Merced River Corridor Restoration Plan

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Tom Dudley

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Forward

This Restoration Plan represents a multi-year collaboration among a broad spectrum of participants. The plan was developed through a joint project led by the Merced County Planning and Community Development Department and Stillwater Sciences, working closely with the California Department of Fish and Game, California Department of Water Resources, Merced Irrigation District, and the Merced River Stakeholder Group and Technical Advisory Committee (Figure 1). The project was implemented in three phases (Figure 2). In Phase I, which was funded by the Central Valley Project Improvement Act-Anadromous Fish Restoration Program, the Merced River Stakeholder Group and Merced River Technical Advisory Committee were established. In Phase II, which was funded by CALFED, Stillwater Sciences conducted baseline geomorphic and ecological studies and evaluated social, infrastructural, and institutional issues and concerns that define opportunities and constraints for restoration in the Merced River corridor. In Phase III, which was also funded by CALFED, Stillwater Sciences completed field and modeling efforts and developed design guidelines for channel and floodplain restoration. The Restoration Plan was developed in Phase III by the Project Team, Stakeholder Group, and Technical Advisory Committee.

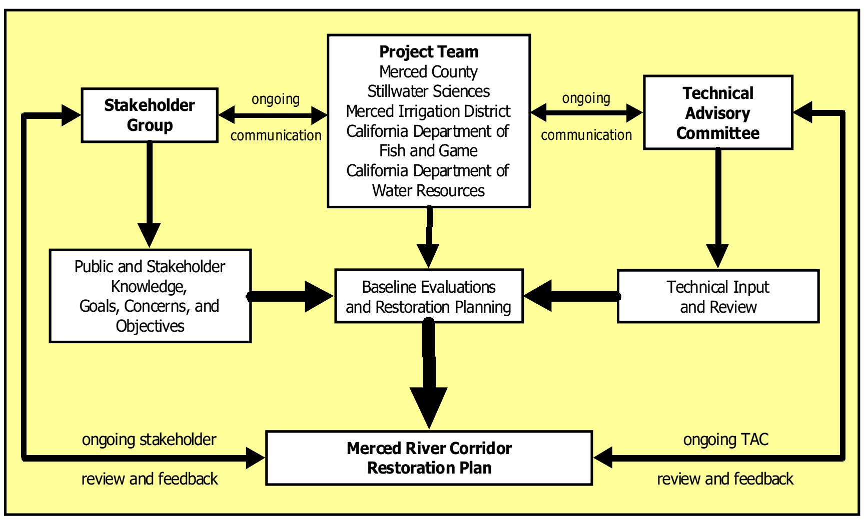


Figure 1. Merced River corridor restoration plan participants and roles.

The formation of the Stakeholder Group and Technical Advisory Committee was critical to the planning process. The Stakeholder Group was formed to provide

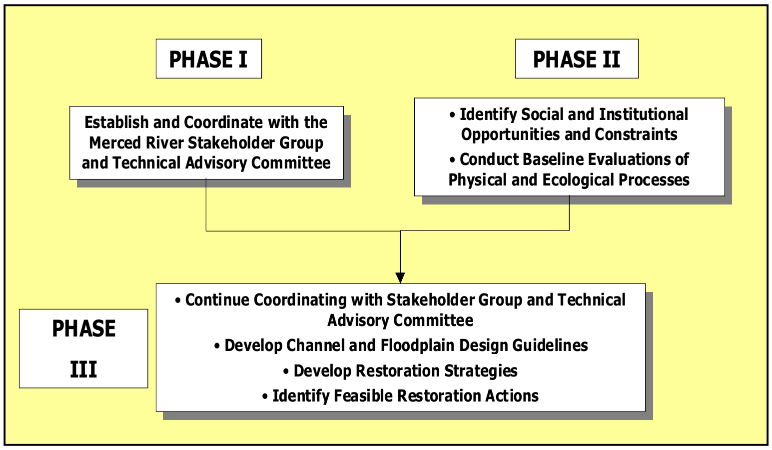


Figure 2. Merced River project phases.

public input to and local leadership of the Plan. This group represents a broad spectrum of interests in the watershed, including landowners, riparian water users, aggregate miners, dairy operators, ranchers, farmers, environmental groups, angling groups, and local, state, and federal management and regulatory agencies. The group met more than 20 times over a three-year period to provide input to baseline studies, define restoration goals and objectives, develop restoration strategies, and identify specific restoration actions. Attendance at Stakeholder Group meetings has varied throughout the planning process. A list of many of the Stakeholder Group participants is provided at the end of this chapter. The Technical Advisory Committee was formed to provide technical review and oversight of the Restoration Plan and studies conducted for the planning process. Technical Advisory Committee participants include agency and industry representatives with management or regulatory interests in the river, as well as landowners and riparian water user representatives. The committee met seven times during the planning process and reviewed and commented on all technical documents completed for the project. Participation in the Technical Advisory Committee varied during the planning process. Individuals and agencies who participated in the Technical Advisory Committee are listed at the end of this chapter. While the Stakeholder Group and Technical Advisory Committee were formed specifically to participate in the planning phase of the Restoration Plan, they will continue to provide support and leadership during long-term restoration implementation and to provide locally based stewardship of the river.

In addition to regular meetings with the Stakeholder Group and Technical Advisory Committee, five public workshops were conducted to obtain broader public input to the Restoration Plan. Project kick-off meetings were held in December 1998 and March 1999. In December 2000, a public workshop was held to present the findings of baseline studies and provide an opportunity for public input to the restoration goals and objectives that were drafted by the Stakeholder Group and Technical Advisory Committee.

Merced River Stakeholder Group Participants and Associations:

Robert Acker (Merced Irrigation District), **Glen Anderson** (property owner and East Merced Resource Conservation District), **Mike Bettencourt** (property owner and aggregate mining), **Gladys Bettencourt** (property owner and aggregate mining), **Cesar Blanco** (U.S. Fish and Wildlife Service), **Maurice Brindeiro** (property owner and dairies), **Kevin Collins** (property owner), **Robert Edminster** (local botanist), **Pat Ferrigno** (property owner and aggregate mining), **Kim Fry** (local biologist), **Art Hardin** (property owner, riparian water rights, aggregate mining), **John Hardin** (property owner and aggregate mining), **Terry Howard** (aggregate mining), **Gwen Huff** (Community Alliance of Family Farms), **Ken Jensen** (Merced Flyfishing Club), **Deidre Kelsey** (Merced County Supervisor and property owner), **Jon Kelsey** (property owner and aggregate mining), **Michelle Langmaid** (aggregate mining), **Cindy Lashbrook** (property owner and agriculture), **Rich Lundin** (aggregate mining), **Randy Mager** (California Department of Water Resources), **Charles Magneson** (property owner and Sierra Club), **Sally Magneson** (property owner and Sierra Club), **Madelyn Martinez** (National Marine Fisheries Service), **Jeff McLain** (U.S. Fish and Wildlife Service), **Michael Mendes** (property owner and dairies), **Joe Mendes** (property owner and dairies), **Jack Mendes** (property owner and dairies), **Lydia Miller** (San Joaquin Raptor Rescue Center and San Joaquin Valley Conservancy), **Joe Mitchell** (property owner), **Chuck Morgan** (Merced County Parks Department), **Ed Murrison** (property owner and Calaveras Trout Farm), **Martha Murrison** (property owner), **Teri Murrison** (East Merced Resource Conservation District), **Bill Nicholson** (Merced County Planning and Community Development Department), **Malia Ortiz** (Natural Resource Conservation Service), **Lloyd Pareira Jr.** (property owner and riparian water rights), **Marsh Pitman** (Sierra Club), **Jill Ratzlaff** (property owner), **Esther Ratzlaff** (property owner), **Rhonda Reed** (California Department of Fish and Game), **Tom Reta** (City of Merced engineer), **Jerry Ripperda** (California Department of Water Resources), **Audrey Robinson** (property owner), **Chris Robinson** (property owner), **Don Robinson** (property owner), **Ezio Sansoni** (property owner and chair of Merced ID Foundation), **Ted Selb** (Merced Irrigation District), **Abigail Smith** (Regional Water Quality Control Board), **Chris Stokes** (California Department of Parks and Recreation), **Steve Stroud** (City of Merced), **Jeff Stuart** (National Marine Fisheries Service), **Henry teVelde** (property owner and dairies), **Jack Uren** (angling and recreation), **Ray Veldhuis** (property owner and dairies), **Ray Gene Veldhuis** (property owner and dairies), **Owen Vowel** (property owner), **Bernard Wade** (property owner and aggregate mining), **Cathy Weber** (property owner), **Scott Wickstrom** (property owner).

Merced River Technical Advisory Committee Participants and Associations:

Brian Beal (California Department of Fish and Game), **Cesar Blanco** (U.S. Fish and Wildlife Service), **Pam Buford** (Regional Water Quality Control Board), **Robert Edminster** (local botanist), **David Encinas** (California Department of Water Resources), **Art Hardin** (property owner, riparian water rights, aggregate mining), **Tim Heyne** (California Department of Fish and Game), **Ken Johnson** (California Department of Fish and Game), **Michelle Langmaid** (aggregate mining), **Randy Mager** (California Department of Water Resources), **Madelyn Martinez** (National Marine Fisheries Service), **Jeff McLain** (U.S. Fish and Wildlife Service), **Lydia Miller** (San Joaquin Raptor Rescue Center and San Joaquin Valley Conservancy), **Teri Murrison** (East Merced Resource Conservation District), **Steve Ng** (CalTrans), **Bill Nicholson** (Merced County Planning and Community Development Department), **Rhonda Reed** (California Department of Fish and Game), **Tom Reta** (City of Merced engineer), **Jerry Ripperda** (California Department of Water Resources), **Ted Selb** (Merced Irrigation District), **Abigail Smith** (Central Valley Regional Water Quality Control Board), **David Tucker** (City of Merced).

Chapter 1
Introduction

Chapter I
Introduction

1.1 Geographic Setting

The Merced River is a tributary to the San Joaquin River in the southern portion of California's Central Valley (Figure 1-1). The river, which drains a 1,276-square-mile watershed, originates in Yosemite National Park and flows southwest through the Sierra Nevada range before joining the San Joaquin River 87 miles south of the City of Sacramento (Figure 1-2). Elevations in the watershed range from 13,000 feet at its crest to 49 feet at the confluence with the San Joaquin River.

1.2 Scope of the Restoration Plan

The restoration planning process was designed to provide a technically sound, publicly supported, and implementable plan to improve geomorphic and ecological functions in the Merced River corridor from Crocker-Huffman Dam to the confluence with the San Joaquin River (Figure 1-2). The Merced River has been affected by a range of human interventions, including water storage and diversion, land use conversion, introduction of exotic plant and animal species, gold and aggregate mining, and bank protec-

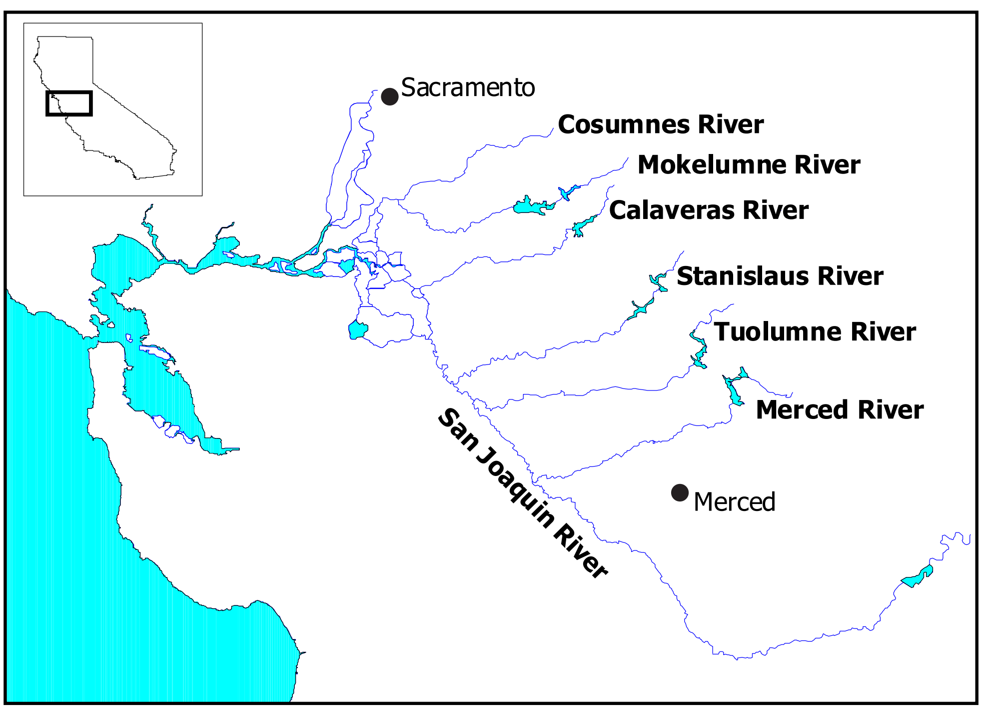


Figure 1-1. The vicinity of the Merced River.

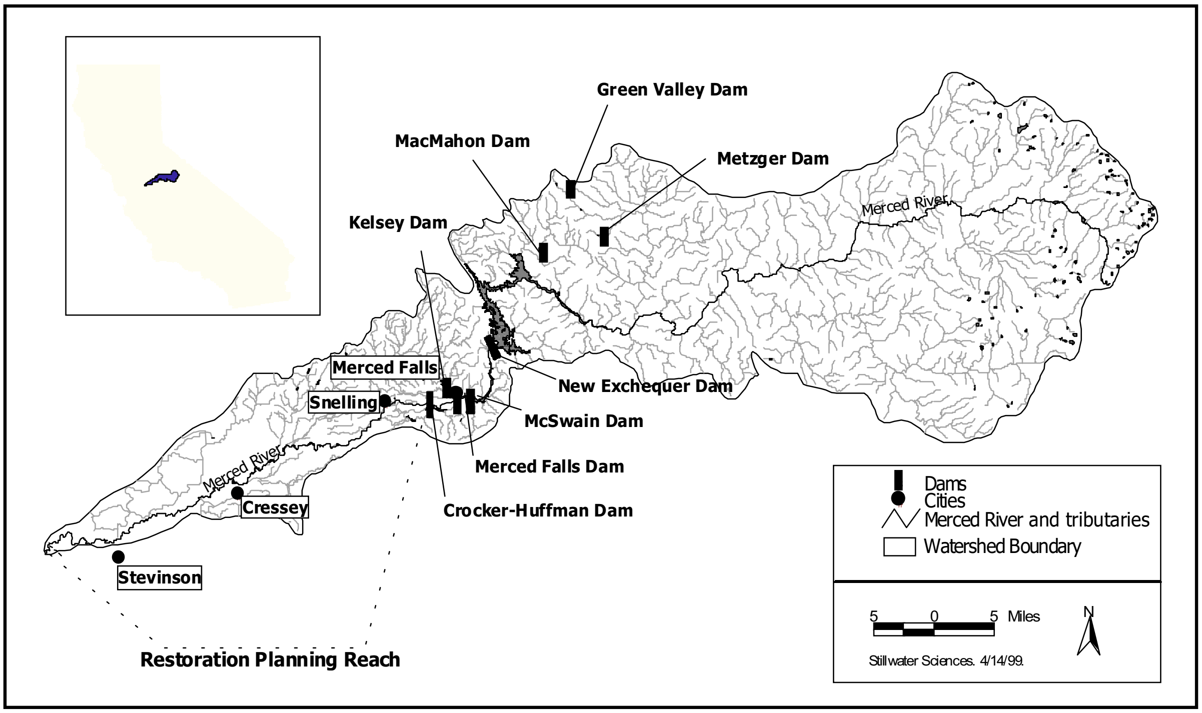


Figure 1-2. The Merced River watershed and planning reach.

tion. Many of these interventions, however, are vital for sustaining local agriculture and the local economy. In addition, the Merced River corridor is almost completely privately owned. Developing an implementable plan, therefore, requires understanding and embracing the needs and concerns of local landowners, water users, and industry, and identifying effective restoration actions that can be implemented within the constraints of the contemporary landscape.

Although the term "restoration" is used throughout this document, completely restoring the Merced River to pre-colonial conditions is not possible and, for many reasons, is not desirable. This Restoration Plan will guide efforts to rehabilitate river function to the fullest extent possible within current and foreseeable land use, water supply, and other constraints in the river corridor. As such, the actions identified in this plan are intended to function within the current water development, land use, and land ownership framework of the river corridor.

1.3 Related Projects

Several restoration projects are currently being implemented or planned that share the Restoration Plan's goal of restoring or rehabilitating ecosystem processes in the Merced River. These projects relate directly to the efforts of this Restoration Plan and are key components in developing a comprehensive vision for restoring the functions in the river. The locations of recently completed, on-going, and planned projects are shown in Figure 1-3. These projects are described in more detail below.

Merced River Salmon Habitat Enhancement Project

The Merced River Salmon Habitat Enhancement Project is being implemented by California Department of Fish and Game (CDFG) working with California Department of Water Resources (CDWR). This project will reconstruct the river channel

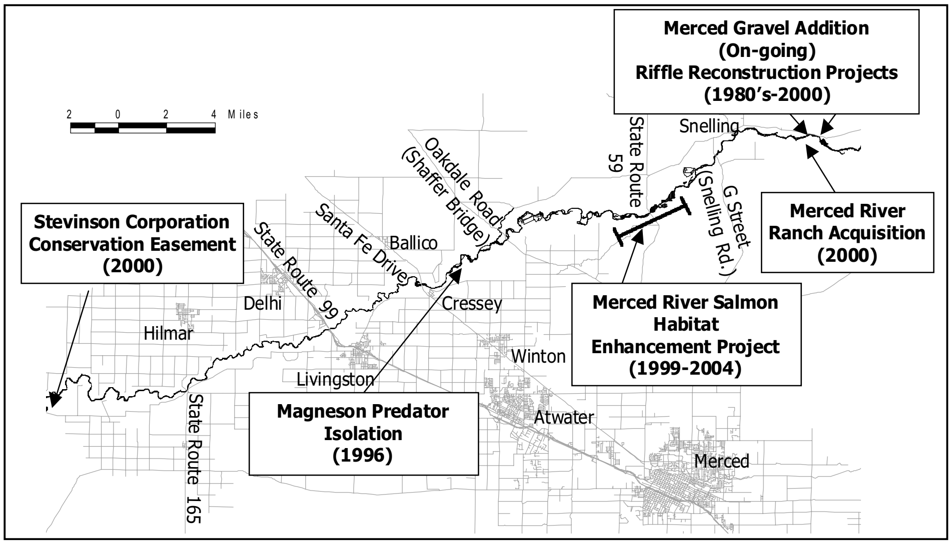


Figure 1-3. Restoration project sites on the Merced River.

and floodplain through 4.3 miles of the Merced River that have been excavated for aggregate mining. The objectives of the project are to: (1) reduce predation on young salmon by non-native fish by isolating habitat in river-captured mining pits that serve as predator habitat, (2) restore or enhance salmon spawning habitat, (3) enhance passage of adult and juvenile salmon, (4) resize the channel and floodplain to restore some natural river processes, and (5) reestablish riparian vegetation. The project is being implemented in four phases. Phase I, the Ratzlaff Reach (River Mile[1] [RM] 40.0–RM 40.5), was constructed in 1999 with funding from the Delta Pumping Plant Fish Protection Agreement (Four Pumps Agreement), Proposition 70, CALFED, and the Central Valley Project Improvement Act-Anadromous Fish Restoration Program (Figure 1-4). Phase II, the Robinson Reach (RM 42.0–RM 44.0), began construction in 2001 and will be completed in 2002. This phase, which is being implemented in cooperation with the Robinson Cattle Company, will include reconstruction of two miles of channel and floodplain (Figure 1-5). This project was also funded by the Four Pumps Agreement, Proposition 70, CALFED, California Wildlife Conservation Board, CDWR's Integrated Storage Investigations, Tracy Fish Agreement, Robinson Cattle Company, and the Central Valley Project Improvement Act-Anadromous Fish Restoration Program.

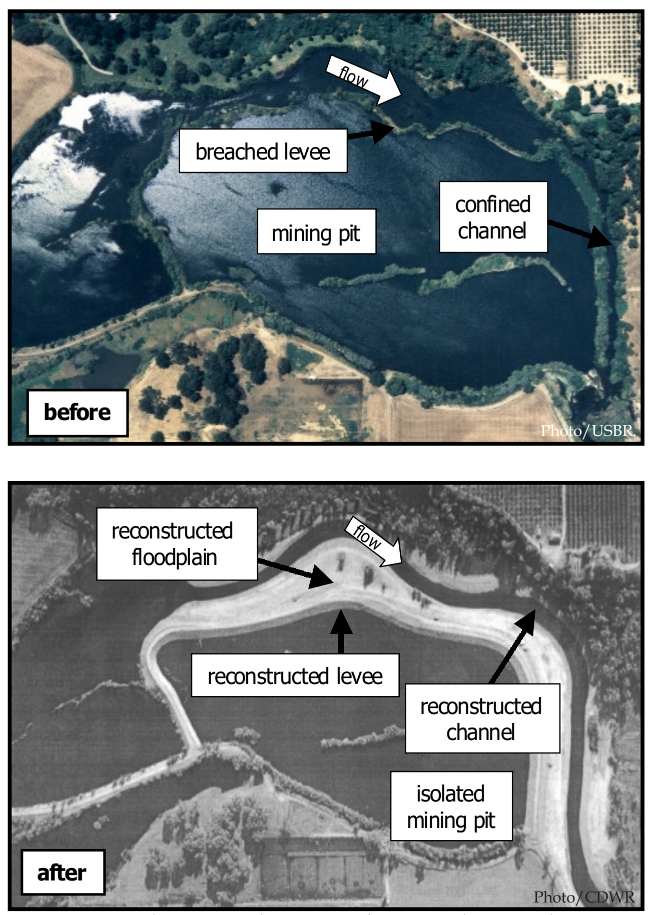


Figure 1-4. The Merced River Salmon Habitat Enhancement Project, Ratzlaff Reach.

[1] River miles represent the distance along the river channel upstream from the San Joaquin River.

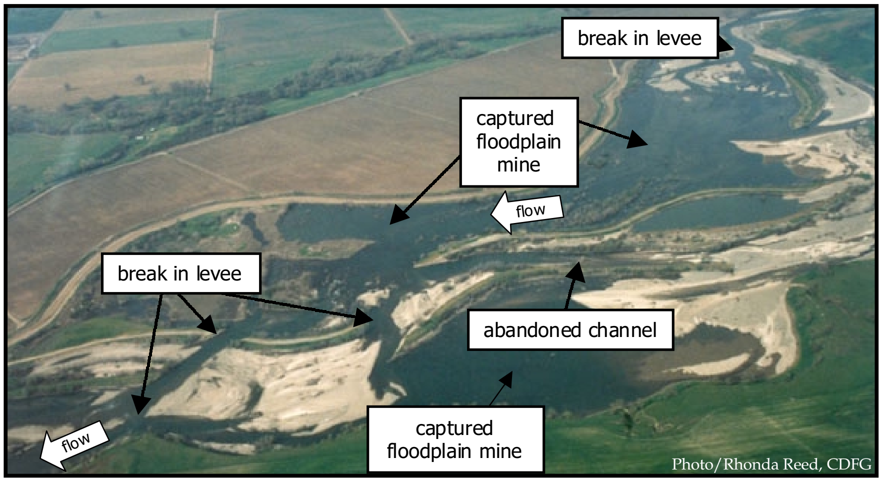


Figure 1-5. The Merced River Salmon Habitat Enhancement Project, Robinson Reach.

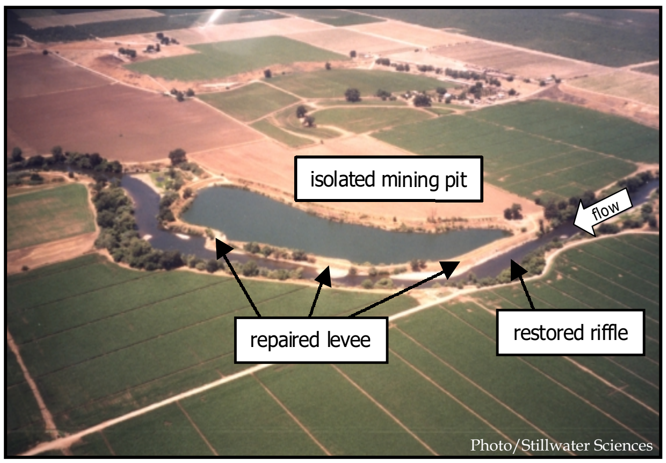


Figure 1-6. The Magneson Predator Isolation Project.

Magneson Predator Isolation Project

In 1996, CDFG, working with CDWR and with funding from the Four Pumps Agreement, completed the Magneson Predator Isolation and Revegetation Project (Figure 1-6). This project reconstructed a levee around a captured gravel mining pit. The primary objective of the project was to isolate the mining pit from the active channel and thus protect young salmon in the river from non-native predatory fishes in the pond.

Chinook Salmon Spawning Gravel Augmentation

CDFG and CDWR have implemented several projects to add gravel suitable for fall chinook salmon spawning to the river. In the 1980s, CDFG added gravel to a small riffle at the Merced River Hatchery, referred to as "Maury's Riffle." In 1990, CDFG, working with CDWR and with funding from the Four Pumps Agreement, reconstructed a spawning riffle at the Merced River Hatchery (Riffle 1A) and added gravel to a depleted riffle two miles downstream. Since completion of the Riffle 1A project, gravel has been added to the site for maintenance. Maintenance gravel was added in 1996, 1997, 1998, and 2000.

In addition to these riffle projects, CDFG is currently working with riparian water diverters to introduce spawning gravel at several riparian diversion dams in the river. At these locations, the riparian diverters construct temporary gravel wing dams in the river to divert flow into irrigation channels. In the past, these dams have typically been built from gravel scraped from the channel bed. In 1998, CDFG, with funding from Proposition 70, provided gravel suitable for chinook salmon spawning to construct the dams. When these dams wash out during high flows, the gravel is expected to become available for chinook salmon spawning. In 2001, Merced Irrigation District (Merced ID), with funding from AFRP, monitored gravel movement from traditionally constructed wing dams using both tracer gravel and radio tagged gravel. In 2002, CDFG, with funding through the Four Pumps Agreement, will again provide gravel to riparian diverters, and Merced ID will monitor changes that occur in gravel movement when gravel is added to the wing dams.

Property Acquisition

In 1998, CDFG obtained funding from CALFED to purchase the Merced River Ranch, a 318-acre parcel located on the south bank of the river approximately one mile downstream of Crocker-Huffman Dam (Figure 1-7). This property was dredged for gold and is covered with dredger tailings. CDFG plans to use the site as a source of sand, gravel, and cobble for future restoration projects and as a floodplain habitat restoration site.

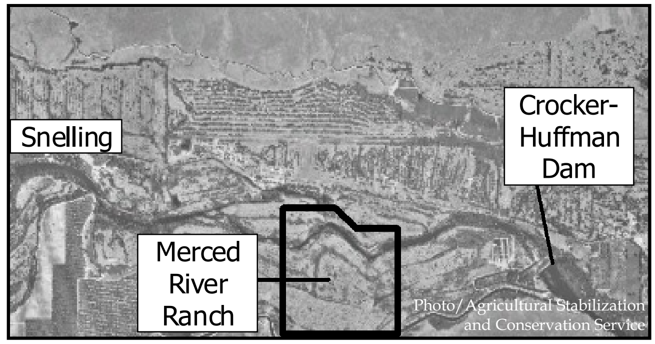


Figure 1-7. Location of the Merced River Ranch.

Stevinson Corporation Conservation Easements

The James J. Stevinson Corporation is in the process of placing conservation easements on nearly 9,000 acres of its landholdings at the confluence of the Merced and San Joaquin rivers in Merced and Stanislaus counties. The Stevinson Corporation landholdings proposed for conservation easements include approximately five miles of riparian habitat along the Merced River. This easement will protect 2,931 acres of riparian habitat and floodplain, which comprise the largest remaining patches of riparian forest along the Merced River. In addition, the easement lands are adjacent to and will serve to expand the San Luis National Wildlife Refuge and the North Grasslands State Wildlife Area (Figure 1-8). By placing the land under easement, the Stevinson Corporation will retain rights to riparian and delivered water, create opportunities for habitat enhancement, and be eligible for tax benefits (Riviere 2000).

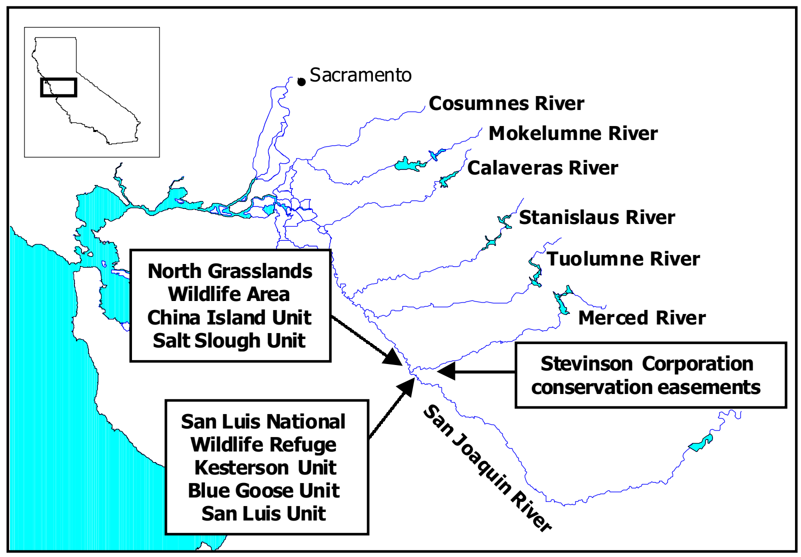


Figure 1-8. Wildlife refuges near the Merced River.

CDFG and Merced Irrigation District Fish Studies

Baseline studies of aquatic species, including salmon and steelhead, were not conducted during Phase II of the restoration planning process because these studies are either being conducted by CDFG or are being developed and will be implemented by Merced ID and CDFG. Since the 1940s, CDFG has conducted escapement surveys to document the number and timing of adult chinook salmon returning to the Merced River to spawn. Since 1998, CDFG, with funding from the Central Valley Project Improvement Act-Comprehensive Monitoring and Assessment Program, also operated a rotary screw trap near the mouth of the river to document juvenile salmon outmigration and abundance.

During the past several years, representatives of Merced ID and CDFG have regularly consulted on potential actions to benefit fall chinook salmon in the Merced River. These consultations have focused on: (1) providing appropriate instream flows for salmon upstream migration, spawning, and egg incubation during the fall; (2) providing interim instream flow improvements for juvenile outmigration; and (3) completing studies on all freshwater salmon life phases, including improved water temperature management for aquatic resources in the lower Merced River.

Merced ID and CDFG have agreed, pending execution of a Memorandum of Understanding between the two agencies, upon an increase in flows during October to benefit chinook salmon upstream migration and spawning. The parties have also agreed, dependent on various factors, upon additional increases in instream flows, above the new minimum flows, during October on an interim and experimental basis to determine potential benefits for salmon. It is expected that these increased instream flows will benefit salmon in the lower Merced River by providing improved habitats for migration and spawning. Merced ID and CDFG have also agreed on interim increased flows during a 30-day period in April and May, in association with the Vernalis Adaptive Management Plan. This action is expected to benefit the downstream migration of juvenile salmon from the Merced River through improved habitat conditions and increased survival.

Merced ID and CDFG jointly developed and agreed upon a formal 10-year study program to determine the potential factors that may limit salmon production in the Merced River. This program is designed to evaluate the habitats necessary for increased salmon production by assessing the needs of each freshwater salmon life stage (i.e., upstream migration, spawning, egg incubation, fry and juvenile rearing, and outmigration). The joint study program defines the objectives, the basic experimental design, and the responsibilities for study implementation. The studies and instream flow scheduling will be coordinated with other studies throughout the San Joaquin Basin and the Delta. Components of this program are presently underway. The completion of the 10-year program is intended to identify the long-term instream flow and other needs of salmon in the Merced River.

Chapter 2
Goals, Principles, and Objectives of the Restoration Plan

Chapter 2

Goals, Principles, and Objectives of the Restoration Plan

The overarching goal, guiding principles, and objectives of the Restoration Plan were developed by the Project Team, the Merced River Stakeholder Group, and the Merced River Technical Advisory Committee based on the results of baseline studies and stakeholder concerns and were presented to a broader audience for their input at a public workshop in December 2000. Baseline studies conducted during the restoration planning process identified social, institutional, and infrastructural opportunities and constraints to restoration in the river corridor (Stillwater Sciences and EDAW 2001) and investigated geomorphic and riparian vegetation processes in the river (Stillwater Sciences 2001a, 2001b). Baseline studies of aquatic species, including salmon and steelhead, were not conducted during Phase II of the restoration planning process. Some biological studies are being conducted by CDFG. Additional studies are being developed and will be implemented by Merced ID and CDFG, as discussed in Section 1.3. Since the goals, principles, and objectives were agreed upon by a broad spectrum of interests represented by the Merced River Stakeholder Group, Technical Advisory Committee, and the broader public, they address not only geomorphic and ecological restoration in the river but also the concerns of local citizens, landowners, and other stakeholders. This inclusion of local citizen and landowner interests will help to ensure that projects developed within these goals and objectives will be widely supported and implementable.

2.1 Overarching Goal

The overarching goal of the Restoration Plan is to improve, to the extent feasible, ecological conditions in the Merced River to benefit native fish and wildlife and recognize, protect, and address the concerns and rights of property owners and other stakeholders. Based on our current understanding of the Merced River, improving ecological conditions will require the following:

- balancing sediment supply with sediment transport competence and capacity;
- reconnecting the river to its floodplain;
- increasing opportunity for channel migration;
- increasing the extent and connectivity of riparian habitat patches; and
- providing conditions suitable for recruitment of native riparian plant species.

These basic concepts are discussed in more detail in Section 3.1.

2.2 Guiding Principles

Because the majority of the corridor is privately owned, comprehensive restoration of the river and floodplain will require implementing actions on private property. The guiding principles were developed to provide guidelines against which to judge the appropriateness of restoration actions to ensure that property owner rights are duly reflected, while the overarching goal is addressed. These guiding principles are that the Restoration Plan will:

- be based on the principles of ecosystem management and will address ecosystem structure and processes within an adaptive management framework;
- be based on voluntary participation of stakeholders and landowners;
- recognize, respect, and work within the bounds of private property and water rights; and
- recognize, respect, and work within local concerns such as flood control, bank erosion, and trespassing.

2.3 Objectives

The objectives developed by the Project Team, Stakeholder Group, Technical Advisory Committee, and public are listed below. In addition to these general objectives, reach-specific restoration issues, objectives, and strategies are discussed in Chapter 4. Together, the general and reach-specific objectives served to guide the development of recommended restoration actions presented in Chapter 6. The order of these objectives does not reflect their priority.

Geomorphic conditions, riparian and aquatic habitat, and water quality

- In spawning reaches, improve sediment supply and channel conditions to improve habitat for salmon and other native aquatic species.
- Identify probable sediment augmentation sites and sediment supplies for restoration, consistent with the overarching goals of the Plan.
- Restore appropriate channel morphology in instream gravel mining pits to improve sediment transport characteristics and continuity, reduce predator habitat, and improve riparian vegetation conditions.
- Avoid capture of abandoned floodplain mining pits.
- Where appropriate, allow the channel to migrate.
- Where appropriate, work with landowners to implement environmentally sensitive bank protection measures.
- Reduce the delivery of sand to the river from Dry Creek.
- Where appropriate, preserve existing high quality riparian habitat and restore degraded riparian habitat.
- Identify riparian planting assemblages and geomorphic relationships for different reaches of the river.
- Identify and prioritize potential sites for restoration easements and projects.
- Contribute information to future studies of water quality conditions in the river.

Private property, land use, and water rights

- Base all projects on voluntary cooperation of landowners and stakeholders.
- Protect agricultural land uses.
- Avoid impacts to property and water rights.
- Avoid increasing risk or vulnerability to trespassing and vandalism.
- Do not increase flooding or bank erosion on private properties and, where possible and appropriate, reduce flooding threat and bank erosion.

- Work within existing flood control operations and mandates.
- Avoid conflicts with potential future recreation.
- Balance mining with preservation and restoration of the river.

Restoration project implementation
- Identify mechanisms, provide information, and work with agencies to streamline the regulatory process and provide regulatory certainty for landowners with regard to restoration project implementation.

Public outreach
- Provide information for river-oriented education and public outreach.
- Provide an information base that will be useful to agencies, planners, and private citizens (including information useful for recreation planning).

2.4 Agency Goals and Objectives

Several state and federal agencies and programs have also developed goals and objectives for the Merced River. Many of the goals and objectives are shared among the agencies and this Restoration Plan. Goals and objectives of major state and federal programs that have contributed to restoration planning and implementation in the Merced River and which will continue to direct future restoration implementation are summarized below.

CALFED

The CALFED Bay-Delta Program is a cooperative state and federal effort established to reduce conflicts in the Sacramento-San Joaquin Delta by solving problems in ecosystem quality, water quality, water supply reliability, and levee and channel integrity. In its Ecosystem Restoration Program Plan (ERPP), CALFED outlines its vision for the Merced River, sets restoration targets, and recommends programmatic actions (CALFED 1999). The goal of the ERPP is to "improve and increase aquatic and terrestrial habitats and improve ecosystem functions in the Bay-Delta to support sustainable populations of diverse and valuable plant and animal species." The ERPP vision for the Merced River includes:
- maintaining suitable water temperatures for native fish species;
- restoring streamflow;
- restoring coarse sediment recruitment;
- restoring stream channel and riparian habitat and ecological functions and processes to improve habitat for fall-run chinook salmon, late-fall-run chinook salmon, steelhead, riparian vegetation, and wildlife resources;
- restoring more natural channel configurations to restore gravel recruitment, transport, and cleansing processes;
- restoring a balanced sediment budget by implementing improved land use and livestock grazing practices;
- reducing non-native fish habitat;
- reducing the loss of young salmon at water diversions;
- reducing the input of contaminants;


Photo/Sally Magneson and Cathy Weber

- reducing the number of adult fish straying into areas with no suitable spawning habitat; and
- reducing illegal salmon harvest.

Central Valley Project Improvement Act-Anadromous Fish Restoration Program

The Anadromous Fish Restoration Program (AFRP) was formed by the Central Valley Project Improvement Act of 1992, which directs the Secretary of the Interior to develop and implement a program that makes all reasonable efforts to ensure that, by the year 2002, natural production of anadromous fish in Central Valley rivers and streams will be sustainable, on a long-term basis, at levels not less than twice the average levels attained during the period of 1967–1991. Recommended restoration actions for the Merced River identified in the Working Paper on Restoration Needs: Habitat Restoration Actions to Double Natural Production of Anadromous Fish in the Central Valley of California (USFWS 1995) are as follows:

- implement the Merced River flow schedule shown in Table 2-1 to manage flows to benefit all life stages of chinook salmon;

Table 2-1. AFRP Target Daily Average Flows for the Merced River Downstream of Crocker-Huffman Dam

Month	Target Daily Average Flow (cfs) (flows rounded to the nearest 50 cfs)				
	During wet years*	During above normal years*	During normal years*	During dry years*	During critically dry years*
October	350	300	300	250	250
November	350	350	300	300	250
December	600	550	300	300	250
January	1,100	600	300	300	250
February	1,450	1,050	500	300	250
March	1,500	1,050	600	450	400
April	1,800	1,350	1,150	950	750
May	2,950	2,300	1,750	1,200	850
June	2,850	1,450	1,150	650	450
July	1,150	400	250	200	200
August	350	300	250	200	200
September	350	300	250	200	200

*Year types based upon San Joaquin Basin 60-20-20 Index
Source: USFWS (1995)

- adjust the flow schedule to maintain water temperatures at 56°F between October 15 and February 15 and 65°F between April 1 and May 31 for chinook salmon spawning, incubation, rearing, and outmigration;
- reduce impacts of rapid flow fluctuations to increase hatching success and juvenile survival by reducing ramping rates and eliminating flow fluctuation during key periods;
- restore and protect instream and riparian habitat through restoration and protection of the stream ecosystem to ensure long-term sustainability of physical, chemical, and biological conditions needed to meet production goals for chinook salmon;
- install and maintain fish protection devices at pumps and diversions to reduce or eliminate loss of juvenile chinook salmon due to entrainment;
- provide additional law enforcement to reduce poaching in an effort to increase spawning success, reduce entrainment, and prevent additional destruction of stream habitat; and
- provide fish passage around reservoirs to increase production and minimize impact on water interests by providing access to additional spawning/rearing habitat upstream of the reservoirs.

The San Joaquin River Management Plan

The San Joaquin River Management Plan (SJRMP 1995) recommends projects and studies to be conducted on the mainstem San Joaquin River and its tributaries to address factors that currently limit populations of aquatic species. The San Joaquin River Management Plan recommendations for the Merced River include:

- improving gravel quality to increase survival of salmon eggs and enhance the channel and riparian corridor;
- increasing the presence of enforcement officers in critical areas during adult upstream migration and spawning to reduce illegal harvest of chinook salmon;
- developing standard GIS maps representing vegetation and habitat types and overlays to indicate, among other things, areas of high wildlife diversity, areas not presently protected, and areas that need protection;
- providing incentive payments to landowners who defer tillage, defer harvest, allow flooding, and/or provide nesting cover to increase habitat and provide more favorable conditions for waterfowl and other wetland-dependant birds and mammals;
- coordinating with on-going recovery planning programs to develop and implement a multi-species recovery plan for listed, proposed, and candidate species in the San Joaquin Valley;
- restoring converted wetlands to provide habitat for threatened and endangered species, flood control, improved water quality, and ground water recharge;
- developing a riparian corridor restoration plan to determine future management of the riparian corridor;

Photo/Sally Magneson and Cathy Weber

- screening riparian diversions to reduce entrainment and increase survival of outmigrating chinook salmon smolts;
- increasing fall flows to levels adequate to attract and provide passage for adult chinook salmon;
- undertaking measures to reduce abundance of non-native predators;
- with the U.S. Corps of Engineers, assessing the potential for modifying flood reservation rules to increase instream releases and benefit fish and water quality;
- completing a U.S. Bureau of Reclamation reconnaissance study of the Montgomery Reservoir, an off-stream storage project on Dry Creek, to determine multi-purpose benefits, identify sponsors, assess environmental impacts, determine mitigation measures, and initiate a feasibility study; and
- with the assistance of government agencies, citizens, and concerned groups, identifying and developing sites that would provide greater access for fishing, boating, hunting, and other recreation.

Delta Pumping Plant Fish Protection Agreement

In 1986, CDFG and CDWR entered into an agreement 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. This agreement funded a survey of restoration needs and provides funds for salmon habitat restoration on the Merced River. In 1993, CDWR surveyed approximately 20 miles of the Merced River from Crocker-Huffman Dam to Oakdale Road and identified 21 potential salmon habitat restoration sites. Site descriptions and recommendations for site restoration are described in CDWR's Comprehensive Needs Assessment for Chinook Salmon Habitat: Improvement Projects in the San Joaquin River Basin (CDWR 1994). Restoration recommendations include replacing spawning gravel, isolating captured and in-channel mining pits, reconstructing the river channel in reaches that have been mined for aggregate, and controlling water hyacinth.

Sacramento and San Joaquin River Basins Comprehensive Study

The U.S. Army Corps of Engineers and the Reclamation Board of California are conducting the Sacramento and San Joaquin River Basins Comprehensive Study, which seeks to develop a system-wide, comprehensive flood management plan for the Central Valley to reduce flood damage and integrate ecosystem restoration. The Comprehensive Study will identify problems and opportunities, set planning objectives and priorities, identify potential measures, and develop new master plans for the flood management systems, including ecosystem restoration. The Comprehensive Study will examine a full range of structural and nonstructural measures that address these purposes. Three broad planning objectives have been identified for the Comprehensive Study: (1) improve flood risk management throughout the systems; (2) integrate protection and restoration of ecosystem into the flood damage reduction measures; and (3) resolve policy issues and address limiting institutional procedures.

Chapter 3
The Merced River and Riparian Ecosystem

Chapter 3
The Merced River and Riparian Ecosystem

This chapter provides a summary of basic concepts of alluvial river ecosystem functions and describes current conditions in the Merced River corridor. Conditions considered to be key in selecting and implementing restoration projects and managing the river include geomorphic characteristics and processes (including flow conditions, sediment supply and transport, floodplain connectivity, and channel migration), riparian vegetation conditions, fish and wildlife species composition and distribution, land use and property ownership, and water quality. These factors are described in the following sections.

For the purposes of restoration planning, the lower Merced River can be divided into five reaches based on physical characteristics of the river and anthropogenic alterations to the river system (Figure 3-1). These reaches are the Dredger Tailings Reach (RM 52 to RM 45.2), Gravel Mining 1 Reach (RM 45.2 to RM 32.5), Gravel

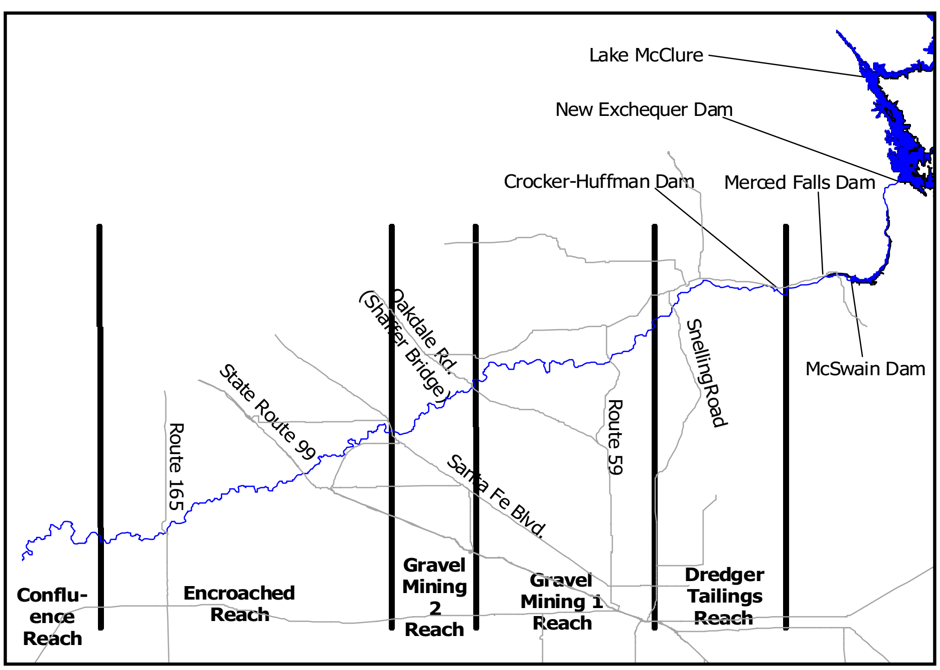


Figure 3-1. Merced River reach delineation.

Mining 2 Reach (RM 32.5 to RM 26.8), Encroached Reach (RM 26.8 to RM 8.0), and Confluence Reach (RM 8.0 to RM 0.0). Conditions and issues in each of these reaches are described in Chapter 4.

3.1 Basic Concepts

The lower Merced River downstream of Crocker-Huffman Dam is an alluvial river-floodplain system. Alluvial rivers are dynamic systems that are affected by complex interactions among numerous inputs and processes. A simplified conceptual model illustrating these interactions is shown in Figure 3-2. In this model, natural watershed inputs (such as water, sediment, and nutrients) drive physical processes (such as sediment transport and channel migration) that, in turn, determine geomorphic attributes and physical habitat structure of the river-floodplain system. These geomorphic attributes and habitat structure drive biological responses and are important determinants of plant and animal species abundance, distribution, and composition. Modification of any of these key inputs or processes is expected to affect channel and floodplain geomorphic attributes and, subsequently, affect plant communities and fish and wildlife populations. For instance, reduction in peak flows (a watershed input) can alter the timing, frequency, extent, and duration of floodplain inundation (a fluvial process). This alteration in inundation patterns can result in changes in riparian plant species composition and age-class structure, which can alter habitat suitability for native birds and thus result in a shift in bird community species composition. In turn, riparian vegetation can feed back to hydraulic and geomorphic processes. For instance, increased roughness provided by newly established vegetation can increase sediment deposition and floodplain accretion, while encroachment of vegetation into the active channel can contribute to channel incision.

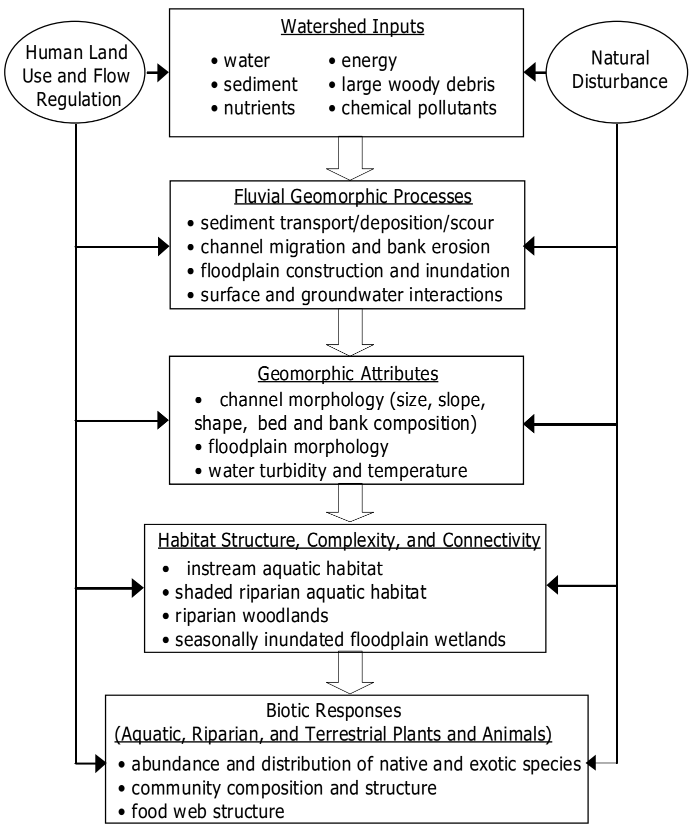


Figure 3-2. A simplified conceptual model of the physical and ecological linkages in alluvial river-floodplain systems.

Developing a restoration vision requires defining a reference state for the river that embodies the attributes of a healthy alluvial river system. Trush et al. (2000) describe key inputs and processes that can be used to define the reference state of a healthy alluvial river system. These inputs and processes include:

- temporally variable streamflow patterns;
- channel morphology that is scaled to flow conditions and sediment supplies that are balanced with sediment transport capacity;
- frequent scour of the bed surface and periodic scour of the bed subsurface;

- channel migration and/or avulsion;
- frequent floodplain inundation; and
- a self-sustaining, diverse riparian corridor.

A schematic diagram of a healthy alluvial river is shown in Figure 3-3. In this figure, the river channel is sinuous, with alternate point bars and pools at meander bends and riffles in the transitions between meander apexes. In cross section (Figure 3-4), the river channel is multi-staged, consisting of a low-flow channel, an active channel, and a bankfull channel. The low-flow channel carries summer and fall baseflows. The active channel includes both the low-flow channel and unvegetated point bars. The bankfull channel extends to the top of the vertical channel banks. The floodplain lies outside of the bankfull channel and is inundated, generally, at flows exceeding the 1.5- to 2-year flood recurrence interval. This floodplain supports a self-sustaining riparian woodland.

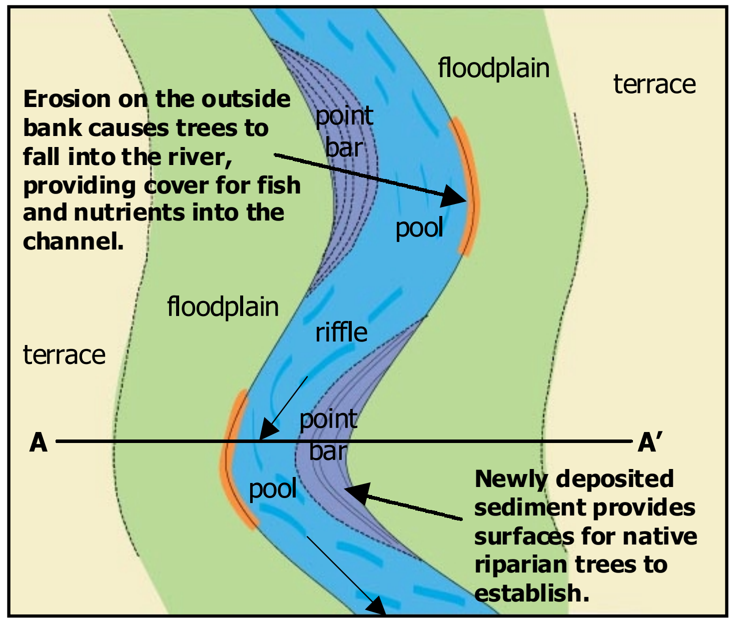


Figure 3-3. Erosion and deposition patterns in a healthy, meandering river system.

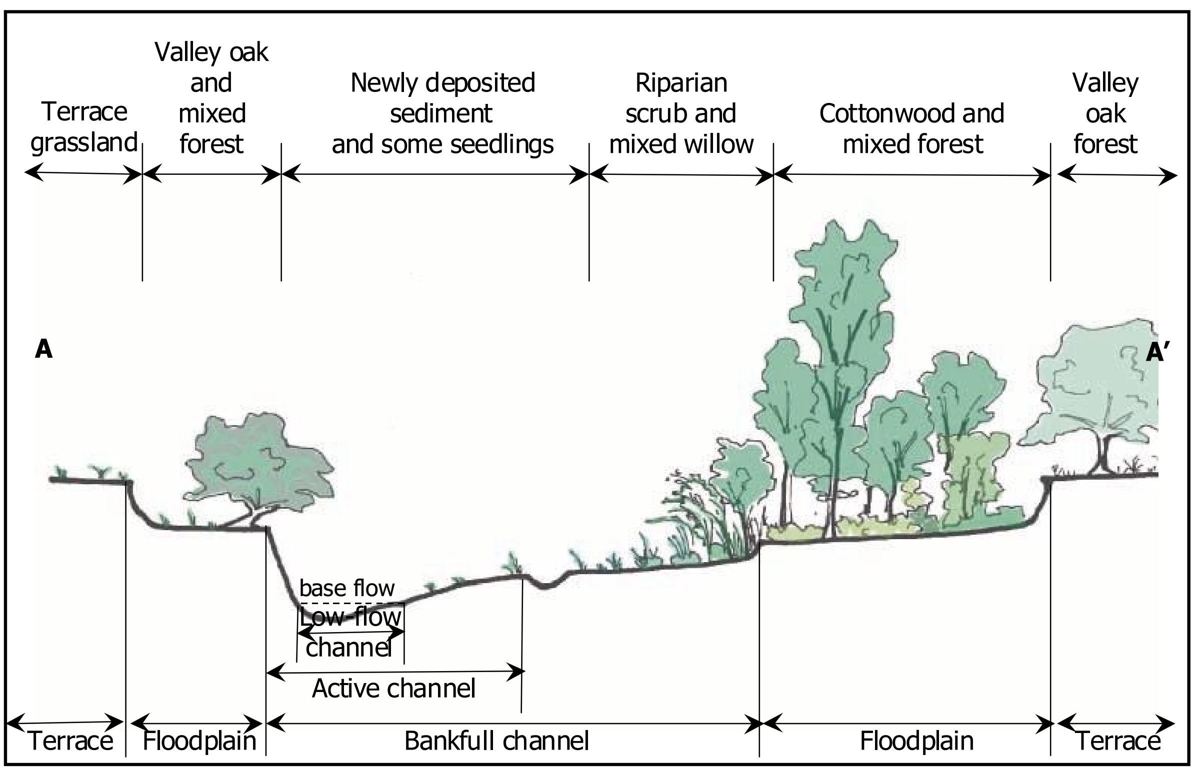


Figure 3-4. Schematic cross section of a "healthy" alluvial river system.

Temporally Variable Streamflow Patterns

In Central Valley river systems that are not controlled by dams, streamflow conditions are highly variable. In rivers draining the east side of the Central Valley, natural flow conditions are characterized by low flows in summer and early fall, large but brief flow peaks in winter caused by rain storms and rain-on-snow events, and prolonged high flows in spring caused by snowmelt from upper Sierra Nevada watersheds (Figure 3-5). Each of these components of the natural hydrograph drives processes that shape and sustain the river-floodplain system. Alteration of any of these components can alter the river ecosystem structure and function.

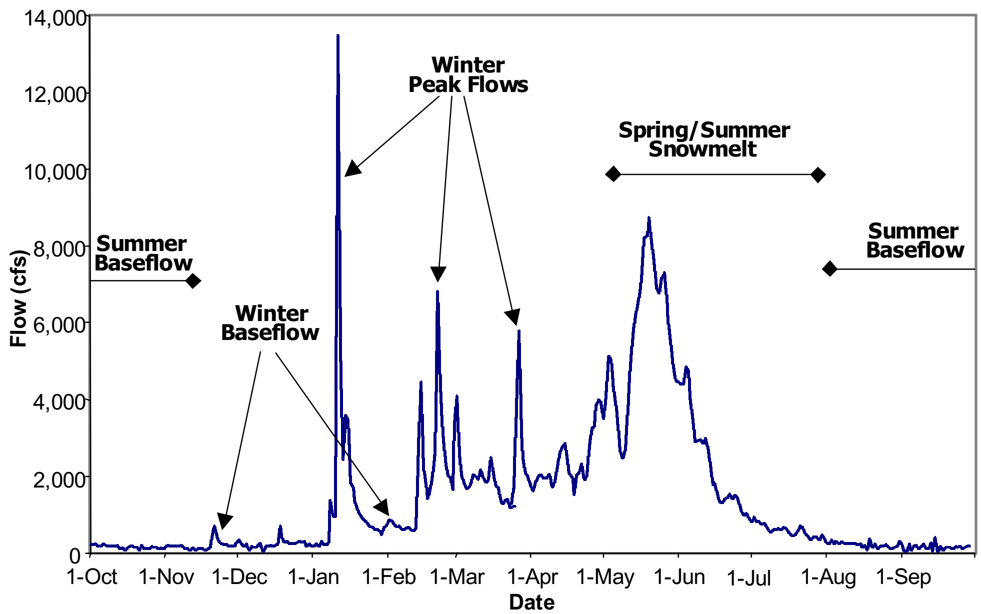


Figure 3-5. Hydrograph components for unregulated flow conditions in the Merced River. Source: Merced Irrigation District

Channel Morphology that is Scaled to Flow Conditions and Sediment Supplies that are Balanced with Sediment Transport Capacity

Channel morphology refers to the size, shape, and slope of the channel and the character of the sediment or rock comprising the river bed and banks. This morphology is determined by interactions between channel slope, flow, boundary shear stress, and sediment supply. In an undisturbed alluvial river, the channel will develop a size to convey a certain discharge, termed the "dominant discharge" or "bankfull flow" (Wolman and Miller 1960, Leopold et al. 1964). This is the flow that over time transports most of the river's sediment load. While the recurrence interval of this flow varies, it is often related to floods having a recurrence interval of 1.5 to 2 years (Leopold et al. 1964). Flows exceeding this discharge spill out over the channel banks onto the river floodplain.

Sediment is a fundamental building block of a river system, providing material for the river to construct riffles, bars, banks, and the floodplain. In an undisturbed alluvial river system, sediment is supplied from the upper watershed, transported through and temporarily stored in the alluvial reaches of the river, and deposited in a downstream delta (Figure 3-6). The sediment supply is balanced with the river's sediment transport capacity, a condition referred to as "dynamic equilibrium" (Schumm 1977). This condition does not imply a static condition but rather reflects a dynamic balance between sediment erosion and deposition. Banks erode, oxbows cut off, and meanders migrate, but the overall channel width, depth, and slope fluctuate only narrowly over time.

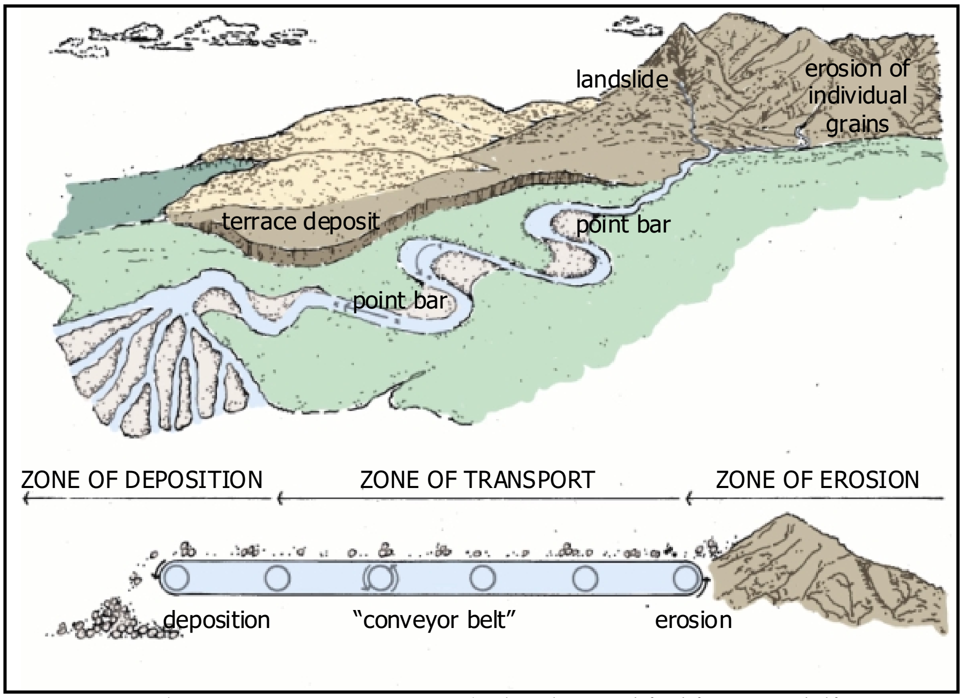


Figure 3-6. Sediment processes at a watershed scale. Modified from Kondolf and Matthews (1993)

Frequent Scour of the Bed Surface and Periodic Scour of the Bed Subsurface
Frequent scour of the bed surface is needed to maintain the active and bankfull channel morphology and habitat conditions. As flow in the river increases, the threshold for mobilizing grains on the channel bed surface is eventually surpassed. This threshold varies depending on channel width, depth, and slope, and the sediment grain size. The channel bed may not be mobilized at all in low flow years but may be mobilized several times during flood years. Over the long-term, the channel bed surface is mobilized on the order of once each year. Larger floods that exceed the threshold of bed mobilization may be required to rejuvenate alternate bar sequences. For undammed rivers, Trush et al. (2000) suggest that floods exceeding the 5- to 10-year recurrence interval are required to scour the channel bed to a sufficient depth to mobilize alluvial bars.

Periodic Channel Migration
In a healthy, meandering river system, the river erodes channel banks and the floodplain on the outside of meander bends and deposits sediment as a bar on the inside of meander bends. This process of erosion and deposition maintains the channel width and diverse in-channel and riparian habitats (Figure 3-4). The erosion on the outside of the bend scours deep pools, and trees falling into the river from the eroding bank provide cover and habitat structure for fish and other aquatic animals. New sediment deposits on the inside of the meander bend provide surfaces for native riparian plants to establish.

Frequent Floodplain Inundation
The floodplain is the flat area adjoining the river channel that was deposited by the river under the present climatic conditions and which is overflowed at times of high flow (Dunne and Leopold 1978, Nanson and Croke 1992) (Figure 3-3). Typically, the floodplain immediately adjacent to the river is maintained at an elevation

equal to the bankfull stage (Wolman and Leopold 1957, Leopold et al. 1964). Inundation of floodplains reduces flood flow magnitude and promotes exchange of nutrients, organisms, sediment, and energy between the terrestrial and aquatic systems. These flood pulses contribute to the high rates of primary productivity documented in functioning floodplain systems (e.g., Junk et al. 1989). In addition, Merced River floodplains provide important winter and spring spawning and rearing habitats for native fish, such as Sacramento splittail (*Pogonichthys macrolepidotus*) and chinook salmon (*Oncorhynchus tshawytscha*). Floodplain inundation is also necessary to maintain a healthy riparian ecosystem, as discussed below.

Self-sustaining, Diverse Riparian Corridor

Riparian zones, defined by Gregory et al. (1991) as "three-dimensional zones of direct interaction between terrestrial and aquatic ecosystems," provide multiple benefits to instream and terrestrial ecosystems and are widely recognized as centers of biodiversity and corridors for dispersal of plants and animals in the landscape (Gregory et al. 1991, Johansson et al. 1996). Riparian forests filter nutrients and agricultural chemicals from runoff, stabilize channel banks, provide leaf litter to aquatic food webs, large woody debris and overhead cover for fish, and nesting habitat and migratory corridors for terrestrial wildlife (CALFED 1999, Naiman and Descamps 1997, Mitsch and Gosselink 1993, Malanson 1993).

A mature riparian zone typically consists of a mosaic of vegetation types of various ages and species. Commonly, mixed riparian forests occupy mid-elevation floodplain sites, and valley oak woodland and savannah occupy the oldest and driest floodplain sites further from the active channel, such as high terraces and cut banks. Riparian vegetation dynamics are tightly coupled with river processes. Physical forces such as flooding, scour, and sediment deposition strongly influence riparian plant species composition, distribution, and physical structure and are major drivers of riparian community succession. Succession is the progressive shift in plant species composition over time in response to outside disturbances, such as floods and fire, or internal competition among plant species (Oliver and Larson 1996, Malanson 1993). Along geomorphically active, meandering streams, riparian vegetation typically exhibits two distinct patterns of vegetation development. Cottonwoods and willows are typically among the first species to colonize bare stream banks and bars. These species have physiological traits, such as high seed output and rapid growth rates, that are well suited for quickly colonizing new geomorphic surfaces. They tend to establish in bands parallel to the channel, with the youngest stands occurring closest to the active channel margin (Figure 3-4) (Gregory et al. 1991, McBride and Strahan 1984, Walker and Chapin 1986). Each band of vegetation represents a separate recruitment event; the position and shape of the stand reflects the favorable flow and sediment conditions (usually a spring flood recession event) that occurred during a particular year's spring seed release period. As vegetation from one cohort matures, it traps sediment and extends the bar surface, creating new seedbeds for successive recruitment events (Johnson et al. 1976, Strahan 1984, Scott et al. 1996).

In addition to the establishment of pioneer species on newly deposited floodplain and bar surfaces, successional processes alter vegetation composition in established riparian stands. Over time, pioneer vegetation traps sediment and adds litter and nutrient inputs to floodplain soils (Walker and Chapin 1986). As the floodplain develops and the riparian stand ages, other riparian species such as Oregon ash

(*Fraxinus latifolia*), box elder (*Acer negundo*), and valley oak (*Quercus lobata*) establish within the riparian zone. These "later successional" species typically produce larger seeds and are more shade tolerant than the early pioneers, which allows them to persist in the seedbank and germinate under the forest canopy when soil temperature and moisture conditions are adequate. Recruitment of these species is not as dependent on flow and sediment conditions as for the willows and cottonwoods, and seedling recruitment typically occurs as a chance event, depending on individual conditions such as microclimate and proximity to parent trees. Over time, these species further alter the soil, light, moisture, and nutrient conditions within the riparian zone and outlive or outcompete the original pioneer species. At any one site, the spatial and temporal patterns of physical processes (such as flooding and sediment dynamics) and biological processes (such as plant establishment and competition) can be complicated and unpredictable, and vegetation composition is often more patchy than the generalized patterns described above.

3.2 Hydrologic and Geomorphic Processes and Conditions in the Merced River

Historical Hydrologic and Geomorphic Processes and Conditions

Review of aerial photographs and maps circa 1915 and 1937 indicates that, under historical conditions, the Merced River valley and channel downstream of Merced Falls was characterized into two distinct segments, or "morphodynamic units" (Stillwater Sciences 2001a). The first unit, which extended from Merced Falls (RM 55) to Dry Creek (RM 31.7), was located in the transition zone from the confined valleys of the Sierra Nevada foothills to the broad alluvial floor of the Central Valley. In this unit, the valley floor was wide, extending up to 4.5 miles across, and the river was a multiple channel, anastomosing system[2] (Figure 3-7). The multiple channels that comprised this system (including the current mainstem channel and Ingalsbe, Dana and Hopeton sloughs) occupied the entire width of the valley floor. The 1.5-year flood flow was approximately 10,000 cfs, and the coarse sediment supply from the upper watershed was approximately 11,000–21,000 tons per year (Stillwater Sciences 2001a). Driven by unregulated flow conditions, coarse

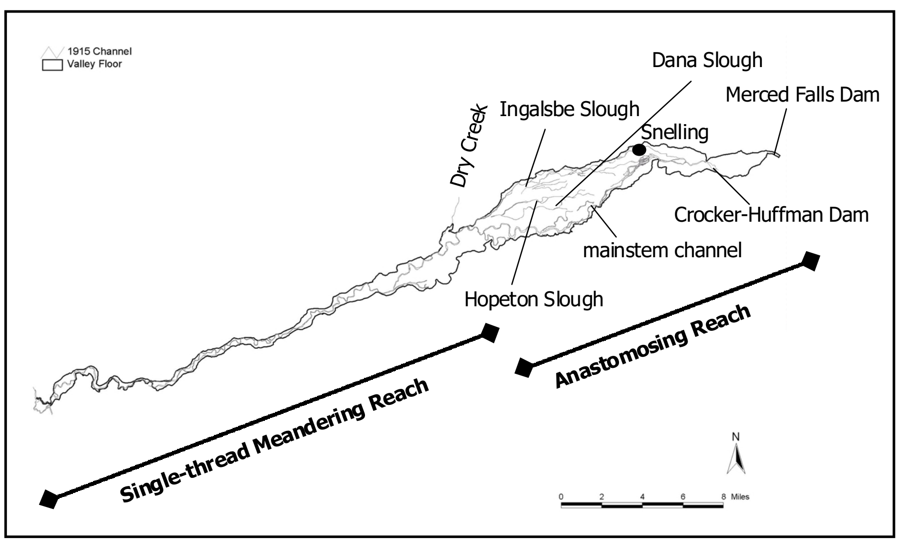


Figure 3-7. Merced River alluvial valley floor boundary and 1915 channel alignment.

[2]"Anastomosing rivers . . . consist of multiple channels separated by vegetated or otherwise stable islands which are usually excised from the continuous floodplain and which are large relative to the width of the channels" (Knighton 1998).

sediment supply from the upper watershed, and local geology, this portion of the river was highly dynamic, with the dominant channel frequently shifting location between the various sloughs. Channel avulsion, in combination with channel migration, maintained diverse in-channel habitats and constructed floodplain surfaces, which supported native flora and fauna.

Figure 3-8. Remnant oxbox lake on the Merced River.

The second unit extended from Dry Creek to the confluence with the San Joaquin River. In this unit, the valley width narrowed to approximately one mile, and the pre-colonial river was a single-thread, meandering system (Figure 3-7). Under historical conditions, the channel migrated across the valley floor, reworking its floodplain and constructing surfaces on which riparian vegetation could establish. As the channel migrated and meanders developed, meanders were periodically cut off, creating oxbow lakes on the floodplain. Remnant oxbow lakes are still apparent today (Figure 3-8).

In both units, the floodplain was inundated frequently. During winter, the floodplain was inundated for brief periods during rain and rain-on-snow events. During spring, the floodplain was inundated for weeks or months by snowmelt flows from the upper watershed. The recession limb of this snowmelt hydrograph was gradual and supported floodplain spawning and rearing for native fish species, such as Sacramento splittail (*Pogonichthys macrolepidotus)* and fall chinook salmon (*Oncorhynchus tshawytscha*). In addition, the supply of fine sediment from the upper watershed allowed deposition of fine sediment on the floodplain during flood events, which provided bare soil patches suitable for germination and establishment of native riparian vegetation. The construction of new floodplain surfaces, availability of bare soil patches, and patterns of inundation and drawdown provided conditions suitable to support a diverse riparian forest, which supported terrestrial wildlife species.

Factors Affecting Hydrologic and Geomorphic Processes and Conditions in the Merced River

Key human interventions in the river valley that have shaped current hydrologic and geomorphic conditions include water supply development, flood control, gold dredging, aggregate mining, bank stabilization, and floodplain encroachment. These interventions and their effects on channel and floodplain morphology and functions are described below.

Water Supply Development

Flow in the Merced River is controlled by several mainstem dams (Figure 1-2 and Table 3-1). The major storage reservoirs in the watershed are Lake McClure, which is impounded by New Exchequer Dam, and Lake McSwain, which is impounded by McSwain Dam. These dams, which are known collectively as the Merced River Development Project, are owned by Merced ID and are licensed by the Federal Energy Regulatory Commission (FERC). In addition to these mainstem dams, three small storage dams—MacMahon, Green Valley, and Metzger dams—have been constructed on tributaries upstream of New Exchequer Dam. The only major tributary to the Merced River downstream of the mainstem dams is Dry Creek. Kelsey Dam impounds a small reservoir on this creek.

New Exchequer Dam, located at RM 62.5, controls runoff from 81 percent of the basin and creates Lake McClure, the largest storage reservoir in the system. This dam replaced the original Exchequer Dam, which was completed in 1926 and which had a reservoir capacity of 281,200 acre-feet[3]. The current maximum reservoir storage capacity at Lake McClure is 1,024,600 acre-feet, equivalent to 103 percent of the average annual runoff from the basin (as measured below Merced Falls Dam, near Snelling). McSwain Dam is located at RM 56, 6.5 river miles downstream of New Exchequer Dam, and is operated as a re-regulation reservoir for Lake McClure and as a hydroelectric facility. Storage capacity in Lake McSwain is 9,730 acre-feet. Together, these dams provide agricultural water supply, power generation, flood control, recreation, and environmental flows including in-stream fisheries flows and flows to the Merced National Wildlife Refuge. Merced ID's state storage water right limits the amount of water that can be stored in Lake McClure to 605,000 acre-feet per year. A minimum pool of 115,000 acre-feet is reserved in Lake McClure to maintain required instream flows for fish.

Table 3-1. Dams Regulated by the California Division of the Safety of Dams in the Merced River Basin

Dam	Stream	Year Completed	Capacity (acre-feet)
Mainstem			
New Exchequer	Merced River	1967	1,024,600
McSwain	Merced River	1966	9,730
Merced Falls	Merced River	1901	900
Crocker-Huffman	Merced River	1910[1]	200
Tributaries to Mainstem			
McMahon[2]	Maxwell Creek	1957	519
Kelsey	Dry Creek	1929	972
North Fork			
Green Valley[2]	Smith Creek	1957	243
Metzger[2]	Dutch Creek	1956	73
		Total:	1,037,237

Source: CDWR 1984

[1] A diversion dam has been operated at this location since the 1870s.

[2] Dam is located upstream of the New Exchequer Dam.

Downstream of McSwain Dam, two low dams divert flow from the river into the Merced ID irrigation system. Merced Falls Dam is located at RM 55. This dam, which was constructed in 1901, diverts flow into Merced ID's Northside Canal to the north of the river and is also used to generate electricity. The capacity of the Northside Canal is approximately 90 cfs. Crocker-Huffman Dam is located at RM 52. This dam, which was constructed in 1910 at the location of previous diversion structures, diverts flow into Merced ID's Main Canal to the south of the river. The capacity of the Main Canal is approximately 1,900 cfs. Combined, these diversions average 522,000 acre-feet annually, or 52 percent of the average unimpaired discharge from the watershed.

Numerous large and small diversions take flow from the river downstream of Crocker-Huffman Dam. The Merced River Riparian Water Users maintain seven riparian diversions between Crocker-Huffman Dam and Shaffer Bridge (Figure 3-9). At these diversions, flow is directed into diversion channels by small, temporary gravel wing dams that are constructed each year. These diversions take up to 94,000 acre-feet of water from the river annually. Downstream of Shaffer Bridge, CDFG has identified 238 diversions, which are typically small pumps used to supply water for agricultural use (G. Hatler, pers. comm., 1999).

