations is administered by the California Transportation Commission. The enabling legislation provides a $10 million annual appropriation through fiscal year 2000/2001 for several purposes, including grants for acquisition, restoration, or enhancement of resource lands to mitigate loss of or detriment to lands near rights-of way. Public agencies and nonprofit organizations are eligible for funding.

Davis-Dolwig Act. In 1961, this legislation established a State policy that enhancement of fish and wildlife is a purpose of State water projects and provided for a system of public recreation facilities as part of State water projects. The Act provided that costs for the preservation of fish and wildlife, determined to be allocable to the costs of the project, should be included by the DWR as a reimbursable cost in determining charges for water and power produced by the project.

Davis-Grunsky Act. This 1967 legislation provides for financial assistance to public agencies for water development, recreation, and fish and wildlife enhancement for projects substantially conforming to the California Water Plan. The DWR has purview over the program.

Urban Streams Restoration Program. The DWR administers this program of granting Proposition 70 funds for urban stream restoration projects that are co-sponsored by local agencies and nonprofit groups. The primary project objectives are flood and erosion control, although qualified projects are enhanced if they provide educational or wildlife benefits. Projects are limited to urban streams, creeks, or small rivers. Projects on lakes, large rivers, wetlands or marshes, in addition to exclusively educational or wildlife enhancement projects, are excluded from consideration.

Agreement Between the Department of Water Resources and the Department of Fish and Game to Offset Direct Fish Losses in Relation to the Harvey O. Banks Delta Pumping Plant (DWR Four Pumps Agreement). The DFG and the DWR entered into an agreement in late 1986 to offset direct losses of striped bass, chinook salmon, and steelhead caused by the diversion of water by the Harvey O. Banks Delta Pumping Plant. Direct losses were defined as losses of fish which occur from the time fish are drawn into Clifton Court Forebay until the surviving fish are returned to the Delta. These losses occur in spite of fish screens located at the Pumping Plant due to enhanced predator efficiency in parts of the system, very poor screening efficiency for fish less than about one inch long, and mortality caused by handling fish during salvage operations.

In addition to annual obligations for losses at their pumping plant, the DWR also agreed to provide $15 million to initiate a program to increase the probability of quickly recovering fish populations.

During the time that the agreement has been in place, the DWR has approved expenditures of about $5.8 million from the $15 million account and has spent about $6 million in annual mitigation projects. Projects funded under both sources of funds have ranged from hyacinth control projects on the Merced River to a major salmon spawning gravel restoration project in the upper Sacramento River (Tables V-1 and V-2). The funds in the account are derived from the SWP contractors.

Agreement to Reduce and Offset Direct Fish Losses Associated with the Operation of the Tracy Pumping Plant and Tracy Fish Collection Facility. In July 1992, the USBR and the DFG entered into an agreement similar to the fish replacement agreement between the DFG

TABLE V-1. Department of Water Resources Direct Fish Loss Agreement Expenditures from the $15,000,000 Account.

Project	Expenditure
Suisun Marsh Fish Screen	$70,000
Merced River Water Hyacinth Control Project	$25,000
Sacramento River Gravel Restoration Project	$2,370,000
Mill Creek Pump Project	$392,000
Striped Bass Stocking Program	$953,000
Enhanced Delta Fishery Enforcement	$1,785,000
Striped Bass Pen Rearing Project	$31,519
Total	$5,626,519

TABLE V-2. Department of Water Resources Direct Fish Loss Agreement Annual Direct Loss Expenditures.

Project	Expenditure
Merced River Hatchery Modernization	$810,750
Merced River Gravel Project, Phase I	$21,727
Merced River Gravel Project, Phase II	$28,969
Ruddy Gravel Restoration, Tuolumne River	$51,089
Mill Creek Gravel Restoration	$78,125
Reed Gravel Restoration, Tuolumne River	$17,850
Magneson Gravel Restoration, Merced River	$5,688
San Joaquin River Electrical Barrier	$116,860
Gravel Restoration, Tuolumne River	$27,170
Total	$1,158,228

and the DWR. This agreement was structured to reduce and offset direct fish losses associated with the operation of the Tracy Pumping Plant and the Tracy Fish Collection Facility operated by the USBR near Byron. The agreement stipulated that the USBR, beginning in federal fiscal year 1993 and for five consecutive years, provide funds to the DFG to be used for mutually agreed upon programs to offset and replace direct losses of striped bass and chinook salmon resulting from the operation of the Tracy Pumping Plant. During the first 5-year period, a total of $6.51 million will be provided. For fiscal years 1993 and 1994, funds will be limited to $600,000 per year. In fiscal years 1995 and through 1997, the USBR will provide $870,000 annually. The USBR will also provide one lump sum of $2.7 million by the end of fiscal year 1995.

Although no funds have yet been used, the DFG will be responsible for ensuring that programs funded by the USBR are implemented in a manner that will offset and replace annual direct losses resulting from export of water from the Tracy Pumping Plant.

Federal Aid in Sport Fish Restoration Act. The federal government levies an excise tax, paid by manufacturers, on fishing tackle, pleasure boat, and motorboat fuel. The revenues are made available to the states on a matching basis (generally 3 Federal dollars for each State dollar) for funding fish restoration and enhancement activities, for wetlands restoration, and for acquisition of motorboat access to the nation's waterways. The Act presently provides $1.7 million to the Salmon and Steelhead Program. Additionally, the act provides part of the funding for Central Valley anadromous fish habitat restoration crews as well as their equipment and facilities. Funding from this source is declining because of decreases in revenues.

Public Law 102-575, the Central Valley Project Improvement Act (CVPIA). On October 30, 1993, the President signed into law the Reclamation Projects Authorization and Adjustment Act of 1992 (Public Law 102-575), including Title 34, the Central Valley Project Improvement Act (CVPIA). The CVPIA amends the authorization of the Department of the Interior's California Central Valley Project (CVP) to include fish and wildlife protection, restoration, and mitigation as project purposes equal to irrigation and domestic uses. It further specifies that fish and wildlife enhancement are a purpose equal to power generation. The CVPIA identifies a number of specific measures to meet these new purposes and sets a broad goal of sustaining natural populations of anadromous fishes produced in Central Valley rivers and streams at double the average levels that existed from 1967 through 1991. By requiring specific fish, wildlife, and habitat measures to be implemented, Congress has largely defined the types of actions to be undertaken. The CVPIA also established in the Treasury of the United States the "Central Valley Project Restoration Fund" and authorized the appropriation of up to $50,000,000 per year to carry out programs, projects, plans, and habitat restoration, improvement, and acquisition as required. Up to $30,000,000 per year for the Restoration Fund are to be collected from Central Valley Project water and power contractors through increased charges for water and power.

Many of the specific habitat restoration and remedial actions of the CVPIA require State-Federal cost sharing. The State and the USBR have developed draft Memoranda of Agreement to facilitate implementation of the provisions and have developed a draft cost sharing agreement. Generally, the agreements are structured so that restoration actions can proceed quickly. In the event that one agency cannot provide its share of an individual project, the other agency can assume the total cost with the understanding that the financial imbalance will be corrected when implementing future projects. The total cost of implementing all the anadromous fisheries and riparian restoration provisions in the CVPIA is unknown but is roughly estimated at $500,000,000. The State's total obligation for its share of the total is also unknown but expected to be about 30% of the total or approximately $150,000,000.

Passage of a State-supported bond act may be required before the State can effectively participate in the implementation of the major provisions of the CVPIA.

VI. PRESENT RESTORATION AND PROTECTION PROGRAM

Anadromous Fisheries

Restoration, mitigation, and enhancement of anadromous fish habitat in the Central Valley requires the combined efforts of the fisheries agencies, water-distribution and land-management agencies, and the public. Restoration efforts seek to increase fish population numbers in debilitated streams to the levels that naturally occurred during prior periods. Mitigation is the intended to avoid or offset adverse effects resulting from project design, construction, or operation. By contrast, enhancement efforts seek to improve on existing conditions, independent of previous factors that affected the fish population.

The DFG, USFWS, and NMFS are the principal agencies responsible for anadromous fish restoration in the Central Valley. The DFG has the only significant fisheries enhancement program. This program uses special bond funds and annual budget appropriations to restore spawning and nursery habitat and to produce fish in hatcheries. The USBR and the USFWS attempted an enhancement program as part of the project that produced RBDD, but the effort has proven unsuccessful. Under the auspices of the Resources Agency, a number of State, Federal, and local agencies and private groups worked together to develop the Upper Sacramento River Fisheries and Riparian Habitat Management Plan as required by Senate Bill 1086 (Chapter 885/86). Segments of the plan are being implemented by the agencies as resources allow.

Several spawning habitat improvement projects have been completed by DFG on the Sacramento River from Redding to Anderson and on tributaries such as Clear, Mill, and Deer creeks. Similar spawning habitat improvement work has been completed on the Merced and Tuolumne rivers. In some cases, spawning riffles have been artificially constructed and in others, gravel has been placed where the river can naturally distribute it downstream. Experience has proven that unless hydraulic controls are present, restored spawning riffles are usually short-lived. Although most of the work to date has been experimental and long-term benefits have not been documented, significant spawning use has occurred at some sites.

Operation of screens and ladders on tributary streams saves many thousands of young salmon and steelhead each year. All diversions on Mill, Deer, and Antelope creeks are provided with screens and ladders. The ladder at McCormick-Saeltzer Dam on Clear Creek has recently been improved. As a condition of FERC relicensing, Pacific Gas and Electric Company (PG&E) constructed a new screen and ladder at their diversion on South Cow Creek. The DFG constructed and operates a screen on the Anderson-Cottonwood Irrigation

District (ACID) diversion at Redding and operates a new Denil fish ladder on the south side of the dam. The ACID diversion at their Bonneyview Pumping Station has recently been screened.

In 1988 and 1989, DFG placed approximately 30,000 cubic yards of gravel in the upper Sacramento River near Keswick Dam. Funding for these projects was partially provided by the USBR. The DFG, in cooperation with DWR, USFWS, and NMFS, has added 100,000 cubic yards of gravel to the river in the Redding-Anderson area for replenishment of spawning beds downstream. Other gravel restoration projects are underway or being planned on the Merced, Tuolumne, and Stanislaus rivers.

Physical constraints typically are features of water development and delivery projects. Many of the major irrigation diverters have been required to screen their intake structures to minimize entrainment of downstream migrating juvenile salmon and steelhead. Rearing facilities are being used at several locations to increase smolt production or produce larger smolts to replace those that would have naturally been produced, were it not for dams and water diversions.

Four salmon and steelhead hatcheries (Mokelumne River, Nimbus, Feather River, and Coleman) were constructed to mitigate for the habitat lost as a result of water project construction. One additional hatchery (Merced) was constructed to supplement runs adversely affected by irrigation demands. To help compensate for and minimize downstream fish losses, permit conditions or memoranda requiring minimum instream flows below project dams were established. Unfortunately, those flows have usually proven inadequate to reliably maintain healthy populations of salmon and steelhead. Project operational features designed to minimize adverse effects on Central Valley fisheries have included: controlling fluctuating flows to protect incubating eggs and small fish on stream edges; maintaining suitable water temperatures for spawning and incubation; trucking smolts from hatcheries to the estuary to reduce mortalities during emigration; releasing large pulses of water to assist and encourage upstream migration of adults and improve survival during the downstream migration of hatchery and naturally produced smolts; and operating major diversion dams in a way to minimize obstruction to upstream and downstream migrating fish. Only recently has the alternative of reducing water diversions during crucial migration times been implemented.

Legal and administrative measures taken to protect inland salmon and steelhead include passing new laws, establishing special fishing regulations, adopting and implementing policies, completing binding agreements between resource agencies and resource developers, and developing, processing, and adopting a variety of planning documents. CEQA, NEPA, the Clean Water Act, the FWCA, CESA, ESA, and the FERC licensing processes provide most of the legal basis for environmental protection and restoration actions for the State's anadromous fisheries.

The Fish and Game Commission (Commission) has adopted various regulations and policies which are designed to protect the State's salmon and steelhead resources. Regulations restrict size and numbers of sport-caught fish to ensure that sufficient numbers of fish survive to spawn. The Commission's policies for the protection of salmon and steelhead have been adopted to guide DFG in its management activities and review of land and water development proposals. The tremendous public value of salmon and steelhead is recognized by the Commission and given a high priority. A number of Federal acts and projects which affect fisheries are appended to the published Fish and Game Code and the California Administrative Code, Title 14.

Many water or hydro-power agencies in the Central Valley are directly or indirectly involved with protection of salmon and steelhead fisheries through their mitigation obligations. These mitigation obligations include: minimum flow releases, hatcheries, spawning channels, diversion intake screening, and maintenance of appropriate downstream water quality and temperatures. Some of the major facilities are:

Coleman National Fish Hatchery (CNFH). This Federally operated hatchery is located on Battle Creek about 15 miles northeast of the town of Red Bluff. This hatchery was constructed by the USBR as part of the salvage plan to mitigate for the loss of historical spawning areas where access for salmon and steelhead was blocked by construction of Keswick and Shasta dams. This hatchery has been in operation since 1943 (at about the same time the older Battle Creek Hatchery was closed) and is funded and operated by the USFWS. The present yearly production goal is 12 million 90/lb (fingerling) fall-run chinook salmon, 2 million 40/lb (fingerling) late-fall-run chinook salmon, and 1 million 7/lb (yearling) steelhead. After admittedly dismal results during the first two years of attempting to propagate Sacramento River winter-run chinook salmon, CNFH now has the capability to rear a limited number. After planned improvements are successfully completed, CNFH may also have the capability to rear spring-run chinook salmon. CNFH has made great strides in improving its operation in the last ten years and is presently the largest juvenile chinook salmon production facility in Oregon, Washington, and California. The hatchery has been undergoing an active multi-million dollar rehabilitation program. Although not all of the planned rehabilitation projects have been completed, nearly all are expected to be finished within five years.

Feather River Hatchery (FRH). This DFG-operated salmon and steelhead hatchery is located in the town of Oroville. The hatchery was built by the DWR to mitigate for the loss of historical spawning areas when access for chinook salmon and steelhead trout was blocked by construction of Oroville Dam. The facility started operation in 1967. The cost of rearing mitigation fish is paid by the DWR. The hatchery has an annual production goal to raise 8 million 30/lb (fingerling) fall-run chinook salmon, 2 million 50/lb (fingerling) fall-run chinook salmon, and 0.4 million 3-4/lb (yearling) steelhead. An adjunct to the hatchery, the Thermalito Annex, has a goal of rearing 2.6 million 30/lb (fingerling) fall-run chinook salmon, paid for principally from Salmon Stamp money and salmon landing tax receipts.

Nimbus Fish Hatchery (NFH). This DFG-operated salmon and steelhead hatchery is located on the American River about 20 miles east of the City of Sacramento. This hatchery was built by the USBR in 1955 to compensate for the loss of access to historical spawning areas resulting from the construction of Nimbus and Folsom dams. The cost of rearing mitigation fish is paid by the USBR. Present yearly production goal is to raise 4.5 million 50/lb (fingerling) fall-run chinook salmon and 0.5 million 3-4/lb (yearling) steelhead.

Mokelumne River Fish Hatchery (MRFH). This DFG-operated fish-rearing facility is located near the town of Clements. This hatchery was built by the East Bay Municipal Utility District (EBMUD) in 1965 to mitigate for the loss of access to historical spawning areas resulting from the construction of Camanche Dam. The hatchery is operated by DFG. The cost of rearing mitigation fish (100,000 salmon or steelhead) is paid by EBMUD. The present annual production goal is to raise 2 million 30/lb (fingerling) chinook salmon and 40,000 yearling steelhead. The cost of rearing the non-mitigation fish is paid by Salmon Stamp funds and DFG.

Merced River Hatchery (MRH). The most southerly salmon hatchery in the Central Valley is located about 5 miles east of the town of Snelling. It was constructed with Davis-Grunsky funds by the Merced Irrigation District (MID) to enhance depleted salmon runs in the Merced River. The facility, in operation since 1971, is operated and primarily funded by DFG with partial facility maintenance paid by MID from the Davis-Grunsky account. The DWR recently funded extensive modernization of the Facility and provides approximately 30% of the total annual cost of operating the hatchery. The annual production goal is 0.3 million 8-10/lb (yearling) and 0.4 million 70/lb (fingerling) fall-run salmon. Satellite egg collection or rearing sites are operated as needed to maintain or supplement MRH operations.

Other Facilities. During the late 1950's and early 1960's, artificial spawning channels were believed to be a viable method of producing salmon. Spawning channels were built in California near the Merced, Feather, and Mokelumne rivers, and at the large Tehama-Colusa

Fish Facility (TCFF) which was built in conjunction with the RBDD project. Although artificial spawning channels work for some species of Pacific salmon, they have generally not been successful for chinook. Some of the above spawning channels have been converted to rearing ponds, others have been abandoned.

Temporary use of Modesto Irrigation District's (ModID) abandoned main canal near La Grange is facilitated by an agreement between DFG, ModID, and Turlock Irrigation District. Juvenile chinook salmon are reared there through the summer months in cool water to avoid temperature related mortality.

Public Participation. Citizens and special interest organizations play a major role in the management of salmon and steelhead in California. The popularity of salmon and steelhead can be measured both by the sport and commercial fisheries and by the public interest in nature films, books, magazines, and nature education. A recent survey conducted for DFG found the vast majority of the public to be interested in protection of fish and wildlife. Salmon and steelhead are especially associated by the public with clean natural streams and have been widely held as a mark for measuring the health of our environment.

Commercial and sport angling organizations take an active part in debates related to harvest regulations and frequently participate in hearings and negotiations regarding land and water project mitigation and restoration. They have shown strong political and financial support for fisheries restoration and enhancement programs.

Riparian Wildlands

Riparian areas in DFG ownership are held as wildlife areas or ecological reserves. They are managed to protect and enhance riparian, and other fish and wildlife habitats. Limited public use is encouraged where not in direct conflict with the primary management goal. DFG ownership is presently in a disconnected mosaic of isolated tracts throughout the Central Valley. Recent acquisitions in the vicinity of Butte Creek and the Sacramento River, and near the town of Anderson on the Sacramento River have protected large contiguous riparian woodland complexes. A riparian non-development easement on the Stanislaus River obtained from the USCOE as part of the New Melones project provides significant protection for existing riparian vegetation in the project area.

Other State lands contain significant parcels of riparian habitat and the SLC and the Reclamation Board have moved toward preservation of these riparian communities. Environmental easements for riparian habitat protection were first established in the Sacramento Valley during the early 1970's on lands controlled by Reclamation Boards.

Environmental easements and purchases by preservation organizations are significantly slowing the loss of riparian habitat. However, this has not been sufficient to overcome the destruction resulting from a rush to convert wildlands to cultivation, and then other uses.

Local zoning and grading ordnances and the environmental review process have proven inadequate preservation tools in many areas. Fee purchase or land exchange has become the only feasible alternative for protection of the large or continuous tracts that provide adequate habitat for larger, or more mobile wildlife.

Recent legislation created a new acquisition and preservation program in the Wildlife Conservation Board. The new program is in its infancy but shows promise for an organized approach to acquisition of viable Central Valley riparian systems supporting fish, wildlife, and plant communities. Parkland and waterway programs through the SLC and the Department of Conservation also have potential for maintaining viable riparian systems.

VII. STREAM AND RIPARIAN HABITAT ACTION PLANS

The Great Central Valley with its thousands of miles of waterways and associated riparian habitats, and thousands of acres of seasonal and permanent wetlands is a national treasure. Nothing like it exists anywhere in the nation.

The streams, riparian corridors, and wetlands of the Central Valley all merge in the Sacramento-San Joaquin Delta. The Delta is a key to the health and survival of the natural plant and animal communities of the Central Valley. This Action Plan addresses the needs of water-dependent natural communities and streams that feed into the Delta. The ultimate success of these planned actions is dependent on successful protection of fish and wildlife that reside in or pass through the Delta.

The specific goals of this plan, as presented in Governor Pete Wilson's April 1992 water policy statement, are to restore and protect California's aquatic ecosystems that support fish and wildlife, and to protect threatened and endangered species. The goals of this plan also incorporate the State-legislated mandate and policy to double populations of anadromous fish in California.

This plan encompasses all Central Valley waters accessible to anadromous fish, excluding the Sacramento-San Joaquin Delta. The descriptions, analyses, conclusions, and action recommendations constitute the California Department of Fish and Game's assessment of the present conditions and needs of Central Valley anadromous fish habitat and of the associated riparian wetlands. The two overriding precepts that guided development and priority rating of all action recommendations were (1) that those fish or wildlife populations in jeopardy of extinction should be restored to a healthy stable condition, and (2) all anadromous populations should be significantly increased with the long-term goal of doubling their 1988 population numbers. The doubling goal for anadromous fish was established by the State legislature in 1988 with the passage of the Salmon, Steelhead Trout, and Anadromous Fisheries Program Act (Chapter 1545/88).

Central Valley salmon and steelhead spawning habitat has been greatly reduced from approximately 6,000 miles that existed prior to the construction of dams to less than 300 miles that exists today. Riparian wetland habitat has been reduced by about the same proportion. Some fish and wildlife species have been irretrievably lost as a result of this drastic decline in habitat. The populations of many other species have also declined to alarmingly low levels. When implemented, the actions recommended in this plan will result in significant recovery of all anadromous fish populations, and create a solid base of riparian wetland habitat to recover and maintain the associated fish and wildlife communities.

The following table lists both completed and proposed fish screen projects, respectively, and either their cost to construct or their estimated cost. The date of the project or estimate is provided to allow adjustment for inflation as needed for cost comparisons (Table VII-3). The preliminary cost estimates assume that all civil works and additional construction will require engineering and design, and that the work will be completed by contractual agreement with appropriate entities. There may be numerous opportunities to reduce actual costs based on creativity and participation by interested or affected parties.

Spawning Gravel Enhancement

Engineering Design. Design for a constructed riffle area must provide for suitable slope, water velocity and depth, gravel size, gravel retainment structures, and low flow channel profile to provide optimum habitat for spawning salmon and steelhead. Gravel enhancement projects are generally performed when gravel quality or quantity has deteriorated and is resulting in poor fish survival.

Cost estimates for engineered spawning gravel projects are based on experience with two recent projects completed in the Merced River. Costs include actual construction and engineering. Construction hardware, gravel, and quarry rock are the principle items that will cause actual project costs to vary (Table VII-4).

Non-engineered Project. When possible, suitable gravel may be placed into a stream without retainment structures. Gravel is distributed downstream through natural processes during high flows. This type of project is generally performed in stream reaches below dams where natural recruitment of gravel has been eliminated.

Cost estimates for non-engineered gravel supplementation projects are based on a recent project in the upper Sacramento River and include permits, environmental documentation, bid specification preparation, access preparation, and material costs (Table VII-4).

River Channel Modification

River channel modification involves habitat enhancement or restoration in larger streams and rivers. Modifications may include changes in channel geometry, increases in channel and floodplain capacities, placement or changes to levees to isolate predator habitat or improve streambank habitat characteristics, and creation or changes to rearing, spawning or migration habitat.

TABLE VII-2. Fish Screening Projects: Approximate Capacity and Date of Completion or Development of Cost Estimate.

Project	Capacity (cfs)	Total cost	Cost per cfs
ACID (Bonneyview Pumps)-1992	60	$330,000	5,500
Contra Costa Canal - Estimate 1992	350	$3,000,000	8,600
Los Vaqueros - Estimate 1992	250	$500,000	2,000
MacDonald Island - 1992	12	$25,000	2,100
USBR Tehama Colusa Canal - 1991	3,000	$17,000,000	5,700
EBMUD Bixler Slough Intake - 1987	90	$50,000	556
City of West Sacramento - 1985	45	$45,000	1,000
DWR North Bay Aqueduct - 1987	180	$250,000	1,400
DWR Roaring River - 1980	750	$1,500,000	2,000
Glenn-Colusa Intake - Estimate 1990	3,000	$30,000,000	10,000

NOTES: The ACID, Los Vaqueros, MacDonald Island, EBMUD Bixler Slough, City of West Sacramento, and the two DWR installations do not include bypass facilities. The EBMUD Bixler Slough, the City of West Sacramento, and the DWR North Bay Aqueduct cost estimates are for the fish screen panels only.
The Contra Costa Canal, Glenn-Colusa, and USBR Tehama Colusa Canal fish screens require extensive bypass facilities.

TABLE VII-3. Cost Estimates for Various Types of Habitat Restoration Projects.