[3]An acre-foot is the volume of water that would inundate one acre of land to a depth of one foot and is equivalent to approximately 326,000 gallons.

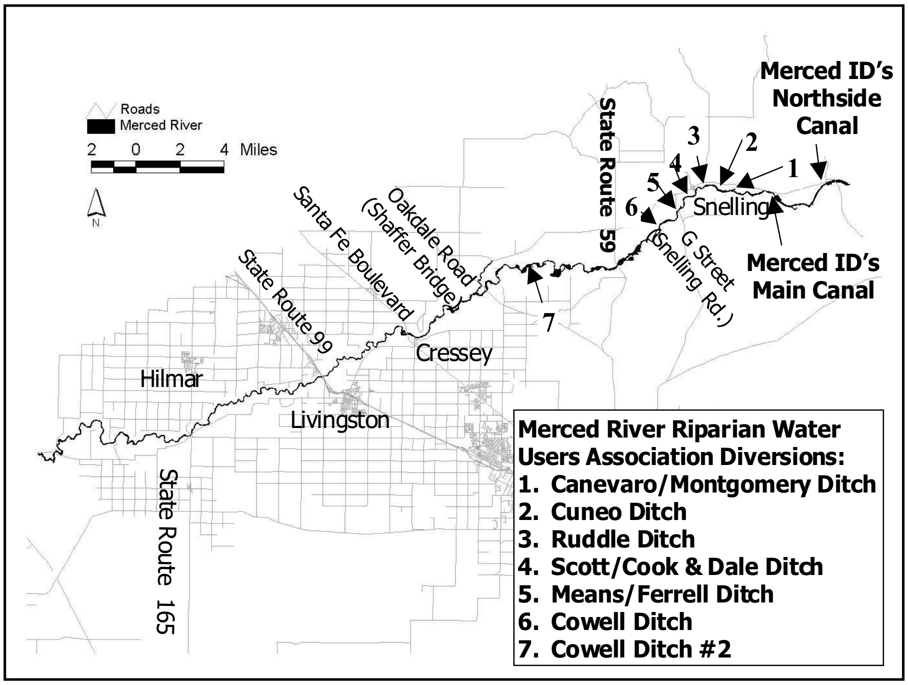


Figure 3-9. Merced River water diversions.

In addition to these reservoirs and diversions, CALFED is currently considering developing a 500,000-acre-foot reservoir in the Dry Creek watershed as one alternative to enlarging Millerton Lake on the San Joaquin River. This reservoir, which would inundate approximately 8,050 acres near the town of Snelling, would be operated to provide spring flows for smolt outmigration. CALFED will assess the potential effects of the proposed reservoir on the Merced River and other environmental resources during their project planning and evaluation process.

Flood Control

The Merced River Development Project is operated to provide flood control for the lower Merced River. Flood control rules for the project are enforced by the U.S. Army Corps of Engineers. These rules require Merced ID to maintain space in Lake McClure to store incoming flood flows and also limit the magnitude of flows that can be released from the reservoirs to the lower river. The required flood pool varies by season. During winter (October 31 through March 15), 350,000 acre-feet of storage space in Lake McClure must be reserved for flood storage. During spring (March 15 through May 15), an additional 50,000 acre-feet must be reserved for "conditional space" to store the forecasted spring snowmelt. Downstream of the dams, the maximum flow in the river allowable under the flood control rules is 6,000 cfs, as measured at the USGS Merced River at Stevinson gauge (no. 11272500) located near the confluence with the San Joaquin River. Flow releases from the project must be timed so that total flow in the river, including inflow from Dry Creek, does not exceed 6,000 cfs.

No state or federal levee system has been constructed on the Merced River, and existing levees are limited to small, privately owned structures. These levees protect extensive agricultural lands and dairies from floodplain inundation during flows up to and exceeding 6,000 cfs. They also have disconnected much of the lower river from its floodplain and have allowed floodplain habitats to be converted to other uses.

Gold Dredging

From 1907 through 1952, the lower Merced River channel and floodplain were dredged for gold. During this period, seven gold dredging companies operated ten dredges in the vicinity of Snelling. These dredges, which had earthmoving capacities of 1.4–3.4 million cubic yards/year, excavated the channel and floodplain deposits to bedrock, usually a depth of 20–36 feet (Clark, no date). After recovering the gold, the dredgers redeposited the remaining tailings in long rows on the floodplain (Figure 3-10). These tailings consist of fine sand and gravel overlain by cobbles and boulders, a stratification pattern that likely resulted from the sluicing and discharge process. Tailings currently cover approximately 7.6 square miles of floodplain in the Snelling vicinity. The volume of these tailings is estimated to be approximately 24 million cubic yards[4]. Some tailings are currently being mined to provide construction aggregate.

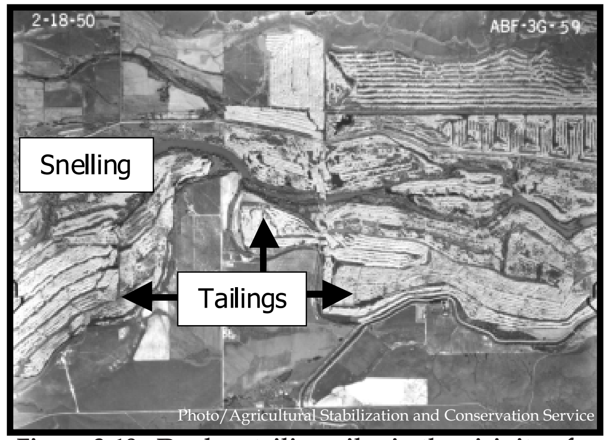


Figure 3-10. Dredger tailing piles in the vicinity of Snelling.

As a result of the dredging, combined with the capture of sediment supply at upstream dams, the river channel in the dredged reach lacks coarse sediment and is characterized by long, deep pools. In addition, the dredger tailings have replaced the once diverse and productive floodplains and riparian forests with barren piles of cobbles and boulders, which currently confine the river channel and floodplain to a narrow corridor.

Aggregate Mining

Large-scale aggregate mining began in the Merced River valley in the 1940s and continues today. Two types of mining, in-channel mining and floodplain mining, occurred in and along the river. At in-channel mines, operators excavated sediment directly from the river channel, leaving behind large in-channel pits. At floodplain mines, operators excavated pits in the floodplain adjacent to the river channel. These pits were typically separated from the channel by narrow, unengineered berms. Many of these berms have since failed, resulting in capture of the river channel by the pits.

Until recently, in-channel and captured pits occupied 7.3 miles (or 40 percent) of the gravel-bedded reach of the river (Figure 3-11). As described in Section 1-3, the CDFG/CDWR Salmon Habitat Enhancement Project is repairing five in-channel and captured mine sites that extend along 4.3 miles of the river in the vicinity of the State Route 59 bridge, and the CDFG/CDWR Magneson Predator Isolation Project repaired a breached levee at another captured mine located at RM 29.2. In addition to these mines that have been or are currently being isolated from the channel, ten abandoned in-channel mines occur in the gravel-bedded reach of the river (Figure 3-11).

In-channel and captured mine pits affect the river by providing suitable habitat for introduced warm-water fish species that prey on native fishes, interrupting sediment transport continuity, and converting floodplains to open-water pits. Captured floodplain and in-channel mining pits provide suitable habitat for largemouth bass (*Micropterus salmoides*), an introduced warm-water fish that preys on native

[4]This assumes an average depth of 3.5 feet, based on McBain and Trush (2000).

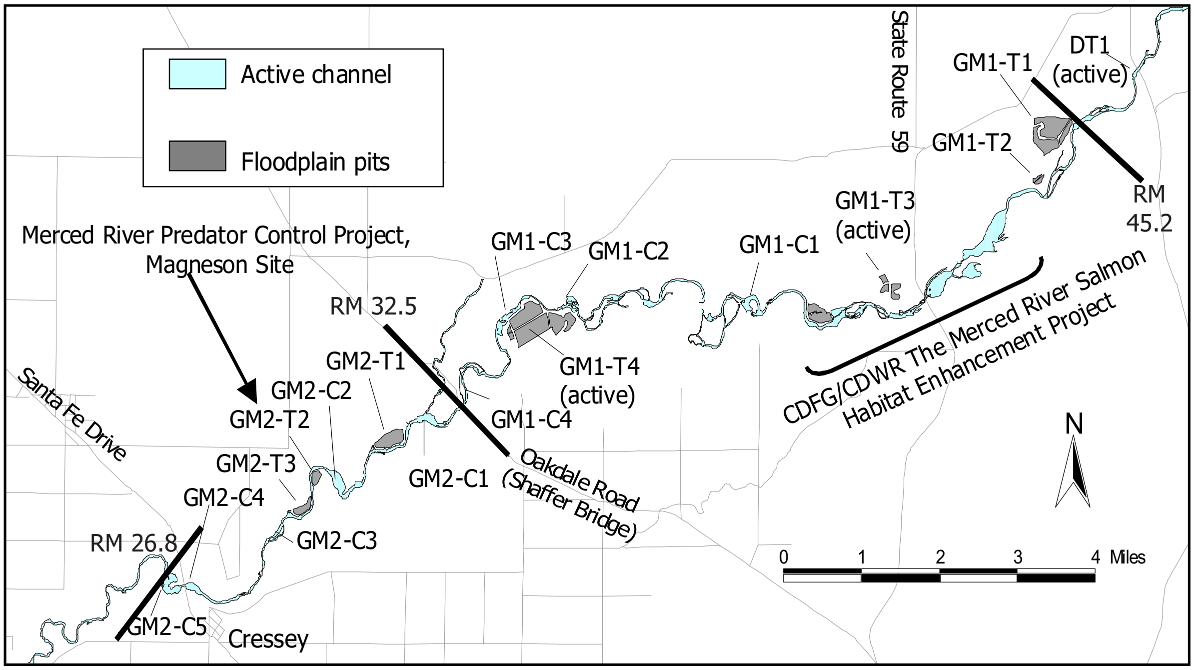


Figure 3-11. Terrace and in-channel aggregate mines along the Merced River. Note: GM2=Gravel Mining 2 Reach, GM1=Gravel Mining 1 Reach, DT=Dredger Tailings Reach, C=in-channel, T=terrace

fishes, including juvenile chinook salmon outmigrants. In the Tuolumne River, located approximately 22 miles to the north of the Merced River, predation by large-mouth bass is believed to be a major factor limiting chinook salmon outmigrant survival (and thus chinook salmon abundance) in the river (TID/MID 1991), and bass abundance has been shown to be significantly higher in in-channel mining pits than in unmined portions of the channel (McBain & Trush and Stillwater Sciences 1999, 2000). Reducing predation on juvenile chinook salmon during their outmigration, therefore, may be a key measure in increasing chinook salmon abundance in the Merced River.

In-channel mining has been discontinued, but floodplain and terrace mining continue today. Three aggregate mines are currently active in the river corridor (DT1, GM1-T3, and GM1-T4 in Figure 3-11). Calaveras Materials Inc. operates two permitted sites just downstream of the Route 59 bridge (GM1-T3). An additional mine, the Woolstenhulme Ranch mine, is currently in the permitting process. This mine would include 456-acres of floodplain pits. Santa Fe Aggregates, Inc. operates the Bettencourt Ranch mine near RM 34 (GM1-T4) and the Doolittle Mine near RM 46 (DT1). The Bettencourt Ranch mine is a floodplain mine immediately adjacent to the river channel. This mine has approximately three to four years of permitted reserves; the currently permitted area is 160 acres. The Doolittle Mine is located in dredger tailings near the Snelling Road bridge. At this mine, tailings are being removed to the floodplain or terrace elevation.

Figure 3-12. Example of bank revetment on the Merced River.

Bank Stabilization

Bank revetment has been used extensively throughout the Merced River to correct and prevent bank erosion. The materials used for revetment vary but commonly consist of rock (or "riprap"), concrete rubble, or gabions (rock-filled wire baskets) (Figure 3-12). Revetment limits channel migration and hinders the establishment of native riparian vegetation. Non-native, invasive vegetation species, such as giant reed (*Arundo donax*), are often associated with bank revetment.

Current Hydrologic and Geomorphic Processes and Conditions

Hydrologic Conditions
As described in Section 3.1, temporally variable streamflow patterns, flows sufficient to periodically scour the channel bed, and frequent floods that inundate the floodplain are key hydrologic attributes of a functioning alluvial river-floodplain system. Historically, natural flow conditions in the Merced River were characterized by low summer and fall baseflows, large brief winter peak flows caused by rain and rain-on-snow events, and prolonged spring and early summer high flows caused by snowmelt in the upper watershed (Figure 3-5).

The hydrology of the Merced River has been altered by water supply development and flood control operations, which together have reduced peak flow magnitude, altered seasonal flow patterns, reduced temporal variability, and reduced summer baseflows. These changes in hydrologic conditions have reduced the frequency of bed scour, the river's capacity to transport sediment, and the frequency, duration, and magnitude of floodplain inundation.

Effects of Flow Regulation on Peak Flows
Flow regulation and flood control have reduced the frequency and magnitude of floods in the Merced River. Prior to flow regulation, floods exceeding 15,000 cfs were common, occurring in 11 of the 21 years of record, and the mean annual flood (Q_{maf}) was 16,200 cfs (Figure 3-13). Since completion of New Exchequer Dam, the

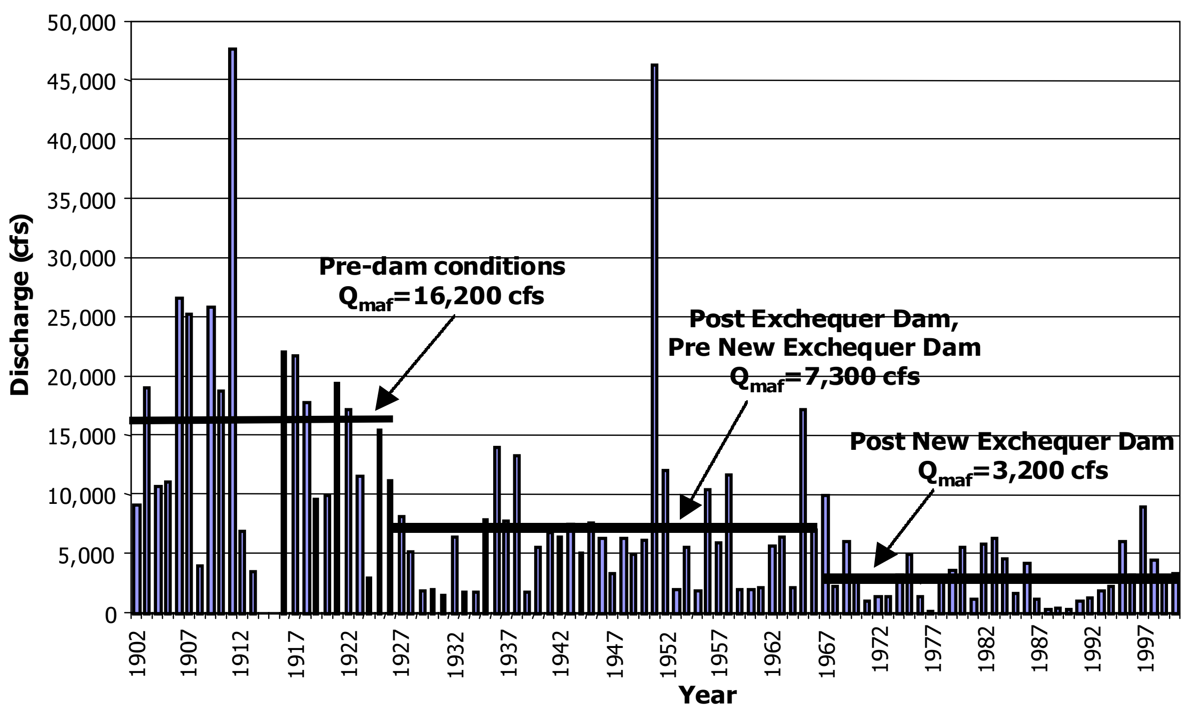


Figure 3-13. Maximum instantaneous flows and mean annual flood (Q_{maf}) at the Exchaquer (1902-1964, Merced Falls (1964-1967), and Snelling (1967-2000) gauges. Sources: USGS gauges 11270000 and 11270900,

largest recorded flows in the river have been 10,000 cfs, which occurred in June–July 1967 due to failure of a valve at New Exchequer Dam, and 8,310 cfs, which occurred in January 1997. The mean annual flood has been reduced by 80 percent, from 16,200 cfs to 3,200 cfs.

The effects of flow regulation on the 1.5-, 2-, 5-, and 10-year floods are shown in Table 3-2. Flow regulation has reduced the magnitude of these floods by 80–84 percent, with the greatest reduction occurring in smaller magnitude floods. Channel-forming floods (represented by 1.5- and 2- year floods) have been reduced by 84 and 82 percent respectively, and flows equivalent to the pre-dam channel-forming flow (approximately 10,000-14,000 cfs) have not occurred since completion of New Exchequer Dam. The 6,000-cfs flood release limit imposed by the Corps of Engineers is only 60 percent of the pre-dam 1.5-year flood.

Table 3-2. Comparison of Instantaneous Annual Peak Floods Under Pre-Dam and Regulated Conditions

Recurrence Interval (years)	Pre-Dam	Post-Dam	Percent Reduction
	Unregulated flow at Exchequer[1] (WY 1902-1925)	Regulated flow at Snelling[1] (WY 1968-2000)	
1.5	10,062	1,594	84
2	13,692	2,404	82
5	24,006	4,701	80
10	31,526	6,287	80

Source: USGS gauge number 11270000 (pre-dam) and CDWR gauge number B05170 (post-dam)

[1] Flood magnitudes and recurrence intervals are based on a Log-Pearson III distribution of instantaneous peak flow data.

Effects of Flow Regulation and Diversion on Seasonal Flow Patterns and Flow Magnitude
Flow regulation has also shifted the timing of peak flows from spring to winter. For the period for which estimates of unimpaired inflow to Lake McClure are available (1977–1996), the annual peak flow into Lake McClure occurred from April through June in 60 percent of years. During the same period, annual peak flows downstream of Crocker-Huffman Dam occurred from April through June in only 25 percent of years and occurred from October through March in 65 percent of years (Figure 3-14). Many important biological processes for native plant and animal species occur between April and June and are timed to coincide with the historical spring snowmelt floods. This shift from spring peaks to winter peaks likely affects riparian vegetation establishment in the river because native riparian species germinate in spring, and plants germinating in areas inundated in spring are vulnerable to drowning and scour during the following fall and winter.

Operation of the Merced River Development Project, combined with diversions at Merced Falls and Crocker-Huffman dams, has increased average monthly flows during late summer and early fall (September and October) and reduced average monthly flows during the remainder of the year (Figure 3-15). Reductions in average monthly flows range from 46 percent in August and November to 87 percent in May and June.

The magnitude of effects of flow regulation on the natural hydrograph vary depending on water year type, with the greatest effects occurring during drier years. The effects of flow regulation on seasonal flow patterns and flow magnitude for representative years of five water year types (critically dry, dry, median, wet, and extremely wet) are shown in Figures 3-16A through E. During all water year types, flow regulation has reduced winter peak flows and spring snowmelt flows in the

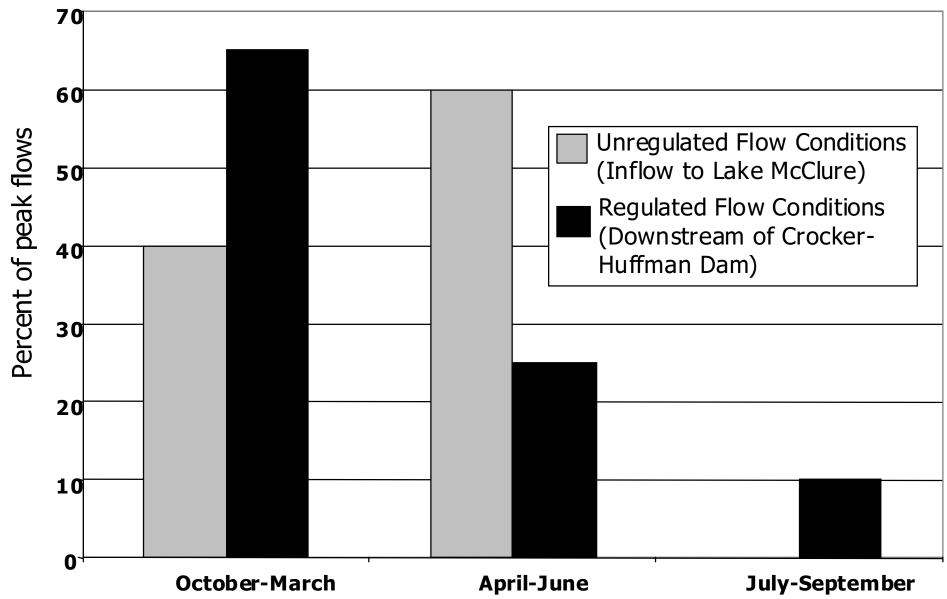


Figure 3-14. Comparison of the timing of regulated and unregulated peak flows (1977-1996). Sources: Merced Irrigation District computed inflow and Crocker-Huffman gauge

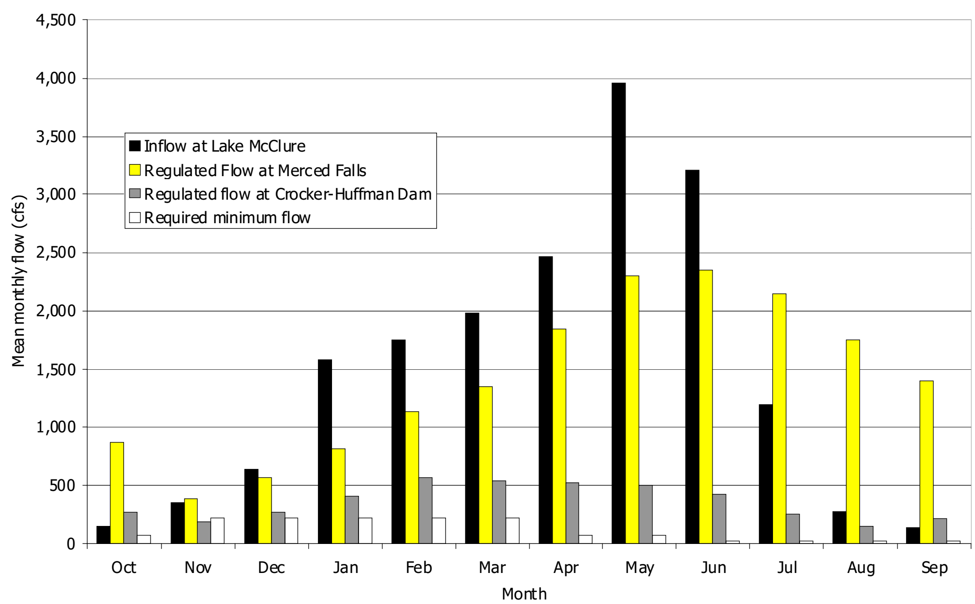


Figure 3-15. Unregulated and regulated monthly average flow in the lower Merced River (1968-1998). Note: Minimum flow requirements represent FERC requirements for normal water years between April and October, and higher minimum flows required by the Davis-Grunsky contract from November through March.

lower river. At Crocker-Huffman Dam, summer and early fall baseflows are similar to or exceed unregulated inflows to Lake McClure. Farther downstream of Crocker-Huffman Dam, however, summer and early fall baseflows are greatly reduced by numerous riparian diversions along the river. The combined result of flow regulation and diversion in the river is a simplified hydrograph that lacks flow variability, reduced or eliminated winter and spring peak flows, and greatly reduced summer and early fall baseflows.

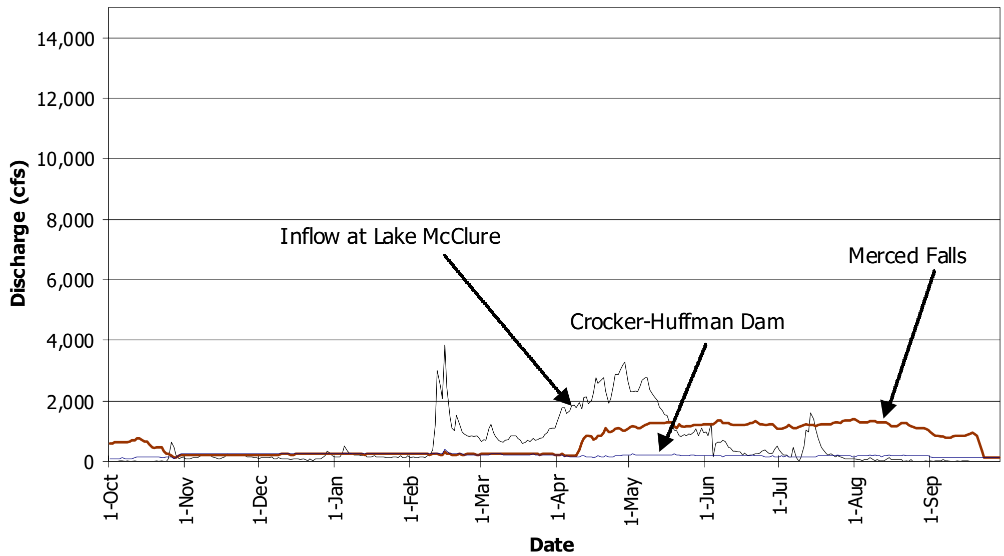


Figure 3-16A. Annual hydrographs of inflow to Lake McClure and flow at Merced Falls and Crocker-Huffman Dam for a critically dry year (water year 1992). Sources: Merced Irrigation District computed flow and Crocker-Huffman gauge, USGS gauge 11270900

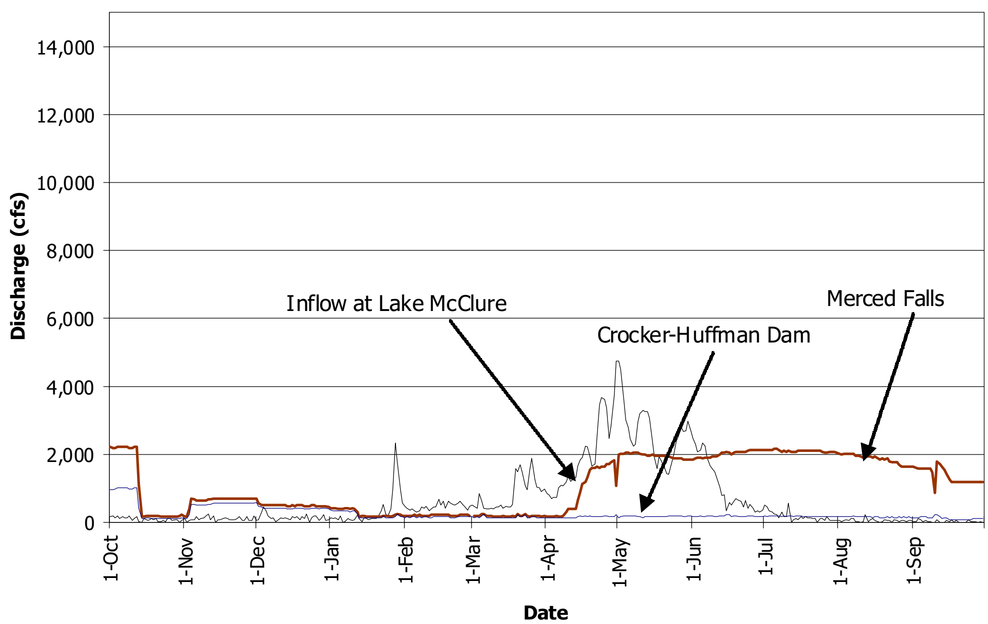


Figure 3-16B. Annual hydrographs of inflow to Lake McClure and flow at Merced Falls and Crocker-Huffman Dam for a dry year (water year 1981). Sources: Merced Irrigation District computed flow and Crocker-Huffman gauge, USGS gauge 11270900

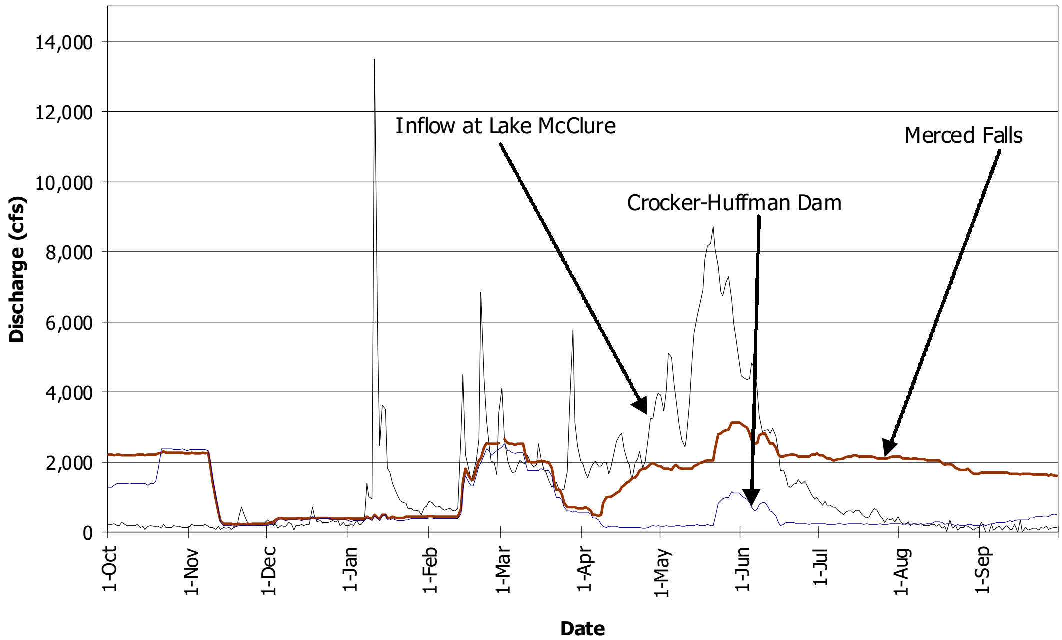


Figure 3-16C. Annual hydrographs of inflow to Lake McClure and flow at Merced Falls and Crocker-Huffman Dam for a median year (water year 1979). Sources: Merced Irrigation District computed flow and Crocker-Huffman gauge, USGS gauge 11270900

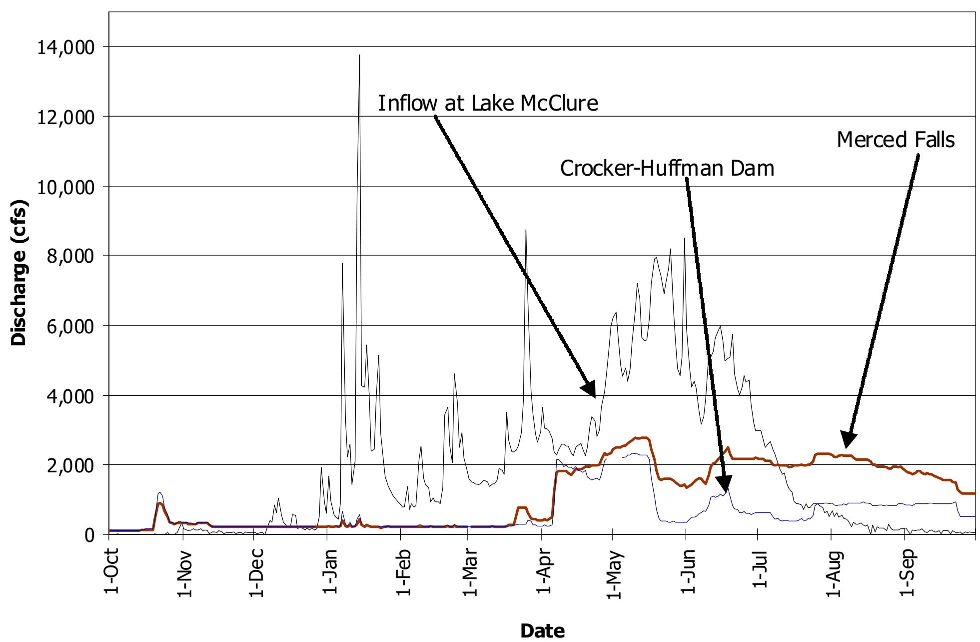


Figure 3-16D. Annual hydrographs of inflow to Lake McClure and flow at Merced Falls and Crocker-Huffman Dam for a wet year (water year 1993). Sources: Merced Irrigation District computed flow and Crocker-Huffman gauge, USGS gauge 11270900

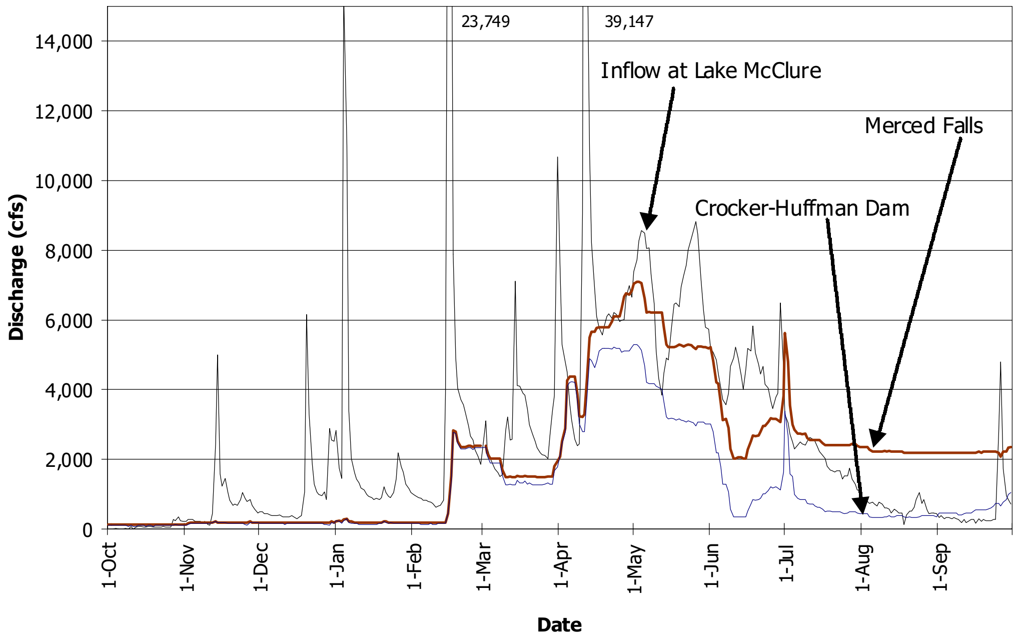


Figure 3-16E. Annual hydrographs of inflow to Lake McClure and flow at Merced Falls and Crocker-Huffman Dam for an extremely wet year (water year 1982). Sources: Merced Irrigation District computed flow and Crocker-Huffman gauge, USGS gauge 11270900

Sediment Supply and Transport

Sediment supply that is balanced with sediment transport capacity, frequent scour of the bed surface, and periodic scour of the bed subsurface are key attributes of a functioning river system. In the Merced River, sediment supply and transport are affected by dams, which intercept sediment supply from the upper watershed; mining, which removes sediment stored in the channel and floodplain downstream of the dams; flow regulation, which reduces the frequency of bed scour; and mining pits, which interrupt sediment transport continuity.

Since 1926, sediment supply from the upper 81 percent of the watershed has been intercepted at the original Exchequer Dam and then the New Exchequer Dam. This interception has eliminated the vast majority of the river's historical sediment supply, thus depriving the river of basic components for maintaining a geomorphic equilibrium. With the elimination of sediment supply from the upper watershed, the only remaining major sources of sediment to the river are erosion of the river bed and banks and input from Dry Creek. Sediment supplied from Dry Creek consists primarily of sand but includes some gravel. The creek, however, enters the river at an in-channel mining pit, which captures most of the sediment delivered from the Dry Creek watershed.

By reducing peak flow magnitude, the dams have also reduced the frequency of sediment scour and bed mobilization in the river. Under pre-dam conditions, the bed in the gravel-bedded reaches of the lower Merced River was likely mobilized by small, relatively frequent floods that occurred about every 1–2 years. Through this frequent sediment transport, the river maintained its multi-staged channel (Figure 3-4). With the reduction in flood magnitude caused by flow regulation, the bed is immobile at flows less than the post-dam 5-year flood (Stillwater Sciences 2001a, 2001b). As a result, the channel bed and formerly active bars have become static, and riparian vegetation had established on formerly active gravel bars, a process referred to as "riparian encroachment" (Pelzman 1973) (Figure 3-17). Riparian encroachment into the active channel has reduced channel width from Crocker-Huffman Dam to RM 15[5] by an average of 85 feet, or 33 percent of the mean 1937 channel width (Vick 1995). As a result, the area of aquatic habitat in the Merced River has been reduced, and the river channel is currently characterized by a simplified cross section with no active bars and no clearly defined low flow channel (Figure 3-17).

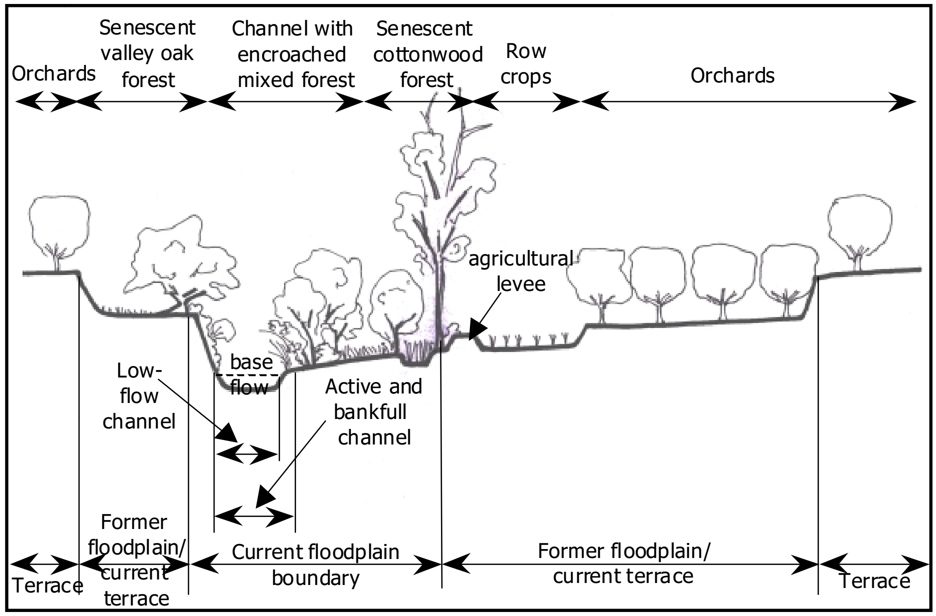


Figure 3-17. Schematic cross section of a regulated (dammed) river with encroached riparian vegetation.

At the same time, bedload stored in the river channel and floodplain downstream of the dams has been removed by gold dredging and aggregate mining. Downstream of the dams, an estimated 7–14 million tons of bedload, or 350–1,350 times the natural annual bedload supply from the upper watershed, has been removed from the channel by mining (Vick 1995). The in-channel mine pits affect sediment transport in the river by capturing coarse sediment that is in transport from upstream. Because flow velocity and channel gradient are low in the pits, all bedload being transported from upstream reaches deposits into the pit. Reaches downstream of the pits are deprived of upstream bedload supply, causing scour of the bed and banks to restore the bedload supply. The pits, therefore, are referred to as "impedance reaches." A total of 11 bedload impedance reaches have been identified in the Merced River (Table 3-3).

Floodplain Inundation

On the Merced River, flow reduction, gold dredging, and levee construction have significantly reduced floodplain extent. The extent of current and historical floodplains is shown in Figures 3-18A through D. In these figures, floodplains identified as "CF" are those that would be inundated by flows of 6,000 cfs. Floodplains identified as "CTFF" are located in areas that have been identified as current terrace, former floodplain, or areas that were historically frequently inundated but that have been converted to terraces as a result of flow regulation (Stillwater Sciences, 2001a). The methods for identifying floodplains shown in these figures are described in Stillwater Sciences (2001a).

Flood control and subsequent conversion of floodplains to other uses have resulted in a 91 percent reduction in floodplain area throughout the 52-mile corridor (Stillwater Sciences 2001a). The greatest reduction in floodplain area occurred up-

[5]Historical aerial photographs used for this anaylsis did not extend downstream of RM 15.

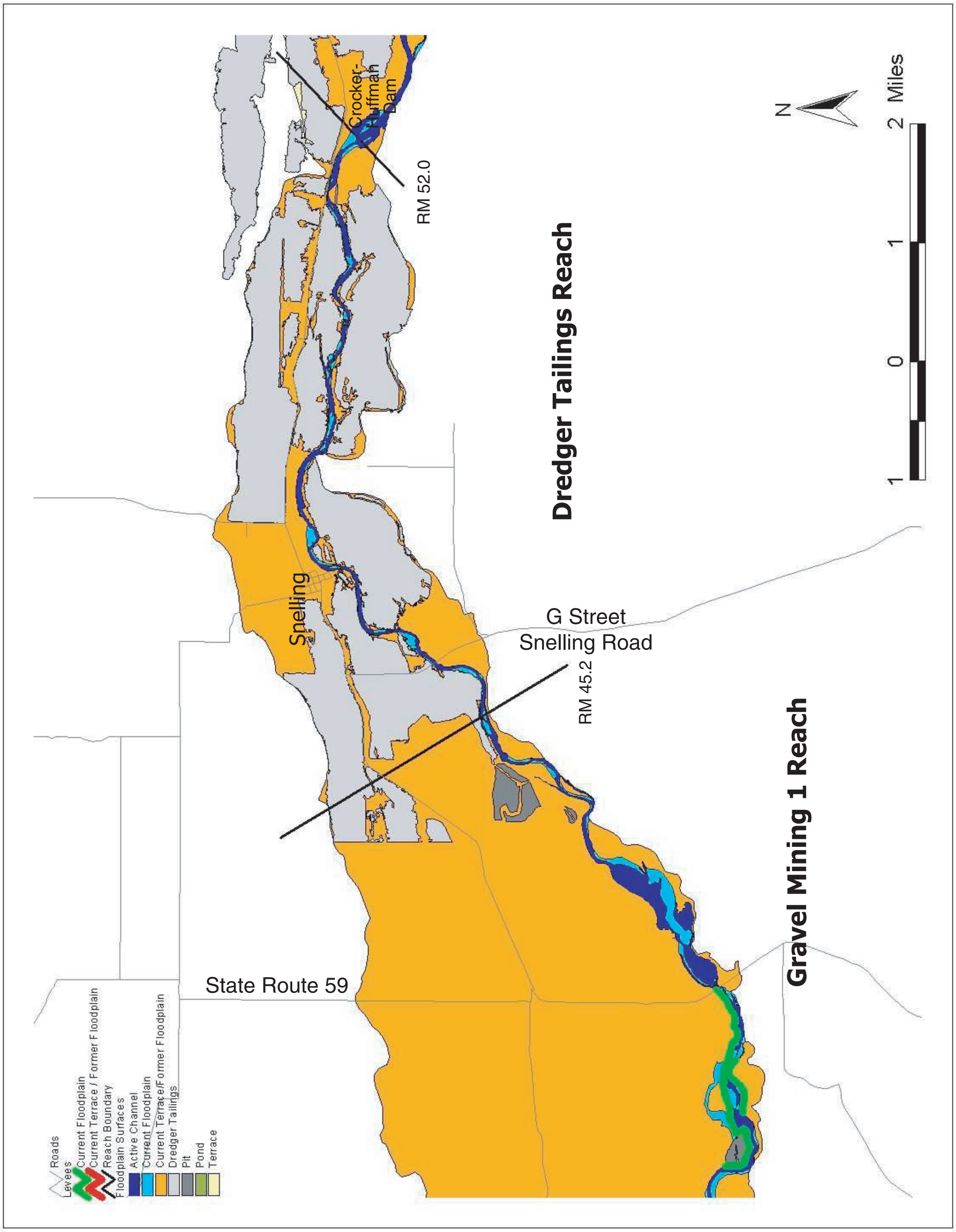


Figure 3-18A. Merced River current and historical floodplain and levees.

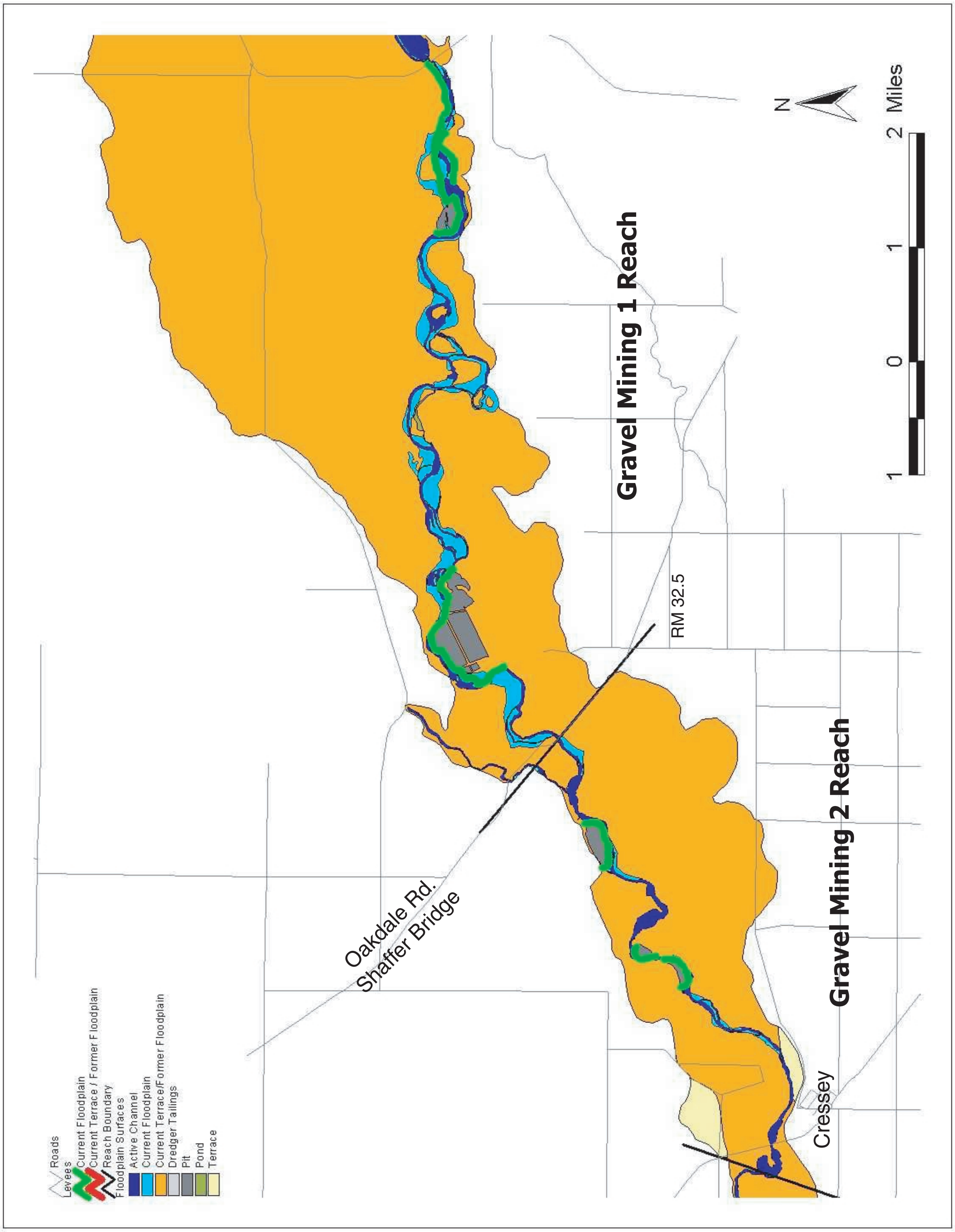


Figure 3-18B. Merced River current and historical floodplain and levees.

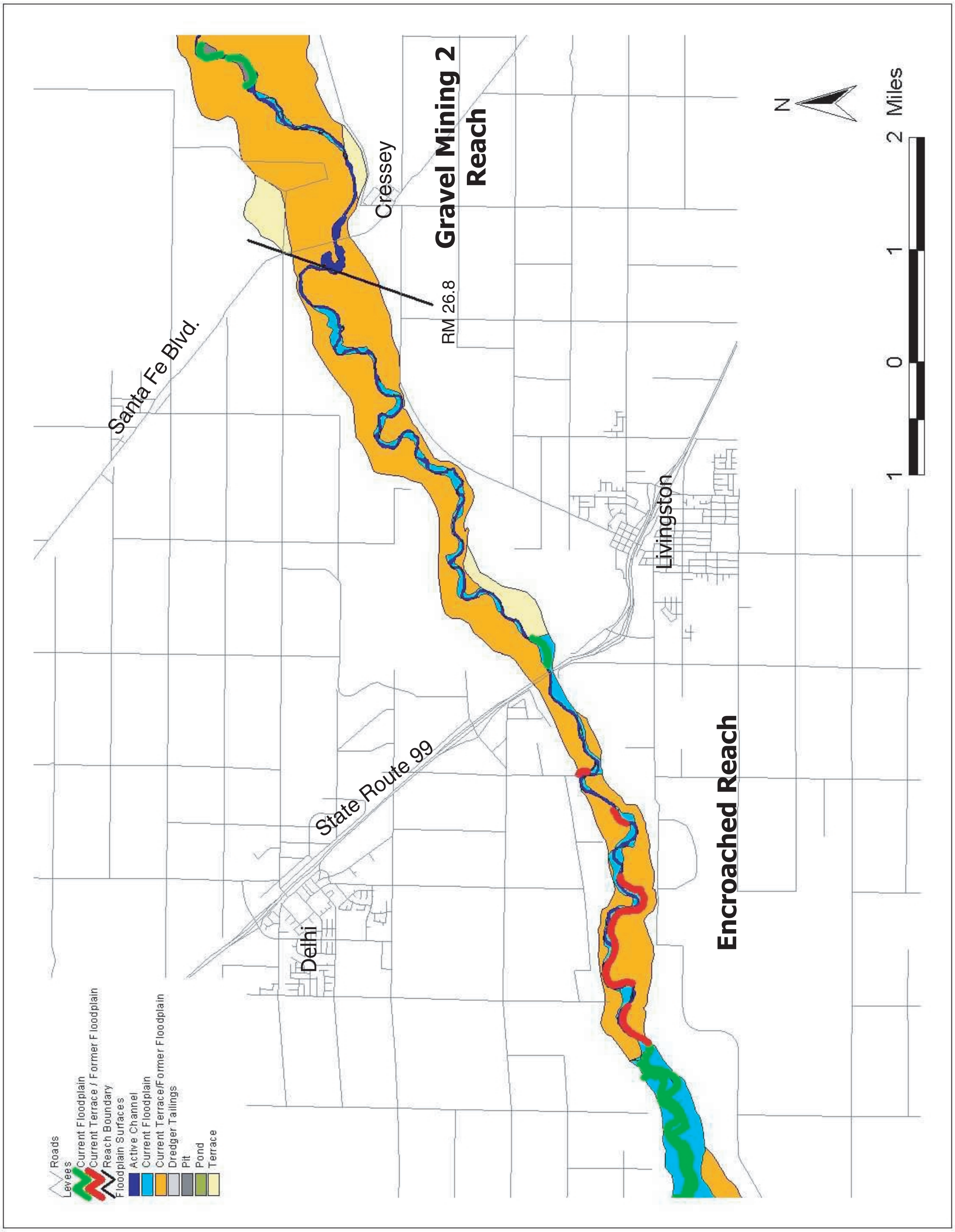


Figure 3-18C. Merced River current and historical floodplain and levees.

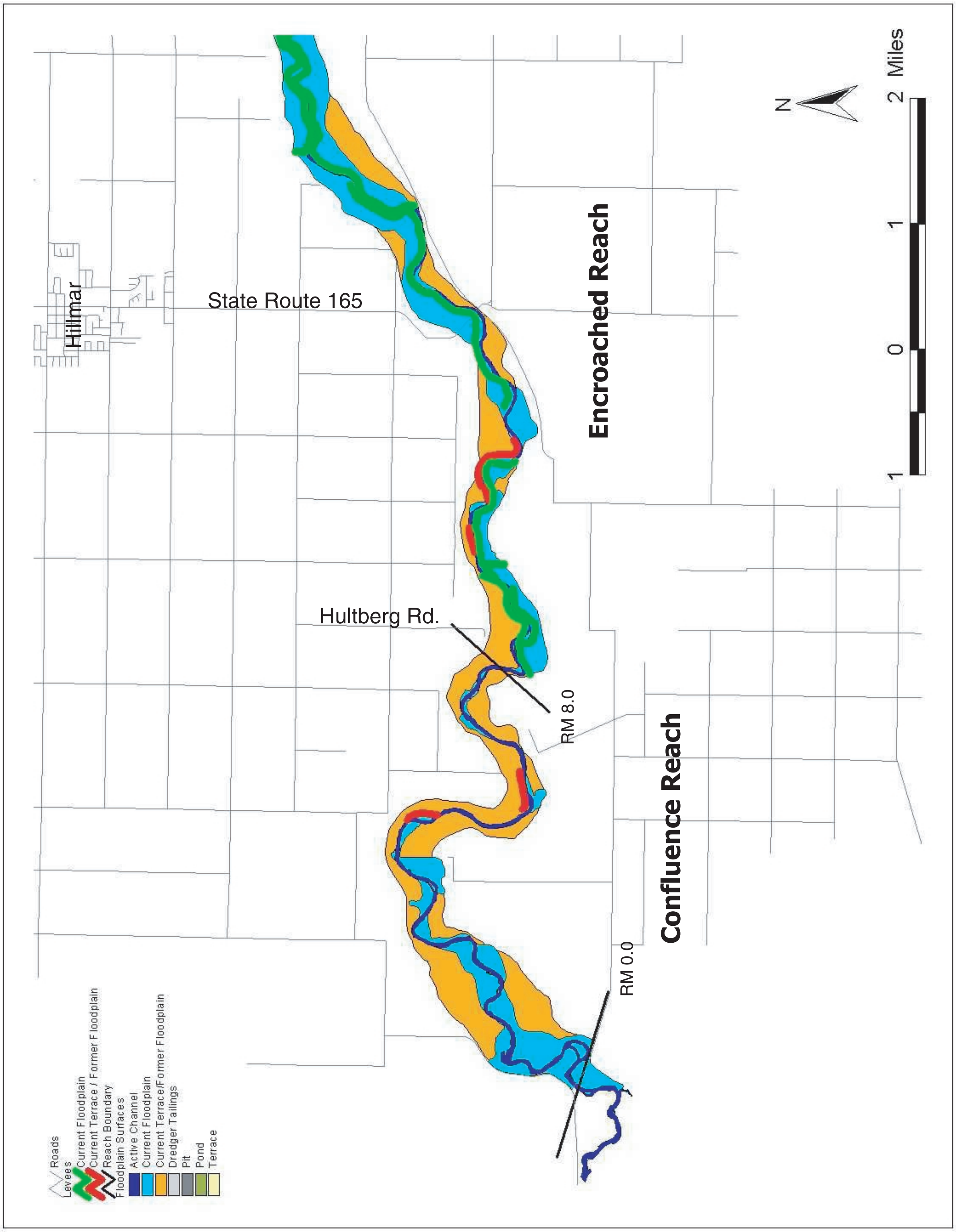


Figure 3-18D. Merced River current and historical floodplain and levees.

Table 3-3. Bedload Impedance Reaches in the Merced River

Reach Name	River Mile	Cause of Impedance
Dredger Tailings 1	50.8-51.4	Dredging
Dredger Tailings 2	50.4-50.6	Dredging
CDFG/CDWR Restoration Reach	40-43.5[1]	Aggregate mining
GM1 - C1	38.9-39.3	Aggregate mining
GM1 - C2	35.1-35.4	Aggregate mining
GM1 - C3	33.9-34.4	Aggregate mining
GM2-C1	31.5-32.1	Aggregate mining
GM2-C2	30.0-30.6	Aggregate mining
GM2-C3	28.7-28.9	Aggregate mining
GM2-C4	27.2-27.4	Aggregate mining
GM2-C5	26.7-27.1	Aggregate mining

[1] Note that Phase I (RM 40-40.5) of the restoration project has been constructed, and Phase II is under construction.

stream of Dry Creek, where the river was formerly a multiple-channel system extending across the alluvial valley floor. Under pre-colonial conditions, the floodplain width in this region averaged 6,533 feet. Under current conditions, flow regulation, elimination of floodplain channels, and gold dredging have reduced average floodplain width by 96 percent to 310 feet. Downstream of Dry Creek, the river was historically a single-thread system, and the pre-colonial floodplain averaged 2,834 feet in width. Under current conditions, flow regulation has reduced floodplain width in the lower reaches to an average of 387 feet, a reduction of 87 percent.

Levees have reduced floodplain width, although they generally have had less of an effect than flow regulation (Figure 3-19). Upstream of State Route 99, levees are isolated and discontinuous, occurring only at abandoned and reclaimed aggregate mine sites (Figures 3-18A through C). These levees function or historically functioned to isolate the river channel from floodplain and terrace aggregate mining pits. Downstream of State Route 99, levees are extensive, occurring along 73,074 feet (71 percent) of the channel length. These levees reduce the width of the current floodplain by as much as 53 percent and have the greatest impact in the reach between Santa Fe Boulevard Bridge (RM 27) and Hultberg Road (RM 8) (Figures 3-18C and D).

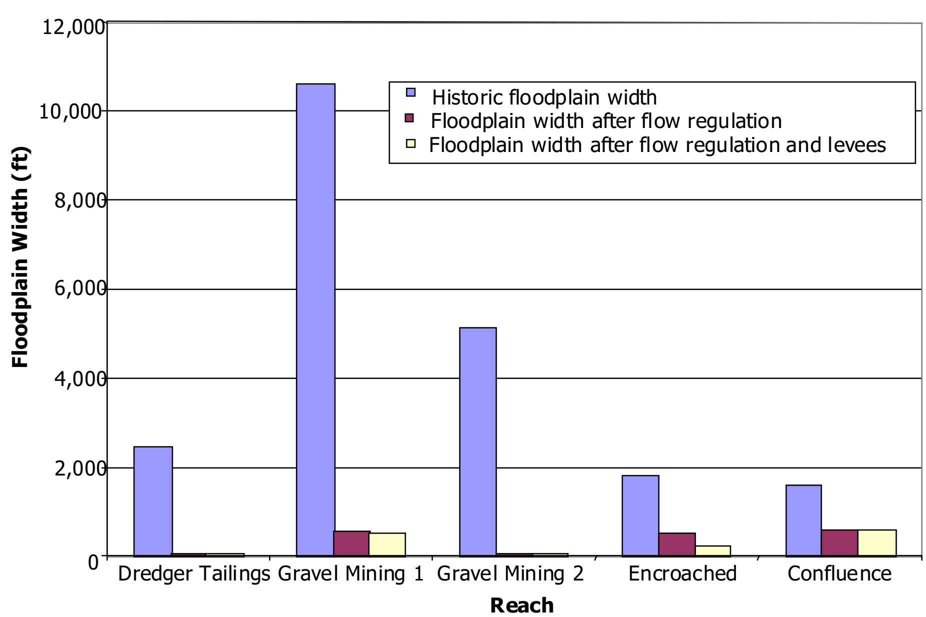


Figure 3-19. Merced River historical and current floodplain width, as affected by flow regulation and levee construction.

Channel Migration Potential

Channel migration involves the erosion of the floodplain on the outside of meander bends and the deposition of sediment on the inside of meander bends. Through this process, the channel moves laterally across the valley floor, while maintaining its equilibrium channel width. Channel migration is an important process for maintaining in-channel and riparian habitat diversity. During migration, the channel erodes deep scour pools and meander apexes. These pools provide important low-velocity, deep-water habitats for some native fish species. As the outer banks erode, trees fall into the river from the river bank, providing cover for fish and substrate for aquatic invertebrates, an important component of the aquatic food web. In addition, as the bar on the inside of the meander grows laterally, the abandoned bar deposits provide surfaces for recruitment of native riparian pioneer species.

Channel migration potential in the Merced River is limited by reduced flows, which reduce erosive force exerted on channel banks, and by dredger tailings and bank revetment, which armor the channel banks (Figures 3-20A through D). In the dredged area of the river, channel migration potential is limited by tailings, which armor nearly the entire extent of banks in the reach. Downstream of the dredged reach, bank revetment limits channel migration. Revetment is most extensive downstream of Santa Fe Boulevard (Figures 3-20C and D). From Santa Fe Boulevard to the confluence with the San Joaquin River, 32 percent of the river bank is covered with revetment.

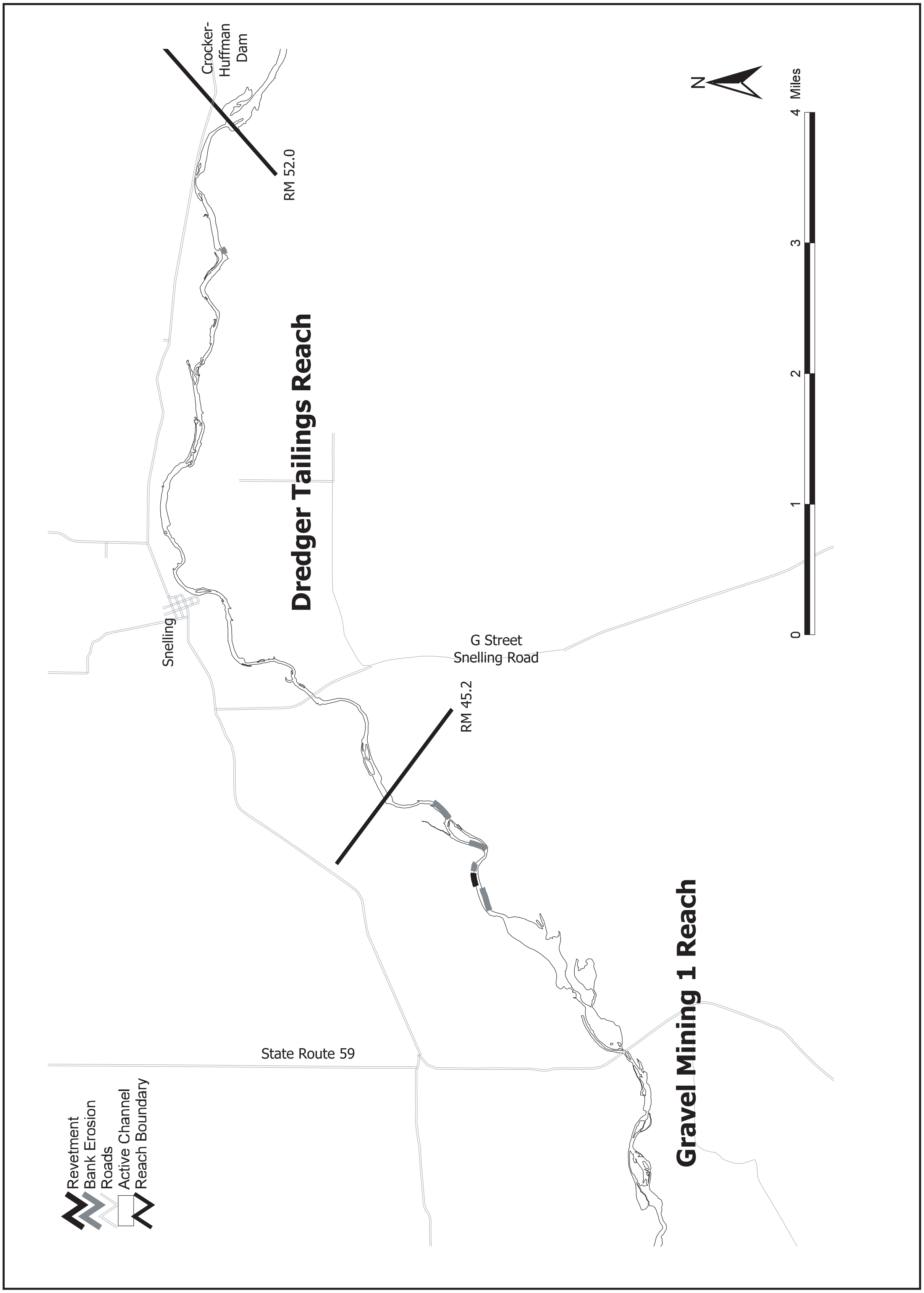


Figure 3-20A. Bank erosion and revetment in the Merced River.

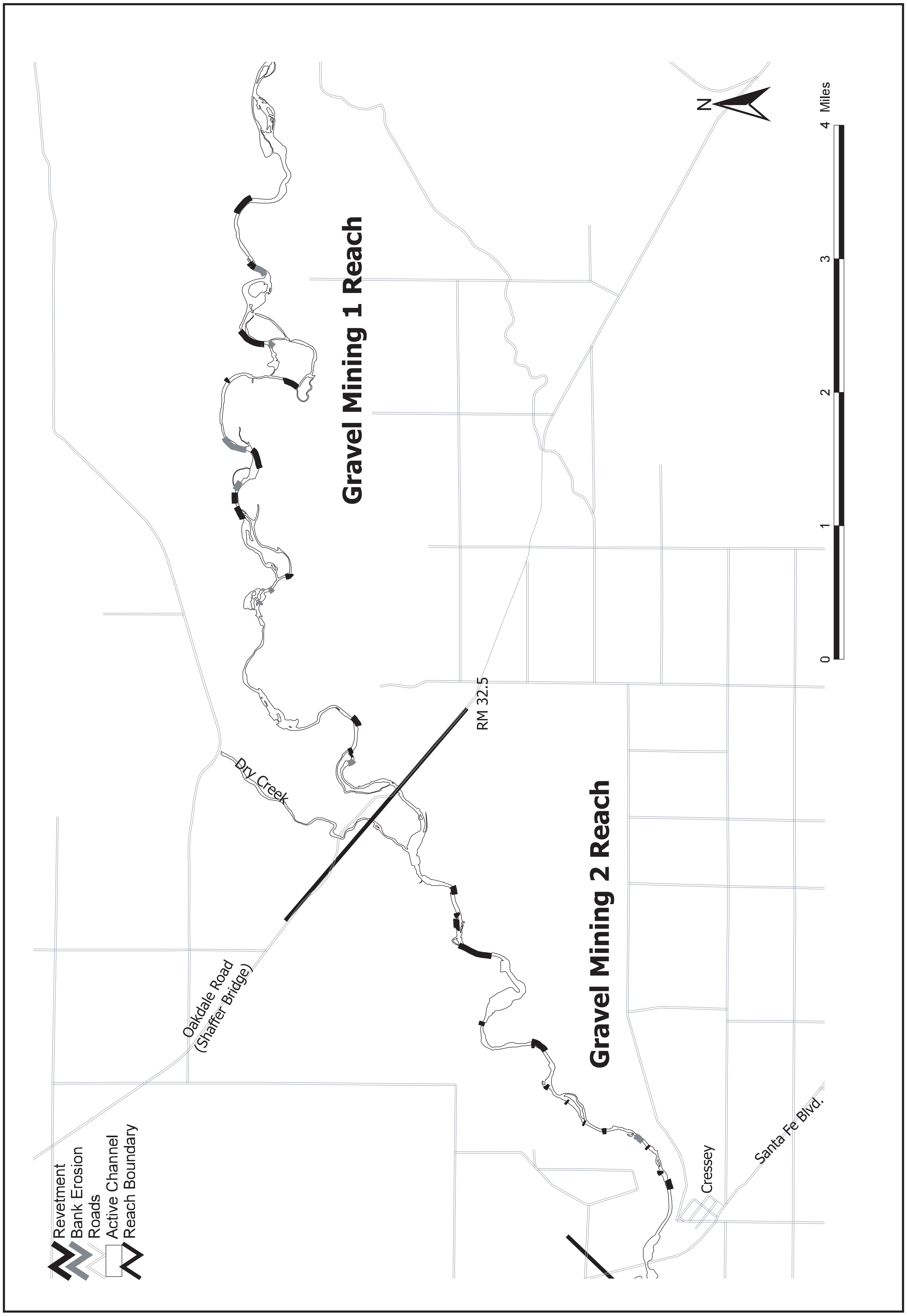


Figure 3-20B. Bank erosion and revetment in the Merced River.

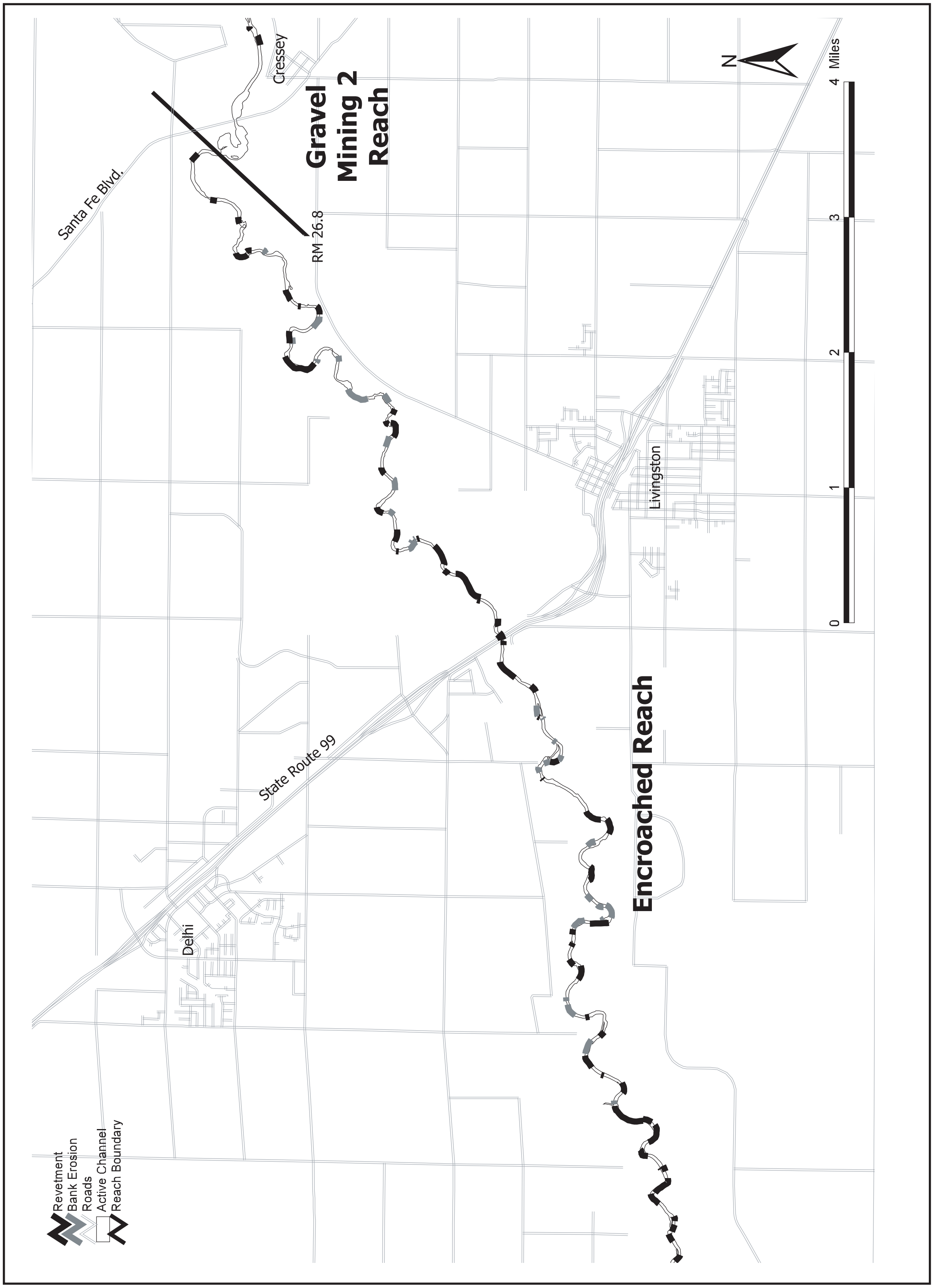


Figure 3-20C. Bank erosion and revetment in the Merced River.

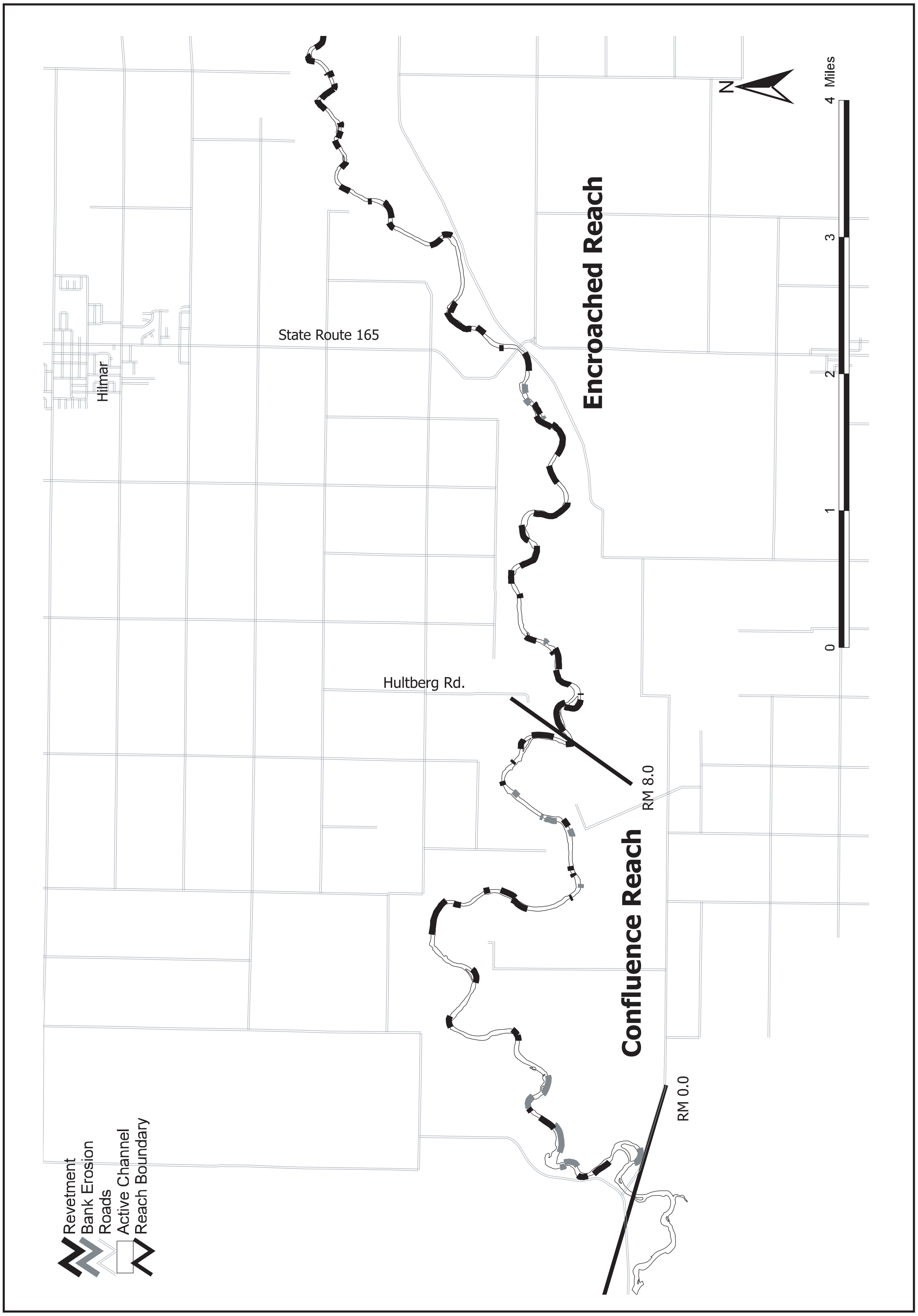


Figure 3-20D. Bank erosion and revetment in the Merced River.

3.3 Riparian Vegetation

Riparian vegetation performs many functions in natural river systems such as filtering runoff and nutrients, providing habitat for terrestrial wildlife, shading the river, and providing energy from leaf litter and woody debris that serves as habitat for in-stream organisms (Gregory et al. 1991, Mitsch and Gosselink 1993, Malanson 1993, Naiman and Descamps 1997). In California, over 225 species of birds, mammals, reptiles, and amphibians depend on riparian habitats, and riparian ecosystems harbor the most diverse bird communities in the arid and semi-arid regions of the western United States (Knopf et al. 1988, Dobkin 1994, Saab et al. 1995). In addition to high species richness, riparian areas during bird breeding season (May–June) can harbor individuals at densities up to ten times greater than the surrounding terrestrial habitats (RHJV 2000).

Studies of changes in riparian vegetation in the Central Valley indicate that the vast majority of historical riparian forest has been cleared since 1850. Katibah (1984) estimated that of 921,000 acres of pre-colonial riparian forest in the Central Valley, only 102,000 acres (11 percent) remain, of which 49,000 acres are in a “disturbed and/or degraded” condition. The 53,000 remaining acres of non-degraded vegetation represent less than 6 percent of the original total.

Several factors currently affect riparian forest extent, species composition, and health on the Merced River. Extensive areas of riparian forest in the valley were cleared to provide land for agriculture. Throughout most of the river corridor, the riparian forest is limited to a narrow bank adjacent to the river. Within this remaining forest, recruitment of new trees is hindered by reduced sediment supply and flood magnitude, and alteration of flood timing that have resulted from flow regulation. In addition, numerous non-native, invasive plant species have invaded the corridor. These factors and the current condition of the Merced River riparian forest are described in the following sections.

Riparian Vegetation Extent and Composition

The Merced River and its floodplain historically supported a diverse mosaic of dense riparian woodland, valley oak savannah, off-channel marsh habitats, and seasonal wetlands. While much of the Central Valley upland and foothills were historically covered by sparsely wooded grasslands, pre-colonial riparian zones supported dense, multi-storied stands of broadleaf trees, including valley oak (*Quercas lobata*), Fremont cottonwood (*Populus fremontii*), white alder (*Alnus rhombifolia*), western sycamore (*Platanus racemosa*), various willows (*Salix* spp.), Oregon ash (*Fraxinus latifolia*), box elder (*Acer negundo*), and other species (Thompson 1961, 1980, Holland and Keil 1995, Roberts et al. 1980, Conard et al. 1980). These riparian forests varied greatly in width, from a narrow strip in confined reaches to several miles wide on broad alluvial floodplains (Thompson 1961). Local accounts of the Merced River describe the rich aquatic and terrestrial fauna supported by these riparian habitats (Edminster 1998). Katibah (1984) estimates that the Merced River and the lower San Joaquin River (from the Merced confluence to Stockton) supported over 90,000 acres of riparian forest.

Currently, the Merced River riparian woodland downstream of Crocker-Huffman Dam is fragmented and narrow compared to historical accounts. The Merced River currently supports approximately 3,928 acres of riparian vegetation[6] (Stillwater Sciences 2001a). For comparison, the pre-colonial floodplain area covered an estimated 19,900 acres (Stillwater Sciences 2001a), though presumably not all of this area was covered by riparian woodland. Some of this area was covered by upland oak savannah and grassland, as well as large areas of grassland, slough, and wetland habitats (Edminster 1998). A wide range of vegetation conditions currently occurs in the Merced River corridor, from a thin band of trees one tree canopy wide in developed reaches to large patches of relatively intact floodplain forest near the confluence with the San Joaquin River. The dominant vegetation cover types typical of the Merced River corridor are listed in Table 3-4 and mapped in Figures 3-21A through D. Historical and current riparian vegetation at a typical location on the Merced River are shown in Figure 3-22.

Table 3-4. Merced River Vegetation and Other Cover Types and Distribution

Cover Type	Description and Habitat	Total Vegetation Coverage in the Merced River Corridor	
		Total Area (acres)	Percent of Total Vegetation Area
Herbaceous Cover	contains herbaceous plant communities, including grassland terraces, tailing transitional areas, and some seasonal wetlands	1,362	35
Mixed Riparian Forest	riparian hardwood forest often including Oregon ash (*Fraxinus latifolia*), white alder (*Alnus rhombifolia*), box elder (*Acer negundo*), valley oak (*Quercus lobata*), and willow (*Salix* spp.)	881	22
Cottonwood Forest	contains >50% Fremont cottonwood (*Populus fremontii*) and various subcanopy species combinations	439	11
Mixed Willow	contains almost exclusively willow, including narrow leaf willow (*S. exigua*), Goodding's black willow (*S. gooddingii*), arroyo willow (*S. lasiolepis*), and red willow (*S. laevigata*)	406	10
Valley Oak Forest	contains >50% valley oak, occurs on terraces, and younger stands have established on former floodplains that are no longer frequently inundated	342	9
Riparian Scrub	contains early seral stage vegetation (shrubs and small trees) of various species that may indicate some form of regular disturbance or scour	297	8
Marsh	areas with surface water supporting emergent plants, occurs in some backwater channels and in some dredger tailing swales	66	2

[6]Additonal patches of riparian hardwoods, primarily Fremont cottonwood and various willows, occur in the dredger tailings but were not quantified in the Merced River riparian vegetation mapping effort.

Table 3-4. Merced River Vegetation and Other Cover Types and Distribution, continued

Cover Type	Description and Habitat	Total Vegetation Coverage in the Merced River Corridor	
		Total Area (acres)	Percent of Total Vegetation Area
Blackberry Scrub	contains >50% Himalayan blackberry (*Rubus discolor*) or California blackberry (*R. ursinus*), occurs commonly adjacent to disturbed areas	47	1
Box Elder	contains >50% box elder, occurs commonly as monospecific stands in the lower river corridor	21	1
Eucalyptus	contains >50% eucalyptus (*Eucalyptus* spp), occurs commonly in monospecific stands on heavily modified banks	45	1
Giant Reed	contains clonal monospecific stands of giant reed (*Arundo donax*), occurs commonly on revetted or otherwise disturbed banks	12	<1
Tamarisk	contains almost exclusively tamarisk (*Tamarix* spp.), an invasive exotic plant	0.4	<1
Tree of Heaven	contains >50% crown canopy tree of heaven (*Ailanthus altissima*), an invasive exotic tree species	10	<1
Total for Vegetation Cover Types		**3,928**	**100**
Dredger Tailings	dredged floodplain areas, which include bare substrate and sparse non-native grasslands, isolated cottonwood and willow, and wetland and pond communities	4,308	N/A
Disturbed Riparian	contains primarily non-native plants which are associated with areas of disturbance, such as roadsides and revetted banks	19	N/A
Total for Other Cover Types		**4,327**	**N/A**
TOTAL		**8,255**	**N/A**

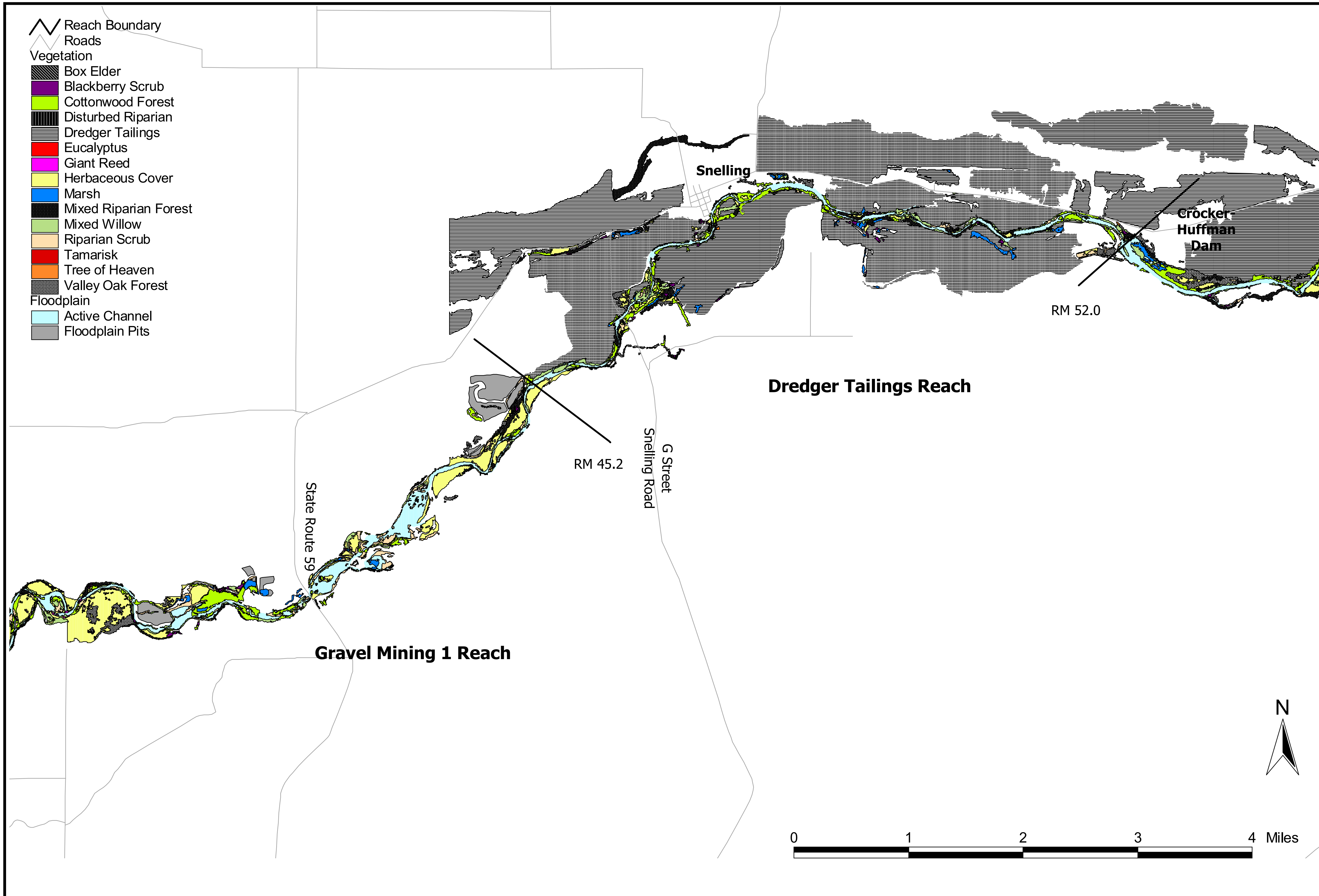


Figure 3-21A. Merced River vegetation distribution.

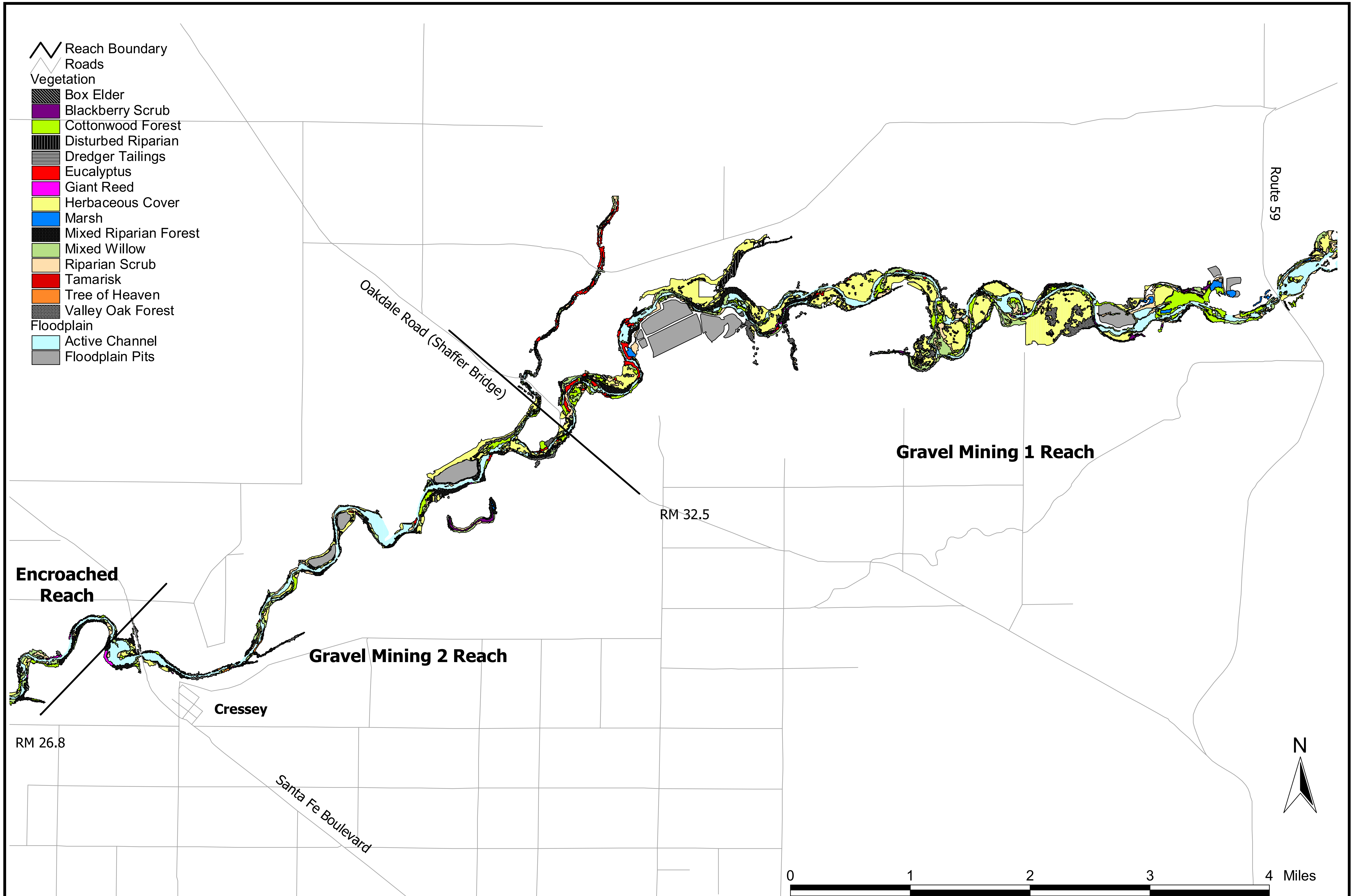


Figure 3-21B. Merced River vegetation distribution.

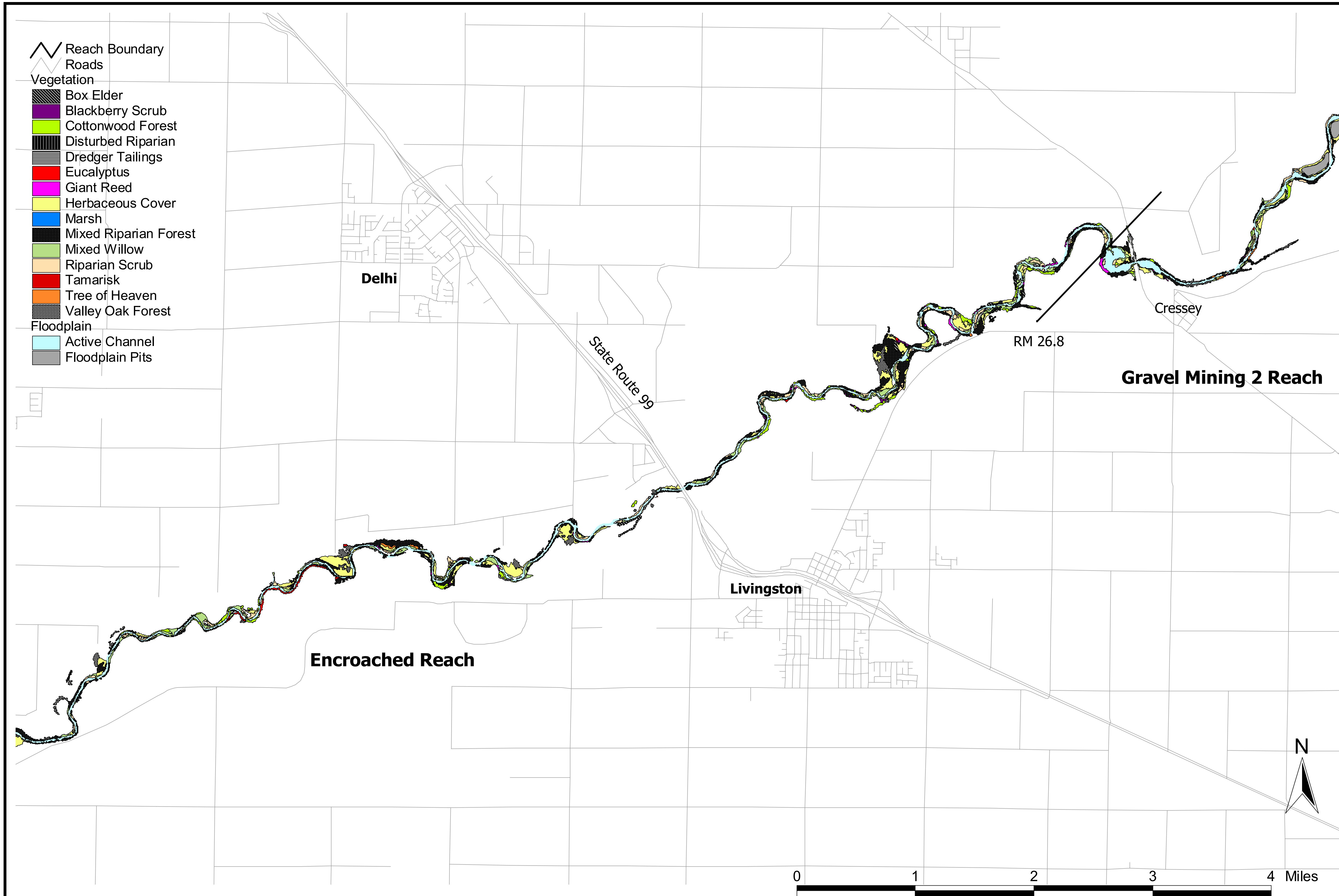


Figure 3-21C. Merced River vegetation distribution.

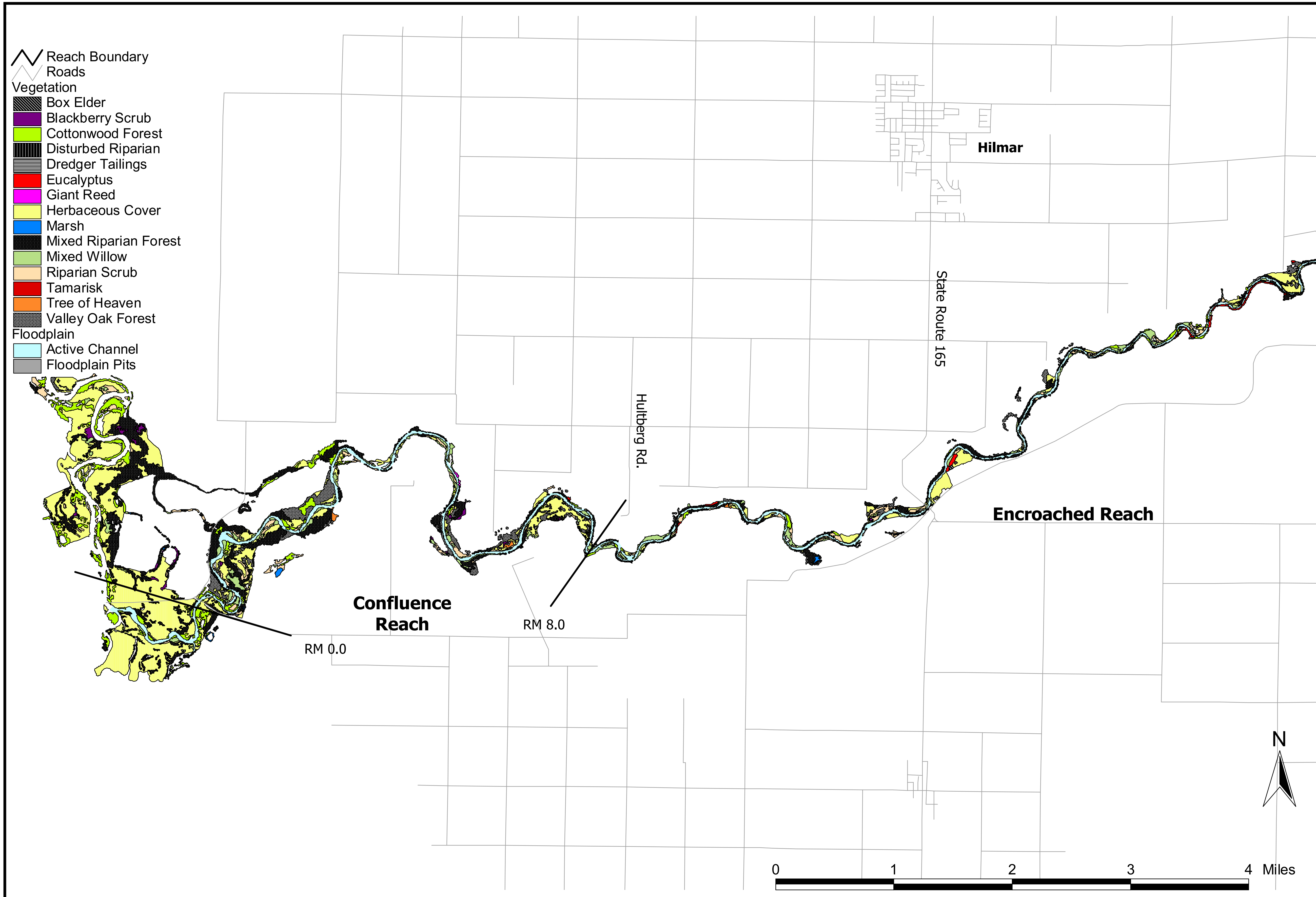


Figure 3-21D. Merced River vegetation distribution.

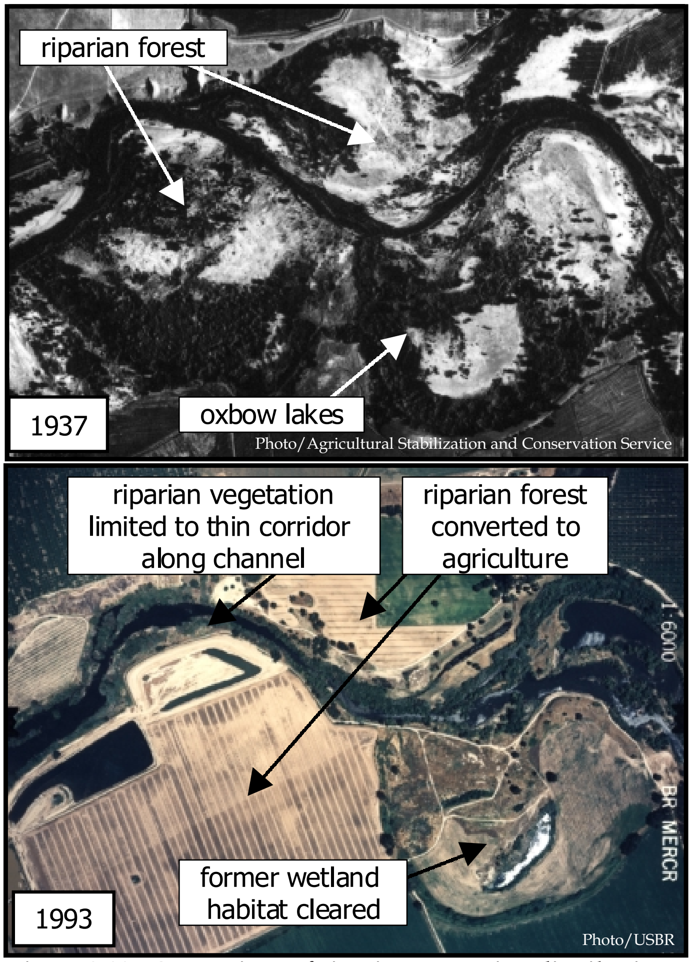


Figure 3-22. Comparison of riparian vegetation distribution in 1937 and 1993.

Riparian tree species on the Merced River demonstrate distinct patterns of zonation along an elevational and hydrologic gradient, with species occurring in the following toposequence (from lowest to highest mean elevation above baseflow): silver maple (*Acer saccharinum*) (non-native), white alder, button-willow (*Cephalanthus occidentalis* var. *californicus*), Oregon ash, arroyo willow (*Salix lasiolepis*), box elder, narrow-leaf willow (*S. exigua*), Fremont cottonwood, valley oak, edible fig (*Ficus carica*) (non-native), and California buckeye (*Aesculus californica*). At survey sites, elevation above summer baseflow was determined to be the best predictor of species occurrence (Stillwater Sciences, 2001b). Elevations above baseflow at which riparian species were observed are shown in Table 3-5. Silver maple, white alder, and button-willow occurred no more than 1–2 feet above summer baseflow elevation. Oregon ash, arroyo willow, box elder, narrow-leaf willow, and Fremont cottonwood occurred 3–4.5 feet above summer baseflow elevation. Valley oak, edible fig, and California buckeye occurred 6.8–7.9 feet above summer baseflow elevation.

Riparian Vegetation Recruitment

In addition to the loss of riparian habitat to agriculture and resource extraction, riparian forests on the Merced River corridor have been affected by flow regulation and bank revetment, which have impaired the geomorphic and ecological processes that, under natural conditions, maintain vegetation recruitment and survival. Consequently, existing mature forest stands along the Merced River may be unsustainable relicts of pre-dam hydrologic regimes.

As discussed in Section 3.2.3, the reduction in bed scour resulting from flow regulation has allowed riparian vegetation to encroach into the formerly active river channel. Vegetation encroachment is one of the most widespread and potentially intractable effects of flow regulation on alluvial river systems (Pelzman 1973; Johnson 1994; Scott et al. 1996).

Table 3-5. Mean Elevation Above Baseflow at which Riparian Plant Species Occur

Species	Elevation above baseflow[1] (ft)	
	n	mean±s.e.[2]
Silver maple (*Acer saccharinum*)	9	0.2±0.7
White alder (*Alnus rhombifolia*)	56	1.2±0.3
Button willow (*Cephalanthus occidentalis* var. *californicus*)	53	1.8±0.3
Oregon ash (*Fraxinus latifolia*)	99	3.0±0.2
Narrow-leaf willow (*Salix exigua*)	102	3.7±0.2
Arroyo willow (*Salix lasiolepis)*	39	3.8±0.3
Box elder (*Acer negundo*)	31	3.8±0.4
Fremont cottonwood (*Populus fremontii*)	9	4.4±0.7
Valley oak (*Quercus lobata*)	138	6.8±0.2
Edible fig (*Ficus carica*)	20	7.7±0.5
California buckeye (*Aesculus californica*)	26	7.9±0.4

Source: Stillwater Sciences (2001b)

[1] Baseflow was defined as 205 cfs, which was calculated as the average of the mean monthly flows for July and August.

[2] Standard error uses a pooled estimate of variance.

In addition to allowing riparian vegetation to encroach into the formerly active channel, flow regulation has impaired the establishment of native riparian vegetation on the floodplain. Native riparian pioneer species have evolved life history traits that depend on natural fluvial processes, particularly spring snowmelt floods. Successful recruitment and establishment (i.e., survival to maturity) of pioneer riparian trees depends on local hydrologic conditions during the spring seed release period and flow patterns during the subsequent summer and fall (Mahoney and Rood 1993; 1998; Scott et al. 1996). For these species, particularly cottonwood, to establish, germination sites must be available during the spring seed release period at sufficiently high bank elevations to protect the seedlings from later scour and flooding. Peak flows during this period must be high enough to thoroughly wet these sites, and flow recession rates must be sufficiently gradual to allow seedlings to develop adequate root systems to ensure survival and vigorous growth in the first growing season. For early successional species such as willows and cottonwoods, recruitment occurs on the surfaces that are moist and bare during the brief (typically 2–3 week) spring period of seed release and viability (Braatne et al. 1996). This timing is species-specific and varies somewhat between years, depending on climatic conditions. Once germination occurs, seedling survival is limited in part by the rate of water table decline, which must be more gradual than the rate of seedling root growth, because cottonwoods and willows must maintain root contact with the water table and are not drought-tolerant. Physiological studies of maximum root growth rates after germination have documented approximately 1–1.5 inches per day for cottonwood, and <1 inches per day for several willow species (McBride et al. 1989; Mahoney and Rood 1993, 1998; Segelquist et al. 1993). Reductions in groundwater table elevations that exceed these potential root growth rates generally result in seedling mortality from desiccation.

On the Merced River, the reduction in sediment supply has reduced the deposition of fine sediment on the floodplain during flood events, thus reducing the creation of suitable substrates for seedling germination. The reduction in floodplain inundation and the shift of peak flows from spring to winter further reduces recruitment potential. Cottonwoods and willows germinate in large numbers on low bars but are killed annually by regulated winter flows. At the one site where seedling recruitment and survival were evaluated during 1999–2000, Fremont cottonwood, arroyo willow, and California button-willow germinated on a low sand bar and experienced high overwinter mortality from scour or prolonged inundation (Stillwater Sciences 2001a). If allowed to grow to maturity, these trees would further constrain the low flow margin and perpetuate the process of vegetation encroachment. Even where higher floodplain recruitment sites are available, current flow recession rates during the seed release period may limit the ability of seedlings to survive desiccation immediately after germinating. During 1999, the Merced River flow recession rate was within tolerable limits for seedling establishment (1.5 inches/day) during only the last part of the cottonwood seed release period, when flow was below 500 cfs and close to summer baseflow levels[7] (Stillwater Sciences 2001a). Before this point, new seedlings would not have survived desiccation because the bank dewatering rate was faster than their root growth rates.

As a result, riparian stands throughout the Merced River exhibit older age structures than are typical for bottomland river systems, and many stands contain large, senescent cottonwoods without sapling cohorts to replace them when they die. Current conditions suggest that riparian vegetation composition is shifting from a patchwork of pioneer and later-successional species to more homogenous mixed forest stands.

Native Plants and Plant Communities of Special Concern

Some native plant species and communities that occur in the Merced River corridor are of special concern due to their ecological importance in the riparian zone, their declining prominence within California's remnant native riparian assemblages, or their role as key habitat for wildlife species. These communities and their distribution in the Merced River corridor are described below.

Cottonwood forest

Cottonwood forest is a multi-layered, native riparian forest type that was once widespread throughout the Central Valley. Fremont cottonwood is the dominant overstory-forming species within this forest type, commonly reaching heights of 75 feet or more. Goodding's black willow (*Salix gooddingii*) is often a co-dominant tree in the overstory canopy layer. The subcanopy layer may include various willow species, box elder, and Oregon ash. California walnut (*Juglans californica*) and western sycamore (*Platanus acerifolia*) are also cottonwood associates throughout the Central Valley, though their current distributions within the Merced River corridor are limited to a few scattered individuals. The shrub layer typically includes various willows, California wild grape (*Vitis californica*), and California wild rose (*Rosa californica*). The ground layer varies from sparse to lush with a mixture of native and non-native grasses and forbs.


Photo/Stillwater Sciences

Because of land use practices that cleared large areas of riparian woodland and changes in flow conditions that impair recruitment and survival of cottonwoods and associated species, there is concern that cottonwood forests are declining in

[7]During 1999-2000 baseline evaluations of riparian vegetation on the Merced River, water table levels were not measured directly, but were assumed to equal the level of surface water. Though factors such as soil texture and upland subsurface water sources may also affect water table depth, riparian researchers studying bottomland alluvial rivers generally use surface water as a proxy for groundwater at coarse textured sites adjacent to the active channel (Mahoney and Rood 1998).

extent and condition in the Merced River corridor, as well as generally throughout the Central Valley. Currently, cottonwood forest covers a total of 439 acres within the Merced River corridor, comprising 11 percent of total vegetated riparian zone (excluding dredger tailing areas). Historically, this vegetation type was much more extensive, and its average patch size was likely much larger.

Most existing stands of cottonwood in the Merced River corridor are mature, and available evidence suggests that new stands are not being created under existing conditions. Most mature cottonwood forest patches on the Merced River occur on abandoned floodplains or in low-lying areas in the dredger tailings, where they appear to have colonized soon after dredging ceased.

Valley oak forest

Valley oak forest (also called valley oak woodland) is dominated by valley oak, one of California's endemic oak species. This hardwood forest type occurs below 2,400 feet elevation on riparian alluvial terraces and low hills throughout the Central Valley from Lake Shasta to northern Los Angeles County, as well as in California's Coast and Transverse ranges. Historically in California, valley oak woodlands formed patches and belts in riparian zones varying in width from a few hundred yards to a few miles (Holland and Keil 1995). Valley oak forest is a community of special concern because of its limited distribution, severe reduction in extent compared to historical times, and currently inadequate regeneration processes (IHRMP 1996).

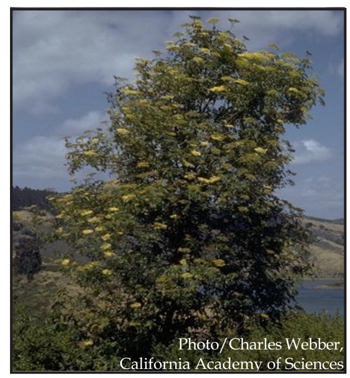
Valley oak forest typically consists of an overstory canopy dominated by valley oak and an understory dominated by grasses and annual forbs. Associated tree species include western sycamore, California black walnut, box elder, Oregon ash, interior live oak (*Quercus wislizenii*), California buckeye, and blue oak (*Quercus douglasii*). In lower, wetter areas common associates include Fremont cottonwood and various willows (IHRMP 1996). This vegetation type is typically best established on the highest parts of the floodplain and on terraces, where it is less subject to physical disturbance but still receives annual subsurface irrigation and periodic inputs of silty alluvium during larger flood events. The valley oak forest canopy averages 50–65 feet in height, and mature dominant trees can reach 120 feet. Canopy closure in valley oak forest type varies from open (representing a savanna or woodland phase) to dense (true forest). Dense stands occur along natural drainages in deep soils, and tree density tends to decrease with increasing elevation from lowlands to uplands (IHRMP 1996).

In many areas of California, valley oak recruitment is not sufficient to replace mature trees lost to natural and human causes. Likely causes of reduced recruitment include competition for moisture with grasses and forbs, acorn predation and seedling grazing by wild and domestic animals, and alteration of the natural flooding regime. In upland areas, fire suppression has limited valley oak recruitment by encouraging competition from drought-tolerant upland trees (IHRMP 1996). Currently, many valley oak woodlands occur as isolated stands within areas heavily modified by agricultural, urban, and suburban development. Most valley oak woodland patches occur on private lands, necessitating cooperative conservation efforts between private landowners, public agencies, and conservation organizations.

As is common throughout the Central Valley, most of the native valley oak forest habitat along the Merced River corridor has been lost due to human activities such as agriculture, firewood harvesting, dredger mining, and urban and suburban development. Though the historical extent of valley oak forest is difficult to determine because many stands were cut for firewood or cleared for agriculture before any accurate records were kept (Holland and Keil 1995), current estimates indicate that up to 90 percent of the original woodlands of the Central Valley have been lost (Crawford 2000). Valley oak forest currently covers 342 acres within the Merced River corridor, comprising nine percent of all vegetation mapped (Stillwater Sciences 2000a)

Blue elderberry

Blue elderberry (*Sambucus mexicana*) is a native plant of special concern which occurs in the Merced River riparian zone. It grows as a shrub or small tree and is the unique habitat for the valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), which is listed as threatened under the federal Endangered Species Act (CDFG et al. 2001). The valley elderberry longhorn beetle historically occurred throughout the Central Valley from Redding (Shasta County) to Bakersfield (Kern County) but population levels are declining (Arnold et al. 1994). In addition to their value as habitat for the beetle, mature elderberry plants produce edible berries, which are an important source of summer food for many species of songbirds and small mammals (Martin et al. 1951). Blue elderberry shrubs are common along the Merced River corridor and typically occur in fully or partially open areas higher on the bank than willow and California button willow. Its occurrence is sporadic in the upper reaches of the Merced River, but densities generally increase in downstream reaches. Near the confluence with the San Joaquin River, blue elderberry is a prominent understory species in various forest cover types and an overstory tree in herbaceous cover type patches on remnant floodplains.



Western sycamore

Western sycamore, a native riparian tree species, occurs in small stands on many Central Valley rivers, but historical accounts and field observations indicate that it does not commonly occur in the Merced River corridor. London plane tree (*Platanus x acerifolia*), a non-native sycamore species planted as a landscape tree, is observed more frequently on the Merced River, typically as naturalized individuals scattered within mixed riparian forest stands. These individuals may be hybrids of western sycamore and London plane trees, since introgression has occurred between the two species within California (T. Dudley, pers. comm., 2001). London plane trees were likely introduced into the Merced River corridor as landscape trees planted on farms, in public parks, and on urban streets. Numerous naturalized trees were observed within the riparian zone in the vicinity of State and County parks along the river.

Non-native Invasive Plant Species in the Merced River Corridor

The Merced River riparian corridor, like most California landscapes, is host to many non-native invasive plant species. Invasive plants can threaten natural habitat value by displacing native plant species and associated animal species. Invasive species documented in the Merced River corridor, the locations where they were observed, and their general invasiveness are shown in Table 3-6. Table 3-6 includes

Table 3-6. Primary Non-native Plant Species Occurring in the Merced River Corridor

Non-native Species (or assemblage)	Observed Distribution within the Merced River Riparian Zone	General Invasibility[1]	CalEPPC Exotic Pest Plant List[3]
Woody or Persistent Perennial Species			
Eucalyptus (*Eucalyptus* spp.)	widely established on Dry Creek and on the mainstem river at the Dry Creek confluence	Moderate	A-1
Tree of Heaven (*Ailanthus altissima*)	commonly distributed throughout the river corridor; dense patches occur at Merced Falls Road between Crocker-Huffman Dam and Snelling, McConnell Park, and along the irrigation canal at RM 3.5	Moderate	A-2
Giant reed (*Arundo donax*)	occurs from Crocker-Huffman Dam to San Joaquin confluence, primarily small patches on disturbed areas such as revetted banks	Serious	A-1
Himalayan berry (*Rubus discolor*)	widespread in disturbed riparian areas such as roadsides and revetted banks and adjacent to fields, less common in undisturbed areas where native blackberry is common	Moderate	A-1
Edible fig (*Ficus carica*)	occurs in disturbed riparian areas, especially in the Dredger Tailings Reach, both in full sun on tailings and adjacent to fields and in mixed riparian forest understory	Potential	A-2
Tamarisk (*Tamarix* spp.)	generally absent from the river corridor; one patch documented on Merced Falls Road, between Merced Falls and Crocker-Huffman Dam	Serious	A-1
Tree tobacco (*Nicotiana glauca*)	common understory shrub on leveed banks downstream of Dry Creek	Moderate	not listed
Pokeweed (*Phytolacca americana*)	increasing abundance towards San Joaquin River confluence	Unknown	not listed
Mulberry (*Morus alba*)	occurs between McConnell Park and San Joaquin River confluence, potentially naturalized from landscaped areas.	Moderate	not listed
Silver maple (*Acer saccharinum*)	scattered within mixed riparian forest near Snelling, presumed to occur throughout Dredger Tailings Reach	Unknown	not listed
London plane tree (*Platanus* x, *acerifolia*)	occurs in Hatfield Park, McConnell Park, Henderson Park, and naturalized within mixed riparian forest	Moderate	not listed

Table 3-6. Primary Non-native Plant Species Occurring in the Merced River Corridor, continued

Non-native Species (or assemblage)	Observed Distribution within the Merced River Riparian Zone	General Invasibility[1]	CalEPPC Exotic Pest Plant List[3]
Osage orange (*Maclura pomifera*)	occurs in mixed riparian forest and in subcanopy in Dredger Tailings Reach	Moderate	not listed
Herbaceous Species			
Non-native annual grassland assemblages	occurs on high floodplains, terraces, dredger tailings, and high-flow channel beds throughout the river corridor	see note[2]	not listed
Yellow star thistle (*Centaurea solstitalis*)	occurs on high floodplains and terraces throughout the river corridor, and as large, dense patches near Stevinson	Serious	A-1
Black mustard (*Brassica nigra*)	occurs as significant component of herbaceous areas	see note[2]	B
Poison hemlock (*Conium maculatum*)	occurs in disturbed grasslands throughout the river corridor	Moderate	B
Lamb's quarters (*Chenopodium* spp.)	occurs on gravel bars throughout the river corridor	Moderate	not listed
Knotweed (*Polygonum* spp.)	occurs on river margins, high-flow channels, and wetlands throughout the river corridor	Moderate	not listed
Aquatic Species			
Water hyacinth (*Eichhornia crassipes*)	not common within river channel, some patches occur in ponds in Dredger Tailings Reach	Serious	A-2
Brazilian water weed (*Egeria densa*)	distribution not well-known, but dense beds occur in the active channel and in dredger tailings ponds	Serious	A-2

[1] Sources: Randall et al. (1998), Dudley (1998), Dudley and Collins (1995), EPA/SFEI (1999), McBride, pers. comm. (2000).
[2] Not rated by sources cited, but already widespread (i.e. invasion has already occurred in many areas).
[3] Designations from the California Exotic Pest Plant Council 1999 list of Exotic Pest Plants of Greatest Ecological Concern in California (CalEPPC 1999). The most invasive wildland pest plants with widespread distributions are designated A-1, whereas those with regional distributions are designated A-2. Wildland pest plants of lesser invasiveness are designated B.

species that were identified and mapped during riparian vegetation surveys on the Merced River in 2000 (Stillwater Sciences 2000a) and is not an exhaustive list of the non-native, invasive species that could occur in the river corridor. Additional species have the potential to occur on the Merced River, such as parrot's feather (*Myriophyllum aquaticum*), an invasive aquatic plant which was recently observed in the Merced River (B. Orr, pers. obs., 2001). The most highly invasive species documented in the river corridor include eucalyptus (*Eucalyptus* spp.), tree of heaven (*Ailanthus altissima*), giant reed (*Arundo donax*), Himalayan berry (*Rubus discolor*), edible fig (*Ficus carica*), tamarisk (*Tamarix* spp.), yellow star thistle (*Centaurea solstitalis*), *Egeria* (*Egeria densa*) and water hyacinth (*Eichhornia crassipes*). These plant species are listed by the California Exotic Pest Plant Council (CalEPPC) as Most Invasive Wildland Pest Plants and are documented as aggressive invaders that displace native plants and disrupt natural habitats (CalEPPC 1999). Methods of controlling or eradicating these species are described in Appendix A.

Highly Invasive and/or Widespread Non-native Plant Species

Eucalyptus

On many Merced County farms, eucalyptus was planted beginning in the nineteenth century for shade, timber, and windbreaks. This species is a slow, though widespread, invader throughout California that, once established, makes its microenvironment hostile to native species by altering soil chemistry and reducing the availability of light, water, and nutrients. Its widespread establishment along the lower portion of the Merced River and Dry Creek make eucalyptus, along with tree of heaven, the non-native species of most concern in the corridor. Several large, monospecific stands of eucalyptus occur in the lower reaches of the Merced River. On Dry Creek, upstream of Oakdale Road, eucalyptus appears to be the dominant vegetation type. Eradication of eucalyptus is straightforward given adequate incentive and funding, though its fast growth and clonal root sprouting often necessitate multiple treatments. Eradication efforts should start in upstream and tributary areas, since these stands provide a persistent river-borne supply of seed and vegetative propagules to the lower river and represent a constant source for reintroduction. The Merced River corridor is also supplied with land-borne eucalyptus propagules from eucalyptus windbreaks, which often border or terminate at the riparian zone.


Photo/Tony Morosco

Tree of heaven

Tree of heaven is the second-most prevalent non-native tree in the Merced River corridor (after eucalyptus) and is the most aggressive invader. Introduced from Asia as a landscape tree (and as a symbol of good luck at the entrances to mines), this tree has fast-growing stems and roots. It is extremely tolerant of wildfires and re-sprouts vigorously afterward. Along road-sides and fields in the river corridor, tree of heaven has invaded former valley oak woodlands in several areas and has formed dense, spreading stands consisting of large, older trees with many sapling root sprouts forming a spreading invasion front. Dense tree of heaven stands occur in the Merced River corridor along Merced Falls Road between Crocker-Huffman Dam and Snelling, on the south bank of McConnell State Recreation Area, and on the south bank of the river at RM 3.5 as a dense thicket lining an irrigation canal.


Photo/Stillwater Sciences

Giant reed

Giant reed is a highly aggressive, naturalized landscape plant that invades riparian zones by establishing dense, monospecific clonal stands. This species is drought- and fire-tolerant (its foliage is highly flammable), and resprouts vigorously after fire by quickly exploiting released nutrients. Giant reed is also very shade-tolerant, establishing under full canopy and exposing the dominant trees to increased fire threat. The species does not propagate by seed (all plants in the U.S. are sterile), and establishment occurs exclusively by vegetative propagules–most often rhizomes that wash downstream from eroded banks. Most commonly, the plant is introduced in disturbed areas such as roads, revetted banks and bridge abutments where native vegetation has been cleared. Giant reed is a strong competitor in systems with increased nutrient supply, and fertilizer movement may be an important factor aiding its dominance in many California riparian areas.

Isolated giant reed stands occur throughout the Merced River corridor, particularly on revetted banks and where agricultural fields extend completely to the river bank. The plant represents one of the most serious exotic pest species in the Merced River corridor and, without control and eradication measures, has a high probability for continued aggressive invasion.

Himalayan blackberry

Himalayan blackberry is widespread in disturbed riparian areas throughout the river corridor such as roadsides, revetted banks, cleared fields, and dredger tailings. This species is less common in interior, undisturbed riparian forest stands, where the native California blackberry (*Rubus ursinus*) is more common, suggesting that invasion of Himalayan blackberry follows routes of disturbance. Himalayan blackberry closely resembles its native counterpart, but can be distinguished by its larger and more curved thorns, its reddish (versus bright green) stem, and its leaves commonly arranged as clusters of five (as opposed to three) leaflets.

Edible fig

Edible fig is an agricultural and landscape plant that is naturalized and pervasive throughout the Merced River riparian zone. It has broad leaves, sweet, wasp-pollinated fruit, and can form dense, monospecific thickets up to 25 feet high. This species forms a significant component of the mixed riparian forest understory, usually on the landward edge of the riparian zone at higher bank elevations and drier soil conditions. Edible fig tolerates shade and well-drained soils, and occurs as a major cover on dredger tailings, gravel bars, road sides, and other disturbed landscapes.

Tamarisk

In contrast to riparian zones in the Sacramento Basin and southern California, tamarisk is not a major invader in the Merced River corridor. Tamarisk recruitment and establishment mirrors that of willows and cottonwood species, requiring open, fine-grained bars to be adequately moist during the brief seed release and viability period. The timing of this period varies by species: *Tamarisk parviflora*, which is distributed in coastal systems, flowers in spring, whereas *T. ramossisima*, a more invasive species, flowers sporadically over the long summer in southern California and has successfully invaded many riparian zones there.

Photo/National Park Service's Plant Conservation Alliance, Alien Plant Working Group

One tamarisk stand, which was likely planted for landscaping, was noted along Merced Falls Road between Merced Falls and Crocker-Huffman Dam. No stands of tamarisk were observed adjacent to the river during boat surveys.

Yellow starthistle

Photo/UC Integrated Pest Management Project

Ubiquitous within California grasslands, yellow star thistle is a low-growing, small-flowered herbaceous species which aggressively invades disturbed areas, pastures, and roadside clearings. This species is present throughout the Merced River corridor. A native of southern Europe, yellow starthistle was introduced in California between 1848 and 1869. As of 1995, it is estimated to have invaded 10–12 million acres in California (Bossard et al. 2000). Infestations of yellow starthistle can displace native plants and animals, deplete soil moisture reserves in annual grasslands (Gerlach, unpublished data), interfere with grazing, and reduce land values. The Sacramento and northern San Joaquin valleys are two areas where yellow starthistle is most widespread in California.

Water hyacinth

Water hyacinth, an aquatic plant, is native to South America, but has been naturalized in most of the southern United States and in many of the world's subtropical and tropical climates. This species spreads rapidly in waterways and forms dense mats on lakes, ponds, and backwater river habitats. Water hyacinth infestations have been known to foul irrigation pumps and block not only salmon migration, but also boat traffic in canals and waterways. Water hyacinth reproduces asexually by breaking into pieces and colonizing new areas. Possibly the greatest propagator of water hyacinth is the active transport by people who introduce it into ponds and lakes for aesthetic reasons. The California Department of Boating and Waterways (CDBW) has used mechanical, biological, and chemical measures to control the spread of water hyacinth, with chemical herbicides proving to be the most effective method (CDBW 2001). In March 2001, the Ninth Circuit Court of Appeals ruled that it is illegal to apply an aquatic herbicide to control aquatic plants such as water hyacinth without first obtaining a National Pollutant Discharge Elimination System (NPDES) permit. The State Water Resources Control Board has since approved an interim NPDES permit process (T. Selb, pers. comm., 2001).

Photo/Stillwater Sciences

Egeria
Egeria densa is a perennial freshwater aquatic plant native to South America. *Egeria* forms dense underwater mats of vegetation that obstruct navigation and recreation, slow water flows, plug agricultural irrigation systems, and disrupt natural ecosystems. The plant is believed to have been introduced to California waterways through discarded plant material via the aquarium trade. Currently, *Egeria* occurs in freshwater ponds, lakes, reservoirs, and slowly-flowing streams in the Sierra Nevada, Central Valley, San Francisco Bay, and San Jacinto Mountains (Bossard et al., 2000). The distribution of *Egeria* in the Merced River is not well-known, but dense beds have been observed in the active channel and in dredger tailings ponds (Stillwater Sciences 2001a). The CDBW is currently conducting research on mechanical and chemical control methods and is completing an Environmental Impact Report for the implementation of the *Egeria Densa* Control Program for the Delta (CDBW 2001).


Photo/R. O'Connell, California Department of Food and Agriculture, Botany Laboratory

Annual grasses
Several non-native grass species that pose a significant threat of invasion to wildlands are established in the Merced River corridor, including slender wild oat (*Avena barbata*), common wild oat (*Avena fatua*), rip-gut brome (*Bromus diandrus*), soft chess brome (*Bromus hordeaceus*), red brome (*B. madritensis* ssp. *rubens*), cheat grass (*B. tectorum*), foxtail barley (*Hordeum murinum*), annual ryegrass (*Lolium multiflorum*), rabbitsfoot grass (*Polypogon monspeliensis*), rat-tail fescue (*Vulpia myuros*), and annual fescue (*Vulpia* spp.). Prior to the late 1800s, native grasslands and oak woodlands (which contained a native grass understory) covered approximately 25 percent of California's land area (Holland and Keil 1995). Native grassland species were primarily perennial bunchgrasses such as purple needle grass (*Nassella pulchra*), California oatgrass (*Danthonia californica*), deergrass (*Muhlenbergia rigens*), pine bluegrass (*Poa secunda*), blue wild-rye (*Elymus glaucus*) and various squirreltails (*Elymus elymoides* and *E. multisetus*), fescues (*Festuca californica* and *F. idahoensis*), and melic grasses (*Melica californica* and *M. imperfecta*). These grasses dominated the Central Valley and coastal grasslands from the end of the last ice age until the arrival of Spanish colonists in the seventeenth century.

Beginning in the Mission period and continuing throughout the nineteenth and twentieth centuries, non-native grass species were transported to California from the Mediterranean region in packing, ballast, grain shipments, hay, and livestock. The combination of overgrazing by introduced domestic cattle, sheep, and horses, suppression of the natural wildfire regime, and intensive land conversion to agriculture greatly altered the ecology of the Central Valley grasslands and shifted the competitive advantage from native bunchgrasses to introduced annual species. Ecosystem nitrogen inputs also tend to favor Mediterranean grasses over native species. Today, Central Valley grasslands are dominated by annual, non-native species, primarily from the Mediterranean region. Eradication of the non-native species listed above is not feasible except in small areas that are isolated from potential non-native seed sources and where aggressive management, including seeding and controlled burning, is implemented.

Other Potentially Invasive Species

Several moderately invasive species also occur in the Merced River corridor, including tree tobacco (*Nicotiana glauca*), pokeweed (*Phytolacca americana*), black mustard (*Brassica nigra*), poison hemlock (*Conium maculatum*), and several *Chenopodium* and *Polygonum* species. CalEPPC lists some of these species as Wildland Pest Plants of Lesser Invasiveness since they spread less rapidly and cause a lesser degree of habitat disruption than the plants described above (CalEPPC 1999) or else does not list them because their distributions are limited primarily to disturbed areas such as roadsides and agricultural fields.

In addition, several non-native landscape tree species have naturalized within the riparian corridor, including mulberry (*Morus alba*), London plane tree, Osage orange (*Maclura pomifera*), and Lombardy poplar (*Populus lombardia*). Mulberry is widely distributed in low densities and appears to be a moderately aggressive invader. The other species are primarily agricultural or landscape plants and are not widespread or considered to be serious threats. Planted commonly in the state and county parks along the Merced River, mulberry trees have characteristic large, dark green, coarsely-toothed leaves. Naturalized individuals are scattered within mixed riparian stands throughout the river, particularly between McConnell State Recreation Area (RM 23.3) and the San Joaquin confluence (RM 0).

3.4 Fish and Wildlife

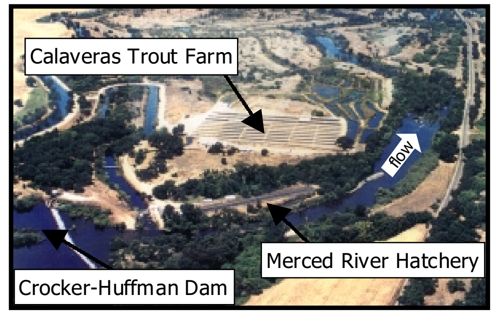
Anadromous Salmonids in the Merced River

Anadromous salmonids currently found in the Merced River include fall chinook salmon (*Oncorhynchus tshawytscha)* and, potentially, steelhead (*O. mykiss*). Fall chinook salmon is an important management species in the Merced River, and numerous state and federal resource programs include increasing the abundance of chinook salmon in their goals. Steelhead is also an important management species, although their occurrence and distribution in the Merced River is not well documented. Central Valley steelhead is listed as threatened under the federal Endangered Species Act, and the Merced River downstream of Crocker-Huffman Dam and the river's adjacent riparian habitat are included in the designated critical habitat for this species (NMFS 2000).

Chinook Salmon

Both spring and fall chinook salmon historically occurred in the Merced River. Historical accounts suggest that salmon occurred up to an elevation of approximately 2,000 feet near El Portal on the Merced River (Yoshiyama 1999). Currently only fall chinook salmon occur in the river; spring chinook salmon have been extirpated. By 1925, Crocker-Huffman, Merced Falls, and Exchequer dams had eliminated salmon and steelhead access to upstream habitats. Only the reach downstream of Crocker-Huffman Dam is accessible to anadromous salmonids. Crocker-Huffman and Merced Falls dams are equipped with fish ladders to allow upstream passage of adult salmon and steelhead. These ladders, however, were shut down when the Merced River Hatchery was constructed and are no longer in use.

Since 1971, CDFG has operated the Merced River Hatchery, located at the base of Crocker-Huffman Dam. The hatchery produces fall chinook salmon subyearlings for release into the Merced River and for studies throughout the San Joaquin Basin.



At the Merced River Hatchery, chinook salmon enter a fish ladder and trap at the entrance to an artificial spawning channel. Eggs and milt are harvested from the adult salmon captured in the trap, and eggs are fertilized and incubated at the hatchery. Maximum annual production is 960,000 smolts. The average take is 1.1 million eggs annually (T. Heyne, pers. comm., 2001). Maximum production of yearling salmon is 300,000 fish (CDFG and NMFS 2001). Approximately 40 percent of the smolts produced at the hatchery are released in the Merced River; the rest are used for study releases on the Tuolumne, Stanislaus, and San Joaquin rivers. Of those released in the Merced River, about 60 percent of the smolts are released at the hatchery, while the remaining 40 percent are trucked to other sites on the river (CDFG and NMFS 2001).

Recent fall chinook salmon escapement to the Merced River is shown in Figure 3-23. During the 1950s and 1960s, adult escapement averaged less than 500 fish annually, except in 1955. After 1967, adult escapement increased substantially, partially in response to increased flow releases from the New Exchequer Dam and releases of hatchery-reared fish to the river (including fish from the Stanislaus and American rivers) (Yoshiyama et al. 2000). Since 1967, escapement to the Merced River has averaged 4,645 (not including returning marked hatchery fish) and peaked at approximately 29,000 fish in 1984.

Chinook salmon life history and population dynamics in the Merced River are not well documented and will be investigated by a joint CDFG-Merced ID study program that is currently being developed. Some aspects of chinook salmon life history in the Merced River have been documented by past and on-going studies, such as redd surveys conducted by CDFG and outmigrant trapping conducted by CDFG and Merced ID. Chinook salmon life history timing for the Merced River is shown in Figure 3-24. Adult chinook salmon typically enter the Merced River to spawn from October through December, with arrivals peaking in November. Adults returning to Central Valley rivers are typically 2 to 4 years old, but the age composition of returning adults varies depending on juvenile survival and ocean harvest of each year class (Yoshiyama 1999).

The majority of chinook salmon spawning in the Merced River occurs upstream of the State Route 59 bridge (RM 42), although spawning has been observed as far downstream as Cressey (RM 27.7) (Yoshiyama et al. 2000). Significant spawning areas in the Gravel Mining 1 Reach were eliminated during the high flows that occurred in January 1997 and are currently being reconstructed by CDFG and CDWR in the Robinson Reach Phase of the Salmon Habitat Enhancement Project. Redd surveys conducted in 1997 and 1998 found that over half of the redds observed in the Merced River corridor occurred in the Dredger Tailings Reach.

Chinook salmon spawn in moderately sized cobble and gravel substrates primarily in riffles and pool tailouts. Substrate size and intragravel flow conditions are important factors affecting chinook salmon spawning distribution and incubation success (Harrison 1923, Hobbs 1937, McNeil 1964, Cooper 1965, Platts et al. 1979). Substrate particle size has been shown to have a significant influence on intragravel flow dynamics, with the presence of fine sediment and sand in the bed reducing

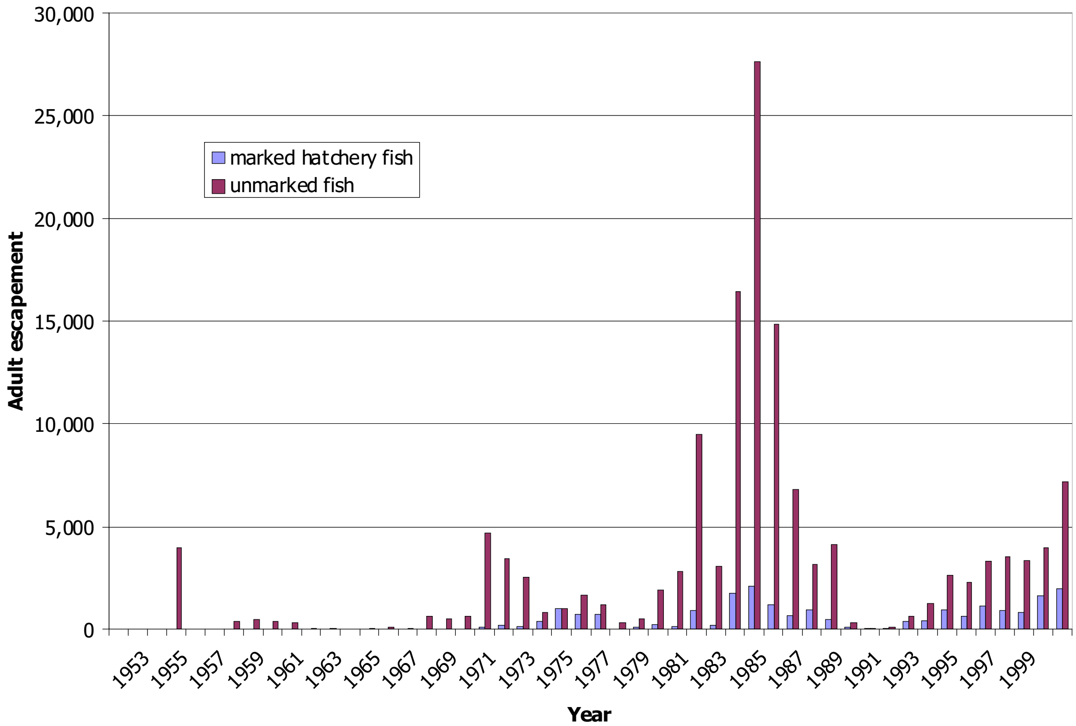


Figure 3-23. Fall chinook salmon escapement to the Merced River. Source: CDFG, unpublished data

intragravel flow in the redd (McNeil 1964, Cooper 1965). In addition, salmon are limited by the size of substrate that they can physically move during the redd-building process. Chinook salmon, therefore, may have evolved to select redd sites with particle sizes that can be moved by the adults and that provide sufficient intragravel flow to the incubating eggs and larvae. Median particle sizes of spawning substrates used by chinook salmon have been found to range from ½-inch to 3 inches (Kondolf and Wolman 1993).

During spawning, the female excavates a nest, referred to as a "redd," into the gravel and cobble substrate. As she excavates the nest, the female salmon deposits eggs into several pockets in the redd, which are then fertilized by the male. The female then covers the eggs with gravel. Chinook salmon redds are large, typically 111–189 square feet in size (Healey 1991). The female remains at the redd to defend the site from excavation by later-arriving salmon until she dies, usually within a few days after spawning. The fertilized eggs incubate in the river substrate for a period of 6–13 weeks, depending on water temperature (Vernier 1969, Bams 1970, Heming 1982, all as cited in Bjornn and Reiser 1991). The larvae that hatch from the eggs, called "alevins," are equipped with yolk sacs that provide nourishment. These larvae remain in the substrate until the yolk sac is absorbed, approximately two to three weeks, then swim up through the gravel substrate and begin rearing in open water. After emerging, fry either disperse downstream or move to stream margins or backwater areas near their natal redd.

The period of fry emergence varies depending upon the timing of adult arrival and incubation temperature. In the Merced River, fry can typically be found in the river from January through May (Merced ID, unpublished data). Large numbers of fry have been captured in traps at the mouth of the river in January and Febru-

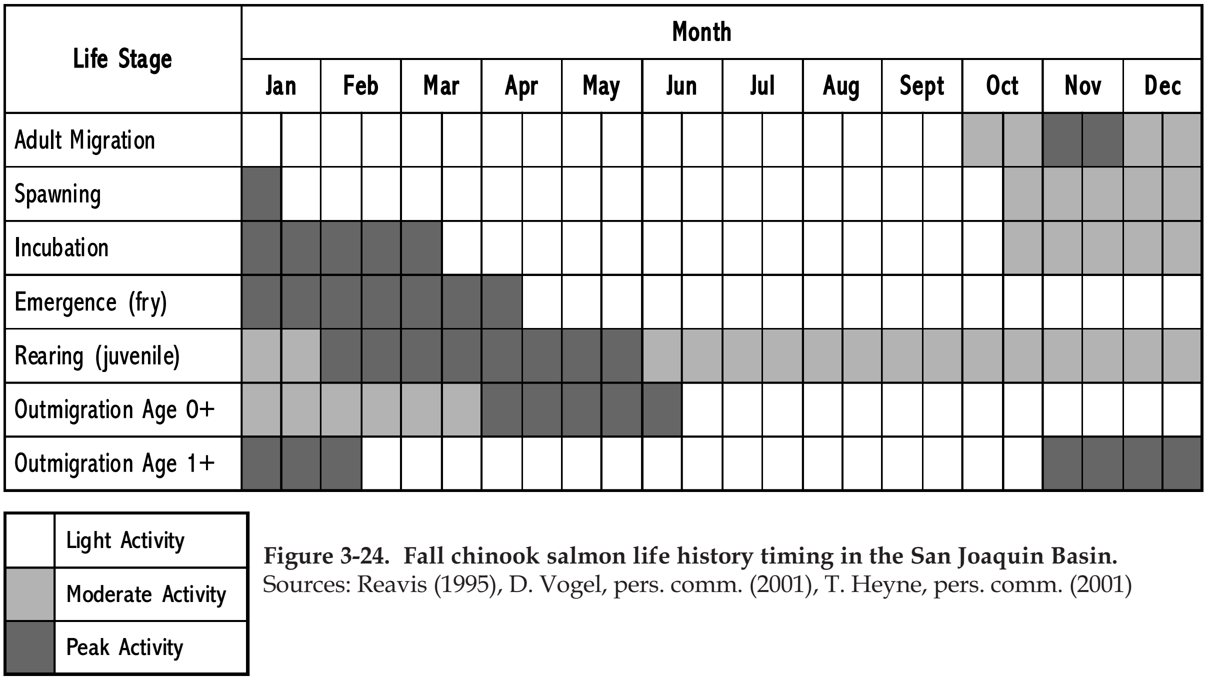


Figure 3-24. Fall chinook salmon life history timing in the San Joaquin Basin.
Sources: Reavis (1995), D. Vogel, pers. comm. (2001), T. Heyne, pers. comm. (2001)

ary during wet years. These fry may rear in the San Joaquin River mainstem or the Sacramento-San Joaquin Delta, or they may continue to the estuary and Pacific Ocean. The fate and survival of these fry and their contribution to the chinook salmon population are not known.

Subyearling smolts typically leave the Merced River from April through mid-June. A few salmon may remain to oversummer in the river and emigrate during the fall and early winter as yearling smolts. Juvenile distribution and habitat use in the Merced River have not been assessed and, therefore, are not well understood. Juveniles that remain to rear in the river can be expected to use a range of habitat types. Everest and Chapman (1972) observed at least small numbers of juvenile chinook salmon in virtually all habitat types sampled. As juveniles increase in size, they move to higher velocity, deeper water habitats (Hilman et al. 1987, Everest and Chapman 1972, Lister and Genoe 1970).

Water temperature is an important factor affecting incubation and juvenile rearing success. Temperature directly affects survival, growth rates, and smoltification. Temperature also indirectly affects vulnerability to disease and predation. Myrick and Cech (2001) provide a review of the effects of water temperature on salmon and steelhead incubation, rearing, and smoltification in the Central Valley. The results of this review are summarized below.

Chinook salmon eggs can survive at temperatures between 35°F and 62°F, with the highest survival rates occurring at temperatures between 39°F and 54°F. Tests of juvenile thermal tolerances indicate that tolerance is influenced by both the water temperature at which the test fish are acclimated and exposure time. The chronic upper lethal temperature for Central Valley chinook salmon is approximately 77°F, with higher temperatures (up to 84°F) tolerated for short periods of time. Sublethal effects, however, occur below these lethal limits. In addition to direct mortality, temperature influences juvenile growth rates through its effects on metabolic processes and food availability. Juvenile chinook salmon are reported to grow at temperatures ranging from 46°F to 77°F, with maximum growth rates reported at 66 °F when fed to satiation. The results of tests on Central Valley chinook are contradictory, reporting maximum growth rates at 56–60°F and 63–68°F. Chinook salmon have been reported to grow at temperatures approaching 75°F, but they became more vulnerable to the effects of water quality and more susceptible to pathogens and predators at these warmer water temperatures. While chinook salmon can rear at temperatures in the range of 66 °F, cooler water temperatures are required for successful smoltification. Chinook salmon can smolt at temperatures ranging from 43°F to 68°F. Salmon that rear at temperatures ranging from 50°F to 64°F exhibit optimal smoltification, and thus would be expected to be best prepared for salt water; salmon that smolt at higher temperatures (greater than 61°F), however, tend to display impaired smoltification and reduced salt water survival.

Steelhead

Steelhead is the term commonly used for the anadromous form of rainbow trout. Steelhead exhibit highly variable life history patterns throughout their range but are broadly categorized into winter and summer reproductive ecotypes. Only winter steelhead currently occur in Central Valley streams (McEwan and Jackson 1996). The relationship between anadromous and resident life history forms of *O. mykiss* is poorly understood, but evidence suggests that the two forms are capable of interbreeding and that, under some conditions, either life history form can produce offspring that exhibit the alternate form (i.e., resident rainbow trout can produce anadromous progeny and vice versa) (Shapovalov and Taft 1954; Burgner et al. 1992; Hallock 1989). The fact that little to no genetic differentiation has been found between resident and anadromous life history forms inhabiting the same basin supports this hypothesis (Busby et al. 1993; Nielsen 1994).

Central Valley steelhead are listed as threatened under the Federal Endangered Species Act. Included in the listing are naturally spawned steelhead occurring in the Sacramento and San Joaquin rivers and their tributaries (excluding the mainstem San Joaquin River upstream of the Merced River confluence). Because it is not possible to discern between juvenile resident trout and juvenile steelhead, the listing includes all *O. mykiss* that are not isolated from the ocean by physical barriers. The Merced River is included in the designated critical habitat for Central Valley steelhead (NMFS 2000). Critical habitat is defined in the Endangered Species Act as specific areas within the geographic range of a species where habitat values are found to be essential to conserving the species. This designated critical habitat includes the river, as well as its adjacent riparian zones that provide key riparian functions–specifically shade, sediment, nutrient or chemical regulation, streambank stability, and input of large woody debris or organic matter (NMFS 2000). NMFS believes that currently accessible habitat may be sufficient for the conservation of listed steelhead but that former spawning and rearing areas, where access has been restored, may be a significant factor in determining the extent of essential habitat for the conservation of the species. NMFS will determine on a case-by-case basis during FERC relicensing whether fish passage facilities will be required (NMFS 2000).

Little information on the steelhead life history in the San Joaquin Basin is available. Steelhead life history timing reported from the Sacramento Basin is shown in

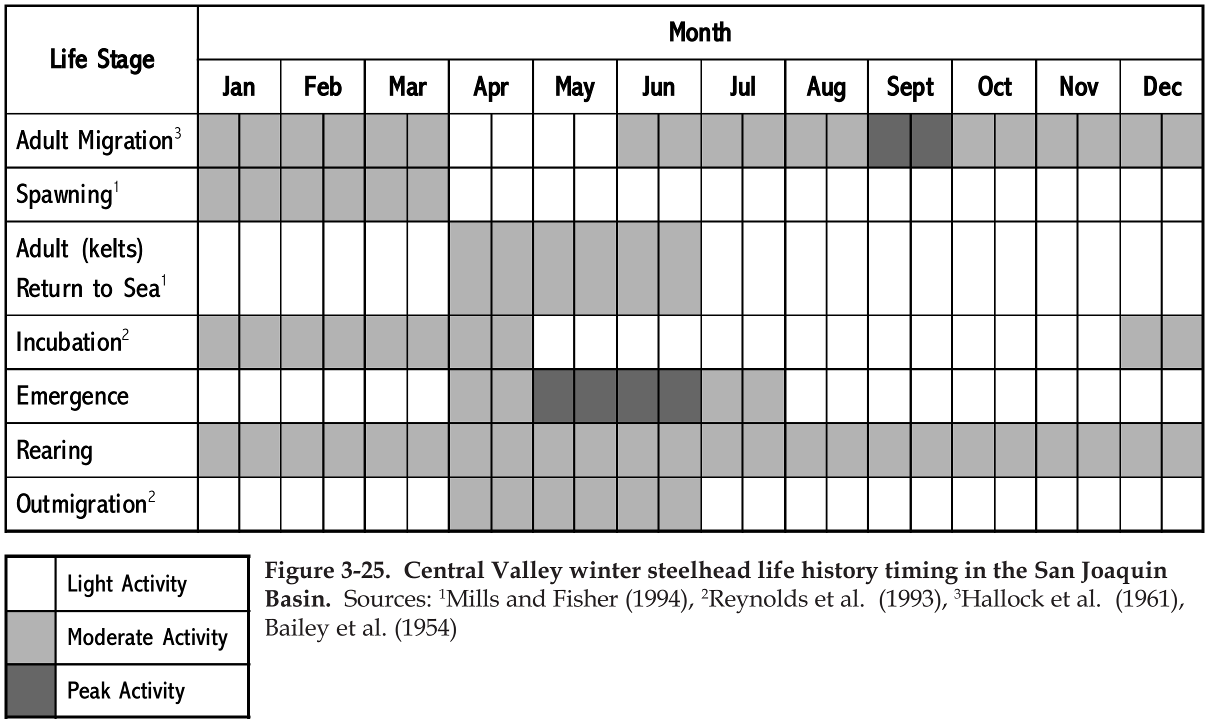


Figure 3-25. Central Valley winter steelhead life history timing in the San Joaquin Basin. Sources: [1]Mills and Fisher (1994), [2]Reynolds et al. (1993), [3]Hallock et al. (1961), Bailey et al. (1954)

Figure 3-25. In the Sacramento River, adult winter steelhead migrate upstream during most months of the year, beginning in July, peaking in September, and continuing through February or March (Hallock et al. 1961, Bailey 1954). Spawning occurs primarily from January through March, but may begin as early as late December and may extend through April (Hallock et al. 1961). In the Central Valley, adult winter steelhead generally return to freshwater at ages 2 and 3 years and range in size from 2 to 12 pounds (Reynolds et al. 1993).

Aside from cutthroat trout (*O. clarki*), steelhead is the only anadromous species of the genus *Oncorhynchus* in which adults can survive spawning and return to fresh water to spawn in subsequent years. Individuals that survive spawning run return to sea between April and June (Mills and Fisher 1994). The frequency of repeat spawning is higher for females than for males (Ward and Slaney 1988, Meehan and Bjornn 1991, Behnke 1992). In the Sacramento River, Hallock (1989) reported that 14 percent of the steelhead returned to spawn a second time.

Similar to fall chinook salmon, female steelhead construct redds in suitable gravels, primarily in pool tailouts and heads of riffles. Steelhead eggs incubate in the redds for 3–14 weeks, depending on water temperatures (Shapovalov and Taft 1954, Barnhart 1991). After hatching, alevins remain in the gravel for an additional 2–5 weeks while absorbing their yolk sacs and emerge in spring or early summer (Barnhart 1991).

After emergence, steelhead fry move to shallow-water, low-velocity habitats, such as stream margins and low gradient riffles, and will forage in open areas lacking instream cover (Hartman 1965, Everest et al. 1986, Fontaine 1988). As fry increase in size and their swimming abilities improve in late summer and fall, they increasingly use areas with cover and show a preference for higher velocity, deeper mid-channel areas near the thalweg (Hartman 1965, Everest and Chapman 1972, Fontaine 1988).

Juvenile steelhead occupy a wide range of habitats, preferring deep pools as well as higher velocity rapid and cascade habitats (Bisson et al. 1982, Bisson et al. 1988). During the winter period of inactivity, steelhead prefer low velocity pool habitats with large rocky substrate or woody debris for cover (Hartman 1965, Swales et al. 1986, Raleigh et al. 1984, Fontaine 1988). During periods of low temperatures and high flows associated with the winter months, juvenile steelhead seek refuge in interstitial spaces in cobble and boulder substrates (Bustard and Narver 1975, Everest et al. 1986). Juvenile emigration typically occurs from April through June. Emigration appears to be more closely associated with size than age, with 6–8 inches being most common for downstream migrants.


Photo/Ken Jensen

Juveniles remain in fresh water for 2–4 years before emigrating to the ocean. Most steelhead south of Alaska and British Columbia smolt after a period of two years in fresh water and spend two years in the ocean before returning to their natal streams to spawn. Populations in Oregon and California, however, have higher frequencies of adults returning after only one year in the ocean (Busby et al. 1996). In the Sacramento River the most common life history pattern is for steelhead to spend two years in freshwater prior to smolting and one year in the ocean. The second most common pattern is two years in freshwater prior to smolting and two years in the ocean.

As for chinook salmon, water temperature is an important factor affecting steelhead incubation and juvenile rearing success. Temperature directly affects survival, growth rates, and smoltification. Temperature also indirectly affects vulnerability to disease and predation. Myrick and Cech (2001) provide a review of the effects of water temperature on salmon and steelhead incubation, rearing, and smoltification in the Central Valley. The results of this review are summarized below.

Steelhead eggs can survive at water temperatures between 36°F and 59°F, with highest survival rates occurring at temperatures between 45°F and 50°F. The chronic upper lethal temperature for Central Valley steelhead is approximately 77°F, with higher temperatures (up to 85°F) tolerated for short periods of time. In tests of thermal preferences, hatchery-reared Central Valley steelhead consistently selected temperatures of 64°F to 66°F, while wild steelhead consistently selected temperatures of 63°F. Juvenile steelhead have been reported to grow at temperatures ranging from 44°F to 73°F. Maximum growth rates reported for Central Valley steelhead occurred at 66°F, but higher temperatures have not been tested. While steelhead can rear at temperatures in the range of 66°F, cooler water temperatures are required for successful smoltification. Steelhead can smolt at temperatures ranging from 44°F to 52°F and show little adaptation to seawater at temperatures exceeding 59°F.