Project Type	Unit Cost Basis	Average cost/unit
Spawning riffles with engineered design and gravel	Square yard	$28
Gravel supplementation, no engineered design or structures built	Cubic yard Ton	$22 $16
River channel modification that includes modifying channel geometry, floodplain contours, levees, channel capacity, or isolation of predator habitat	Linear foot	$110
Well drilling for surface water exchange or supplementation	5 cfs	$100,000
Water supplementation	Acre foot	$75

Cost estimates for river channel modification are based on three proposed projects in the San Joaquin River system, and include engineering design, permits, environmental documentation, construction, revegetation, monitoring, and maintenance. Construction materials are not imported to the project site. The principal project costs are labor and equipment (Table VII-3).

Ground Water Exchanges

The objective of ground water exchange is to maintain a minimum flow in small streams for migration, rearing, or spawning. These projects involve drilling a well(s) so that ground water can be exchanged for surface water. Cost of well-drilling will vary depending upon bore size, depth, pumping equipment, power availability, and access. The cost estimate provided is based on a 600 feet deep well, a 16-inch diameter well casing, an electric pump with a capacity of 2,000 to 3,000 gallons per minute, and typical site and access preparation. Operating costs for an electric pump are about $25 per AF (Table VII-3).

Surface Water Purchases

The cost of surface water varies according to water availability, but for budgeting or cost estimation purposes, $75 per AF is used (Table VII-3). DWR's water bank costs ranged from $50 to $125 per AF during 1991 and 1992.

SACRAMENTO REGION STREAM ACTION PLANS

SACRAMENTO RIVER

The Sacramento River is the largest river system in California and yields 35% of the State's water supply (Figure VII-1). The chinook salmon populations of the Sacramento River provide most of the State's sport and commercial catch, and supports one of the largest contiguous riverine and wetland ecosystems in the Central Valley even though the existing riparian habitat is only 5% of the historical total. At least eight State and federally listed endangered and threatened species and several species of special concern occur in the river and adjacent riparian forest.

Most of the Sacramento River flow is controlled by the USBR's Shasta Dam which stores up to 4.5 million AF. River flow is augmented in an average year by transferring up to one million AF of Trinity River water through a tunnel to Keswick Reservoir. The USBR operates the Shasta-Trinity Division of the CVP. This division includes Shasta, Keswick, Trinity, Lewiston, Whiskeytown, and Spring Creek Debris dams, Red Bluff Diversion Dam (RBDD), and the Tehama-Colusa and Corning canals (TCC).

The Sacramento River is the most important waterway in the Central Valley. It provides for passage, spawning, and rearing for all species of anadromous fish found in the Central Valley.

The Sacramento River supports a variety of anadromous species including four races of chinook salmon, green sturgeon, white sturgeon, steelhead trout, striped bass, American shad, river lamprey, and Pacific lamprey. The NMFS has determined that critical habitat for Sacramento winter-run chinook salmon includes the entire Sacramento River from Keswick Dam, river mile (RM) 302 to Chipps Island (RM 0), Honker, Grizzly, Suisun, and San Pablo bays, and the San Francisco Bay to the Golden Gate Bridge. Providing for salmon populations will benefit the other native anadromous species; particularly steelhead, a close relative of Pacific salmon. The life history and distribution of the non-native anadromous fish do not closely parallel those of the native species and, therefore, the proposed restoration efforts may only be of marginal benefit to them.

Major problems in the Sacramento River affecting anadromous fish include: Anderson-Cottonwood Irrigation District's (ACID) seasonal flashboard dam in Redding that diverts approximately 400 cfs; RBDD fish passage delay and fish losses; Glenn-Colusa Irrigation District (GCID) Pumps that divert 3,000 cfs and approximately one million AF of water per year through inadequate fish screens; hundreds of small unscreened diversions;

protection and flood control projects. Reestablishment of this edge vegetation would significantly improve water temperatures and riparian habitat along the Sacramento River.

Completion of studies and subsequent implementation of EPA remedies for the Iron Mountain Mine (IMM) Superfund site are needed to attain the safe metal concentrations identified in the Basin Plan. Pollution control remedies are required at the IMM portal discharges from remaining sulfide ore deposits inside the mountain, the discharges from tailing piles, and the metal sludge in Keswick Reservoir.

Operations needed to achieve proper dilution of IMM effluent:

1) establish a minimum elevation in Keswick Reservoir to prevent scouring of metal sludge present in the Spring Creek Arm;
2) operate the Spring Creek Power plant to prevent the intermittent resuspension of waste that accumulates in Keswick Reservoir when the powerhouse is off line for extended periods;
3) replace existing monitoring instruments with more sensitive ones to monitor metal concentrations in the waste for compliance with the terms of the Memorandum of Understanding for the Spring Creek Operation.

Construction of Shasta Dam blocked recruitment of spawning gravel to the river below the dam. This is especially true in the 15 to 20 mile river reach below Keswick Dam. Existing spawning gravel is adequate to support salmon and steelhead, however, spawning gravel may become limiting as fish populations increase and gravel replenishment may become necessary.

A recent spawning gravel restoration project in the upper Sacramento River included the addition of tracer rock at two of the sites to monitor gravel movement. Monitoring the movement of the tracer rock will help determine the most biologically sound and cost effective replenishment techniques.

Natural gravel recruitment from tributary streams needs to be protected to insure that the gravel deficit does not increase. Spawning gravel needs protection from degradation caused by excessive silt entering the river from the tributaries. Watershed protection is needed in the tributaries to reduce erosion.

The spillway at Keswick Dam attracts salmon, including winter-run, into a stilling basin that becomes isolated from the river when spills cease. There is a small, ineffective escape portal built into the basin. More effective escape passage can be provided by creating a small channel through the bedrock at the west corner of the basin.

Fish passage over the 75-year-old ACID diversion dam should be improved. Also, a water control device should be installed at the dam, or operational changes instituted, to permit flash board adjustment and removal without affecting releases from Keswick Dam. A feasibility study is being conducted to identify alternatives to achieve this goal. ACID canal operations need to be standardized to protect Sacramento River salmon. This requires draining canal water through waste gates only on channels with fish barriers at their confluence with the river, limiting waste gate releases to 5 or 10 cfs to minimize attraction of salmon from the river, and providing total containment of canal waters when toxic herbicides are present. The canal intakes and fish screens at the ACID Bonnyview Pumps and the main dam require maintenance and routine inspection.

Installation of the USBR's proposed research pumping plant will allow "gates up" operation at RBDD from mid-September through mid-May. With the gates raised, fewer squawfish congregate below the dam thereby reducing predation of juvenile salmon as they pass under the dam gates. This also provides unimpaired upstream and downstream migration for all anadromous fish in the river. Fish losses and delayed migration, however, will still occur during the four months the dam gates are lowered. The USBR is preparing the necessary environmental analysis for a permanent solution to fish passage problems at the dam. A supplement to the original Coordination Act Report is being prepared by the USFWS to address unmet mitigation, unforeseen impacts, and failed enhancement features of the original project.

The Tehama-Colusa Fish Facilities at RBDD have been decommissioned due to low salmon production and because the recent seasonal gates-up operation to allow unimpaired adult winter-run salmon passage does not allow delivery of water to the channels. The USBR is examining alternative future uses of the facility. The facility has recently been used for research on temperature tolerance of salmon eggs. This use requires a flow between 25 and 40 cfs which is returned to the river via Coyote Creek. A fish barrier at the mouth of Coyote Creek is needed to prevent adult salmon from ascending the stream when future studies are conducted.

The GCID diversion on the Sacramento River near Hamilton City has been the cause of a significant loss of juvenile fish. The existing screens cause losses by impingement and entrainment. The NMFS filed suit and obtained an injunction against GCID for the illegal take of winter-run chinook salmon at their diversion. The injunction stipulates operational criteria by which the district may operate. A permanent solution to the problem is needed,

Recommendations for administrative actions to improve anadromous fish habitat in the Sacramento River:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
A-1	Meet flow standards and objectives and diversion limits set forth in all laws and judicial decisions that apply to CVP facilities.	USBR
A-1	Adopt instream flow, seasonal fluctuations, and ramping rates for the Sacramento River as recommended by DFG: <u>Shasta Reservoir carryover storage < 2.8 million AF</u> October 1- April 30 3,500 cfs May 1 - September 30 4,000 cfs <u>Shasta Reservoir carryover storage > 2.8 million AF</u> All Year 4,500 cfs Ramping rate should not exceed 15% in a 12-hour period for flows above 6,000 cfs, 200 cfs per 24-hour period for flows between 4,500 and 6,000 cfs, and 100 cfs per night for flows less that 4,500	SWRCB EPA
A-1	Implement Basin Plan objectives for all water quality parameters.	RWQCB
A-1	Develop and implement a mechanism for real-time water projects operations coordination between the CVP and SWP.	USBR DFG
A-1	Seek general plan amendments to establish protection zones for riparian vegetation.	Local Govt's
A-2	Develop and implement a continuing program for the purpose of restoring and replenishing, as needed, spawning gravel lost due to the construction and operation of CVP dams, bank protection projects, and other actions that have reduced the availability of spawning gravel and rearing habitat in the Sacramento River from Keswick Dam to RBDD.	USBR DWR DFG USCOE

Recommendations for evaluation of anadromous fish habitat in the Sacramento River:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
A-1	Evaluate the performance of all structural remedies implemented to protect and restore the anadromous fish.	No Estimate
A-1	Reevaluate carryover storage and operational criteria for the Shasta-Trinity Division of the CVP.	No Estimate
A-1	Complete the Sacramento River instream flow study.	No Estimate
A-1	Continue monitoring upper Sacramento River spawning gravel restoration.	No Estimate
A-1	Monitor metal, dioxin, and nutrient contaminants.	No Estimate
C-2	Evaluate the effectiveness of spring pulse flows on the survival of juvenile anadromous fish.	No Estimate
C-2	Develop predictive models for hydrology, temperature, fish populations, fish harvest, water development, and wetlands.	No Estimate

AMERICAN RIVER

The American River is a major tributary entering the Sacramento River at RM 60 in the city of Sacramento (Figure VII-2). It accounts for approximately 15% of the total Sacramento River flow. The American River drains about 1,900 square miles and ranges in elevation from 23 to over 10,000 feet. Average annual precipitation over the watershed ranges from 23 inches on the valley floor to 58 inches in the headwaters. Approximately 40% of the American River flow results from snow melt. The American River has three major branches, the South Fork, the Middle Fork, and the North Fork. Average historical unimpaired runoff at Folsom Dam is 2.8 million AF.

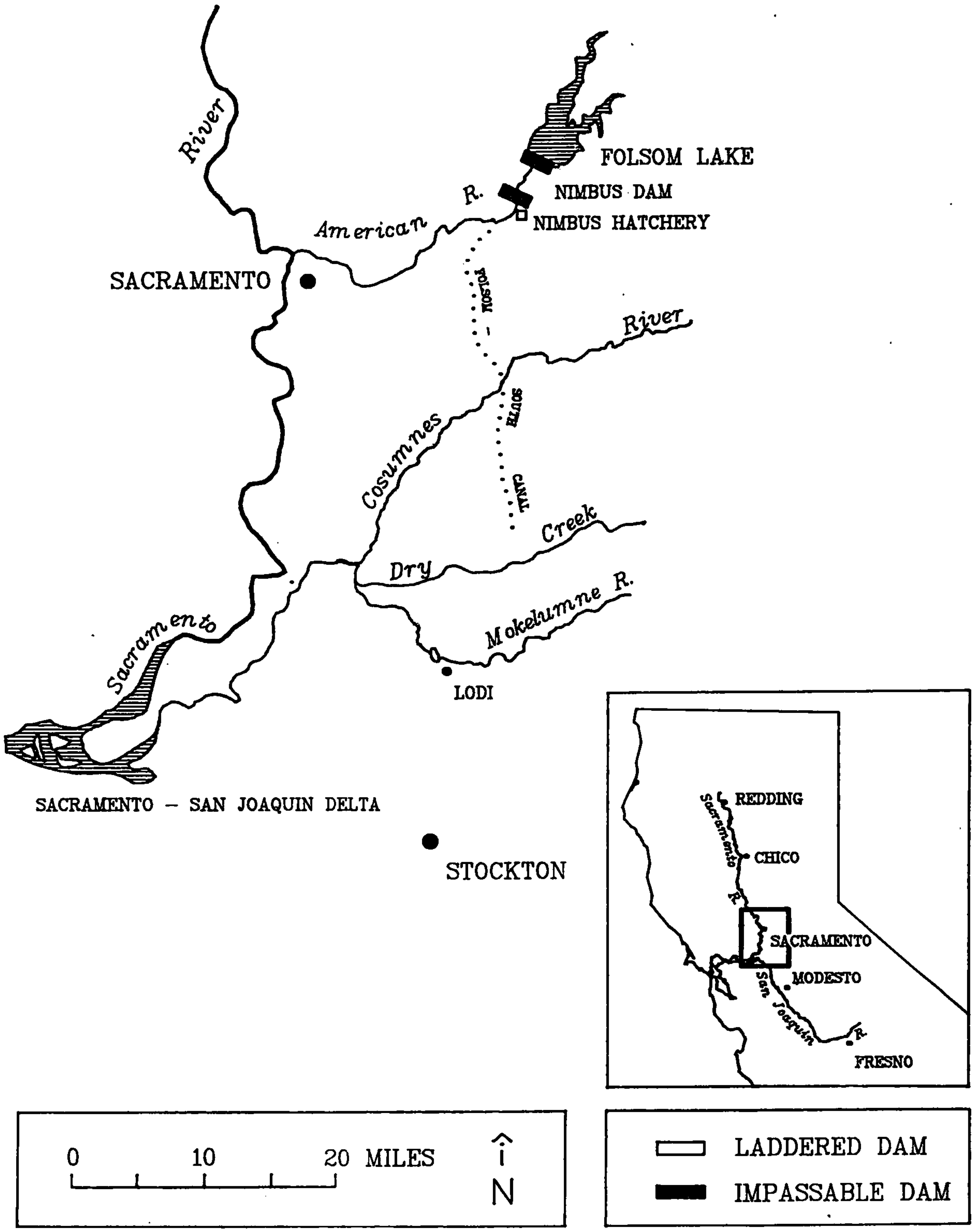
Development on the American River began in the earliest Gold Rush days when numerous small dams and canals were constructed. Today, 13 major reservoirs exist in the drainage with total storage capacity of 1.9 million AF. Folsom Lake, the largest reservoir in the drainage, was constructed in 1956 and has a 974,000 AF capacity. Proposed additional water project developments in the basin include the 2.3 million AF Auburn Dam and the 225,000 AF South Fork American River project. Folsom Dam, located approximately 30 miles upstream from the mouth, is a major element of the CVP operated by the USBR as an integrated system to meet contractual water demands and instream flow and water quality requirements.

The American River is an important spawning and rearing area for fall-run chinook salmon, steelhead trout, and American shad.

The American River historically provided for steelhead trout and chinook salmon which spawned principally in the watershed above the valley floor. Each population probably exceeded 100,000 fish. Completion of Folsom and Nimbus dams in 1955 blocked access to the historical spawning and rearing habitat for each race and altered the flow regime in the lower American River (LAR). Salmon and steelhead runs have declined significantly in the LAR due to the combined effects of project-induced low flows, severe flow fluctuations which expose and dry redds and strand juvenile salmonids, and high water temperatures during salmon and steelhead development.

SWRCB Decision 893 (D893) established the minimum allowable river flow in the LAR as 500 cfs from September 15 through December 31, and 250 cfs from January 1 through September 14. The DFG has determined this flow regime is inadequate to maintain anadromous fishery resources. In fact, except for drought years such as 1976-77 and water years 1989 through 1992, river flows seldom dropped to these minimum levels.
SWRCB Decision 1485 (D1485) established water quality standards for the Delta which

FIGURE VII-2. Map of the lower Sacramento River depicting the locations of the American, Cosumnes, and Mokelumne rivers.



required additional releases from upstream storage, including Folsom Reservoir. The USBR has relied heavily upon Folsom to meet the standards imposed by D1485 due to its close proximity to the Delta and the high probability of refill in the winter. This change in operation has resulted in reduced carryover storage in Folsom Reservoir and a concomitant increase in water temperatures in the LAR.

SWRCB Decision 1400 (D1400), adopted following hearings for the proposed Auburn Dam, will supersede D893 should the dam be constructed. D1400 will require fish maintenance flows of 1,250 cfs from October 15 through July 15 and 800 cfs for the remainder of the year. The USFWS has estimated that a reduction in flow from pre-drought levels to those required under D1400 will drastically reduce salmon and steelhead runs.

In 1972, the Environmental Defense Fund filed suit against East Bay Municipal Utility District (EBMUD) challenging the proposed diversion of water from Nimbus Dam through the Folsom South Canal, bypassing the LAR. The suit also challenged the adequacy of flows required under both D893 and D1400. The lawsuit resulted in a 1990 court order appointing a Special Master to report on issues and facts in the case. Studies of fishery and aquatic resources in the LAR, pursuant to the court order, are presently underway. The court has ordered that the following flows must be met before EBMUD can divert water down the Folsom South Canal: 3,000 cfs between March 1 and June 30, 1,750 cfs between July 1 and October 14, and 2,000 cfs between October 15 and February 28. These flows will not be changed by the court unless the results of the fishery and aquatic studies indicate a change is warranted.

In 1986 the DFG completed a stream evaluation report for the American River which contained recommendations for a range of flows in the LAR to protect salmon and steelhead. Subsequently, the court order was issued with the above flow schedule. The DFG is working with the litigants to develop specific flows in the LAR and a final agreement is expected soon. The flows are expected to fall within the range of flows recommended in the 1986 report.

The DFG recently completed the Lower American River Steelhead Management Plan which recognizes the existing problem of poor habitat conditions in the LAR for steelhead. Year-round cold water in the LAR is difficult to maintain due to present operations at Folsom Dam. Additionally, the practice of clearing trees and other objects from the river to eliminate hazards to recreationists reduces instream cover. The feasibility of establishing vegetative cover in the LAR should be explored.

Priority Ranking and Cost of Implementation

Recommendations for administrative actions to improve anadromous fish habitat in the lower American River:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
B-1	Require the following instream flow releases below Nimbus Dam: Period / Flow (cfs) Oct 15 - Feb 28: 1,750 - 4,000 cfs Mar 1 - Jun 30: 3,000 - 6,000 cfs Jul 1 - Oct 14: 1,500 cfs	Court SWRCB DFG USBR
B-1	Establish minimum fall carryover storage at Folsom Reservoir to maintain suitable year-round stream temperatures.	SWRCB
B-1	Adopt ramping rate criteria to protect eggs and fry of anadromous fish.	DFG USBR
B-1	Develop a coordinated multi-agency management plan.	DFG/USFWS NMFS/COE USBR/County
B-2	Develop and implement a continuing program for the purpose of restoring and replenishing, as needed, spawning gravel lost due to the construction and operation of CVP dams, bank protection projects, and other actions that have reduced the availability of spawning gravel and rearing habitat in the American River downstream from Nimbus Dam.	USBR DFG

Recommendations for evaluation of anadromous fish habitat in the lower American River:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
B-1	Complete instream flow studies and conduct monitoring as required by court order.	$250,000
B-1	Evaluate establishing vegetative cover along the streambanks.	No Estimate
B-1	Evaluate the need for gravel restoration.	$100,000

ANTELOPE CREEK

Antelope Creek flows southwest from the foothills of the Cascade Range entering the Sacramento River at RM 235, nine miles southeast of the town of Red Bluff (Figure VII-1). The drainage is approximately 123 square miles and the average stream discharge is 107,200 AF per year. Antelope Creek fish habitat is relatively unaltered above the valley floor but lack of adequate migratory flows from the Sacramento River to this habitat prevents optimum use by anadromous fish.

Antelope Creek has the potential to produce a sustainable population of 3,000 fall-run and 2,000 spring-run chinook salmon.

Fall-, late-fall-, and spring-run chinook salmon and steelhead trout use Antelope Creek. Population estimates for fall-run salmon on Antelope Creek during 1953-1984 ranged from 50-4,000, with an average annual run of about 467 fish. Historically, an estimated 500 spring-run chinook salmon and approximately 300 steelhead trout annually used Antelope Creek. In the past eight years, too few salmon and steelhead have ascended Antelope Creek to permit population estimation. The recent drought, in conjunction with excessive in-basin water diversions, has resulted in inadequate migration flows in the fall and spring for all species and races of anadromous fish in Antelope Creek.

Antelope Creek has the potential to produce a sustainable population of 3,000 fall-run and 2,000 spring-run chinook salmon. Habitat presently exists for holding, spawning, and rearing of these fish. With adequate migration flows, runs approaching historical sizes could once again be achieved, benefiting fall-run, late-fall-run, and spring-run chinook salmon, and steelhead trout.

There are two water diversions at the canyon mouth on Antelope Creek. One operated by the Edwards Ranch with a water right of 50 cfs, and the other by the Los Molinos Mutual Water Company (LMMWC) with a water right to 70 cfs. Antelope Creek flow is typically diverted April 1 through October 31. Average annual flows during this time of year, measured from 1940-1980, was 92 cfs. The lower reach of the stream is usually dry when both diversions are operating. Adult fall-run and spring-run chinook salmon are generally unable to enter the stream during the irrigation and diversion season.

To re-establish and increase salmon and steelhead in Antelope Creek, priority must be given to providing and maintaining adequate passage flows from October 1 through June 30 below the Edwards and LMMWC diversion dam. Furthermore, adequate migration flows and temperatures to attract salmon must be provided at Antelope Creek's confluence with the Sacramento River.

Priority Ranking and Cost of Implementation

Recommendations for administrative actions to improve anadromous fish habitat in Antelope Creek:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
A-1	Negotiate with the Los Molinos Mutual Water Company for additional instream flows for salmon and steelhead.	DFG Water District
A-1	Establish a program to exchange surface water for ground water with landowners with existing wells.	DFG
A-1	Evaluate the benefit of drilling new wells to establish a water exchange program with private landowners.	DFG
A-1	Consider administrative or legal remedies to obtain streamflows to ensure restoration of habitat for salmon and steelhead.	DFG SWRCB

Recommendations for evaluation of anadromous fish habitat in Antelope Creek:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
A-2	Evaluate existing spring-run chinook salmon and steelhead holding, spawning, and rearing habitat to identify opportunities for habitat restoration.	No Estimate
A-2	Conduct a fish problem passage survey in the lower creek.	$15,000
A-2	Reestablish the abandoned USGS gauging station upstream of the existing agricultural diversion dam.	$25,000
A-2	Conduct annual spring-run chinook salmon snorkel surveys.	$10,000
A-2	Continue to install and monitor thermographs in the headwaters to record summer water temperatures in spring-run chinook salmon holding area.	$5,000
A-2	Install and operate a thermograph and streamflow gauge near the mouth to determine flow-temperature relationships.	No Estimate
A-2	Conduct surveys for fall-run and late-fall-run chinook spawning habitat.	$5,000

BATTLE CREEK

Battle Creek enters the Sacramento River at RM 271, approximately five miles southeast of the Shasta County town of Cottonwood (Figure VII-3). It flows into the Sacramento Valley from the east, draining a watershed of approximately 360 square miles.

Battle Creek was once among the most important chinook salmon streams in the Sacramento Valley and supported fall-, winter-, and spring-run chinook salmon and steelhead trout.

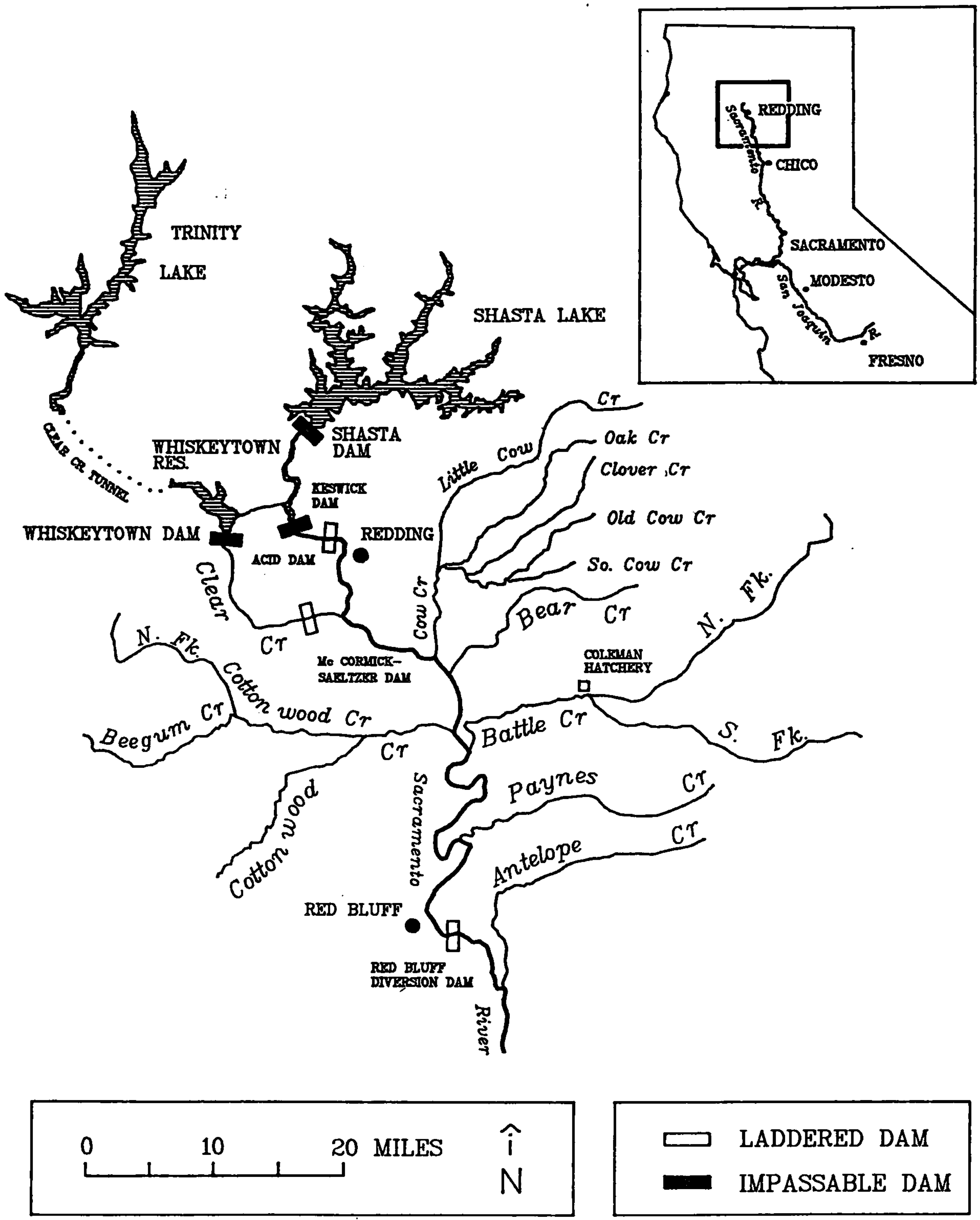
Prior to development, Battle Creek was one of the most important chinook salmon spawning streams in the Sacramento Valley. Runs of fall-, winter- and spring-run chinook salmon were all found there. Although there is little supportive information available, steelhead trout undoubtedly also spawned in Battle Creek. Natural spawning of salmon and steelhead in Battle Creek between the Coleman National Fish Hatchery (CNFH) weir and the mouth is still significant. The blockage of the fall-run chinook salmon migration at CNFH and the affect of low flows caused by Pacific Gas and Electric's (PG&E) hydropower operations, have combined to eliminate salmon spawning above the hatchery.

PG&E owns and operates the Battle Creek Project (FERC Project Number 1121) consisting of two storage reservoirs, four unscreened hydropower diversions on the North Fork Battle Creek, three unscreened hydropower diversions on South Fork Battle Creek, a complex system of canals and forebays, and five powerhouses. In addition, there are two significant agricultural diversions on the main stem of Battle Creek, only one of which is screened.

CNFH, located approximately six miles upstream from the mouth of Battle Creek, is operated by the USFWS. CNFH was constructed by the USBR as partial mitigation for the construction of Shasta Dam and produces fall-run chinook salmon, late-fall-run chinook salmon, and steelhead trout. Winter-run chinook salmon, a State-listed endangered and federally listed threatened species, are also propagated in small numbers at the hatchery.

Restoration of Battle Creek's anadromous fish habitat above the valley floor should focus on the potential for restoring winter-run chinook salmon, spring-run chinook salmon, and steelhead trout. The feasibility of winter-run chinook salmon restoration will require substantial investigation and analysis before a decision to proceed can be made. An additional population of winter-run chinook would increase the possibility of recovery of the species and reduce the probability of the race becoming extinct. Presently, the entire spawning population is dependent on habitat conditions in the Sacramento River below Shasta

FIGURE VII-3. Map of the upper Sacramento Valley depicting the locations of the Sacramento River and its tributaries.



Dam. During critically dry, or consecutively dry years, it is unlikely that Shasta Reservoir will be capable of maintaining or providing the necessary cold water in the river to support winter-run chinook salmon. This race of salmon will continue to be imperiled by such situations; and years of low rainfall and low water storage may delay their recovery. Reintroducing winter-run chinook salmon into the Battle Creek drainage will allow them access to unimpaired flows in the upper creek. This source of water is capable of protecting incubating winter-run chinook eggs and fry during severe drought years due to the cool water provided by the springs in the upper reaches of the creek. A successful reintroduction of winter-run chinook into Battle Creek will likely shorten their recovery period and allow delisting earlier than would occur by recovering a single population in the Sacramento River.

Surveys conducted prior to the construction of Shasta Dam indicate that with sufficient water, the stream reaches above CNFH could provide spawning for over 1,800 pairs of salmon. The North Fork of Battle Creek, Eagle Canyon in particular, contains deep, cold, and isolated pools ideal for holding spring-run chinook salmon throughout the summer. A recent evaluation identified 186,000 square feet of spawning gravel distributed between Coleman Powerhouse and Macumber Dam on the North Fork and between the powerhouse and South Diversion Dam on the South Fork. Because of the critically low numbers of spring-run chinook salmon within the Sacramento River drainage, any expansion of available habitat for that race has a high priority.

During 1985-89, adult fall-run chinook salmon, surplus to CNFH egg-taking needs, were released into Battle Creek above the hatchery weir to spawn naturally. Because of potential disease problems at the hatchery related to decomposing carcasses, the fish ladders on PG&E's two lowermost diversions (Wildcat Diversion on the North Fork and Coleman on the South Fork) were closed. This action prevented fish from ascending into the area above the CNFH water supply intake and eliminated the possibility of salmon migrating into the middle or upper reaches of those streams. Excess juvenile fall-run chinook salmon should be planted above CNFH to take advantage of the available rearing habitat.

There is one large unscreened agricultural diversion (Battle Creek Diversion). DFG constructed a screen for this diversion but, due to landowner concerns, the screen has not been installed.

Restoration of naturally spawning anadromous fish populations in Battle Creek above CNFH will conflict with the operation of PG&E's Battle Creek Project and the traditional operation of the hatchery. Physical and operational changes of PG&E's projects include the screening of the diversions on North Fork and South Fork of Battle Creek, increased releases from project diversions, and cessation of the practice of removing stream gravel which accumulate at project diversions.

The foregone power generation resulting from restoration of instream flows below PG&E diversions will be costly. Inasmuch as the CVP operations have resulted in a very large adverse affect Sacramento River salmon populations, it may be appropriate for the USBR to compensate PG&E for lost generation or replace that power with power of its own.

CNFH egg-taking opportunities may be reduced if some of the returning adult fall-run salmon are allowed to spawn naturally in Battle Creek above the hatchery. This would be a short-term concern until salmon populations increase to fully use the natural spawning habitat above the hatchery.

Priority Ranking and Cost of Implementation

Recommendations to improve anadromous fish habitat in Battle Creek:

Priority	Anadromous Fish Habitat Restoration Action	Cost
A-1	In the absence of a water exchange program, install fish screens on the agricultural diversion.	$110,000
A-1	Improve fish passage in Eagle Canyon.	$5,000
A-1	Screen all unscreened hydropower diversions.	$900,000
C-2	Restore spawning gravel in the North Fork.	$50,000

Recommendations for administrative actions to improve anadromous fish habitat in Battle Creek:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
A-1	Through the FERC and water rights process, increase releases from PG&E power plant diversions to provide for anadromous fish.	FERC SWRCB
A-1	Prepare and implement a comprehensive plan to restore Battle Creek for winter- and spring-run chinook salmon and steelhead.	DFG USFWS PG&E
B-1	After installation of an effective water treatment system at CNFH, allow fall-run salmon to migrate past the hatchery to spawn naturally in Battle Creek.	USFWS

Recommendations for evaluation of anadromous fish habitat in Battle Creek:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
A-1	Complete an instream flow study.	No Estimate
A-1	Investigate developing a disease-free water supply for CNFH.	No Estimate

BEAR CREEK

Bear Creek is a small eastside tributary entering the Sacramento River five miles below Anderson (Figure VII-3). The stream has low streamflow in the spring through fall months of most years and no flow during periods of below normal rainfall. During spring and summer, the limited natural streamflow is further reduced by irrigation diversions in the lower reaches where the stream enters the valley floor. Adequate streamflows in the fall and spring are prerequisites for anadromous fish migration and reproduction.

Bear Creek is able to support populations of fall-run chinook salmon only when early fall rains create suitable conditions for passage over shallow riffles and allow access to the limited spawning habitat. Because of low and warm streamflow conditions in the spring, juvenile salmon and steelhead must emigrate early in the season to survive. Unscreened irrigation diversions operating during the juvenile emigration period can significantly reduce survival.

Salmon spawning surveys conducted during years with sufficient flows to attract adult salmon indicate that Bear Creek can support 150 to 300 spawning salmon. Steelhead have been observed in the creek but no population estimates have been made.

The limited runoff in this small stream makes it difficult to meet agricultural water demands and meet the instream flow needs of anadromous fish, especially in below normal water years. During above normal water years there is a reduced risk to juvenile salmon and steelhead during the spring diversion season due to reduced irrigation water demands and since the diversion rates are relatively small compared to the total streamflow.

The DFG should negotiate with the water users for a mutually acceptable flow schedule which would not only provide protection for downstream migrating salmon and steelhead but would also recognize the needs of agriculture.

Priority Ranking and Cost of Implementation

Recommendation to improve anadromous fish habitat in Bear Creek:

Priority	Anadromous Fish Habitat Restoration Action	Cost
C-1	Install fish screens on all major water diversions.	No Estimate

Recommendation for administrative action to improve anadromous fish habitat in Bear Creek:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
C-1	Negotiate for increased instream flows.	DFG

Recommendation for evaluation of anadromous fish habitat in Bear Creek:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
C-2	Conduct annual salmon spawning surveys.	No Estimate

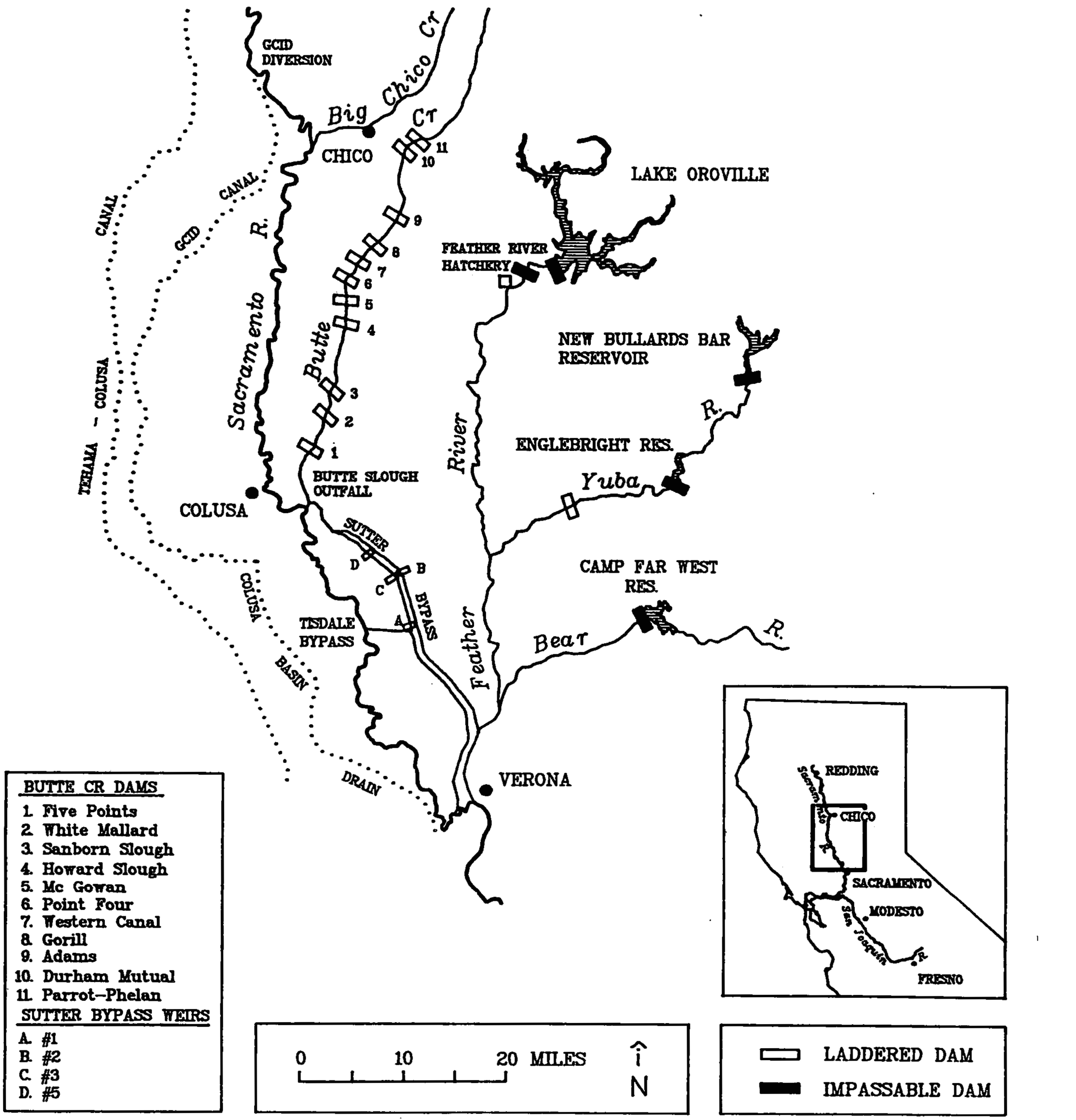
BEAR RIVER

The Bear River is the second largest tributary to the Feather River, entering the Feather River at RM 12, immediately upstream from the town of Nicolaus (Figure VII-4). The upstream limit of anadromous fish is the South Sutter Irrigation District's (SSID) diversion dam, approximately 15 miles above the confluence with the Feather River. The Bear River once supported substantial runs of salmon and steelhead, but due to inadequate flow releases at the SSID diversion dam, there are presently no self-sustaining runs of salmon or steelhead. Occasionally, when heavy fall rains and sufficient spillage occur at the SSID, hundreds of fall-run chinook salmon and steelhead may ascend and spawn in the Bear River. The demise of the anadromous fishery in the Bear River has been caused by a variety of factors including development of numerous water diversions and hydroelectric projects. Most of these projects were developed by the Nevada Irrigation District, PG&E, Placer County Water Agency, and SSID. The proposed Garden Bar Project, which would have captured and allowed the diversion and delivery of greater amounts of water from the river, is currently inactive. There was an instream flow study prepared to evaluate the potential affects the project would have on the river, however, the study was flawed which resulted in the conclusions of the report to be unacceptable. Another instream flow study will need to be completed before recommending a flow regimen for the lower Bear River.

The Bear River could support sustainable populations of chinook salmon and steelhead if adequate flows were provided.

In 1990 the DFG began preparation of a comprehensive fishery management plan to identify measures for the restoration of anadromous fish populations in the lower Bear River. The *Lower Bear River Fishery Management Plan*, however, has not been completed due to a lack of funding.

FIGURE VII-4. Map of the Sacramento Valley from Chico to Verona, including the Feather, Yuba, and Bear river drainages, and Butte Creek.



Priority Ranking and Cost of Implementation

Recommendations for administrative actions to improve anadromous fish habitat in Bear River and Dry Creek:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
B-1	Complete an instream flow study for the lower Bear River.	DFG
B-1	Evaluate the existing water rights throughout the watershed and, if warranted, petition the SWRCB for a change to obtain increased instream flow.	DFG SWRCB

Recommendation for evaluation of anadromous fish habitat in the Bear River:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
B-2	Conduct an inventory of diversions and identify those needing fish screens.	$10,000

BIG CHICO CREEK

Big Chico Creek enters the Sacramento River at RM 193, five miles west of the city of Chico (Figure VII-5). It flows into the Sacramento Valley from the east, draining a watershed of approximately 72 square miles. There are no significant impoundments on the stream and the only major water diversion is within a mile of the mouth. The stream is the focal point of the local community. The creek flows through Bidwell Park, the third largest city park in the nation, downtown Chico, and also the State University campus. Lindo Channel is an element of the local flood control system and originates at the Five Mile Recreation Area. The channel returns water to the creek near its mouth below the city of Chico.

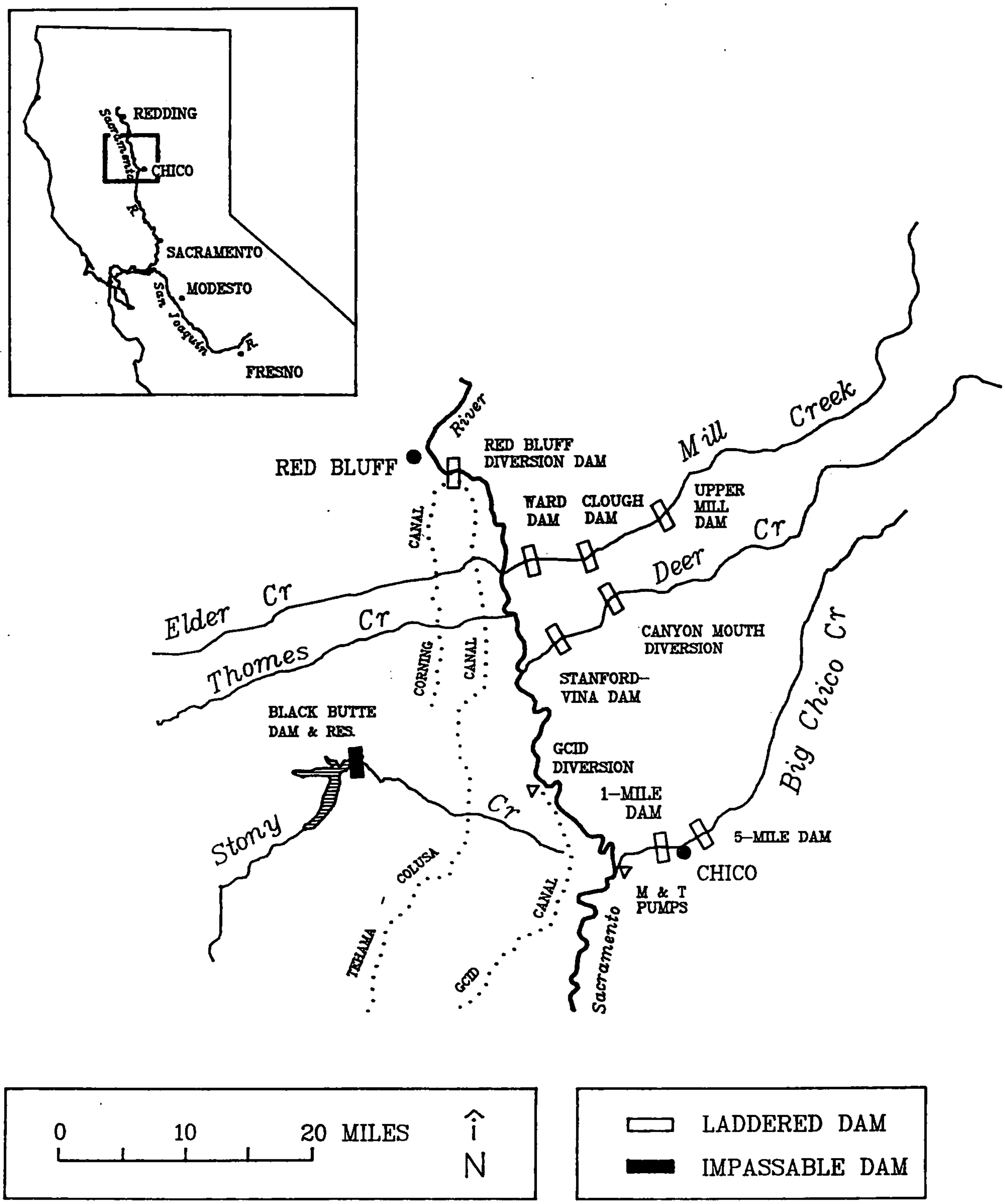
Big Chico Creek is used by spring-run, fall-run and late-fall-run chinook salmon and steelhead trout. Spawning populations, however, have declined to low levels in recent years.

Spring-, fall-, and late-fall-run chinook salmon, and steelhead trout use Big Chico Creek. In 1958 the spring-run chinook salmon population was estimated at 1,000 adults, although the average annual run was probably less than one-half this amount during the 1950's and 1960's. Steelhead populations are thought to have averaged around 150 returning adults during this same period. Recent estimates indicate only a remnant spring-run chinook population, a low steelhead population, and highly variable spawning populations of fall- and late-fall-run chinook salmon.

The unscreened M&T pumping station, comprised of five large pumps with a combined capacity to divert more than 135 cfs, is located on Big Chico Creek near its confluence with the Sacramento River. Water diverted by the M&T pumps is used on the M&T Ranch as well as on lands owned and operated by the DFG, USFWS, and The Nature Conservancy. Substantial streamflow reversal during juvenile salmon emigration occurs in approximately one of four years. During these periods, all downstream migrants are lost.

Adult spring-run chinook migrating up the Sacramento River on their return have difficulty locating the mouth of Big Chico Creek when flows are reversed. In addition, adult spring-run chinook are deterred by intermittent flow in Lindo Channel, inadequate fish passage at the One and Five Mile Recreation areas, and at Iron Canyon in upper Bidwell Park. Marginal spawning and rearing habitat in Big Chico Creek and Lindo Channel below the Five Mile Recreation Area is used by fall- and late-fall-run chinook salmon. Even though excellent spawning gravel exists in Lindo Channel, in most years intermittent flows preclude successful spawning.

FIGURE VII-5. **Map of the central Sacramento Valley depicting the locations of the Sacramento River and Mill, Deer, and Big Chico creeks.**



Improving fish passage and flow management in Big Chico Creek, and restoring spawning habitat, will greatly increase the spawning success and survival of fall-, late-fall-, and spring-run chinook salmon, and steelhead.

Priority Ranking and Cost of Implementation

Recommendations to improve anadromous fish habitat in Big Chico Creek:

Priority	Anadromous Fish Habitat Restoration Action	Cost
A-1	Relocate the M&T diversion to the Sacramento River and install fish screens.	$2,500,000
A-1	Repair or rebuild the water control structures at Five Mile Dam and Lindo Channel following completion of the hydrologic study.	$100,000
A-1	Inspect and repair existing fish ladders.	$100,000
B-3	Assist the City of Chico in eliminating siltation problems at One Mile Dam.	$50,000

Recommendations for administrative actions to improve anadromous fish habitat in Big Chico Creek:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
A-2	Prepare a watershed management and restoration plan.	DFG/DWR RWQCB/Chico
B-1	Implement waste discharge requirements for operation of the One Mile Recreation Area.	Chico DFG RWQCB
B-3	Prepare a gravel management plan.	DFG DWR Chico

Recommendations for evaluation of anadromous fish habitat in Big Chico Creek:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
A-2	Monitor salmon and steelhead passage.	$50,000
A-2	Reestablish the Upper Bidwell Park USGS gauge.	$25,000
A-2	Complete a sediment transport and hydrologic study.	$100,000
A-2	Install and monitor thermographs.	$10,000
B-2	Identify spawning gravel restoration sites.	$10,000

BUTTE CREEK

Butte Creek originates in the Jonesville Basin, Lassen National Forest, on the western slope of the Sierra Nevada Mountains, and drains about 150 square miles in the northeast portion of Butte County. Butte Creek enters the Sacramento Valley southeast of Chico and meanders in a southwesterly direction to the initial point of entry into the Sacramento River at Butte Slough (RM 139). A second point of entry into the Sacramento River is through the Sutter Bypass and Sacramento Slough (RM 80) (Figure VII-4).

Fish passage in Butte Creek is impaired by numerous dams and diversions with the Centerville head dam located immediately below the DeSabla powerhouse as the upper limit of anadromous fish migration. Water diverted from three adjacent watersheds co-mingles with the natural flows of Butte Creek and often comprises the major portion of the flow. Feather River water enters Butte Creek at two locations: via the West Branch into DeSabla Reservoir and through the Thermalito Afterbay and the Western Canal. Flows from both Big and Little Chico creeks enter Butte Creek from agricultural diversions that empty into Little Butte Creek. Flows from the Sacramento River reach Butte Creek from various diversion points from as far north as the mouth of Big Chico Creek to the Reclamation District 1004 pumps located near Princeton.