In addition to the effects of temperature on incubation and smoltification time and success, increased temperature can increase susceptibility to pathogens and disease. The effects of water temperature on pathogens, however, is not well understood. On-going evaluation of the changing temperature needs of steelhead should be considered when making management recommendations.

Other Fish Species Occurring in the Merced River

No comprehensive assessment of fish species composition and distribution has been conducted in the Merced River. CDFG has operated a rotary screw trap at Hagaman County Park (RM 12.2) from January through June since 1998 (only sampled March through June in 1998), and Merced ID has operated two rotary screw traps at Hopeton (RM 40) from January through June since 1999 to assess chinook salmon outmigration timing, abundance, and survival. These traps also provide incidental information on other fish species occurring in the river.

Thirty-seven fish species have been captured in the rotary screw traps operated by the Merced ID and CDFG (Table 3-7). Of these, 11 species (30 percent) are native and 26 species (70 percent) are introduced (based on Moyle [1976]). Introduced species are primarily sunfish (such as largemouth and smallmouth bass, bullhead,

Table 3-7. Fish Species Documented in the Merced River

Family	Species	Native (N) or Introduced (I)	Recovered by CDFG at Hagaman County Park (RM 12)	Recovered by MID at Hopeton (RM 40)
Atherinidae: Silversides	Inland Silverside (*Menidia beryllina*)	I	X	
Catostomidae: Suckers	Sacramento sucker (*Catostomus occidentalis)*	N	X	X
Centrarchidae: Sunfish	Bluegill (*Lepomis macrochirus*)	I	X	X
	Green sunfish (*Leopomis cyanellus*)	I	X	X
	Redear sunfish (*Lepomis microlophus*)	I	X	X
	Largemouth bass (*Micropterus salmoides*)	I	X	
	Smallmouth bass (*Micropterus dolomieui*)	I	X	X
	Redeye bass (*Micropterus coosae*)	I	X	
	Spotted bass (*Micropterus punctulatus)*	I	X	
	Warmouth (*Lepomis gulosus*)	I	X	
	White crappie (*Pomoxis annularis*)	I	X	
	Black crappie (*Pomoxis nigromaculatus*)	I	X	X

Table 3-7. Fish Species Documented in the Merced River, continued

Family	Species	Native (N) or Introduced (I)	Recovered by CDFG at Hagaman County Park (RM 12)	Recovered by MID at Hopeton (RM 40)
Clupeidae: Shad	American shad (*Alosa sapidissima*)	I	X	
	Threadfin shad (*Dorosoma petenense*)	I	X	
Cottidae: Sculpin	Prickly sculpin (*Cottus asper*)	N	X	X
Cyprinidae: Minnows and Carps	Hardhead (*Mylopharodon conocephalus)*	N	X	
	Golden shiner (*Notemigonus crysoleucas)*	I	X	X
	Fathead minnow (*Pimephales promelas*)	I		
	Goldfish (*Carassius auratus*)	I	X	X
	Red shiner (*Notropis lutrensis*)	I	X	
	Sacramento blackfish (*Orthodon microlepidotus)*	N	X	
	Sacramento squawfish (*Ptychocheilus grandis*)	N	X	
	Splittail (*Pogonichthys macrolepidotus)*	N	X	
	Common carp (*Cyprinus carpio*)	I	X	X
	California roach (*Hesperoleucus symmetricus*)	N		X
Ictaluridae: Bullhead and Catfish	Black bullhead (*Ictalurus melas*)	I	X	X
	Channel catfish (*Ictalurus punctatus*)	I	X	X
	Brown bullhead (*Ictalurus nebulosis*)	I	X	
	Yellow bullhead (*Ameiurus natalis*)	I	X	
	White catfish (*Ictalurus catus*)	I	X	X

Table 3-7. Fish Species Documented in the Merced River, continued

Family	Species	Native (N) or Introduced (I)	Recovered by CDFG at Hagaman County Park (RM 12)	Recovered by MID at Hopeton (RM 40)
Percidae: Perch	Bigscale logperch (*Percina macrolepida*)	I		X
Percichthyidae: Temperate Perches	Striped bass (*Morone saxatilis*)	I	X	
Poeciliidae: Mosquitofish	Western mosquitofish (*Gambusia affinis*)	I	X	X
Petromysontidae: Lampreys	Pacific lamprey (*Lampetra tridentata*)	N	X	X
	Kern Brook lamprey (*Lampetra hubbsi*)	N	X	
Salmonidae: Salmon and Trout	Steelhead/rainbow trout (*Oncorhynchus mykiss*)	N	X	X
	Fall chinook salmon (*Oncorhynchus tshawytscha*)	N	X	X

Sources: Natural Resource Scientists, Inc. unpublished data; CDFG, unpublished data; T. Heyne, pers. comm. (2001)

and catfish) but also include shad, shiners, fathead minnow, goldfish, carp, and others. Native fish captured in the traps include Sacramento sucker, prickly sculpin, hardhead, Sacramento blackfish, Sacramento squawfish, Sacramento splittail, California roach, Pacific lamprey, Kern Brook lamprey, steelhead, and fall chinook salmon.

Threatened, Endangered and Sensitive Plant and Animal Species

Numerous threatened, endangered, and sensitive plant and animal species occur or potentially occur in the Merced River corridor. No comprehensive surveys of the presence of threatened, endangered, and sensitive species in the river corridor have been conducted, but recent surveys at specific sites conducted for construction and restoration projects provide some information on species occurrences. Also, the potential for some species to occur in the corridor can be evaluated based on their known geographic range and habitat requirements.

Fifty-six special status species occurring or potentially occurring in the Merced River corridor were identified through a query of the California Natural Diversity Database (CNDDB) (CDFG 2001) and reviews of other local surveys (Table 3-8)[8]. Summary accounts for species that are known to occur or very likely occur in the corridor based on the presence of suitable habitat are provided in Appendix B.

Habitat Requirements and Ecosystem Health

The Riparian Habitat Joint Venture (RHJV), which was established under the inter-

[8]Upland and vernal pool species were not considered likely to occur in the Merced River corridor or its adjacent riparian forest and, therefore, are not included in this summary.

Table 3-8. Potential for Occurrence of Threatened, Endangered, and Special Status Species and Their Habitats in the Merced River Corridor

Species[a]	Status[b]	Local Habitat Associations[c]
Plants		
Hospital Canyon larkspur (*Delphinium californicum* spp. *interius*)	FSC; 1B	found within wet boggy meadows in cismontane woodlands and chaparral habitats
Four-angled spikerush *(Eleocharis quadrangulata)*	2	marshes and swamps; not documented in the river corridor but suitable habitat occurs
Delta button-celery *(Eryngium racemosum)*	FSC; SE; 1B	riparian scrub in fine clay with low pH (Edminster clay)
California hibiscus *(Hibiscus lasiocarpus (=californicus))*	2	freshwater marsh; not documented in the river corridor, but suitable habitat occurs
Northern California black walnut *(Juglans hindsii)*	FSC; 1B	deep alluvial soils near streams or creeks within riparian forest and woodland; occurs along Merced River (Stillwater Sciences 2001a)
Delta tule pea *(Lathyrus jepsonii var jepsonii)*	FSC; 1B	margins of freshwater sloughs and rivers in upper estuaries
Mason's lilaeopsis *(Lilaeopsis masonii)*	FSC; CR; 1B	mudflats of Sacramento, San Joaquin, and Napa rivers and sloughs
Delta mudwort *(Limosella subulata)*	2	sandy mudflats along the San Joaquin River
Merced monardella *(Monardella leucocephala)*	FSC; 1A	valley and foothill grassland and riverbeds, in sandy, subalkaline soils; documented occurrence ¾ mile north of Merced River, near Delhi (CDFG 2001)
Sanford's arrowhead *(Sagittaria sanfordii)*	FSC; 1B	shallow freshwater marsh; not documented in the river corridor, but suitable habitat occurs
Blue skullcap *(Scutellaria lateriflora)*	2	freshwater marshes and wet meadows below 1,500 feet in elevation; not documented in the river corridor, but suitable habitat occurs
Invertebrates		
Valley elderberry longhorn beetle *(Desmocerus californicus dimorphus)*	FT	associated with elderberry plants; documented occurrence along Merced River, 2 miles northwest of Livingston at McConnell State Recreation Area, near State Route 99 bridge, and both sides of Santa Fe Drive (CDFG 2001); elderberry plants observed throughout the corridor (Stillwater Sciences 2001a)
Molestan blister beetle *(Lytta molesta)*	FSC	unknown

Table 3-8. Potential for Occurrence of Threatened, Endangered, and Special Status Species and Their Habitats in the Merced River Corridor, continued

Species[a]	Status[b]	Local Habitat Associations[c]
Fish		
Kern Brook lamprey *(Lampetra hubbsi)*	FSC; CSC	rivers, backwater habitats; documented occurrence in Merced River near Merced Falls (CDFG 2001) and at Hagaman County Park trap (T. Heyne, pers. comm., 2001)
Pacific lamprey *(Lampetra tridentata)*	FSC	streams, estuaries, and marine waters; documented in the CDFG and Merced ID rotary screw traps (Natural Resource Scientists, Inc. unpublished data)
River lamprey *(Lampetra ayersi)*	FSC	streams, estuaries, and marine waters; not documented in the river corridor, but suitable habitat occurs
Green sturgeon *(Acipenser medirostris)*	FSC	spawn in the Sacramento River
Hardhead *(Mylopharodon conocephalus)*	CSC	low to mid-elevation streams in the Sacramento-San Joaquin drainages; documented occurrence on Merced River near State Route 59 (CDFG 2001) and in the CDFG and Merced ID rotary screw traps (Natural Resource Scientists, Inc. unpublished data)
Central Valley steelhead *(Oncorhynchus mykiss)*	FT	streams, estuaries, and marine waters; documented in the CDFG and Merced ID rotary screw traps (Natural Resource Scientists, Inc. unpublished data)
Chinook salmon (fall and late-fall run) *(Oncorhynchus tshawytscha)*	FPT	streams, estuaries, and marine waters; documented throughout the Merced River
Sacramento splittail *(Pogonichthys macrolepidotus)*	FT, CSC	fresh to brackish rivers and streams; documented in the CDFG and Merced ID rotary screw traps (Natural Resource Scientists, Inc. unpublished data)
Amphibians		
California tiger salamander *(Ambystoma californiense)*	FC; CSC	ephemeral or permanent pools and ponds (usually with no fish) and underground refuges required for reproduction, annual grasslands (primary), valley foothill riparian, valley oak woodland, blue oak woodland (secondary); documented at Kesterson National Wildlife Refuge (CDFG 2001)
Western spadefoot *(Scaphiopus hammondii)*	FSC; CSC	primarily in grassland habitats, secondarily in valley-foothill hardwood woodlands; temporary rain pools that lack aquatic predators; documented at Kesterson National Wildlife Refuge (CDFG 2001)
California red-legged frog *(Rana aurora draytonii)*	FT, CSC	ponds, streams, ditches; not documented in the river corridor, but suitable habitat occurs; likely extirpated by bullfrog predation

Table 3-8. Potential for Occurrence of Threatened, Endangered, and Special Status Species and Their Habitats in the Merced River Corridor, continued

Species[a]	Status[b]	Local Habitat Associations[c]
Reptiles		
Western pond turtle *(Clemmys marmorata)*	FSC; CSC	slow-moving backwater, ponds, lakes, gravel mining pits; occurs in vicinity State Route 59 bridge over Merced River (CDFG 2001); observed along Robinson Reach, RM 42.1-44.4 (USFWS 2001)
Giant garter snake *(Thamnophis gigas)*	FT, ST	wetlands for foraging, burrows for winter hibernation
Birds		
Double-crested cormorant (rookery) *(Phalacrocorax auritus)*	CSC	nests on islands, inaccessible steep cliffs, or large inaccessible manmade structures
Great blue heron (rookery) *(Ardea herodias)*	S	nests in large trees near open water; observed along Robinson Reach, RM 42.1-44.4 (USFWS 2001)
Great egret (rookery) *(Casmerodius albus)*	S	nests in large trees near open water; observed along Robinson Reach, RM 42.1-44.4 (USFWS 2001)
Snowy egret (rookery) *(Egretta thula)*	SA	nests in dense marshes or in trees near open water; not documented in the river corridor, but suitable habitat occurs
White-faced ibis (rookery) *(Plegadis chihi)*	FSC; CSC	nests in dense, large, contiguous, fresh emergent wetland; observed along Robinson Reach, RM 42.1-44.4 (USFWS 2001)
Aleutian Canada goose (wintering) *(Branta canadensis leucopareia)*	FT (Proposed for de-listing, 1999)	open water (lakes and ponds), forages on grasslands
Short-eared owl (nesting) *(Asio flammeus)*	FSC; CSC	forages in densely vegetated grasslands and emergent wetlands with abundant prey from October through April; not documented in the river corridor, but suitable habitat occurs
White-tailed kite (nesting) *(Elanus leucurus)*	FP	nests in trees near open foraging areas; observed near Dana and Hopeton sloughs (ESA 2000), and along Robinson Reach, RM 42.1-44.4 (USFWS 2001)
Bald eagle *(Haliaeetus leucocephalus)*	FT; SE (Proposed for de-listing, 1999)	near large bodies of fish-bearing water with adjacent snags or other perches; observed near Merced Falls (J.Kelsey, pers.comm., 2000)
Northern harrier (nesting) *(Circus cyaneus)*	CSC	grasslands and wetlands; known to occur along undisturbed portions of both Dana and Hopeton sloughs (ESA 2000)
Cooper's hawk (nesting) *(Accipiter cooperii)*	CSC	woodland and riparian zones
Sharp-shinned hawk (nesting) *(Accipiter striatus)*	CSC	nest in riparian areas and oak woodlands, forages in open areas; known to occur along undisturbed portions of both Dana and Hopeton sloughs (ESA 2000)

Table 3-8. Potential for Occurrence of Threatened, Endangered, and Special Status Species and Their Habitats in the Merced River Corridor, continued

Species[a]	Status[b]	Local Habitat Associations[c]
Prairie falcon (nesting) *(Falco mexicanus)*	CSC	nests in cliff areas, riparian areas and oak woodlands, forages in open areas; known to occur along undisturbed portions of both Dana and Hopeton sloughs (ESA 2000)
Swainson's hawk (nesting) *(Buteo swainsoni)*	ST	riparian areas and oak savannah; observed near Hatfield State Park (CDFG 2001); nesting observed at Robinson Reach (R. Mager, pers. comm. 2000)
Western yellow billed cuckoo *(Coccyzus americanus occidentalis)*	SE	nests in riparian forest along the broad, lower flood-bottoms of larger river systems
Western burrowing owl (burrow sites) *(Speotyto cunicularia hypugea)*	FSC; CSC	grasslands, shrublands, levees, open habitat; not documented in the river corridor, but suitable habitat occurs
Loggerhead shrike *(Lanius ludovicianus)*	FSC; CSC	grassland, woodland and scrubland; observed near Dana and Hopeton sloughs (ESA 2000)
Bell's sage sparrow *(Amphispiza belli belli)*	FSC	grasslands, shrublands, levees, open habitat; not documented in the river corridor, but suitable habitat occurs
California yellow warbler (nesting) *(Dendroica petechia brewsteri)*	CSC	riparian woodland and conifer forest; observed near Dana and Hopeton sloughs (ESA 2000)
Yellow-breasted chat (nesting) *(Icteria virens)*	CSC	riparian woodland and early seral riparian vegetation; not documented in the river corridor, but suitable habitat occurs
Tricolored blackbird (nesting colony) *(Agelaius tricolor)*	FSC; CSC	thick stands of bulrushes, tules, blackberries, or cattails usually adjacent to freshwater emergent marsh; known to occur along undisturbed portions of both Dana and Hopeton sloughs (ESA 2000)
Little willow flycather *(Empidonax traillii brewsteri)*	FSC; CE	breeding habitat is limited to extensive willow thickets within riparian areas; not documented in the river corridor, but suitable habitat occurs
Bank swallow *(Riparia riparia)*	ST	nests in holes dug in sandy cliffs and river banks near water; not documented in the river corridor, but suitable habitat occurs
Mammals		
Myotis spp.: Long-eared myotis (*M. evotis*) Fringed myotis (*M. thysanodes*) Long-legged myotis (*M. volans*) Small-footed myotis (*M. ciliolabrum*) Yuma myotis (*M. yumanensis*)	FSC	roost in buildings, trees, mines, caves, crevices, buildings, or bridges; feeds over water, along edge of woodlands, forests, and scrub, or in variety of open habitats; observed along Robinson Reach, RM 42.1-44.4 (USFWS 2001)
Townsend's western big-eared bat *(Corynorhinus (=Plecotus) townsendii townsendii)*	FSC; CSC	as above
Pallid bat *(Antrozous pallidus)*	CSC	as above; observed along Robinson Reach, RM 42.1-44.4 (USFWS 2001)

Table 3-8. Potential for Occurrence of Threatened, Endangered, and Special Status Species and Their Habitats in the Merced River Corridor, continued

Species[a]	Status[b]	Local Habitat Associations[c]
California mastiff bat *(Eumops perotis californicus)*	FSC; CSC	as above
San Joaquin pocket mouse *(Perognathus inornatus inornatus)*	FSC	dry, open grasslands or woodlands with fine-textured soil; documented occurrence in Snelling (CDFG 2001) and observed along Robinson Reach, RM 42.1-44.4 (USFWS 2001)
Merced kangaroo rat *(Dipodomys heermanni dixoni)*	FSC	grassland and savannah communities within Merced and Stanislaus counties, requires deep, fine, well-drained soil for burrowing; documented occurrence at UC-Merced Planning Area and in Snelling (CDFG 2001)
San Joaquin kit fox *(Vulpes macrotis mutica)*	FE; ST	grasslands, chenopode scrub, alkali sink, subshrub scrub, oak woodland, agricultural lands; found in vicinity of San Luis National Wildlife Refuge and Kesterson Wildlife Refuge (CDFG 2001)

[a] Species list adapted from USFWS (2001), ESA (2000), and CDFG (2001).

[b]
- FE Listed as endangered under the federal Endangered Species Act.
- FT Listed as threatened under the federal Endangered Species Act.
- FPT Proposed for listing as threatened under the federal Endangered Species Act.
- FC Federal candidate species.
- FSC Species of Concern (former C2 candidate) (Note: Although the U. S. Fish and Wildlife Service does not maintain a list for these species, in most cases they represent species that are sensitive to impacts and/or that are documented as or suspected to be undergoing population declines.)
- SE Listed as endangered under the California Endangered Species Act.
- ST Listed as threatened under the California Endangered Species Act.
- CSC CDFG species of special concern.
- FP CDFG fully protected.
- SA CDFG special animal. These species are considered to be biologically rare or declining in California, the population considered peripheral to the major portion of a taxon's range, or closely associated with a declining habitat.
- 1A Plants presumed extinct in California by the CNPS.
- 1B Plants considered rare, threatened or endangered in California and elsewhere by CNPS.
- 2 Plants considered rare, threatened or endangered in California, but more common elsewhere by the CNPS.

[c] Where documented occurrence of the species exists, specific locations are identified and source is given in parentheses.

national cooperative Partners in Flight, has developed a Riparian Bird Conservation Plan to guide conservation policy and action to benefit riparian habitats and terrestrial birds in California (see Box 3-1, page 3-65) (RHJV 2000). This plan, which is the first iteration in a continuing processes of developing and updating conservation recommendations, is based on the latest available data and on the use of bird species abundance and diversity information as an indicator of ecosystem health. Habitat requirements for nesting and foraging vary widely between species, covering every niche of a riparian ecosystem. For example, while Swainson's hawk (*Buteo swainsoni*), Western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), and Nuttall's woodpecker (*Picoides nuttallii*) prefer the canopy for nesting and foraging, Bell's vireo (*Vireo belli*), spotted towhee (*Pipilo maculatus*), willow flycatcher, and black-headed grosbeak (*Pheucticus melanocephalus*) prefer shrubs. Others species, like the song sparrow (*Melospiza melodia*), can be even more specific, preferring habitats adjacent to water in low-lying, dense shrub habitats. A healthy riparian ecosystem, therefore, must provide diverse vegetative structure to support a diverse bird community.

Table 3-9. Focal Species of the Riparian Habitat Joint Venture Riparian Bird Conservation Plan

Species	Occurs on Merced River?	Special Status[1]	Reduction In Breeding Range	Nest Site Location	Breeding Habitat Requirements
Swainson's hawk *Buteo swainsoni*	Yes	CT	X	canopy	prefers open habitats with suitable nest trees in riparian forests
Warbling vireo *Vireo gilvus*	Yes	none	X	canopy	prefers large deciduous trees associated with streams with a semi-open canopy
Yellow-billed cuckoo *Coccyzus americanus*	No[2]	CE	X	canopy to midstory	prefers high canopy cover with low to moderate shrub and forb cover in the understory
Yellow warbler *Dendroica petechia*	Yes	CSPC	X	midstory	generally found in wet areas with early successional riparian communities and a semi-open canopy
Black-headed grosbeak *Pheucticus melanocephalus*	Yes	none		midstory	prefers semi-open canopy with moderate shrub cover and vertical stratification of vegetation layers
Swainson's thrush *Catharus ustulatus*	Yes	none	X	understory	prefers riparian areas with complex shrub/forb layers and moderate to dense canopy cover
Willow flycatcher *Empidonax traillii*	Yes	CT	X	understory	prefers dense patches and early successional riparian areas
Common yellowthroat *Geothlypis trichas*	Yes	CSPC	X	understory	prefers wetlands and open, early successional riparian areas
Blue grosbeak *Guiraca caerulea*	Yes	CSPC	X	understory	prefers annual forbs, young deciduous plants, and low canopy cover along the riparian edge
Song sparrow *Melospiza melodia*	Yes	none	X	understory	known to breed in early successional riparian, wetland, coastal scrub, and marsh habitats
Bank swallow *Riparia riparia*	Yes	CT	X	sandy banks	requires vertical banks and bluffs, often from flooding and associated erosion events
Least Bell's vireo Vireo bellii	No[3]	FE	X	understory	prefers early successional riparian areas
Wilson's warbler *Wilsonia pusilla*	Yes	none		understory	prefers willows, alders, and shrub thickets and areas with tall trees and moderate to thick canopy cover

Source: RHJV (2000)

[1] CT=California Threatened, CE=California Endangered, CSPC=California Species of Special Concern, FE=Federal Endangered

[2] Once present but considered to be extirpated from the San Joaquin Basin. Breeding populations (>5 pairs) occur on the Sacramento and South Fork Kern rivers.

[3]Once present but considered to be extirpated from the San Joaquin Basin. Breeding populations each consisting of several hundred breeding pairs or more found in southern California.

The RHJV Riparian Bird Conservation Plan has developed guidance for several focal species that represent a range of habitat requirements. Theoretically, a landscape managed to meet the diverse needs of these species will also provide the habitat requirements of many other species. The focal species included in the plan are shown in Table 3-9. Of the 13 focal species, 11 occur in Merced County and can be expected to occur along the Merced River (Stanislaus Audubon Society, unpublished data) (Table 3-9).

The RHJV Riparian Bird Conservation Plan is not a regulatory document, nor does it represent the policies of specific agencies or organizations. It does, however, provide the best available scientifically-based information for prioritizing riparian habitat preservation and restoration and for defining restoration design criteria. The guidelines provided in the plan are intended to aid managers and planners and must be adapted to work in concert with private property and water rights.

The RHJV recommends restoring habitat in 25 locations in the Central Valley to support 625 pairs of yellow-billed cuckoos (25 pairs/location) (RHJV 2000). This goal is based on population simulation modeling that indicates that subpopulations consisting of a minimum of 25 pairs and having interchange with other subpopulations are reasonably safe from extinction resulting from stochastic events. Given that stable subpopulations must consist of a minimum of 25 pairs and that territory averages 50-60 acres per pair (minimum 25 acres), the RHJV recommends establishing minimum 50-acre patches totaling 1,250 acres in a watershed or river reach. The RHJV target for the Merced River is one subpopulation consisting of 25 breeding pairs. The RHJV identifies no acreage on the Merced that is currently suitable for yellow-billed cuckoo breeding and targets restoration of 2,500 acres. Although similar data are not available for the other species, establishing minimum requirements for cuckoos would be expected to improve conditions for a range of target riparian bird species.

In addition, restoration projects should also consider reducing habitats used by brown-headed cowbirds. The brown-headed cowbird is one of North America's most notorious nest parasites. Cowbirds use other bird species as nest hosts, laying their eggs in host nests and having the host bird incubate and feed the cowbird young. The young cowbirds often outcompete the other nestlings and may lower the reproductive success of the host bird species. Hosts include many songbirds occurring in the Merced River corridor including yellow warblers and willow flycatchers. Rates of parasitism depend on the proximity of cowbird feeding sites (grasslands, agricultural lands, pastures, grazing yards, and grain silos) to the host breeding sites (Halterman and Laymon 1997). Partners In Flight (1997) found that large, contiguous forests sustained lower rates of cowbird parasitism than fragmented forests, suggesting that cowbirds search for hosts along forest edges. Fragmented forests have more edge habitat, often alongside agricultural or pastural habitats, and species within these areas are more susceptible to cowbird parasitism.

The Riparian Bird Conservation Plan (RHJV 2000) identifies the following objectives and conservation recommendations to improve riparian bird habitat in California.

Objective 1: Prioritize riparian sites for protection and restoration.
1a. Prioritize potential riparian protection sites according to current indicators of avian population health.
1b. Prioritize restoration sites according to their proximity to existing high quality sites.
1c. Protect and restore riparian areas with intact adjacent upland habitats.
1d. Prioritize sites with an intact natural hydrology or the potential to restore the natural processes of the system.
1e. Prioritize sites according to surrounding land use.

Objective 2: Promote riparian ecosystem health (i.e., a self-sustaining functioning system).
2a. Ensure that the patch size, configuration, and connectivity of restored riparian habitats adequately support the desired populations of riparian-dependent species.
2b. Restore natural hydrology in riparian systems whenever possible.

Objective 3: Increase the value on-going restoration projects for bird species.
3a. Restore and manage riparian forests to promote structural diversity and volume of the understory.
3b. Restore the width of the riparian corridor.

Objective 4: Ensure that large landscape-scale management and flood control projects maximize benefits to wildlife while benefiting agriculture and urban populations. Achieving multiple goals simultaneously enhances the overall value of such projects to the people of California.
4a. Management of new or existing flood bypass areas should consider the benefits of a regenerating riparian habitat against those of other uses.

Objective 5: Design and implement cultivated restoration projects that mimic the diversity and structure of a natural riparian plant community.
5a. Plant a minimum of two or more species of native shrubs or trees (i.e., avoid monotypic plantings).
5b. Increase shrub richness, shrub density, and the rate of natural reestablishment by including plantings of understory species in restoration design.
5c. Plant native forb and sedge species, as well as willow, alder, herbaceous cover, and valley oak, to benefit birds in the Central Valley and foothill riparian habitats.
5d. Plant willows and other vegetation common to early successional riparian habitat in a mosaic design with dense shrub patches interspersed with trees to achieve a semi-open canopy, which invigorates shrub growth.
5e. Retain at least some existing trees on restoration sites, planting around them, to promote occupancy of the plot by birds requiring mature trees.
5f. Connect patches of existing riparian habitat with strips of dense, continuous vegetation that are at least 10–33 feet wide.

Objective 6: Implement and time land management activities to increase avian reproductive success and enhance populations.
6a. Manage riparian and adjacent habitats to maintain a diverse and vigorous understory and herbaceous layer, particularly during the breeding season.
6b. Manage or create "soft" edges (gradual boundaries) appropriate to historical vegetation patterns.
6c. Avoid the construction or use of facilities and pastures that attract and provide foraging habitat for brown-headed cowbirds.
6d. Manage or influence management at the landscape-level (preferably the whole watershed).
6e. Limit restoration activities and disturbance events such as grazing, disking, herbicide application, and high-water events to the non-breeding season.

Objective 7: Protect, enhance or recreate natural riparian processes, particularly hydrology and associated high-water events, to promote the natural cycle of channel movement, sediment deposition, and scouring that create a diverse mosaic of riparian vegetation types.
7a. Avoid impacts on the natural hydrology of meadows, streams, and river channels.
7b. In sites with dams or other flood control devices, manage flow to allow a near-natural hydrograph sufficient to support scouring, deposition, and point bar formation.

Box 3-1. Riparian Bird Conservation Plan objectives and conservation recommendations.

3.5 Land Use and Property Ownership

The area of analysis for land use, zoning, and property ownership is shown in Figure 3-26. Note that this area was evaluated to describe the land use and property ownership context of the area adjacent to the river. This area does not necessarily reflect the area in which restoration projects would be implemented.

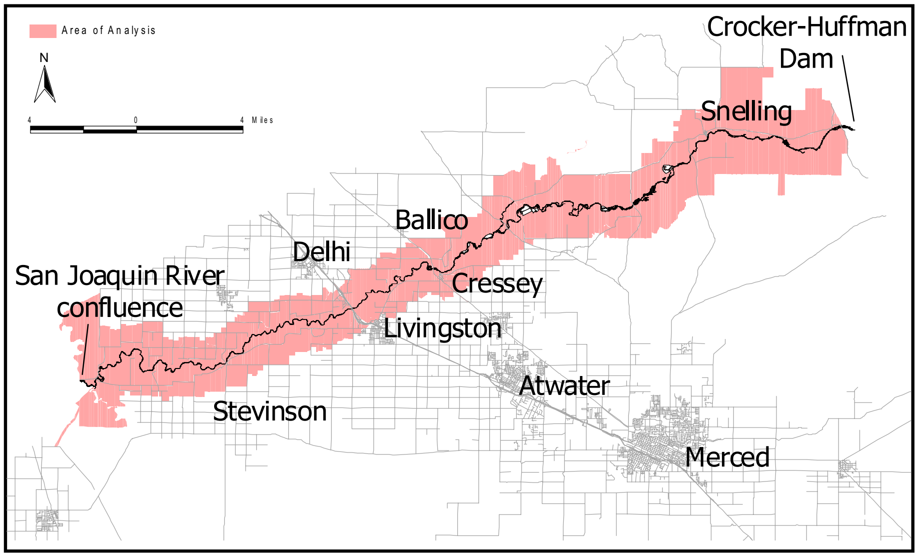


Figure 3-26. Restoration planning analysis area.

Only three urbanized areas occur in the Merced River corridor–Cressey, Livingston, and Snelling. With a population of 63,000, the city of Merced is the largest urban center in the vicinity of the Merced River. The Merced River lies within 10-miles of the city of Merced and, therefore, will potentially be affected by urban growth in the Merced area. Over the past nine years, the city of Merced has had an annual growth rate of 3.4 percent. This growth rate will likely increase with the completion of the University of California–Merced campus (scheduled for 2004) which will have an estimated attendance of 25,000 students.

Outside of the towns of Cressey, Livingston, and Snelling, land parcels in the Merced River corridor are generally privately owned, and are primarily in agricultural uses. Ninety-eight percent (by area) of the land in the Merced River corridor analysis area is privately owned (Figure 3-27). The large extent of private property in the river corridor requires that restoration actions rely heavily on voluntary participation by landowners and address landowner concerns. Sixty parcels, or approximately 2 percent of the river corridor, are publicly owned (Figure 3-27), although most do not offer recreational opportunities or public access to the river. Five parks and public access points are located along the river downstream of Crocker-Huffman Dam (Figure 3-28). From upstream to downstream, state and local parks that provide access to the river include the Cuneo Fishing Access (RM 50.5), Henderson County Park (RM 49.0), McConnell State Recreation Area (RM 23.3), Hagaman County Park (RM 12.2), and George Hatfield State Recreation Area (RM 2.3).

Privately owned parcels in the corridor range in size from 0.1 acres to 970 acres, with the smallest parcels occurring in urban areas such as Snelling and Cressey

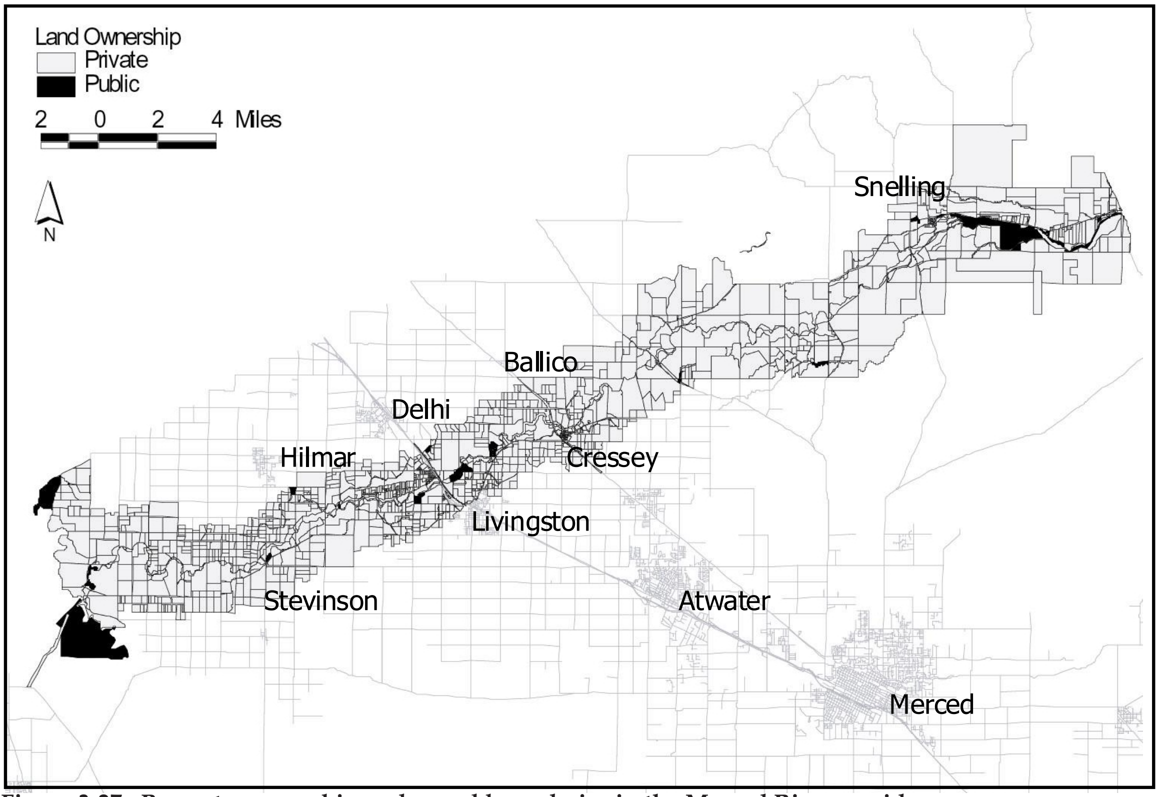


Figure 3-27. Property ownership and parcel boundaries in the Merced River corridor.
Source: Merced County Planning and Community Development Department

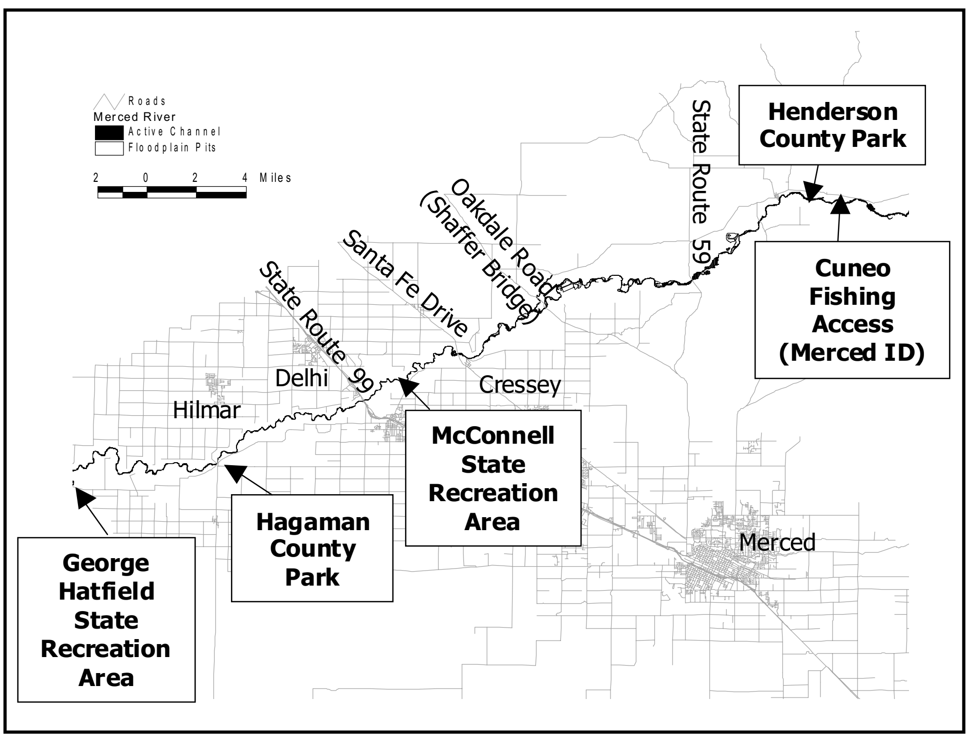


Figure 3-28. Public access sites in the Merced River corridor.

(Figure 3-27). The average parcel size is 82 acres. Private property parcels are typically larger upstream of Cressey than downstream of Cressey.

The Merced County General Plan (Merced County 1990) classifies land in the unincorporated areas of Merced County into zoning districts to: (1) help implement the goals, objectives, and policies of the General Plan; (2) ensure compatibility between land uses; and (3) encourage development that protects and promotes the public health, safety, and general welfare of the unincorporated areas of the county. Zoning districts within the Merced River corridor are shown in Figure 3-29 and Table 3-10.

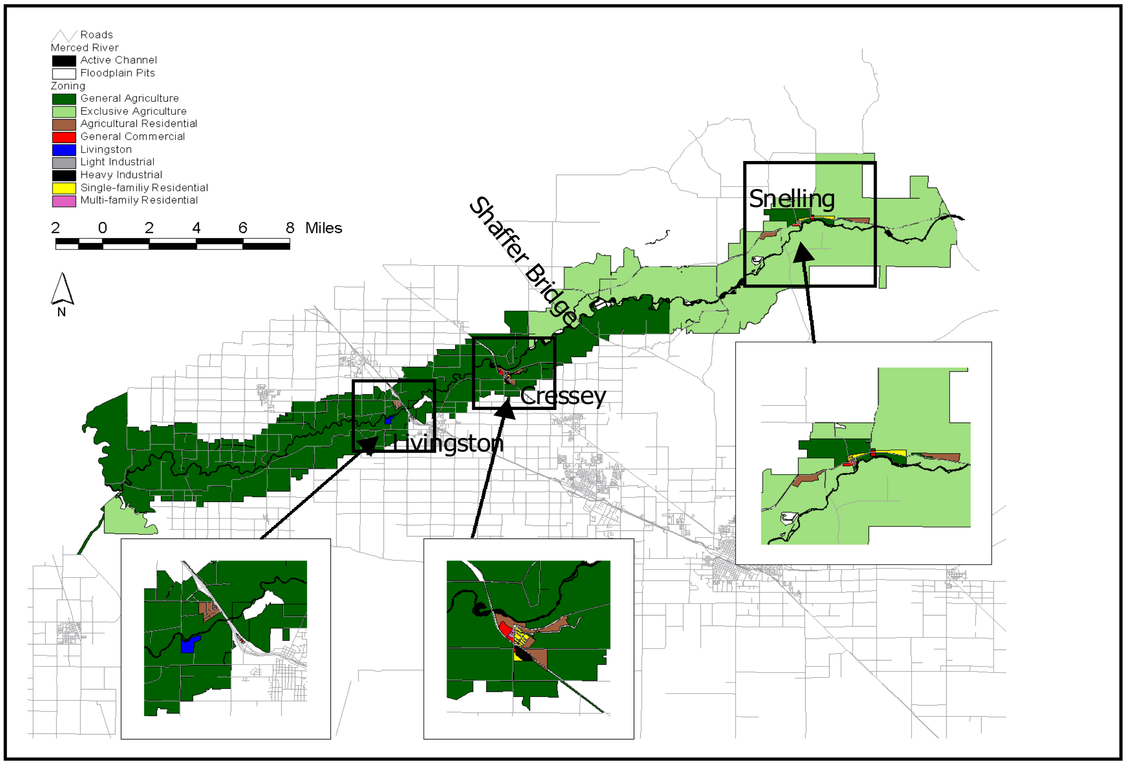


Figure 3-29. Zoning districts in the Merced River corridor. Source: Merced County Planning and Community Development Department

The majority of land within the analysis area is zoned General or Exclusive Agricultural. The General Agricultural zoning designation provides area for open space, agricultural, agricultural/commercial, and/or industrial uses dependent on proximity to urban areas or uses that require location in sparsely populated, low-traffic areas. Parcels with this zoning are 20 to 40 acres or larger in size and tend to rely on good soil quality, water availability, and minimal slopes. Lands zoned General Agricultural are located primarily downstream of Shaffer Bridge. The Exclusive Agricultural zoning designation is used primarily for foothill pastureland and open space and allows for expanded agricultural enterprises with a minimum parcel size requirement of 160 acres. Lands zoned Exclusive Agricultural are located primarily upstream of Shaffer Bridge.

Only 1,102 acres, or 1 percent of land within the Merced River corridor, are zoned for urban land uses such as residential, commercial, industrial, and related institutional uses (Table 3-10). Large-scale restoration actions would not be appropriate on lands zoned for urban or residential uses. These areas have or could potentially have intensive development and concentrated populations, factors which limit the effectiveness of restoration activities for ecological function but provide opportunities for public education and river-oriented recreation. Where appropriate, smaller-scale, urban-oriented restoration projects, such as parks and greenways, could be implemented in urban and residential areas. Such urban-oriented restoration projects could also benefit park users from the City of Merced.

Zoning districts define the types of land use that can occur on particular parcels. Some land uses, such as farming, are allowed by rights which accompany agricultural zoning designations, while other land uses require a special permit. For example, mining and mineral extraction are allowed with a Conditional Use Permit in areas zoned General or Exclusive Agriculture. Land uses in the river corridor are shown in Figure 3-30 and Table 3-11.

Current land uses in areas zoned General or Exclusive Agricultural in the river corridor include field and orchard crop farming, dairies, poultry farming, cattle grazing, and mining. Agricultural production is Merced County's leading industry, grossing $1.5 billion in 1999 (Merced County 1999). Seventy-one percent of agricultural land (50,641 acres) in the river corridor has been categorized by production value and mapped by the California Department of Conservation's (CDC) Farmland Mapping and Monitoring Program (Figure 3-31). The production value classification, which includes Prime Farmland, Farmland of Statewide Importance, Unique Farmland, and Farmland of Local Importance, is used to prioritize California's agricultural land conservation (CDC 2001). Prime Farmland is defined as having the best combination of physical and chemical features to sustain long-term production of agricultural crops. This land has the soil quality, growing season, and moisture supply needed to produce sustained high crop yields. Farmland of Statewide Importance is similar to Prime Farmland, but with slightly reduced production value due to factors such as greater slope or less ability to store soil moisture. Unique Farmland occurs on lesser quality soils, and Farmland of Local Importance is determined by an individual county as important to the local agricultural economy. In the Merced River corridor, the CDC has identified 28,322 acres of Prime Farmland, 13,237 acres of Farmland of Statewide Importance, 3,868 acres of Unique Farmland, and 5,214 acres of Farmland of Local Importance (Figure 3-31) (CDC 2001).

Table 3-10. Zoning within the Merced River Corridor

Zoning Type	Acres	Percent of Total Analysis Area
A-1 General Agricultural	41,987	53
A-2 Exclusive Agricultural	36,573	46
A-R Agricultural Residential	397	<1
C-2 General Commercial	58	<1
R-1 Single-Family Residential	118	<1
R-2 Multi-Family Residential	4	<1
M-1 Light Industrial	5	<1
M-2 Heavy Industrial	22	<1
City of Livingston Separate zoning district	498	
Total	**79,662**	**100**

Source: Merced County Planning and Community Development Department

Table 3-11. Land Use within the Merced River Corridor

Land Use Type	Acres	Percent of Total Analysis Area
Urban	1,030	1
Agriculture	24,433	31
Orchard	27,204	34
Grazing	12,688	16
Dairy	4,223	5
Poultry	2,430	3
Sand and Gravel (Aggregate)	1,331	2
Government	2,924	4
Vacant, Unclassified, Utility/Railroad, Misc.	3,399	4
Total	**79,662**	**100**

Source: Merced County Tax Assessor's Office

Aggregate (sand, gravel, and crushed stone) mining along the Merced River is another economically important industry in Merced County, producing approximately 1.7 million tons of construction aggregate in 1998 valued at more than $9 million (Clinkenbeard 1999). Demand for aggregate resources in Merced County is increasing with the growing population. The California Department of Conservation Division of Mines and Geology (CDMG) has designated the area along the Merced River between Snelling Road and Oakdale Road as MRZ-2a SG-2, meaning that the mineral deposits contained therein are suitable as marketable commodity (Figure 3-32). Pressure for aggregate mining will likely increase in the Merced River corridor. Depending on how mining is implemented, this increase in mining could result in conversion of extensive areas of floodplain (including farmland, grassland, oak woodland, and riparian areas) to mining pits. Innovative planning and mining approaches in these floodplain areas, however, could be used to minimize resource conflicts, and current reclamation and mitigation regulations present opportunities for the aggregate producers to interface with the Merced River Corridor Restoration Plan in providing grassland, farmland, oak savannas, and riparian areas. In some instances, innovative mining approaches could be used to enhance river function and habitat values. In addition, mining in the dredger tailings could be combined with extensive floodplain and riparian habitat restoration.

Although no wildlife refuges occur within the river corridor, a number of refuges and wildlife areas are located close to the confluence of the Merced River with the San Joaquin River (Figure 1-8). The San Luis National Wildlife Refuge (managed by the U.S. Fish and Wildlife Service [USFWS]) is a 26,000-acre refuge of managed seasonal and permanent wetlands, riparian habitat, native grasslands, and vernal pools. The refuge is managed primarily for migratory and wintering birds. Several riparian and floodplain habitat restoration projects are currently being implemented within the refuge. The North Grasslands Wildlife Area (managed by CDFG) encompasses 7,000 acres of wetlands, riparian habitat, and upland habitats near Gustine. The China Island Unit and the Salt Slough Unit of the North Grasslands Wildlife Area provide important habitat for Swainson's hawk (*Buteo swainsoni*) and sandhill crane (*Grus canadensis*).

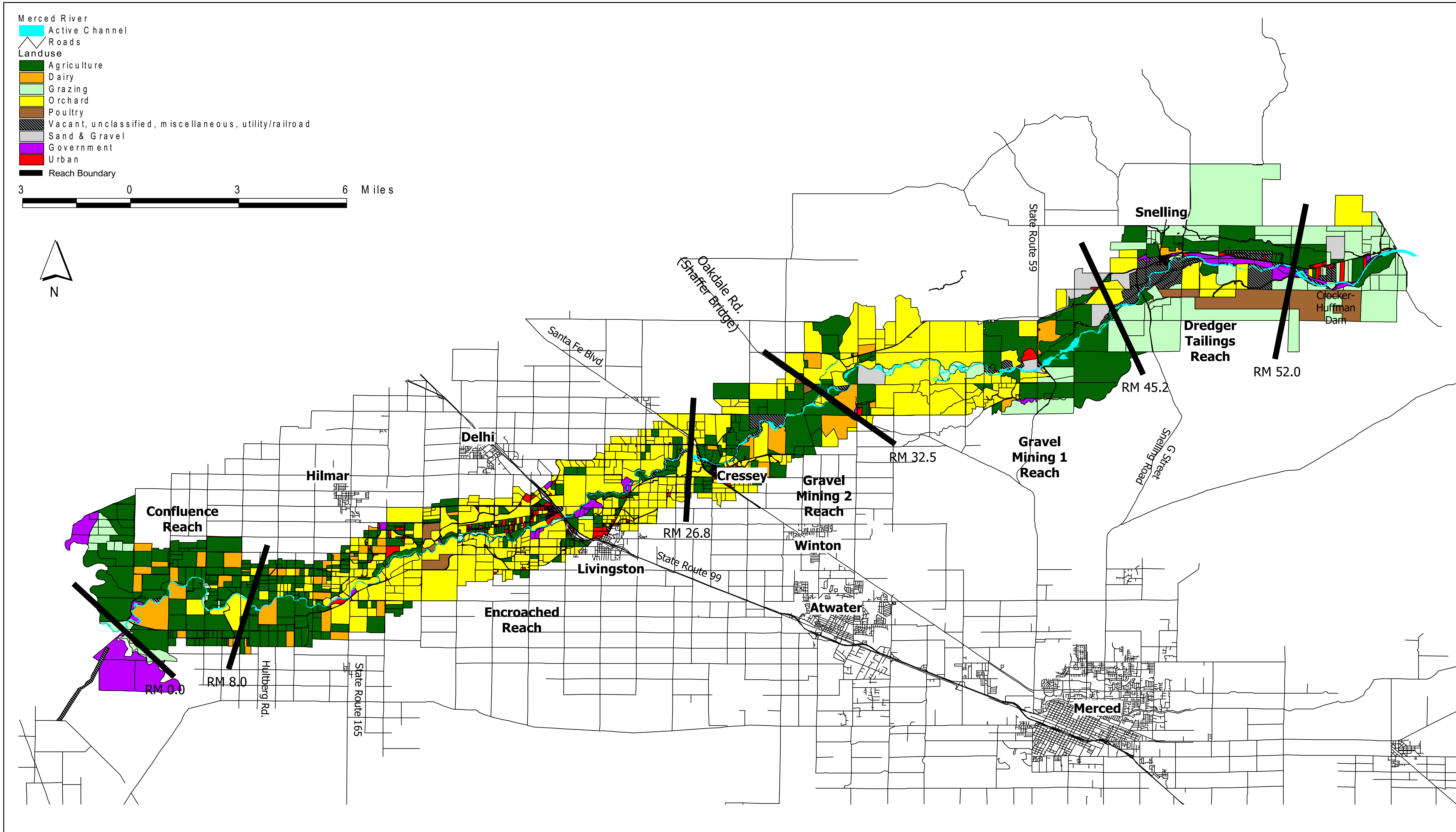


Figure 3-30. Land use in the Merced River corridor. Source: Merced County Tax Assessor's Office

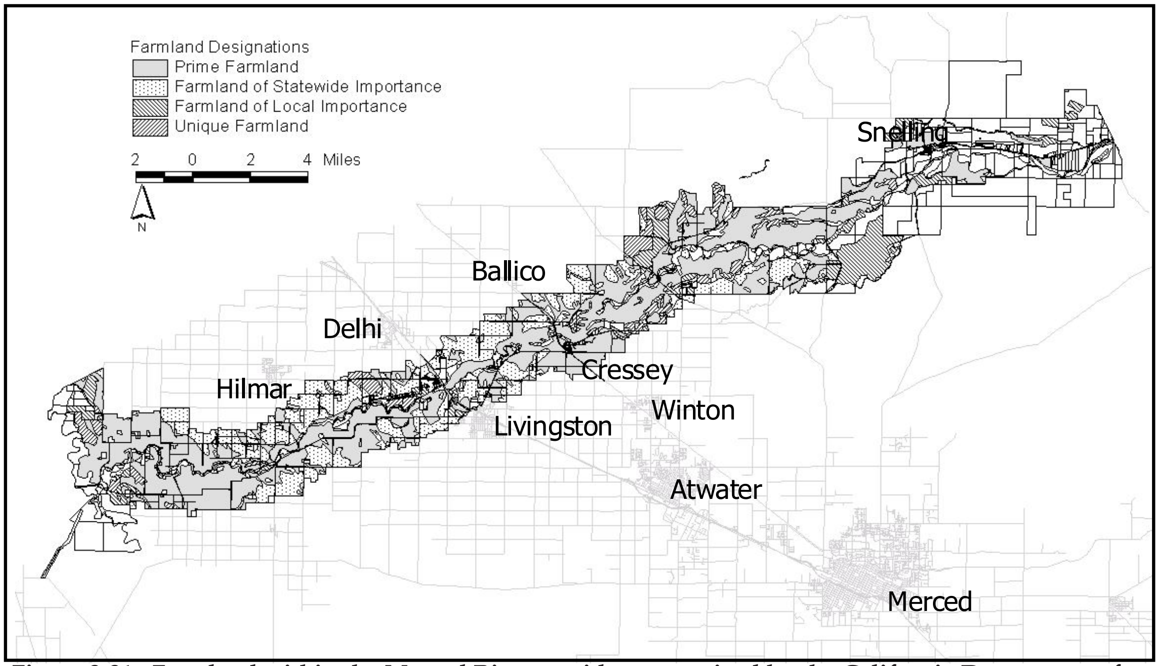


Figure 3-31. Farmland within the Merced River corridor categorized by the California Department of Conservation. Source: CDC (2001)

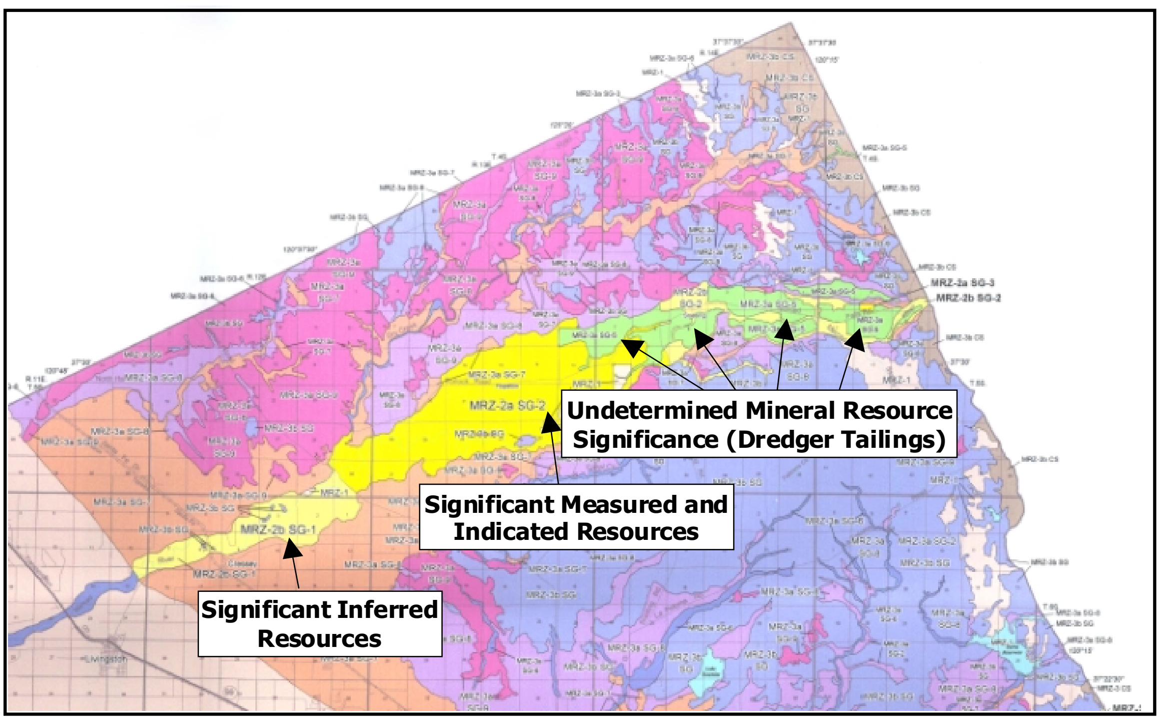


Figure 3-32. Mineral Resource Zones (MRZs) for concrete aggregate in Merced County. Source: Clinkenbeard (1999)

3.6 Water Quality

Little is known about water quality conditions in the Merced River and the effects of water quality on aquatic biota. Water quality factors that may affect ecological functions in the Merced River include temperature, nutrients, and point source discharges from wastewater treatment facilities.

The U.S. Geological Survey (USGS) and the Regional Water Quality Control Board are currently monitoring water quality at several locations in the river. In addition, the Central Valley Regional Water Quality Control Board (CVRWQCB) has issued waste discharge permits to the City of Livingston and Foster Farms wastewater treatment facilities near the city of Livingston (P. Buford, pers. comm., 2001). The permits allow the discharge of specific quantities and strengths of waste, consistent with the water quality objectives in the San Joaquin River Basin Plan (CVRWQCB 1998). These permits require monitoring reports and a Report of Waste Discharge (CVRWQCB 2001).

Water temperatures and the effects of water temperature on aquatic biota of the Merced River are currently being assessed by Merced ID. In 2001, AFRP funded the Merced River Water Temperature Management Feasibility Study, which will identify and recommend alternatives to improve temperature management for chinook salmon in the Merced River and at the Merced River Hatchery. The project will compile and summarize pertinent water development project specifications, project operational strategies and requirements, related flow agreements, existing thermal and flow data, and biological monitoring data at the four Merced River reservoirs and in the lower Merced River (USBR 2000).

National Water Quality Ranking

Since 1991, USGS has been collecting and analyzing data in more than 50 major river basins and aquifers across the country under the National Water Quality Assessment (NAWQA) Program. The NAWQA Program provides long-term, nationwide information on water quality in streams, groundwater, and aquatic ecosystems. The Merced River watershed is one of the subbasins for the San Joaquin-Tulare Basins study unit of the NAWQA Program. The NAWQA surveys indicate that the Merced River, relative to other rivers surveyed by the program, has higher concentrations of trace elements in bed sediments and a greater degree of non-native fish predominance (Dubrovsky et al. 1998). Nutrient concentrations in the Merced River were close to the median for all rivers studied by the NAWQA program. In 2001, the USGS began a second cycle of investigations in the national study units during which original study units will be systematically reassessed under the NAWQA program. Testing will focus on pesticides with high usage in agricultural and high population areas, indicators of waterborne diseases in drinking water supplies, and total mercury and methylmercury. More frequent sampling for nutrients and pesticides in stormwater began in October 2001 and will continue until 2005.

Pesticide Contamination

The Merced River has been identified by the CVRWQCB as impaired for the agricultural pesticides diazinon, chlorpyrifos, and group A pesticides. Group A pesticides include aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexanes (including lindane), endosulfan, and toxaphene. The EPA considers diazinon and chlorpyrifos in the Merced River to be a high priority and group A pesticides to be low priority (EPA 2000a and 2000b).

Diazinon is one of the most commonly used organophosphate insecticides in the United States and particularly in California (EPA 2000a). In the Merced River, diazinon was detected in over half of all winter storm runoff samples collected between 1992 and 1995 (Dubrovsky et al. 1998). The main agricultural application of diazinon in the San Joaquin Basin occurs during the winter rainy season to control wood-boring insects in dormant almond orchards. Because it is applied during the rainy season, diazinon can be transported to the river by rain and run-off. Diazinon is moderately mobile and persistent and is highly toxic to aquatic insects, with decreasing toxicity for fish, birds, and mammals. Studies have shown that exposure of chinook salmon to diazinon can result in diminished responsiveness to predators and reduced homing responses (EPA 2000a). Because of food chain effects and because it is so widely used, diazinon had the highest number of reported bird mortality incidents of any pesticide from 1994 to 1998 (EPA 2000a). The EPA is currently evaluating the need to discontinue and phase out diazinon usage in the United States (EPA 2000a), and in 1998 the EPA canceled the registration of diazinon for applications on golf courses and sod farms due to bird mortality.

Chlorpyrifos methyl is an organophosphate pesticide used to protect stored grain and a variety of orchard and row crops. Chlorpyrifos is commonly applied to nut and stone fruit trees during the dormant season to control pests. Additionally, chlorpyrifos is applied to orchards during the March-to-September irrigation season to control worms in alfalfa and sugarbeets, codling moths, and twig borers in walnuts and almonds. Ecological risk assessments indicate that risks to birds, fish, and mammals are high and risks to aquatic invertebrates are very high (EPA 2000b). Fish and aquatic invertebrate mortality can result from application rates as low as 0.01 pounds/acre. Chlorpyrifos bioaccumulates in the tissues of aquatic organisms and, due to its acute toxicity and persistence in sediments, is a hazard to bottom feeding species (Extoxnet 2001). According to the EPA (2000b) outdoor uses of chlorpyrifos result in acute reproductive risks to many nontarget aquatic and terrestrial animals.

In addition to diazinon and chlorpyrifos, the USGS has detected DDT in samples taken from the Merced River. Brown (1997) analyzed tissue samples from freshwater clams and bed sediments from 18 sites in the San Joaquin Valley, including one site on the lower Merced River in the vicinity of RM 5. Of all organochlorine chemicals tested, the most commonly found compounds were in the DDT family, which has been banned in the United States since 1972. Although concentrations of DDT compounds in the Merced River decreased by 32 percent from 1978 to 1992, Gilliom and Clifton (1990) found that the Merced River had the highest concentration of DDT compounds of the eastside tributaries to the San Joaquin River.

Total Maximum Daily Load Process

Section 303(d) of the Clean Water Act requires states to identify impaired water bodies that do not meet or are not expected to meet water quality standards and to initiate a planning process to identify Total Maximum Daily Loads (TMDLs) of contaminants and bring the impacted water bodies into compliance with water quality standards. During the TMDL process, stakeholders and regulators determine the amount of pollutants that are allowed to occur in the waterbody and specify responsibility for managing those pollutants. Section 13242 of the California Water Quality Control Act requires including TMDL studies in the Basin Plan for each management area (SWRCB 2001a; SWRCB 2001b). The completion dates for establishing TMDLs on the lower Merced River are December 2005 for chlorpyrifos and diazinon and December 2011 for group A pesticides. Currently the CVRWQCB is completing the San Joaquin River Salinity and Boron TMDL and the San Joaquin River Selenium TMDL. The CVRWQCB is scheduled to complete the San Joaquin River Organophosphate Pesticide TMDL by June 30, 2002. With the exception of the Dissolved Oxygen TMDL Steering Committee activities on the lower San Joaquin River, little work has been initiated for TMDL studies for tributaries to the San Joaquin River.

Chapter 4
Reach-specific Conditions and Restoration Issues, Objectives, and Strategies

Chapter 4
Reach-specific Conditions and Restoration Issues, Objectives, and Strategies

For the purposes of the Restoration Plan, the Merced River can be divided into five reaches based upon physical characteristics of the river and anthropogenic alterations to river system (Figure 4-1). Attributes of each reach are summarized in Table 4-1. These reaches are the:

- Dredger Tailings Reach, which extends from Crocker-Huffman Dam (RM 52) to RM 45.2, approximately 1.2 RM downstream of the Snelling Road bridge;
- Gravel Mining 1 Reach, which extends from RM 45.2 to Shaffer Bridge (RM 32.5);
- Gravel Mining 2 Reach, which extends from Shaffer Bridge to RM 26.8, approximately 0.3 miles downstream of the Santa Fe Boulevard bridge;
- Encroached Reach, which extends from RM 26.8 to Hultberg Road (RM 8); and
- Confluence Reach, which extends from RM 8 to the San Joaquin River confluence (RM 0).

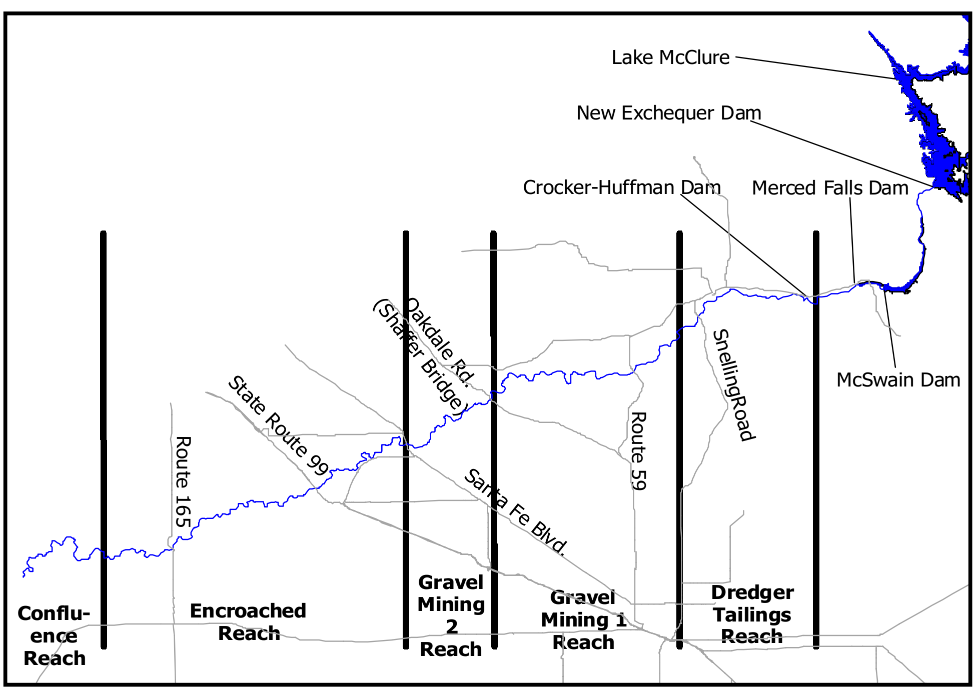


Figure 4-1. Merced River reach delineation.

Table 4-1. Summary of Reach Characteristics

Reach Name	Channel Slope[1]	Surface D50 (mm)	Total Vegetated Area (acres)	Vegetated Area per River Mile (acres/mile)
Dredger Tailings Reach (RM 52.0-45.2)	0.0023	36-128	210	70
Gravel Mining 1 Reach (RM 45.2-32.5)	0.0015	25-90	378	56
Gravel Mining 2 Reach (RM 32.5-26.8)	0.0008	22-85	1,084	85
Encroached Reach (RM 26.8-8.0)	0.0003	22-1	237	42
Confluence Reach (RM 8.0-0.0)	0.0002	1	618	33

Certain issues affecting the river, such as flow regulation, flood control, and elimination of sediment supply by upstream dams, are common to all of these reaches. Other issues, however, vary in nature and magnitude among the reaches. For example, in some reaches levees are extensive, while in others they are relatively absent. Appropriate restoration actions, therefore, must be tailored to address the issues and geomorphic conditions specific to each reach. This chapter describes geomorphic characteristics, riparian vegetation conditions, and land use and land ownership patterns for each of the five reaches, as well as reach-specific restoration issues, objectives, and strategies. Specific restoration actions recommended for each reach are described in Chapter 6.

4.1 Dredger Tailings Reach

The Dredger Tailings Reach extends from Crocker-Huffman Dam (RM 52) to RM 45.2, approximately 1.2 miles downstream of the Snelling Road bridge (Figure 4-1). The channel in this reach is confined by piles of dredger tailings, which have replaced the natural floodplain soils and floodplain forest and have increased floodplain elevation along the river (Figure 4-2). Within this reach, riparian vegetation is sparse, occurring primarily in narrow bands along the river channel and in fragmented patches in low-lying areas among the dredger tailings piles. Features in the Dredger Tailings Reach are identified in Table 4-2.

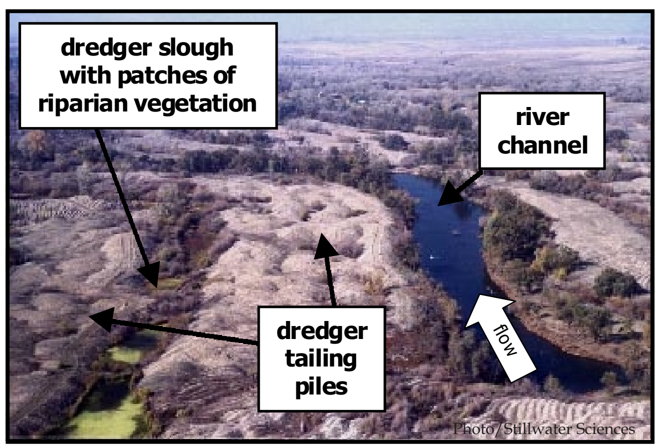


Figure 4-2. Aerial photograph showing conditions in the Dredger Tailings Reach.

Historically, this reach was part of a highly dynamic, multiple channel system. Under pre-colonial conditions, as the river exited the Sierra Nevada foothills near Merced Falls, the river spread out across a broad alluvial valley floor that ranged up to 4.5 miles in width (see Section 3.2). Within this reach, the historic river was a complex, multiple channel system. This system included numerous channels, such as the mainstem river channel and Ingalsbe, Dana and Hopeton sloughs (Figure 4-3). Under pre-colonial flow conditions, the dominant, or "mainstem," channel likely switched between the multiple channels, and channel avulsions during large flows were likely common.

Table 4-2. Features of the Dredger Tailings Reach

River Mile	Feature
52.0	Crocker-Huffman Dam and beginning of Dredger Tailings Reach
52.0	CDFG gravel augmentation project
52.0	CDFG riffle reconstruction project
52.0	Merced River Hatchery
51.0	CDFG Merced River Ranch
50.5	Cuneo fishing access
49.8	Canavero/Montgomery diversion ditch
49.2	Cuneo diversion ditch
49.0	Henderson County Park
48.2	Ruddle diversion ditch
48.0	town of Snelling
47.7	Scott/Cook and Dale diversion ditch
46.4	Snelling Road bridge
46.3	Means/Ferrell diversion ditch
46.0	Santa Fe Aggregates Doolittle Mine
45.8	Cowell diversion ditch
45.2	end of Dredger Tailings Reach

In addition to the effects of flow regulation and loss of sediment supply from the upper watershed, this reach has been extensively modified by gold dredging. In the early-to-mid twentieth century, gold dredges excavated the river channel, floodplain, and valley floor. The dredges had earthmoving capacities of 1.4–3.4 million cubic yards/year and excavated the channel and floodplain deposits to bedrock, usually a depth of 20–36 feet (Clark, no date). After recovering the gold, the dredgers redeposited the remaining tailings in long rows on the floodplain. These tailings consist of fine sand and gravel overlain by cobbles and boulders (Goldman 1964), a stratification pattern that likely resulted from the sluicing and discharge process. As a result of gold dredging, the channel has been depleted of coarse sediment and the adjacent floodplain has been raised and covered with dredger tailings piles. An estimated 24 million cubic yards of dredger tailings currently cover approximately 7.6 square miles of the floodplain in this reach and in the dredged area upstream of Crocker-Huffman Dam (Stillwater Sciences 2001a).

The combined effects of gold dredging, flow regulation, elimination of coarse sediment supply, and land use development have converted this reach from a complex, multiple-channel system to a simplified, single-thread system with a narrow floodplain adjacent to the channel. The complex slough channels that once dominated the floodplain have been converted to agricultural irrigation and return-flow ditches.

The river channel in this reach is moderately steep, with a slope averaging 0.0023. The channel bed is composed of coarse gravel and cobble. The D_{50} (the median particle size) of the bed surface ranges from 36 to 128 mm, and the particle size of 84 percent of the bed surface (D_{84}) ranges from 85 to 270 mm (Vick 1995, CDWR 1994, Stillwater Sciences 2001a). The dredger tailings on the floodplain confine the river channel width, resulting in high shear stresses in the reach during even moderate flow events. High shear stresses, combined with the lack of coarse sediment supply caused by upstream dams, has produced a channel that is typified by long, deep pools that are scoured to bedrock or to a coarse cobble armor layer.

As discussed in Chapter 3, under pre-dam conditions, the bed was likely mobi-

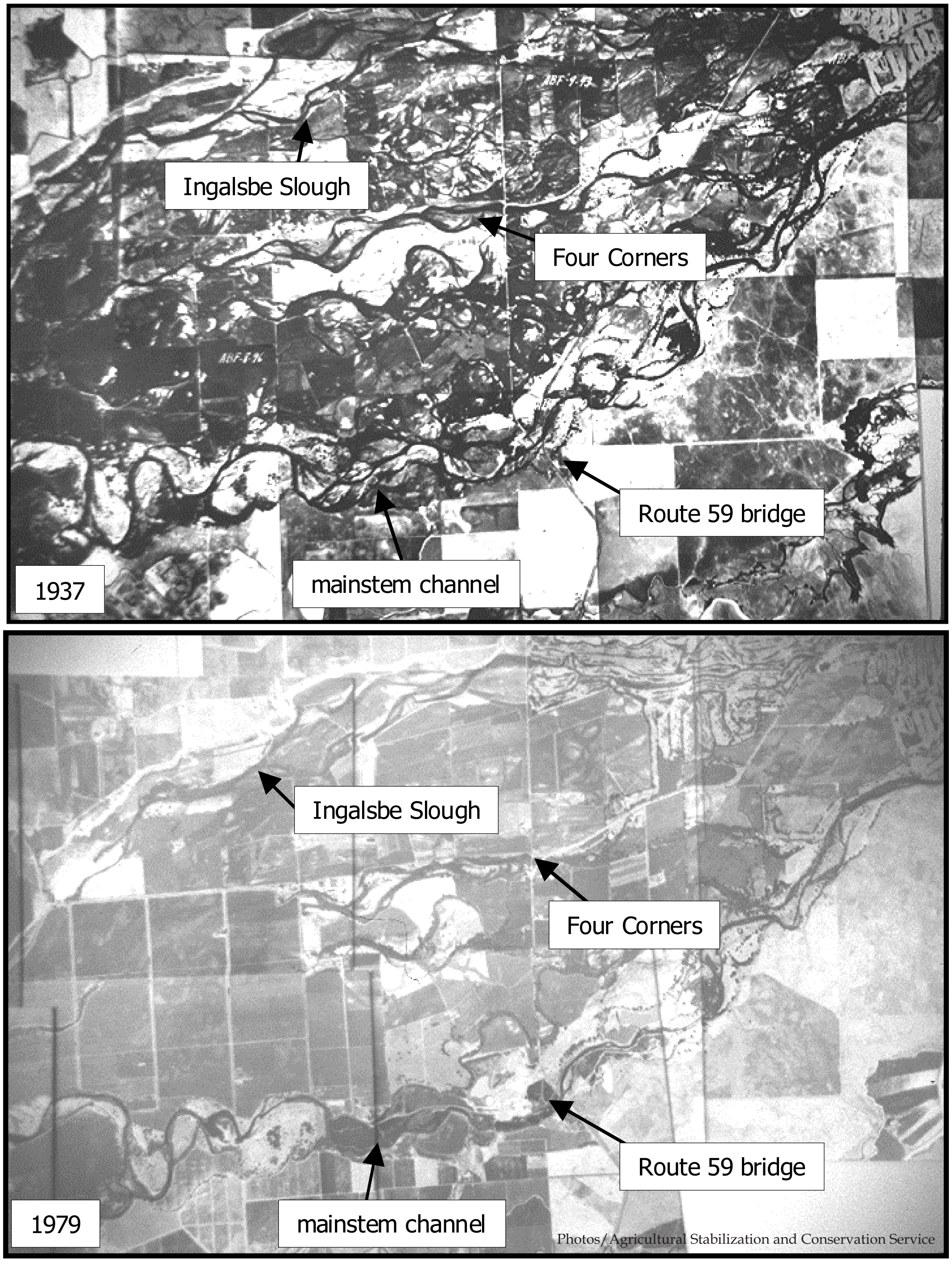


Figure 4-3. Historical and recent aerial photographs of the anastomosing reaches of the Merced River.

lized by small, relatively frequent floods that occurred about every 1–2 years. With the reduction in flood magnitude caused by flow regulation, the bed is currently immobile at flows up to the 5-year recurrence interval flow (Q_5) (Stillwater Sciences 2001a). As a result, the channel bed and formerly active bars are static, and riparian vegetation has encroached into the formerly active channel.