The decline of Butte Creek's chinook salmon and steelhead is due to inadequate flows, unscreened diversions, inadequate fish passage over diversion dams, poor water quality, and spawning gravel degradation.

Fall-, late-fall-, and spring-run chinook salmon, and steelhead trout exist in Butte Creek. As late as the 1960's, Butte Creek supported over 4,000 adult spring-run chinook salmon, a lesser number of fall- and late-fall-run, and a small number of steelhead trout. More recently, the spring-run chinook populations have ranged from fewer than 200 adults to over 1,000. DFG annual estimates of spring-run chinook and PG&E fish surveys indicate that, typically, few adult spring-run salmon reach upper Butte Creek where conditions are most favorable for holding and spawning. The fall-run chinook salmon population varies between a few fish to as many as 1,000. The numbers of late-fall-run salmon and steelhead are unknown.

The decline of Butte Creek's chinook salmon and steelhead is attributed to inadequate flows, unscreened diversions, inadequate passage over diversion dams, unblocked agricultural return drains that attract and strand adult fish, poor water quality, declining availability of adequate spawning gravel, and poaching. There are 10 diversion dams on Butte Creek above Butte Slough that supply water for power generation, irrigation, gun clubs, and domestic use. All are known to impair and delay migrating fish, although one, Point Four Ranch Dam, was removed in July, 1993. Passage at seven of the dams could be improved by upgrading the ladders (Table VII-4). All of the diversions from these dams are unscreened (Table VII-5). Parrott-Phelan Ranch Dam, however, is scheduled to be screened during 1993.

TABLE VII-4. Fish Passage Improvements Needed at Existing Dams on Butte Creek.

Location	Timing	Action Needed	Cost
Parrott-Phelan	Nov-June	Increase capacity of existing ladder or new middle structure	$50,000
Durham Mutual	Nov-June	Rehabilitate existing structure	$50,000
Adams	Nov-June	Rehabilitate existing structure and construct new center ladder	$75,000
Gorrill	Nov-June	Rehabilitate existing structures	$75,000
Western Canal	Nov-June	Construct center ladder	$50,000
Howard Slough (McPherrin)	Nov-May	Rehabilitate existing ladder	$75,000
White Mallard	Nov-Apr	Rehabilitate existing ladder and dam	$100,000
Total			$475,000

Adult spring-run chinook salmon migrate into Butte Creek during March-June, over-summer primarily in pools from the confluence of Little Butte Creek to the Centerville Head Dam, and begin spawning in late September. Spring-run chinook fry emigrate as early as December, while smolts emigrate the following spring. Generally, adequate migration flow exists to the Western Canal Dam; however, during dry years there are several areas above Western Canal that may hinder upstream passage. In these dry years, adult spring-run chinook salmon encounter low, warm flows above Western Canal and may become stranded.

Adult fall-run chinook salmon enter lower Butte Creek during late September and early October. Their upstream passage is often blocked by dewatered stream reaches caused by diversions for flooding of State and Federal refuges and private duck clubs. Below the Western Canal, adult fall-run chinook often encounter impassable barriers, dewatered areas, areas of silt deposition, lack of suitable gravel, and inadequate cover and shade. Several

TABLE VII-5. Fish Screening Needs at Existing Diversions on Butte Creek.

Diversion	Diversion Season	Diversion Rate (cfs)	Cost
Parrott-Phelan	All year	200	$130,000
Durham-Mutual	Mar-Nov	70	$46,000
Adams	Mar-Oct	120	$78,000
Gorrill	Mar-Oct	100	$65,000
Western Canal (1) Western Canal (2)	Mar-Oct Mar-Oct	400 1,100	$260,000 $7,500,000
McGowan	Mar-Oct	100	$65,000
Howard Slough (McPherrin)	Mar-Oct	100	$65,000
Sanborn Slough	All year	250	$1,250,000
White Mallard	All year	200	$130,000
Butte Slough	Mar-Nov	100-1,000	$5,000,000
Total			$14,589,000

barriers exist above the Western Canal which impede the adult migration until high flows occur. Most fall-run chinook salmon spawn in the area from Durham to the Parrott-Phelan Dam, although some are known to spawn above these dams. Spawning generally occurs from October through December. Fall-run fry begin to emigrate during January and February and smolts emigrate during April and May. However, many juveniles are entrained at the diversions or perish due to poor water quality.

Although little is known about the late-fall-run chinook, they probably enter Butte Creek from December through February, spawning above Parrott-Phelan Dam during January through March. Few barriers, except during extremely dry years, impede the passage of late-fall-run adult salmon. Fry and smolts are thought to emigrate from April through June facing the same potential losses to diversions and poor water quality as the spring and fall runs.

Little is known about steelhead in Butte Creek, however, adults probably ascend in the late fall and winter and spawn in tributaries such as Dry Creek and the main stem creek above Parrott-Phelan diversion in winter and spring.

Restoration of habitat in Butte Creek would allow the spring-run chinook population to return to an annual spawning population of about 4,000 fish and the fall-run chinook to about 2,000 fish. Late-fall-run chinook salmon and steelhead runs could also be increased.

Butte Creek water management is extremely complex. Maintenance of adequate fishery flows will require close coordination among all water users in the basin. Extension of State Watermaster Service into the lower reach of Butte Creek should be considered to fulfill these management goals. State Watermaster Service presently exists down to Western Canal. Extension of this service below Western Canal would require adjudication of the remaining water rights.

Wildlife refuges and hunting clubs dependent on Butte Creek water provide some of the most valuable wildlife and waterfowl habitat in the Sacramento Valley. The timing of the need for water among duck clubs, agriculture, and the anadromous fisheries compete. Seasonal flooding of refuges and duck clubs conflicts with the need for flows for spawning fall-run chinook salmon and irrigation of rice fields overlaps with the need for transportation flows for both spring-run adults and juvenile salmon in April and May. Evaluating and determining water rights, water use, and instream flow needs will be a long-term effort requiring the involvement of irrigation districts, private landowners, and agency personnel. Rebuilding salmon runs in Butte Creek will require a negotiated balance among wildlife, agriculture, and fishery needs.

Priority Ranking and Cost of Implementation

Recommendations to improve anadromous fish habitat in Butte Creek:

Priority	Anadromous Fish Habitat Restoration Action	Cost
A-1	Acquire water rights from willing sellers.	$500,000
A-1	Identify and correct fish passage problems at diversions through dam removal or improvements to existing fish ladders.	$475,000
A-1	Install fish screens on 11 agricultural diversions that range in capacity from 70 to 1,100 cfs.	$14,589,000
A-2	Improve spawning and rearing habitat.	$200,000

Recommendations for administrative actions to improve anadromous fish habitat in Butte Creek:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
A-1	Prepare a salmon and steelhead management and habitat restoration plan.	DFG
A-1	Seek amendments to existing water rights and power licenses to provide additional flow for salmon and steelhead.	FERC SWRCB

Recommendations for evaluation of anadromous fish habitat in Butte Creek:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
A-1	Conduct water quality study.	$100,000
A-2	Monitor fish passage.	$50,000
A-2	Conduct an instream flow study.	$150,000
A-2	Develop hydrologic model.	No Estimate

CLEAR CREEK

Clear Creek is a major tributary to the Sacramento River and drains approximately 238 square miles. It originates in the mountains east of Trinity Lake and flows into the Sacramento River near the south Redding city limits (Figure VII-3). Whiskeytown Reservoir stores natural creek flows and water diverted from the Trinity River at Lewiston Dam through the Clear Creek Tunnel. All the diverted Trinity River water and most of the natural flow of Clear Creek is diverted through the Spring Creek Tunnel to the Sacramento River above Keswick Dam.

Whiskeytown Dam, constructed in 1963, is ten miles upstream from McCormick-Saeltzer (Saeltzer) Dam. It resulted in 87% of Clear Creek's natural flow being diverted to the Spring Creek powerhouse at Keswick Reservoir on the Sacramento River. Existing Clear Creek habitat supports an estimated 2% of the Sacramento River's salmon population. Restoration of habitat and increased flow releases from Whiskeytown Reservoir could triple the present production of salmon in Clear Creek. Steelhead populations would similarly benefit.

Clear Creek has the potential of producing spring-run, fall-run, late-fall-run, and steelhead if flows are substantially increased and spawning habitat restored and protected.

Restoration of the Clear Creek salmon and steelhead populations has been the focus of fishery management efforts in the upper Sacramento River drainage below Shasta Dam for most of the Twentieth Century. Interest and concern regarding the status of salmon and steelhead in this stream began shortly after the construction in 1903 of the Saeltzer Dam, located six miles upstream of the Sacramento River, and has continued to the present. Early restoration efforts attempted to provide suitable adult fish passage at Saeltzer Dam but as watershed and instream habitats continued to decline, the need for additional habitat restoration efforts expanded. The cumulative affects of water export, gold mining, gravel extraction, logging, road building, residential development, and the construction of Whiskeytown Dam have contributed to the decline of the Clear Creek anadromous fishery. Only in recent years has there been a recognition of the complexity of the problem and a multi-agency cooperative effort to seek corrective actions designed to restore habitat and fish passage in Clear Creek. Local environmental groups and individuals have also been seeking solutions to the problems limiting Clear Creek's fishery potential.

DFG manages Clear Creek for fall-, late-fall-, and spring-run chinook salmon, and steelhead trout. The stream is uniquely suited for intensive management because of the potential to segregate and isolate fish species and races above and below Saeltzer Dam. The stream below Saeltzer Dam is suitable for fall- and late-fall-run chinook salmon but unsuitable for over-summering spring-run chinook salmon or for year-round residence by steelhead. Conditions above the dam are suitable for steelhead and spring-run chinook salmon. To optimize benefits for all anadromous species, only spring-run chinook salmon and steelhead should be allowed access to the upper reach above Saeltzer Dam. Until recently, the fish ladder constructed at Saeltzer Dam had never successfully passed salmon or steelhead. DFG has modified the existing fish ladder several times, most recently in 1992. If these modifications are successful then fall- and late-fall-run chinook salmon can be restricted to the lower reach of stream while allowing spring-run chinook salmon and steelhead into the creek above Saeltzer Dam. This segregation is essential to successful restoration of spring-run chinook salmon to Clear Creek.

The USBR has expressed a willingness to assist in the restoration of Clear Creek fish habitat by providing additional water from Whiskeytown Reservoir. The City of Redding, owner of the hydroelectric power plant on Whiskeytown Dam, and the Western Area Power Administration (WAPA), the federal agency which controls the power production of the CVP, have been negotiating terms for the windfall profits Redding will receive and the lost revenues WAPA expects due to the change in operations. The amount of water necessary to maintain salmon and steelhead in this reach of stream is presently unknown but is believed to be approximately double the present release. The DFG has made a commitment to the USBR to conduct flow studies.

Spawning gravel in the lower Clear Creek drainage has been significantly depleted due to excessive mining. Recruitment of any new gravel into this area has been restricted by Saeltzer and Whiskeytown dams. This has resulted in Shasta County adopting an ordnance in 1977 prohibiting new gravel mines in Clear Creek below Saeltzer Dam. Although the future of this ordnance is uncertain, it presently constitutes the best protection for spawning and incubation gravel. It does not, however, prohibit or limit existing gravel mining operations.

In 1992, the DWR requested Proposition 70 funds for spawning habitat restoration work in Clear Creek. The proposal is to develop plans for placement of spawning gravel at appropriate locations and to assess the feasibility of dredging the pond behind Saeltzer Dam. DWR is obtaining the required permits and preparing the necessary environmental documentation. The WCB has indicated it will fund the gravel restoration work following completion of planning and engineering documents by DWR. Implementation of this restoration will require monitoring of spawning gravel to determine if they successfully meet the needs of adult salmon and steelhead.

Clear Creek cannot support an increased population of salmon and steelhead until the spawning areas are restored and adequate flows provided. Experimental stocking of juvenile spring-run chinook salmon below Whiskeytown Dam began in 1991 and continued for two additional years. Suitable habitat must be present for these returning fish to successfully reproduce which will require releasing water of sufficient quantity and quality from Whiskeytown Dam.

Priority Ranking and Cost of Implementation

Recommendations to improve anadromous fish habitat in Clear Creek:

Priority	Anadromous Fish Habitat Restoration Action	Cost
A-1	Provide flows from Whiskeytown Dam to provide adequate spawning, incubation, rearing, and emigration habitat for salmon and steelhead.	No Estimate
A-1	Restore spawning gravel in Clear Creek for salmon and steelhead.	$500,000
A-2	Purchase land adjacent to the stream to preserve remaining sources of spawning gravel.	$1,000,000+
C-3	Dredge behind Saeltzer Dam to provide a sediment trap.	$50,000

Recommendations for administrative actions to improve anadromous fish habitat in Clear Creek:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
A-1	Prepare a multi-agency Comprehensive Resource Management Plan to address excessive erosion in the watershed.	Federal State Local agencies
A-1	Obtain increased streamflow below Whiskeytown Dam to improve migration, spawning, and rearing habitat.	DFG USBR FERC SWRCB

Recommendations for evaluation of anadromous fish habitat in Clear Creek:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
A-1	Conduct an instream flow study.	$300,000
A-2	Monitor adult salmon and steelhead passage at Saeltzer Dam.	$10,000
B-2	Monitor and evaluate spawning gravel quality and quantity.	$75,000

COTTONWOOD CREEK

Cottonwood Creek drains the west side of the Central Valley and enters the Sacramento River a short distance downstream from the Redding-Anderson area (Figure VII-3).

> Gravel mining operations in Cottonwood Creek should be eliminated as other source areas become available.

Cottonwood Creek supports fall-, late-fall-, and spring-run chinook salmon, and a small run of steelhead. The average annual return of fall-run salmon is about 1,000 to 1,500 adults, but has ranged from a few hundred to over 8,000 fish. Late-fall-run salmon enter and spawn in the main stem and lower reaches of the North Fork, Middle Fork, and South Fork Cottonwood Creek. This is a small run and consists of less than 500 fish each year.

Spring-run chinook salmon enter Cottonwood Creek and migrate to the headwaters of the South and Middle forks during April, May, and June. The two principal holding areas are the South Fork above Maple Gulch, and Beegum Creek, a tributary to the Middle Fork. During the spring, low flows and high water temperatures in some years may impede or prevent the upstream migration of adult spring-run salmon to summer holding areas. There are no recent estimates of spring-run chinook populations; however, historic runs averaged about 500 salmon.

Steelhead trout enter Cottonwood Creek during late fall and early winter then spawn during the winter and spring months. The upper reaches of the Middle Fork, Beegum Creek, and the South Fork provide spawning and nursery areas. There are no recent steelhead population estimates for Cottonwood Creek.

Cottonwood Creek is similar to adjacent streams and responds quickly to rainfall. In years when storms arrive late in the season, migrating salmon and steelhead are delayed until such time that streamflow increases. In some years with early rainfall that does not sustain flows, fish enter the creek and spawn in areas that are subsequently dewatered by receding flows and their offspring perish.

Silt in Cottonwood Creek is derived from many sources, some natural, but mostly a result of poor land-use practices including timber harvest and road-building activities on private and National Forest lands in the upper drainage. Overgrazing, fires, extensive land clearing in the foothill and valley areas, and discharges of decomposed granite from Rainbow Dam are also sources of sediment.

Salmon spawning gravel in the lower reaches of Cottonwood Creek have been degraded. Some areas are entirely covered with sand and silt, others are compacted with sediments or have become armored.

Extensive gravel mining in Cottonwood Creek has damaged spawning areas and significantly reduced gravel recruitment to the Sacramento River. In addition, mining creates passage and stranding problems by allowing the creek to spread over the large extraction zones. Two major gravel mines exist in Cottonwood Creek near the Interstate 5 highway. Applications for additional gravel mines have been submitted to Tehama County for sites upstream from existing operations.

Instream gravel extraction should be regulated to protect salmon spawning and rearing habitat. Implementing such a regulation will result in immediate benefits to salmon in Cottonwood Creek and the Sacramento River. Spawning gravel is a finite resource in the Sacramento River system and Cottonwood Creek contains one of the most important reserves. Excessive mining will directly affect the potential of the river to provide spawning gravel. Restricting or eliminating gravel mining on Cottonwood Creek would significantly affect the local economy. This could be reduced by mining off-stream gravel terraces not directly tributary to Cottonwood Creek, by mining only gravel of a size not used by spawners, and by mining gravel from streams that do not support anadromous fish.

Streamflow in Crowley Gulch, tributary to Cottonwood Creek, is intermittently augmented by release of water from a waste gate on the Anderson-Cottonwood Irrigation District (ACID) canal. Waste gate releases during the fall attract salmon into an area where they become stranded and subsequently die without spawning.

Priority Ranking and Cost of Implementation

Recommendations to improve anadromous fish habitat in Cottonwood Creek:

Priority	Anadromous Fish Habitat Restoration Action	Cost
B-2	Require stockpiling of spawning size gravel from existing mining operations for subsequent placement in the Sacramento River.	$100,000
C-2	Construct a barrier at the mouth of Crowley Gulch to prevent entry of adult fish.	$50,000

Recommendation for administrative action to improve anadromous fish habitat in Cottonwood Creek:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
B-1	Develop and implement a gravel management program.	Shasta Co. DFG

COW CREEK

Cow Creek flows through the southwest foothills of the Cascade Range and enters the Sacramento River at RM 280, four miles east of the town of Anderson in Shasta County (Figure VII-3). Cow Creek is comprised of five major tributaries: Little (North) Cow, Oak Run, Clover, Old Cow, and South Cow creeks. The drainage area is approximately 425 square miles and the average discharge is 501,400 AF per year.

Fall-run and late-fall-run chinook salmon spawn in the creek on the valley floor and in all five tributaries. Adult spring-run chinook salmon have been reported in South Cow Creek and steelhead trout have been observed in South Cow, Old Cow, and North Cow creeks. Previous management plans have estimated the potential of fall-run salmon in Cow Creek at 5,000 spawners, however, fall-run chinook salmon populations have been reported as high as 7,600. The average run size from 1953-1969 was 2,800 salmon. In recent drought years, there have been too few salmon in Cow Creek to make population estimates. No major diversions exist within the fall-run spawning reach and the average monthly flow for the October through December period has actually increased since 1969. The decline in the Cow Creek fall-run salmon population coincides with salmon population declines throughout the Sacramento River Basin. There are no estimates for late-fall run chinook in Cow Creek.

Cow Creek offers a unique opportunity to restore salmon and steelhead even as nearby communities continue to grow.

In 1992, DFG conducted stream surveys of four of the five Cow Creek tributaries. Emphasis was placed on evaluating habitat for spring-run chinook salmon and steelhead trout, holding, spawning, and rearing. The survey results concluded that Cow Creek is not suitable for spring-run chinook salmon due to warm summer water temperatures and lack of large holding pools. Steelhead, however, could survive if provided access to the tributaries above the valley floor. North Cow, Clover, and Old Cow Creeks all have natural bedrock falls which are either complete or partial barriers to anadromous fish.

Land use activities in the Cow Creek drainage include timber harvest, livestock grazing, and hydropower production. Loss of habitat and water diversions are largely due to activities associated with livestock production. The only laddered dams and screened diversions are part of hydropower facilities. Agricultural diversions are unscreened, ditches are unlined and poorly maintained, and grazing is destroying the riparian corridor and causing excessive erosion.

Population growth in the towns of Palo Cedro, Bella Vista, Oak Run, and Millville is resulting in increased demand for domestic water and is affecting riparian habitat within the Cow Creek watershed. Measures are required to protect the existing habitat from further damage associated with gravel extractions, water diversions, creek-side development and livestock grazing. Cow Creek presents a unique opportunity to maintain and preserve fall- and late-fall-run salmon and steelhead habitat while nearby development increases.

Priority Ranking and Cost of Implementation

Recommendations to improve anadromous fish habitat in Cow Creek:

Priority	Anadromous Fish Habitat Restoration Action	Cost
C-1	Screen, as needed, any diversion (each diversion < 5 cfs) that entrains juvenile salmon or steelhead.	$180,000
C-2	Fence riparian corridors to exclude livestock.	$800,000

Recommendations for administrative actions to improve anadromous fish habitat in Cow Creek:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
C-1	Establish a riparian corridor protection zone.	County DFG/Private Property Owners
C-1	Obtain 50 cfs for fish migration through an agreement with private water right holders.	DFG/Water Right Holders

Recommendation for evaluation of anadromous fish habitat in Cow Creek:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
C-1	Conduct an instream flow study to determine migration, spawning, and rearing needs for fall- and late-fall-run chinook salmon and steelhead.	No Estimate

DEER CREEK

Deer Creek is a major tributary to the Sacramento River originating upstream of Deer Creek Meadows on the slopes of Butt Mountain. The creek enters the Sacramento River at RM 230, approximately 1.5 miles north of Woodson Bridge State Park (Figure VII-5). The watershed drains 200 square miles and is 60 miles in length. Part of the upper stream is paralleled by State Highway 32. The lower ten miles flows through the valley where most of the flow is diverted. In many years, three diversion dams and four diversion ditches deplete all of the natural flow from mid-spring to fall. All of the diversion structures have fish ladders and screens. Of all Sacramento Valley streams, Deer Creek has the greatest potential for spring-run chinook salmon restoration.

Fall-, late-fall-, and spring-run chinook salmon, and steelhead trout use Deer Creek. During the past decade, approximately 550 spring-run and 1,000 fall-run chinook have spawned annually in Deer Creek. The creek could support sustainable populations of 4,000 spring-run and 6,500 fall-run chinook salmon. In one season, over 1,000 adult steelhead were observed migrating upstream. Habitat in the upper watershed is relatively intact with numerous holding areas and an abundance of spawning gravel. Some spawning areas in lower Deer Creek are lightly armored, but could be enhanced for use by fall-run chinook salmon.

> **Deer Creek has the greatest potential of all Sacramento Valley streams for increasing naturally spawning populations of steelhead and spring-run chinook salmon.**

Except for the lack of stream flows on the valley floor below the agricultural diversions, fish habitat throughout the drainage is generally of good quality. Water right holders on Deer Creek have recently expressed interest in cooperating with the DFG to develop alternative water sources and to provide fishery flows. Water users are concerned about the depleted status of the spring-run chinook salmon and are willing to work towards mutually acceptable solutions to restore the fishery. Flows necessary to provide unimpaired migration for adult salmon and steelhead are unknown but have been estimated to be approximately 50 cfs.

Inadequate flow for upstream passage is the most significant problem on Deer Creek. During low flow periods, the fish ladder on the lower diversion dam does not pass fish. The water right permit for this diversion does not require adequate bypass flows to provide for fish passage.

Juvenile spring-run chinook salmon and steelhead need protection from possible predation and competition from hatchery fish stocked in the headwater rearing areas. DFG no longer allows stocking of rainbow trout in the upper three miles of rearing habitat. Eliminating this planting location and shifting the trout allotment to above Upper Deer Creek Falls will alleviate any possible conflict between anadromous salmonids and the catchable trout stocking program.

Adequate spawning gravel occurs in lower Deer Creek for present population levels of fall- and late-fall-run salmon. However, gravel rehabilitation at selected sites could increase available spawning habitat.

Priority Ranking and Cost of Implementation

Recommendation to improve anadromous fish habitat in Deer Creek:

Priority	Anadromous Fish Habitat Restoration Action	Cost
C-3	Restore spawning gravel in the lower reach.	$100,000

Recommendation for administrative action to improve anadromous fish habitat in Deer Creek:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
A-1	Through negotiations, obtain instream flows for salmon and steelhead in the lower reach.	DFG, SWRCB Water Districts

Priority Ranking and Cost of Implementation

Recommendation to improve anadromous fish habitat in Elder Creek:

Priority	Anadromous Fish Habitat Restoration Action	Cost
C-2	Construct a fish passage structure over the Corning Canal siphon.	$250,000

Recommendation for administrative action to improve anadromous fish habitat in Elder Creek:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
C-2	Institute an erosion control ordinance to minimize sediment input.	Tehama County

FEATHER RIVER

The Feather River, with a drainage area of 3,607 square miles, is the largest tributary of the Sacramento River below Shasta Dam (Figure VII-4). Oroville Reservoir, the lowermost reservoir on the river and the upstream limit for anadromous fish, is the keystone of the State Water Project and operated by the DWR. Water is released from Oroville Dam through a multi-level outlet to provide appropriate water temperatures for the operation of Feather River Hatchery and to protect downstream fisheries. Approximately five miles downstream from Oroville Dam water is diverted at the Thermalito Diversion Dam into the Thermalito Power Canal, thence the Thermalito Forebay and another powerhouse, and finally into the Thermalito Afterbay. Water can be pumped from the Thermalito Diversion Pool back into Oroville Reservoir to generate peaking power. The Oroville-Thermalito complex, completed in 1968, provides water conservation, hydroelectric power, recreation, flood control, and fisheries benefits.

Feather River flows between the Thermalito Diversion Dam and the Thermalito Afterbay Outlet are a constant 600 cfs. This section is often referred to as the "low-flow" river section. Water is released through a powerhouse, then through the Fish Barrier Dam to the Feather River Hatchery, and finally into the low-flow section of the Feather River. Thermalito Afterbay has a dual purpose; an afterbay for upstream peaking power releases to assure constant river and irrigation canal flows, and a warming basin for the irrigation water going to the rice fields. Thus, water temperatures in the approximately 14 miles of salmon spawning area from the Thermalito Afterbay Outlet to the mouth of Honcut Creek (referred to as the "high-flow" section) are always higher than in the eight miles of the low-flow section.

Feather River Hatchery is the only source of spring-run chinook salmon eggs in the Central Valley and may play a key role in restoration of that race.

Most importantly, the Feather River supports spring-run chinook salmon. Feather River Hatchery is the only Central Valley egg source for this race of salmon. Spring-run chinook salmon adults ascend the river in the spring, hold over the summer in deep pools in the low-flow section, and are allowed into the hatchery in September. These fish are artificially spawned in the hatchery and also spawn naturally on the riffles in the low-flow section during late September to late October. Adult spring-run chinook salmon holding and early spawning requirements form the basis of the DFG's water temperature and flow recommendations for the low-flow section.

Creek consist primarily of large cobble and boulders with very little spawning gravel. Spawning gravel does naturally recruit to the lower reaches of the stream but is either trapped behind the diversion dams or is flushed from the stream.

All anadromous fish populations in this stream have declined despite the relatively pristine habitat available in the upper watershed. In some years, water right holders may divert the entire flow or reduce the flow to such an extent that the creek becomes impassable for upstream migrating adult and downstream migrating juvenile salmon and steelhead. Reduced stream flows may also result in increased water temperatures creating a thermal barrier preventing or delaying salmonid migration.

Three diversion dams have been constructed on the stream. Two of the dams have ladders that function properly and fish are not delayed. The middle and tallest one, Clough Dam, has a ladder with a poorly designed entrance which is difficult for fish to locate under certain flow conditions. All three of the water diversions have DFG-owned screens in place and in good operating condition.

One of the key elements in restoring Mill Creek's anadromous fisheries is obtaining dependable flow in the lower stream reaches. A negotiated agreement between the water users and DFG would be the preferable means of achieving this goal as it would minimize conflicts between historic land uses and restoration of salmon and steelhead habitat.

Proposed timber harvest in the upper watershed threatens loss of holding and spawning areas due to habitat degradation. Selective harvest and well-planned road construction may minimize this effect. Development of additional recreation areas must be carefully planned and implemented to preserve existing fish habitat.

Improving flows to allow unobstructed passage, removing barriers to migration, and protecting existing adult holding habitat could restore spring-run chinook salmon and steelhead trout to historic levels. Enhancement of downstream habitat, including flow management and spawning gravel replenishment, will greatly increase the spawning success and survival of both fall- and late-fall-run salmon.

Priority Ranking and Cost of Implementation

Recommendations to improve anadromous fish habitat in Mill Creek:

Priority	Anadromous Fish Habitat Restoration Action	Cost
A-1	Remove Clough Dam and move the existing diversion to allow salmon and steelhead unimpaired access to spawning areas.	No Estimate
C-2	Renovate existing spawning gravel.	$100,000
C-2	Construct gravel detention structures to provide new or additional spawning areas.	$500,000

Recommendations for administrative actions to improve anadromous fish habitat in Mill Creek:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
A-1	Continue to provide recommendations to the USFS for developing land use policies to protect spring-run chinook salmon habitat.	DFG USFS
A-1	Obtain increased flows to allow adult and juvenile salmon and steelhead unimpaired up- and downstream passage.	DFG/SWRCB Water Agencies

Recommendations for evaluation of anadromous fish habitat in Mill Creek:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
A-1	Conduct a stream flow study.	$25,000
A-1	Install a stage recorder to monitor flows.	$20,000
A-2	Investigate the flow-temperature relationship.	$25,000

PAYNES CREEK

Paynes Creek enters the Sacramento River at RM 253, five miles north of the town of Red Bluff (Figure VII-3). It flows into the Sacramento Valley from the east, draining a watershed of approximately 93 square miles. Paynes Creek originates in a series of small lava springs about six miles west of the town of Mineral. There are no significant dams on the stream; however, as many as 16 diversions seasonally divert water. Diverted water is used for irrigation, stock watering, and fish culture. The lowermost irrigation diversion, about two miles upstream from the mouth, is the largest with a capacity of approximately eight cfs. It provides water to irrigate the Bend District. DFG owns and operates a screen on this diversion. In addition to low flow, inadequate spawning gravel has been identified as a significant factor limiting salmon production. In 1988, the DFG built five spawning riffles using 1,000 tons of spawning gravel. Low flows, due principally to the recent drought, have caused the reconstructed riffles to be sparsely used.

Fall-run chinook salmon and steelhead trout use Paynes Creek when water conditions allow upstream passage. Surveys in the 1960's documented an average run size of 143 fall-run salmon while 300 fish were the most observed in a single season. Lack of water due to drought conditions, and, to a lesser extent, water diversion, is a major reason for the recent decline of salmon in Paynes Creek. Normally, rainfall provides water for fall-run chinook migration and spawning, and diversions are minimal at that time. Significant losses of juveniles can occur in the spring if the irrigation season begins when juvenile salmon are attempting to emigrate.

The size of the salmon run in Paynes Creek and rainfall are directly correlated. The very low salmon runs in recent years can be attributed to the recent drought. A normal rainfall pattern would provide the greatest benefit to salmon. A reduction in water diversions during critical migration periods would also be beneficial. Reduced diversions could be achieved through voluntary restrictions, direct purchase of water, or developing alternative sources such as wells or storage facilities.

Priority Ranking and Cost of Implementation

Recommendation to improve anadromous fish habitat in Paynes Creek:

Priority	Anadromous Fish Habitat Restoration Action	Cost
C-2	Replenish gravel on reconstructed spawning riffles on an as-needed basis.	$3,000/yr

Recommendation for administrative action to improve anadromous fish habitat in Paynes Creek:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
C-2	Obtain increased flow to allow adult and juvenile salmon and steelhead unimpaired up- and downstream passage.	DFG SWRCB Water Users

Recommendation for evaluation of anadromous fish habitat on Paynes Creek:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
C-2	Investigate the feasibility of developing alternative water supplies for diverters in Paynes Creek drainage.	$25,000

THOMES CREEK

Thomes Creek enters the Sacramento River at RM 225, four miles north of the town of Corning (Figure VII-5). It flows into the Sacramento Valley from the west, draining a watershed of approximately 188 square miles. There are no significant dams on the stream other than two seasonal diversion dams, one near Paskenta and the other near Henleyville. Several small pump diversions are seasonally operated in the stream. The stream is usually dry or intermittent below the USGS stream gauge near Paskenta until the first heavy fall rains occur. Fall-run chinook salmon enter and spawn in Thomes Creek in years of sufficient rainfall.

In 1966, the DFG estimated that Thomes Creek could support 5,800 fall-run chinook salmon. However, due to inconsistent flows, Thomes Creek will never support that population level.

Spawning fall-run chinook were observed only once between 1957 and 1962 when heavy rains occurred in October 1957 and the discharge at Paskenta reached 2,610 cfs. An estimated 155 adult fall-run chinook spawned in Thomes Creek in 1980; however, 97% of those fish spawned in the Tehama-Colusa Canal outlet channel. A survey by the DFG in 1966 estimated that the creek could support 5,800 adults if usable spawning area were the single limiting factor for fall chinook. Inconsistent stream flows will prevent a run of this magnitude to develop.

Spring-run chinook were observed by DFG personnel in 1946 and 1961. In 1958, 30 to 40 spring-run salmon were reported moving upstream near Henleyville. Spring-run chinook have not been observed in Thomes Creek since then, although some suitable habitat exists.

Fishery enhancement features associated with the construction of the RBDD included a water turnout constructed on the TCC to augment the natural flows and create additional spawning and rearing habitat for fall-run chinook salmon. The facilities, however, were never operated for that purpose.

The TCC siphon has been a partial barrier to salmon migration in recent years because of streambed degradation downstream of the siphon crossing. This problem is caused by downstream gravel mining which is removing gravel faster than it is being replaced through natural processes. Additionally, the lower reach of Thomes Creek has been significantly altered with flood control levees and bank protection projects.

The lower reaches of Thomes Creek contain large amounts of sediment and gravel, much of which was deposited during the 1964 flood. There are at least three year-round gravel mining operations on Thomes Creek and several seasonal ones.

Gravel extraction has impaired migration of adult salmon attempting to ascend the creek to spawn. The stream has numerous braided channels and pits that trap salmon, particularly during rapid flow fluctuations. The most stable spawning areas occur above the gravel extraction reach, but unimpaired access is essential for successful spawning.

Priority Ranking and Cost of Implementation

Recommendations for administrative actions to improve anadromous fish habitat in Thomes Creek:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
C-2	Require fish passage when issuing permits for the TCC siphon crossing.	COE
C-2	Require all gravel extraction permit applications to provide protection for fish passage.	DFG Tehama County
C-2	Institute an erosion control ordinance to protect salmon habitat.	Tehama County

Recommendations for evaluation of anadromous fish habitat on Thomes Creek:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
C-2	Conduct an annual review of gravel operations to ensure unimpaired fish migration.	$25,000
C-2	Conduct a fish passage study.	$10,000

YUBA RIVER

The Yuba River watershed drains 1,339 square miles of the western slope of the Sierra Nevada Mountain Range, and includes portions of Sierra, Placer, Yuba, and Nevada counties. The Yuba River is tributary to the Feather River, which in turn feeds into the Sacramento River (Figure VII-4).

Most of the water from Englebright Dam, the lowermost dam on the river and the upstream limit of anadromous fish, is released through the Narrows 1 and 2 powerhouses for hydroelectric power generation. The 0.2 miles of river between the dam and the two powerhouses has no flowing water except when the reservoir is spilling. The 0.7 miles of river downstream of the Narrows 1 and 2 powerhouses to the mouth of Deer Creek is characterized by steep rock walls, long deep pools, and short rapids. Below this area the river cuts through 1.3 miles of sheer rock gorge called the Narrows, where the river forms a single large, deep, boulder-strewn pool.

Fall-run chinook salmon are the most abundant and important fish in the Yuba River. The Yuba is used also by spring-run chinook salmon and American shad.

The river canyon opens into a wide flood plain at the downstream end of the Narrows where large quantities of hydraulic mining debris remain from past gold mining operations. This 18.5-mile section is typified as open valley plain. Daguerre Point Dam, located 12.5 miles downstream from Englebright Dam, is the major diversion point on the lower river. The open valley plain continues 7.8 miles below Daguerre Point Dam to beyond the downstream terminus of the Yuba Goldfield. This section is composed primarily of alternating pools, runs, and riffles with a gravel and cobble substrate and, by virtue of the quality and size of the substrate, contains most of the suitable chinook salmon spawning habitat found in the lower Yuba River.

The remaining section of the lower Yuba River extends approximately 3.5 miles to the confluence with the Feather River. This section of river is bordered by levees and is subject to backwater influence of the Feather River.

Fall-run chinook salmon are the most abundant and important anadromous fish in the lower Yuba River. Historically, the Yuba River supported up to 15% of the annual run of fall chinook salmon in the Sacramento River system. Run sizes in the Yuba River have varied over the period of record (1953-1989) ranging from 1,000 fish in 1957 to 39,000 fish in 1982. Approximately 60% of those salmon spawned between Daguerre Point Dam and the Highway 20 Bridge. During the 1970's and 1980's, increased chinook salmon and American

4. Develop and adopt a comprehensive State riparian habitat restoration, preservation, and management policy and plan for the Central Valley administered by the Department of Fish and Game under the authority of the Secretary of Resources. Request the Legislature to enact the comprehensive policy.

5. Fully fund an accelerated Wildlife Conservation Board riparian habitat acquisition program for lands to be administered for fish and wildlife by the Department of Fish and Game.

6. Maximize preservation and restoration of riparian habitats and streamside corridors to meet open space, greenbelt, and other wildlands and parkland objectives through mandated State and local land use planning and zoning programs.

7. Recognize plants, fish, wildlife, and invertebrates with equal emphasis in riparian habitat acquisition, restoration, and management programs.

8. Conduct a fish and wildlife oriented survey of Central Valley streams to identify existing riparian wildlands and areas of high potential for restoration of riparian woodlands.

9. Incorporate riparian habitat restoration into all State fish, wildlife, recreation, and other land management and environmental restoration programs.

10. Amend the Forest Practices Act to include greater protection for riparian hardwoods through harvest, regeneration, and conversion regulations similar to, or more restrictive than, those provided for other commercial species.

shad populations were anticipated following the completion of the New Bullards Bar Dam, however, these increases were not realized. Presently, fall-run chinook spawning runs average 13,050 fish annually, far below the 38,000 fish anticipated.

A small spring-run chinook population occurred historically in the Yuba River. However, the run virtually disappeared by 1959, presumably due to diversion and hydraulic developments on the river. A remnant population of spring-run chinook salmon persists in the lower Yuba River and is maintained by fish produced in the river, salmon straying from the Feather River, and from infrequent stocking of hatchery-reared fish by the DFG.

The lower Yuba River supports a seasonal shad sport fishery from late April to July. The fishery is generally confined to the area between Daguerre Point Dam and the confluence with the Feather River. Studies have shown that the shad fishery on the Yuba River has declined significantly in the past two decades. In 1968, the run was estimated at 30,000 to 40,000 spawners, and in 1969 at 40,000 adult fish. In recent years, the shad run has only been a fraction of 1968-69 levels. Daguerre Point Dam is believed to affect shad spawning movements. The dam is equipped with two conventional pool and weir type fishways. Shad do not generally enter fish ladders and, therefore, the majority of the population is restricted to the river below the dam.

Since the turn of the century, water development projects and diversions have had significant adverse effects on the river and its anadromous fish populations. Modification of the timing of natural flows, reduction of flows during critical periods, and alteration of spring, summer, and fall stream temperatures have contributed to the decline of the salmon, steelhead, and American shad populations. These factors affect salmon and steelhead migration flows, spawning, and growth. American shad attraction, passage, and spawning activities are also adversely affected.

The three most significant diversions along the lower Yuba River are located at or near Daguerre Point Dam, and water extraction generally occurs from late March through October. The Hallwood Irrigation Company, the Cordua Irrigation District, and the Ramirez Water District share one diversion; Brophy and South Yuba water districts another; and Browns Valley Irrigation District the third. The combined diversions add up to a maximum of 1,085 cubic feet per second (Table VII-6).

Juvenile chinook salmon are lost at all diversion intake structures due to impingement, entrainment, or predation. While losses at individual diversions may not be significant, the cumulative impact from all diversions is substantial.

TABLE VII-6. Summary of Diversion Rates in Acre-feet per Month for the Major Water Districts Supplied by the Yuba County Water Agency (YCWA), Lower Yuba River, California, from DFG Lower Yuba Fisheries Management Plan, 1991.

Hallwood Irrigation Company		Cordua Irrigation District		Ramirez Water District	Browns Valley Irrigation District		Brophy Water District	South Yuba Water District
Month	WR*	WR	PW+	WR	WR	PW	PW	PW
March	0	0	0	0	0	0	520	300
April	10,000	4,500	900	2,010	2,269	1,667	4,795	3,000
May	14,500	10,600	2,120	3,270	2,345	1,666	6,460	4,000
June	14,100	10,400	2,080	2,745	2,269	1,667	6,670	4,200
July	13,600	11,100	2,620	1,920	2,345	2,500	6,985	4,400
August	12,900	11,000	2,600	1,755	2,345	2,000	5,525	3,400
Sept.	8,000	5,900	1,180	1,500	2,269	0	3,750	2,400
Oct	4,900	6,500	500	700	2,345	0	625	400
Total	78,000	60,000	12,000	13,900	16,187	9,500	35,330	22,100
Max cfs	275	–*	275	75	38.2	42	230	150

* (WR) Basic water right of respective water district.
+ (PW) Purchase water through contract with YCWA.

During planning for the development of the Yuba River Basin in the late 1950's and early 1960's, projections were made of the expected benefits to the Yuba River fishery of construction of New Bullards Bar Dam and Reservoir. The DFG projected that increased streamflow and better water temperature control would result in improving the average fall-run chinook salmon run to over 38,000 fish. The maximum run was expected to exceed 80,000 fish. However, since impoundment of New Bullards Bar Reservoir in 1969, the average fall chinook salmon run has not improved.

The DFG estimated that prior to 1970, approximately 200 steelhead trout spawned in the river annually, and there was a potential for about 2,000 spawners after completion of New Bullards Bar Reservoir. While no definitive population estimates exist, limited information suggests that lower Yuba River steelhead trout populations may have increased.

At present, sufficient quantity of uncommitted water remains in the Yuba River system (New Bullards Bar Reservoir) to restore the river's anadromous fishery. Unless action is taken immediately to obtain increased flows and adequate temperatures for fish, the opportunity to increase anadromous fish populations will be lost. Obtaining the needed streamflow, temperature, and screening for the lower Yuba River will affect storage in Bullards Bar Reservoir and will require changing operations at the existing diversions.

Priority Ranking and Cost of Implementation

Recommendations to improve anadromous fish habitat in the Yuba River:

Priority	Anadromous Fish Habitat Restoration Action	Cost
A-1	Install screen on Browns Valley Irrigation District diversion.	No Estimate
A-1	Replace screens on South Yuba-Brophy and the Hallwood-Cordua diversions.	No Estimate
A-2	Improve spawning and rearing habitat.	$1,000,000
B-3	Protect and manage riparian habitat.	$100,000/yr

Recommendations for administrative actions to improve anadromous fish habitat in the Yuba River:

<table>
<tr><th>Priority</th><th>Administrative Action to Improve Anadromous Fish Habitat</th><th>Agency</th></tr>
<tr><td>A-1</td><td>Ensure compliance with fish screening requirements in Fish and Game Code Section 6100.</td><td>DFG</td></tr>
<tr><td>A-1</td><td>Require the following temperatures and streamflows to protect salmon and steelhead in the Lower Yuba River:
Maximum Temperature (°F)
<table>
<tr><th>Period</th><th>@Daguerre</th><th>@Marysville</th></tr>
<tr><td>Oct - Mar</td><td>56</td><td>57</td></tr>
<tr><td>April</td><td>60</td><td>60</td></tr>
<tr><td>May</td><td>NR</td><td>60</td></tr>
<tr><td>June</td><td>NR</td><td>65</td></tr>
<tr><td>Jul - Aug</td><td>65</td><td>NR</td></tr>
<tr><td>Sept</td><td>NR</td><td>65</td></tr>
</table>
Streamflow (cfs)
<table>
<tr><th>Period</th><th>@Marysville</th></tr>
<tr><td>Oct-Mar</td><td>700</td></tr>
<tr><td>April</td><td>1,000</td></tr>
<tr><td>May</td><td>2,000</td></tr>
<tr><td>June</td><td>1,500</td></tr>
<tr><td>Jul-Sept</td><td>450</td></tr>
</table>
</td><td>SWRCB</td></tr>
<tr><td>A-2</td><td>Develop a plan to increase rearing habitat for juvenile salmon and steelhead.</td><td>DFG</td></tr>
<tr><td>B-1</td><td>Regulate gravel extraction to protect salmon and steelhead spawning areas.</td><td>DFG
County</td></tr>
</table>

Recommendation for evaluation of anadromous fish habitat in the Yuba River:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
A-1	Inventory all water diversions in the drainage from Englebright Dam to the Feather River.	$25,000

WESTSIDE TRIBUTARIES

Small streams draining the westside of the Sacramento Valley in the Redding-Anderson municipal area include Olney, Anderson, Salt, Middle, and Churn creeks. These creeks do not have natural flow during the dry season and during the wet season, have large flows for the small size of the watersheds. The flashy nature of the streamflow regime is due to the intensity of the rainstorms at the north end of the valley and is further amplified by urbanization of the watershed. These tributaries enter the Sacramento River downstream of Shasta Reservoir.

The watersheds of these streams drain parts of the Coast Range and Klamath Mountains. The soils in these mountains are moderately to severely erodible in contrast with the soils of the eastside Sierra Nevada watersheds. Also, in contrast with the eastside tributaries, the geology of the westside of the valley is not as conducive to the large groundwater springs that provide cold sustained flows in the dry season.

The rainfall in the westside of the Central Valley is less than the east side, with mean seasonal precipitation in the higher elevations of about 60 inches. The lower elevations in the vicinity of Redding receive 40 inches of precipitation while low elevations near Red Bluff only receive 20 inches of precipitation. Thus, these smaller tributaries draining the region below the northern end of the Central Valley have inconsistent stream flow.

Large peak flows attract salmon from the Sacramento River into these streams. The influence of these attraction flows on salmon is probably increased because the river flow does not increase proportionally during the storms. Shasta Dam, upstream from the confluence of the tributaries, captures most of the storm runoff.

These small streams can provide spawning for fall-run and late-fall-run salmon spawning in the lowermost reaches. Although annual salmon spawning surveys have not been conducted on these creeks, adults have been observed in the fall and winter, and large numbers of juveniles have been rescued from the streams in the late spring.

The abundance of salmon in these small streams appears to be a function of the number of salmon in the Sacramento River and the proximity of the stream to Keswick and ACID dams. The operation of the ACID canal waste gates on the streams that it crosses, results in the attraction of salmon into these tributaries. ACID canal water is released into these streams in large volumes when the dam diverts too much water or when the canal is being drained at the end of the irrigation season. The juvenile fish produced by adult salmon attracted to these streams are destroyed because the natural flow that remains after the waste gates are closed is not adequate to maintain fish.

The occurrence of steelhead in these tributaries is not known. During the winter, there are hundreds of large rainbow trout (12 to 24 inches) spawning in each of these streams. It is believed that these are almost exclusively resident rainbow trout from the river and not steelhead.

The quality of the spawning habitat in these streams is degrading due to sedimentation from land development. The combination of steep slopes, highly erodible soils, high rainfall, and large areas denuded by clearing and construction has greatly accelerated erosion in the watersheds. The worst sediment problem occurs in the Middle Creek watershed where the Soil Conservation Service estimated over 2,000 cubic yards of sediment (primarily decomposed granite) is presently moving down the creek to the river. The sediment has destroyed spawning habitat in the creek and, unless abated, will damage spawning habitat in the Sacramento River below its confluence.

Water quality in these urban tributaries is becoming increasingly degraded by runoff from developed areas. Contaminants in urban storm water include oils, metals, industrial chemicals used in landscape maintenance, and other harmful materials. The largest storm water problems occur in Churn Creek. The creek also receives poorly treated sewage discharges as well as contaminated storm drainage.

Urbanization has increased the peak flow in the heavily developed watersheds due to the rapid runoff characteristics of pavement, roofs, cement-lined stream channels, and other impervious surfaces. The elevated peak flows increase the potential of attracting salmon into these streams.

Maintaining salmon habitat in the urbanized streams, while limiting the attraction flows to those streams, is expected to protect 100 to 300 adult salmon annually.