Riparian Vegetation

Tailing piles consisting largely of bare cobbles comprise the most extensive cover type in the Dredger Tailing Reach and represent 90 percent of the riparian area mapped within the reach (Table 4-3). The area of tailings alone (approximately 3,500 acres) rivals the total amount of vegetative cover mapped in the entire river corridor (approximately 3,000 acres). Sparse, weedy herbaceous assemblages consisting of non-native grasses and forbs dominate the large expanses of disturbed tailing surfaces and floodplain areas. Native riparian vegetation in this reach is typically restricted to narrow bands adjacent to the river, measuring 100 feet or less in width on each bank of the river, and linear patches confined to swales within the dredger tailings (Figure 3-21A). In general, native trees and shrubs dominate larger riparian patches, though non-native trees, shrubs, and vines are common along roads and at the edges of the tailing areas. The dominant vegetation between the channel and the tailing piles is a mix of native forest cover types (cottonwood, valley oak, and mixed riparian forest) interspersed with patches of mixed willow, grassland, riparian scrub, and off-channel marsh habitat (Table 4-3).

Low-lying swales within the tailings that were created during the dredging operations are occupied by a combination of woody riparian and wetland vegetation. These swales are typically connected to a perennial or seasonal groundwater supply and support a variety of wetland vegetation types (primarily freshwater emergent marsh, seasonal wetland, open water/ponds, mixed willow, and cottonwood forest). Most of the smaller, linear patches of riparian scrub and forest in the swales are dominated by Fremont cottonwood, Goodding's black willow, and arroyo willow. Narrow-leaf and red willows, edible fig, California buckeye, and California wild grape are common associated species in these swales. In the deeper swales and wetter sites, this riparian scrub/forest occurs as a band around lower elevation emergent wetlands and/or ponds.

Approximately half of all the remnant marsh habitat remaining in the river corridor (28 acres) is located in the Dredger Tailing Reach. The deepest, wettest tailing swales support cattail (*Typha latifolia*) marsh habitat and/or perennial ponds. These ponds support floating plants, such as various duckweeds (*Lemna* spp. and *Wolfiella* spp.) and water fern (*Azolla filiculoides*). The introduced water hyacinth

Table 4-3. Riparian Cover Types and Distribution in the Dredger Tailings Reach

Cover Type[1]	Total Area Within the Reach (acres)	Percent of Riparian Area within Reach
Vegetation		
Blackberry Scrub	11	<1
Box Elder	0.3	<1
Cottonwood Forest	71	2
Eucalyptus	0	0
Giant Reed	0.2	<1
Herbaceous Cover	40	1
Marsh	28	1
Mixed Riparian Forest	103	3
Mixed Willow	68	2
Riparian Scrub	22	1
Tamarisk	0	0
Tree of Heaven	1	<1
Valley Oak Forest	34	1
Other		
Disturbed Riparian	0	0
Dredger Tailings[2]	3,494	89
Total	**3,872**	**100**

[1] Cover types are described in Table 3-4.
[2] The numerous small vegetation patches within dredger swales were not mapped individually. The area represented by these patches is included within the Dredger Tailings cover type total.

also occurs in some ponds. Many of the ponds also contain beds of submergent macrophytes, primarily *Egeria*. Marsh pennywort (*Hydrocotyle* spp.) forms dense beds in some shallower ponds.

Native species of concern include western sycamore, which is generally a component of the mixed riparian forest but is absent from the Dredger Tailing Reach, and blue elderberry, which is uncommon in the Dredger Tailing Reach relative to reaches further downstream. Non-native, invasive species occurring in the reach include tree of heaven, non-native grasses and forbs within the tailings (including yellow starthistle, poison hemlock, and black mustard), and naturalized landscape trees within the mixed riparian forest, including London plane tree, Osage orange, sugar maple (*Acer saccharum*), and mulberry.

Land Ownership, Zoning, and Land Use

The majority (92 percent) of the land within the analysis area in the Dredger Tailings Reach is zoned Exclusive Agricultural (Figure 3-29). The Exclusive Agricultural zoning designation has a minimum parcel size requirement of 160 acres and is primarily used for grazing and open space. The remaining area that is not zoned agricultural is restricted to the town of Snelling. Snelling (population 453) is the only urbanized area in the Dredger Tailings Reach. Zoning in Snelling includes 93 acres of residential, 34 acres of general commercial, one acre of light industrial, and 209 acres of agricultural-residential development.

Within the agricultural zoning, land uses include 6,649 acres of cattle grazing, 887 acres of poultry farming, 1,636 acres of orchards, 73 acres of dairies, and 2,123 acres of miscellaneous agriculture (including row crops) (Figures 3-30 and 4-4). Over 2,430 acres of agricultural land (17 percent of the reach analysis area) in this reach have been mapped and categorized by production value by the California Department of Conservation (Figure 3-31) (see Section 3.5 for more detail on farmland categories).

Within the reach, land parcels are generally large and privately owned (Figure 3-27). Ninety-six percent of land is privately owned, and the average parcel size is 58 acres. This large parcel ownership may simplify potential restoration implementation by reducing the number of people contributing to the design process, reducing the number of easements and access agreements required, and potentially streamlining the permit process. Publicly owned parcels in the reach include lands owned by the CDFG, Merced County, Merced ID, and the Snelling and Merced Falls school districts. Public access to the river is provided at two locations,

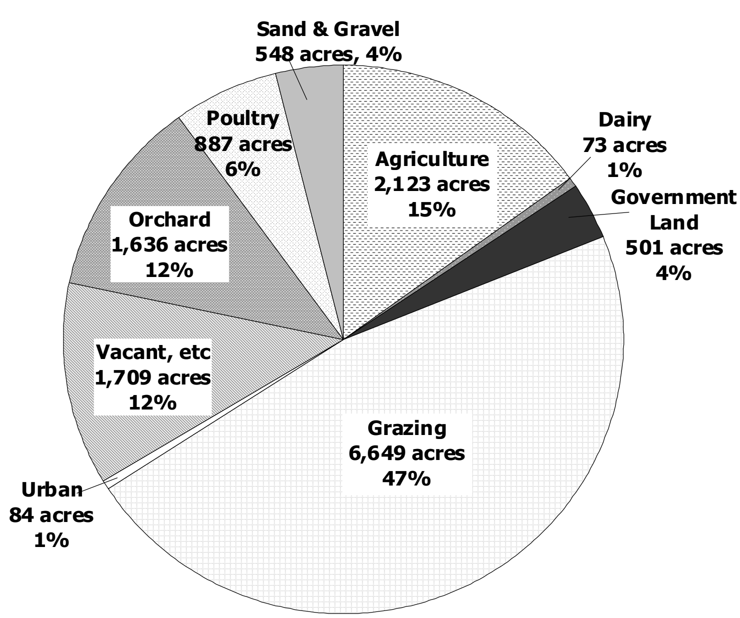


Figure 4-4. Land uses in the Dredger Tailings Reach.

Henderson County Park and the Cuneo Fishing Access (Figure 3-28). Henderson County Park is a 74-acre park that provides river access for fishing, ball fields and play equipment, and picnicking facilities. The Cuneo Fishing Access, which is owned and operated by the Merced ID, is located approximately 1.5 miles downstream of Crocker-Huffman Dam and provides river access for fishing.

In addition to agricultural land uses that dominate the reach, aggregate mining also occurs in the reach. The California Department of Conservation Division of Mines and Geology (CDMG) classifies the aggregate quality of the dredger tailing piles in the reach as uncertain because the composition of the aggregate and, therefore, its commercial value may have been altered during the dredging process (Clinkenbeard 1999). The Upper Merced Property Owners Group, however, is currently studying the aggregate quality and the feasibility of mining in the tailings area upstream of Crocker-Huffman Dam and has found that the tailings meet commercial quality standards (J. Kelsey, pers. comm., 2001). Three mines are currently operating in the dredger tailings, including the Blasingame, Doolittle, and Merced River Mining and Reclamation Company mines.

Riparian Diversions

Six riparian diversion ditches occur in the reach through which riparian water users divert flows from the river for agriculture (Figure 3-9). Riparian water rights usually come with ownership of parcel of land that is adjacent to a source of water and entitle the owner to use a share of the water flowing past his or her property. No permits, licenses, or government approval are required for this use, but the rights apply only to the water that would naturally flow in the stream.

Completed and On-going Restoration Projects

Several restoration projects have been implemented or are being planned in the Dredger Tailings Reach (Figure 1-4). These projects are discussed in more detail in Section 1.3. On-going restoration projects in the reach include:

- the CDFG and CDWR Chinook Salmon Spawning Gravel Augmentation Project; and
- the CDFG acquisition and restoration of the Merced River Ranch.

Restoration Issues

The primary restoration issues in the Dredger Tailings Reach include flow reduction and alteration of seasonal flow patterns, lack of bed-mobilizing flows, lack of coarse sediment supply, conversion of the floodplain to tailings piles, channel confinement, and lack of large woody debris. The lack of coarse sediment supply and lack of bed-mobilizing flows have resulted in channel simplification and confinement and prevent the accumulation and retention of valuable salmon spawning gravel. The conversion of floodplain to tailings and the confinement of the channel by the tailings piles prevents floodplain inundation during high flows and has eliminated the processes by which riparian vegetation is established and renewed, resulting in encroachment of vegetation into the channel and reduced riparian habitat.

Restoration Objectives

Restoration objectives developed for the Dredger Tailings Reach include:

- balance sediment supply and transport capacity to allow the accumulation and retention of spawning gravel and prevent riparian vegetation encroachment;

- restore floodplain functions to improve the establishment of riparian vegetation and the quality of riparian habitat;
- increase in-channel habitat complexity to improve aquatic habitat for native aquatic species; and
- scale low-flow and bankfull channel geometry to current flow conditions.

Conceptual Restoration Strategy

The conceptual restoration strategy for the Dredger Tailings Reach includes removing tailings from the floodplain to provide a functional riparian and floodplain corridor and adding gravel to the channel. Dredger tailings would be removed from the floodplain adjacent to the channel to establish a floodplain with a functional elevation (i.e., an elevation that is inundated at flows exceeding approximately 1,700 cfs) and provide a suitable surface for restoration of riparian vegetation (Figure 4-5). During removal of the dredger tailings, existing riparian vegetation would be preserved. The width of the floodplain and riparian corridor would be determined in coordination with landowners and others involved in the project design. For initial evaluation, a preliminary *minimum* riparian corridor width of 300 feet on each side of the river should be considered. Since a wider corridor would provide increased wildlife habitat values, however, the widest cor-

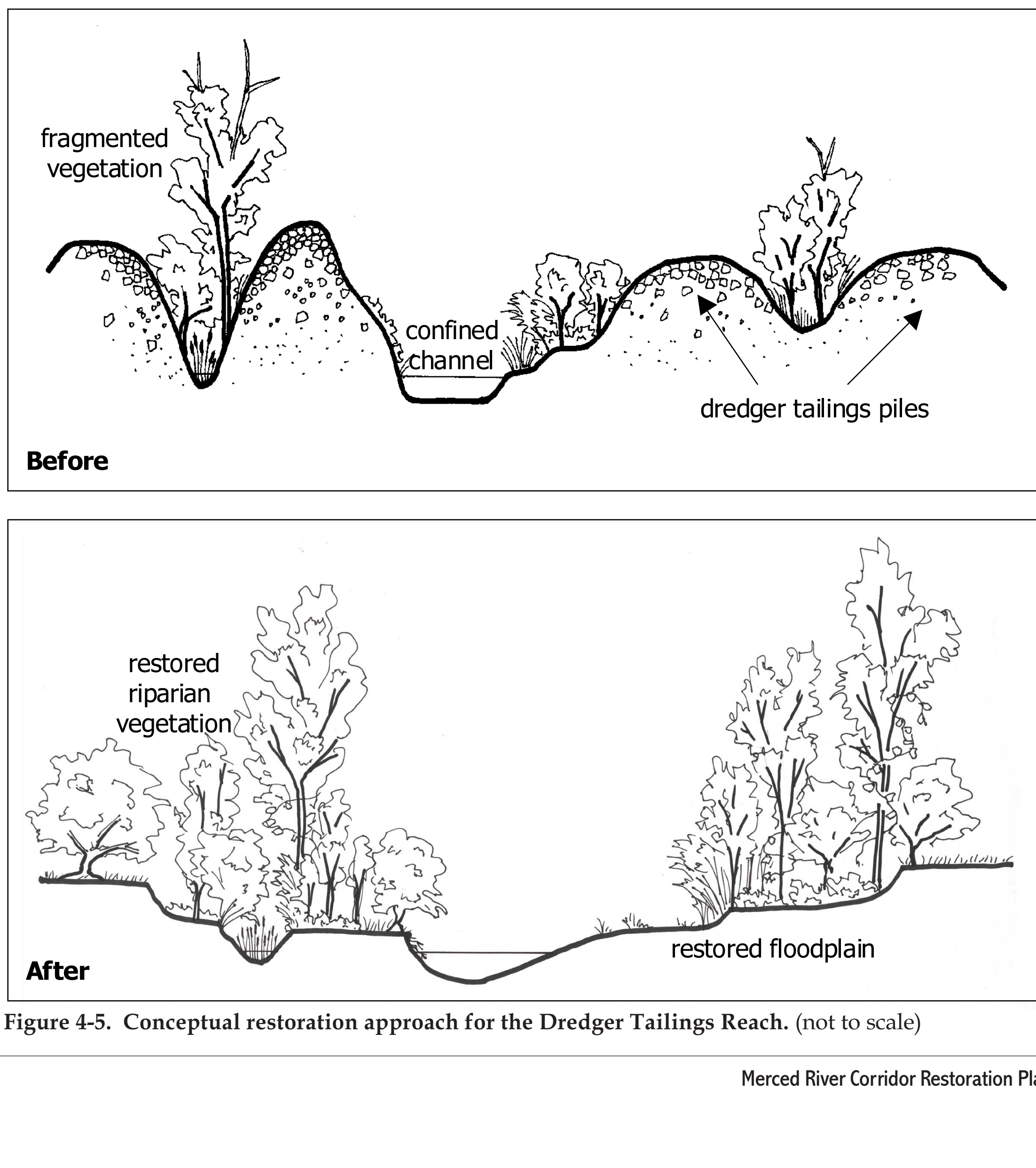


Figure 4-5. Conceptual restoration approach for the Dredger Tailings Reach. (not to scale)

ridor possible within landowner constraints should be pursued. Outside of the riparian restoration corridor, areas from which dredger tailings are removed could be converted to other uses, such as grazing or planted agriculture, depending upon landowner objectives. Floodplain restoration would be combined with introduction of coarse sediment to the channel, thus providing the necessary building blocks for the river to construct riffles and bars and improve aquatic habitat complexity. These actions are described in more detail in Chapter 6.

Design guidelines for this reach have been developed using a combination of field studies and sediment transport and hydraulic modeling. These guidelines are discussed in detail in Stillwater Sciences (2001b).

4.2 Gravel Mining 1 Reach

The Gravel Mining 1 Reach extends from RM 45.2, approximately 1.2 miles downstream of the Snelling Road bridge, to Shaffer Bridge (RM 32.5), located just upstream of the Dry Creek confluence (Figure 4-1). In this reach, the river channel and floodplain have been extensively mined for aggregate (sand and gravel) both on the floodplain and in the river channel. As a result, the reach is characterized by large mining pits (Figure 4-6). Four in-channel or captured mining pits and four terrace pits, two of which are active, occur in this reach. Features in the Gravel Mining 1 Reach are identified in Table 4-4.

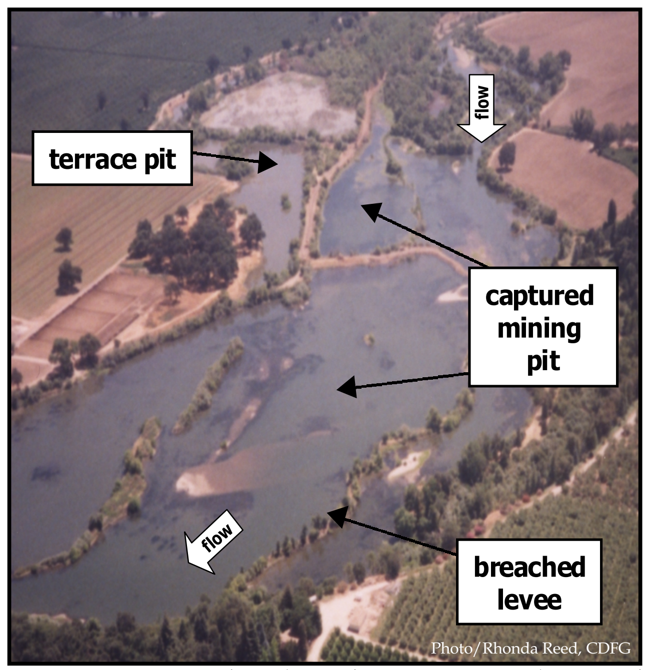


Figure 4-6. Captured in-channel mining pits in the Gravel Mining 1 Reach. The berm isolating this pit was set back from the river channel and repaired in 1999 by CDWR and CDFG as the Ratzlaff Reach phase of the Salmon Habitat Enhancement Project.

Geomorphic Characteristics

This reach occupies the downstream portion of the historically multiple-channel system described for the Dredger Tailings Reach. As in the Dredger Tailings Reach, the river in this reach was historically a highly dynamic system, comprised of many channels including the mainstem river channel and Ingalsbe, Dana and Hopeton sloughs (Figure 4-3). Under pre-colonial flow conditions, the dominant, or “mainstem” channel likely switched between the multiple channels, and channel avulsions during large flows were common. At the downstream end of this reach, the valley width narrows to approximately one mile, and the pre-colonial river transitioned to a single, thread meandering system. As in the Dredger Tailings Reach, the river in the Gravel Mining 1 Reach has been converted to a single-thread system, and floodplain sloughs have been converted to irrigation ditches and drains. The reach-averaged channel slope is 0.0015, and the channel bed is composed of coarse gravel and cobble. The D_{50} ranges from 25 to 90 mm; the D_{84} ranges from 48 to 150 mm.

This reach has been extensively modified by aggregate mining. Large-scale aggregate mining began in the reach in the 1940s. Older mines excavated sand and

Table 4-4. Features of the Gravel Mining 1 Reach

River Mile	Feature
45.2	beginning of Gravel Mining 1 Reach
40.0-44.0	Merced River Salmon Habitat Enhancement Project
42.0	Route 59 Bridge
42.0	Calaveras Materials Inc. Silva Expansion mine
36.3	Cowell diversion ditch #2
33.2-34.1	Santa Fe Aggregates Bettencourt Ranch mine
32.5	Shaffer Bridge and end of Gravel Mining 1 Reach

gravel directly from the riverbed, leaving behind deep pits within the channel (Figure 4-6). More recent mines have been located on floodplains and terraces adjacent to the river. These mines are typically separated from the river by narrow soil berms. Many of the berms at older mines were breached by high flows, resulting in the capture of the floodplain mines by the river channel. In-channel and terrace mines occurring in the reach are summarized in Table 4-5 and are shown in Figure 4-7. These mines occupy 35 percent of river channel in the reach and 44 percent of the adjacent banks (Stillwater Sciences 2001a). Current mining operations in the reach are described under Land Ownership, Zoning, and Land Use below (Section 4.2.3).

In addition to the effects of mining, geomorphic conditions in the reach are also affected by loss of floodplain connectivity and by bank revetment, which limits channel migration. Floodplain extent in the reach has been significantly reduced by flow reduction. Under pre-colonial conditions, floodplain width averaged 10,625 feet (Figures 3-18A and 3-18B). Flow regulation has reduced floodplain width to an average of 555 feet, or 5 percent of its historic width (Figure 3-19). Levees are generally absent from the reach and occur only in association with floodplain and terrace aggregate mines. Levees, therefore, have little effect on floodplain connectivity in the reach. While bank revetment in this reach armors only 5 percent of the total bank reach length, 33 percent of all meander apexes are armored (Figures 3-20A and 3-20B). The channel, therefore, has only very limited opportunities to migrate and is generally held in its current location.

Table 4-5. Terrace and In-Channel Aggregate Pits in the Gravel Mining 1 Reach

Pit Identification	Mine Name	RM	Length[1] (ft)	Width[1] (ft)	Depth[2] (ft)
In-channel Pits					
GM1 - C1	Unknown	38.9-39.3	1,500	800	No data
GM1 - C2	Unknown	35.1-35.4	1,000	200	6-9
GM1 - C3	Unknown	33.9-34.4	2,200	400	5-8
GM1 - C4	Unknown	36.3-36.9	2,000	100	4
Terrace Pits					
GM1-T1	Carson Pit I	--	2,800	2,300	No data
GM1-T2	Carson Pit II	--	1,100	450	No data
GM1-T3	Silva Expansion	42	No data	No data	No data
GM1-T4	Bettencourt Ranch	33.2-34.1	4,500	1,500	No data

[1] Measured from 1998 aerial photographs (scale: 1:6,000)
[2] Depth from water surface measured in the field (June 2000)

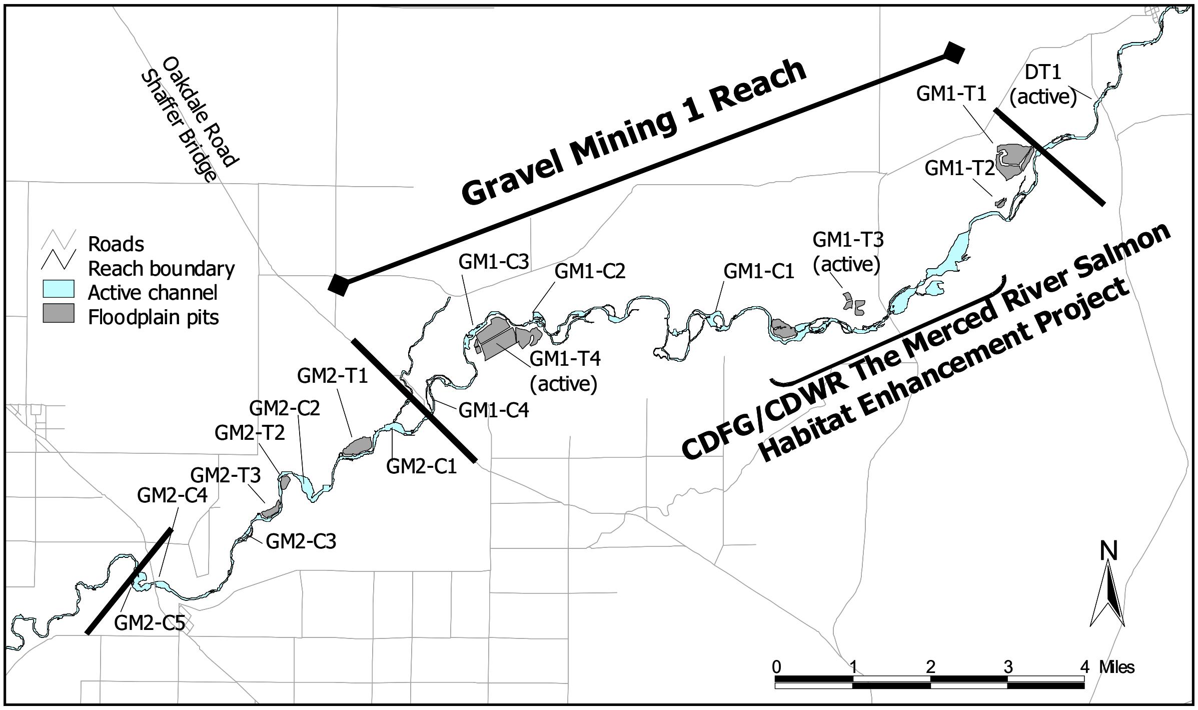


Figure 4-7. Terrace and in-channel aggregate mines in the Gravel Mining 1 Reach.

Riparian Vegetation

The width of riparian vegetation on each bank of the main channel in the Gravel Mining 1 Reach varies from 100 to 500 feet (Figures 3-21A and 3-21B), representing the second highest vegetation area per mile of river of the five reaches (Table 4-1). Numerous former channels and sloughs are lined with narrow bands of riparian vegetation, most commonly mixed willow and herbaceous patches with scattered valley oaks. These bands are separated from the mainstem river by agricultural fields. Vegetated areas along the main channel are dominated by herbaceous communities on floodplains and terraces and a mixture of forest and riparian scrub types primarily along the river channel (Table 4-6). Herbaceous vegetation is most commonly found on sites with poorly developed and well-drained soils, such as abandoned bars with coarse substrate and some terraces. The herbaceous cover type includes a variety of vegetation series which are primarily dominated by non-native grasses and forbs. Lower elevation sites near the river that experience seasonal inundation or saturated soils are generally dominated by sedges and grasses, while drier, higher elevation terrace or abandoned floodplain sites are generally dominated by non-native forbs and grasses, including black mustard, poison hemlock, yellow starthistle, and ripgut brome. Riparian scrub and herbaceous vegetation cover types are prevalent throughout the reach and are generally associated with modified banks and gravel pits. Riparian scrub is an early seral stage vegetation type, typically dominated by California button-willow and narrow-leaf willow. Common associated plants include seedlings or saplings of Fremont cottonwood, Goodding’s black willow, Oregon ash, box elder, and white alder. Young valley oaks also occur in this vegetation type in some locations. Valley oak woodland in this reach ranges in composition from dense forest patches to open-canopy stands that intergrade into purely herbaceous patches. This reach contains 20 acres of marsh habitat, representing approximately 30 percent of all marsh area mapped within the river corridor (Table 4-1). Most of the area mapped as marsh in the Gravel Mining 1 Reach is associated with gravel pits rather than off-channel oxbows or sloughs.

Table 4-6. Riparian Cover Types and Distribution in the Gravel Mining 1 Reach

Cover Type[1]	Total Area Within the Reach (acres)	Percent of Riparian Area within Reach
Vegetation		
Blackberry Scrub	9	1
Box Elder	4	<1
Cottonwood Forest	106	10
Eucalyptus	29	3
Giant Reed	3	<1
Herbaceous Cover	461	41
Marsh	20	2
Mixed Riparian Forest	109	10
Mixed Willow	118	11
Riparian Scrub	121	11
Tamarisk	0	0
Tree of Heaven	0.2	0
Valley Oak Forest	105	10
Other		
Disturbed Riparian	14	1
Dredger Tailings	0	0
Total	**1,099**	**100**

[1] Cover types are described in Table 3-4.

Generally throughout the reach, former gravel mines and associated roads extend to the channel margin and occupy formerly-vegetated areas. This reach contains the largest area of disturbed riparian area (14 acres total), which consists largely of heavily modified banks and roads with scatterings of primarily non-native grasses and forbs. As a result, the existing riparian vegetation is patchy and discontinuous. The steep banks common to pit berms throughout this reach do not provide the low-gradient, alluvial surfaces necessary for recruitment of native tree seedlings. Patches of giant reed, Himalayan blackberry, and other non-native scrub communities are common on gravel pit berms and other disturbed areas. In parts of the channel where mining pits have been captured by the river, vegetation assemblages are highly fragmented and are limited to banks, former berm surfaces, and mid-channel bars. Remnant off-channel oxbows and sloughs contain patches of marsh and seasonal wetland habitats and are typically bordered by linear stands of riparian scrub, valley oak forest, and remnant cottonwood and mixed riparian forest.

Plant communities of concern within the Gravel Mining 1 Reach include cottonwood forest and valley oak forest, which have been fragmented and reduced in extent by the mining pits and agricultural development. As discussed above, these communities are generally maturing and are not self-sustaining because of inadequate regeneration. Native species of concern include blue elderberry, which is uncommon in this reach relative to reaches further downstream. Non-native species of concern in the Gravel Mining 1 Reach include eucalyptus, giant reed, and non-native grasses and forbs such as yellow starthistle, poison hemlock, and black mustard.

Eucalyptus is the most prominent invasive species in the Gravel Mining 1 Reach; monospecific stands cover approximately 30 acres total in this reach and account for two-thirds of all the eucalyptus area mapped in the river corridor (Table 4-1). This species, which is fast-growing and sprouts prolifically has become established in dense, monospecific stands near the Dry Creek confluence between RM 31.5 and RM 36.7. Ecological issues related to eucalyptus invasion include loss of biological diversity due to displacement of native plant communities and their corresponding wildlife habitat, the loss of understory species resulting from chemical inhibition from eucalyptus litter, and high fire danger due to large, volatile fuel loads (Bossard et al. 2000). Vigorous recruitment of eucalyptus by seed and sprouting appears to be occurring in several areas, and eradication or control of eucalyptus species is an important management consideration. Eucalyptus is also widespread on Dry Creek upstream of Oakdale Road, where it is the dominant vegetation type. Eucalyptus eradication efforts on the mainstem river will need to address the issue of these upstream propagule sources, as well as cultivated, land-borne sources on farms and along roads.

Although the current extent of giant reed along the Merced River appears limited compared to many other Central Valley rivers and streams (EPA/SFEI 1999), this species is highly invasive and eradication or control of this species is an important management consideration. Where it becomes widely established, giant reed displaces native plants and associated wildlife, including special status species. It provides less in-stream shade, less forage for insect populations, and greater fire danger than native riparian species (Bossard et al. 2000).

Land Ownership, Zoning, and Land Use

All of the land in the reach is zoned General or Exclusive Agricultural (Figure 3-29). Land parcels in the reach are generally large and privately-owned (Figure 3-27). The average parcel size in this reach is 104 acres. Only 0.3 percent of the area in the reach is publicly owned, and there are no public access points to the river.

Agricultural land uses occupy 94 percent of the total analysis area in the reach and include 8,278 acres of orchards (46 percent of the analysis area), 5,919 acres of other agriculture (33 percent of the analysis area), 1,873 acres of grazing (10 percent of the analysis area), and 929 acres of dairy (5 percent of the analysis area) (Figures 3-30 and 4-8). Next to agricultural land uses, sand and gravel mining is the most common land use (3 percent of the reach) in the reach. Two mines are currently in operation. Urban, commercial, industrial uses combined comprise less than 1 percent of the analysis area in the reach and are limited to small, isolated areas along Route 59 (Figure 3-30). In the Gravel Mining 1 Reach, 13,704 acres of agricultural land (76 percent of the reach analysis area) have been mapped and categorized by production value by the California Department of Conservation (Figure 3-31).

Aggregate mining along the Merced River is an economically important industry and provides aggregate resources needed for current and future development in Merced County. Within the Gravel Mining 1 Reach, 631 acres (3 percent of the land use area) are used for sand and gravel production. Two active terrace mines (the Bettencourt Ranch and the

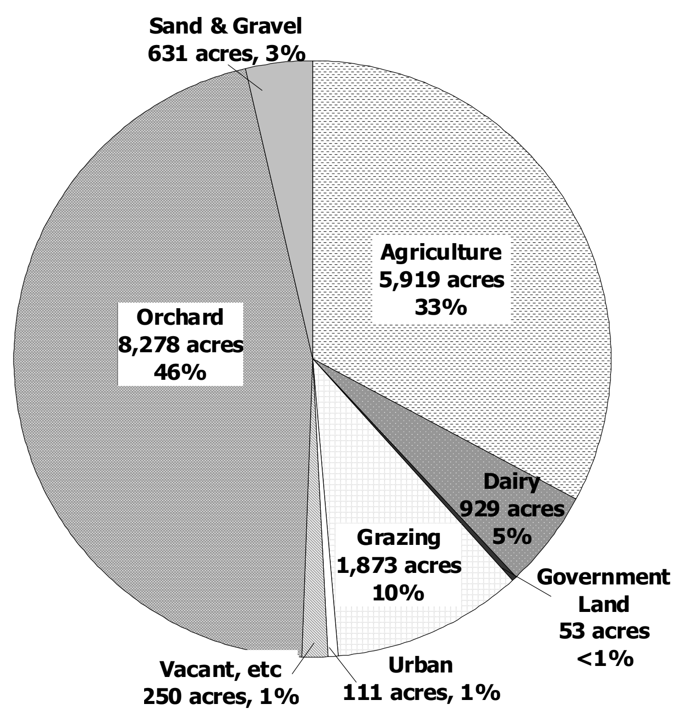


Figure 4-8. Land uses in the Gravel Mining 1 Reach.

Calaveras Materials Inc. Silva Expansion), one recently permitted mine (the Woolstenhulme Ranch), and two mines currently in the final phases of reclamation (the Silva and Carson mines) occur in this reach. Santa Fe Aggregates, Inc. operates the Bettencourt Ranch mine near RM 34. The mine was permitted in 1989 and has approximately three to four years of permitted reserves, depending on market demands. The current permitted area is 160 acres. Upon completion of the mining operation, the site will be reclaimed to open space, wildlife habitat, and agriculture. Calaveras Materials Inc. operates the 40-acre Silva Expansion site just downstream of the Route 59 Bridge. An additional site, the Woolstenhulme Ranch, was permitted for operation on 456 acres in 2000.

Riparian Diversions

The Cowell Diversion Ditch #2 occurs in this reach and is part of the system of diversion ditches through which riparian water users divert flows from the Merced River, primarily for agriculture (Figure 3-9).

Completed and On-going Restoration Projects

Several restoration projects have been implemented or are being planned in the Gravel Mining 1 Reach. CDFG and CDWR are currently implementing the Merced River Salmon Habitat Enhancement Project to reconstruct the channel and floodplain through 4.3 miles of the Merced River that have been excavated for aggregate mining. This project is discussed in more detail in Section 1.3.

Restoration Issues

Primary restoration issues in the Gravel Mining 1 Reach include flow reduction and the alteration of seasonal flow patterns, lack of bed-mobilizing flows, lack of sediment supply, bedload transport impedance at in-channel pits, risk of capture of floodplain pits, reduced floodplain inundation, fragmentation of riparian vegetation by pits, lack of seedling establishment sites on steep pit berms and revetted banks, occurrence of invasive plant species (primarily eucalyptus and giant reed), lack of large woody debris, and potential predation on native fish species by introduced largemouth bass.

Restoration Objectives

Restoration objectives developed for the Gravel Mining 1 Reach include:

- scale low-flow and bankfull channel geometry to current flow conditions;
- restore floodplain functions to improve the establishment of riparian vegetation and the quality of riparian habitat;
- reduce habitat for introduced predatory fish species (primarily largemouth bass) to increase salmonid survival rates;
- improve sediment transport continuity to supply sediment to downstream reaches;
- increase in-channel habitat complexity to improve aquatic habitat for salmonid species;
- balance sediment supply and transport to allow the accumulation and retention of spawning gravels and prevent riparian vegetation encroachment; and
- reduce or eliminate expansion of eucalyptus stands and giant reed patches.

Conceptual Restoration Strategy

The restoration strategy for the Gravel Mining 1 Reach includes reconstructing the channel and floodplain where in-channel pits currently occupy the river channel, eradicating giant reed, controlling the spread of eucalyptus, and potentially eradicating existing eucalyptus stands. Reconstruction of the channel and floodplain at in-channel pits would entail fully or partially filling pits, reconstructing the floodplain at a functional elevation, and providing a suitable surface for restoration of riparian vegetation (Figure 4-9). Completely filling the pits (Approach A) is the preferred approach because it provides the largest extent of floodplains and riparian forest and minimizes the risk of future pit capture. Complete elimination of the pits, however, can be cost prohibitive. As an alternative, pits could be isolated by broad floodplains and berms (Approach B). The width of the floodplain and riparian corridor would be determined in coordination with landowners and others involved in the project design. A *minimum* initial riparian corridor width of 300 feet on each side of the river is recommended. Since a wider corridor would provide increased wildlife habitat values, however, the widest corridor possible within landowner constraints should be pursued.

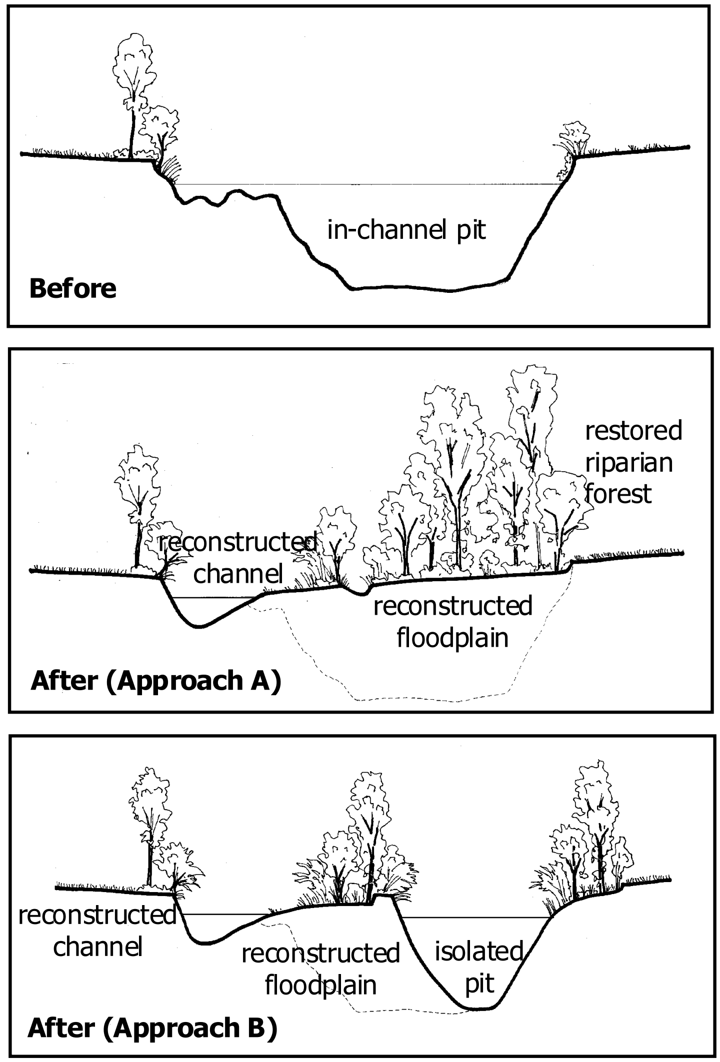


Figure 4-9. Conceptual restoration approaches for the Gravel Mining 1 and Gravel Mining 2 reaches. (not to scale)

Eradicating giant reed, controlling the spread of eucalyptus, and potentially eradicating existing eucalyptus stands would require working with landowners to monitor establishment of young eucalyptus trees and removing young trees from the riparian corridor. Eradication of existing stands would require further assessment of potential wildlife values provided by these stands.

4.3 Gravel Mining 2 Reach

The Gravel Mining 2 Reach extends from Shaffer Bridge (RM 32.5) to RM 26.8, approximately 0.3 RM downstream of the Santa Fe Boulevard bridge (Figure 4-1). This reach includes the confluence with Dry Creek (RM 32.7) and the remaining in-channel and floodplain aggregate

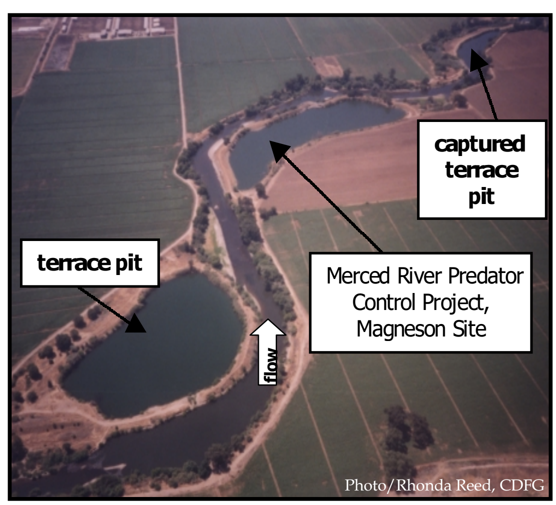


Figure 4-10. Aerial photograph showing typical conditions in the Gravel Mining 2 Reach.

Table 4-7. Features of the Gravel Mining 2 Reach

River Mile	Feature
32.5	Shaffer Bridge and beginning of Gravel Mining 2 Reach
31.7	Dry Creek confluence
29.0	Merced River Predator Control Project, Magneson Site
27.7	Town of Cressey
27.1	Santa Fe Boulevard Bridge
26.8	end of Gravel Mining 2 Reach

mining pits (Figure 4-10). Five in-channel or captured mining pits and three terrace pits, none of which are active, occur in this reach. The riparian vegetation width in this reach is narrower than in the Gravel Mining 1 Reach and is approximately 50 feet on each bank in most places. Features of the Gravel Mining 2 Reach are listed in Table 4-7.

Geomorphic Characteristics

Under historical conditions, the river in this reach transitioned from the multiple-channel system described for the Dredger Tailings and Gravel Mining 1 reaches to a single-thread, meandering system (Figure 3-7). Under current conditions, the reach is a single-thread system, and the channel has been isolated from its floodplain by flow reduction and channel incision. In addition, due to reduced sediment supply and reduced frequency of sediment transport, the reach no longer exhibits alternate bars which are apparent in historical (1937) aerial photographs. The reach-averaged channel slope is 0.0008. The channel bed is composed of sand, gravel, and cobble; the D_{50} of the bed surface ranges from 22 to 85 mm; the D_{84} ranges from 33 to 130 mm (CDWR 1994b, Vick 1995, Stillwater Sciences 2001b).

This reach, like the Gravel Mining 1 Reach, has been extensively mined for aggregate both on the floodplain and in the channel. Five in-channel or captured mining pits and three terrace pits (including one pit that was isolated from the channel by a CDFG/CDWR restoration project) occur in this reach (Figure 4-11, Table 4-8). In-channel and captured mines currently occupy two miles (35 percent) of the river, and terrace mines border an additional 1.3 miles (23 percent) of the river banks in this reach.

Dry Creek, the only major tributary to the river downstream of Crocker-Huffman Dam, delivers large volumes of sediment (primarily sand) to this reach. Dry Creek drains a 110-square mile watershed to the north of the river. Under current conditions, sediment supply from Dry Creek to the Merced River has been increased by channel incision in the creek and resulting bank and terrace failures, as well as erosion from orchards in the upper watershed. The creek enters the mainstem Merced River at an in-channel mining pit (GM2-C1). The presence of this pit has reduced the baselevel elevation at the mouth of the creek and has initiated a process of channel incision that is migrating upstream from the creek's mouth. This channel incision will likely continue to migrate upstream in Dry Creek until a stable slope is achieved or a geologic control is reached. As incision migrates upstream, bank erosion rates in upstream reaches and sediment delivery to the Merced River will likely increase. Sediment eroded from orchards, combined with sediment supplied by channel incision and bank erosion, have greatly increased sediment supply to the mainstem river from this watershed. Much of this sediment, however, is currently captured in the GM2-C1 mining pit.

Flow reduction and channel incision have isolated the channel from its floodplain in this reach. Based on reoccupation of historical cross sections, Vick (1995) documented incision of up to five feet in this reach since 1964. Under historical condi-

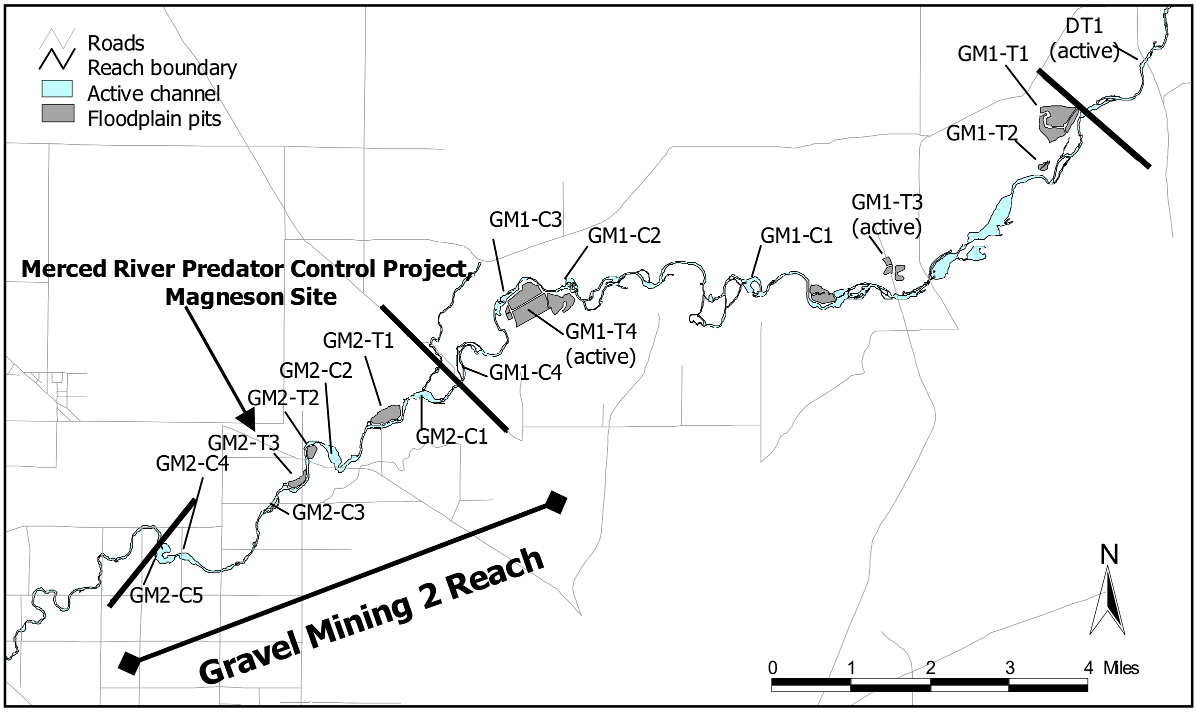


Figure 4-11. Terrace and in-channel aggregate mines in the Gravel Mining 2 Reach.

tions, floodplain width in this reach averaged 5,100 feet (Stillwater Sciences 2001a). With the combined effects of reduced flood flows resulting from operation of the upstream dams, excavation of in-channel and floodplain pits, and channel incision, floodplain width in this reach has been reduced to 46 feet (Figures 3-18B and 3-19). Levees in this reach are limited and occur only in association with terrace mining pits, separating these pits from the active channel. Bank revetment in the reach is moderately extensive, armoring 7 percent of the banks and 61 percent of the meander apexes within the reach (Figure 3-20B).

Table 4-8. Aggregate Pits in the Gravel Mining 2 Reach

Pit Identification	Mine Name	RM	Length[1] (ft)	Width[1] (ft)	Depth (ft)
In-channel Pits					
GM2-C1	River Rock	31.5-32.1	2,000	600	4-13[2]
GM2-C2	Silva/Turlock Rock	30.0-30.6	3,300	400	13-19[2]
GM2-C3	Turlock Rock	28.7-28.9	1,400	200	23[2]
GM2-C4	Cressey Sand and Gravel	27.2-27.4	1,400	300	11-29[2]
GM2-C5	Turlock Rock	26.7-27.1	1,800	800	10[2]
Terrace Pits					
GM2-T1	Turlock Rock	31.1-31.4	2,100	900	No data
GM2-T2	Turlock Rock	29.7-29.9	800	600	20[3]
GM2-T3	Turlock Rock	29.2-29.5	1,600	500	20[3]

[1] Measured from 1998 aerial photographs (scale: 1:6,000)
[2] Measured from water surface in the field (June 2000)
[3] Source: Vick (1995)

Riparian Vegetation

The riparian zone width in the Gravel Mining 2 Reach is approximately 50 feet (approximately the canopy width of one tree) on each bank, which is narrower than in upstream reaches (Figure 3-21B). The areal extent of riparian vegetation within the Gravel Mining 2 Reach (237 acres) is lowest of all the reaches. Gravel mine pits and agricultural fields confine the native riparian vegetation in most areas to one canopy width. Vegetation in this reach is highly fragmented, as in the Gravel Mining 1 Reach, and also includes off-channel oxbows and sloughs that are isolated within agricultural fields. Unlike the Gravel Mining 1 Reach, virtually no marsh habitat (<1 acre) occurs in this reach (Table 4-9). As in the Gravel Mining 1 Reach, gravel pit berms extend to the channel margin and hinder the recruitment of riparian species because bank revetment, steep slopes, and the construction of access roads adjacent to the channel eliminate the hydrologic and topographic conditions necessary for seedling establishment. Issues regarding regeneration of cottonwood and valley oak forests discussed in the Gravel Mining 1 Reach description apply to this reach as well.

Table 4-9. Riparian Cover Types and Distribution in the Gravel Mining 2 Reach

Cover Type[1]	Total Area Within the Reach (acres)	Percent of Riparian Area within Reach
Vegetation		
Blackberry Scrub	6	2
Box Elder	2	1
Cottonwood Forest	19	8
Eucalyptus	3	1
Giant Reed	3	1
Herbaceous Cover	68	27
Marsh	0.5	<1
Mixed Riparian Forest	70	28
Mixed Willow	26	11
Riparian Scrub	18	8
Tamarisk	0	0
Tree of Heaven	2	1
Valley Oak Forest	23	10
Other		
Disturbed Riparian	4	2
Dredger Tailings	0	0
Total	**241**	**100**

[1] Cover types are described in Table 3-4.

Patches of eucalyptus are common on Dry Creek and in the Gravel Mining 2 Reach, although eucalyptus is not as extensive in area as in the Gravel Mining 1 Reach. Eucalyptus trees are non-native species considered to be moderately invasive, and eradication and control of eucalyptus is an important management consideration.

Patches of giant reed, a non-native species associated with areas of disturbance such as bank revetment and mining pit berms, occur scattered throughout the Gravel Mining 2 Reach. Giant reed generally occurs in relatively small, dense patches on disturbed sites and is most common on revetted banks. Although the current extent of giant reed along the Merced River appears limited compared to many other Central Valley rivers and streams (EPA/SFEI 1999), this species is highly invasive and eradication or control of this species is an important management consideration. Where it becomes widely established, giant reed displaces native plants and associated wildlife, including special status species. It provides less in-stream shade, less forage for insect populations, and greater fire danger than native riparian species (Bossard et al. 2000).

Land Ownership, Zoning, and Land Use

More than 97 percent of the land in the reach is zoned Exclusive or General Agricultural (Figure 3-29). The remaining area is zoned primarily for Agriculture-Residential and Residential. Land parcels in the reach are generally large and privately owned (Figure 3-27). Ninety-seven percent of land within this reach is privately owned; the average parcel size is 35 acres. No public access points to the river are available in this reach.

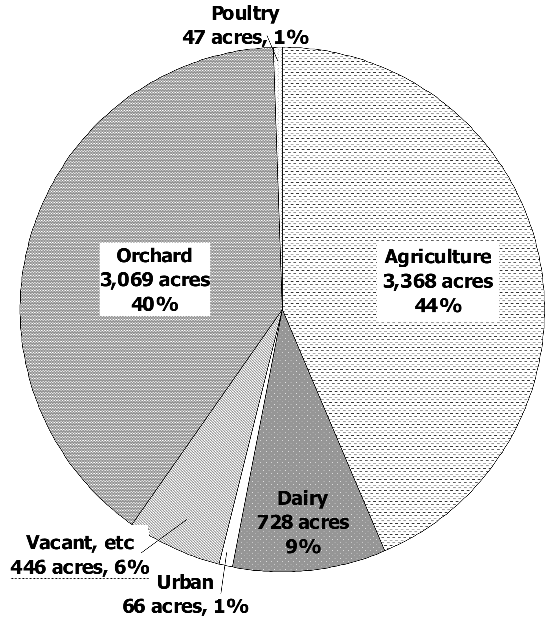


Figure 4-12. Land uses in the Gravel Mining 2 Reach.

Agricultural land uses occupy 93 percent of the total analysis area in the reach and include 3,069 acres of orchards (40 percent of the analysis area), 3,368 acres of other agriculture (44 percent of the analysis area), and 728 acres of dairy (9 percent of the analysis area) (Figures 3-30 and 4-12). Land uses in the remaining area include vacant and other lands (446 acres, 6 percent of the analysis area), urban uses (66 acres, 1 percent of the analysis area), and poultry (47 acres, 1 percent of the analysis area). In the Gravel Mining 2 Reach, 7,105 acres of agricultural land (92 percent of the reach analysis area) have been mapped and categorized by production value by the California Department of Conservation (Figure 3-31).

The town of Cressey (population 840) is the only area zoned for urban development in the Gravel Mining 2 Reach (Figure 3-29). Urban zoning designations within Cressey include 30 acres of residential, 21 acres of general commercial, 22 acres of heavy industrial, and 121 acres of agricultural-residential development.

Currently, no active aggregate mines occur in this reach. Aggregate mining along the Merced River, however, is likely to become more extensive as Merced County's population grows and demand for local aggregate sources increases. The California Department of Conservation Division of Mines and Geology has classified the valley floor in this reach as MRZ-2a SG-2, meaning that it is underlain by significant measured or indicated mineral resources (Clinkenbeard 1999). Considering the presence of the underlying mineral resources, demand for aggregate mining in the Gravel Mining 2 Reach may increase in the future. Depending on implementation, this increase in mining could result in conversion of extensive areas of floodplain (including farmland, grassland, oak woodland, and riparian areas) to mining pits and further impacts to the river. Innovative planning and mining approaches in these floodplain areas, however, could be used to minimize resource conflicts. In some instances, innovative mining approaches could be used to enhance river function and habitat values.

Completed and On-going Restoration Projects

In 1996, the CDFG, working with the CDWR and with funding from the Four Pumps Agreement, completed the Merced River Predator Control Project, Magneson Site Project. This project isolated a pit (referred to as GM2-T3 in Table 4-8) that had captured the river channel. The pond was left in place behind the repaired berm to retain recreational fishing opportunities important to the landowner. This project is discussed in more detail in Section 1.3.

Restoration Issues

Primary restoration issues in the Gravel Mining 2 Reach include flow reduction and alteration of seasonal flow patterns, lack of bed-mobilizing flows, lack of coarse sediment supply, bedload transport impedance at in-channel pits, channel incision and resulting floodplain isolation, large volumes of sand supplied from Dry Creek, fragmentation of riparian vegetation by pits, lack of seedling establishment sites on steep pit berms and revetted banks, extensive invasion by eucalyptus, giant reed establishment on revetted banks, lack of large woody debris, and potential predation by introduced largemouth bass.

Restoration Objectives

Restoration objectives developed for the Gravel Mining 2 Reach include:

- scale low-flow and bankfull channel geometry to current flow conditions;
- restore floodplain functions to improve the establishment of riparian vegetation and the quality of riparian habitat;
- reduce habitat for introduced predatory fish species (primarily largemouth bass) to increase salmonid survival rates;
- improve sediment transport continuity to supply sediment to downstream reaches;
- increase in-channel habitat complexity to improve aquatic habitat for salmonid species;
- balance sediment supply and transport;
- control the spread of invasive, exotic plant species in the riparian corridor to prevent terrestrial habitat quality degradation; and
- reduce the supply of sand and finer sediment from Dry Creek.

Conceptual Restoration Strategy

The restoration strategy for the Gravel Mining 2 Reach is similar to the strategy for the Gravel Mining 1 Reach and includes reconstructing the channel and floodplain where in-channel pits currently occupy the river channel, eradicating giant reed, controlling the spread of eucalyptus, potentially eradicating existing eucalyptus stands, and reducing the supply of fine sediment and sand from Dry Creek. As discussed for the Gravel Mining 1 Reach, reconstruction of the channel and floodplain at in-channel pits would entail fully or partially filling pits, reconstructing the floodplain at a functional elevation, and providing a suitable surface for restoration of riparian vegetation (Figure 4-9). Completely filling the pits (Approach A) is the preferred approach because it provides the largest extent of floodplains and riparian forest and minimizes the risk of future pit capture. Complete elimination of the pits, however, can be cost prohibitive. As an alternative, pits could be isolated by broad floodplains and berms (Approach B). The width of the floodplain and riparian corridor would be determined in coordination with landowners and others involved in the project design. An initial *minimum* riparian corridor width of 300 feet on each side of the river is recommended. Since a wider corridor would provide increased wildlife habitat values, however, the widest corridor possible within landowner constraints should be pursued.

Eradicating giant reed and controlling the spread of eucalyptus and potentially eradicating existing eucalyptus stands would require working with landowners to monitor establishment of young eucalyptus trees and removing young trees from the riparian corridor. Eradication of existing stands would require further assessment of potential wildlife values provided by these stands.

Reducing input of sand and fine sediment from Dry Creek would likely entail implementing measures to reduce incision (channel downcutting) in Dry Creek and reduce sediment delivery from orchards in the upper watershed. Design and implementation of these measures would require additional assessment of the magnitude and source of sediment supplied from the Dry Creek watershed.

4.4 Encroached Reach

The Encroached Reach extends from RM 26.8 (approximately 0.3 RM downstream of the Santa Fe Boulevard Bridge) to Hultberg Road (RM 8) (Figure 4-1). In this reach, development in the former floodplain and extensive levees confine the channel and floodplain to a narrow corridor (Figure 4-13). Bank revetment is also extensive and limits bank erosion and channel migration. Features in the Encroached Reach are listed in Table 4-10.

Figure 4-13. Aerial photograph showing typical conditions in the Encroached Reach.

Geomorphic Characteristics

As in the Gravel Mining 1 Reach, the river in this reach was historically a single-thread, meandering system. Historical aerial photographs provide evidence of past channel migration, both as remnant channel scars and oxbow lakes. The reach-averaged channel slope is 0.0003. Within this reach, the channel substrate transitions from gravel to sand. The transition zone extends from RM 25.5 to RM 16.5 (almost half the length of the reach). The downstream portion of this reach may be subject to backwater effects from the San Joaquin River.

Table 4-10. Features of the Encroached Reach

River Mile	Feature
26.8	beginning of Encroached Reach
23.3	McConnell State Recreation Area
22.5	city of Livingston
20.7	State Route 99 Bridge
19.8	Foster Farms wastewater treatment facility
19.5	city of Livingston sewage treatment facility
12.2	Hagaman County Park
12.0	Route 165 Bridge
8.0	Hultberg Road and end of Encroached Reach

The channel in this reach is isolated from its floodplain by a combination of flow regulation and levees. Flow regulation has had the greater effect on floodplain width, reducing average floodplain width by 70 percent from its historical width of 1,800 feet (Figures 3-18C, 3-18D, and 3-19). Unlike the Dredger Tailings, Gravel Mining 1, and Gravel Mining 2 reaches, levees are extensive in the Encroached Reach, occurring on 26 percent of the right bank floodplain and 29 percent of the left bank floodplain. All levees in this reach are privately owned. These levees further reduce the width of the remaining floodplain (i.e., the floodplain that would be expected to be inundated by flows of 6,000 cfs) by an additional 53 percent (Figures 3-18C, 3-18D, and 3-19). Under current conditions, average floodplain width in the reach is 245 feet. The channel in this reach is trapezoidal and exhibits no active bars or clearly defined low flow channel.

Bank revetment is extensive in this reach, occurring on 21 percent of the bank length and on 76 percent of meander apexes (Figures 3-20C and 3-20D). The combined effects of flow regulation, levee construction, and bank revetment limit channel migration in this reach, thus preventing the river from forming a floodplain that is scaled to the current flow conditions. In addition, isolation of the river from its floodplain and the elimination of channel migration impair the recruitment and establishment of native riparian trees.

Table 4-11. Riparian Cover Types and Distribution in the Encroached Reach

Cover Type[1]	Total Area Within the Reach (acres)	Percent of Riparian Area within Reach
Vegetation		
Blackberry Scrub	3	<1
Box Elder	13	2
Cottonwood Forest	35	6
Eucalyptus	12	2
Giant Reed	6	1
Herbaceous Cover	130	21
Marsh	1	<1
Mixed Riparian Forest	210	34
Mixed Willow	96	15
Riparian Scrub	61	10
Tamarisk	0.4	<1
Tree of Heaven	3	1
Valley Oak Forest	51	8
Other		
Disturbed Riparian	2	<1
Dredger Tailings	0	0
Total	**624**	**100**

[1] Cover types are described in Table 3-4.

Riparian Vegetation

The riparian zone in the Encroached Reach ranges from 50 to 300 feet wide on each bank and is composed primarily of mixed riparian forest, herbaceous patches, and mixed willow species (Figures 3-21C and 3-21D). The Encroached Reach is the longest of the five reaches, but because vegetation is so confined to the channel banks, it contains the lowest vegetated area per length of river, 33 acres/river mile (Table 4-1). Almost all of the native riparian vegetation in the Encroached Reach is located within the agricultural levees, and for much of the reach vegetation width is one tree wide. The distribution of cover types within the reach is listed in Table 4-11.

Common species in the mixed riparian forest include Oregon ash, white alder, box elder, valley oak, and various willows. The canopy layer typically reaches 40 to 50 feet in height. Mixed willow vegetation includes stands dominated almost entirely by willow species, particularly narrow-leaf willow, Goodding's black willow, and arroyo willow. Mixed willow patches tend to be larger and more extensive than in upstream areas and exhibit distinct shrub and tree canopy layers. Goodding's black willow and arroyo willow tend to dominate the tree overstory canopy, which reaches heights of 20 to 35 feet. Narrow-leaf willow is the most common component of the shrub layer, and it also contributes to the subcanopy or canopy layers in some patches. Red willow may occur as an associated species. Box elder is most common within the Encroached Reach, occurring in monospecific stands along the banks (13 acres total) or as an understory species within the mixed riparian forest.

Giant reed, tree of heaven, and mulberry are non-native, invasive plant species which have established in the Encroached Reach. Giant reed acreage (6 acres total) is highest in this reach compared to all other reaches. Tree of heaven shares the highest area total with the Confluence Reach (3 acres each). Giant reed patches are typically associated with cleared areas and revetted banks, whereas tree of heaven commonly invades mixed riparian forest and grassland areas on floodplains. Although distribution of these species is currently limited to small isolated patches, these species are highly invasive and eradication or control is an important management consideration. Several non-native shrubs, such as tree tobacco and pokeweed, are also scattered throughout the understory in this reach.

Compared to upstream reaches, densities of blue elderberry are higher in the Encroached Reach and increase in a downstream direction. These plants are important habitat for the federally threatened valley elderberry longhorn beetle, and conservation of the existing elderberry population is an important management concern.

Land Ownership, Zoning, and Land Use

More than 99 percent of land in the Encroached Reach is zoned General Agricultural (Figure 3-29). The remaining area is zoned Agriculture-Residential (67 acres), Commercial (2 acres), and Industrial (4 acres). The City of Livingston comprises a separate zoning district of 498 acres.

Land parcels in the reach average 22 acres in size and are generally privately owned (Figure 3-27). Only 320 acres of land in the analysis area of this reach is in public ownership. Public access to the river is provided at two locations, McConnell State Recreation Area (RM 23.3) and Hagaman County Park (RM 12.2) (Figure 3-28). McConnell State Recreation Area, located two miles north of Livingston, has 75 acres of parkland for camping and picnicking. Hagaman County Park is a county park located just upstream of the Route 165 bridge and has playgrounds, river access, and facilities for picnicking.

Agricultural land uses occupy 93 percent of the analysis area in the reach (Figures 3-30 and 4-14). Agricultural land uses in the reach include 13,264 acres of orchards (60 percent of the analysis area), 5,700 acres of other agriculture (26 percent of the analysis area), 1,092 acres of dairy (5 percent of the analysis area), 318 acres of poultry (1 percent of the analysis area), and 127 acres of grazing (1 percent of the analysis area). Land uses in the remaining area include vacant and other lands (514 acres, 2 percent of the analysis area), urban uses (617 acres, 3 percent of the analysis area), and government land (320 acres, one percent of the analysis area). In the Encroached Reach, 19,939 acres of agricultural land (91 percent of the reach analysis area) have been mapped and categorized by production value by the California Department of Conservation (Figure 3-31).

Livingston, one of the larger cities in Merced County, is located in this reach (Figure 3-30). In 2000, the estimated population of Livingston was 10,183. Although the city accounts for less than one percent of the total zoned lands within the reach, Livingston is the largest urban area along the Merced River. The City of Livingston sewage treatment plant is located on the south bank of the river at RM 19.5. The Foster Farms wastewater treat-

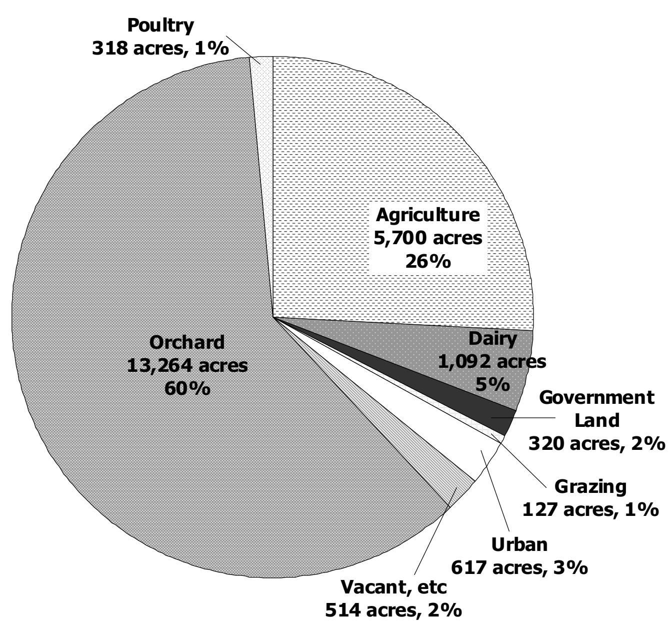


Figure 4-14. Land uses in the Encroached Reach.

ment facility is located at RM 19.8, just upstream of the City of Livingston treatment plant. The effects of these point source discharges on water quality in the river have not been determined. Both discharges are permitted by the Central Valley Regional Water Quality Control Board.

Completed and On-going Restoration Projects

No restoration projects have been completed or are on-going in the Encroached Reach.

Restoration Issues

The primary restoration issues in the Encroached Reach are flow reduction and alteration of seasonal flow patterns, agricultural development in the former floodplain and riparian corridor, isolation of the floodplain from the river by levees, bank revetment and resulting prevention of channel migration, lack of large woody debris, elimination of vegetation successional patterns due to levees and bank revetment, and invasion of the riparian corridor by non-native plant species. Opportunities for restoration in this reach are extremely limited due to the conversion of the floodplain to agricultural land uses. Increasing floodplain connectivity and reinitiating channel migration in this reach would need to be supported by a voluntary easement program that would compensate landowners who choose to participate in restoration projects.

Restoration Objectives

Restoration objectives developed for the Encroached Reach include:

- where feasible and supported by landowners, reconstruct a multi-staged channel and floodplain that is scaled to current flow conditions to provide a suitable surface for the establishment of riparian vegetation;
- increase the width of the riparian corridor to provide terrestrial habitat and filter pollutant and fine sediment run-off to the river;
- reduce the need for bank protection by increasing the allowable meander belt to provide suitable surfaces for the establishment of riparian vegetation; and
- control the spread of invasive, non-native plant species.

Conceptual Restoration Strategy

Establishment of a river-floodplain meander belt in this reach would require working with landowners to identify and implement opportunities to provide conservation easements adjacent to the river. Such easements could be used as mechanisms to allow bank erosion (within set limits) and increase the width of the riparian corridor. Where allowing bank erosion is not desirable, such as at bridge abutments or near structures, biotechnical methods of erosion control which strengthen banks and provide terrestrial and in-stream habitat should be considered. Where possible, a functional floodplain could be excavated adjacent to the channel or allowed to form through natural erosion and deposition processes, in order to increase channel and floodplain width and provide a suitable surface for restoration of riparian vegetation (Figure 4-15). It may not be possible to implement channel and floodplain restoration projects in this reach in the near future because of adjacent land uses and landowner concerns. Opportunities, however, may become available to develop projects further in the future. As in upstream reaches, a *minimum* width of 300 feet should be targeted for conservation easements. Where possible within landowner constraints, wider easements should be sought.

Distribution of invasive, non-native plant species in this reach is currently limited to small isolated patches. Removal of these patches and future monitoring and eradication could prevent these species from becoming major problems, as has occurred in other rivers in the Central Valley and coastal California. Control and eradication of these species would require working with landowners to identify and remove patches of these species.

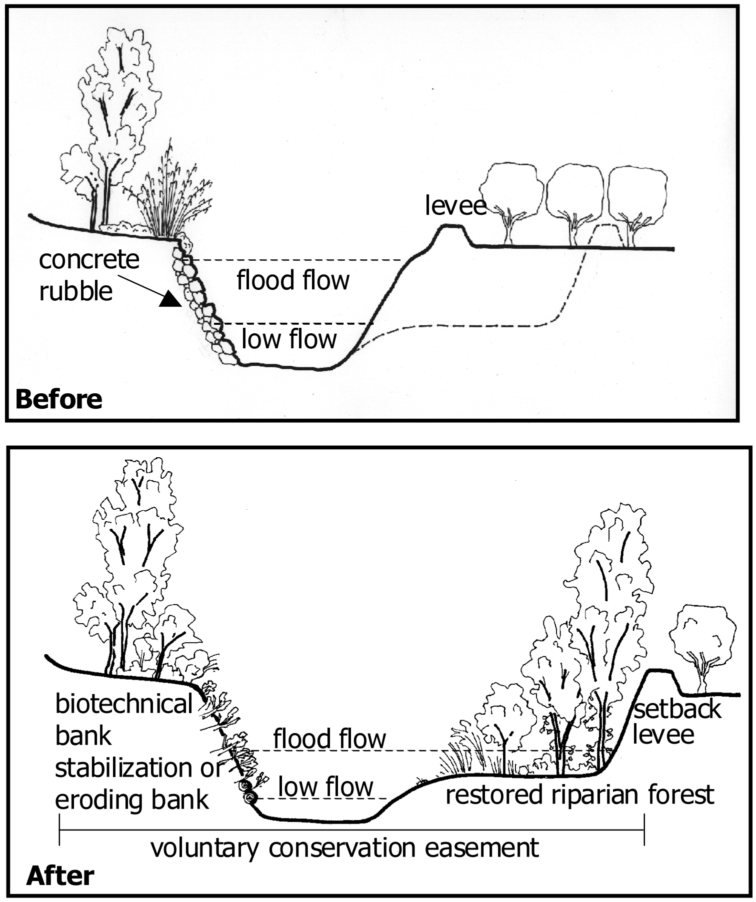


Figure 4-15. Conceptual restoration approach for the Encroached and Confluence reaches.

4.5 Confluence Reach

The Confluence Reach extends from Hultberg Road (RM 8) to the San Joaquin River confluence (RM 0) (Figure 4-1). This reach is entirely sand-bedded and is subject to backwater effects from the San Joaquin River. The most extensive and continuous stands of native vegetation remaining along the Merced River corridor are located in this reach in the three miles upstream from the confluence with the San Joaquin River. Bank revetment is moderately extensive, though less so than in the Encroached Reach. Figure 4-16 shows typical conditions in the Confluence Reach. Features of the Confluence Reach are listed in Table 4-12.

Figure 4-16. Aerial photograph showing typical conditions in the Confluence Reach.

Table 4-12. Features of the Confluence Reach

River Mile	Feature
8.0	Hultberg Road and beginning of Confluence Reach
2.3	George Hatfield State Recreation Area
0	San Joaquin River confluence and end of Confluence Reach

Geomorphic Characteristics

This reach encompasses the lower eight miles of the river upstream of the confluence with the San Joaquin River. This reach is subject to backwater effects from the San Joaquin River and historically exhibits a complex, distributary channel network morphology, with numerous channels branching off from the mainstem channel and joining the San Joaquin River. The reach-averaged channel slope is 0.0002, and the reach is entirely sand-bedded. The average floodplain width in this reach under pre-colonial conditions is estimated to have been 1,600 feet (Stillwater Sciences 2001a). Under current conditions, floodplain width has been reduced by flow regulation, and the estimated width of the current floodplain (that is inundated by flows of 6,000 cfs) is 600 feet (Figures 3-18D and 3-19). Levees are not extensive in the reach and do not isolate any floodplains that would be expected to be inundated by flows of 6,000 cfs. Levees occur along terraces bordering 7 percent of the north bank. Bank revetment is moderately extensive in the reach (Figure 3-20D) and armors 11 percent of the bank length of the reach and 67 percent of the meander apexes in the reach.

Table 4-13. Riparian Cover Types and Distribution in the Confluence Reach

Cover Type[1]	Total Area Within the Reach (acres)	Percent of Riparian Area within Reach
Vegetation		
Blackberry Scrub	16	1
Box Elder	1	<1
Cottonwood Forest	136	10
Eucalyptus	1	<1
Giant Reed	1	<1
Herbaceous Cover	643	47
Marsh	4	<1
Mixed Riparian Forest	347	25
Mixed Willow	67	5
Riparian Scrub	63	5
Tamarisk	0	0
Tree of Heaven	3	<1
Valley Oak Forest	91	7
Other		
Disturbed Riparian	0	0
Dredger Tailings	0	0
Total	**1,371**	**100**

[1] Cover types are described in Table 3-4.

Riparian Vegetation

Riparian vegetation in the Confluence Reach typically extends from 500 to 1,500 feet on each bank from the river channel and includes dense remnant valley oak and cottonwood forests (Figure 3-21D). The understories of these forests consist of box elder, Oregon ash, Goodding's black willow, blue elderberry, and California wild grape. These forest stands, which contain very large individual valley oaks (up to 85 inches diameter at breast height), occupy the river's historical floodplain and presumably were never cleared. These stands represent the nearest approximation to pre-colonial Central Valley riparian gallery forests in the Merced River corridor (Thompson 1961 and 1980, Conard et al. 1980, Roberts et al. 1980, Holland and Keil 1995, Edminster 1998) and provide some of the largest and most contiguous patches of floodplain and riparian habitat in the corridor. The Confluence Reach contains the highest vegetated area per mile of river, 171 acres/river mile (Table 4-1). The distribution of cover types within the reach is listed in Table 4-13.

Non-native species such as tree of heaven, edible fig, and mulberry, are scattered in the understories of the valley oak and cottonwood forests. These species are invasive and threaten terrestrial habitat quality. Tree of heaven is a particularly aggressive invader, and large, dense patches occur along irrigation canals in the Confluence Reach. Eradication or control of these species before they become more widely established is an important management consideration because aggressively-invading non-native species can displace native plants and associated wildlife.

Land Ownership, Zoning, and Land Use

All of the land in the Confluence Reach is zoned General Agricultural (Figure 3-29). Land parcel size in the reach averages 68 acres, and parcels are generally privately owned (Figure 3-27). Six percent of the land in the analysis area in the reach is in public ownership. Public access to the river is provided at George Hatfield State Recreation Area, a 46-acre park located near the confluence with the San Joaquin River (Figure 3-28). This park provides camping, fishing, and boating opportunities and is the only park on the river that includes public education signage. Other publicly owned lands in the reach include a portion of the China Island Unit of the North Grasslands Wildlife Area (managed by CDFG) south of the confluence with the San Joaquin River and additional CDFG-owned lands north of the confluence.

Agricultural land uses in the reach include 6,817 acres of miscellaneous agriculture (66 percent of the analysis area), 1,400 acres of dairy (13 percent of the analysis area), 899 acres of grazing (9 percent of the analysis area), and 589 acres of orchards (6 percent of the analysis area) (Figures 3-30 and 4-17). Land uses in the remaining area include government land (635 acres, 6 percent of the analysis area) and vacant and other lands (57 acres, 1 percent of the analysis area). In the Confluence Reach, 7,457 acres of agricultural land (72 percent of the reach analysis area) have been mapped and categorized by production value by the California Department of Conservation (Figure 3-31).

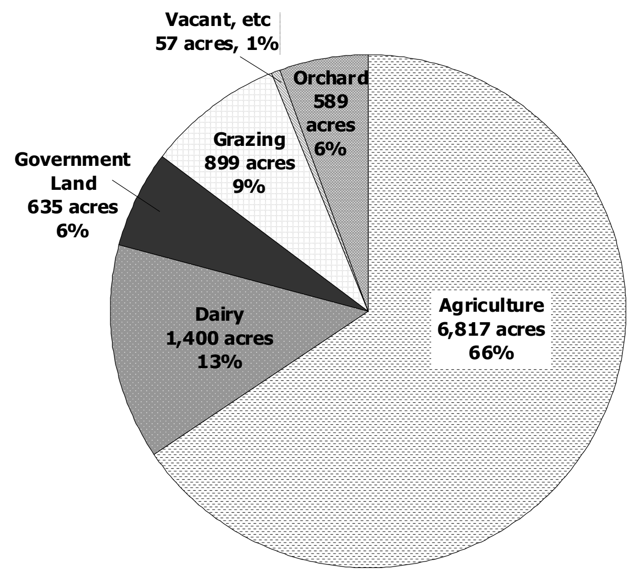


Figure 4-17. Land uses in the Confluence Reach.

Completed and On-going Restoration Projects

The James J. Stevinson Corporation, which is owned and operated by the Kelley family, is in the process of placing conservation easements on nearly 9,000 acres of its landholdings at the confluence of the Merced and San Joaquin rivers in Merced and Stanislaus counties. The Stevinson Corporation landholdings proposed for conservation easements include approximately five miles of riparian habitat along the Merced River in the Confluence Reach (see Section 1.3 for more detail on this project).