Priority Ranking and Cost of Implementation

Recommendations for administrative actions to improve anadromous fish habitat in the westside tributary streams:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
C-1	Coordinate and implement an agreement with ACID for future canal operations.	DFG/NMFS ACID
C-1	Continue coordination with local agencies to develop and implement sediment control measures.	DFG/W. Shasta RCD/Local Government
C-1	Coordinate with local agencies to develop a program to improve water quality of runoff from urban areas.	DFG/W. Shasta RCD/Local Government/ RWQCB
C-2	Reduce sewage discharge into Churn Creek.	RWQCB DFG
C-2	Coordinate with local agencies to develop stream overflow areas to attenuate storm water runoff from urban areas.	W. Shasta RCD & Local Government

SAN JOAQUIN REGION STREAM ACTION PLANS

SAN JOAQUIN RIVER

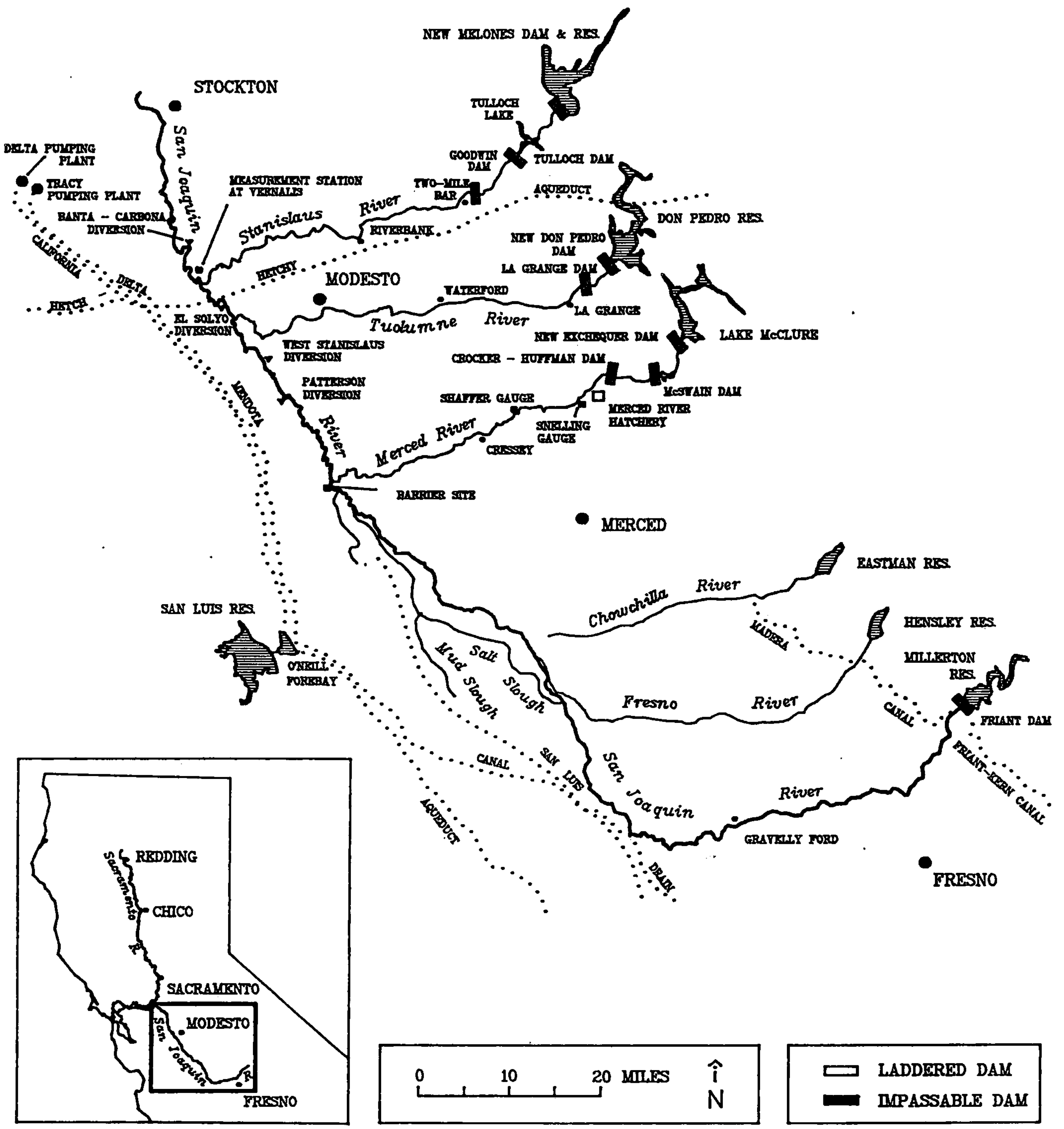
The 250-mile-long San Joaquin Valley comprises the southern half of the Central Valley. The Tulare Lake basin to the south is normally considered a separate drainage basin, but during wet years has historically contributed occasional flood overflows and subsurface flows to the San Joaquin River. The San Joaquin River basin is bounded on the west by the Coast Range and on the east by the Sierra Nevada Range. The San Joaquin River drains to the west from the Sierra Nevada, turns sharply north at the center of the valley floor and flows northerly through the valley into the Sacramento-San Joaquin Delta (Figure VII-6). On the arid westside of the basin, relatively small intermittent streams drain the eastern flanks of the Coast Range but rarely reach the San Joaquin River. Natural runoff from westside sloughs is augmented by agricultural drainage and spill flows. On the eastside, numerous streams and three major rivers drain from the west slope of the Sierra Nevada and contribute flow to the San Joaquin River. The major eastside tributaries south of the Delta, all of which support salmon spawning and rearing, are the Stanislaus, Tuolumne, and Merced rivers.

> Spring-run and fall-run chinook salmon were extirpated from the upper San Joaquin River with the closure of Friant Dam in 1949.

Precipitation in the San Joaquin River basin averages about 27.3 inches per year. Snowmelt runoff is the major source of water to the upper San Joaquin River and the larger eastside tributaries. Historically, peak flows occurred in May and June and flooding occurred in most years along all the major rivers. When flood flows reached the valley floor, they spread out over the lowlands, creating several hundred thousand acres of permanent tule marshes and over 1.5 million acres of seasonally flooded wetlands. The rich alluvial soils of natural levees once supported large, diverse riparian forests. It has been estimated that as much as two million acres of riparian vegetation grew on levees, floodplains, and along small stream courses. Above the floodplain, the riparian zone graded into valley oak savannah and native grasslands interspersed with vernal pools.

Agricultural development in the basin, beginning in the 1850's, brought dramatic changes in the hydrologic system. The upper San Joaquin River drainage (1,650 square miles) presently has seven power generation reservoirs which alter flows in the upper basin. Friant Dam near Fresno is the major storage reservoir on the upper San Joaquin River. Completed in 1949, the dam is operated by the USBR for flood control, irrigation, and

FIGURE VII-6. **Map of the San Joaquin basin depicting the locations of the Stanislaus, Tuolumne, Merced, and San Joaquin rivers.**



power generation. Millerton Lake, formed by Friant Dam, has a gross storage capacity of 520,000 AF and provides for deliveries into the Friant-Kern Canal, the Madera Canal, and other CVP facilities. Mean annual runoff of the San Joaquin River into Millerton Lake totals 1.9 million AF with 2.2 million AF per year committed in water contracts.

Historically, the upper San Joaquin River supported spawning and rearing habitat for the southernmost stocks of spring- and fall-run chinook salmon, and perhaps steelhead. Early dams along the river restricted passage of adult salmon. By the early 1940's, large runs of salmon in the upper San Joaquin River near Fresno were predominantly spring-run fish. This spring run, ranging from 2,000 to 56,000 fish between 1943 and 1948, was extirpated after 1949 as a result of the closure of Friant Dam. The fall-run, averaging about 1,000 spawners in the 1940's, was also eliminated by construction of Friant Dam. Presently, streamflow releases below the dam are insufficient to support salmon passage, spawning, or rearing.

In recent years, fall-run chinook spawning escapements in the San Joaquin basin have declined to alarmingly low levels. In the fall of 1991, a basinwide estimate of 658 fish returned to spawn, compared to historic highs of 135,000 in 1944, 80,500 in 1953, 53,400 in 1960, and 70,000 in 1985.

The closure of Friant Dam also damaged anadromous fish runs in the tributaries by significantly reducing total basin outflow. The reduction in fall attraction flows and spring outflows on the main stem San Joaquin River significantly reduced adult returns, production, and survival of salmon throughout the system. When spring outflow at Vernalis on the main stem San Joaquin River is high, the total adult salmon escapement in the San Joaquin basin 2 1/2 years later is increased. Since Friant Dam went into operation, low spring outflows from the basin in most years have been a major factor contributing to low salmon production.

A streamflow of 35 to 230 cfs is required in the river between Friant Dam and Gravelly Ford to support riparian diversions. Major reaches of the river between Gravelly Ford and the confluence with the Merced River are essentially dry for much of the year. The stream channel has been negatively affected by in-channel gravel mining and vegetative encroachment. The main stem San Joaquin River downstream from the confluences with the major eastside tributaries provides the migration corridor for anadromous fish to the Delta and Pacific Ocean.

Typical flow and water quality conditions in the Delta are detrimental to the survival of San Joaquin salmon smolts due to low inflow from the San Joaquin River and high exports by Delta water diversions. Studies have shown that survival of chinook smolts released in the southern Delta was higher for smolts migrating down the San Joaquin River than for those diverted to the west toward the Delta diversions through upper Old River.

In recent years, drainage practices in western Merced County have increased agricultural return flows from Salt and Mud sloughs into the main stem San Joaquin River. These flows attract significant numbers of adult salmon into the sloughs and, subsequently, into irrigation canals where no suitable spawning habitat is available. As spawning runs have declined in recent years, the proportion of the San Joaquin drainage salmon run straying into the westside area has increased. In the fall of 1991, an estimated 31% of the run in the basin strayed into westside canals.

In the fall of 1992, using funding from DWR Four Pumps Agreement, DFG installed a temporary electrical fish barrier across the main stem San Joaquin River, immediately upstream from the confluence with the Merced River, to guide fish into the lower Merced River. The temporary barrier, in combination with additional attraction flow releases from the lower Merced River, was highly effective in blocking fish passage. A fish barrier should be operated at this site each fall to prevent straying of adults into the westside irrigation canals.

Fish screens were installed on the Banta-Carbona, El Solyo, West Stanislaus, and Patterson irrigation district diversions in the late 1970's. Due to the low number of returning adult salmon and low production of juveniles, inappropriate design and inefficiency of the screens, and high cost of maintenance, the screens were abandoned within a few years of their installation. The El Solyo diversion has the capacity to withdraw up to 80 cfs; the other three diversions each have capacities of 249 cfs. These diversions can cumulatively withdraw a significant proportion of the main stem river flow, particularly in dry years. Several alternatives exist to reduce or prevent entrainment at these sites: re-screening using state-of-the-art fish screening technology, using alternative electronic or sonic avoidance technology, or providing the irrigation districts with alternative water supplies from the Central Valley Project in lieu of diverting directly from the San Joaquin River. Screens at these four sites might only need to be operated during late winter and spring in normal to dry water years, when the potential for entraining juvenile salmon is high.

Numerous small- and medium-size irrigation diversions on the main stem San Joaquin River entrain juvenile salmon in addition to those at the Banta-Carbona, El Solyo, West Stanislaus, and Patterson Irrigation District diversions. Losses at these other sites may be cumulatively significant. The effect these diversions have on salmon should be evaluated, corrective measures identified, and priorities set for implementation.

Developing alternative water supplies for the districts from the CVP through the Delta-Mendota Canal has been discussed, but little progress has been made toward resolution. This action would probably require formal changes in the districts' water rights, construction of new diversion facilities, and extensions to lateral canals. A major advantage of this option over re-screening is that additional outflow would remain in the river and could increase through-Delta survival of juvenile salmon.

San Joaquin basin outflow standards should be established to protect upstream migrating adults in the fall and emigrating smolts in the spring. Increased outflow from the basin has been demonstrated to increase survival of smolts into and through the Delta. Although the study data are old, upstream migration of adult salmon into the San Joaquin basin is probably delayed due to the lack of attraction flow, elevated water temperatures, and low dissolved oxygen (D.O.) levels which commonly occur in the San Joaquin River in the fall. Delta export, Port of Stockton operations, City of Stockton waste discharges, channel dredging, tides, and San Joaquin River inflow are also important factors affecting migration. There are no specific flow requirements for the main stem San Joaquin River to meet the needs of immigrating and emigrating salmon.

Elevated water temperatures during emigration probably reduce smolt survival in the main stem river. DFG Exhibit 15 to the SWRCB for Phase I of the Bay-Delta hearings identified that, in years when the Vernalis flow was 5,000 cfs or less in May, water temperatures were at levels associated with chronic stress. Temperature stress is additive and increases with successive exposures to diversions, predation, handling in the Delta fish salvage process, and migration delays.

Significantly low D.O. levels commonly occur in the vicinity of Stockton each fall. Acoustic tagging studies have shown that adult salmon migration is inhibited at D.O. levels below 5 ppm. Low D.O. levels often result from dredging activities in the Stockton Ship Channel and turning basin, flow reversals due to high Delta exports, and effluent discharge from the Stockton Municipal Sewage Plant and other sources. DWR, under an agreement associated with the original proposal for the peripheral canal, installs a barrier at the head of Old River during the fall when the Vernalis flow drops below 1,800 cfs or critical problems are predicted. This barrier is believed to improve D.O. concentrations. Improvement in the treatment of discharges at the Stockton sewage plant has also helped alleviate the problem. However, in the fall of 1992, monitoring revealed a significant dissolved oxygen sag in the river near Rough and Ready Island. DWR staff identified dredging in the ship channel as the major factor contributing to the severe oxygen sag.

Several on-going habitat restoration programs may assist salmon restoration efforts on the upper San Joaquin River. The San Joaquin River Management Program was established through state legislation (Chapter 1068/90) to develop comprehensive and compatible solutions to water supply, water quality, flood control, fisheries, wildlife habitat, and recreational needs in the San Joaquin River basin. Final recommendations will be provided to the California Legislature by January, 1995.

The CVPIA directs the Secretary of the Interior to develop a comprehensive plan to address fish, wildlife, and habitat concerns on the San Joaquin River. Issues to be addressed include improvements in streamflow, channel, riparian habitat, and water quality which would re-establish and sustain naturally reproducing anadromous fish populations from Friant Dam to its confluence with the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. However, the Secretary is directed not to make releases for the restoration of flows between Gravelly Ford and the Mendota Pool on the San Joaquin River until a specific Act of Congress authorizes such releases.

Six consecutive drought years have had such a disastrous effect on San Joaquin salmon that all remaining year classes in the ocean are now extremely small. Even if conditions in the basin were significantly improved in the near future and were to continue, there is small hope for a rapid recovery of the stock. Immediate actions are needed to protect each year class of salmon to maintain the San Joaquin basin fall-run chinook salmon stock.

In 1992, DWR entered into an agreement with DFG to provide feasibility studies for a salmon and steelhead hatchery at two potential sites within the San Joaquin River basin. Although the feasibility study was completed, no decision by the DFG to construct a hatchery has been made. This potential hatchery would be constructed on either the Stanislaus or Tuolumne rivers and would be conservatively operated to protect the naturally spawning chinook salmon while producing enough fish to reduce or eliminate the drastic year-to-year fluctuations in spawner escapements. This hatchery would not be a large-scale production facility.

Restoration of fall-run chinook salmon and steelhead runs in the San Joaquin River basin could have significant benefits to local and ocean sport and commercial fisheries. In recent years, natural fall-run spawning escapements in the basin have accounted for up to 27% of the total natural escapement of fall-run chinook salmon in the Central Valley. Restoration of steelhead runs could restore a valuable aesthetic and recreational fishery. Failure to resolve issues surrounding the decline of salmon and steelhead may cause harm to the fishery resource, require petitions to list the San Joaquin fall-run chinook salmon as a threatened or endangered species under the State or Federal acts, and potentially affect the agriculture-based economies that rely heavily on the water resources of the San Joaquin basin.

Priority Ranking and Cost of Implementation

Recommendations to improve anadromous fish habitat in the main stem San Joaquin River:

Priority	Anadromous Fish Habitat Restoration Action	Cost
A-1	Install and operate a temporary fish barrier on San Joaquin River at Merced River confluence each fall to prevent adult salmon from straying into irrigation canals. The barrier should be operated until a decision is made regarding restoration of chinook salmon in the upper San Joaquin River below Friant Dam.	$650,000
A-1	Install a fish protective device at Banta-Carbona Irrigation District diversion, or provide alternate water supplies to the district.	$1,245,000
A-1	Install a fish protective device at West Stanislaus Irrigation District diversion, or provide alternate water supplies to the district.	$1,245,000
A-1	Install a fish protective device at Patterson Irrigation District diversion, or provide alternate water supplies to the district.	$1,245,000
A-1	Install a fish protective device at El Solyo Irrigation District diversion.	$400,000

Recommendations for administrative actions to improve anadromous fish habitat in the San Joaquin River:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
A-1	Develop a comprehensive plan to address fish, wildlife, and habitat concerns on the San Joaquin River, including streamflow, channel, riparian habitat, and water quality improvements needed to re-establish naturally reproducing anadromous fisheries below Friant Dam.	USFWS DFG USBR NMFS DWR
A-1	Establish interim basin outflow objectives, criteria, or standards to protect juvenile salmon and steelhead during April 15 - May 15. The following minimum flow objectives should be adopted for Vernalis on the San Joaquin River for the April 15 through May 15 period during a defined interim period: Year type — Flow (cfs) Wet — 10,000 Above Normal — 8,000 Below Normal — 6,000 Dry — 4,000 Critical — 2,000	SWRCB EPA
A-1	Establish interim basin outflow objectives, criteria, or standards to protect the upstream migration of adults.	SWRCB EPA
A-1	Establish water temperature protection objectives for the San Joaquin River at Vernalis (fall and spring)	SWRCB EPA
A-2	Prohibit dredging operations during late summer/fall in the Stockton Ship Channel to protect anadromous fish.	COE RWQCB

Recommendations for evaluation of anadromous fish habitat in the San Joaquin River:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
A-1	Evaluate the benefits of interim increases in outflow in the spring and fall months.	$25,000
A-1	Develop a water temperature model.	$100,000
A-1	Develop a dissolved oxygen model for the San Joaquin River near Stockton area to evaluate all options to decrease or avoid adult migration delays.	$100,000
A-1	Evaluate screening needs and set priorities for small (<10 cfs) and medium-size (15-250 cfs) diversions.	$25,000

MERCED RIVER

The Merced River is presently the southernmost stream used by chinook salmon in the San Joaquin River basin and in California (Figure VII-6). The river flows westward into the valley, draining approximately 1,040 square miles. The average unimpaired runoff in the basin is approximately 1.02 million AF, similar to the Stanislaus River drainage. Agricultural development began in the 1850's, and significant changes have been made to the hydrologic system since that time. The enlarged New Exchequer Dam, forming Lake McClure with a gross storage capacity of 1,024,000 AF, was constructed in the late 1960's and now regulates releases to the lower Merced River. The dam is operated by Merced Irrigation District (MID) for power production, irrigation, and flood control. The river is also regulated by McSwain Dam (an afterbay for New Exchequer Dam), and Merced Falls and Crocker-Huffman dams located downstream.

The Merced River is the southernmost viable chinook salmon spawning stream in California. In 1991, fewer than 100 fall-run chinook adults returned to spawn.

Crocker-Huffman Dam near the town of Snelling is the upstream barrier for salmon migration. Salmon spawn in the 24-mile reach between Crocker-Huffman Dam and the town of Cressey. Rearing habitat extends downstream of the designated spawning reach, requiring the protection of the entire tributary from Crocker-Huffman Dam to its mouth.

Historically, the river supported spring- and fall-run chinook salmon, and perhaps steelhead trout. The river now supports fall-run chinook salmon, and occasionally steelhead and late-fall-run chinook salmon. As with other tributaries in the basin used by salmon, escapements in the lower Merced River have varied significantly since surveys were initiated. Construction and operation of the Merced River Hatchery (MRH), in combination with increases in instream flows due to the 1967 Davis-Grunsky Contract, have increased the Merced River salmon run. Prior to 1970, spawning escapements were generally less than 500 fish annually; since that time, annual runs have averaged 5,800 fish. In recent years, spawning escapements in the lower Merced River have declined to seriously low levels. In the fall of 1991, less than 100 fish returned to spawn, compared to a recent high of 23,000 fish in 1985. Extremely low returns to the MRH in recent years have severely limited production of San Joaquin basin salmon at this facility.

The MRH, located below Crocker-Huffman Dam, is presently the only salmon hatchery in the San Joaquin River drainage south of the Delta. The MRH, operated by DFG, was constructed in 1970 and operated for 10 years with funding provided in the Davis-

Grunsky Agreement. The hatchery has been valuable in augmenting salmon runs in the lower Merced River and providing fish for study purposes throughout the basin. The facility was recently modernized, using funding from Salmon Stamp and the DWR Four Pumps Agreement. The production capacity was increased from 300,000 to 360,000 yearling salmon and from 400,000 to 600,000 salmon smolts and egg incubation capacity was increased to 4,000,000. However, fish produced at MRH have experienced recurrent disease problems due to warm water. The existing ultra-violet water treatment system is inadequate to sterilize the entire water supply to the hatchery.

DFG has conducted juvenile rearing and annual spawning escapement studies since 1953, but no instream flow, stream temperature modeling, or smolt survival studies have been conducted. Little local data are available, therefore, to define the flow needs for salmon spawning, egg incubation, rearing, and emigration. DFG is planning to conduct an IFIM, stream temperature modeling, and sediment transport modeling study over the next three years to better define flow needs for spawning and rearing.

Physical habitat for salmon spawning and rearing has been lost or degraded due to low flow releases, siltation of spawning gravel, lack of spawning gravel recruitment below the reservoirs, removal of bank-side riparian vegetation reducing stream shading and bank stability, and in-channel mining which has removed spawning gravel, altered the migration corridor, and created excellent salmon predator habitat.

Spawning and rearing habitat in the Merced River is the most degraded among the San Joaquin basin tributaries. Legally required summer flow releases are low (15 to 25 cfs) and are usually depleted before they reach the mouth of the river due to riparian diversions throughout the lower river. In portions of the spawning reach and below, riparian vegetation has been removed in favor of agricultural development, cattle grazing, urban development, and gravel mining.

Gold dredging in the early 1900's removed significant quantities of spawning gravel from the Merced River. Large tailing piles remain along the spawning reach, but there is a lack of recruitment of new spawning gravel. In many riffles, significant armoring has also occurred, with only large cobble remaining. In-channel gravel mining was very extensive along the Merced River. Downstream from the State Highway 59 bridge, the river flows through large mined-out pits in the channel. Some of the pit areas have been isolated from the active channel by levees, however, most of these were poorly designed and have been breached. The ponds and small lakes resulting from these pits create excellent salmon predator habitat, disrupt salmon migration, and result in elevated stream temperatures.

Significant numbers of juvenile salmon are probably entrained at the six medium-sized irrigation diversions on the salmon spawning portion of the Merced River. The Davis-Grunsky contract between DWR and MID requires the District to install and maintain fish screening devices at these diversions. Rock screens, consisting of perforated conduit buried in cobble-filled gabions, have been installed at four of the diversions. These structures are only moderately effective at preventing entrainment of juvenile salmon. The screens quickly become clogged with vegetation and bypass gates, which allow diversion without water passing through the screens, are often opened when the screens become clogged. DFG contracted with MID to construct self-cleaning perforated plate screens at two sites and to improve two of the other screens. Bypass efficiencies on these screens should be improved. All four of the gabion structures should be replaced with perforated plate screens.

DFG surveys on the lower Merced River have identified 68 small pump irrigation diversions, none of which are adequately screened to prevent entrainment of juvenile salmon. Losses at these sites may be cumulatively significant. The need for screening of these diversions should be evaluated and appropriate screens installed.

Flow releases are not sufficient to accommodate salmon migration, spawning, egg incubation, juvenile rearing, and smolt emigration on the Merced River. Flows within the spawning reach during the spawning and early rearing period are further depleted due to riparian diversions. Spring flows for smolt emigration are particularly inadequate.

Stream flows for fishery purposes in the lower Merced River are designated in FERC License No. 2179 for the New Exchequer Project, issued April 1964 (Table VII-7) and Davis-Grunsky Contract No. D-GGR17 (DWR Contract No. 160282) between DWR and MID, executed October 1967. The Davis-Grunsky contract requires MID to maintain a continuous flow of between 180 and 220 cfs from November 1 through April 1 throughout the reach from Crocker-Huffman Dam to Shaffer Bridge.

Adequate releases for upstream attraction of adults and spawning do not begin until November 1, while upstream migration typically begins in October. The present spawning and rearing flow requirements were not based on results of scientific studies, and may be too low to meet spawning and rearing needs. In addition, six major riparian diversions within the spawning reach from Crocker-Huffman Dam to below Snelling deplete these flows, so at times, significant portions of the spawning reach receive flows less than the legally required amounts. Required streamflows are measured at the Shaffer Bridge gauge, which is downstream from several irrigation returns.

TABLE VII-7. Instream Flows Required for the Lower Merced River as Measured at Shaffer Bridge.

Period	Normal Year (cfs)	Dry Year (cfs)
June 1 - October 15	25	15
October 16 - October 31	75	60
November 1 - December 31	100	75
January 1 - May 31	75	60

The most significant deficiencies in the present flow requirements occur in the spring emigration period. Flows during April and May, required in the FERC license, are 75 cfs in a normal year, and 60 cfs in a dry year. Smolt survival studies conducted in the other tributary streams in the San Joaquin drainage indicate that significantly higher spring flows are needed in the lower Merced River.