Restoration Issues

Major restoration issues in this reach include flow reduction and alteration of seasonal flow patterns, the presence of revetment that limits channel migration, lack of large woody debris, and the establishment of non-native, invasive plants. The dense remnant valley oak and cottonwood forests and their native understory species in this reach provide some of the largest and most contiguous patches of floodplain and riparian habitat in the corridor and provide an excellent opportunity for preservation of floodplain and riparian habitats.

Restoration Objectives

Restoration objectives developed for the Confluence Reach include:

- preserve valley oak and cottonwood forests to protect and preserve existing riparian habitat values;
- where feasible, increase the width of the riparian corridor to provide terrestrial habitat and filter pollutant and fine sediment run-off to the river;
- where feasible, reduce the need for bank protection by increasing the allowable meander belt width to supply sediment through erosion and provide suitable surfaces for the establishment of riparian vegetation; and
- reduce the threat of spread of invasive, exotic species in the riparian corridor to prevent degradation of terrestrial habitat quality.

Conceptual Restoration Approach

Establishment of a river-floodplain meander belt in this reach would require working with landowners to identify and implement opportunities to provide conservation easements adjacent to the river. Such easements could be used as mechanisms to allow bank erosion (within set limits) and increase the width of the riparian corridor. Where allowing bank erosion is not desirable, such as at bridge abutments or near structures, biotechnical methods of erosion control which strengthen banks and provide terrestrial and in-stream habitat should be considered. Where possible, a functional floodplain could be excavated adjacent to the channel or allowed to form through natural erosion and deposition processes, in order to increase channel and floodplain width and provide a suitable surface for restoration of riparian vegetation (Figure 4-15). It may not be possible to implement channel and floodplain restoration projects in this reach in the near future because of adjacent land uses and landowner concerns. Opportunities, however, may become available to develop projects further in the future. As in upstream reaches, a *minimum* width of 300 feet should be targeted for conservation easements. Where possible within landowner constraints, wider easements should be sought.

Distribution of invasive exotic plant species is currently patchy in the understory of valley oak and cottonwood forests. Removal of these patches and future monitoring and eradication could prevent these species from becoming major problems, as has occurred in other rivers in the Central Valley and coastal California. Removal and eradication would require working with landowners to identify and remove patches of these species.

Chapter 5
Adaptive Management

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Adaptive Management

River-floodplain ecosystems are by nature dynamic and complex, and our understanding of these systems is incomplete. In many instances, managers lack basic baseline information, such as which species are present in the river and their spatial and temporal distributions. More broadly, managers and researchers have incomplete understanding of processes, such as energy and nutrient cycles, that drive riverine ecosystems, how human actions affect these processes, and how the ecosystem could be expected to respond to human intervention. In the face of this uncertainty, multiple state and federal programs are tasked with managing and/or restoring river systems throughout the Central Valley.

It is neither feasible nor desirable to postpone action until a complete understanding of each river system can be developed. Developing even a basic understanding can require years or decades, and a complete understanding can likely never be achieved. In light of the lack of knowledge, many programs are attempting to adopt an adaptive management approach to restoration and management. Adaptive management is the process of implementing policy decisions as scientifically driven management experiments that test predictions and assumptions in management plans, and using the resulting information to improve the plans (FEMAT 1993). Adaptive management provides a framework for recognizing uncertainty in management decisions and for reducing uncertainty through experimentation and monitoring. This structured, scientifically driven approach provides an alternative to charging ahead blindly or being paralyzed by indecision, both of which have social, economic, and ecological costs.

5.1 The Adaptive Management Framework

The components and pathways of an adaptive management program are shown in Figure 5-1. These components include:

- identification of the problem;
- establishment of goals and measurable objectives;
- development of conceptual models that articulate the current set of working hypotheses of cause-and-effect relationships in the system and anticipated respones to management actions;
- initiation of actions (including targeted research, pilot or demonstration projects, or large-scale restoration actions);

- monitoring, evaluation, and learning; and
- revision of the problem statement, goals and objectives, models, and actions.

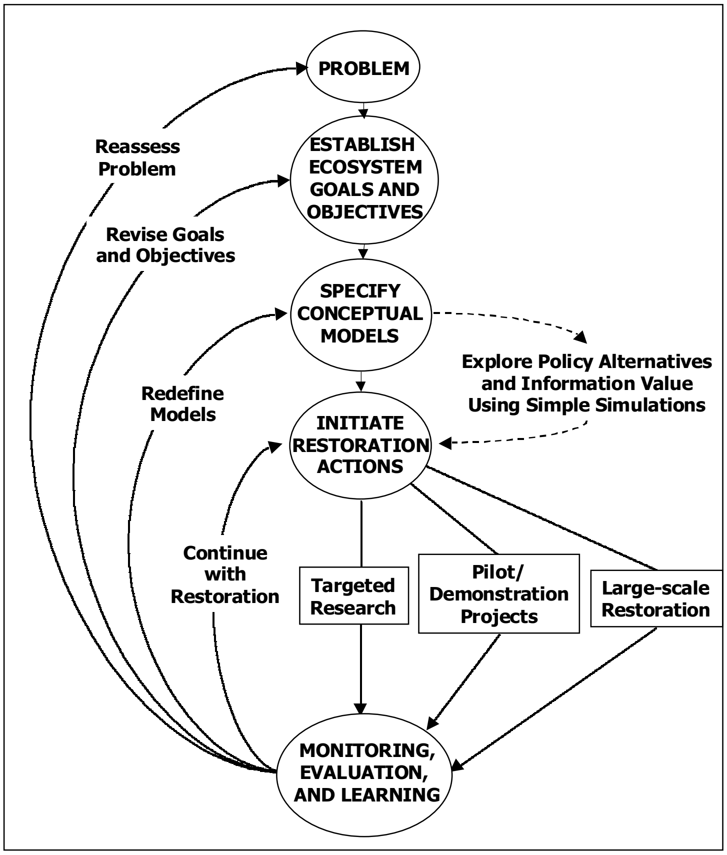


Figure 5-1. The adaptive management process. Source: Strategic Plan Core Team 1998

River-wide goals and objectives for the Merced River were established based on completed baseline studies of geomorphic and riparian ecosystem processes and through coordination with the Merced River Stakeholder Group and Technical Advisory Committee. Additional project-specific goals and objectives will be established as recommended actions are further developed. In addition, certain biological objectives, such as chinook salmon abundance, will be established based on the results of the Merced ID-CDFG joint study program and additional baseline studies that are recommended in Chapter 6.

5.2 Conceptual Models

Conceptual models provide a useful tool for structuring and articulating the current understanding of linkages between ecosystem inputs, physical processes, habitat structures, and biotic responses; identifying information gaps; and developing and articulating hypotheses about the effects of restoration actions on river ecosystems. For this restoration plan, eight conceptual models were developed to depict our understanding of reference conditions and actual current conditions in the river. The reference condition models represent our understanding of how the river functioned under pre-colonial (i.e., natural) conditions. Three models were developed to represent reference state conditions in each of the three overarching reaches of the river–the anastomosing, gravel-bedded reach, which extends from Crocker-Huffman Dam to the Dry Creek confluence; the single-thread, gravel-bedded reach, which extends from the Dry Creek confluence to approximately RM 16.5; and the single-thread, sand-bedded reach, which extends from RM 16.5 to the confluence with the San Joaquin River. These reaches represent the three overarching channel types of the river. The conceptual models are presented in Figures 5-2 through 5-4 and are described below.

Anthropogenic alterations to the river system have resulted in changes relative to the reference state. Key alterations to the system have included:

- flow regulation and reduction in coarse and fine sediment supply as a result of dams;
- increase in fine sediment and sand supply downstream of Dry Creek as a result of channel incision in Dry Creek and land use in the Dry Creek watershed;

- floodplain and channel alterations as a result of gold dredging and aggregate mining;
- clearing of riparian vegetation; and
- construction of levees.

These alterations have affected ecosystem inputs and processes, habitat structure, and biotic responses throughout the river. Five models were developed to represent current conditions in each of the five reaches defined for the Restoration Plan– the Dredger Tailings, Gravel Mining 1, Gravel Mining 2, Encroached, and Confluence reaches. These reaches are defined by the geomorphic characteristics and anthropogenic alterations that occur in each reach. The conceptual models are presented in Figures 5-5 through 5-9 and are described below.

Historic (or Reference) Conditions

Anastomosing Reach

The conceptual model of the reference state conditions in the anastomosing, gravel-bedded reach is shown in Figure 5-2. This reach includes the present Dredger Tailings and Gravel Mining 1 reaches and is located at the transition zone from the confined valleys of the Sierra Nevada foothills to the broad alluvial floor of the Central Valley. Review of maps and aerial photographs circa 1915 and 1937 indicates that, under historical conditions, the river in this reach was a complex, multiple-channel system consisting of a mainstem and numerous secondary channels (or sloughs). Driven by unregulated flow conditions, coarse sediment supply from the upper watershed, and local geology, this portion of the river was likely highly dynamic, with the location of the mainstem channel switching between the various secondary channels. Under these reference conditions, the 1.5-year flood was approximately 10,100 cfs and the coarse sediment supply from the upper watershed was approximately 11,000–21,000 tons/year (Stillwater Sciences 2001a). In this reach, channel avulsion in combination with channel migration likely maintained diverse in-channel habitats and constructed floodplain surfaces. These complex habitats supported diverse and abundant native species, including invertebrates, chinook salmon, and potentially steelhead. Abundant salmon carcasses in the river following spawning periods likely increased nutrient inputs to the river, which provided additional foodweb support to the aquatic ecosystem and provided a nutrient subsidy to the adjacent terrestrial ecosystem (e.g., through bird and animal species feeding on the carcasses). In addition, the unregulated flow regime resulted in water temperatures that supported native aquatic species. The snowmelt-dominated hydrograph provided the cool water temperatures in spring and early summer that are important to rearing and outmigrating salmon and steelhead.

Similar processes maintained a diverse riparian habitat structure. Under the unregulated flow regime, the floodplain was inundated frequently. During the winter, the floodplain was most likely inundated for brief periods during rain and rain-on-snow events. During spring, the floodplain was inundated for weeks or months by snowmelt flows from the upper watershed. The recession limb of this snowmelt hydrograph was gradual. In addition, the supply of fine sediment from the upper watershed allowed deposition of fine sediment on the floodplain during flood events, which provided bare soil patches suitable for germination and establishment of native riparian vegetation. The construction of new floodplain surfaces, availability of bare soil patches, and inundation and flow recession patterns provided conditions suitable to support a diverse riparian forest habitat structure that extended across the valley floor. This riparian habitat supported an abundance and diversity of terrestrial species. In addition, riparian vegetation and terrestrial invertebrates provided nutrients to the river, thus contributing to the aquatic foodweb.

Single-thread Gravel-bedded Reach

The conceptual model of reference state conditions in the single-thread, gravel-bedded reach of the Merced River is shown in Figure 5-3. This reach includes the current Gravel Mining 2 Reach and portions of the Encroached Reach. The reference model for this reach is very similar to the reference model for the anastomosing reach with the exception that channel avulsion was likely a much less important process and the river was a single-thread, meandering system. In this reach, channel migration and meander cut-off constructed floodplains and supported diverse riparian and aquatic habitats, and the mainstem channel was scaled to convey the bankfull flow. Flows exceeding the bankfull discharge spilled out onto the adjacent floodplain. Downstream of the Dry Creek confluence, fine sediment and sand were supplied to the mainstem channel from the Dry Creek watershed. In addition, flows from Dry Creek increased the magnitude of winter baseflows and peak flows in the mainstem river.

Sand-bedded Reach

The conceptual model of reference state conditions in the sand-bedded reach is shown in Figure 5-4. This reach includes the remaining portions of the Encroached Reach and the Confluence Reach. The conceptual model for this reach is similar to that presented for the single-thread, gravel-bedded reach (Figure 5-3). The major difference is that coarse sediment is not supplied to this reach because it is too far from the coarse sediment sources and the slope of the reach is not sufficient to transport gravels. Additionally, sediment transport and deposition occurs on a daily rather than annual scale in the sand-bedded reach, with the bed being in near-constant transport. Because it is sand-bedded, salmon and steelhead did not spawn in this reach, although the reach was likely used for rearing.

Current Conditions

Dredger Tailings Reach

The conceptual model of current conditions in the Dredger Tailings Reach is shown in Figure 5-5. Key anthropogenic modifications to this reach include:

- removal of riparian forests;
- flow regulation;
- interception of sediment in Lake McClure, which intercepts sediment supply from the upper 81 percent of the watershed;
- direct removal of sediment from the channel and floodplain through dredger mining;
- placement of mined sediment on the floodplain in irregular tailings piles; and
- potential input of nutrients and contaminants.

The reduction in peak flow magnitude resulting from flow regulation and flood control has resulted in reduced frequency of bed transport and elimination of channel avulsion in the reach. Under current conditions, the channel bed in this reach is immobile at flows up to the 5-year flood (Stillwater Sciences 2001a, 2001 b) and

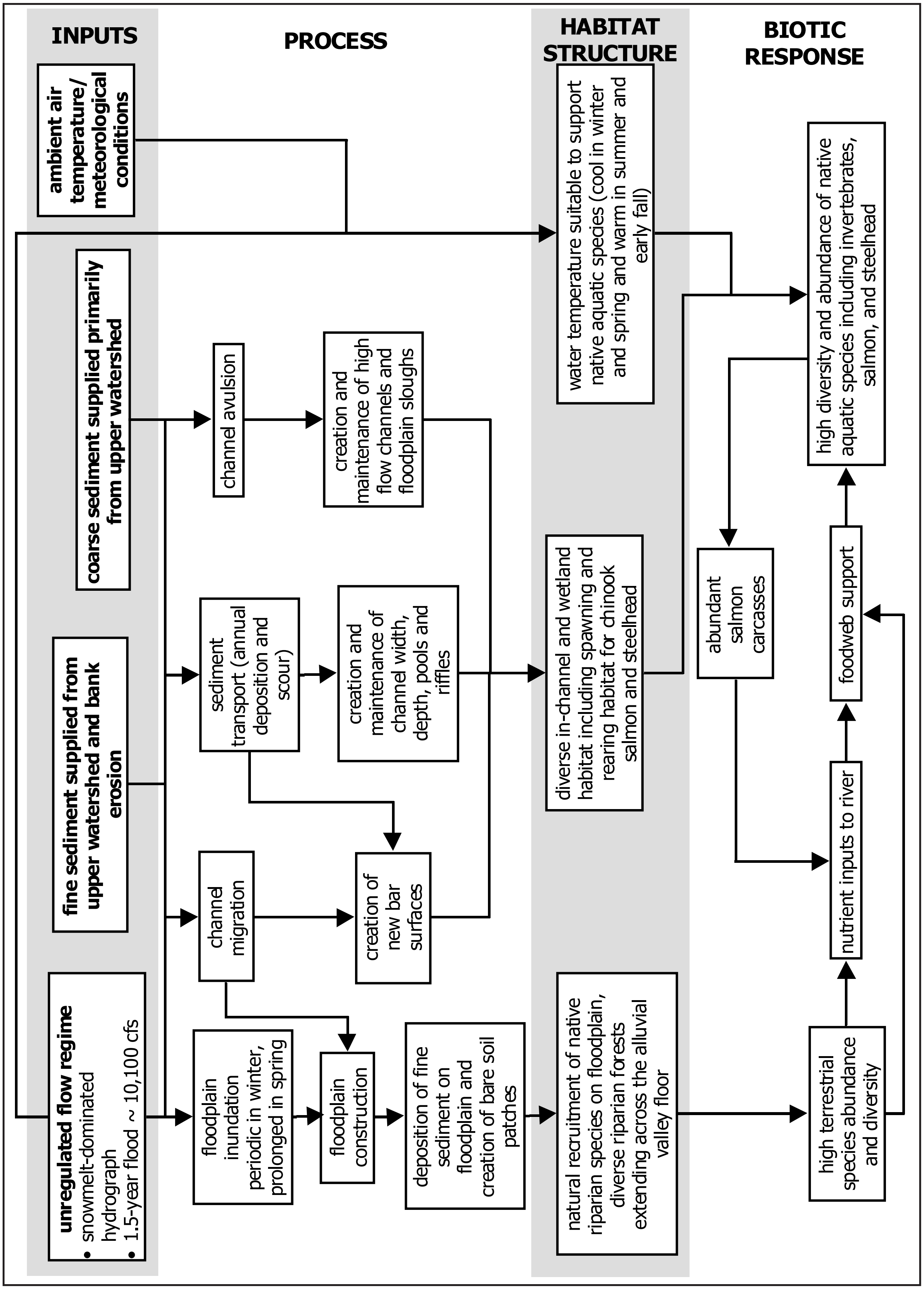


Figure 5-2. Conceptual model of reference state processes and linkages in the anastomosing, gravel-bedded reach of the Merced River, including the Dredger Tailings and Gravel Mining 1 reaches. Channel slope in these reaches = 0.0023 and 0.0015, respectively.

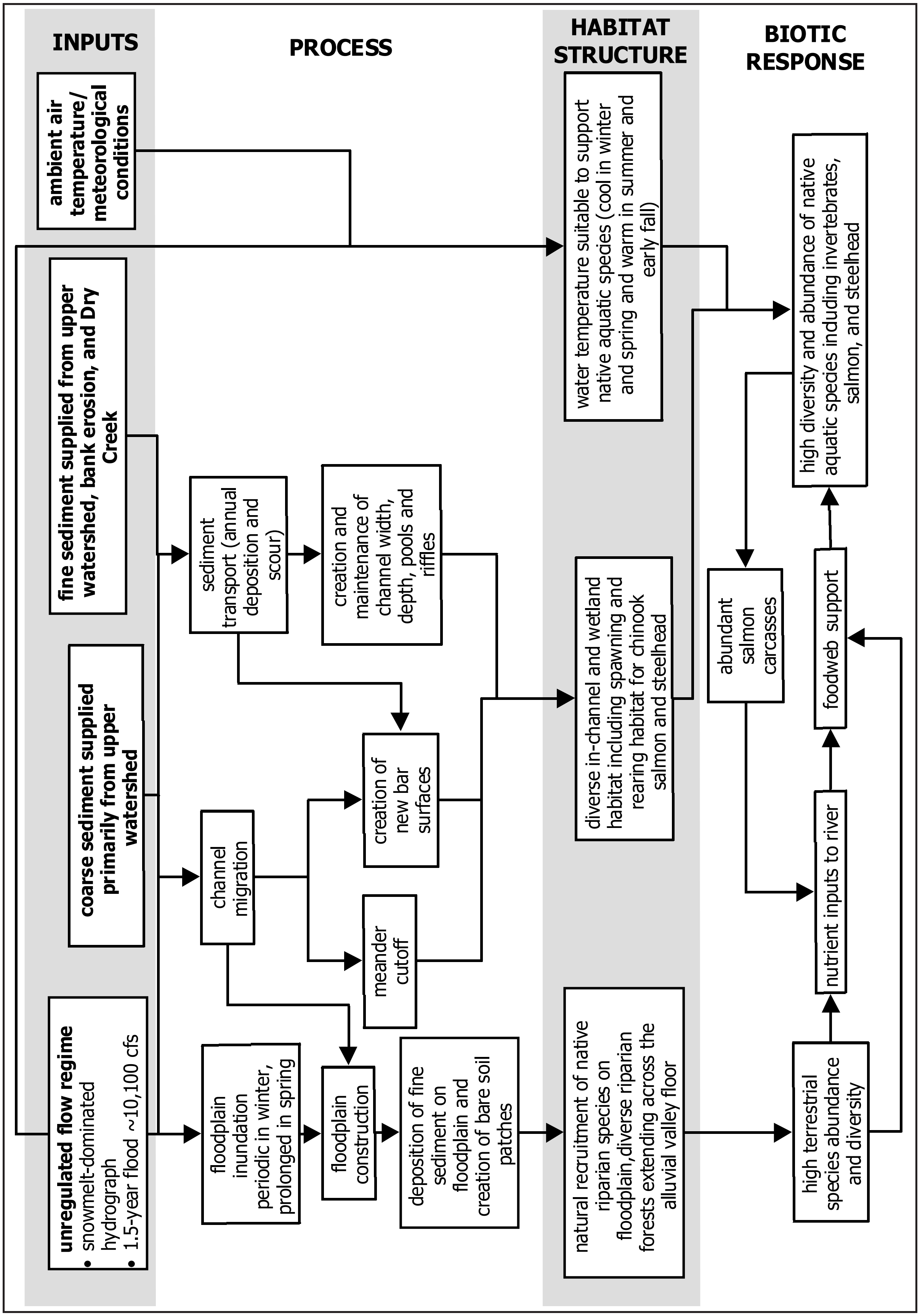


Figure 5-3. Conceptual model of reference state processes and linkages in the single-thread, gravel-bedded reach of the Merced River, including the Gravel Mining 2 and Encroached reaches. Channel slope in these reaches = 0.008 and 0.0003, respectively.

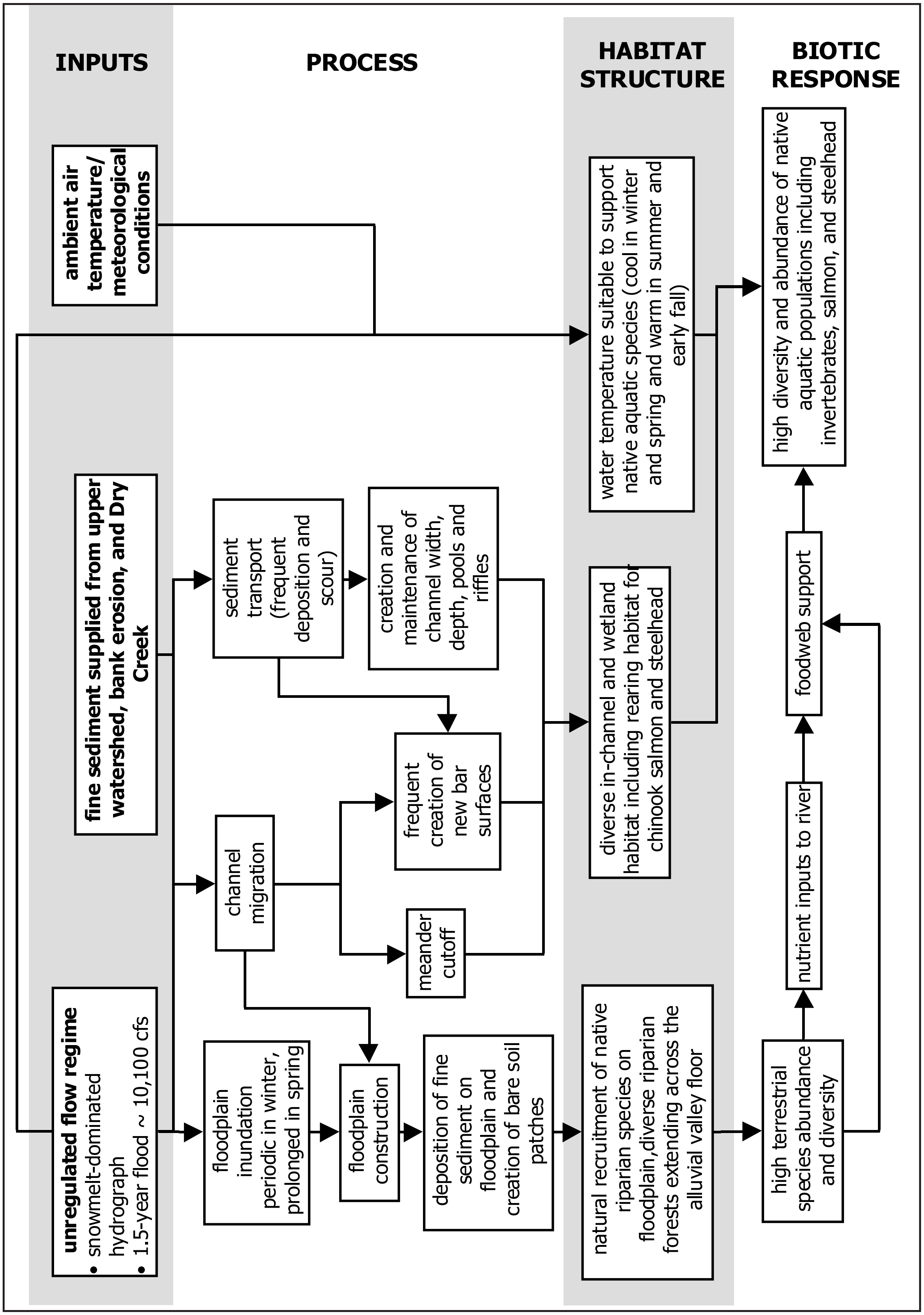


Figure 5-4. Conceptual model of reference state processes and linkages in the single-thread, sand-bedded reach of the Merced River, including the Encroached and Confluence reaches. Channel slope in these reaches = 0.0003 and 0.00002, respectively.

the 1.5-year flood has been reduced from 10,100 cfs to 1,300 cfs (a reduction of 87 percent). The reduction in sediment supply caused by upstream dams, combined with direct removal of sediment from the channel during dredger mining, has depleted the bed of coarse sediment. The bed has also coarsened as finer gravels that can be transported under the current flow regime have been selectively transported out of the reach. Under the current flow regime, the remaining sediment is too coarse to be transported at intervals necessary to maintain healthy aquatic ecosystems. These processes have resulted in a channel bed that is immobile and that is now characterized by long, deep pools, with few bars or riffles. As a result, riparian vegetation has encroached into the active channel, reducing the area of aquatic habitat, and sand has infiltrated into the channel bed, degrading conditions for salmon egg incubation and alevin survival. The channel in this reach is now fairly homogenous with little spawning or rearing habitat for chinook salmon and steelhead and a limited diversity of aquatic species. A reduction in the number of salmon carcasses has reduced the nutrient input to the reach, thus providing less food web support and further reducing the abundance of native aquatic species.


Photo/Stillwater Sciences

The placement of dredger tailings onto the floodplain has also eliminated riparian forests, replaced floodplain soils with barren rock surfaces, increased floodplain elevation, and confined the channel. The dredger tailings, combined with the reduction in flow magnitude, have reduced floodplain inundation and channel migration in the reach. The direct modification of the floodplain and removal of riparian forests caused by the gold dredging, combined with modification of fluvial processes, has resulted in a simplified riparian forest with limited extent and an altered species composition. This has in turn reduced terrestrial species abundance and diversity and reduced nutrient inputs to the river.

The regulated flow regime has also potentially affected water quality. The transformation of the flow regime from a snowmelt-dominated to a fall/winter dominated hydrograph has likely increased spring and summer water temperatures. These warmer spring water temperatures may affect salmon and steelhead rearing and outmigration. The input of nutrients and contaminants to the reach and the effects of nutrients and contaminants on aquatic biota are not known.

Gravel Mining 1 Reach

The conceptual model of current conditions in the Gravel Mining 1 Reach is shown in Figure 5-6. This conceptual model is similar to that of the Dredger Tailings Reach, with two exceptions. First, the river and floodplain in this reach were not dredged for gold. The reach, therefore, has not experienced the channel and floodplain effects of gold dredging and tailings disposal. Second, the reach has been mined extensively both in the channel and on the floodplain for aggregate. In addition to the effects of flow regulation and elimination of sediment supply described above for the Dredger Tailings Reach, aggregate mining has created large pits in the river channel that provide habitat for introduced largemouth bass, which prey on native fish species including juvenile salmon and steelhead. These pits also capture coarse sediment that is in transport from upstream, further reducing sediment transport and coarsening the bed downstream of the pits. Although the channel is not constrained by dredger tailings piles, levees and bank revetment constrain the channel in this reach eliminating channel avulsion and migration.

Riparian vegetation in this reach is affected by reduced floodplain inundation and channel migration, as described for the Dredger Tailings Reach. In addition, eucalyptus (an invasive, non-native species) has invaded the riparian corridor in this reach.

Gravel Mining 2 Reach
The conceptual model of current conditions in the Gravel Mining 2 Reach is shown in Figure 5-7. This reach differs from the Gravel Mining 1 Reach in two important aspects. First, the reach was historically a single-thread channel rather than an anastomosing complex of channels, as in the Dredger Tailings and Gravel Mining 1 Reaches. Channel avulsion in this reach, therefore, was limited to meander cutoffs and was a less dominant process than in upstream reaches. Second, this reach receives fine sediment input from the Dry Creek watershed. A large in-channel pit at the mouth of Dry Creek traps some of this sediment, but some passes the pit and is delivered downstream. In addition to the effects of flow regulation, reduction in sediment supply, and in-channel and floodplain mining, as described for the Gravel Mining 1 Reach, this reach is affected by delivery of sand from Dry Creek. Eucalyptus have also invaded the riparian corridor in this reach.

Encroached Reach
The conceptual model of current conditions in the Encroached Reach is shown in Figure 5-8. This reach was historically a single-thread meandering channel, and the bed undergoes a transition from gravel to sand in this reach. In addition to the effects of flow regulation and elimination of coarse sediment supply described for upstream reaches, levees and bank revetment in this reach are extensive and have reduced floodplain inundation and channel migration. As a result, in-channel habitats are simplified and riparian vegetation recruitment processes are impaired. The reduction in extent and complexity of the riparian forest, combined with clearing of riparian forests for agriculture and other land uses and the invasion of the corridor by exotic species, has resulted in reduced abundance and diversity of terrestrial animal species and reduced nutrient and other inputs to the aquatic system.

Confluence Reach
The conceptual model of current conditions in the Confluence Reach is shown in Figure 5-9. This reach differs from the Encroached Reach in that it is much less constrained by levees and was not cleared as extensively for land use. Levees in this reach lie along 7 percent of the right (north) bank terraces on the river. These terraces may have been inundated under reference conditions but are not expected to be inundated by the current 6,000-cfs maximum flood control release. The reduction in floodplain area in this reach, therefore, results primarily from flow regulation. This reach is completely sand-bedded but experiences only infrequent overbank deposition due to reduced floodplain inundation. Because the riparian vegetation was not extensively cleared, the most extensive and complex stands of riparian forest in the corridor occur in this reach.

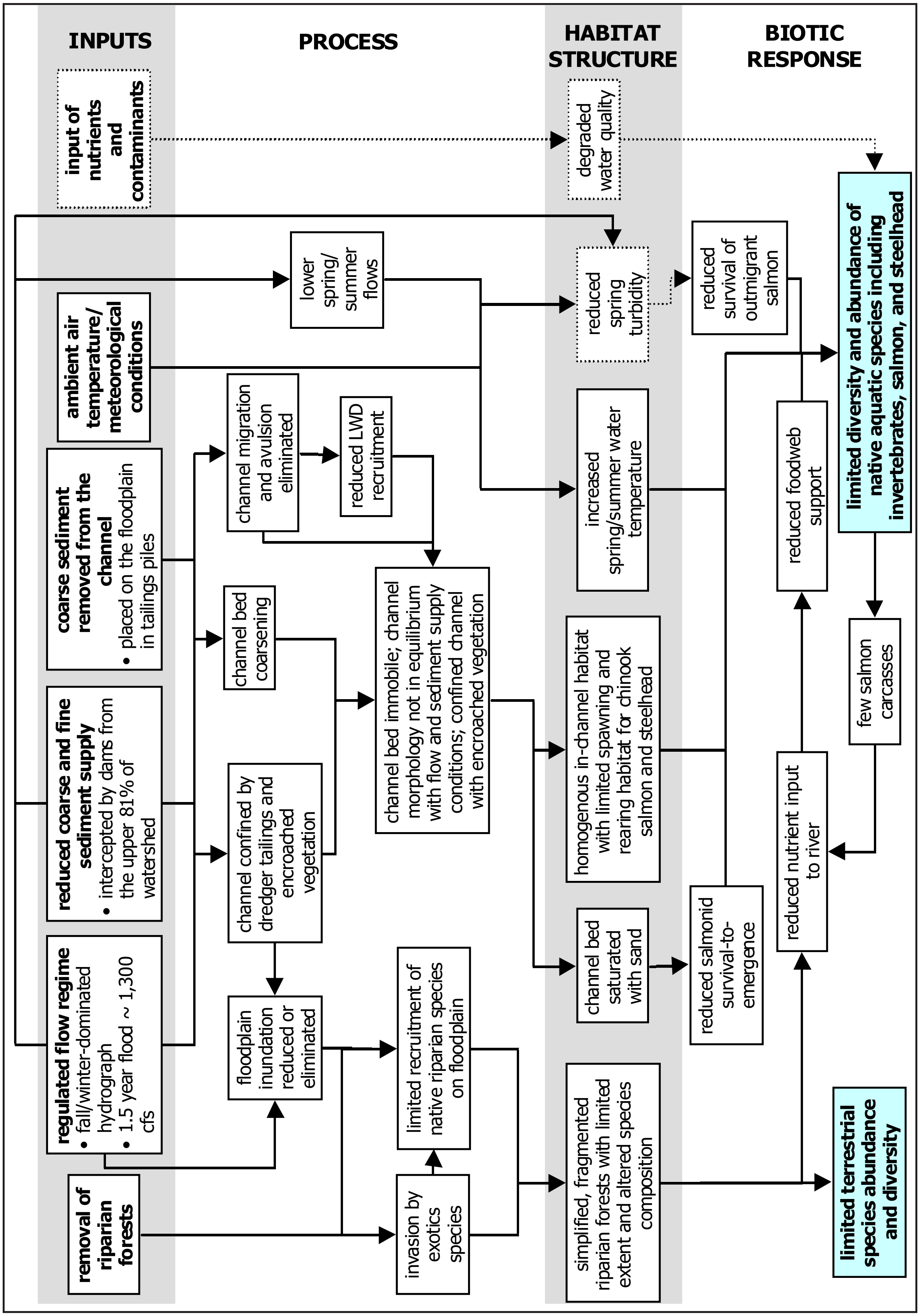


Figure 5-5. Conceptual model of current processes and linkages in the Dredger Tailings Reach of the Merced River. Channel slope in this reach = 0.0023. Dashed boxes indicate areas of high uncertainty based on available data.

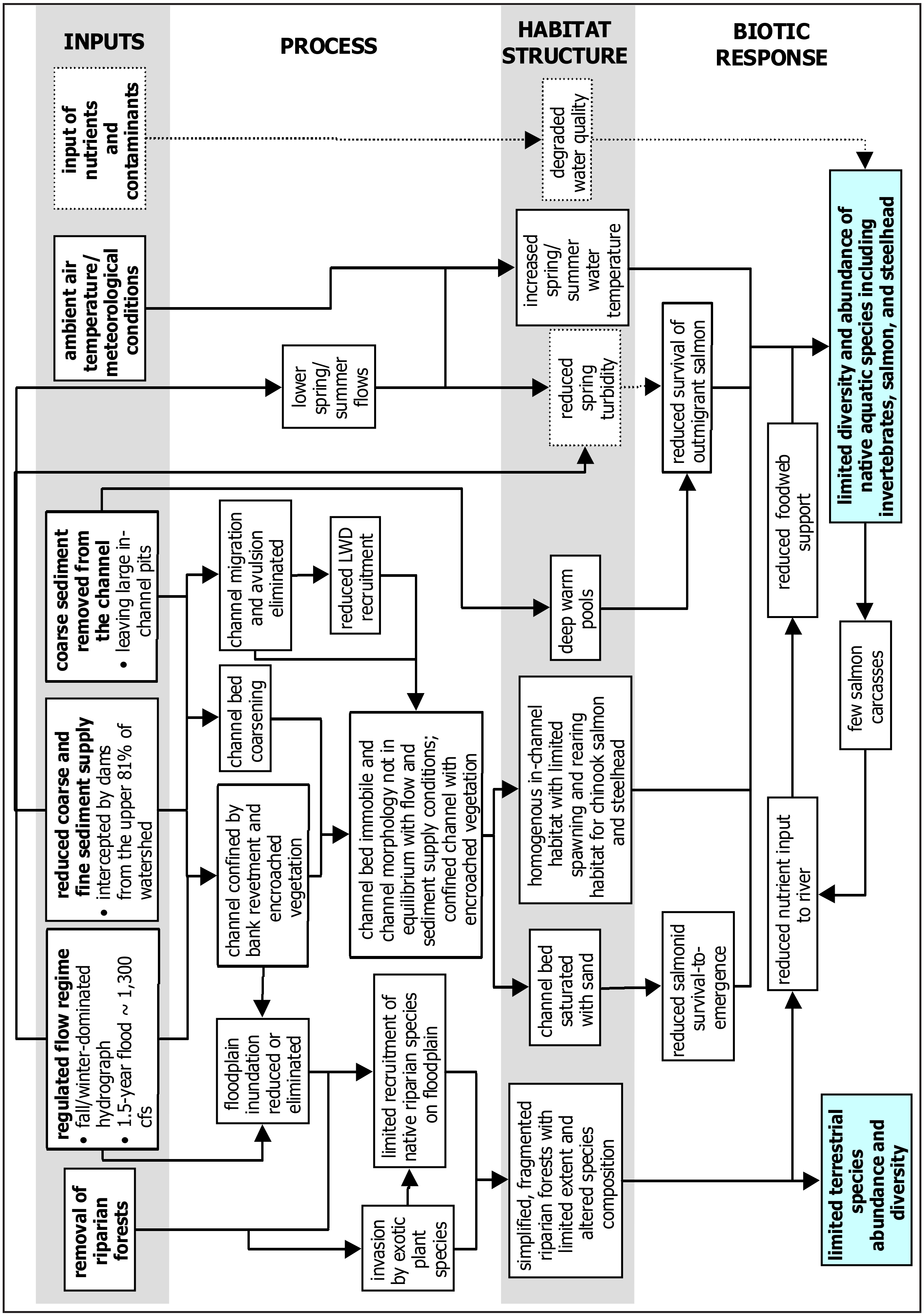


Figure 5-6. Conceptual model of current processes and linkages in the Gravel Mining 1 Reach of the Merced River. Channel slope in this reach = 0.0015. Dashed boxes indicate areas of high uncertainty based on available data.

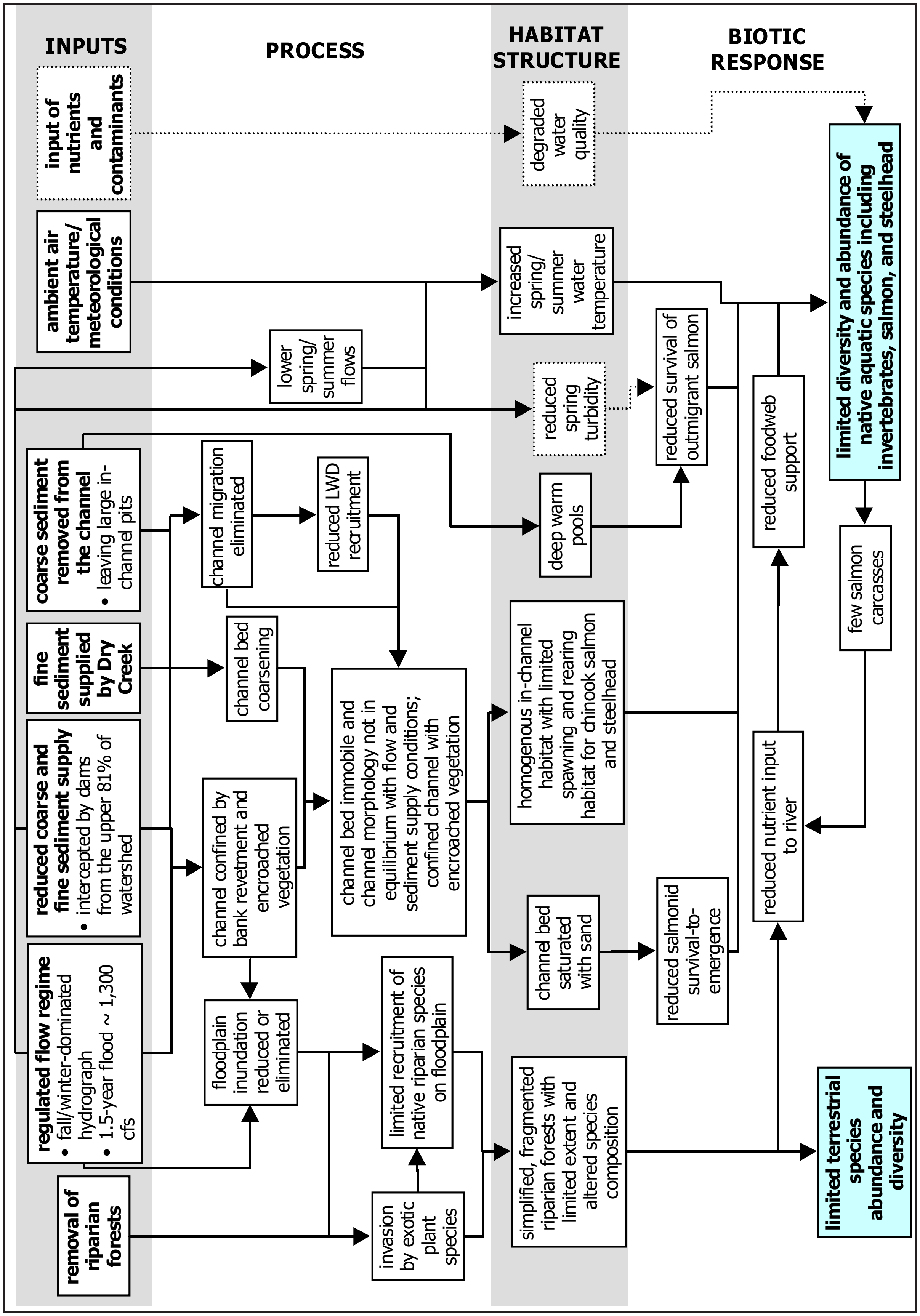


Figure 5-7. Conceptual model of current processes and linkages in the Gravel Mining 2 Reach of the Merced River. Channel slope in this reach = 0.0015. Dashed boxes indicate areas of high uncertainty based on available data.

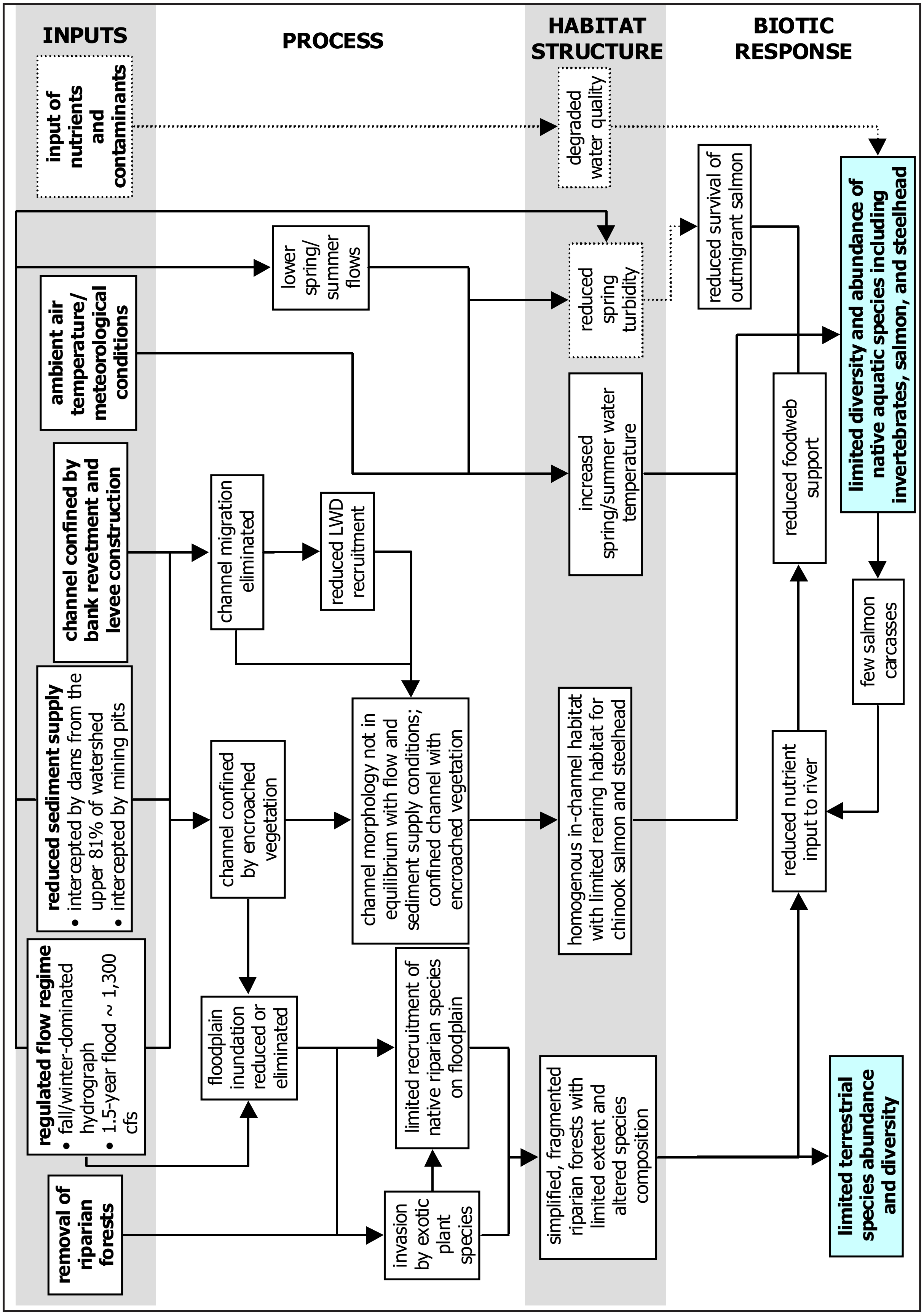


Figure 5-8. Conceptual model of current processes and linkages in the Encroached Reach of the Merced River. Channel slope in this reach = 0.0003. Dashed boxes indicate areas of high uncertainty based on available data.

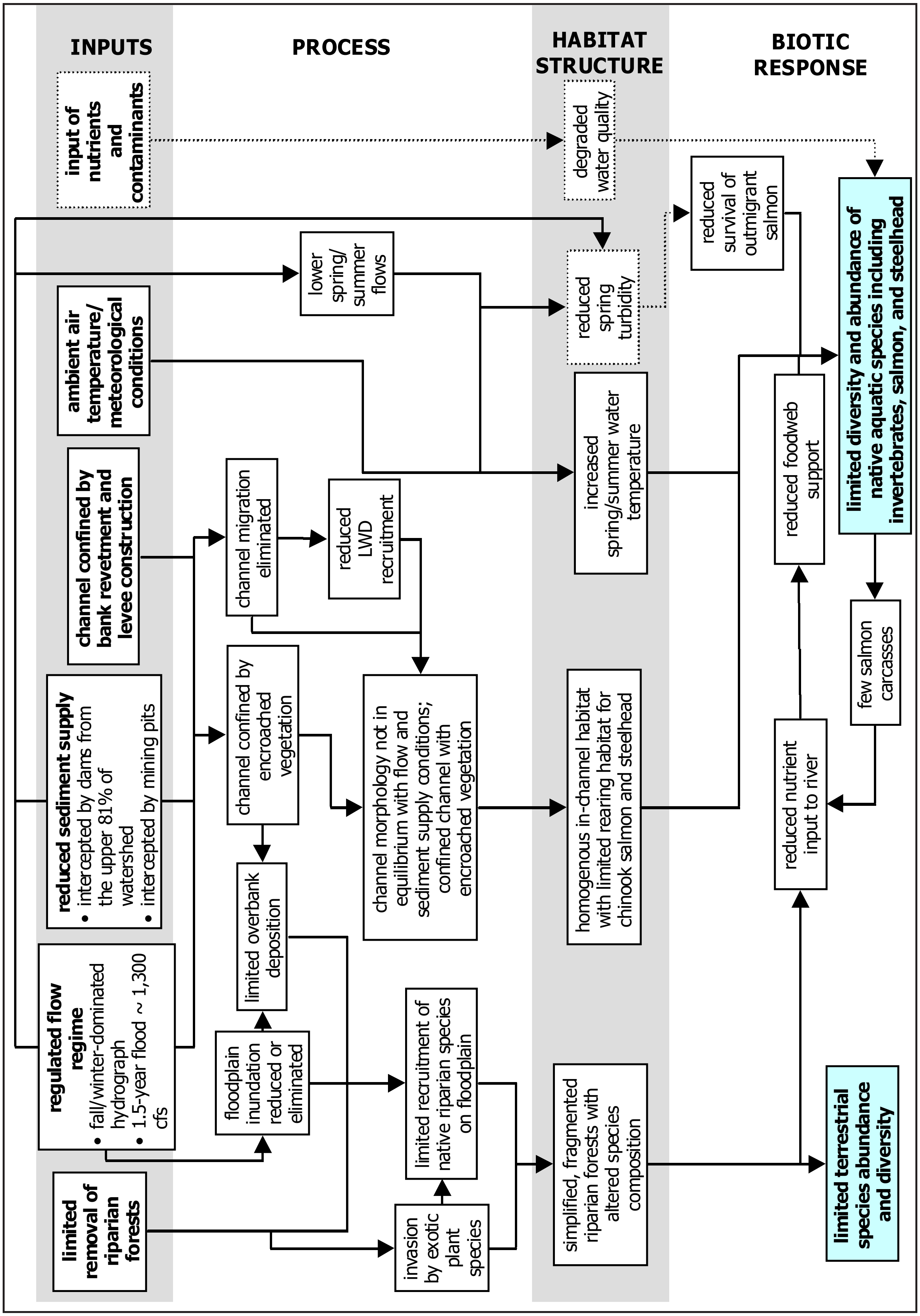


Figure 5-9. Conceptual model of current processes and linkages in the Confluence Reach of the Merced River. Channel slope in this reach = 0.0003. Dashed boxes indicate areas of high uncertainty based on available data.

5.3 Monitoring

An adaptive management approach requires a carefully planned structure for monitoring, reviewing management actions, and refining management actions (Holling 1978). Monitoring is fundamental to an adaptive management program because it provides the feedback necessary to evaluate the effectiveness of management actions and to identify when objectives, models, and/or actions should be revised. General types of monitoring used in adaptive management include: (1) inventory and baseline assessments, (2) implementation monitoring, (3) effectiveness monitoring, and (4) validation monitoring. Inventory and baseline assessments include collection of physical and biological information that is not designed to test specific hypotheses but rather provides general information to develop more detailed studies. Data from baseline inventories and assessments may also serve as the foundation for monitoring long-term changes in resource conditions (trend monitoring). Implementation monitoring simply assesses how well management policies and actions are being implemented. Effectiveness monitoring is used to determine whether implementation of the management action results in achieving the targeted management goals or objectives. Validation monitoring is used to test the validity of hypotheses or critical assumptions upon which the management actions were based and to test the model of the physical-biological linkages upon which population responses to habitat conditions were predicted.

Baseline information has been gathered on the Merced River through several programs, including the AFRP Comprehensive Assessment and Management Program (CAMP), water quality monitoring conducted by USGS and CVRWQCB, cooperative studies of salmon population ecology being conducted by Merced ID and CDFG, baseline evaluations conducted for this Restoration Plan, and project-specific evaluations conducted by CDFG and CDWR at their restoration project sites. Ecological and biological parameters for which baseline and/or trend data are available are shown in Table 5-1.

Table 5-1. Baseline and Trend Monitoring Data Being Collected on the Merced River

Parameter	Method and Location	Period of Record	Contact
Fall chinook salmon juvenile abundance, size, and outmigration timing	rotary screw trap operated at Hagaman County Park (RM 12.2)	March-June 1998 January-June 1999-2001	CDFG (Funded by CAMP)
	rotary screw trap operated at Hopeton (RM 4.0)	January-June 1999-present	Merced ID
Fall chinook salmon escapement and spawning location	weekly carcass surveys conducted from Crocker-Huffman Dam to RM 33.2	October 15-December 31 1957-present, although methods vary among years	CDFG
Adult fall chinook salmon returns to the Merced River Hatchery	counts at hatchery trap	October 1-December 31 1971-present	CDFG
Fall chinook salmon outmigrant survival (river-wide)	paired releases of coded-wire-tagged hatchery juveniles	1994-2000	CDFG

Table 5-1. Baseline and Trend Monitoring Data Being Collected on the Merced River, continued

Parameter	Method and Location	Period of Record	Contact
Fish species composition	rotary screw trap operated at Hagaman County Park (RM 12.2)	March-June 1998 January-June 1999-2001	CDFG (Funded by CAMP)
	rotary screw trap operated at Hopeton (RM 4.0)	January-June 1999-present	Merced ID
Riparian vegetation composition and distribution	remote sensing with field verification from Merced Falls Dam (RM 55.0) to the San Joaquin River Confluence	1999-2000	Stillwater Sciences
	pilot study of vegetation-elevation-hydrology relationships with vegetation transects at RMs 48.2, 32.5, 2.2	1999-2000	Stillwater Sciences
Water quality	temperature, dissolved oxygen, electrical conductivity, nutrients, minerals, pH, and pesticides at RM 1.0	1983-present	CVRWQCB
	pesticide, water-borne diseases, and nutrient testing at RM 1.0	1991-present	USGS
Water temperature	thermographs throughout the river from Crocker-Huffman Dam (RM 52.0) to the San Joaquin River confluence (RM 0.0)	1997-present	Merced ID
Flow	streamflow gauge at Crocker-Huffman Dam (RM 52.0)	January 1939-present	Merced ID
	streamflow gauges at · Dry Creek (no. 11271320) · Stevinson (no. 11272500)	· 1966-1992 · 1941-present	USGS
	streamflow gauges · below Snelling (no. B05170) · Cressey (no. B05155)	· 1961-present · 1965-present	CDWR

Table 5-1. Baseline and Trend Monitoring Data Being Collected on the Merced River, continued

Parameter	Method and Location	Period of Record	Contact
Sediment transport thresholds	marked rock experiments and numerical modeling at Snelling Site (RM 48.2) Shaffer Bridge (RM 32.5)	2000, 2001	Stillwater Sciences
	marked rock experiments conducted for Merced River Salmon Habitat Enhancement Project	2000, 2001	CDWR
Bank erosion and revetment	field mapping from Crocker-Huffman Dam (RM 52.0) to Hatfield Park (RM 0.0)	1999-2000	Stillwater Sciences
Floodplain extent	aerial photograph and map interpretation from Crocker-Huffman Dam (RM 52.0) to Hatfield Park (RM 0.0)	1999-2000	Stillwater Sciences

Even with the existing monitoring in place, many uncertainties remain and basic information needed to implement an adaptive management program on the Merced River is lacking. Referring back to Figure 3-1, many of the key inputs, processes, attributes, and biotic responses identified in this simplified conceptual model of the physical and ecological linkages in an alluvial river-floodplain system are poorly understood. For example, data on sediment supply, nutrient loading, and chemical pollutants (all of which are key watershed inputs) are very limited, and there is no information available regarding the effects of reservoir operation, land use, and point source and non-point source inputs to the river on water temperature, nutrient and contaminant loading, and other water quality parameters. In addition, very little baseline information is available for fish and wildlife species other than fall chinook salmon. The few wildlife surveys that have been completed in the corridor were conducted to assess the impacts of specific construction projects. Fish and wildlife species composition, abundance, and distribution in the corridor, therefore, is not understood. Also, other than incidental data acquired through salmon-oriented monitoring, no data are available describing aquatic communities in the river.

Additional baseline information will be acquired through planned study programs, including the joint Merced ID-CDFG salmon studies program. This information, while important, will not be adequate to provide a solid base upon which to implement a corridor-wide adaptive management program to meet the objectives identified in Chapter 2. Additional baseline information should be gathered to provide a foundation for developing hypotheses, prioritizing actions, and monitoring trends. High priority baseline studies include the following:

- water quality, including the spatial and temporal occurrence of nutrients and chemical contaminants and identification of key point and non-point sources;

- wildlife species composition, abundance, and distribution, especially of native, neotropical migrant birds that utilize or depend on the riparian corridor and habitat associations in which these species are found;
- distribution and abundance of brown-headed cowbirds in the corridor and the effects of nest predation by cowbirds on native bird populations;
- benthic macroinvertebrate species composition, abundance, and distribution (including the distribution and abundance of non-native, invasive species) as an indicator of water quality and aquatic food web dynamics;
- fish community species composition and distribution;
- *O. mykiss* abundance, distribution, and migratory behavior;
- largemouth bass abundance, preferred prey species, and predation rates on juvenile chinook salmon and *O. mykiss;*
- field measurement of bedload transport rates as a function of flow in the gravel-bedded reach;
- modeling of riparian vegetation species recruitment for willows, cottonwoods, and other species; and
- distribution of non-native, invasive aquatic macrophytes, particularly egeria, parrot's feather, and water hyacinth.

In addition to the baseline information described above, each project implemented under the restoration plan or through related programs should include effectiveness monitoring to assess whether the project is meeting its stated objectives and to inform the design and implementation of future projects. Effectiveness monitoring currently being conducted or planned for future implementation is shown in Table 5-2.

Table 5-2. Project-specific Effectiveness Monitoring in the Merced River

Project	Parameters Being Monitored	Implementing Agency
Riffle 1A gravel augmentation	· channel cross section and profile · bed mobilization threshold	CDWR/CDFG
Salmon Habitat Enhancement Program - Ratzlaff Reach	· vegetation survival and establishment · salmon spawning utilization · salmon outmigrant survival · bed mobilization thresholds · channel cross section and profile	CDWR/CDFG
Salmon Habitat Enhancement Program - Robinson Reach	· vegetation survival and establishment · salmon spawning utilization · salmon outmigrant survival · bed mobilization thresholds · channel cross section and profile	CDWR/CDFG

In addition to baseline and effectiveness monitoring, mechanistic models could provide important tools for developing hypotheses and designing experiments to test potential restoration actions. These models should be tested through validation monitoring that could be implemented in conjunction with baseline and effectiveness monitoring or in conjunction with field experiments designed specifically to test the models. Basic modeling needs include spatially explicit bed scour and deposition, effects of flow on water temperature, and effects of flow magnitude and timing and floodplain elevation on riparian vegetation establishment and recruitment.

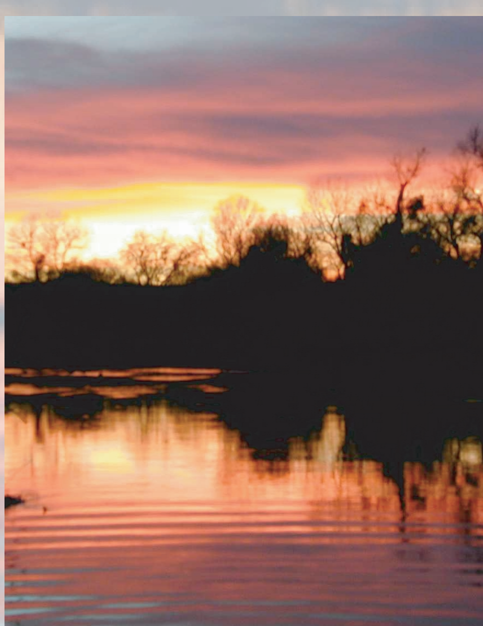
Reach-scale bedload transport modeling has been conducted at selected sites in the gravel-bedded reach of the river to predict transport thresholds and rates. Limited validation monitoring has been conducted to test the mobility threshold predictions of the model. No validation monitoring of transport rates has been conducted. Baseline transport rate data could be used to test and improve the model. More detailed, spatially explicit modeling of sediment transport in the gravel-bedded reach should be completed prior to initiation of large-scale gravel augmentation to provide better quantitative prediction of bedload transport rates and spatial patterns of bedload scour and deposition against which to test project performance. Field data of sediment transport thresholds and rates collected as part of the effectiveness monitoring of this project could provide useful validation data to test and improve the more detailed model.

As discussed in Section 3.6, water temperature is a key factor affecting salmon and steelhead abundance and distribution. Temperature modeling could serve as a tool for predicting the effects of flow on water temperature for a range of meteorological conditions. Merced ID has received funding from CALFED to develop a temperature model for the river. Once developed, this model should be tested using field measurements of water temperature throughout the river.

Stillwater Sciences is currently calibrating a model of the effects of flow timing, magnitude, and drawdown rates on the establishment of willows and cottonwoods–pioneer woody riparian species in the San Joaquin Basin. This model, combined with topographic surveys and hydraulic modeling from the Merced River, will provide a foundation for developing quantitative hypotheses of the effects of flow conditions on woody riparian plant establishment in the corridor. These hypotheses could be tested through experimentation, which will provide information for developing floodplain restoration designs and flow recommendations for riparian tree establishment. This model, however, will not include riparian species other than willows and cottonwoods. Additional data of factors affecting seed dispersal, germination, and survival of woody species other than cottonwoods and willows are needed. In addition, information on herbaceous understory species and their value to terrestrial wildlife is needed.

5.4 Institutional Requirements

Implementation of an adaptive management framework requires an institutional structure that can design and implement management actions, develop and implement rigorous monitoring, and synthesize and respond to monitoring results. On the Merced River, this institutional framework could be provided by the Technical Advisory Committee, with input from the Stakeholder Group. The Technical Advisory Committee, which includes representatives from CDFG, USFWS, CalTrans, Merced ID, CVRWQCB, and Merced County, would be an appropriate forum to guide the development of a comprehensive adaptive management plan for the river. Appropriate components of the plan could be implemented by various members of the Technical Advisory Committee. The Technical Advisory Committee could also provide funding oversight, design input, and technical review and oversight of management actions and monitoring to be conducted under the adaptive management program. For the Technical Advisory Committee to fill this role, staff would be required to coordinate and record meetings, distribute information, and act as a clearinghouse for relevant reports. Such a coordinator could potentially be provided through funding of a position in an existing entity, such as the East Merced Resource Conservation District, through a contractor, or through an appropriate agency.



Chapter 6
Restoration Recommendations

Chapter 6
Restoration Recommendations

This chapter identifies actions recommended for implementation. Recommended actions include monitoring, experimentation, pilot projects, large-scale restoration, and other actions. As discussed in Chapter 5, these actions should be implemented in a phased, adaptive management process. Potential funding sources for these actions are included in Appendix C.

The recommended actions are summarized in Table 6-1 and Figure 6-1 and are described in more detail in the following sections. The recommended timeframe for implementing actions is identified as near-term, moderate-term, or long-term. Near-term actions are the highest priority for immediate implementation. Moderate-term actions have more uncertainty in their implementation or benefits, and it is recommended that implementation be postponed pending results from effectiveness monitoring of similar projects. Long-term actions are typically programmatic in nature and may require years or decades to begin implementation. Actions are also identified as river-wide or by specific reaches in which they would occur. Order of actions does not reflect priority.

Table 6-1. Recommended Restoration Actions in the Merced River Corridor

Reach/Actions		Initiation Timeframe
River-wide		
Action 1	Identify opportunities for and implement flow-related experiments.	near-term
Action 2	Preserve existing floodplain and riparian vegetation and establish riparian buffers/corridors on river-wide scale.	near-term/long-term
Action 3	Control non-native, invasive plant species throughout the river corridor.	near-term
Action 4	Improve understanding of chinook salmon and steelhead population dynamics.	near-term
Action 5	Document fish community characteristics in the river.	near-term
Action 6	Document avian community characteristics in the Merced River riparian corridor.	near-term

Table 6-1. Recommended Restoration Actions in the Merced River Corridor, continued

Reach/Actions		Initiation Timeframe
Action 7	Document aquatic benthic macroninvertebrate communities in the Merced River.	near-term
Action 8	Develop an understanding of water quality in the river.	near-term/long-term
Action 9	Continue to support the Merced River Stakeholder Group and Technical Advisory Committee.	near-term
Action 10	Continue to coordinate with the U.S. Army Corps of Engineers Comprehensive Plan Study Program.	near-term
Action 11	Develop general guidelines for urban and industrial setbacks from the river.	near-term
Action 12	Evaluate risk of juvenile salmon and steelhead entrainment into riparian diversions. Develop and implement projects to reduce entrainment at high-risk diversions.	near-term
Action 13	Fund and hire a river-keeper to monitor the river.	near-term
Dredger Tailings Reach		
Action 1	Increase coarse sediment supply and balance coarse sediment supply with transport capacity.	near-term
Action 2	Remove tailings from the floodplain adjacent to the river to establish floodplains at an elevation that is functional under the contemporary, regulated flow regime.	near-term
Action 3	Assess current and potential habitat values of off-channel wetlands in remnant floodplain slough areas. Identify opportunities to work with landowners to preserve or enhance those values.	near-term
Gravel Mining 1 Reach		
Action 1	Continue implementation of CDFG/CDWR Salmon Habitat Enhancement Project.	near-term
Action 2	Control the spread of eucalyptus in the reach.	near-term
Action 3	Reconstruct the channel and floodplain at in-channel mining pits.	moderate-term
Gravel Mining 2 Reach		
Action 1	Reduce sand supply from the Dry Creek watershed.	near-term/long-term
Action 2	Control the spread of eucalyptus in the reach.	near-term
Action 3	Establish a biotechnical erosion control demonstration project in the reach. Where erosion control is needed, provide technical assistance to construct biotechnical erosion control.	near-term/long-term
Action 4	Reconstruct the channel and floodplain at terrace and in-channel mining pits.	moderate-term

Table 6-1. Recommended Restoration Actions in the Merced River Corridor, continued

Reach/Actions		Initiation Timeframe
Encroached and Confluence Reaches		
Action 1	Establish a biotechnical erosion control demonstration project in the Encroached Reach. Where erosion control is needed, provide technical assistance to construct biotechnical erosion control.	near-term/long-term
Action 2	Identify opportunities and implement projects to establish a river migration/floodplain corridor through voluntary conservation easements.	near-term
Action 3	Once a sufficient river migration/floodplain corridor is established, develop and implement projects to reconnect the river to its floodplain and reestablish riparian vegetation and functions.	long-term
Action 4	Preserve existing riparian forests near the San Joaquin River confluence.	long-term

6.1 River-wide Actions

ACTION 1. Identify opportunities for and implement flow-related experiments (near-term).

Project Objective:
To capitalize on opportunities to purchase water through existing programs or coordinate studies with planned or unplanned flow releases to:
- test bed mobilization thresholds and scour depths;
- document bedload transport rates during a range of flows; and
- test riparian vegetation recruitment potential.

Project Description:
Working with Merced ID, CDFG, and other agencies, identify opportunities to conduct experiments to test the effects of flow on bed mobility, riparian vegetation recruitment, and other parameters of interest. Opportunities would rely on taking advantage of flood releases, planned water transfers, water purchases, planned fisheries releases, and other releases being made through available programs. These experiments could be incorporated into specific actions described for each reach, such as gravel augmentation in the Dredger Tailings Reach (see Section 6.2).

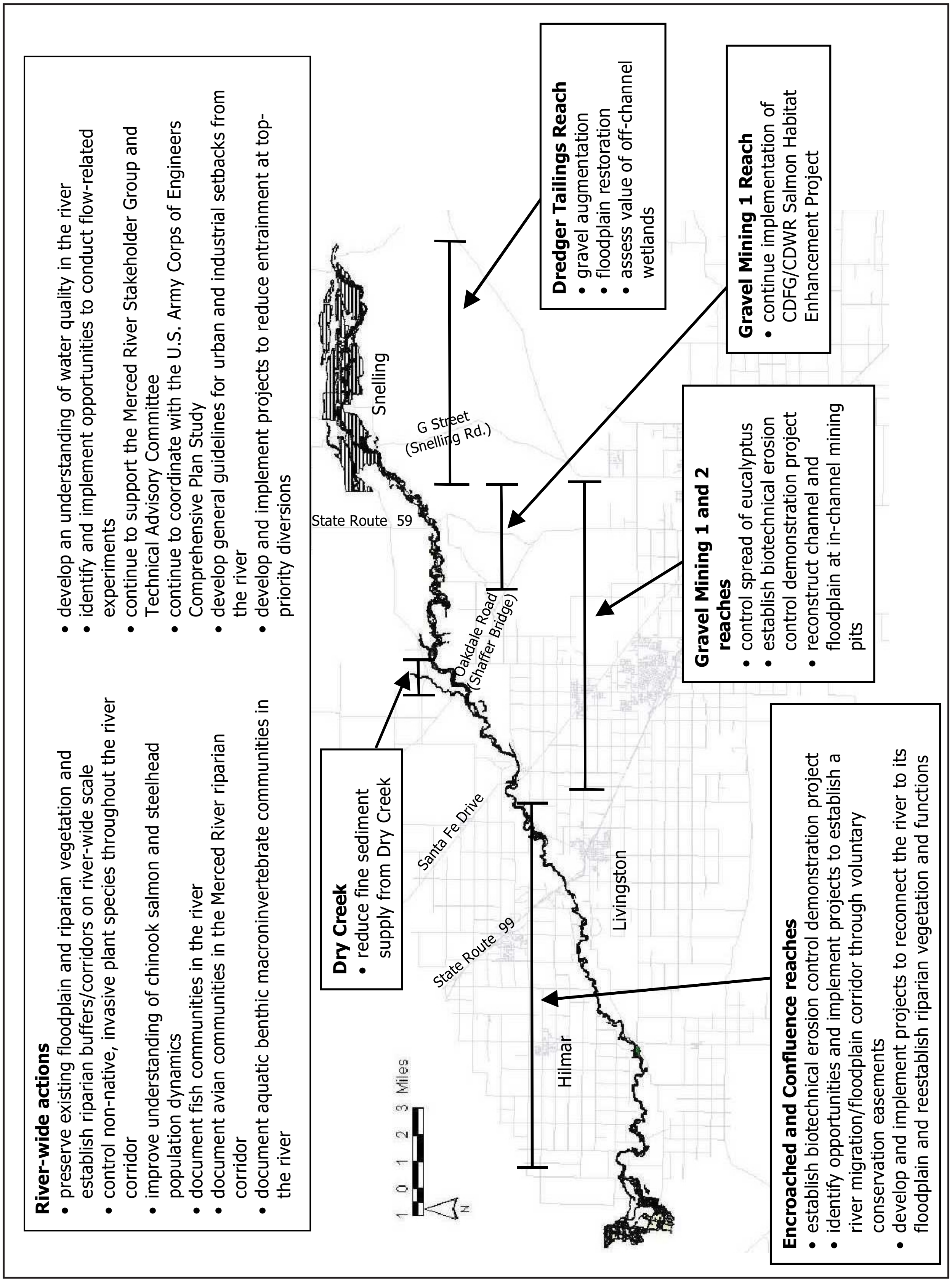


Figure 6-1. Summary of recommended actions in the Merced River and riparian corridor.

ACTION 2. Preserve existing floodplain and riparian vegetation and establish riparian buffers/corridors on river-wide scale (near-term/long-term).

Project Objectives:
- Maintain and increase riparian forest extent and connectivity.
- Maintain and improve habitat conditions for native terrestrial wildlife, particularly native bird species that depend on riparian forests for all or portions of their life history.

Project Description:
Through voluntary conservation easements, protect existing riparian vegetation patches in the river corridor. Conservation easement purchases should focus on patches that are 50 acres or larger in size. Suggested criteria for prioritizing conservation easement purchases include:
- connectivity to or synergistic effects with other preservation or restoration projects or intact aquatic or terrestrial habitat;
- proximity to existing intact riparian and upland habitats;
- expected benefits to special status terrestrial or aquatic species;
- expected benefits to multiple species;
- potential increase in or preservation of meander belt width;
- expected benefits to floodplain and riparian habitats and processes;
- potential to increase riparian habitat extent;
- expected longevity of project and benefits;
- provision of adequate buffer width between the site and adjacent land uses;
- project size (length or acreage);
- biological response time;
- self-sustainability; and
- certainty of benefits.

High priority sites for preservation of riparian habitats are identified in Figure 6-2. Conservation easements are available through a variety of programs. Easement opportunities and the benefits of conservation easements to landowners are summarized in Appendix D.

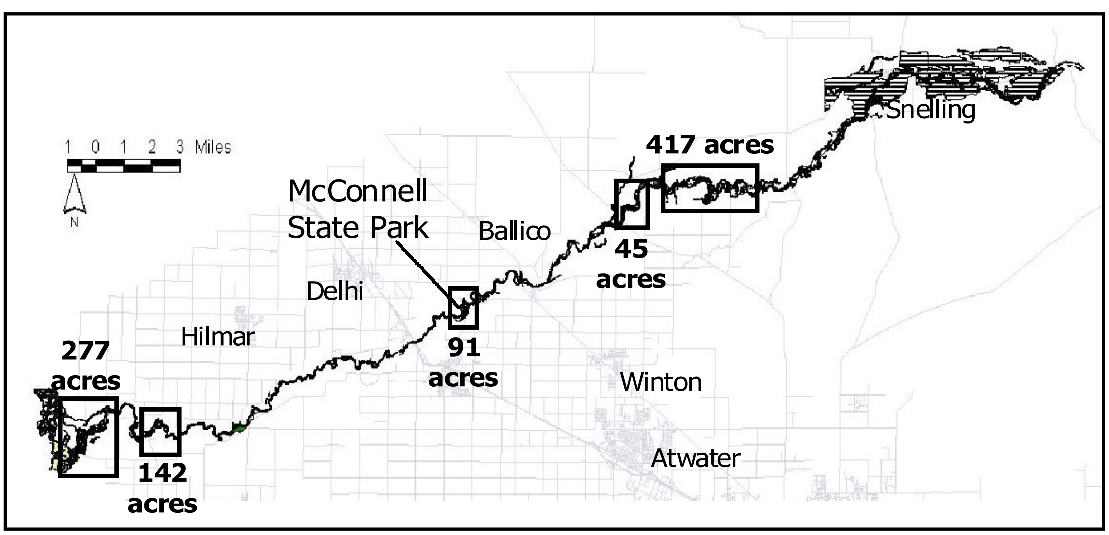


Figure 6-2. High priority vegetation conservation areas in the Merced River corridor.

ACTION 3. Control non-native, invasive plant species throughout the river corridor (near-term).

Project Objectives:
- Conduct additional baseline surveys of the distribution and abundance of non-native, invasive plant species, particularly aquatic species such as egeria, parrot's feather, and water hyacinth.
- Reduce the extent of non-native, invasive plant species in the river and the riparian corridor.
- Reduce the threat of spread of these species in the river and riparian corridor.

Project Description:
The recommendation is to develop an outreach program to educate landowners about high priority non-native, invasive species and appropriate methods for their eradication. The initial targets for eradication and control are eucalyptus seedlings and saplings and all age classes of tree of heaven, giant reed, tamarisk, water hyacinth, parrot's feather and egeria. The recommended approach for eradicating and/or preventing spread of these species in the corridor is through landowner outreach, technical assistance, and implementation assistance through existing agencies and programs, such as the East Merced Resource Conservation District, Natural Resource Conservation Service, Community Alliance with Family Farmers, or other agencies or programs. These programs can provide information and technical support to allow landowners to identify and eradicate target species on their properties. Methods of controlling or eradicating these species that could be applied by landowners or local agencies are described in Appendix A.

An early task under Action 3 should be to conduct baseline surveys of non-native, invasive aquatic plant species (such as egeria, parrot's feather, and water hyacinth) and supplement existing data on non-native, invasive plants in the riparian zone. Recommended eucalyptus control initially targets seedlings and saplings to prevent further spread of eucalyptus in the riparian corridor. Adult trees occurring along the Merced River and Dry Creek, however, will continue to provide a source of seeds and propagules to the corridor. These adult trees may provide habitat values to herons, egrets, and other birds and wildlife. While eliminating the seed and propagules source to the river is a high priority, removal of adult eucalyptus trees should not be done without consideration of potential wildlife effects. Prior to implementing a program to remove adult eucalyptus trees on the Merced River and Dry Creek, the wildlife habitat value and utilization of these stands should be assessed, and eradication should proceed in a manner that avoids impacts to wildlife species.

ACTION 4. Improve understanding of chinook salmon and steelhead population dynamics (near-term).

Project Objectives:
- Document juvenile chinook salmon and steelhead distribution in the river during emergence, rearing, and outmigration.
- Document temporal variability in chinook salmon and steelhead emergence,

rearing, and outmigration.
- Identify relationships between environmental factors and steelhead and chinook salmon survival, abundance, distribution, and outmigration timing.