A revised flow schedule for the lower Merced River was formulated based on instream flow study and smolt survival data from similar drainages (Table VII-8). Recommended flows during the spring emigration period are consistent with proposed spring outflow objectives for the basin at Vernalis on the San Joaquin River. To ensure that flow releases at the dam are not depleted by riparian diversions, required flows should be measured at the Crocker-Huffman and DWR Snelling gauges, which have been shown in a DWR study to better reflect flows throughout the spawning reach. Flow monitoring below Snelling is also needed due to additional points of diversion within that section. The recommended flow schedule for the lower Merced River should be considered preliminary until further study results are available. Although the flows are a significant improvement over the presently required releases, they are not optimum for salmon spawning, rearing, or emigration, particularly in drier years.

There are several mechanisms available to obtain additional flow in the Merced River. The FERC, through licensing of the New Exchequer Project, has the authority to require changes in instream flow conditions for the protection of anadromous fish in the lower Merced River. DWR has the authority to enforce the provisions of the Davis-Grunsky contract with MID. The SWRCB has authority to establish minimum standards to protect beneficial uses including fisheries. Voluntary land fallowing programs, water use efficiency improvements, temporary purchase of water, acquisition of water rights or lands with water

TABLE VII-8. Lower Merced River Interim Instream Flow Schedules for Five Water Year Types.[1]

Date	Days	CRITICAL		DRY		BELOW NORMAL		ABOVE NORMAL		WET	
		Flow Release (cfs)	Release (Acre-feet)	Flow Release (cfs)	Release (Acre-feet)	Flow Release (cfs)	Release (Acre-feet)	Flow Release (cfs)	Release (Acre-feet)	Flow Release (cfs)	Release (Acre-feet)
10/01 - 10/14	14	200	5,544	225	6,237	250	6,930	275	7,623	300	8,316
10/15 - 12/31	78	250	38,610	275	42,471	300	46,332	325	50,193	350	54,054
01/01 - 03/31	90	200	35,640	250	44,550	300	53,460	375	66,825	350	62,370
04/01 - 05/31	61	300	36,234	350	42,273	400	48,312	450	54,351	500	60,390
06/01 - 09/30	122	200	48,312	200	48,312	250	60,390	300	72,468	350	84,546
[2] Spring Outmigrant Flows (April-May)			2,376		19,602		36,828		54,054		71,280
Fall Attraction Flows (October)			15,000		15,000		15,000		15,000		15,000
Totals			181,716		218,445		267,252		320,514		355,956

[1] Year types based on the 60-20-20 index for the San Joaquin basin developed by the water Year Classification Subgroup, and adopted by the SWRCB in draft Decision 1630, December 1992. Schedules by water year, based on the similarity of Merced River channel configurations and hydrology with the Stanislaus River IFIM, temperature model, and other studies necessary to determine Merced River instream flow needs are underway, completion estimated by 1996.

[2] Spring outmigrant flows (April and May) based on additional flow needed to meet the following flow objectives (Merced River flow contribution at Vernalis = 17%, based on proportion of natural unimpaired flow):

Critical Year: 30 days at 340 cfs.
Dry Year: 30 days at 680 cfs.
Below Normal Year: 30 days at 1,020 cfs.
Above Normal Year: 30 days at 1,360 cfs.
Wet Year: 30 days at 1,700 cfs.

rights, exchanges and transfers of water through the State Water Bank, or other means should also be considered as alternatives to augment instream flows.

Poor water quality causes delayed spawning, decreased egg survival, and high juvenile mortality. Although a temperature modeling study has not yet been completed for the lower Merced River, measured stream temperatures on the river often exceed temperature tolerances for salmon spawning and egg incubation in October and early November in at least a portion of the spawning reach. Elevated temperatures probably result in delayed upstream migration and spawning. In recent drought years, salmon have not spawned in the river until after the first week of November when water temperatures become tolerable.

In late April and May, stream temperatures often exceed stressful levels for emigrating smolts. Elevated spring temperatures are a more significant problem in the lower Merced River than in the other San Joaquin tributaries due to the high ambient air temperatures and low flows. Fish disease and other temperature-related problems continue to cause mortality to fish reared at MRH. A temperature modeling study will be needed to fully evaluate temperature effects on chinook salmon spawning and rearing in the lower Merced River. The results of this study will be used to identify maximum temperature objectives for steelhead and late-fall run chinook salmon.

Existing wildlife protection staffing is not adequate to effectively enforce provisions of the Fish and Game Code pertaining to streambed alterations, fish screening, and water pollution. Additional protection could be provided for salmon spawning and rearing habitat by funding additional law enforcement personnel.

Preliminary surveys on the Merced River indicate that the major needs for salmon habitat improvement include rehabilitation of riffle areas, levee and channel construction or repair to isolate mining pit areas from the active stream channel, and modification of diversion structures. The overall estimated cost of habitat rehabilitation on the Merced River, based on preliminary DFG/DWR surveys, is higher than for the other San Joaquin tributaries due to the relatively high cost of levee building and repairs, and the extensive lack of suitable-sized spawning gravel in the channel. DWR will provide engineering assistance in the identification and prioritization of potential habitat projects. Final results of this study, to be available by February 1994, will help guide future habitat project development in the basin.

Priority Ranking and Cost of Implementation

Recommendations to improve anadromous fish habitat in the Merced River:

Priority	Anadromous Fish Habitat Restoration Action	Cost
A-1	Upgrade screens on four medium-sized riparian diversions (diversion capacities in cfs: 20, 25, 27, 52), and upgrade fish bypasses on two additional diversions.	$620,000
A-1	Restore habitat for migration, spawning, and rearing by rehabilitating riffle areas, repairing or constructing levees and channels, and isolating mining pit areas from the active stream channel.	$4,000,000

Recommendations for administrative actions to improve anadromous fish habitat in the Merced River:

Priority	Administrative Actions to Improve Anadromous Fish Habitat	Agency
A-1	Require the following interim total annual instream flow releases (AF) for fisheries: Water Year Type — Total Release (AF) Wet water year - 355,956 Above-normal water year - 320,514 Below-normal water year - 267,252 Dry water year - 218,445 Critical water year - 181,716.	SWRCB FERC DWR
A-1	Require measurement of instream flow requirements at the Crocker-Huffman and Snelling stream gauges.	DWR
A-1	Establish the following water quality objectives for the protection of spawning, rearing, and emigration: 56°F maximum from October 15-February 15 to protect incubating eggs throughout the designated spawning reach from Crocker-Huffman Dam to Cressey. 65°F maximum surface water temperature from April 1 - May 31 to protect emigrating salmon throughout the lower Merced River.	SWRCB RWQCB
A-2	Provide additional law enforcement coverage to protect salmon habitat through diligent enforcement of pollution, screening, and streambed alteration Fish and Game Code sections.	DFG

Recommendations for evaluation of anadromous fish habitat in the Merced River:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
A-1	Conduct instream flow, stream temperature modeling, and related studies.	$350,000
A-1	Evaluate fish screening needs at 68 small riparian pump irrigation diversions. Set priorities for screen installation.	$15,000
A-1	Complete evaluation of spawning, rearing, and migration habitat restoration needs.	$33,000

STANISLAUS RIVER

The Stanislaus River is the northernmost tributary in the San Joaquin River basin used by chinook salmon (Figure VII-6). The river flows westward into the valley, draining approximately 900 square miles. The average unimpaired runoff in the basin is about 1.2 million AF. Significant changes have been made in the basin hydrology since agricultural development began in the 1850's. New Melones Dam, completed by the COE in 1978 and approved for filling in 1981, is now the largest storage reservoir in the Stanislaus basin, with a gross storage capacity of 2.4 million AF. The project is operated by the USBR as part of the CVP. Downstream from New Melones, Tulloch Reservoir, with a gross storage capacity of 68,400 AF, regulates water releases from New Melones Dam. Goodwin Dam, downstream, regulates releases from Tulloch Reservoir and diverts water for power and irrigation to South San Joaquin Irrigation District and Oakdale Irrigation District.

Goodwin Dam is the upstream barrier for salmon migration. Salmon spawn in the 23-mile reach between Goodwin Dam and the town of Riverbank, and rear in the entire lower river. Historically, the river supported steelhead, and spring- and fall-run chinook salmon. The river now supports fall-run chinook, and small populations of late-fall-run chinook and steelhead. Similar to conditions in other tributaries in the basin, fall-run spawning escapements in the lower Stanislaus River have varied significantly since surveys were initiated in 1939. In recent years, spawning escapements have declined to seriously low levels on the lower Stanislaus River. In the falls of 1991 and 1992, fewer than 300 salmon returned to spawn in the lower Stanislaus, compared to a recent historic high of 35,000 fish in 1953.

The Stanislaus River historically was used by spring-run and fall-run chinook salmon and steelhead. Restoration of the salmon and steelhead runs could provide a valuable recreational resource.

Interim flow releases for fishery purposes in the lower Stanislaus River are designated in a 1987 Study Agreement between the USBR and DFG. This agreement, enacted pursuant to a DFG protest of USBR's water right applications to redivert water from New Melones Dam, specifies interim annual flow allocations for fisheries between 98,300 and 302,100 AF based primarily on the carryover storage at New Melones and inflow. The agreement also identifies a seven-year cooperative study program.

The seven study elements specified in the agreement are in various stages of completion. The USFWS completed an IFIM study on the lower Stanislaus in 1992 to define flow needs for salmon spawning and rearing. Other studies in the agreement include spawning escapement surveys, juvenile distribution and growth studies, smolt survival studies, habitat improvement needs study, and stream temperature modeling. DFG has annually completed spawning escapement studies and juvenile distribution and growth studies. Progress on smolt survival studies has been delayed due to the lack of fish available for study purposes. Habitat improvement opportunities in the river are being identified through initial DFG and DWR studies. USBR is conducting a stream temperature modeling study on the river.

Instream flow schedules are set annually by DFG, within the total annual flow allocation specified in the agreement. Due to the formula in the agreement for determining fishery water supplies, only 98,300 AF has been allocated for fisheries annually since the agreement was signed in 1987. This quantity is not adequate flow for all salmon life stages.

In addition to flow allocations for fisheries, 70,000 AF is a minimum annual allocation for water quality purposes. To meet Delta water quality standards, USBR commonly releases additional water over the 70,000 AF requirement. In recent years, the coordination of fishery and water quality flow releases, and releases for water sales and transfers, has resulted in schedules that significantly benefit anadromous fish.

Flows needed for spring smolt emigration, in particular, cannot be adequately met with the present annual flow allocations. There is a relationship between spring outflow at Vernalis on the San Joaquin River and at Ripon on the Stanislaus River to adult escapements into the basin 2 1/2 years later. Results of smolt survival studies completed thus far on the lower Stanislaus River indicate a positive relationship between smolt survival and spring flow releases. Consequently, DFG now allocates as much flow as possible in the critical spring months to improve smolt survival. Fall flows, however, must be curtailed since the annual flow allocations do not provide sufficient water to meet the minimum need. Strong year classes of salmon have resulted only in years when additional spring flow releases have been made.

Results of the DFG smolt survival study and the USFWS instream flow study were used to formulate revised minimum instream flow schedules for the lower Stanislaus River (Table VII-9), which were submitted by DFG to the USBR and DWR in August, 1992. The Stanislaus County Water Coordinating Advisory Committee made similar recommendations. Water year classifications were based on the 60-20-20 index developed for the San Joaquin basin by the Sub-workgroup on Water Year Classification for the SWRCB Bay-Delta Proceedings. Flows for the October 1 through March 31 period were based on results of the instream flow study for salmon spawning, egg incubation, and rearing. Flows during

TABLE VII-9. Lower Stanislaus River Interim Instream Flow Schedules for Five Water Year Types.

Date	Days	CRITICAL		DRY		BELOW NORMAL		ABOVE NORMAL		WET	
		Flow Release (cfs)	Release (Acre-feet)	Flow Release (cfs)	Release (Acre-feet)	Flow Release (cfs)	Release (Acre-feet)	Flow Release (cfs)	Release (Acre-feet)	Flow Release (cfs)	Release (Acre-feet)
10/01 - 10/14	14	200	5,544	250	6,930	250	6,930	300	8,316	300	8,316
10/15 - 12/31	78	250	38,610	275	42,471	300	46,332	350	54,054	400	61,776
01/01 - 03/31	90	200	35,640	225	40,095	250	44,550	300	53,460	350	62,370
04/01 - 05/31	61	300	36,234	350	42,273	400	48,312	450	54,351	500	60,390
06/01 - 09/30	122	200	48,312	200	48,312	250	60,390	300	72,468	350	84,546
* Spring Outmigrant Flows (April-May)			5,940		26,730		47,520		68,310		89,100
Fall Attraction Flows (October)			15,000		15,000		15,000		15,000		15,000
Totals			185,280		221,811		269,034		325,959		381,498

* Based on 30 day flow of 400 cfs (100 cfs for 30 days in addition to spring base flow of 300 cfs) for critical year. Stanislaus River flow contribution at Vernalis = 20 percent.

Based on 30 day flow of 800 cfs (450 cfs additional flow for 30-days from base spring flow of 350 cfs) for dry year.

Based on 30 day flow of 1,200 cfs (800 cfs for 30-days in addition to spring base flow of 400 cfs) for below normal year.

Based on 30 day flow of 1,600 cfs (1,150 cfs for 30 days in addition to spring base flow of 450 cfs) for above normal year.

Based on 30 day flow of 2,000 cfs (1,500 cfs for 30-days in addition to spring base flow of 500 cfs) for wet year.

April 1 through May 31 for late rearing and smolt emigration were based on results of the smolt survival studies. These flows for the lower Stanislaus River are consistent with meeting spring outflow objectives proposed for the basin at Vernalis on the San Joaquin River. Summer flows were based on needs of over-summering yearling salmon and steelhead.

The recommended flows represent the minimum needed for salmon spawning, rearing, and emigration on the lower Stanislaus River. These flows would represent a significant improvement over existing required instream releases, but are not optimum flows, particularly in drier water years. Amendment of the interim flow agreement and redirection of the scope of the study are needed to reflect knowledge gained from the recent studies.

The CVPIA authorized the dedication and management of 800,000 AF of CVP yield annually for the purpose of implementing the fish, wildlife, and habitat restoration purposes and measures. A portion of this allocation was released to the lower Stanislaus River in 1993 to improve salmon rearing and emigration. The CVPIA also directed the Secretary of the Interior to evaluate and determine the existing and anticipated future basin needs in the Stanislaus River basin in the course of preparing the Stanislaus River Basin and Calaveras River Water Use Program Environmental Impact Statement. DFG is participating in this program to ensure that appropriate instream flows for anadromous fish are incorporated in project planning.

Poor water quality results in delayed spawning, decreased egg survival, and high juvenile mortality. Water quality (temperature) on the lower Stanislaus River is influenced by ambient air temperatures, late summer storage levels and thermocline development at New Melones Reservoir, the depth of diversions from New Melones storage, and Tulloch Reservoir temperatures and operations. Fall flow releases to the lower Stanislaus River can exceed critical temperatures for salmon spawning and egg incubation when storage levels at New Melones Reservoir are low. In recent drought years, the first fish entering the river to spawn did not arrive until early November rather than October as in previous years. Elevated water temperatures are probably a major cause of this delay. Late spawning salmon result in juvenile fish not being ready to emigrate until later in the spring when elevated temperatures occur in the tributaries and main stem San Joaquin River. Egg mortality has been shown to increase when temperatures exceed 56°F. When storage levels at New Melones are low, water temperature exceeds 56°F in much of the salmon spawning reach until ambient air temperatures cool the river during November.

Elevated water temperatures during emigration reduce smolt survival in the San Joaquin basin. In May, smolts emigrating from the Stanislaus River routinely encounter water temperatures exceeding stress levels. The revised interim instream flow schedules proposed in this plan would ameliorate temperature effects. However, results of the USBR's stream temperature model for the lower Stanislaus River will be needed to thoroughly evaluate temperature effects.

Forty-four small pump diversions have been identified on the lower Stanislaus River, none of which are adequately screened to protect juvenile salmon. Losses at these diversions are not known, but may be significant. These diversions should be evaluated, and priorities set for the installation of appropriate screens.

Habitat improvement opportunities for salmon in the San Joaquin basin, including the lower Stanislaus River, are being assessed through a DFG-funded study. DWR will provide engineering assistance in the identification and setting of priorities for potential habitat improvement projects. Final results of this study, to be available by February 1994, will help guide future habitat project development in the basin. Projects identified will include gravel renovation projects, channel modifications to create new spawning riffles, channel modifications to isolate existing excavated areas from the active river channel to reduce predation and to improve the migration corridor, and restoration of riparian vegetation.

Physical habitat for salmon spawning and rearing has deteriorated due to low instream flow releases which resulted in siltation of spawning gravel, loss of side channels and channel diversity, and reduced spawning gravel recruitment to the active stream channel. In-channel gravel mining has removed spawning gravel, altered the migration corridor, and created salmon predator habitat.

No habitat improvement projects have been completed on the lower Stanislaus River; however, funding has been obtained through to the DWR Four Pumps Agreement for three riffle renovations. Preliminary DFG/DWR surveys have identified an additional twelve high priority sites for salmon habitat improvement on the lower Stanislaus River. Highest priority projects identified are spawning riffle renovations (replacement of cobble with suitable size spawning gravel and recontouring of existing gravel), and isolation of excavated areas from the active channel. Overall cost estimates for habitat rehabilitation on the lower Stanislaus River were based on preliminary DFG/DWR surveys.

Additional habitat protection could be provided to chinook salmon through comprehensive enforcement of Fish and Game Code provisions pertaining to screening, streambed alterations, and water pollution.

operation, the licensees would be required to maintain minimum instream flows as required by the FERC upon its own motion, or upon recommendation by the DFG or the Secretary of the Interior, and findings by the FERC that such flows are necessary and consistent with the Federal Power Act. The licensees were also required to cooperate with DFG in conducting studies aimed at assuring continuation and maintenance of the fishery in the lower Tuolumne River. The City and County of San Francisco, upstream diverters on the lower Tuolumne under the provisions of the Raker Act, are not party to the FERC license, and are not required to provide instream releases for salmon below New Don Pedro.

The original FERC project license only required a May through September release of 3.0 cfs to the lower Tuolumne River. This minimal flow eliminated the possibility for any over-summering of yearling salmon and resulted in the degradation of spawning habitat over the summer through encroachment of riparian vegetation, deposition of silt in spawning gravel, and proliferation of predator fish species. In response to a complaint filed with the SWRCB, the Districts agreed to provide additional flow releases during the summer varying from 10 to 150 cfs, based on water year type. Except during wet water years when greater releases occur for flood control or other purposes, these releases are not adequate to provide holding and rearing habitat for salmon, or prevent degradation of spawning habitat. During the recent drought, significant habitat degradation has resulted from low summer flow releases and a lack of high winter flushing flows.

In 1967, the licensees submitted a Fish Study Program to the FERC, which was approved in 1968. The Study Program was revised in September 1971. In 1986, the Fish Study Program was again revised. The present agreement, adopted by the FERC, identifies a fishery study program and provides 60,000 AF of additional water releases in the spring for two years of smolt survival studies. In March, 1992, the DFG entered into an agreement with the licensees which provided for additional fishery studies and set new instream flow schedules. This agreement will not become effective until approved by the FERC.

The 1986 agreement does not provide adequate flow releases for salmon migration, spawning, egg incubation, juvenile rearing, smolt emigration, and over-summering of yearlings. Spring flows for smolt emigration are particularly inadequate. Flow fluctuations during peaking power operations cause disruption of adult passage and spawning, scouring of redds, and stranding and downstream displacement of juvenile salmon. In dry years, the situation is particularly dismal, with not enough water to meet the needs of any of the life stages.

New interim instream flows for the Tuolumne River are detailed in the March 1992, agreement between DFG and ModID/TID (Table VII-10). Results of on-going fishery studies will be used to define final instream flow needs for the lower Tuolumne River.

During the late spawning and rearing period (December, January, and February), hydroelectric power releases into the lower Tuolumne River from the New Don Pedro Project can cause significant fluctuations in downstream river levels over a 24-hour period (commonly varying from 200 to 4,500 cfs). These releases are typically made in average or better water years when there are no diversions for irrigation purposes and when releases are made in anticipation, or as a direct result, of flood control requirements. Such fluctuating flows can disrupt adult passage and spawning, and affect emerging salmon fry by lateral stranding and downstream displacement. Since fry are most abundant and are typically involved in passive movements during January and February, they are particularly vulnerable to rapid streamflow changes and conveyance to downstream areas where they encounter less suitable rearing conditions. Stranding of juvenile salmon following rapid flow changes has been documented at several sites along the lower Tuolumne River, and may be a significant factor affecting survival in years when power peaking occurs. The March 1992 agreement specifies fluctuating flow criteria, but these may not be adequate for the protection of all life stages. The Districts will be conducting additional studies of the effects of flow fluctuations on juvenile salmon. Upon completion of these studies, revised operational criteria, such as ramping rates and/or curtailment during critical periods, should be developed for the New Don Pedro Project to reduce these affects.

Poor water quality can result in delayed spawning in the fall, decreased egg survival, and high juvenile mortality during the spring emigration period. Results of the stream temperature modeling study on the lower Tuolumne River indicate that, with present fall flow allocations, suitable temperatures for salmon spawning are commonly exceeded in a portion of the spawning reach in October. This contributes to delayed upstream migration and spawning. In recent drought years, the first fish have returned to spawn in the lower Tuolumne River in early November, rather than in October as in previous years. This is probably due primarily to elevated water temperatures encountered during upstream migration.

As with the other San Joaquin basin tributaries, elevated water temperatures on the lower Tuolumne River during the spring emigration period may be a significant factor affecting smolt survival. Results of the stream temperature modeling study indicate that in May, and at times in late April, smolts emigrating from the Tuolumne River commonly encounter excessive water temperatures. Temperature was a consideration in formulating the

In-channel gravel mining has removed gravel from long stretches of the spawning reach. In roughly half of the spawning reach, extensive mining has left long deep pools and widened the channel. These pools also provide excellent salmon predator habitat.

ModID/TID have agreed to fund spawning gravel improvement projects on the lower Tuolumne River. The projects will contribute to the overall restoration of chinook salmon in the river. Cost estimates of other habitat rehabilitation projects on the lower Tuolumne River were based on preliminary DFG/DWR surveys, and are comparable to cost estimates for the lower Stanislaus River, where similar habitat problems occur.

Existing wildlife protection staffing is not adequate to effectively enforce provisions of the Fish and Game Code pertaining to streambed alterations, fish screening, and water pollution. Additional protection could be provided for salmon spawning and rearing habitat by funding additional law enforcement personnel.

Thirty-six small irrigation pump diversions have been identified in surveys on the lower Tuolumne River, none of which are screened. Losses of juvenile salmon at these sites are not known, but cumulatively, they may be significant. Screening needs at these diversions should be evaluated and appropriate screens installed.

The lower Tuolumne River has been surveyed as part of a DFG/DWR study to assess habitat restoration needs in the San Joaquin River basin. A preliminary assessment has identified seventeen sites for additional habitat restoration. The overall basin study which will identify and set priorities for habitat projects will be completed by February 1994.

Restoration of the fall chinook salmon run in the lower Tuolumne River could have significant benefits to sport and commercial fisheries. Historically, spawning escapements in the Tuolumne River alone have amounted to up to 12% of the total fall-run salmon escapement in the Central Valley. Implementing the action items will result in habitat restoration with the potential to return populations to recent historic levels.