Project Description:
Merced ID is implementing a 10-year joint study program with CDFG to assess chinook salmon and steelhead abundance, distribution, and population dynamics. The components of this evaluation are currently being negotiated but will include studies to assess the needs of each freshwater life stage (i.e., upstream migration, spawning, egg incubation, fry and juvenile rearing, and outmigration). Components of this study, such as monitoring water temperature, salmon and steelhead abundance and distribution, and chinook salmon smolt survival are currently underway.

Based on the outcome of the final study design, additional studies may be necessary to assess chinook salmon and steelhead population dynamics. Additional study needs should be determined upon completion of the Merced ID-CDFG study plan.

ACTION 5. Document fish community characteristics in the river (near-term).

Project Objectives:
- Document fish community species composition (native and non-native) and distribution in the Merced River.
- Document temporal variability in fish species composition and distribution.
- Evaluate the influence of environmental factors, such as flow magnitude, water temperature, and habitat structure, on species composition and distribution.


Photo/Ken Jensen

Project Description:
Develop and implement programs to provide baseline information on fish species composition and distribution in the Merced River. Recommended methods include periodic seining and snorkel surveys at reference sites that represent a range of habitat types throughout the river (from Crocker-Huffman Dam to the San Joaquin River confluence). Surveys should be conducted throughout the year, as feasible, to identify temporal shifts in species composition, distribution, and relative abundance. These studies should be coordinated through the Technical Advisory Committee and the Merced ID-CDFG joint study to capitalize on efficiencies with and address data gaps in ongoing studies. The baseline surveys, combined with other ongoing monitoring of environmental factors (such as water temperature), will provide information from which hypotheses describing factors affecting native and non-native fish species in the river can be developed and studies to test these hypotheses can be designed.

ACTION 6. Document avian community characteristics in the Merced River riparian corridor (near-term).

Project Objectives:

- Document avian community species composition (native and non-native) in the Merced River riparian corridor during the breeding season.
- Document temporal variability in species composition, density, and distribution during the breeding season.
- Evaluate the influence of vegetation patch size, composition, and structure on avian species composition and distribution of species nesting in the corridor.
- Provide baseline data that can be integrated with ongoing surveys being conducted on the San Joaquin, Tuolumne, and Sacramento rivers.

Project Description:

Develop and implement a study program to provide baseline information on the avian species composition, density, and distribution in the Merced River riparian corridor and evaluate relationships between these parameters and riparian vegetation patch size, species composition, and structure. To be consistent with ongoing surveys being conducted in the Central Valley, recommended surveys include a combination of point-count avian census surveys (modified by Point Reyes Bird Observatory from Ralph et al. 1993) and vegetation relevé plots (Sawyer and Keeler-Wolf 1995). Avian census surveys should include five-minute point counts conducted a minimum of three times during the breeding season (May 1 through June 30). At each census point, a vegetation relevé survey documenting species, percent cover, and canopy layer should be conducted once annually. Survey locations should include sites throughout the river corridor from Crocker-Huffman Dam to the confluence with the San Joaquin River that represent a range of riparian vegetation conditions, patch sizes, and adjacent land uses. These studies should be coordinated through the Merced River Technical Advisory Committee to capitalize on efficiencies with ongoing project-specific surveys being conducted for restoration project implementation, bridge widening, and other projects. In addition, since nearly all surveys would occur on private property, the study should be coordinated through the Merced River Stakeholder Group and individual landowners in the corridor.

ACTION 7. Document aquatic benthic macroinvertebrate communities in the Merced River (near-term).

Project Objectives:
- Document aquatic benthic macroinvertebrate composition, distribution, and abundance in the corridor as an indicator of ecosystem health.
- Document abundance and distribution of non-native, invasive aquatic invertebrate species such as the Asiatic clam (*Corbicula fluminea*), or Chinese mitten crab (*Eriocheir sinensis*).

Project Description:
Develop and implement a study program to provide baseline information on benthic macroinvertebrate composition, density, and distribution in the Merced River as an indicator of ecosystem health. Macroinvertebrate communities can provide an effective indicator of ecosystem health, particularly with regard to water quality, water temperature, and nutrient availability. Several metrics of invertebrate community composition have been developed to relate community composition to environmental conditions. The Biotic Condition Index is a rapid assessment protocol that was developed and has been applied extensively throughout the western United States. In this index, taxa are assigned sensitivity scores to reflect tolerance to water quality degradation, and a dominance-weighted Community Tolerance Quotient is computed to reflect an average sensitivity score. This method could be applied at a range of sites throughout the Merced River to assess water quality as well as describe macroinvertebrate community composition. In addition, the distribution and abundance of non-native, invasive invertebrates can provide a useful indicator of aquatic ecosystem health and potential risks to native species.

ACTION 8. Develop an understanding of water quality in the river (near-term/long-term).

Project Objectives:
- Assess levels of nutrients and contaminants in the Merced River.
- Identify key point- and non-point sources of nutrients and contaminants in the Merced River.
- Coordinate the RWQCB TMDL process with the Merced River Restoration Plan process.

Project Description:
Develop and implement a plan to assess the presence, distribution, and concentration of nutrients and contaminants in the Merced River and the effects of water quality on aquatic biota. This plan should include identification of nutrient and contaminant sources and water quality monitoring at these sources and at control sites. The water quality assessment should be coordinated with the RWQCB TMDL process and ongoing water quality monitoring being conducted by the National Water Quality Assessment Program (NAWQA) and could possibly be incorporated into those ongoing programs.

ACTION 9. Continue to support the Merced River Stakeholder Group and Technical Advisory Committee (near-term).

Project Objectives:

- Provide adequate support to allow continued facilitation and coordination of the Stakeholder Group and Technical Advisory Committee.
- Provide a consistent and available contact for stakeholders, landowners, and other parties to inquire about the Restoration Plan and ongoing restoration activities.
- Provide a clearinghouse for information developed through the Merced River restoration planning process.
- Provide a forum for continued development and implementation of an adaptive management process.

Project Description:

Identify and acquire adequate funding for a part-time position to coordinate and facilitate the Stakeholder Group and Technical Advisory Committee, including setting meeting dates, developing and distributing agendas, taking and distributing minutes, maintaining an information clearinghouse, and coordinating with individual stakeholders and technical advisory committee participants.

ACTION 10. Continue to coordinate with the U.S. Army Corps of Engineers Comprehensive Plan Study Program (near-term).

Project Objectives:

- Coordinate the U.S. Army Corps of Engineers Comprehensive Plan Study Program with the ongoing Stakeholder Group and Technical Advisory Committee process.
- Avoid conflicts between future implementation of the Merced River Corridor Restoration Plan and the Comprehensive Plan.

Project Description:

Work with the Corps of Engineers to provide information developed through the Merced River restoration planning process. When and if the Corps of Engineers begins to develop flood control alternatives for the Merced River, work with the Corps of Engineers team to help ensure that the proposed measures are consistent with the goals and objectives of the Restoration Plan.

ACTION 11. Develop general guidelines for urban and industrial setbacks from the river (near-term).

Project Objective:

- Avoid conflicts between urban, residential, and industrial uses in the Merced River corridor and ongoing and future restoration efforts.

Project Description:
Through a facilitated process with the Stakeholder Group, other industry and government representatives, and private individuals, develop urban and industrial setback recommendations for the corridor. These recommendations should be based on factors such as risk of conflicts between land uses and bank erosion or other fluvial processes, riparian habitat widths and buffer needs, and economic considerations.

ACTION 12. Evaluate risk of juvenile salmon and steelhead entrainment into riparian diversions. Develop and implement projects to reduce entrainment at high-risk diversions (near-term).

Project Objectives:
- Identify and determine the most significant entrainment risks to juvenile chinook salmon and steelhead in the river from Crocker-Huffman Dam to the confluence with the San Joaquin River.
- Based on this determination, implement projects such as screening or other modification of diversions to reduce entrainment risk.

Project Description:
Identify and secure funding for CDFG to complete its ongoing survey of diversion locations and operation in the river.

ACTION 13. Fund and hire a river-keeper to monitor the river.

Project Objectives:
- Provide a point of contact for Merced River issues and a clearinghouse for Merced River information.
- Provide a person to periodically monitor discharges, invasive vegetation, poaching, and other factors affecting the river. This person, however, would not have regulatory authority.

Project Description:
Fund a ¼-time position for a person to periodically monitor conditions in the river and identify issues of potential concerns as they arise. Factors that could be monitored by a river-keeper include, but are not limited to, spread of invasive plant species in the riparian corridor, water hyacinth invasion, dumping, and illegal discharges. This person would provide “eyes on the river” and would report back to the Merced River Stakeholder Group. The river-keeper, however, would not have regulatory or law enforcement authority.

6.2 Dredger Tailings Reach

ACTION 1. Increase coarse sediment and balance coarse sediment supply with transport capacity (near-term).

Project Objectives:
- Provide an immediate increase in coarse sediment in the reach to provide areas suitable for chinook salmon spawning and increase local coarse sediment supply for eventual transport and downstream deposition.
- Balance sediment texture and sediment transport competence.
- Balance sediment supply with sediment transport capacity.

Project Description:
This project would include two components: (1) an initial large-scale gravel infusion to immediately increase coarse sediment supply in the reach, and (2) smaller, long-term infusions to maintain coarse sediment supply throughout the reach. The volume of sediment needed for the initial infusion should be determined based on detailed topographic surveys in the reach. For initial feasibility assessment and planning, the infusion volume can be estimated using simplified assumptions about average channel geometry throughout the reach. Assuming a project length of 6.8 miles (36,000 feet), an average infusion depth of 2–4 feet, an average channel top width of 115 feet, and a bank slope of 1:3, the initial gravel volume would be approximately 270,000–480,000 cubic yards (230,000–410,000 tons).

Photo/Stillwater Sciences

Long-term maintenance would be required to replace sediment transported out of the Dredger Tailings Reach. Sediment transport modeling completed for this project at the Shaffer Bridge and Snelling sites (Stillwater Sciences 2001b) can be used to assess the predicted volume of sediment that would be transported out of the reach (assuming sediment continuity for the reach as a whole). Based on this modeling, the predicted volume of sediment needed for long-term maintenance would be 2,600 cubic yards (2,200 tons) annually under current, regulated flow conditions. Actual maintenance needs would be determined based on monitoring of transport rates and sediment storage in the reach.

Due to their proximity and availability, dredger tailings in the Merced River corridor are the preferred sediment source for the initial infusion and long-term maintenance. Stream restoration is not the only potential use for this aggregate along the Merced River corridor. Aggregate mining in the Merced River corridor is currently expanding in response to construction needs for the University of California-Merced campus and associated growth demands. The California Department of Conservation Division of Mines and Geology predicts that demand for concrete grade aggregate will continue to increase with the population growth projected for Merced County and the construction of the University of California–Merced campus. This demand will place strong pressure to increase mining in the Merced River corridor.

River restoration poses a potentially competing use for aggregate resources. River restoration, however, can use aggregate that is lower quality than that needed for commercial uses. Targeting dredger tailings for the restoration projects, therefore, could reduce potential conflicts between commercial aggregate supply and restoration implementation. As discussed in Section 4.1, extensive dredger tailings remain in the Merced River corridor. McBain and Trush (2000) estimated the volume of dredger tailings on lands owned by Merced ID, Merced County, and CDFG to be 3.6 million cubic yards (3.0 million tons). Of this total, approximately 1.9 million cubic yards (1.6 million tons) are located on Merced River Ranch, a property recently purchased by CDFG to provide a sediment supply for river restoration. Additional supplies are potentially available from privately owned lands in the reach and upstream of the reach. Landowners upstream of Crocker-Huffman Dam are currently assessing the feasibility of mining dredger tailings from their properties to provide a commercial supply and reclaim the properties for other uses.

In addition to their use as a gravel supply for river restoration, removal of the dredger tailings can also be implemented in conjunction with floodplain restoration, thus providing the dual benefits of an in-channel sediment supply combined with floodplain and riparian habitat enhancement. Floodplain restoration is discussed below. Use of the tailings, however, poses a potential risk of mercury contamination. During gold dredging, mercury was used to separate gold from the excavated alluvial deposits throughout the western United States (Alpers and Hunerlach 2000). This use of mercury resulted in potential mercury contamination in tailings piles remaining along rivers (Churchill 1999; Hunerlach et. al. 1999). The occurrence and distribution of mercury within dredger tailings along the Merced River corridor has not yet been assessed. A mercury assessment should be completed prior to the use of these tailings in restoration projects.

ACTION 2. Remove tailings from the floodplain adjacent to the river to establish floodplains at an elevation that is functional under the contemporary, regulated flow regime (near-term).

Project Objectives:

- Establish floodplains at an elevation that is functional under the contemporary, regulated flow regime.
- Reduce shear stresses in the main channel during large flood events.
- Enhance potential for channel migration.
- Increase width of the riparian forest corridor, thus improving wildlife habitat.
- Provide surfaces and reestablish processes suitable for recruitment of native riparian plants.
- Increase connectivity of riparian vegetation patches.

Project Description:
This project would remove dredger tailings immediately adjacent to the river channel and would provide a floodplain surface at an elevation that supports floodplain and riparian habitat functions under the contemporary, regulated flow regime. The floodplain should be wide enough to provide sufficiently shallow depths and low flow velocities over the floodplain during large flood events to prevent damage to the restoration area and should provide adequate width for wildlife values and buffers. A target minimum floodplain width of 300 feet from the top of the river bank on each side of the river is recommended. Increasing riparian buffer widths beyond the 300-foot target would provide further benefits to terrestrial and aquatic habitats. This target may need to be adjusted based on site-specific physical conditions and landowner requirements.

Implementation of floodplain restoration in this reach would require the participation of three public landowners (Merced County, Merced ID, and CDFG) and 10 private landowners.

Due to the length of the reach, floodplain restoration should be implemented in phases. The CDFG Merced River Ranch property provides a good opportunity to implement a demonstration project and for experimentation to identify the appropriate methods for establishing native riparian vegetation. Implementation of subsequent phases should proceed from upstream to downstream, as voluntary landowner participation allows. Four phases have been preliminarily identified, as follows:

Phase I. Merced River Ranch (owned by CDFG) (RM 50.3–RM 51.2);
Phase II. Crocker-Huffman Dam (RM 52.0) to Henderson County Park (RM 49.0);
Phase III. Henderson County Park (RM 49.0) to Snelling (RM 47.8), south bank; and
Phase IV. Snelling (RM 47.8) to end of reach (RM 45.2), north bank.

Each restored site should be protected by conservation easements, which would be negotiated with the landowner of each parcel. Easements should generally prohibit grazing, mining, grading, construction, and land-clearing in the restoration area. Conservation easements and the potential benefits of conservation easements to landowners are discussed in Appendix D.

ACTION 3. Assess current and potential habitat values of off-channel wetlands in remnant floodplain slough areas. Identify opportunities to work with landowners to preserve or enhance those values (near-term).

Project Objective:
- Identify and assess the current and potential value of wetland habitats in remnant floodplain sloughs.

Project Description:
Develop and implement a plan to conduct biological surveys in wetlands occurring in remnant floodplain slough to document their current habitat value and

utilization by native species and to determine their potential value as restoration sites. If potential value is determined to be high, work with landowners to identify potential restoration strategies.

6.3 Gravel Mining 1 Reach

ACTION 1. Continue implementation of CDFG/CDWR Salmon Habitat Enhancement Project (near-term).

Project Objective:

- Reconstruct the river channel and floodplain through 4.3 miles of the Merced River that have been excavated for aggregate mining.

Project Description:

The Merced River Salmon Habitat Enhancement Project is being implemented by CDFG, working with CDWR. This project will reconstruct the river channel and floodplain through 4.3 miles of the Merced River that were excavated for aggregate mining. The project is being implemented in four phases, as follows:

Phase I. Ratzlaff Reach (RM 40.0–RM 40.5);
Phase II. Robinson Reach (RM 42.0–RM 44.0);
Phase III. Western Stone Reach (RM 42.0–RM 41.5); and
Phase IV. Lower Western Stone Reach (RM 41.5–RM 40.5).

Phase I, the Ratzlaff Reach, was constructed in 1999. Phase II, the Robinson Reach, began construction in 2001 and will be completed in 2002. The next phase proposed for implementation is Phase III, the Western Stone Reach.

ACTION 2. Control the spread of eucalyptus in the reach (near-term).

Project Objectives:

- Reduce the extent of eucalyptus in the river and the riparian corridor.
- Reduce the threat of spread of eucalyptus in the river and riparian corridor.

Project Description:

Control and eradication of non-native invasive plant species in the river and its adjacent riparian corridor are identified as a river-wide action in Section 6.1. Extensive eucalyptus invasion is unique to the Gravel Mining 1 and 2 reaches and, therefore, is identified as a separate reach-specific action. Large stands of eucalyptus occur in the Gravel Mining 1 and 2 reaches and recruitment of eucalyptus saplings has been observed in the reach. Controlling the spread of eucalyptus in this reach, therefore, is a high priority. The initial targets for eradication and control are eucalyptus seedlings and saplings. The recommended approach is to eradicate and/or prevent spread of eucalyptus in the corridor through landowner outreach, technical assistance, and implementation assistance through existing agencies and programs, such as the East Merced Resource Conservation District, Natural Resource Conservation Service, Community Alliance with Family Farmers, or other agencies or programs. These programs can provide information and technical support to allow landowners to identify and eradicate eucalyptus seedlings and saplings on their properties. Methods for controlling or eradicating eucalyptus that could be applied by landowners or local agencies are described in Appendix A.

Recommended eucalyptus control initially targets seedlings and saplings to prevent further spread of eucalyptus in the riparian corridor. Adult trees occurring along the Merced River and Dry Creek, however, will continue to provide a source of seeds and propagules to the corridor. These adult trees may provide habitat values to herons, egrets, and other birds and wildlife. While eliminating the sources of seeds and propagules is a high priority, removal of adult eucalyptus trees should not be done without considering potential wildlife effects. Prior to implementing a program to remove adult eucalyptus trees on the Merced River and Dry Creek, the wildlife habitat value and utilization of these stands should be assessed, and eradication should proceed in a manner that avoids impacts to wildlife species.

ACTION 3. Reconstruct the channel and floodplain at in-channel mining pits (moderate-term).

Project Objectives:

- Scale the low flow and bankfull channel to function within the contemporary flow regime.
- Reduce habitat for introduced predatory fish species.
- Improve sediment transport continuity.
- Balance coarse sediment supply and transport.
- Restore or enhance salmon spawning habitat.
- Enhance passage of adult and juvenile salmon.
- Provide a floodplain that functions within the contemporary, regulated flow regime.
- Reestablish riparian vegetation and provide conditions that support natural recruitment of riparian vegetation species.

Table 6-2. Estimated Volume of Sediment Required to Complete Reconstruction of In-channel Pits

Pit Identification[1]	Location (RM)	Estimated Fill Volume for Complete Reconstruction	
		(yd^3)	(tons)
GM1 - C1	38.9-39.3	89,000	74,000
GM1 - C2	35.1-35.4	17,000	14,000
GM1 - C3	33.9-34.4	57,000	48,000
GM1 - C4	36.3-36.9	4,000	3,000
Total		167,000	139,000

[1] See Figure 4-7.

Project Description:

Reconstruct the channel and floodplain at in-channel pits by either fully or partially filling pits (Figure 4-9). Four in-channel pits, which occupy 1.8 miles of channel, occur in this reach. Filling of in-channel and terrace pits would require large volumes of sediment. Preliminary estimates of the volume of sediment required to reconstruct the channel and floodplain at each pit are shown in Table 6-2. This volume could be reduced by leveeing the pits rather than completely filling them (Figure 4-9, Approach B). This alternative, however, should include sufficient floodplain width within the levees to support a minimum 300-foot wide riparian corridor.

Projects to reconstruct a functional channel and floodplain at in-channel and captured terrace pits are currently being implemented on the Merced and Tuolumne rivers and on Clear Creek, a tributary to the Sacramento River. These projects, because they require the purchase and transport of hundreds of thousands of tons fill, are very costly. Projects that have been implemented to date or that are currently being implemented range in cost from $4.5 million (Ratzlaff Reach) to $7.5 million (Robinson Reach). These projects have the potential to provide substantial benefit to the river-floodplain ecosystem. Due to their cost and experimental nature, however, it is recommended that implementation of additional projects of this nature be delayed until monitoring results from currently planned or implemented projects are available.

6.4 Gravel Mining 2 Reach

ACTION 1. Reduce sand supply from the Dry Creek watershed (near-term/long-term).

Project Objective:
- Reduce the supply of sand to the mainstem Merced River from Dry Creek.

Project Description:
The recommended approach to reducing the supply of sediment to the mainstem Merced River from the Dry Creek watershed includes three components, as follows:
- conducting a watershed-scale assessment of the Dry Creek watershed to identify primary sediment sources (near-term);
- if pit reconstruction proceeds and the pit at the mouth of Dry Creek is eliminated (see Action 4 below), providing a sedimentation basin at the mouth of Dry Creek (moderate-term); and
- working through existing programs such as Community Alliance with Family Farmers, Natural Resources Conservation Service, and the East Merced Resource Conservation District to implement measures to reduce erosion at primary sediment sources identified in the watershed-scale assessment and thus reduce sand delivery to the Merced River (near- to long-term).

ACTION 2. Control the spread of eucalyptus in the reach (near-term).

Project Objectives:
- Reduce the extent of eucalyptus in the riparian corridor.
- Reduce the threat of spread of eucalyptus in the river corridor.

Project Description:
Control and eradication of non-native invasive plant species in the river and its adjacent riparian corridor are identified as a river-wide action in Section 6.1. Extensive eucalyptus invasion is unique to the Gravel Mining 1 and 2 reaches and its control is therefore identified as a separate reach-specific action. This action is described in Section 6.3, Action 2.

ACTION 3. Establish at least one biotechnical erosion control demonstration project in the reach (near-term). Where erosion control is needed, provide technical assistance to construct biotechnical erosion control (near- to long-term).

Project Objectives
- To reduce the extent of bank revetment in the river corridor by providing an alternative method of erosion control.
- To demonstrate to local landowners that biotechnical methods can be cost-effective, safe, successful, and implementable.

Project Description:
Concrete rubble bank revetment in the reach armors 7 percent of the bank length and 61 percent of the meander apexes within the reach. Where erosion control is necessary, provide technical assistance to landowners to identify locations where this is feasible and use biotechnical methods that incorporate native plant species rather than rubble revetment. Also, establish at least one biotechnical erosion control demonstration project in the reach. The project(s) should include application of at least one (but preferably more) appropriate biotechnical erosion control methods, as well as monitoring, documentation, and outreach to nearby riverbank landowners. Biotechnical methods of erosion control are outlined in Appendix E.

ACTION 4. Reconstruct the channel and floodplain at terrace and in-channel mining pits (moderate-term).

Project Objectives:
- Scale the low flow and bankfull channel to function within the contemporary flow regime.
- Reduce habitat for introduced predatory fish species.
- Improve sediment transport continuity.
- Balance coarse sediment supply and transport.
- Restore or enhance salmon spawning habitat.
- Enhance passage of adult and juvenile salmon.
- Provide a floodplain that functions within the contemporary, regulated flow regime.
- Reestablish riparian vegetation and provide conditions that support natural recruitment of riparian vegetation species.

Project Description:
Reconstruct the channel and floodplain at in-channel and terrace pits by either fully or partially filling pits (see Figure 4-9). Filling of in-channel and terrace pits would require large volumes of sediment. Five in-channel pits and two abandoned terrace pits occur in this reach. Preliminary estimates of the volume of sediment required to reconstruct the channel and floodplain at each pit are shown in Table 6-3. This volume could be reduced by leveeing the pits rather than completely filling them (Figure 4-9, Approach B). This alternative, however, should include sufficient floodplain width within the levees to support a minimum 300-foot wide riparian corridor.

As described for the Gravel Mining 1 Reach, projects to reconstruct a functional channel and floodplain at in-channel and captured terrace pits are currently being implemented on the Merced and Tuolumne rivers and on Clear Creek, a tributary to the Sacramento River. These projects, because they require the purchase and transport of hundreds of thousands of tons fill, are very costly. Projects that have been implemented to date or that are currently being implemented range in cost from $4.5 million (Ratzlaff Reach) to $7.5 million (Robinson Reach). These projects have the potential to provide substantial benefit to the river-floodplain ecosystem. Due to their cost and experimental nature, however, it is recommended that implementation of additional projects of this nature be delayed until monitoring results from currently planned or implemented projects are available.

Table 6-3. Estimated Volume of Sediment Required to Complete Reconstruction of In-channel Pits

Pit Identification[1]	Location (RM)	Estimated Fill Volume for Complete Reconstruction	
		(yd^3)	(tons)
GM2-C1	31.5-32.1	122,000	102,000
GM2-C2	30.0-30.6	318,000	265,000
GM2-T2	29.7-29.9	151,000	126,000
GM2-C3	28.7-28.9	104,000	87,000
GM2-C4	27.2-27.4	132,000	110,000
GM2-C5	26.7-27.1	187,000	156,000
Total		1,014,000	846,000

[1] See Figure 4-11.

6.5 Encroached and Confluence Reaches

ACTION 1. Establish at least one biotechnical erosion control demonstration project in the reach (near-term). Where erosion control is needed, provide technical assistance to construct biotechnical erosion control (near- to long-term).

Project Objective:

- To reduce the extent of bank revetment in the river corridor by providing an alternative method of erosion control.
- To demonstrate to local landowners that biotechnical methods can be cost-effective, safe, successful, and implementable.

Project Description:

Concrete rubble bank revetment in these reaches is extensive, armoring 21 percent of the bank length and 76 percent of the meander apexes in the Encroached Reach, and 11 percent of the bank length and 67 percent of the meander apexes in the Confluence Reach. Where erosion control is necessary, provide technical assistance to landowners to identify locations where this is feasible and use biotechnical methods that incorporate native plant species rather than rubble revetment. Also, establish at least one biotechnical erosion control demonstration project in the reach. The project(s) should include application of at least one (but preferably more) appropriate biotechnical erosion control methods as well as monitoring, documentation, and outreach to nearby riverbank landowners. Once a demonstration project has been successfully implemented, work with landowners to identify opportunities to allow bank erosion and channel migration. Biotechnical methods of erosion control are outlined in Appendix E.

ACTION 2. Identify opportunities and implement projects to establish a river migration/floodplain corridor through voluntary conservation easements (near-term).

Project Objectives:

- Through voluntary easements or other voluntary agreements with landowners, to establish a corridor within which the river can migrate, thus reducing the need for bank revetment and providing opportunities to reconnect the floodplain to the river and increase the width of the riparian corridor.
- Document the effects of removing revetment and providing opportunities for the river to migrate.

Project Description:

Work directly with landowners in the reach to identify opportunities for establishing a meander corridor through a voluntary conservation easement program. This evaluation should focus on identifying easement opportunities immediately adjacent to the river and should emphasize voluntary participation. Highest priority lands are those which would be inundated by the 6,000-cfs maximum flood release in the absence of levees. These lands are shown in Figure 6-3. Where feasible, develop a pilot project to remove bank revetment and allow the channel to migrate. This pilot project should include public outreach and detailed monitoring to document and assess the benefits of revetment removal to channel migration, riparian vegetation, and aquatic habitat.

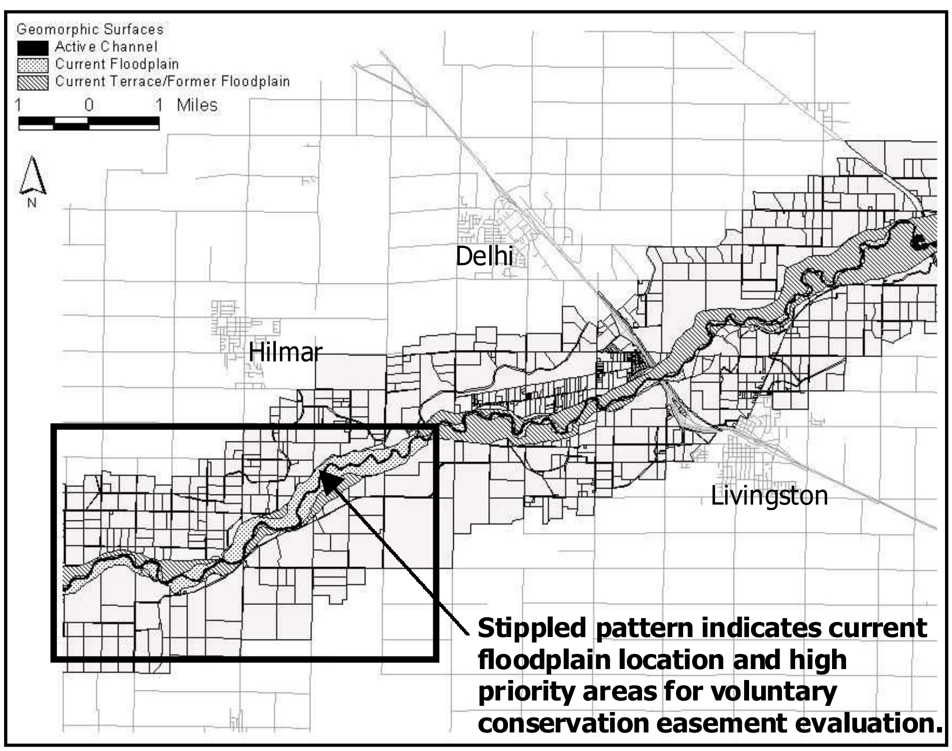


Figure 6-3. High priority areas for evaluation of voluntary conservation easements.

ACTION 3. Once a sufficient river migration/floodplain corridor is established, develop and implement projects to reconnect the river to its floodplain and reestablish riparian vegetation and functions (long-term).

Project Objectives:
- Reconnect the floodplain to the river.
- Increase the width of the riparian corridor.
- Allow the river to migrate within the protected corridor.
- Document the effects of re-initiation of channel migration on aquatic and riparian processes and communities.

Project Description:
Where possible, restore floodplain function by establishing a floodplain at an elevation that is inundated under the current, regulated flow regime. This could be accomplished by allowing the river to migrate and naturally establish a floodplain within its incised channel, through relocation of levees, or through excavation of a new floodplain bench (Figure 4-15). It may not be possible to implement channel and floodplain restoration projects in this reach in the near future because of adjacent land uses and landowner concerns. Opportunities, however, may become available to develop projects further in the future.

ACTION 4. Preserve existing riparian forests near the San Joaquin River confluence (long-term).

Project Objectives:
- Maintain and increase riparian forest extent and connectivity.
- Maintain and improve habitat conditions for native terrestrial wildlife, particularly native bird and bat species dependent on riparian forests for all or portions of their life history.

Project Description:
Through voluntary conservation easements, protect existing riparian vegetation patches in the river corridor. Preservation of riparian forests is also identified as a river-wide action in Section 6.1, but is reiterated here due to the unique and extensive forests occurring in the Confluence Reach. Much of this forest is currently being put into easements by the Stevinson Corporation. Conservation efforts should focus on increasing connectivity between these large forest patches in the Confluence Reach.

Appendices

APPENDIX A
Methods for Eradicating Non-native, Invasive Plants

This appendix describes methods of controlling or eradicating several non-native, highly invasive plants that aggressively invade or displace native plant species and disrupt natural habitat. The species in this appendix were included based upon their occurrence in the Merced River corridor and their listing by the California Exotic Pest Plant Council as some of the most invasive wildland pest plants in California. This appendix was developed from review of Bossard et al. (2000), The Nature Conservancy (2001), and Alien Plant Working Group (2001).

Methods of invasive plant eradication or control are commonly categorized as physical, thermal, managerial, biological, or chemical methods. Physical methods include manual and mechanical techniques. Physical methods are most effective when combined with another control method such as herbicide application. Thermal methods include broadcast burning or spot treatment with a flame thrower. Prescribed burning for pest plant control must be done in accordance with local fire regulations, and the consequences of fire for native plants and soil chemistry must be considered. Biological control involves the introduction of insects or pathogens which are highly selective for a particular weed species. Biological control has some risk of non-target impacts associated with it, though very few have been reported for biological control of weed pests. Currently, no biological methods have been approved for use by the U.S. Department of Agriculture on any of the species in this appendix, though there is some experimental research underway on biological control of giant reed and tamarisk. Managerial weed control methods include prescribed grazing and the encouragement of competitive displacement by native plants. Chemical control includes both broadcast and spot application of herbicides. Remember to use pesticides wisely: always read the entire pesticide label carefully, follow all mixing and application instructions and wear all recommended personal protective gear and clothing. Contact your state Department of Agriculture for any additional pesticide use requirements, restrictions, or recommendations.

The most desirable, and often most effective approach to controlling or eradicating pest plants is that of an integrated pest management plan. This involves the optimum use of several control strategies to control pest plants, such as the manual or mechanical removal of the woody plant material combined with the application of herbicide to the remaining stump. Integrated pest management is generally accepted as the most effective, economical, and environmentally sound long-term method of controlling or eradicating pest plants. If various control techniques are used, however, they must be compatible with one another to achieve the best results. Broadcast herbicide application, for example, may not be compatible with competitive displacement.

Tree of heaven (*Ailanthus altissima*)

The conditions promoting germination and establishment of tree of heaven are not well-known. Though seed propagation occurs, most expansion is from root-sprouting. Tree of heaven is very shade-tolerant and aggressive, so few plants compete effectively with it. Elimination of tree of heaven requires diligence due to its abundant seed production, high seed germination rate, and vegetative reproduction. Follow-up monitoring and treatment when needed should be an integral part of any serious tree of heaven management program. Regardless of method selected, treated areas should be rechecked one or more times a year and any new suckers or seedlings treated (cut, sprayed or pulled) as soon as possible, especially before they are able to rebuild root reserves. Establishing a thick cover of trees (preferably native and non-invasive) or grass sod helps shade out and discourage establishment of tree of heaven seedlings. Targeting large female trees for control helps reduce spread of tree of heaven by seed. Female trees can be identified by their flowers. Female flowers have no stamen and two to five carpels which develop into a winged fruit with a single central seed. In addition, the female flowers have an unpleasant odor.


Photo/Stillwater Sciences

Physical Control

Young seedlings can be removed manually after a rain when the soil is loose. This method removes the root system, which can resprout if left in the ground. Seedlings should be pulled as soon as they are large enough to grasp but before they produce seeds (generally during summer). Tree of heaven develops a strong tap root making manual removal of mature plants extremely difficult.

Hand digging is a suitable method for controlling small infestations of tree of heaven, or when it is present around other vegetation that should not be disturbed. This method of removing the rootstocks by hand is a slow but sure way of destroying tree of heaven, which resprouts from its roots. Rootstock removal must be thorough to be effective since every piece of root that remains in the soil may produce a new plant.

Manually operated tools such as brush cutters, power saws, axes, machetes, and loppers can be used to remove the above-ground portion of the plant. This is an important first step in any tree of heaven eradication or control effort. In thickly growing patches of multi-stemmed shrubs and trees, access to the base of the plant for cutting may be difficult.

Saplings can be trimmed back by tractor-mounted mowers on even ground or by scythes on rough or stony ground. This mechanical control method is faster and more economical than manual methods of removal, but it is non-selective and can open up new niches for other undesirable plant species to become established.

This method also reduces or eliminates wildlife habitat. Saplings usually require several cuttings until the root system exhausts it reserve food supply. The ideal time for cutting saplings is while they are in-flower (late spring to early summer) because food supply in the roots is nearly exhausted and new seeds have not yet been produced. After cutting or chopping with mechanical equipment, tree of heaven resprouts from root crowns in even greater densities if not treated with an herbicide.

Managerial Control
Grazing by cattle and browsing by deer can aid in eradication efforts. Tree of heaven may suffer extensive browse herbivory, particularly the young growth of sprouts.

Plant competition is not a highly effective method of tree of heaven control. Seedlings of native plants usually cannot establish fast enough to compete with tree of heaven sprout growth. In addition, tree of heaven is shade tolerant, so it can sprout and establish itself under other plants.

Chemical Control
The most effective method of tree of heaven control seems to be through the use of herbicides, which may be applied to foliage, basal bark, a cut stump, or a frilled (having a ring of bark removed) trunk. Keep in mind that though it is relatively easy to kill the above ground portion of the tree, the root system needs to be killed or seriously damaged to prevent or limit stump sprouting and root suckering.

Herbicide application is most effective in spring, just after leaves are fully expanded. Smaller sprouts can usually be controlled by spraying foliage with 4 percent glyphosate (such as Roundup®). Young stems can usually be killed by generously applying 15–20 percent triclopyr (sold as Garlon®) to all of the bark from the stem base to 20 inches above the ground. Applying herbicide directly to freshly cut stumps is generally the most effective method for controlling tree of heaven. The thicker bark of larger plants interferes with the uptake of herbicide, so to kill large individuals, a combination of physical and chemical controls, referred to as the hack and squirt method, or frilling, can be used. A hatchet is used to make a series of downward cuts in the bark around the entire circumference of the tree trunk and then herbicide is immediately applied into the cuts. In order to damage the root system, concentrated herbicide such as 15–20 percent triclopyr or 15–40 percent glyphosate should be applied. Wiping the stump with full strength, 41 percent glyphosate within several minutes of cutting should also reduce or eliminate subsequent root suckering.

Giant reed (*Arundo donax*)

Areas infested with giant reed are best restored through chemical means. Mechanical control (e.g., repeated mowing) may be somewhat effective, but if small fragments of root are left in the soil, reestablishment can occur. Control of giant reed is a major concern of CALFED, a cooperative of state and federal agencies, and California land and water managers.

Physical Control
Minor infestations of giant reed can be eradicated using manual methods, especially where sensitive native plants and wildlife occur. Hand pulling young plants that are less than 6 feet in height is effective, but care must be taken to remove the

entire rhizome material. This method is best used after rains have loosened soils. Hand tools can also be used to dig up plants, especially in combination with cutting of stems near the base with pruning shears, machete, or chainsaw. Stems and roots should be removed or burned on site to avoid re-rooting. Chipping cut material can also be used, but the fibrous material of giant reed can clog chippers. Large infestations can be cut down using heavier tools such as chainsaws, brush-cutters, or tractor-mounted mower, and followed up by rhizome removal or chemical treatment.

Using a backhoe or tractor to control giant reed is largely unsuccessful because rhizomes are often buried 3–10 feet deep, making complete removal infeasible especially where extensive disturbance to soils is undesirable. There has been some success using a 'flailer,' which is towed behind a tractor, to reduce vegetation in combination with foliar herbicide treatments to kill resprouts (T. Dudley, pers. comm. 2001).

Thermal Control
Burning live or chemically treated giant reed should not be attempted. Burning does not kill the rhizomes and generally favors giant reed regeneration over native species. Cut material is often burned on-site, subject to local fire regulations.

Managerial Control
Cattle, sheep, and goats can be useful in controlling giant reed but are unlikely to reduce the plant sufficiently to eliminate the risk of further invasion. Livestock will feed on young plant growth, but avoid older, woody material that is unpalatable. Grazing alone is unlikely to eradicate giant reed infestations.

Chemical Control
Eradication efforts that use chemical methods, especially in combination with mechanical removal, are the most successful method of eradicating giant reed. Giant reed generally occurs near water or wetland, making it vital that an herbicide that does not have effects on non-target plant or animal species is used. Glyphosate formulated as Rodeo® is approved for use in wetlands and is the most common herbicide treatment. Glyphosate formulated as Roundup® can only be used away from water. The standard treatment is a foliar spray application of 1.5 percent per volume glyphosate with a 0.5 percent non-ionic surfactant. Glyphosate is a broad-spectrum herbicide and care should be taken to avoid contact with desirable vegetation. One currently experimental technique involves a combination treatment of low-dose imazapyr and glyphosate together (both are amino-acid pathway inhibitors). Early results indicate high mortality using this method (T. Dudley, pers. comm., 2001).

Application after flowering and pre-dormancy (usually late August to early November) is the most effective timing. Foliar applications work best in fall, when plants are translocating nutrients to roots for storage, and herbicides can penetrate the root systems most effectively. Small patches can be treated from the ground using backpack or towed sprayers, and major infestations have been aerially sprayed by helicopter.

Direct treatment to cut stalks can reduce herbicide costs and drift on desirable plants, with fair results year-round and best results in fall. This method is most effective in shaded sites. Concentrated glyphosate is applied with a cloth-covered wand, sponge, or hand mister directly to stalks cut 2–4 inches above the ground. Herbicide must be applied to the stalk within five minutes of cutting. It is helpful to add a dye to the herbicide in order to identify treated material.

New growth is sensitive to herbicides, so another method to control giant reed is to cut or mow a patch and then return three to 12 weeks later to apply a foliar spray of glyphosate to the new growth. With all methods, follow-up assessment and treatment should be conducted. Some professional herbicide applicators suggest a series of 6 spot treatments over 6 months.

Egeria (*Egeria densa*)

Egeria, or Brazilian waterweed, is a perennial freshwater aquatic plant native to South America, that is believed to have been introduced to California waterways through discarded plant material via the aquarium trade. Methods of removing *Egeria* in California are currently limited and highly regulated.

Physical Control

Physical methods of controlling or eradicating *Egeria* are largely ineffective. Pulling, cutting, and digging *Egeria* with machines is costly, provides only temporary control, and encourages further establishment through fragmentation.


Photo/Douglas Barbe, California Department of Food and Agriculture, Botany Laboratory

Managerial Control

No biological control agents are currently permitted for use in Merced County.

Chemical Control

Chemical methods must be used carefully and with the involvement of an aquatic weeds specialist in order to avoid worsening the situation or effecting aquatic ecosystems. Currently diquat, products containing copper, acrolein, and fluridone can be used at label concentrations to control egeria in California. California, however, has limited chemical control efforts following a March 2001 Ninth Circuit Court of Appeals ruling which makes it illegal to apply an aquatic herbicide to control aquatic plants such as *Egeria* without first obtaining a National Pollutant Discharge Elimination System permit (MID 2001).

The California Department of Boating and Waterways is currently conducting research on mechanical and chemical control methods, and completing an EIR for the implementation of the Egeria Densa Control Program for the Delta (CDBW 2001).

Eucalyptus (*Eucalyptus* spp.)

Eucalyptus has evolved such highly effective mechanisms for coping with fire that its persistence overwhelms most single attempts to eradicate it. After a tree is felled, follow-up treatments to control stump sprouting are nearly always necessary.

The initial step in any eucalyptus control or eradication effort is to cut down any young or mature trees. Felling the trees can be expensive, and the cost is not likely to be offset by the low value of the wood as fuel or pulp. Using an effective method of controlling regrowth from the stump is absolutely necessary to control or eradicate eucalyptus.

Physical Control

Mechanical methods of controlling eucalyptus have the least amount of impact on the surrounding area. Initially felling and removing the tree and returning twice a year to remove new growth can take up to six years to achieve a high percentage of kill. Removal should commence in the spring when biomass production is most vigorous. Regrowth is most vulnerable to cutting when the shoots are six to eight feet high. Where the native understory is fairly dense, pulling the seedlings and saplings up to an inch in diameter has proven to be a successful method of halting a grove's spread.

Another mechanical method of controlling eucalyptus is to remove the stump with a stump grinder. A stump grinder can be positioned by a small tractor and, depending upon the model used, blades cut the stump to ground level or down into the root crown. Stump grinding can eliminate sprouting, as well as removing all evidence of trees. The stump must be ground to a depth of approximately 2 feet, and then covered with soil, black plastic, or herbicide to slow and prevent regrowth. Stump removal is effective, but costly and impractical on a large scale.

Thermal Control

A flame gun can be used to kill new growth and some cambium of the stump. This technique appears to be most effective when the new growth is water-stressed, such as in late summer, but has little effect after the onset of rain. Using a flame gun for eucalyptus eradication is not appropriate in many environments and can potentially cause more harm than good.

Chemical Control

Two types of chemical methods are effective in controlling eucalyptus; application of herbicides to foliage in the form of a spray, or application of chemical directly onto the inner tissue of the tree. Application of triclopyr or glyphosate directly to the stump's cut surface at the time of tree felling is the most effective control of sprouting. Triclopyr (as Garlon 4® and Garlon 3A®) should be applied at the rate of 80 percent in an oil carrier. Imazapyr (as Arsenal® or Stalker®) can be used as an alternative to Garlon®. Glyphosate (as Roundup® or Rodeo®) should be applied at 100 percent. Stumps should be cut as low to the ground as possible and brushed clean of sawdust to maximize absorption of the herbicide. For best results, herbicides should be applied to the freshly cut surface as soon after cutting as possible. Maximum success is achieved if cutting and application of herbicides occurs in the fall. Complete control of sprouting will not always be achieved. Resprouts should be treated with a foliar application of 2 percent triclopyr or glyphosate.

Edible fig (*Ficus carica*)

No efficient way to control edible fig has been developed. The trees resprout vigorously after cutting and are difficult to control without herbicides.


Photo/Stillwater Sciences

Physical Control
Edible fig is shallow-rooted in the wet soils typical of riparian areas, making hand pulling of young trees fairly easy. They often root-sprout and an individual sapling may be one of many from a large network of roots. A small or medium-sized weed wrench may be helpful in removing some of the mid size specimens. Although it has not been demonstrated, repeated cuttings may eventually exhaust the root reserves of a tree or small thicket if done frequently.

Chemical Control
In the only documented effective use of herbicides on edible fig, all trunks and sucker shoots in a thicket on the Cosumnes River Preserve were cut six to eighteen inches above ground and treated with a 100 percent solution of triclopyr (sold under the names Garlon 3A® and Brush-B-Gone®). This was successful, although some stands had to be retreated several times because of resprouting.

Himalayan blackberry (*Rubus discolor*)

Manual removal, burning, and foliar application of glyphosate herbicide are the most effective methods of controlling Himalayan blackberry. Initial and subsequent herbicide treatments should be done cautiously because some herbicides may promote vegetative growth from lateral roots and because the plant is often located in riparian areas where the herbicide may come into contract with bodies of water.

Reestablishment of Himalayan blackberry can be prevented by planting fast-growing shrubs or trees, since the species is usually intolerant of shade. Regrowth has also been controlled by grazing sheep and goats in areas where mature plants have been removed.

Physical Control
Most mechanical control techniques, such as cutting or using a weed wrench, are suitable for Himalayan blackberry removal. Cane cuttings can reproduce vegetatively, so slash piles should be burned or removed from the site. An advantage of physical removal is that, unlike foliar herbicides, it does not stimulate sucker formation on lateral roots. Physical removal alone, however, is not sufficient to control Himalayan blackberry, as root crowns will resprout and produce more canes.

Removing rootstocks by hand digging is a slow but effective way of destroying Himalayan blackberry. This must be done thoroughly as any piece of root that remains in the soil may produce a new plant. Hand digging is appropriate for small infestations and around trees or shrubs that should not be disturbed.

Himalayan blackberry may be trimmed back using a tractor-mounted mower on flat ground or with scythes on rough or uneven surfaces. It takes several cuttings before the root system depletes its food supply and the plant dies. If only one cutting can be made, it should be made while the plant is in flower, when the reserve food supply in the roots is nearly exhausted and new seeds have not yet been produced.

Thermal Control
Prescribed burning is effective for removing the above-ground vegetation of large infestations. This method, however, requires follow-up to remove the root system or control resprouts.

Managerial Control
Sheep, goats, cattle, and horses can be effective in controlling the spread of Himalayan blackberry. Grazing by goats has been effective in preventing canes from covering large areas (Featherstone 1957), and goats have been observed to eat Himalayan blackberry throughout the year, even when there is an abundant supply of other plants (Crouchley 1980).

Chemical Control
Foliar applications of glyphosate work well to control Himalayan blackberry (T. Dudley, pers. comm., 2001).

Tamarisk (*Tamarix* spp.)

Early detection and control of tamarisk is essential as it achieves dominance rapidly under favorable conditions. Tamarisk establishes in sites disturbed by, among others, fire, increased soil salinity, and ground disturbance. Monitoring is essential following any control effort, as some tamarisk is capable of resprouting following treatment. In addition, seedlings will continue to establish as long as tamarisk infestations persist upwind or upstream of the target area.

Physical Control
Tamarisk is difficult to kill with mechanical methods, as it is able to resprout vigorously following cutting or burning. Root plowing and cutting are effective ways of initially clearing heavy infestations, but are successful only when combined with follow-up treatment with herbicide. Seedlings and plants less than 5 feet tall can be uprooted by hand using a weed wrench.

Thermal Control
Fire does not kill tamarisk root systems, and plants will return quickly unless treated by other methods. Fire is used primarily for thinning heavy infestations prior to the application of herbicide.


Photo/National Park Service's Plant Conservation Alliance, Alien Plant Working Group

Biological Control
In May 2001, UC Berkeley and the U.S. Department of Agriculture's Agricultural Research Service released Chinese leaf beetle (*Diorhabda elongata*), a small black-and-yellow striped beetle, within cages at four sites in the Central Valley (Butte Creek and Bear Creek) and the Owens Valley in an effort to biologically control tamarisk (California Agriculture 2001). It is hoped that the

beetle, along with a leafhopper that already lives on the trees, will aid in tamarisk eradication efforts. The quarter-inch-long beetle is a good prospect for biocontrol of tamarisk because both larvae and adults feed exclusively on the plant, and the adults produce two or more generations of offspring per year. In addition to eating green vegetation, the beetles create leaf wounds that allow water to escape, causing branches to wither and die. A 3-year test in the field with beetles confined to cages showed that the beetle can survive the winter and reproduce, and that it effectively defoliates tamarisk. The release of the beetle will be intensively researched to evaluate the success of beetle establishment, the beetle's effect on tamarisk, and the recovery of riparian ecosystems impacted by tamarisk (California Agriculture 2001).

Managerial Control
Some studies indicate that cattle can graze significant amounts of sprout growth (Gary 1960), but in general the plant is poor forage. Flooding thickets for one to two years can be effective at killing most tamarisk plants, but tamarisk occurs in few locations where flooding is ecologically or economically feasible. Promoting competition from fast-growing natives such as willow can be effective because tamarisk is intolerant to shade, though planting natives early is key to competition success.

Chemical Control
Controlling heavy infestations is more effective if the stand of tamarisk is thinned through controlled burns or mechanical removal with heavy equipment prior to treatment with herbicides. Imazapyr, triclopyr, and glyphosate are three of the more commonly used herbicides used to control tamarisk.

In California, the most frequently used technique is to cut the shrub off near the ground and apply triclopyr as either Garlon 4® or Garlon 3A®. This technique usually results in a kill rate of 90 percent or better. Triclopyr, as Pathfinder II®, can also be applied directly to the basal bark of stems less than 4 inches in diameter without cutting the stem, although the bark must be wetted completely around the base of each stem. To kill large individuals, a combination of physical and chemical controls, referred to as the hack and squirt method, or frilling, can be used. A hatchet is used to make a series of downward cuts in the bark around the entire circumference of the tree trunk and then herbicide is immediately applied into the cuts. In order to damage the root system, concentrated herbicide such as 15–20 percent triclopyr or 15–40 percent glyphosate should be applied. Garlon 4® or Pathfinder II® have no timing restrictions, but Garlon 3A® should be applied during the growing season. Resprouts are best controlled if treated with foliar applications of glyphosate or imazapyr in late spring to early fall during good growing conditions. Only Rodeo® has an aquatic registration, making it the legal choice for application over or around water.

Yellow starthistle (*Centaurea solstitialis*)

Any successful strategy for controlling established stands of yellow starthistle requires dramatic reduction or, preferably, elimination of new seed production, multiple years of management, and follow-up treatment or restoration to prevent rapid reestablishment. Prevention of large-scale infestation, therefore, is ideal and best accomplished through spot eradication, which is the least expensive and most effective method of preventing establishment. Effective control using any of the available techniques depends on proper timing and combinations of techniques generally prove more effective than any single treatment. Effective combinations may depend on location or on the objectives and restrictions imposed on land managers.

Physical Control
During dry summer months, tillage practices designed to detach roots from shoots prior to seed production are effective; tillage during or just before rainfall can expose the soil for rapid reinfestation. Mowing can be effective if conducted at a stage where 2 to 5 percent of the seed heads are flowering, and the lowest branches of the plant are above the height of the mower blades. Mowing after this period will not prevent seed production, as many flowerheads will have already produced viable seed. Mowing a second or third time may be necessary to ensure reduced recovery and seed production.

Thermal Control
Prescribed burning can provide effective control if done after native species have dispersed their seeds but before the starthistle has produced viable seeds. Reseeding with native species immediately after a burning treatment may be effective as well, since star thistle seeds will be somewhat depleted from the seed bank. This method can enhance the survival of native forbs and perennial grasses, but can also lead to increased starthistle seedbank if the site is not monitored and retreated.

Biological Control
Six insect species that feed on yellow starthistle have become established in California. The two most effective insects, a weevil (*Eustenopus villosus*) and a fly (*Chaetorellia succinea*), attack yellow starthistle flowerheads, and the larvae utilize the developing seeds as a food source. The insects so far, however, do not appear to be drastically reducing starthistle populations, but success may take a few years until insect numbers increase to sufficient levels. Other insects are being studied for use in controlling starthistle but are not approved for use yet.

Managerial Control
Grazing by sheep, goats, and cattle can be used to reduce yellow starthistle biomass and seed production, but must be done before the plant bolts (generally between May and June) and is most effective if large numbers of animals are used for short durations. However, grazing alone is not guaranteed to kill plants and stop their reproduction, and overgrazing and the attendant soil disturbance are considered prime mechanisms that promote initial star thistle invasion.

Planting yellow starthistle-infested pastures with annual legumes capable of producing viable seed has shown to provide some level of control via plant competition. Depending upon location, subterranean clover (*Trifolium subterraneum*) or rose clover (*T. hirtum*) may be the preferred species. Control of starthistle was enhanced when revegetation was combined with repeated mowing (Whitson et al. 1987).

Chemical Control

Triclopyr, 2,4–D, dicamba, and glyphosate are the primary post-emergence herbicides used for control of starthistle in non-crop areas. With the exception of glyphosate, these herbicides are selective and most effective if applied in late winter or early spring to control seedlings without harming grasses. A one percent solution of glyphosate is the most effective treatment once plants have reached the bolting stage. Application of glyphosate is most effective in May and June, after annual grasses and forbs have senesced but prior to yellow starthistle seed production. Clopyralid (sold as Transline®), a broadleaf-selective herbicide, provides excellent control both pre- and post-emergence if applied at rates between 4–10 ounce of formulated product per acre. This method is the most common chemical treatment used. Excellent control has been achieved when clopyralid was applied between December and April, but earlier applications allowed the establishment of grasses and other forage species.

Water hyacinth (*Eichornia crassipes*)

Prevention is the best way to control water hyacinth introduction to freshwater systems. Prevention includes educating the public about the consequences of disposing unwanted water garden or aquarium plants into natural freshwater systems or by not thoroughly cleaning boats, trailers, and other water sport and fishing equipment before moving the equipment into another freshwater system.

Physical Control

Manual and mechanical methods of control have been largely replaced by chemical methods. Manual methods of removing water hyacinth are appropriate for small ponds and lakes but are labor-intensive and expensive. Removal of the plant must be thorough because remaining, small fragments can resprout. A less expensive method of control is to contain the plants into a small area by placing floating barriers around the infestation. Dredging the plants onto the shore to then be dried and burned is another method of control but it is also expensive.

Biological Control

Three insects have been approved by the USDA for use in controlling water hyacinth in California. These biological agents have been successful in many, but not all, areas. Two weevils, *Neochetina eichhorniae* Warner and *N. bruchi* Hustache, have been used successfully in the southern United States to effectively control hyacinth, while the weevils combined with a fungus (*Cercospora rodmanii* Conway) have produced good results in Florida. In California, only *Neochetina eichhorniae* has established, and its impact on water hyacinth density has been slight.

Chemical Control

Application of glyphosate (formulated as Rodeo®) and copper complexes as foliar sprays can control water hyacinth. Herbicide use in aquatic systems is more highly regulated than in terrestrial systems. Consult your county agricultural agent or a certified herbicide applicator to obtain a current label for the herbicide to determine suitability for a given system and amount of active ingredient to be applied. The California Department of Boating and Waterways (CDBW) has used mechanical, biological, and chemical measures to control the spread of water hyacinth, with chemical herbicides proving to be the most effective method (CDBW 2001). In March 2001, however, the Ninth Circuit Court of Appeals ruled that it is illegal to apply an aquatic herbicide to control aquatic plants such as water hyacinth without first obtaining a National Pollutant Discharge Elimination System permit (MID 2001).

APPENDIX B
Threatened, Endangered, and Sensitive Species in the Merced River Corridor

PLANTS

Four-angled spikerush

Four-angled spikerush (*Eleocharis quadrangulata*) is a perennial herb that is native to California (Hrusa 1998). The species is described as occurring in freshwater-marsh habitats and under natural conditions, it almost always occurs in wetlands (CNPS 1994).

The California Natural Diversity Database identifies one record of four-angled spikerush in the vicinity of the Gustine airport (CDFG 2001).

Delta button-celery

Delta button-celery (*Eryngium racemosum*) generally occurs in seasonally inundated floodplains on clay soils, although it can also grow in sand. Bob Edminster (pers. comm., 1999) indicated that this species is typically found on acidic (around pH of 6) fine clay soils that are leached every year by seasonal flooding.

The California Natural Diversity Database identifies three records of delta button-celery within the nine quadrangles covering lands within the Merced River corridor (CDFG 2001). Two records are along the San Joaquin River, south of the confluence with the Merced River, and one record is in the vicinity of Turlock Lake.

California hibiscus (Rose-mallow)

The California hibiscus (*Hibiscus lasiocarpus* (=*californicus*)) is endemic to California and occurs in freshwater marshes and on moist banks along rivers and streams (Hickman 1993). This species is threatened by riverbank alteration (Hickman 1993).

No records of this species are recorded in the California Natural Diversity Database for Merced, Mariposa, Stanislaus, or Tuolumne counties or for the nine quadrangles covering lands within and adjacent to the Merced River corridor (CDFG 2001), although suitable habitat for the California hibiscus is present along the Merced River corridor.

Northern California black walnut

Northern California black walnut (*Juglans hindsii*) is a tree that is endemic to California (Walker 1992). It is described as occurring in riparian habitats and is equally likely to occur in wetlands or non wetlands. It is ranked by the California Native Plant Society as extremely rare (CNPS 1997).

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

Merced monardella

The Merced monardella (*Monardella leucocephala*) is restricted to extremely sandy subalkaline soils in low-lying areas bordering rivers. Most of the former range of this species was converted to agriculture (Williams et al. 1997). *The Draft Recovery Plan for Upland Species of the San Joaquin Valley, California* (Williams et al. 1997) states that “surveys for Merced monardella must be continued in both historical sites and suitable habitats, especially in years of above-average precipitation” (Williams et al. 1997).

The California Natural Diversity Database identifies five records of Merced monardella in Merced and Stanislaus counties (CDFG 2001, Williams et al. 1997). Most plants were collected in grasslands, but several collections were made in dry-farmed fields. There is one record for the species within the nine quadrangles covering lands within the Merced River corridor, in the vicinity of Delhi.

Sanford’s arrowhead

Sanford’s arrowhead (*Sagittaria sanfordii*) is endemic to California and occurs in slow-running or standing water of sloughs and streams, as well as in ditches and ponds (Hickman 1993). Sanford’s arrowhead is threatened by development (Hickman 1993).

Three extant populations have been recorded in Merced County. No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

Blue skullcap

Blue skullcap (*Scutellaria lateriflora*) is a perennial herb that is native to California (Hrusa 1998). The species is described as occurring under moist conditions in meadow and freshwater-marsh habitats. It usually occurs in wetlands, but occasionally is found in non wetlands (CNPS 1994).

Blue skullcap is ranked by the California Native Plant Society as extremely rare (CNPS 1997). No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

INVERTEBRATES

Valley elderberry longhorn beetle

The valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) (VELB) historically was distributed throughout the Central Valley from Redding (Shasta County) to Bakersfield (Kern County). These beetles depend on elderberry plants (*Sambucus* spp.), which occur within riparian forests of the Central Valley. Mating occurs in late June. Eggs are laid in crevices in elderberry bark and hatch in about 10 days. Larvae bore into the pith of elderberry roots, branches, and trunks for one or two years before they emerge as adults. Larvae feed on tree pith, while adults eat the foliage and possibly the flowers of the plants. Habitat destruction due to the clearing of riparian forests for housing, farms, levees, and fuel represents the greatest threat to this species.

photo/Charles Webber, California Academy of Sciences

The California Natural Diversity Database identifies three records of valley elderberry longhorn beetle within the nine quadrangles covering lands within the Merced River corridor (CDFG 2001). These occurrences were at McConnell State Recreation Area (2 miles northwest of Livingston), Livingston Bridge (Highway 99) across Merced River, and Santa Fe Drive (Road J7), just north of the Merced River.

Molestan blister beetle

Little information is available regarding the ecology and life history of the Molestan blister beetle (*Lytta molesta*). All ten of the type specimens for this species were collected in central California (Selander 1960), and it is believed to inhabit the Central Valley from Contra Costa to Kern and Tulare counties. The Molestan blister beetle belongs to the subgenus *Paralytta*. The host plants for this group include representatives of the Asteraceae, Convolvulaceae, Papaveraceae, Boraginaceae, Campanulaceae, Fabaceae, Liliaceae, Scrophulareaceae, Lamiaceae, and Primulaceae families. Although details are not available on the foraging habits of the Molestan blister beetle, other members of the genus *Lytta* have been observed to feed on flowers and leaves. Because these beetles have seldom been collected, their associated habitat types are virtually unknown. Very few *Lytta* would be expected to be associated with riparian habitats (J. Pinto, pers. comm., 1998).

The California Natural Diversity Database identifies one record of Molestan blister beetle within the nine quadrangles covering lands within the Merced River corridor (CDFG 2001). This occurrence was in the vicinity of Yosemite Lake.

FISH

Kern brook lamprey

The Kern brook lamprey (*Lampetra hubbsi*) is found in the lower reaches of the Merced, Kaweah, Kings, and San Joaquin rivers. It requires silty backwaters located in large rivers. The ammocoetes (larval stage lamprey) are usually found in shallow pools along the edge of run areas; common substrates used by ammocoetes include sand, gravel, and rubble (Moyle et al. 1995). The Kern brook lamprey is impacted by fragmentation of its habitat, and reduction of backwater habitat used by ammocoetes due to channelization (Moyle et al. 1995).

The California Natural Diversity Database identifies one record of Kern brook lamprey within the nine quadrangles covering lands within the Merced River corridor (CDFG 2001). This occurrence was downstream of Merced Falls Dam.

Pacific lamprey

The Pacific lamprey (*Lampetra tridentata*) occurs in most Pacific coast streams from the Santa Ana River (Orange County) north. Large spawning runs, however, are unusual south of Monterey, California.

Pacific lampreys, with the exception of landlocked populations, are anadromous and spend the predatory phase of their adult life in the ocean or estuaries. Little is known of the oceanic life of California populations of Pacific lamprey, except that they parasitize blood and body fluids from a wide variety of larger fishes. This is accomplished by attaching themselves to their host with a round, sucking mouth, and rasping their file-like tongue until the skin is penetrated. Adult migration to spawning grounds takes place at night during the months from April to late July. Often lampreys will migrate for several months before spawning. After hatching, the ammocoetes remain in silt-sand substrate backwaters and eddies for several years and feed on algae and microorganisms (Moffet and Smith 1950).

In the Central Valley, Pacific lamprey has been recorded in the San Joaquin River downstream of Friant Dam and in the Tuolumne River (Moyle 1976, Lee et al. 1980). It is unlikely that they wander far from the mouths of their home spawning streams, as their host fish are most abundant in estuaries and other nearshore areas. No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

River lamprey

The river lamprey (*Lampetra ayresi*) is widely distributed along the western Pacific coast from coastal streams near Juneau, Alaska to San Francisco Bay (Moyle 1976). In California, it is probably most abundant in the Sacramento-San Joaquin River system but has not been observed or collected in large numbers (Moyle et al. 1989).

Little is known of the life history of California populations of river lamprey, but it is presumably similar to that of British Columbia populations (Moyle et al. 1989). In British Columbia, the adults migrate from the ocean to small tributary streams in the fall, where they dig depressions in sand-gravel riffles for spawning (Wydoski and Whitney 1979, Beamish and Youson 1987). Spawning takes place during the winter, and adults die soon after spawning. The ammocoetes remain in silt-sand substrate backwaters and eddies for several years and feed on algae and microorganisms (Wydoski and Whitney 1979). Metamorphosis begins in July and is completed in April the following year, when the esophagus opens (Beamish and Youson 1987). This extended metamorphosis differs from other lamprey species. Just prior to the completion of metamorphosis, the ammocoetes congregate immediately upriver of salt water and enter the ocean from May to July (Beamish and Youson 1987). In the ocean they are obligate parasites, and typically kill their host (mainly mid-sized salmonids) in the process of feeding.

Insufficient information is currently available to determine population trends of river lamprey. Moyle et al. (1989) presume that this species is widely distributed in northern California coastal areas. No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

Hardhead

The hardhead (*Mylopharodon conocephalus*) is a freshwater fish native to California, with a distribution limited to the Sacramento-San Joaquin river system and the Russian River system (Moyle 1976). Juvenile hardhead inhabit both shallow regions and deeper lakes and reservoirs, and may be also be found in various temperature gradients. Spawning occurs as early as May and June in sand, gravel, and rocky areas of pools and side pools. Juvenile hardhead feed on plankton, insects, and small snails (Reeves 1964). They also take filamentous algae in the intermittent pools of upper San Joaquin River, particularly in the fall months.

Moyle and Nichols (1973) have reported that the overall population of hardhead has been declining rapidly in their original ranges. The California Natural Diversity Database identifies one record of hardhead within the nine quadrangles covering lands within the Merced River corridor (CDFG 2001). This occurrence was in the Merced River at river mile 42.0.

Central Valley steelhead

Steelhead (*Oncorhynchus mykiss*) is the anadromous form of rainbow trout. Steelhead exhibit one of the most complex life histories of any Pacific salmonid species. Steelhead typically migrate to the ocean after spending 1–4 (usually 2) years in fresh water and may remain at sea for 1–3 years before returning to spawn in freshwater. Unlike most other salmonid species, steelhead are iteroparous, or capable of returning to spawn more than once before dying. Most individuals, however, spawn only once. Spawning typically occurs from December through June, and redds (nests) are constructed in gravel substrate. The eggs incubate in the gravels and hatch as alevins (larval fish that are nourished by a yolk sac), which remain in the gravel for several weeks, before emerging as free-swimming fry.

Few detailed studies have been conducted regarding the interrelationships between resident rainbow trout and anadromous steelhead populations (NMFS 1996). As a result of this uncertainty, the National Marine Fisheries Service, which enforces Endangered Species Act protection of this species, currently considers rainbow trout that are not physically isolated from the ocean to be steelhead (C. Mobley, pers. comm., 1998). Taking this approach, steelhead have the potential to occur in the Merced River.

Fall chinook salmon

The San Joaquin River system once supported large runs of both spring and fall chinook salmon. Adult spring chinook salmon entered the system during periods of high spring snowmelt, held over in deep pools during the summer, then spawned in the upper reaches of the San Joaquin River and its major tributaries–the Stanislaus, Tuolumne, and Merced rivers – in the early fall. Dam construction, which eliminated access to upstream spawning and holding areas, extirpated the spring run from the basin by the late 1940s (Skinner 1962).

Fall chinook salmon are currently the most abundant race of salmon in California (Mills et al. 1997). In the San Joaquin Basin, fall chinook historically spawned in the mainstem San Joaquin River upstream of the Merced River confluence and in the mainstem channels of the major tributaries. Dam construction and water diversion dewatered much of the mainstem San Joaquin River, limiting fall chinook to the three major tributaries where they spawn and rear downstream of mainstem dams.

Chinook salmon are the largest of Pacific salmon species, reaching weights of up to 99 pounds, although most adults weigh from 10 to 40 pounds (Healey 1991, Meehan and Bjornn 1991, Kostow 1995). In the San Joaquin system, adult fall chinook typically enter spawning streams from October through December, with spawning activity peaking in early to mid-November. The duration of incubation varies depending on water temperature but generally extends over a two to three month period. After hatching, alevins remain in the gravel for two to three weeks, absorbing most of their yolk sac before emerging into the water column. Upon emergence, fry swim or are displaced downstream (Healey 1991). In general, fry (length <50 mm) and juveniles (length >50 mm) outmigrate from the spawning areas between January and May. Outmigration of larger juveniles generally occurs from April though June with smolts entering the ocean between April and July (Leet et al 1992). Hatton and Clarke (1942) trapped emigrating fry and juveniles in fyke nets at Mossdale from 1939–1941. Their data and recent studies throughout the Central Valley suggest bimodal peaks in emigration during wet years, with one peak occurring in February and one in April. A small number of juveniles may remain in freshwater over the summer and outmigrate as yearlings.

Sacramento splittail

The Sacramento splittail (*Pogonichthys macrolepidotus*) is endemic to the California Central Valley and the Sacramento-San Joaquin delta and estuary. The species' historical range included much of the San Joaquin Valley. Although primarily a freshwater species, they are tolerant of moderate salinities (Moyle et al. 1995). Sacramento splittails feed extensively on opossum shrimp (*Neomysis mercedis*). Splittail spawn from March through April in the upper reaches of large streams. The adults tend to congregate for two to three months before spawning in areas of inundated floodplain vegetation. After spawning, they move into the lower Delta, where they remain until the fall rains begin. Larvae move downstream during May, and the juvenile splittail spend their first year of life in the lower Delta and lower reaches of streams. The range of this California native species has been reduced by 35 to 60 percent due to dams, water diversions, and agriculture. Introduced fish and invertebrate species may also decrease prey abundance and increase predation pressures on this species.

AMPHIBIANS

California tiger salamander

The California tiger salamander (*Ambystoma californiense*) is restricted to California, ranging from Sonoma County and the Colusa-Yolo county line in the Central Valley south to Tulare County. This species can be found up to elevations of approximately 3,000 feet (915 m) (Jennings and Hayes 1994).


photo/Gerald and Buff Corsi, California Academy of Sciences

This species breeds in long-lasting rain pools or vernal pools that usually dry up during the hot summer months. Pools used by the California tiger salamander are primarily located in grasslands and the lowest valley-foothill hardwood habitat regions of central and northern California (Jennings and Hayes 1994). The vegetation surrounding breeding ponds may vary, but annual grassland is considered to be one of the most suitable habitat types (CDFG 1996). California tiger salamander can make local migrations of up to 3,000 feet (915 m) from subterranean summer refuge habitat (usually small mammal burrows) to breeding sites.

The habitat for the California tiger salamander has been fragmented by the destruction of vernal pools and introduction of fishes (including mosquitofish [*Gambusia affinis*]) and crayfish into breeding ponds (Jennings and Hayes 1994). Breeding is very uncommon in ponds and pools where fish or bullfrogs (*Rana catesbeiana*) are present. Ground squirrel eradication programs have reduced or eliminated summer habitat (burrows) in some areas.

It is considered to occur in the northern corner of Merced County based on verified sightings and museum records (Jennings and Hayes 1994). There are 14 California Natural Diversity Database records of California tiger salamanders within the nine quadrangles covering lands within and adjacent to the Merced River corridor. These occurrences were north of Snelling, in the vicinities of Yosemite and Turlock lakes, and along the San Joaquin River, several miles south of the confluence with Merced River.

Western spadefoot toad

The western spadefoot (*Scaphiopus hammondii*) was once believed to range from California to western Texas and Oklahoma. However, researchers have since identified a number of differences that resulted in reclassification of the California populations as a unique species. Currently, western spadefoot in California are found in the Central Valley and Coast Ranges from Shasta County south into northwestern Baja California.

The western spadefoot is almost completely terrestrial, entering water only to breed.

Breeding occurs in temporary rain pools or sometimes in pools in ephemeral stream courses that lack predators such as fish and crayfish (Jennings and Hayes 1994). The species spends the summer months in small mammal burrows, primarily in grassland habitats and secondarily in valley-foothill hardwood woodlands. The western spadefoot feeds on a variety of insects. The western spadefoot has suffered drastic population reductions due to land conversion and placement of mosquitofish and other introduced species into ponds and pools (Jennings and Hayes 1994).

The California Natural Diversity Database identifies three records of western spadefoot within the nine quadrangles covering lands within the Merced River corridor. These occurrences were in the vicinity of Turlock Lake and along the San Joaquin River, south of the confluence with Merced River.

California red-legged frog

The California red-legged frog (*Rana aurora draytonii*) is one of two subspecies of the red-legged frog that occur along the Pacific Coast. A highly aquatic species invariably associated with water, the California red-legged frog inhabits still or slow water in streams, marshes, ponds, reservoirs, and canals (Stebbins 1951). Like all frogs, tadpoles are herbivorous and switch to carnivory after metamorphosis (Zeiner et al. 1988). The California red-legged frog preys on terrestrial and aquatic insects, crustaceans and mollusks, sometimes taking small fish and tadpoles as well. This species prefers shorelines with dense, overhanging vegetation such as willow, and deep, still pools. On occasion, individuals may be found in less optimal habitat. California red-legged frogs utilize small mammal burrows and moist leaf litter up to 85 feet from water in dense riparian vegetation for estivation. Permanent, deep pools are required for reproduction and larval development (Zeiner et al. 1988). Rain or moist conditions may be necessary for dispersal.

The subspecies occurs west of the Sierra-Cascade crest and along the Coast Ranges for the length of the state of California (Stebbins 1985). The California subspecies historically ranged from the vicinity of Point Reyes National Seashore (Marin County) along the coast and from the vicinity of Redding (Shasta County) inland south to northwestern Baja California.

The California red-legged frog, once considered a culinary delicacy, was harvested to the brink of extinction in the late 1800s. Some remaining populations are highly restricted and consist of small numbers of individuals (Jennings et al. 1992). Human activities that result in habitat destruction and the introduction of exotic competitors and predators may have a negative effect on populations (Moyle 1973). The species population is believed to be declining.

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor. According to Jennings and Hayes (1994), there are several records for the California red-legged frog from western Stanislaus County and western Tuolumne County.

REPTILES

Western pond turtle

The western pond turtle (*Clemmys marmorata*) is the only freshwater turtle native to most of the west coast of temperate North America. It occurs from sea level to 6,000 feet (1,829 m) from British Columbia south to northwestern Baja California, principally west of the Sierra-Cascades crest. Two subspecies are present in California, the southwestern pond turtle (*C. m. pallida*) and the northwestern pond turtle (*C. m. marmorata*). The San Joaquin Valley is within an intergrade zone for the two subspecies (Stebbins 1985). The western pond turtle inhabits a wide range of fresh or brackish water habitats including ponds, lakes, slow-moving streams, ditches, or pools remaining from drying of intermittent streams. Although adults are habitat generalists, hatchlings and juveniles require very specialized habitat for survival through their first few years. Habitats preferred by juveniles are relatively scarce and subject to disturbance (Jennings et al. 1992). Prime habitat for early life stages includes low flow regions and backwater areas of rivers. Deep, still water with abundant emergent woody debris, overhanging vegetation, and rock outcrops is optimal for older life stages as basking and thermoregulation habitat. Egg-laying sites vary from sandy shoreline to forest soil types. Little is known about overwintering habitat, but individuals have been recorded overwintering on land close to their summer water source, at sites up to 1,000 feet (300 m) away from water, and underwater (Rathbun et al. 1992, 1993; Jennings and Hayes 1994). In regions of California with cold winters, western pond turtles take refuge in aestivation or overwintering sites in October or November. Western pond turtles are active year-round in warmer coastal sites (Jennings and Hayes 1994). Breeding activity peaks from June to July, when females begin to search for suitable nesting sites up to 325 feet (99 m) away from the watercourse (Nussbaum 1983).

Low fecundity, low hatchling and juvenile survivorship, high adult survivorship, and potentially long lifespan are characteristic of this species (Jennings et al. 1992). Potential competitive exclusion by introduced turtle species and predation on hatchlings by introduced bullfrogs, largemouth bass, and mesopredators such as raccoons are increasing threats to this species. Off-road vehicle use of streambeds and habitat destruction due to sedimentation are potential threats as well. Reasons for the decline in this species are numerous and complex; however, alteration of aquatic and adjacent upland habitats by logging and dam building are also causes for concern (Jennings et al. 1992).