Priority Ranking and Cost of Implementation

Recommendation to improve anadromous fish habitat in the Tuolumne River:

Priority	Anadromous Fish Habitat Restoration Action	Cost
A-1	Restore spawning, rearing, and migration habitat at 17 sites by renovating spawning gravel and riffle areas, increasing side channel and channel diversity, recontouring channels, and isolating predator habitat.	$2,000,000

Recommendations for administrative actions to improve anadromous fish habitat in the Tuolumne River:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
A-1	Require adequate instream flow releases for the protection of salmon spawning, rearing, and emigration.	SWRCB FERC
A-1	Establish water quality objectives for the protection of spawning, rearing, and outmigration: **56°F maximum from October 15 - February 15 to protect spawning and egg incubation throughout the designated spawning reach from LaGrange Dam to Waterford.** **65°F maximum surface water temperature from April 1 - May 31 throughout the lower Tuolumne River to protect emigrating smolts.**	SWRCB RWQCB EPA
A-2	Provide additional law enforcement coverage to protect salmon habitat through diligent enforcement of screening, streambed alteration and water pollution Fish and Game Code sections.	DFG

Recommendations for evaluation of anadromous fish habitat in the Tuolumne River:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
A-1	Evaluate effects of fluctuating flows due to power peaking on salmon spawning and rearing. Develop appropriate fluctuation criteria.	$100,000
A-1	Evaluate fish screening needs at 36 small riparian pump irrigation diversions. Set priorities for installation of screens.	$15,000
A-1	Complete evaluation of spawning, rearing, and migration habitat restoration needs.	$33,000

EASTSIDE REGION STREAM ACTION PLANS

CALAVERAS RIVER

The Calaveras River, tributary to the Delta, enters the San Joaquin River at Stockton (Figure VII-7). The river drains approximately 362 square miles and has an average annual runoff of 166,000 AF. River flows are controlled by New Hogan Dam (NHD), constructed by the COE and operated by the USBR since 1964. Conservation yield from New Hogan Reservoir, with a gross pool capacity of approximately 325,000 AF, is contracted to Calaveras County Water District and Stockton East Water District. The dam and reservoir are located in western Calaveras County near Valley Springs.

The Calaveras River drainage is almost entirely below the effective average snow level (5,000 feet in elevation), and thus receives runoff primarily as rainfall. About 93% of the runoff occurs from November through April. The portion of the river in the valley commonly experienced periods of low or even no flow for many days or weeks in late summer and early fall. However, deep pools in the approximately six-mile-long reach from NHD to Jenny Lind, which were formerly warmwater gamefish habitat, now provide suitable summer holding areas for salmon and resident trout in all but the driest of years.

Sporadic returns of winter-run chinook salmon occur on the Calaveras River. Adequate fish passage and flows are required to sustain salmon in this river on a consistent basis.

In 1963, DFG concluded that project irrigation releases below NHD would generally enhance anadromous fish populations but no minimum flow releases below NHD were recommended. It was expected that flows in this reach would increase and be more stable from March through October, thus eliminating the "no flow" problem during August, September and October. However, due to diversion of the irrigation releases, this benefit did not occur below Bellota Dam, 15 miles downstream from NHD.

Runs of chinook salmon into the Calaveras River were known to occur historically on an irregular basis. Operation of the NHD project may have increased the frequency of the salmon runs into the Calaveras River. Since the project, returns of winter-run chinook salmon were documented in the Calaveras River in 1972, 1975, 1976 (tidewater only), 1978, 1982 (tidewater only) and 1984 (Table VII-11). Juvenile chinook salmon have been reported in the river as recently as 1987.

FIGURE VII-7. Map of the lower Sacramento and San Joaquin rivers depicting the eastside tributary streams.

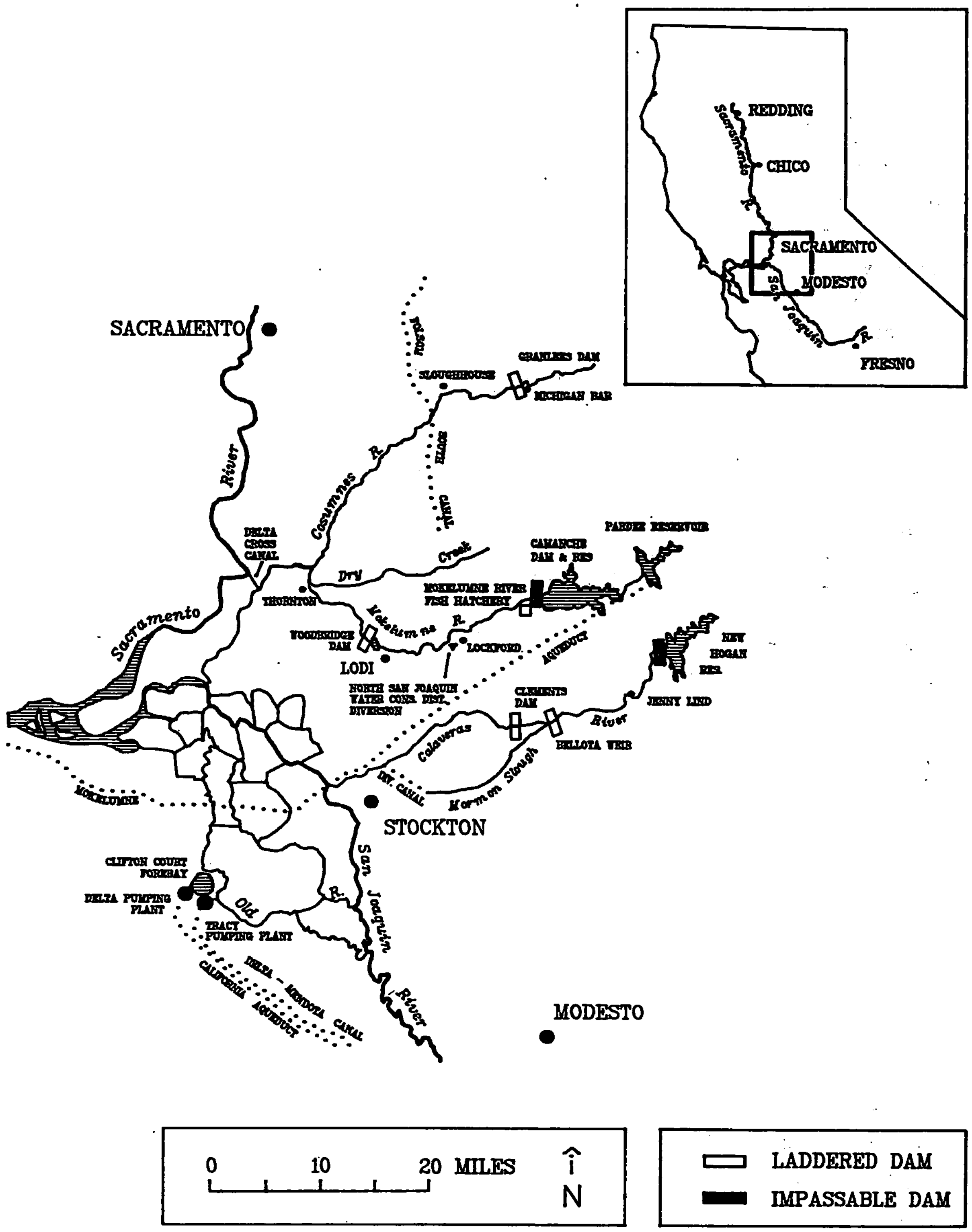


TABLE VII-11. Winter-run Chinook Salmon Documented in the Calaveras River Since Construction of New Hogan Dam.

Year of Survey	Estimated Number of Winter-run Chinook Salmon Observed
1972	1,000
1973	100
1975	500
1976	1,000
1982	100
1984	100

Stockton East Water District has an appropriative water right to divert up to 100 cfs from the Calaveras River. This diversion is presently unscreened. There are several other unscreened diversions along the river. Although these diversions have not been quantified or investigated, it is probable that losses of juvenile salmon occur during years when chinook salmon enter and spawn in the Calaveras River.

A preliminary Instream Flow Incremental Methodology (IFIM) study was completed on the lower Calaveras River by USFWS in 1992. Results of this study indicate that between 50 and 225 cfs, depending on time of year and water year type, is needed to provide habitat for winter-run chinook salmon spawning and rearing. This study included few transects and was conducted over a limited range of flow conditions. A complete IFIM study is needed on the river to further define flows for spawning and rearing.

Water Permit No. 14434 for New Hogan Reservoir allows storage of Calaveras River water to storage only when surface flow exists in the Calaveras River between NHD and the Calaveras River below Mormon Slough. However, there are no requirements to maintain releases for fishery purposes.

The channels which carry Calaveras River water, and are migratory routes for salmon below Bellota Dam, include the original Calaveras River stream channel, Mormon Slough, and the Stockton Diverting Canal (into which drains Mormon Slough). In some years, typically in March, partial or complete blockage of the adult salmon migration coincides with the annual placement of approximately thirty temporary irrigation dams in these channels. Fish are prevented from reaching the deep holding pools and spawning gravel above Bellota and are subjected to poaching below the flashboard dams. Reclamation Board permit (No. 7594, August 27, 1971) requires that some of the flashboards and slide gates be removed from the channel prior to November 1 of each year and not replaced before April 15. The Reclamation Board requirements for the other check dams are unknown at this time. Two of the diversion structures, Clements Dam and Cherryland Dam, have been identified as barriers to salmon movement, and require the installation of fishways.

The Bellota Dam (weir) has also been known to block upstream salmon migrants at flows below about 200 cfs. In some years, salmon have been observed in the tidewater reach, apparently unable to move upstream at lower flows.

Although it has not yet been evaluated, restoration of winter-run chinook salmon to this river might hasten their recovery and eventual delisting under both the State and Federal Endangered Species Acts. However, at this time, restoration of the winter-run on the Calaveras River is not a high priority compared to restoration of the run in its range in the Sacramento River.

Physical habitat conditions are adequate for salmon spawning and rearing, including abundant spawning gravel and a dense riparian canopy. With appropriately timed flows and improved fish passage, runs of winter-run and fall-run chinook salmon could be maintained on a consistent basis.

Priority Ranking and Cost of Implementation

Recommendation to improve anadromous fish habitat in the Calaveras River:

Priority	Anadromous Fish Habitat Restoration Action	Cost
C-1	Construct fish passage facilities at Bellota Weir (Mormon Slough Diversion), Clements Dam (Clements Road Bridge), and Cherryland Dam, unless sufficient flow is obtained for adult salmon passage.	$150,000

Recommendations for administrative actions to improve anadromous fish habitat in the Calaveras River:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
C-1	Require adequate instream flows for chinook salmon spawning, rearing, and outmigration.	SWRCB
C-1	Require removal of all temporary flashboard dams in the Calaveras River, Mormon Slough, and Stockton Diverting Canal during the upstream migration period, or require provision of adequate fish passage facilities at these sites.	SWRCB DFG USACOE USBR

Recommendations for evaluation of anadromous fish habitat in the Calaveras River:

Priority	Evaluation Action to Improve Anadromous Fish Habitat	Cost
C-1	Conduct a complete instream flow and stream temperature modeling study to determine flow needs for spawning and rearing.	$300,000
C-1	Determine the number and capacity of unscreened water diversions. Establish a priority for installing screens.	$25,000

COSUMNES RIVER

The Cosumnes River is tributary to the Mokelumne River, joining from the north near the town of Thornton (Figure VII-7). There are no water storage reservoirs on this system, and due to the low elevation of its headwaters, the river receives most of its water from rainfall.

The Cosumnes River historically supported an average annual run of approximately 1,000 chinook salmon, but during recent years, escapement estimates have generally been 100 fish or less. The river has extensive gravel areas suitable for salmon spawning, and provides good rearing conditions for juvenile salmon.

> Opportunities to increase fall-run chinook salmon escapements in the Cosumnes River are limited. The river has supported an average annual run of about 1,000 chinook.

Adult fall-run salmon must await the runoff following rains in late October and November to ascend to the spawning areas between Michigan Bar and Sloughhouse. The flow regime is the primary factor affecting the size of the salmon run. The early portion of the run experiences considerable difficulty in negotiating the shallow bar and shoal areas in most years. At times, adult salmon become stranded by receding flows following a freshet and perish before spawning. During average water years, spring flows are usually adequate for the emigration of young salmon. Much of the river is dry during the summer and early fall months.

There is one diversion dam (Granlees Diversion Dam) on the river, located approximately one mile upstream from the Highway 16 crossing. This dam has two functional fishways and the diversion canal was originally screened. It is not known if the screen remains functional.

Opportunities to increase fall-run chinook salmon habitat on the Cosumnes River are limited. At present, the major limiting factor is low or non-existent flows in the lower reaches during the early spawning migration period. In years when the fall rains are late, salmon are not able to ascend the Cosumnes River.

Priority Ranking and Cost of Implementation

Recommendation for evaluation of anadromous fish habitat in the Cosumnes River:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
C-2	Determine adequacy of fish screen at Granlees Diversion Dam.	$15,000

MOKELUMNE RIVER

The Mokelumne River drains approximately 661 square miles, with its headwaters at 10,000 feet on the crest of the Sierra Nevada mountains (Figure VII-7). It is a major tributary to the Delta, entering the lower San Joaquin River northwest of Stockton.

Four species of anadromous fishes are present in the lower Mokelumne River: fall-run chinook salmon, steelhead trout, American shad, and striped bass. Fall-run chinook salmon are the most abundant and important anadromous fish in the lower Mokelumne River.

> **Mokelumne River salmon and steelhead populations have failed to consistently achieve population levels believed possible following the completion of Camanche Dam.**

Condition of the aquatic habitat and variation in environmental conditions in the lower Mokelumne River have resulted in widely varying population levels of these species. Prior to the completion of Camanche Dam in 1964, salmon spawned primarily between Clements and the canyon about three miles below Pardee Dam, with a few fish spawning upstream in the canyon below Pardee Dam and downstream between Clements and Lockeford. An undetermined number of salmon spawned in the river above Pardee Dam prior to its construction. In 1959, DFG determined the Mokelumne River downstream from Pardee Reservoir was capable of sustaining an annual run of 15,000 adult chinook salmon and 2,000 adult steelhead trout, and under conditions of satisfactory water quality and flow, existing spawning beds could easily accommodate 60,000 chinook salmon.

As mitigation for the loss of spawning habitat between Camanche Dam and Pardee Dam, a hatchery capable of processing 10,000 adult chinook salmon and 2,000 steelhead trout was recommended. The river below the hatchery could be expected to provide habitat for 5,000 chinook salmon, while the hatchery would produce the entire run of steelhead trout. In 1961, DFG and East Bay Municipal Utility District (EBMUD) signed a mitigation agreement for the Camanche Dam project that provided for the Mokelumne River Fish Hatchery (MRFH) with full capacity to produce 100,000 yearling steelhead trout and to process 15,000,000 chinook salmon eggs per year.

During 1964-1988, the MRFH has received an average annual return of only 490 adults (range: 0 to 1,782) and 28 adult steelhead trout (range: 0 to 215). Total chinook salmon run sizes in the Mokelumne River varied over the period of record (1940-1990) from 100 to 15,900 fish.

Presently, the majority of salmon spawning takes place in the five miles between Camanche Dam and Mackville Road, with 95% of the suitable habitat within 3.5 miles of Camanche Dam. During and following the spawning season of 1986, spawning salmon were observed one to two miles downstream of Mackville Road, indicating that available spawning habitat extends to seven miles below Camanche Dam.

For the 19-year period prior to the impoundment of Camanche Reservoir (1940 to 1942, 1945, and 1948 to 1963), the salmon run averaged 3,300 spawners, and for the 27-year post-impoundment period (1964 to 1990), the run averaged 3,200 spawners.

Prior to completion of Camanche Reservoir, steelhead trout was the most important fish in the lower Mokelumne River based on creel census data. The present natural production of steelhead in the Mokelumne River is thought to be very low. DFG estimates that the runs are probably less than 200 fish per year. Steelhead eggs or fry are transferred from hatcheries located on the Feather or American rivers, reared at the MRFH to 10-16 inches, and planted in the river below the MRFH as "catchable" steelhead. Efforts to establish a naturally spawning run of steelhead have been unsuccessful.

The Mokelumne River has had a long history of water development. Existing developments on the Mokelumne River upstream of Camanche Reservoir include facilities for hydroelectric, irrigation, and municipal use. Downstream of Camanche Reservoir, developments include both hydroelectric and irrigation facilities. Since the turn of the century, increasing demand for the river's water supply has resulted in decreased water downstream of Camanche Reservoir to maintain the river's anadromous fish, particularly chinook salmon and steelhead trout. Habitat degradation has occurred through the modification of the timing of natural flows, reduction of flows during critical periods, and alteration of spring, summer, and fall stream temperatures. These factors affect salmon, steelhead, and American shad attraction, passage, spawning, growth, and emigration.

Mokelumne River salmon and steelhead populations have failed to consistently achieve population levels believed possible following the completion of Camanche Dam in 1963. American shad are nearly non-existent. The operation of the East Bay Municipal Utility District (EBMUD) Delta diversion at Bixler could provide increased flows and adequate water temperatures.

The Woodbridge Irrigation District diversion at Woodbridge Canal allows losses of juvenile chinook salmon and steelhead trout as the screen does not meet present DFG criteria for approach velocity and mesh size. The existing screen should be upgraded.

North San Joaquin Water Conservation District is the second largest single diversion existing below Camanche Dam with a maximum entitlement of 20,000 AF annually. This diversion is unscreened. The diversion should be screened to meet present DFG criteria.

Numerous small irrigation diversions occur on the lower Mokelumne River. Entrainment losses of juvenile salmon at these diversions may be cumulatively significant. The fish screening needs at these sites should be evaluated and appropriate screens installed.

Adult fish passage over Woodbridge Dam is best achieved through the existing fishways but access is obscure and hazardous due to the poor attraction flows, channel, and pool. The following corrective measures should be implemented: (a) attraction flows should be improved both within the fishway and across the dam face leading to the fishway entrance pool; (b) a training fence should be placed downstream from the dam to guide fish toward the fishway entrance pool and to prevent them from reaching the face of the dam; (c) access from the river to the fishway entrance pool should be deepened, (d) an additional suitable fishway should be constructed at the east abutment of the dam; and (e) flows within fishways should be maintained at design capacity.

Recruitment of suitable spawning gravel below Camanche Dam is minimal. Camanche Dam blocks the movement of gravel from upstream sources and immediately below the dam there is no source of replacement gravel. Most gravel present is in the small range of the preferred sizes used by spawning chinook salmon. Thus, spawning habitat improvement projects are needed to optimize habitat for spawning chinook salmon and steelhead trout. Spawning habitat for salmonids should be maintained through conditions that prevent sedimentation and armoring of gravel. It is estimated that approximately 22,727 cubic yards of gravel should be added to the river to improve spawning habitat.

Gravel extraction within the Mokelumne River floodplain should be restricted to skimming type operations that only remove materials not suitable as substrate for spawning chinook salmon and steelhead. Excavations within the thalweg should be allowed only behind levees capable of protecting the work area from a 100-year flood event. No activities should be allowed which could result in adverse changes in channel location or stability.

Riparian vegetation along the lower Mokelumne River is valuable as it provides food (terrestrial insects) for juvenile salmon and steelhead, nutrient input to the river system, shade to reduce water temperatures, and is used by many wildlife species. Programs for restoration, improvement, and acquisition of riparian habitat should be implemented.

TABLE VII-12. Instream Flows and Stream Temperatures Needed in the Lower Mokelumne River.

Period	Minimum streamflow (cfs) at:		Mean daily temperature (°F) at:		
	Hwy. 99	Woodbridge	Elliott Rd.	Cosumnes River	Hwy. 99
Normal water years:					
Oct 15 - Feb. 29	300*	300	56		
Mar 1 - Mar 31	350	350	56		
Apr 1 - Apr 30	400+	400		60	
May 1 - May 31	450	450		60	
June 1 - June 30	400	400			65
July 1 - July 31	150	150			65
Aug 1 - Sept 30	100	100			65
Oct 1 - Oct 14	250	250			65
Dry years:					
Nov 1 - Mar 31	200	200	56		
Apr 1 - Apr 14	200	200		65	
Apr 15 - Apr 30	250	250		65	
May 1 - May 31	300	300		65	
June 1 - Sept 30	200	20			65
Oct 1 - Oct 31	100	20			65
Wet years:					
Oct 15 - Feb 29	350	350	56		
Mar 1 - Mar 31	400	400	56		
Apr 1 - May 31	450	450		60	
June 1 - Oct 14	300	300			65

* Attraction flow in addition 10/1 - 11/15 to be 20,000 AF below Camanche Dam and Woodbridge Dam during wet and normal water years, 10,000 AF during dry years.

\+ Emigration flow in addition 4/1 - 6/30 to be 10,000 AF below Camanche Dam and Woodbridge Dam during wet and normal water years and 5,000 AF during dry water years.

Improved flow conditions in the lower Mokelumne River are needed to restore salmon, steelhead trout, and American shad habitat (Table VII-12). Attraction flows in addition to the minimum proposed flow schedule necessary to induce chinook salmon and steelhead trout into the lower Mokelumne River should be provided below Camanche Dam and Woodbridge Dam during the period October 1 through November 15 in the amount of 20,000 AF during wet and normal years and 10,000 AF during dry years. A dry year is defined as less than 50% of the 50-year average unimpaired runoff of the Mokelumne River in AF at Pardee Reservoir for the present water year as published annually in the May 1 Report of Conditions in California (Bulletin 120 Series) by DWR. A wet year is defined as estimated unimpaired runoff greater than 110% of the 50-year average unimpaired runoff at Pardee Reservoir. Results of future studies should be used to refine the timing, magnitude, and duration of the attraction flow and the benefits of coordinating the release with lowering of Woodbridge Dam.

Increased spring flows of short duration during April through June should be provided to increase survival of young chinook salmon and steelhead trout during downstream migration, with 10,000 AF set aside for this purpose during wet and normal water years and 5,000 AF during dry water years. Results of future studies should be used to refine the timing, magnitude, and duration of the spring flow. These flows should be coordinated with other similar releases and limits on water exports.

Restoration of the lower Mokelumne River through implementation of these recommendations has the potential to increase populations of fall- and spring-run chinook salmon, steelhead trout, and American shad. It is anticipated that implementation of the restoration actions will result in escapement to the Mokelumne River of 15,000 adult chinook salmon and 2,000 adult steelhead spawners annually during normal water years. This can to be achieved through 5,000 adult chinook salmon spawners to the river as natural reproducing stocks, and 10,000 chinook and 2,000 steelhead to the Mokelumne River Fish Hatchery.

Priority Ranking and Cost of Implementation

Recommendations to improve anadromous fish habitat in the Mokelumne River:

Priority	Anadromous Fish Habitat Restoration Action	Cost
B-1	Upgrade existing fish screens at Woodbridge Irrigation District diversion.	$2,000,000
B-1	Improve upstream fish passage at Woodbridge Irrigation District Dam.	$100,000 to $700,000
B-1	Install fish screens at North San Joaquin Water Conservation District diversions (north and south).	$300,000
B-1	Improve spawning habitat but placement of approximately 23,000 cubic yards of gravel.	$500,000

Recommendations for administrative actions to improve anadromous fish habitat in the Mokelumne River:

Priority	Administrative Action to Improve Anadromous Fish Habitat	Agency
B-1	Require provision of the following total annual instream flow releases (AF): Water Year Type — Total Release (AF) Wet water year - 284,628 Normal water year - 236,217 Dry water year - 161,124.	SWRCB FERC
B-1	Establish water quality objectives for the protection of spawning, rearing, and emigration.	SWRCB
B-2	Restrict gravel extraction activities within the floodplain.	County

Recommendation for evaluation of anadromous fish habitat on the Mokelumne River:

Priority	Evaluation Action to Determine Habitat Needs for Anadromous Fish	Cost
B-1	Evaluate screening needs at small riparian diversions.	$15,000

Riparian Habitat Action Plan

Riparian lands suitable for maintenance and restoration should be acquired by fee purchase, easement, or deed restriction throughout the Central Valley. All state lands should be examined and existing or potential riparian habitats enhanced and permanently preserved. Federal and local agencies should be strongly encouraged to retain or acquire riparian lands for permanent preservation.

Acquisition programs for protection or regeneration of riparian lands should focus on developing corridors to link existing valley riparian tracts. Accelerated regeneration of riparian plant communities should be undertaken on public lands under long-term lease to establish corridors following streams and wetlands to link riparian plant communities. Where corridors already provide sufficient continuity, regeneration on acquired or set-aside lands should be allowed to occur through natural successional processes to maximize the variety of ecological niches.

Riparian systems will naturally regenerate wherever suitable environmental conditions exist. Regeneration can be artificially accelerated by enhancing conditions for pioneer plants and rapid succession or by planting and cultivating cover vegetation and climax species. Development of a simple functioning riparian woodland system requires a minimum of 25-30 years but some systems restarted in about 1973 along the Sacramento River already have the general appearance of a mature woodland. Fire can set back succession at any time and has been a frequent invited, or uninvited, visitor to riparian stands throughout the Valley.

Specific actions recommended for immediate implementation to protect and restore riparian habitat include:

1. Examine all State-owned Central Valley lands and establish riparian areas for permanent restoration and preservation by the Department of Fish and Game for fish and wildlife.

2. Allocate surface and ground water for restoration and maintenance of key riparian tracts and corridors.

3. By Executive Order establish preservation and restoration of riparian wildland communities as a high priority for all State agencies.