Jennings and Hayes (1994) report that the western pond turtle has been documented over a half-dozen times across most portions of Stanislaus County. The California Natural Diversity Database identifies four records of western pond turtle within the nine quadrangles covering lands within the Merced River corridor. These occurrences were in the vicinity of river mile 45.2, approximately two miles southwest of Snelling, and near river mile 43.0.

Giant garter snake

The giant garter snake (*Thamnophis gigas*) is the largest member of its genus and one of the most aquatic of the garter snakes, feeding on small fish, tadpoles, and frogs (Fisher et al. 1994). Hibernation occurs from late October to mid- or late March in the abandoned burrows of small mammals located above prevailing flood elevations (Fisher et al. 1994). Breeding occurs in March and April (Hansen and Hansen 1990, as cited in USFWS 1993). Females give birth to live young from July through September, with litter size varying between 10 and 46 young (Fisher et al. 1994). Age of sexual maturity averages 3 years for males and 5 years for females (G. Hansen, pers. comm., 1991, as cited in USFWS 1993).

According to Fitch (1940, as cited in USFWS 1993), the historical range of the giant garter snake extended from the vicinity of Sacramento and Contra Costa Counties south to Buena Vista Lake, near Bakersfield in Kern County. The giant garter snake was apparently extirpated from the southernmost portion of its range by the 1940s to 1950s due to loss of wetlands to agriculture and other land uses (Hansen and Brode 1980, as cited in USFWS 1993).

According to Fisher et al. (1994), the giant garter snake currently is found from Butte County south to the Mendota Wildlife Area, 10 miles west of Fresno. The California Natural Diversity Database identifies one record of giant garter snake within the nine quadrangles covering lands within and adjacent to the Merced River corridor. This occurrence was south of the San Joaquin River confluence with the Merced River.

BIRDS

Great blue heron

The great blue heron (*Ardea herodias*) breeds over much of North America, including the Caribbean. Only its rookeries are tracked under the "California Special Animal" designation. Great blue herons are sometimes solitary nesters, but often occur in mixed colonies with great egrets and other birds. This species usually nests near brackish or freshwater marshes, swamps, rivers, or lakes, selecting trees, shrubs, or rock ledges for nest sites. Large trees or snags in secluded locations are preferred nesting sites, but it will occasionally nest on the ground. The species is monogamous, and courtship and nesting activities begin in February. Clutch size averages three to four eggs but can range from one to five eggs. Young reportedly reach maturity at two years of age (Pratt 1970).

This species is susceptible to biological concentration of pesticides in wetland habitats (Jackman and Scott 1975). Populations are also jeopardized by the continuing loss of wetlands and by human disturbance of nesting sites (Ehrlich et al. 1992). Despite persistent threats, populations appear to be rebounding in habitats of the eastern United States. California populations, however, may not be following this trend (Ehrlich et al. 1992).

The California Natural Diversity Database identifies one record of great blue heron along the San Joaquin River, south of the confluence with the Merced River.

Great egret

Great egrets (*Casmerodius albus*) are widely distributed across North America and throughout the length of California. Only its rookeries are covered under the "California Special Animal" designation.

This species nests in large trees, often choosing eucalyptus, redwood, or Monterey pine, but forages in aquatic habitats such as streams, marshes, wet meadows, shallow lakes, and estuaries. It often nests in mixed colonies with great blue herons. The great egret is a monogamous, colonial nester, breeding March to July (Maxwell and Kale 1977, Palmer 1962).

Great egret populations were greatly reduced by plume hunters in the late nineteenth century but appear to be recovering. Contemporary threats include loss of habitat due to wetland conversion and human disturbance to nesting sites (Cogswell 1977). This species is recovering and is expanding in some parts of its range (National Geographic Society 1983).

The California Natural Diversity Database identifies one record of great egret along the San Joaquin River, south of the confluence with the Merced River.

Snowy egret

The snowy egret (*Egretta thula*) occurs throughout North America and only its rookeries are covered under the "California Special Animal" designation. Nesting usually occurs in colonies, and nests are placed low in trees, shrubs, or in dense marshes near suitable foraging habitat (Zeiner et al. 1990a). Snowy egrets feed in a variety of fresh and brackish habitats, where they catch small fish, crustaceans, and a variety of insects. In California, it is a resident species with a widespread distribution, though known nesting areas in the Central Valley are rare.

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

White-faced ibis

The white-faced ibis (*Plegadis chihi*) was formerly common in the San Joaquin Valley but is now rare and found mainly near Los Banos during wintering from August to April. This species feeds in fresh water emergent wetlands, shallow lacustrine waters, wet meadows, and irrigated or flooded pastures and croplands. It eats earthworms, insects, crustaceans, amphibians, small fishes, and invertebrates. White-faced ibis nest in dense, fresh emergent wetland where they build nests of dead tules or cattails amidst tall marsh plants or on mounds of vegetation.

White-faced ibis populations have declined and no longer breed regularly anywhere in California. In the Central Valley, population decline is believed to be due to destruction of marshes used for nesting (Remsen 1978). Pesticides have caused declines in numbers elsewhere in the species' range (Terres 1980).

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

Black-crowned night heron

The black-crowned night heron (*Nycticorax nycticorax*) is found throughout most regions of California where appropriate habitat is present, except at very high elevations. Only its rookeries are covered under the "California Special Animal" designation.


photo/Gerald and Buff Corsi, California Academy of Sciences

This nocturnal piscivore forages in a wide variety of marine and freshwater habitats. Black-crowned night herons require daytime roosts in willows or other trees that are relatively undisturbed by human activities. They nest in the dense foliage of trees, marshes, shrubbery, or vines, usually close to water (Zeiner et al. 1990a). Black-crowned night herons are impacted by human disturbance at roosting and nesting sites as well as reduction of wetland habitat (Zeiner et al. 1990a).

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor or for Merced, Mariposa, Stanislaus, and Tuolumne counties.

Aleutian Canada goose

The Aleutian Canada goose (*Branta canadensis leucopareia*) breeds in the Aleutian Islands of Alaska and occurs in California only as a winter migrant between September and April. The members of this subspecies that breed in the western Aleutian Islands follow a migration route that takes them along California's north coast. A segment of the population remains through the winter near Crescent City (Del Norte County), while the majority of the population continues south to overwintering sites in Colusa County and the San Joaquin Valley (Palmer 1976, Garrett et al. 1994). In spring, virtually all of the California overwintering population moves to a staging area at the Castle Rock National Wildlife Refuge near Crescent City (Small 1994; USFWS 1978, 1979; Garrett et al. 1994).

The diet of the Aleutian Canada goose is similar to that of other Canada geese and includes a wide variety of marsh vegetation, algae, seeds of grass and sedges, grain (especially in the winter), and berries. Insects and other terrestrial invertebrates, crustaceans, and mollusks are also taken (Ehrlich et al. 1992). On their wintering grounds, these birds feed on grain remaining in the fields after harvest and graze in pasture lands and winter wheat fields (Zeiner et al. 1990a).

The Aleutian Canada goose was proposed for delisting by the USFWS in 1999. A final decision on its delisting is expected in 2000. It is believed that numbers have increased from 400 in 1972 to more than 30,000 currently, preliminary due to the elimination of arctic foxes that were introduced to nesting islands in the 1830s.

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

Short-eared owl

The short-eared owl (*Asio flammeus*), currently occurs primarily in the Central Valley, southwestern Sierra Nevada foothills, and southern desert region (Zeiner et al. 1990a). Breeding occurs from early March through July. Nests are built in depressions in dry ground, concealed by vegetation, and are lined with grasses, sticks and feathers. Eggs are laid in April and May, and clutch size is usually 5-7 eggs. The species inhabits open areas, such as grasslands, prairies, dunes, irrigated lands, and emergent wetlands. This species preys on voles and other small mammals, as well as birds, reptiles, amphibians and anthropods.

Short-eared owl populations have declined in recent decades throughout most of their range due to destruction and fragmentation of grassland and wetland habitats (Remsen 1978). No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

White-tailed kite

The white-tailed kite (*Elanus leucurus*) is a resident of coastal and valley lowlands west of the Sierra Nevada throughout the year. This raptor is generally monogamous and breeds from February to October. It nests in loosely piled sticks built near the top of dense oak or other tree stands (Dixon et al. 1957). Mating behavior peaks from May to August, when a single clutch of four to eight eggs is laid. This species preys on voles and other small mammals, as well as birds, insects, and reptiles. They often roost communally in winter (up to 100 or more birds) but are usually solitary hunters (Ehrlich et al. 1988). Preferred foraging sites include wetlands and grasslands. Prime habitat includes herbaceous lowlands with limited tree growth and abundant small mammal prey. Dense or open groves of trees are required for perching and nesting.

Rapid urbanization of agricultural lands in southern California resulted in declines in white-tailed kite populations in the 1980s (Small 1994). There is evidence of a recent upswing in the California population of this species, possibly due to increased habitat for microtine rodents (Small 1994). No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

Bald eagle

The bald eagle (*Haliaeetus leucocephalus*) occurs across North America, breeding in most of central and southern Canada south to the Great Lakes along the Atlantic and Gulf coasts, and from Alaska to Baja California along the Pacific Coast. Breeding populations were formerly distributed throughout northern California and south to Mexico along the Pacific Coast. Nesting of this species in California is now primarily restricted to Butte, Lassen, Lake, Trinity, Modoc, Plumas, Siskiyou, and Shasta counties (Zeiner et al. 1990a). Bald eagles winter throughout most of California, with large concentrations in the Klamath Basin (Zeiner et al. 1990a).

Bald eagles require large bodies of water or free-flowing rivers for foraging. Fish are plucked from the water by birds diving from the air or adjacent perches, or are stolen from other birds such as osprey. Open, easily approached perches and feeding areas are preferred. High snags, trees, and open rocky slopes provide hunting perches, while large, old-growth, or dominant live trees provide nesting sites. Very large trees in stands of approximately 40 percent canopy cover are preferred for nesting. Nest trees are usually located close to a permanent body of water. Bald eagles are easily disturbed during nesting and require areas free of human activities for successful reproduction.

The bald eagle is highly vulnerable to DDT-induced eggshell thinning. Human activities such as logging and recreation have resulted in loss of suitable nesting sites and nest abandonment (Thelander 1973). The breeding population of this species is increasing, and the wintering population appears to be stable, if not increasing (CDFG 1992). In summer 1999, the USFWS proposed to delist this species.

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor, although the species has been documented on Dry Creek at Kelsey Reservoir (J. Kelsey, pers. comm., 2001).

Northern harrier

The northern harrier (*Circus cyaneus*) is a fairly common winter visitor and formerly nested throughout California. The species occurs throughout California, although the breeding population now appears to be restricted to the northern Central Valley, Klamath Basin, and Great Basin. It rarely breeds along the north coast area, and numbers of breeding pairs have been reduced throughout the San Joaquin Valley. Only nest sites of the species are covered under the "California Species of Special Concern" designation.

This highly territorial species breeds from April to September, with peak activity occurring in June and July. Harriers nest on the ground in shrubby vegetation, usually along the edge of marshes (Brown and Amadon 1968). Nests are constructed of large, loosely mounded sticks in wet areas or a small cup of woven grasses at drier sites. Females lay a single clutch averaging 5 eggs. Males provide food for females during incubation and until young are fledged at 53 days (Craighead and Craighead 1956). The pair and their juveniles may roost communally until the following spring. The northern harrier feeds mostly on voles and other small mammals, birds, frogs, reptiles, and crustaceans; it will occasionally take fish as well. Preferred habitats include flat, hummocky open areas with tall grasses, shrubs, and aquatic edges (Zeiner et al. 1990a, Remsen 1978).

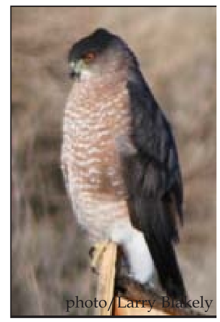
Destruction of wetlands and annual grasslands throughout California have led to a decline in northern harrier populations. In addition, grazing and agricultural practices, including plowing and burning of nesting areas during early stages of the nesting season, have contributed to the decline of this ground-nesting species (Remsen 1978).

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

Cooper's hawk

The Cooper's hawk (*Accipter cooperii*) winters throughout most of the United States and south to Guatemala and Honduras (Johnsgard 1990). Only nest sites are covered under the "California Species of Special Concern" designation. The species' nesting distribution extends from southern Canada to the southern United States. In California, Cooper's hawks breed throughout most of the state, with the exception of the Sacramento Valley and higher elevation portions of the Sierra Nevada.

Breeding occurs from March through August, with peak activity occurring in May to July. Nests consist of a dense stick platform either in the crotch of a deciduous tree or in the lower horizontal branches of conifers. Nest height is usually at least 10-80 feet above the ground. Cooper's hawks feed mostly on birds but occasionally will take mammals, frogs, and reptiles. This species uses a variety of woodland and brushy habitat edges for cover and perching during foraging and prefers patchily distributed forest stands rather than contiguous forest (Johnsgard 1990). Preferred habitats include oak woodland, riparian deciduous, mixed conifer, and any other woodland type with abundant edge habitat (Remsen 1978). Asay (1987) found that active nests were most likely to be found in oak woodlands.


photo/Larry Blakely

Destruction of riparian areas and mixed conifer and deciduous forests throughout California have caused declines in Cooper's hawk populations (Remsen 1978). In addition, grazing and agricultural conversion affecting small bird populations have contributed to the decline of the species' prey base. Take of nestlings for falconry has also been implicated in population decreases (Remsen 1978).

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

Sharp-shinned hawk

The sharp-shinned hawk (*Accipiter striatus*) is a common migrant and winter resident of California (Zeiner et al. 1990a). This species prefers, although it is not restricted to, riparian habitats. It breeds in ponderosa pine, black oak, riparian deciduous, mixed conifer, and Jeffrey pine habitats. Sharp-shinned hawks usually nest in dense stands of confers which are cool, moist, well shaded, and near water. Breeding peaks in late May to July. This species preys on small birds, as well as small mammals, insects, reptiles, and amphibians.

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

Prairie falcon

The prairie falcon (*Falco mexicanus*) is an uncommon permanent resident and migrant in California, ranging from southeastern deserts northwest along the inner coast ranges and Sierra Nevada (Zeiner et al. 1990a). The species is primarily associated with perennial grasslands, savannahs, rangeland, some agricultural fields, and desert scrub areas. Prairie falcons use open terrain for foraging small mammals, birds, and reptiles, and nesting were there are canyons, cliffs, escarpments, or rock outcrops. This species is vulnerable to DDT poisoning and predation by mammals and predatory birds.

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

Swainson's hawk

The Swainson's hawk (*Buteo swainsoni*) historically nested throughout the lowlands of California. Migrants are still seen over much of its historical range, but most nesting is confined to parts of the Central Valley and Great Basin. Nesting occurs primarily in the southern Sacramento Valley and northern San Joaquin Valley regions, but moderate numbers of Swainson's hawks also nest in the Klamath Valley area and in northeastern California. Only nest sites are considered under the "State Threatened" designation. Individuals breeding in California winter in South America as far south as Argentina.

Breeding requires large open grasslands with abundant prey in association with suitable nest trees. Suitable nest sites may include riparian forests, lone trees, groves of oaks and other species in agricultural fields, and mature roadside trees. The diet of Swainson's hawks during the breeding season is based largely on voles, though a variety of birds and insects are also taken. Suitable foraging habitat includes native grasslands or lightly grazed pastures, alfalfa and other hay crops, and certain grain and row crop lands. Unsuitable foraging habitat includes row crops in which prey are scarce, such as vineyards, orchards, rice, corn, and cotton. Over 85 percent of the Swainson's hawk territories in the Central Valley are in riparian systems adjacent to suitable foraging habitat (CDFG 1992).


photo/USFWS

Swainson's hawks are very sensitive to disturbances near nest sites. A trend toward planting crops unsuitable for Swainson's hawk foraging and urban expansion into agricultural and grassland areas represent the major threats to this species' breeding grounds (CDFG 1992). Populations of this species are declining statewide (CDFG 1992). The largest threat to Swainson's hawks may be the impact of pesticides used on wintering grounds in South America.

The California Natural Diversity Database identifies three records of Swainson's hawk within the nine quadrangles covering lands within the Merced River corridor. Occurrences were recorded on the Merced River near river mile 14 and near Hagaman County Park, and at the confluence of the Merced and San Joaquin rivers.

Ferruginous hawk

The ferruginous hawk (*Buteo regalis*) is an uncommon winter resident and migrant in the Modoc Plateau, Central Valley, and Coast Ranges of California, as well as along the coast. It is frequently seen in grasslands and agricultural areas in southwestern California and occurs infrequently in the northeast portion of the state (Small 1994). This species is not known to breed in California, although appropriate habitat is available.

In Oregon and north to Canada, this species nests on low cliffs, buttes, trees and other elevated structures, and occasionally nests on the ground. The ferruginous hawk forages in a variety of open areas, feeding on rabbits, ground squirrels, and mice. It frequents open grasslands, agricultural lands, sagebrush flats, desert scrub, low foothills, and fringes of pinyon-juniper habitats and roosts in open areas, typically in a lone tree or utility pole (Zeiner et al. 1990a). The wintering population may be declining in California (Remsen 1978).

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

Golden eagle

The golden eagle (*Aquila chrysaetos*) occurs throughout California, although it is rare (Small 1994). Golden eagles are somewhat non-migratory, although individuals may move to lower elevations in winter or to higher elevations for breeding. Sexually immature golden eagles often disperse during fall and winter. Breeding occurs from late January to August, peaking in March through July.

The golden eagle usually preys on mammals, such as jackrabbits and ground squirrels, although these birds will opportunistically take large birds, reptiles, insects, and carrion (Ehrlich et al. 1992). For nesting, golden eagles require steep cliffs or medium to tall trees in open woodland. Preferred nesting territories include open country for hunting or scavenging, such as open woodlands and oak savannahs, grasslands, farms, ranches, chaparral, sagebrush flats, desert edge, montane valleys, and occasionally alpine tundra. These birds generally avoid dense coastal and montane coniferous forests (Small 1994).

Threats to golden eagles are varied, but are largely attributable to habitat destruction and fragmentation (Ehrlich et al. 1992). Shooting by ranchers, power line electrocution, and poisons intended for coyotes also represent serious threats (Ehrlich et al. 1992).

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

Western yellow-billed cuckoo

The yellow-billed cuckoo (*Coccyzus americanus*) ranges across most of the U.S. and northern Mexico. The western subspecies of the yellow-billed cuckoo (*Coccyzus americanus occidentalis*) historically nested from British Columbia south to Mexico, but it has been extirpated from large portions of its former habitat. Its current distribution is limited to scattered locations in California and along the Colorado River.

This species forages primarily on grasshoppers, cicadas, caterpillars and other insects, which it gleans from foliage, and occasionally on small vertebrates and fruits (Bent 1940, Preble 1957). It is monogamous, with both sexes sharing in incubation of eggs and feeding of young during mid-June to late July, and it nests in extremely dense willows, cottonwood or occasionally mesquite vegetation (Hamilton and Hamilton 1965). Densely foliated, deciduous trees and shrubs, particularly willows, with a dense understory formed by blackberry, nettles and/or wild grapes are required for roosting, nesting and foraging. River bottoms and other mesic habitats, including valley foothill and desert riparian sites are necessary for breeding.

The yellow-billed cuckoo's population has been severely reduced by loss of riparian habitats. Grazing, cutting of streamside vegetation, and water diversion projects have also impacted habitat for this species. In addition, pesticide use has resulted in eggshell thinning and reproductive failure (Laymon and Halterman 1987).

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

Western burrowing owl

The burrowing owl (*Speotyto cunicularia*) is found from southwestern Canada through the western United States and in the southern tip of Florida (Peterson 1990). All burrowing owls in California belong to the subspecies *Speotyto cunicularia hypugea*, or the western burrowing owl (Grinnell and Miller 1944). In California, the western burrowing owl is widely distributed in appropriate habitats throughout the lowlands of the state but is rare along the coast north of Marin County and extremely rare east of the Sierra Nevada crest (Small 1994). The species was formerly common in central and southern California coastal habitats, smaller interior valleys, and the Central Valley, but urbanization and agriculture have eliminated it from many parts of its historical range (Small 1994). Only the burrows of the species are covered under the "California Species of Special Concern" designation, but the birds are often associated with burrows throughout the year.

The burrowing owl is found in a variety of habitats, including annual and perennial grasslands, deserts, and shrublands characterized by low-growing vegetation (Zarn 1974). Suitable burrowing owl habitat may also include open shrub stages of pinyon-juniper and ponderosa pine habitats (Zeiner et al. 1990a) if the canopy covers less than 30 percent of the ground surface (California Burrowing Owl Consortium 1993). Burrows are the essential component of the species' habitat. Owls typically use burrows made by fossorial mammals, such as ground squirrels, but they may also use human-made structures, such as cement culverts, debris piles, or openings beneath cement or asphalt (California Burrowing Owl Consortium 1993). They may also dig their own burrows in soft soil (Zeiner et al. 1990a).

Conversion of grassland to agriculture, other habitat destruction, and poisoning of ground squirrels have contributed to the reduction in numbers in recent decades (Grinnell and Miller 1944, Zarn 1974, Remsen 1978). Census figures from 1991 burrowing owl surveys indicated a decreasing number of breeding owls in the outer coast, San Francisco Bay Area, and Central Valley regions of California (DeSante et al. 1992).

The California Natural Diversity Database identifies three records of western burrowing owl within the nine quadrangles covering lands within the Merced River corridor. Occurrences were recorded in the vicinities of Kelsey Reservoir and Yosemite Lake, and three miles north-east of Snelling.

Loggerhead shrike

The loggerhead shrike (*Lanius ludovicianus*) breeds throughout most of North America from central Canada south to southern Mexico (Ehrlich et al. 1992). The wintering range for this species overlaps with the southern portions of its breeding range. This species is a widespread resident and winter visitor in lowlands and foothills throughout California (Small 1994), but is absent from heavily forested high mountains, higher portions of the desert ranges, and the heavily timbered northwestern area of the state.

Loggerhead shrikes eat mostly large insects but may also take birds, mammals, amphibians, reptiles, fish, carrion, and invertebrates (CDFG 1992). This species searches for prey from a perch at least two feet above the ground (Grinnell and Miller 1944) or higher (Zeiner et al. 1990a) and frequently skewers prey on thorns, sharp twigs, or wire barbs, either for immediate consumption or as a cache for later feeding (Zeiner et al. 1990a, Ehrlich et al. 1992). It can also take aerial insects on the wing (Zeiner et. al 1990a). The loggerhead shrike is territorial, with territories averaging 18.7 acres (Miller 1931) that include lookout perches, feeding areas, and a roost site (Zeiner et al. 1990a). Shrikes are monogamous and build their well-concealed nests on stable branches in densely foliated shrubs or trees from 1 to 50 feet above the ground (Zeiner et al. 1990a, Miller 1931, Bent 1950). Loggerhead shrikes prefer open country for hunting, with perches for scanning for prey and fairly dense shrubs and brush for nesting (Small 1994).

A number of factors, including habitat destruction and degradation, pesticide contamination, collisions with automobiles (Ehrlich et al. 1992), and magpie predation on eggs and nestlings (Zeiner et al. 1990a), may have detrimental effects on this species. There is, however, little agreement among biologists concerning the causes of the observed population declines in some parts of the range of this species (Ehrlich et al. 1992).

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

Bell's sage sparrow

Bell's sage sparrow (*Amphispiza belli belli*) is a common to uncommon resident and summer visitor in California (Zeiner et al. 1990a). The species frequents low, fairly dense stands of shrubs, breeding in dense chaparral and desert scrub habitats and foraging on the ground beneath and between shrubs. Bell's sage sparrows breed from late March to mid-August and build their nests of dry twigs, herb stems, bark, and grass. The species feeds mostly on insects, spiders, and seeds.

Destruction and fragmentation of chaparral and desert scrub habitat has significantly reduced the original range of this species (Lovio 1999). No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

California yellow warbler

The California yellow warbler (*Dendroica petechia brewsteri*) is an uncommon to locally common summer resident in the northern part of California and a locally common summer resident in the southern part of the state. Historically, this species was locally common throughout the entire northern portion of California (from the north coast to the Nevada border), the Coast Ranges (from Oregon to the Mexico border), the Central Valley, the western foothills of the Cascade-Sierra Nevada ranges, the eastern slope of the Sierra Nevada, and the foothills and valleys of the Transverse and Peninsular ranges. Currently, yellow warblers are much reduced and more locally distributed within this broad range (Small 1994). Only the nesting sites of this species are covered under the "California Species of Special Concern" designation.

Yellow warblers feed mainly on insects and spiders and a few berries (Bent 1953, Ehrlich et al. 1988). Breeding occurs from mid-April through early August, with peak activity occurring in June (Zeiner et al. 1990a). Warbler territories often include tall trees for singing and foraging and a heavy brush understory for nesting (Ficken and Ficken 1966). In summer, this species occupies riparian deciduous habitats consisting of cottonwoods, willows, alders, and other small trees and shrubs typical of low, open-canopy riparian woodland (Zeiner et al. 1990a). It also occasionally nests in montane chaparral in open coniferous forests, which may be a more recent phenomenon (Gaines 1977). In migration, yellow warblers utilize a variety of woodland forest and shrub habitats (Zeiner et al. 1990a).

Destruction and deterioration of riparian habitat are the most recognized threats to the yellow warbler. Brood parasitism by brown-headed cowbirds (*Molothrus ater*) has become an increasing threat (Gaines 1974b).

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

Yellow-breasted chat

The yellow-breasted chat (*Icteria virens*) breeds throughout most of the United States and northern Mexico, as well as parts of southern Canada. Only the nesting sites of this species are covered under the California Species of Special Concern designation. Due to the decline of this species in recent years, the breeding distribution in California is incompletely understood. As a breeding bird, it is local and uncommon from the Klamath Mountains in Del Norte, Humboldt, and Siskiyou counties south through the northern Coast Ranges to the San Francisco Bay area. In northeastern California, its breeding status is uncertain, but it probably still breeds on the Modoc Plateau and in the Great Basin valleys of Modoc and Lassen counties. It is a rare to very uncommon breeder throughout the southern Coast Ranges from Monterey County through San Diego counties. Yellow-breasted chats breed sparingly throughout much of the Central Valley, White Mountains, Owens Valley, along the Mojave River, and at Morongo Valley (San Bernardino County). During spring migration, the chat may occur throughout the state, particularly in the southeastern interior (Small 1994). The species winters from southern Baja California and southern Texas south to western Panama (Dennis 1958). A few birds may overwinter in southern California (Zeiner et al. 1990a).

These large warblers feed on insects and spiders, as well as berries and other fruits, mostly from shrubs and low trees (Zeiner et al. 1990a). They breed from early May into early August with peak activity in June. Yellow-breasted chats breed and winter in dense second growth, and scrub habitats. They are typically associated with early seral stages of forest regeneration such as is found in abandoned agricultural lands, fields, and floodplains (Thompson and Nolan 1973). In California, they can be found in dense thickets of willows or other brushy tangles of riparian woodlands (Small 1994, Zeiner et al. 1990a). Gaines (1974b) characterized this species in the Sacramento Valley as an "edge-nester," nesting in the forest/field and forest/gravel bar interface.

The yellow-breasted chat has declined over much of its range (Remsen 1978). Destruction of riparian woodland is the major threat to this species, though its absence in areas of intact habitat indicate that other factors, such as nest parasitism by the brown-headed cowbird (*Molothrus ater*), may be influencing populations (Remsen 1978).

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

Tricolored blackbird

The tricolored blackbird (*Agelaius tricolor*) is nearly endemic to California, with its range barely extending into southern Oregon and northern Baja California (Small 1994). The species is common locally throughout the Central Valley and in coastal districts from Humboldt and Mendocino counties south (Zeiner et al. 1990a, Small 1994). The San Joaquin Valley was once considered the center of the tricolored blackbird's range, but they have declined substantially in this region (Beedy et al. 1991). During winter, the species is more abundant and widespread along the central coast and San Francisco Bay Area (Grinnell and Miller 1944, McCaskie et al. 1979, Garrett and Dunn 1981). Only the nesting colonies of this species are covered under the "California Species of Special Concern" designation.

This species is highly gregarious in all seasons, forming colonies ranging from about 50 to 100,000 nests (Zeiner et al. 1990a, Small 1994). Colonies may have reached sizes of up to 200,000 nests in previous decades (Zeiner et al. 1990a). Nest densities within these colonies are apparently the highest occurring for any blackbird in North America (Ehrlich et al. 1988). The breeding season lasts from mid-April into late July, though Orians (1960) has reported breeding in October and November. These birds are polygynous, with each male that holds a territory having several mates (Zeiner et al. 1990a). Nests are built of mud and plant material and are located over or near the water (Zeiner et al. 1990a). For breeding, these birds prefer freshwater marshes with dense stands of cattails and/or bulrushes, though they will occasionally use willows, thistles, mustard, blackberry tangles, and other dense shrubs and grains (Neff 1937). After breeding, individuals may wander widely over agricultural lands, cattle feedlots, and horse and cattle ranches (Zeiner et al. 1990a). Food consists of spiders, insects, seeds, and cultivated grains such as rice and oats (Zeiner et al. 1990a).

Extensive marsh drainage and habitat destruction has reduced breeding habitat for tricolored blackbirds (Zeiner et al. 1990a). Dense breeding colonies are vulnerable to massive nest destruction by mammalian and avian predators, including Swainson's hawks (Bent 1958). The species is apparently declining. DeHaven et al. (1975) estimated that in the 35 years prior to 1972, the Central Valley populations of this species had declined by at least 50 percent.

The California Natural Diversity Database identifies several records of tricolored blackbird within the nine quadrangles covering lands within and adjacent to the Merced River corridor. These occurrences were in the vicinities of Snelling, Gustine, Turlock Lake, and Stevinson.

Bank swallow

Bank swallow (*Riparia riparia*) is a migrant in California found primarily in riparian and other lowland habitats (Zeiner et al. 1990a). The species arrives in California from South America in early April with numbers peaking in early May. In summer, the species is restricted to riparian areas with vertical cliffs and banks with fine-textured or sand soil, into which it digs its nesting holes. Breeding occurs from early May through July, with pairs generally breeding and nesting colonially. It is believed that approximately 75% of the current breeding population in California is concentrated along the banks of Central Valley steams.

Bank swallow range is estimated to have been reduced by 50% since 1900 (CDFG 1992). Stream channelization and bank revetment of nesting rivers are major factors causing the marked decline in numbers in recent decades.

No records of this species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

MAMMALS

Bats

Seven special-status bat species have the potential to occur in the vicinity of the Merced River corridor: pallid bat (*Antrozous pallidus*), small-footed myotis (*Myotis ciliolabrum*), long-eared myotis (*M. evotis*), fringed myotis (*M. thysanodes*), long-legged myotis (*M. thysanodes*), Townsend's western big-eared bat (*Corynorhinus* (=*Plecotus*) *townsendii townsendii*), and California mastiff bat (*Eumops perotis californicus*). The myotis bats listed above, however, are not generally found in the

Central Valley (Zeiner et al. 1990b).

These species are treated here as a group because these bats have relatively similar habitat requirements and life histories. All seven species are insectivorous. Roost sites for these bats generally include rock outcrops, mines, caves, hollow trees, buildings, bridges, cracks in cliffs and boulders, or trees (especially large hollow trees or snags, or trees with big slabs of broken bark). All are considered to be resident species, and all engage in hibernation for all or part of the winter months, with the exception of the California mastiff bat, which is active year-round at lower elevations (Brown and Pierson 1996). In California, bats have been declining due to timber harvest, oak woodland conversion, pest control exclusion, renewed hardrock mining, bridge replacement, disturbance at roost sites, building demolition, agricultural spraying, recreational caving, and/or pest control (Brown and Pierson 1996).

No records of these species are recorded in the California Natural Diversity Database for the nine quadrangles covering lands within and adjacent to the Merced River corridor.

San Joaquin pocket mouse

The San Joaquin pocket mouse (*Perognathus inornatus inornatus*) is restricted to California. It can be found throughout most of the Central Valley and in a portion of the southern Coast Ranges and the Carrizo Plain, where it occurs in dry, open grasslands, scrub, and blue oak woodland with fine-textured soils (Zeiner et al.1990b, Biosystems Analysis, Inc. 1991). The CWHR (1997) indicates that it can also be found in valley oak woodland (low to medium habitat suitability ranking). This species constructs its own burrows and feeds on a variety of seeds and green vegetation (Zeiner et al. 1990b).

The San Joaquin pocket mouse is impacted by construction and maintenance activities that can compact soil and destroy foraging habitat (Biosystems Analysis, Inc. 1991). This likely includes housing developments and agricultural practices.

The California Natural Diversity Database identifies two records of San Joaquin pocket mouse within the nine quadrangles covering lands within and adjacent to the Merced River corridor. These occurrences were both just outside of the town of Snelling.

Merced kangaroo rat

The Merced kangaroo rat (*Dipodomys heermanni dixoni*) is a subspecies of Heerman's kangaroo rat (*D. heermanni*). Heerman's kangaroo rat is distributed in the foothills of the Sierra Nevada, in the San Joaquin Valley and in the Coast Ranges (Zeiner et al. 1990b). The species is commonly found in annual grassland, coastal scrub, mixed and montane chaparral, and early stages of hardwood habitats. It frequents dry grassy plains, and occurs on hillsides, knolls, and ridges. The species dig burrows where there is fine soil or relies on abandoned burrows in rocky substrates.

Principle predators of the kangaroo rat include rattlesnakes, gopher snakes, owls, badgers, foxes, and coyotes. Habitat loss, fragmentation, and destruction are believed to be the major causes of population declines (Zeiner et al. 1990b).

The California Natural Diversity Database identifies five records of Merced kangaroo rat within the nine quadrangles covering lands within and adjacent to the Merced River corridor. These occurrences were in the vicinities of Snelling and Yosemite Lake.

San Joaquin kit fox

The historical range of the San Joaquin kit fox (*Vulpes macrotis mutica*) included most of the San Joaquin Valley from southern Kern County northwest to Tracy (San Joaquin County) and northeast to near La Grange (Stanislaus County) (Williams et al. 1997).

The kit fox feeds on a variety of small rodents, insects, ground squirrels, and black-tailed hares. Generally, kit foxes prefer areas with friable soil to facilitate digging of dens, but they can be found in many soil types. This species utilizes a variety of habitats, including grasslands, scrublands, row crops, irrigated pasture, vineyards, and grazed grasslands. Kit foxes sometimes den in small parcels of native habitat surrounded by intensively managed agricultural lands (Knapp 1978). The San Joaquin kit fox has declined because of loss and fragmentation of habitat in the San Joaquin Valley (Williams et al. 1997). Pesticides and rodenticides may also directly and indirectly affect kit foxes.

The California Natural Diversity Database identifies five records of San Joaquin kit fox in Merced County and two records within the nine quadrangles covering lands within and adjacent to the Merced River corridor. One record was near the town of Winton and the other was south of the confluence of the Merced and San Joaquin Rivers.

APPENDIX C
Potential Restoration Funding Sources

Development and implementation of restoration actions for the Merced River will require cooperation and funding from various federal, state, and local agencies. Table C-1 is a list of sources that may be available to provide funding to implement recommended restoration actions. These funding sources are described in more detail below.

Table C-1. Summary of Potential Funding Sources for the Implmentation of Restoration Actions in the Merced River Corridor

Grant Name	Administered By	Available to		Goal				Cost-share Requirement
		Private	Public	Aquatic Species	Terrestrial Species	Ecosystem	Other	
Abandoned Mine Land Reclamation Program	Dept of the Interior, Office of Surface Mining		✓				✓	
Bring Back the Natives Program	National Fish and Wildlife Foundation	✓	✓	✓	✓	✓		✓
CALFED Ecosystem Restoration Program	CALFED	✓	✓	✓	✓	✓		
CALFED Watershed Program	CALED			✓		✓	✓	
California Farmland Conservancy Program	California Dept of Conservation		✓				✓	
California Riparian Habitat Conservation Program	Wildlife Conservation Board		✓			✓		
Central Valley Project Improvement Act	U.S. Bureau of Reclamation	✓	✓	✓	✓			
Conservation Reserve Program	U.S. Dept. of Agriculture, Farm Service Agency	✓	✓			✓	✓	
Cooperative Endangered Species Conservation Fund	U.S. Fish and Wildlife Service		✓	✓	✓	✓		
Delta Pumping Plant Fish Protection Agreement	California Dept of Water Resources	✓	✓	✓				
Environmental Water Program	California Dept of Water Resources	✓	✓			✓		✓
Environmental Quality Incentives Program	Natural Resource Conservation Service	✓	✓			✓	✓	✓
Federal Aid in Sport Fish Restoration Act	U.S. Fish and Wildlife Service		✓	✓				✓
Fishery Restoration Grants Program	California Dept of Fish and Game	✓	✓	✓		✓		

Table C-1. Summary of Potential Funding Sources for the Implmentation of Restoration Actions in the Merced River Corridor, continued

Grant Name	Administered By	Available to		Goal				Cost-share Requirement
		Private	Public	Aquatic Species	Terrestrial Species	Ecosystem	Other	
Flood Mitigation Assistance	National Flood Insurance Program		✓				✓	
Habitat Conservation Fund	California Dept of Parks and Recreation		✓	✓	✓	✓		✓
Land and Water Conservation Fund	U.S. Forest Service		✓			✓	✓	
LEGACI Grants	Great Valley Center		✓			✓	✓	
Nonpoint Source Implementation Grants	California Water Resources Control Board		✓				✓	✓
Water Quality Planning Grants	California Water Resources Control Board		✓				✓	✓
North American Wetlands Conservation Act	U.S. Fish and Wildlife Service	✓	✓		✓		✓	✓
Partners for Fish and Wildlife Program	U.S. Fish and Wildlife Service	✓		✓	✓	✓		
Urban Streams Restoration Program	California Dept of Water Resources		✓			✓	✓	
Wetlands Reserve Program	Natural Resources Conservation Service	✓				✓	✓	✓
Wildlife Conservation and Appreciation Program	U.S. Fish and Wildlife Service		✓	✓	✓	✓		
Wildlife Habitat Incentive Program	Natural Resources Conservation Service	✓				✓		

Abandoned Mine Land Reclamation Program

The Abandoned Mine Land Reclamation (AMLR) Program is designed to protect the public and correct environmental damage caused by coal and, to a limited extent, non-coal mining practices that occurred prior to August 3, 1977. AMLR provides for the restoration of eligible lands and waters mined and abandoned or left inadequately restored. The AMLR program is administered by the Department of the Interior Office of Surface Mining and is divided into two programs: the State Indian Reclamation Program and the Federal Reclamation Program. Both programs address problems such as dangerous highwalls, slides, subsidence, dangerous portals, and polluted waters.

For more information regarding the
Abandoned Mine Land Reclamation Program
contact:

U.S. Department of the Interior
Office of Surface Mining,
Division of Reclamation Support
1951 Constitution Ave., NW
Washington, DC 20240

Tel: (202) 208-2937
Website: http://www.epa.gov/owow/watershed/wacademy/fund/abandoned.html

Grants are distributed only under the State/Indian Reclamation Program and are 100 percent federally funded. States and Indian tribes with eligible lands and mining operations that are paying into the Abandoned Mine Reclamation Fund are eligible to apply for funding. The Department of the Interior awarded 26 grants (23 states and 3 Indian tribes) in Fiscal Year 1999, ranging from $94,000 to $23.8 million. Applications for funding are accepted anytime during the year.

Bring Back the Natives Program

Bring Back the Natives is a cooperative effort between the National Fish and Wildlife Foundation, Bureau of Land Management, Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Forest Service, and Trout Unlimited to restore native aquatic species and their habitats through local and regional partnerships. Preserving the biodiversity and ecological integrity of unique areas is an essential component of the restoration strategy, and establishing innovative and successful partnerships with organizations and individuals such as landowners, watershed groups, Trout Unlimited chapters, and state and federal agencies is one of the primary goals of the Bring Back the Natives program. Examples of funded projects include restoration of riparian corridors, reconnection of fragmented stream fish populations, and development of captive breeding programs. The majority of Bring Back the Natives projects have focused on salmonid populations and habitats, but projects have also targeted Yaqui chub, razorback sucker, gila topminnow, blueback herring, Toiyabe spotted frog, freshwater mussels, and native fish communities.

The National Fish and Wildlife Foundation contributes money to the program in the form of a challenge grant to U.S. Forest Service and U.S. Bureau of Land Management. To receive funding, the project proponent must secure an equal amount of funds from non-federal sources (e.g., private, corporate, or state sources).

For more information regarding the
Bring Back the Natives Program
contact:

Pam McClelland
National Fish and Wildlife Foundation
1120 Connecticut Avenue, NW, Suite 900
Washington, DC 20036

Telephone: (202) 857-0166
Website: http://www.cotrout.org/BBN/index.html

Additionally, both U.S. Forest Service and U.S. Bureau of Land Management can contribute money to the projects. Project proposals are generally due in mid-August.

CALFED Ecosystem Restoration Program

CALFED's Ecosystem Restoration Program (ERP) goal is to "improve and increase aquatic and terrestrial habitats and improve ecosystem functions in the Bay-Delta to support sustainable populations of diverse and valuable plant and animal species." The program objectives are to:

- improve and increase aquatic habitats so that they can support the sustainable production and survival of native and other desirable estuarine and anadromous fish in the estuary;
- improve and increase important wetland habitats so that they can support the sustainable production and survival of wildlife species; and
- increase population health and population size of Delta species to levels that ensure sustained survival.

For more information regarding the **Ecosystem Restoration Program** *contact:*

Lauren Hastings
CALFED Ecosystem Restoration Program
1416 Ninth Street
Sacramento, CA

Tel: (866) 752-2434
Fax: (916) 914-2043
Website: http://www.calfed.water.ca. gov/ecosystem_rest.html

The CALFED ERP is based on the premise that restoration of ecological processes and functions is a fundamental tool for successful ecosystem restoration. These natural processes serve to create and maintain habitats needed by fish, wildlife and plant communities. Restoration efforts based on restoration of natural processes are likely to be more cost-effective in the long-term because they should be self-sustaining and require less human intervention. Restoration of processes such as hydrologic regime is also important if habitats such as tidal, perennial, and shaded riverine aquatic are to function.

Over the last three years the ERP has funded 195 projects for a total of approximately $228 million through a proposal-grant process. Funded projects have included fish screens and ladders, land acquisition, habitat restoration, and focused research and monitoring. Proposal Solicitation Packages are generally distributed in August, with proposals due in mid-September. Funds are obtained from stakeholder contributions, state Proposition 204 funds, and the Federal Bay-Delta Act. The CALFED ERP funded Phases II and III of the Merced River Corridor Restoration Plan.

CALFED Watershed Program

The CALFED Watershed Program was established in 2001 as an aid to achieving CALFED's overall goal to restore ecological health and improve water management of the Bay-Delta system by working with stakeholders at the local community and watershed level. Watershed Program priorities include:

- build local community involvement and capability to effectively manage wa-

tersheds that affect the Bay-Delta system;
- develop or refinement of watershed assessments and plans; and
- design, develop and implement specific watershed conservation, maintenance and restoration activities.

Proposal Solicitation Packages are generally distributed in January, with proposals due in mid-February.

For more information regarding the
CALFED Watershed Program
contact:

CALFED Bay-Delta Watershed Program
John Lowrie, Program Manager
1416 Ninth Street
Sacramento, CA

Tel: (916) 653-5422
Website: baydeltawatershed.org

California Farmland Conservancy Program

The California Farmland Conservancy Program (CFCP), formerly known as the Agricultural Land Stewardship Program, is a voluntary program that seeks to encourage the long-term, private stewardship of agricultural lands through the use of agricultural conservation easements. The CFCP was created in 1996 in the California Department of Conservation and provides grant funding for projects which use and support agricultural conservation easements for protection of agricultural lands.

Local governments, resource conservation districts, non-profit organizations, regional park or open-space districts, and regional park or open-space authorities that have conservation of farmland among their stated purposes are eligible to apply for CFCP grants. Available funding for Fiscal Year 2001-2002 includes over $5 million of bond funds and $1.5 million in non-bond funds. The CFCP accepts proposals on an ongoing basis.

For more information regarding the
California Farmland Conservancy Program
contact:

California Farmland Conservancy Program
California Department of Conservation-DLRP
801 K Street, MS 13-71
Sacramento, CA 95814

Tel: (916) 322-9721
Fax: (916) 327-3430
Website: http://www.consrv.ca.gov/dlrp/CFCP/

California Riparian Habitat Conservation Program

The California Riparian Habitat Conservation Program was established in 1991 through the Wildlife Conservation Board (WCB) to protect, preserve, and restore riparian habitat throughout California. To accomplish the goal of the California Riparian Habitat Conservation Program, the WCB may acquire real property and water rights, coordinate activities with any governmental program for surplus property sales in the state, and award grants and loans to non-profit groups and local public, state, or federal agencies. Private landowners cannot receive funds directly, but can partner with a sponsoring agency to accomplish restoration on their land. Projects eligible for funding under the California Riparian Habitat Conservation Program include:

- acquisition of land, conservation easements, or water, development and access rights;
- restoration and enhancement projects, including revegetation, exclusion fencing, and streambank stabilization using biotechnical methods; and
- demonstration projects which encourage the development of new and innovative types of restoration and enhancement techniques.

All funded acquisition projects require a permanent commitment by the project sponsor or landowner to manage and maintain the property, while restoration and enhancement projects require a 25-year commitment. Project proposals are accepted throughout the year and are decided upon in February, May, August, and November.

For more information regarding the **California Riparian Habitat Conservation Program** *contact:*

California Department of Fish and Game
Wildlife Conservation Board
Attn: Scott Clemons, Program Manager
1807 13th Street, Suite 103
Sacramento, CA 95814
Tel: (916) 445-1072
Fax: (916) 323-0280
Website: wwwdpla.water.ca.gov/environment/habitat/stream/wldconsbrd.html

Central Valley Project Improvement Act

The Central Valley Project Improvement Act (CVPIA), passed by Congress in 1992, contains 40 separate titles providing for water resource projects throughout the West. The CVPIA mandates changes in management of the Central Valley Project (CVP), particularly for the protection, restoration, and enhancement of fish and wildlife, including providing 800,000 acre-feet of water dedicated to fish and wildlife annually. The Secretary of the Interior directed the U.S. Fish and Wildlife Service and the U.S. Bureau of Reclamation to jointly implement the CVPIA, and Section 3406(b)(1) in particular. The Anadromous Fish Restoration Program (AFRP) was developed in response to Section 3406(b)(1) of the CVPIA. This Section requires the Department of the Interior to "develop within three years of enactment and implement a program which makes all reasonable efforts to ensure that, by the year 2002, natural production of anadromous fish in Central Valley rivers and streams will be sustainable, on a long-term basis, at levels not less than twice the average levels attained during the period of 1967–1991..." Anadromous fish species addressed by the CVPIA include chinook salmon, steelhead, white and green sturgeon, striped bass, and American shad. Further, sub-section 3406(b)(1)(A) requires that the program "give first priority to measures which protect and restore natural channel and riparian habitat values through habitat restoration actions, modifications to Central Valley Project operations, and implementation of the supporting measures mandated by this subsection."

The CVPIA provides for other reforms, including improving water supply to wildlife refuges; reducing current water use through water conservation, water transfer programs, water pricing and contracting reform; programs to eliminate or reduce fish losses due to flow fluctuations, replenishing spawning gravel, and screen diversions; and programs to retire agricultural land. AFRP also provides incentives to encourage farmers to participate in a program to keep fields flooded during appropriate time periods for the purposes of waterfowl habitat creation and maintenance and for CVP water yield enhancement.

For more information regarding the **Central Valley Project Improvement Act** *contact:*

Bureau of Reclamation Mid-Pacific Region
Public Affairs Office
2800 Cottage Way
Sacramento, CA 95825-1898
Attn: Lynnette Wirth, Deputy Director

Telephone: (916/978-5100
Fax: (916) 978-5114
Website: http://www.mp.usbr.gov/cvpia/

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, habitat restoration, improvement, and acquisition as required by the CVPIA. The Restoration Fund is replenished by fees on renewed water contracts, surcharges on water from certain CVP facilities, and other water use fees. Many of the specific habitat restoration and remedial actions of CVPIA require state-federal cost sharing. Potential recipients of the funding include the State of California or an agency or subdivision thereof, Native American tribes, and non-profit entities concerned with restoration, protection, or enhancement of fish, wildlife, habitat, or environmental values, which is able to assist in implementing any action authorized by this title in an efficient, timely, and cost effective manner.

Conservation Reserve Program (CRP)

The Conservation Reserve Program, which is administered by the U.S. Department of Agriculture's (USDA) Farm Service Agency, encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as native grasses, trees, filterstrips, or riparian buffers. The program is intended to reduce soil erosion and sedimentation in streams and improve water quality and wildlife habitat. Participation is voluntary, with a monetary incentive to participate. Farmers receive an annual rental payment for the term of a multi-year contract and can receive cost-sharing funds to establish vegetative cover.

For more information regarding the **Conservation Reserve Program** *contact:*

U.S. Department of Agriculture
Farm Service Agency
Conservation Reserve Program
1400 Independence Ave., S.W.
STOP 0506
Washington, DC 20250-0506

Tel: (202) 720-7807
Website: http://www.fsa.usda.gov/dafp/cepd/crpinfo.htm

Applicants submit bids for the price they want for their enrolled lands, and if the bid is accepted, participants enroll in contracts for 10 to 15 years and, in some cases, easements, in exchange for annual rental payments and cost share assistance for installing certain conservation practices.

Cooperative Endangered Species Conservation Fund

The Cooperative Endangered Species Conservation Fund provides federal financial assistance to state agencies to assist in the development of programs for the conservation of endangered and threatened species. The fund is administered by the U.S. Fish and Wildlife Service, through the Endangered Species Act of 1973. Assistance provided to state agencies can include animal, plant, and habitat surveys; research; planning; monitoring; habitat protection, restoration, management, and acquisition; and public education. Assistance is restricted to those state agencies with which the Fish and Wildlife Service has a current cooperative agreement for the species involved.

In Fiscal Year 2000, $22.5 million in grants were distributed. Grants generally range from $1,000 to $14 million. To be considered for funding, a standard

For more information regarding the **Cooperative Endangered Species Conservation Fund** *contact:*

Fish and Wildlife Service, Dept. of the Interior
Endangered Species: Division of Consultation, Habitat Conservation Planning, and Recovery
1849 C St., NW.
Washington DC 20240.

Tel: (703) 358-2171.
Website: http://www. endangered.fws.gov

application for federal assistance must be submitted by the state fish and wildlife agency. Applications are accepted all year.

Delta Pumping Plant Fish Protection Agreement (Four Pumps Agreement)

In 1986, CDFG and CDWR entered into an agreement 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 that 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, poor screening efficiency for fish less than one inch in length, and mortality caused by handling fish during salvage operations. In addition to annual obligations for losses at the pumping plant, CDWR also agreed to provide $15 million to initiate a program to increase the probability of fish populations quickly recovering. Recently, another $3.7 million became available after the cancellation of a project on the Tuolumne River. Since 1999, CDWR has funded $18.3 million in annual mitigation projects. Projects funded have ranged from water hyacinth control projects on the Merced River to habitat restoration. Through this agreement, projects are developed by CDFG, reviewed for funding by the Fish Advisory Committee, and approved for funding by Directors of CDFG and CDWR. Approved funds are administered by CDWR. The Fish Advisory Committee includes representatives from CDFG, CDWR, water contractors, fishery interests and environmental organizations (Mager, pers. comm., 2000). The funds in the account are derived from the State Water Project contractors. On the Merced River, the Four Pumps Agreement has provided funds for implementation of the Merced River Salmon Habitat Enhancement Plan, two riffle reconstruction projects, and ongoing gravel augmentation projects.

> *For more information regarding the* **Four Pumps Agreement** *contact:*
>
> California Department of Water Resources
> Stephani Spaar
>
> Tel: (916) 227-7536
> Website: calfed.ca.gov/ecosystem/funding_sources.html

Environmental Enhancement and Mitigation Program

The Environmental Enhancement and Mitigation Program (EEMP) was established by the enactment of the Transportation Blueprint Legislation of 1989 (AB 421). This program for mitigating negative effects of highways and vehicle operations is administered by the California Transportation Commission, but the Resources Agency evaluates initial fund applications and makes recommendations to the California Transportation Commission. The enabling legislation (Section 164.56 of the Streets and Highways Code) 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. The program provides grants to local, state, and federal agencies and nonprofit entities to provide enhancement or additional mitigation for the

> *For more information regarding the* **Environmental Enhancement and Mitigation Program** *contact:*
>
> EEMP
> California Resources Agency
> Bill Borden, EEMP Coordinator
> 1416 Ninth Street, Room 1311
> Sacramento, CA 95814
>
> Tel: (916) 653-5656
> Website: http://ceres.ca.gov/cra/eemp_new.html

environmental impact of modified or new public transportation facilities. Categories of environmental enhancement and mitigation projects eligible for funding include highway landscaping and urban forestry; the acquisition, restoration, or enhancement of resource lands to mitigate the loss of resource lands lying within or near rights-of-way acquired for proposed transportation improvements; and acquisition and/or development of roadside recreation opportunities. Resource lands include natural areas, wetlands, forests, woodlands, meadows, streams, or other areas containing fish or wildlife habitat.

Environmental Water Program

The Environmental Water Program was created by the Environmental Water Act of 1989 and provides funding for enhancement and restoration projects (not studies) that will contribute significant environmental benefits to the state. Grant monies must be matched by either an equal amount of funding, or a combination of funding and in-kind services. Eligible projects include fisheries habitat restoration and enhancement; riparian habitat acquisitions, restoration or enhancement; and wetland habitat acquisitions, restoration or enhancement. Funds for this program are administered by the California Department of Water Resources.

For more information regarding the **Environmental Water Program** *contact:*

Terry Mills
California Department of Water Resources
Tel: (916) 657-0199

Environmental Quality Incentives Program (EQIP)

The Environmental Quality Incentives Program (EQIP) is administered by USDA's Natural Resource Conservation Service (NRCS) and encourages environmental enhancement of private ranch and farmland. EQIP aims to address significant natural resource needs and objectives by providing a voluntary conservation program for farmers and ranchers. EQIP provides technical, financial, and educational assistance. Nationally, half of EQIP funds are targeted for livestock-related natural resource problems, while the other half is appropriated to more general conservation priorities. EQIP participants implement activities based on a conservation plan. EQIP offers 5- to 10-year contracts that provide incentive payments and cost sharing for conservation practices needed at the site. Cost sharing may pay up to 75% of the costs of certain conservation practices, such as grassed waterways, filter strips, manure management facilities, capping of abandoned wells, and other practices important to improving and maintaining the health of natural resources in the area.

For more information regarding the **Environmental Quality Incentives Program** *contact:*

Malia Ortiz
Merced Service Center
2135 Wardrobe Ave., Suite C
Merced, CA 95340-6445

Tel: (209) 722-4119
Fax: (209) 725-2964
Website: http://www.nhq.nrcs.usda.gov/PROGRAMS/COD/cit/eqipsmry.htm

Federal Aid in Sport Fish Restoration Act

The Federal Aid in Sport Fish Restoration Act, commonly referred to as the Dingell-Johnson Act, was passed in 1950 to establish a program for management, conservation, and restoration of fishery resources. The Sport Fish Restoration program is administered through the U.S. Fish and Wildlife Service and is funded by revenues collected from the manufacturers of fishing rods, reels, creels, lures, flies and artificial baits, who pay an excise tax on these items to the U.S. Treasury.

State agencies are the only entities eligible to receive grant funds. The program is a cost-reimbursement program, where the state covers the full amount of an approved project then applies for reimbursement through Federal Aid for up to 75 percent of the project expenses. The state must provide at least 25 percent of the project costs from a non-federal source.

For more information regarding the
Federal Aid in Sport Fish Restoration Act
contact:

Tim Hess
USFWS, Division of Federal Aid
Arlington Square, Room 140
4401 N. Fairfax Drive
Arlington, Virginia 22203

Tel: (703) 358-2156
Fax: (703) 358-1837
Website: http://fa.r9.fws.gov/sfr/fasfr.html

Fishery Restoration Grants Program

The California Department of Fish and Game administers a number of funds through the Fishery Restoration Grants Program. These include Proposition 99, the Commercial Salmon Stamp Account, the Steelhead Trout Catch Report-Restoration Card funds, Wildlife Conservation Board, Salmon and Steelhead Trout Restoration Account (SB 271), Proposition 13, Striped Bass Restoration Program Mitigation Obligation, Timber Tax Credit Program, the Bosco-Keene Renewable Resources Investment Fund (RRIF), and the Central Valley Project Improvement Act (Public Law 102-575). The program funds fishery restoration projects with an emphasis on coastal salmon and steelhead trout habitat restoration. Projects on the Merced River that are eligible for funding include:

- instream-habitat restoration;
- public school watershed and fishery conservation education project; and
- cooperative fish rearing.

Public agencies, non-profit organization, Indian tribes, and private entities are eligible to apply for funding under the Fishery Restoration Grants Program. In Fiscal Year 2000-2001, $20,204,489 were granted. Requests for proposals are generally distributed in February, with proposals due in mid-May.

For more information regarding the
Fishery Restoration Grants Program
contact:

California Department of Fish and Game
Restoration Grants
Attn: Michael Bird, Grants Coordinator
1807 13th Street
Sacramento, CA 95814

Tel: (916) 327-8842
Website: http://www.dfg.ca.gov/nafwrb/fishgrant.html

Flood Mitigation Assistance

The Flood Mitigation Assistance (FMA) program helps states and communities identify and implement measures to reduce or eliminate the long-term risk of flood damage to homes and other structures insurable under the National Flood Insurance Program. Projects may include (1) elevation, relocation, or demolition of insured structures; (2) acquisition of insured structures and property; (3) dry floodproofing of insured structures: (4) minor, localized structural projects that are not fundable by state or other federal programs (e.g., erosion control and drainage improvements), and (5) beach nourishment activities, such as planting of dune grass.

For more information regarding
Flood Mitigation Assistance
contact:

California Office of Emergency Services
2800 Meadowview Road
Sacramento, California 95832

Tel: (916) 262-1816
Fax: (916) 262-1677
Website: http://www.oes.ca.gov/

Any State agency, participating National Flood Insurance Program community, or qualified local organization is eligible to participate in FMA. A project must, at a minimum, be cost effective, cost beneficial to the National Flood Insurance Fund, technically feasible, and physically located in a participating NFIP community or must reduce future flood damages in a National Flood Insurance Program community.

Habitat Conservation Fund Grant Program

The Habitat Conservation Fund (HCF) Grant Program was created under the California Wildlife Protection Act of 1990 and is provided by the General Fund. The California Department of Parks and Recreation administers HCF grants for the acquisition, restoration, or enhancement of deer and lion habitat, habitat for rare, endangered, or threatened species, wildlife corridors and urban trails, wetlands, aquatic habitat for the spawning and rearing of anadromous salmonids and trout, and riparian habitat.

For more information regarding the
Habitat Conservation Fund Grant Program
contact:

California Department of Parks and Recreation
Planning and Local Services Section
1416 Ninth Street, Room 940
P.O. Box 942896
Sacramento, CA 94296-0001

Tel: (916) 653-7423
Fax: (916) 653-6411
Website: http://cal-parks.ca.gov/grants/hcf/hcf.htm

Two million dollars are available each year through the HCF for eligible project types. In Fiscal Year 2001-2002, 13 projects were funded for a total of $2,145,277. Only local public agencies are eligible to apply, although non-profits are encouraged to participate as partners. A 50/50 local funding match is required. Applications for the funding are due by October 1.

Land and Water Conservation Fund

Created by Congress in 1964, the Land and Water Conservation Fund (LWCF) provides monies to federal, state and local governments to acquire land, water and conservation easements on land and water for the benefit of all Americans. The acquisitions become part of our national forests, parks, wildlife refuges and other public areas.

For more information regarding the
Land and Water Conservation Fund
contact:

Pat Romeiro
U.S. Forest Service
Pacific Southwest Region

Tel: (707) 562-8961
Website: http://www.fs.fed.us/land/staff/LWCF/

Lands are purchased from willing sellers at fair-market value or through partial or outright donations of property. Landowners can also sell or donate easements on their property that restrict commercial development while keeping the land in private ownership. Each year, four federal agencies — the U.S. Forest Service, National Park Service, Fish and Wildlife Service, and Bureau of Land Management — identify important properties available for purchase. Congress appropriates up to $900 million each year for Land and Water Conservation Fund projects. The funding for these purchases comes primarily from revenues received from offshore oil and gas drilling.

LEGACI Grants

Land use, Economic development, Growth, Agriculture, and Community Investment (LEGACI) grants are administered through the Great Valley Center, a private, non-profit, and non-partisan organization committed to building support for California's Central Valley as a distinct region and assisting in the process of planning for the 21st century. Each year, the Great Valley Center awards over $500,000 in monetary grants to non-profit groups, community organizations, and local government that are working to improve the well being of the Central Valley. LEGACI grants fund a variety projects. LEGACI funding areas which would cover restoration projects on the Merced River include environmental for projects that promote conservation or rehabilitation of natural areas, general benefit for projects which serve the greater good of the valley and may combine types of grants, and planning and land use for projects that encourage smart planning policy including agricultural conservation easements.

For more information regarding the **LEGACI Grants** *contact:*

The Great Valley Center
911 13th Street
Modesto, CA 95354

Tel: (209) 522-5103
Fax: (209) 522-5116
Website: http://www.greatvalley.org/programs/legaci/legaci_grants.htm

In fiscal year 2001, the Great Valley Center funded a total of $788,733 in LEGACI grants, $299,200 of which were for environmental projects. To be eligible for funding, projects must have an area of focus within at least one of the Valley's 19 counties. Proposals that incorporate collaboration with other local groups are viewed favorably by the Center's Board of Directors.

Applications for LEGACI grants are generally available in late November.

Nonpoint Source Implementation (Clean Water Act Section 319[h]) Grants

For more information regarding the **Nonpoint Source Implementation Grants** *contact:*

SWRCB, Division of Water Quality
Regional Programs Unit
Attn: Lauma Jurkevics, Chief
1001 I Street, 15th Floor
Sacramento, CA 95814

Tel: (916) 341-5498
Website: http://www.swrcb.ca.gov/nps/docs/fldpl319.doc

Clean Water Act Section 319(h) funds are provided by the State Water Resources Control Board to state and tribal agencies, non-profit organizations, and education institutions for watershed management and implementation programs that reduce, eliminate, or prevent water pollution from nonpoint sources and enhance water quality. Funding can be used for technical and financial assistance, education, training, technology transfer, demonstration projects, and regulatory programs. Projects submitted for funding must target specific watersheds identified by Regional Water Quality Control Boards and support watershed management and should be consistent with the Plan for California's Nonpoint Source Pollution Control Program. In addition, a 40% project cost share is required. Requests for proposals are generally issued in March, with proposals due in June. In Fiscal Year 2001, the projected project funding levels were $25,000–$500,000 per project.

Water Quality Planning (Clean Water Act 205[j]) Grants

Water Quality Planning Grants provide funding to local public agencies for water quality planning projects that reduce, eliminate, or prevent water pollution and enhance water quality. Funds are granted by the U. S. Environmental Protection Agency to the State Water Resources Control Board, which distributes the funds and administers the grants and contracts. Funded projects may include broad watershed planning or plans to resolve specific water quality issues, though the latter should incorporate the watershed planning approach, ensuring involvement of all interested parties. Submitted projects should address one or more significant water quality problems, and priority is given to projects which target specific watershed issues identified by Regional Water Quality Control Boards. Water Quality Planning Grants will fund up to 75% of project costs; the remaining 25% of costs must be from a non-federal source. Requests for Proposals are generally issued in March, with proposals due in June. In Fiscal Year 2001, the total funding available was approximately $700,000, with project funding levels of $25,000–$125,000 per project (SWRCB 2001c).

For more information regarding the **Water Quality Planning Grants** *contact:*

SWRCB, Division of Water Quality
Attn: Paul Lillebo
1001 I Street, 15th Floor
Sacramento, CA 95814

Tel: (916) 341-5551
Website: http://www.swrcb.ca.gov/nps/docs/fldpl205.doc

North American Wetlands Conservation Act

The North American Wetlands Conservation Act of 1989 provides matching grants to carry out wetlands conservation projects in the United states, Canada, and Mexico. The act was passed, in part, to support activities under the North American Waterfowl Management Plan. This plan is an international agreement between the three countries for the long-term protection of wetland/upland habitats on which waterfowl and other migratory birds in North America depend. Both the Standard and Small Grants programs help deliver funding to on-the-ground projects through the protection, restoration, or enhancement of an array of wetland habitats.

Project grants range from $50,000 to $1 million (standard grants) to less than $50,000 (small grants). Public or private, profit or nonprofit entities or individuals establishing public-private sector partnerships may apply for grants. Proposals may be submitted at any time, although Standard Grant applications are generally due in March and July and Small Grant application are due in December.

For more information regarding the **North American Wetlands Conservation Act** *contact:*

U.S. Department of the Interior
U.S. Fish and Wildlife Service
North American Waterfowl and Wetlands Office (NAWWO)
4401 North Fairfax Drive, Room 110
Arlington, VA 22203

Tel: (703) 358-1784
Website: http://www.fws.gov/r9nawwo/granpro.html

Partners for Fish and Wildlife Program

The Partners for Fish and Wildlife Program (formerly the Partners for Wildlife Program) is administered through the U.S. Fish and Wildlife Service and offers technical and financial assistance to private landowners who voluntarily restore wetlands and other fish and wildlife habitat on their land. The program emphasizes the reestablishment of native vegetation and ecological communities for the benefit of fish and wildlife in concert with the needs and desires of private landowners. Restoration projects include, but are not limited to, restoring wetland hydrology, planting native trees, shrubs, and grasslands, installing fencing and off-stream livestock watering facilities, removal of exotic plant and animal species, prescribed burns, and reconstruction of in-stream aquatic habitat.

To date, the Partners for Fish and Wildlife Program has restored over 360,000 acres of wetlands, 128,000 acres of prairie grassland, 930 miles of riparian habitat, and 90 miles of instream aquatic habitat. Projects must involve U.S. Fish and Wildlife staff during project planning and development before submitting a proposal in January.

For more information regarding the
Partners for Fish and Wildlife Program
contact:

U.S. Fish and Wildlife Service
Partners of Fish and Wildlife Program
Attn: Debra Schlafmann, State Coordinator
2800 Cottage Way, W-2610
Sacramento, CA 95825

Tel: (916) 414-6446
Fax: (916) 414-6462
Website: http://partners.fws.gov/

Urban Streams Restoration Program

Urban Streams Restoration Program grants are administered through the California Department of Water Resources to support actions that prevent property damage caused by flooding and bank erosion, restore the natural value of streams, and promote community stewardship. Funded projects range from neighborhood stream clean-ups to complete restoration of a stream to its original, natural state. The Urban Streams Restoration Program was funded with the passage of the Costa-Machado Water Bond Act of 2000 (Proposition 13) and had $2 million available for grants in Fiscal Year 2000-2001.

The grant cap is $200,000 per project, but is currently being amended to raise the cap to $1 million per project. Potential projects must have both a local agency and a community group as sponsors, and either sponsor may act as the primary applicant of the project. Applications for Urban Streams Restoration Program grants are generally available in mid-February, with application due by late-March.

For more information regarding the
Urban Streams Restoration Program
contact:

California Department of Water Resources
Division of Planning and Local Assistance
Urban Streams Restoration Program
Attn: Sara Denzler, Program Coordinator
1020 Ninth Street, Third Floor
Sacramento, CA 95814

Telephone: (916) 327-1664
Website: http://wwwdpla.water.ca.gov/environment/habitat/stream/usrp.html

Wetlands Reserve Program

The Wetlands Reserve Program (WRP) is a voluntary program administered by the Natural Resources Conservation Service (NRCS) to restore wetlands. Participating landowners can establish conservation easements of either permanent or 30-year duration, or can enter into restoration cost-share agreements where no easement is involved. In exchange for establishing a permanent easement, the landowner receives payment of up to the agricultural value of the land and 100% of the restoration costs for restoring the wetlands. The 30-year easement payment is 75% of what would be provided for a permanent easement on the same site and 75% of the restoration cost. The restoration cost-share agreements are for a minimum 10-year duration and provide 75% of the cost of restoring the involved wetlands. Easements and restoration cost-share agreements establish wetland protection and restoration as the primary land use for the duration of the easement or agreement. In all instances, landowners continue to control access to their land.

For more information regarding the
Wetlands Reserve Program
contact:

Wetland Reserve Program Coordinator, Alan R. Forkey
USDA Natural Resources Conservation Service
430 G Street, #4164
Davis, CA 95616-4164

Tel: (530) 792-5653
Website: http://www.wl.fb-net.org/

Wildlife Conservation and Appreciation Program

The Wildlife Conservation and Appreciation Program provides grants to fund projects that bring together U.S. Fish and Wildlife Service, state agencies, and private organizations and individuals. Projects include; identification of significant problems that can adversely affect fish and wildlife and their habitats, actions to conserve species and their habitats, actions that will provide opportunities for the pubic to use and enjoy fish and wildlife through nonconsumptive activities, monitoring of species, and identification of significant habitats.

State fish and wildlife agencies are eligible for funding. Private organizations and individuals can work with their State fish and wildlife agency to apply for grants. Applications are due to regional U.S. Fish and Wildlife Service offices by September 1 of each year.

For more information regarding the
Wildlife Conservation and Appreciation Program
contact:

U.S. Fish and Wildlife Service
Division of Federal Aid
4401 North Fairfax Drive
Arlington, VA 22203

Tel: (703) 358-1852
Website: http://www.epa.gov/owow/watershed/wacademy/fund/appreciation.html

Wildlife Habitat Incentives Program

The Wildlife Habitat Incentives Program (WHIP) provides technical assistance and cost-share payments to help establish and improve fish and wildlife habitat on private lands. Participants work with Natural Resource Conservation Service (NRCS) to prepare a wildlife habitat development plan in consultation with the local conservation district. The plan describes the participant's goals for improving wildlife habitat, includes a list of practices and a schedule for installing them, and details the steps necessary to maintain the habitat for the life of the agreement. This plan may or may not be part of a larger conservation plan that addresses other resource needs such as water quality and soil erosion. NRCS and the participant enter into a cost-share agreement for wildlife habitat development. This agreement generally lasts from 5 to 10 years from the date the agreement is signed.

For more information regarding the
Wildlife Habitat Incentives Program
contact:

Wildlife Habitat Incentives Program
USDA Natural Resources Conservation Service
2121-C 2nd Street, Suite 102
Davis, CA 95616-5475

Website: http://www.nhq.nrcs.usda. gov/PROGRAMS/wwd/whipindex. htm

APPENDIX D
Conservation Options for Landowners

Conservation easements and incentive programs provide a mechanism for preserving natural and agricultural resource values on private properties. Through easements and incentives, private property owners maintain title to the properties and their riparian water rights, while forfeiting some potential uses of that property in return for compensation. Conservation easements can be funded through a variety of public and private sources and can be administered by both government agencies, such as the Wildlife Conservation Board, and non-governmental agencies, such as land trusts and land conservancies. In addition to the compensation provided to the landowner for purchase of the easement, conservation easements can reduce property tax burden by reducing the assessed property value. The duration of a conservation easement can be determined on a case-by-case basis, depending on the funding source. Typical sources will provide funds for easements lasting from 10 years to perpetual easements.


Photo/Stillwater Sciences

Conservation buffers are small strips of land adjacent to permanent vegetation that can effectively mitigate the movement of sediment, nutrients, and pesticides from and within farm fields. By using buffer strips along with other environmentally sound agricultural practices (such as integrated pest management and crop residue management), farmers can to achieve both economic and environmental sustainability. In addition, buffer strips can improve soil, air, and water quality, create scenic landscapes, provide valuable habitat for wildlife and promote healthy ecosystems. Buffers minimize negative impacts to aquatic ecosystems by slowing the velocity of stormwater runoff and reducing erosion; trapping sediment and reducing turbidity; and improving water quality by intercepting fertilizers, pesticides, pathogens, and heavy metals. Buffers have the potential to remove up to 50% of nutrients and pesticides, 60% of pathogens, and 75% of sediment that otherwise could end up in aquatic systems (NRCS 2001). Buffers provide many benefits to wildlife, including: reducing noise and odor from commercial activities; acting as a source for food, nesting cover, and shelter; and providing corridors that enable wildlife to move safely from different habitat areas. Many financial incentives are available to farmers who commit to using buffer strips. Some incentives are not competitive and can be submitted continuously. Most of the funding for these programs comes from the NRCS, which leads the National Conservation Buffer Initiative. Launched in 1997, the initiative pledges to install 2 million miles of buffers nationwide by the year 2002. One million miles have been installed thus far. The various programs described below are being used in this effort to promote buffer strips. This appendix provides information on buffer strip installation and available easement and incentive programs that could be used for preserving resources in the Merced River corridor.

A number of programs are in place to coordinate easements and incentive programs with interested landowners. A range of easement and incentive programs available to landowners is summarized in Table D-1. These programs are described in more detail below.

Table D-1. Summary of Conservation Options for Landowners

Program	Purpose	Term	Eligibility	Requirements	Incentives	Agency and Website
Conservation Easements						
Federal Programs						
Wetlands Reserve Program	restore wetlands on private lands by retiring marginal agricultural lands	Perman-ent, 30 years, and 10 years	Landowner must have owned the land for at least one year.	Land must be restorable and suitable for wildlife benefits.	varies with time commitment, but pays up to 100% of the cost of restoration plus an easement payment	NRCS http://www.nh-q.nrcs.usda.go-v/OPA/FB96OP-A/WRPfact.html
Farmland Protection Program	protect farmland from residential and commercial development by providing matching funds to state, local, tribal governments, and NGOs to purchase easements	Minimum 30 years to perman-ent	Land must be covered by a conservation plan and privately owned.	Productive soils and property must be large enough and surrounded by other agricultural parcels to sustain long-term agricultural production.	conservation easement payments	NRCS http://www.nh-q.nrcs.usda.go-v/OPA/FB96OP-A/FPPfact.html
Emergency Watershed Protection Program	relieve imminent hazards to life and property caused by floods, fires, windstorms, and other natural hazards	N/A; provided on emerge-ncy basis	Projects must be on public and private land and benefit more than one landowner.	Projects must reduce threats to life and property, be economically and environmentally defensible, sound from an engineering standpoint, and represent the least expensive alternative.	covers 75% of construction cost of emergency measures, remaining 25% must come from local sources	NRCS http://www.nh-q.nrcs.usda.go-v/CCS/ewpFs.h-tml

Table D-1. Summary of Conservation Options for Landowners, continued

Program	Purpose	Term	Eligibility	Requirements	Incentives	Agency and Website
Conservation Easements						
State Programs						
California Land Conservation Act of 1965 (Williamson Act)	lower property taxes for lands maintained in agricultural and certain open space uses	10 years	Can be on public or private land.	Land must be designated by a city or county as an agricultural preserve, scenic highway corridor, or wildlife habitat area.	Property taxes are recalculated based on the actual use of the land instead of the its potential value assuming full development.	Local planning or community development departments http://ceres.ca-.gov/wetlands/-introduction/w-illiamson.html
California Farmland Conservancy Program	provide long-term private stewardship of agricultural lands through the use of agricultural easements	Perman-ent	Local governments, resource conservation districts, non-profit organizations, regional park districts that have conservation of farmland among their stated purposes.	Property must be large enough to support commercial agricultural activities.	Easement payout is the difference between the fair market value of the land and the restricted value of the property	California Department of Conservation http://www.con-srv.ca.gov/dlrp-/CFCP/index.ht-m
Resource Conservation District Assistance Program	implement projects on public or private lands that conserve natural resources and to educate landowners and the public about resource conservation	Project-depend-ent	Only resource conservation districts are eligible to apply for grants. Eligible projects include: land restoration, fish and wildlife enhancement, urban/rural water conservation, and public outreach and education.	Each application must include a narrative that summarizes the project, provides an overview of the partners and funding sources, and justifies the project. Applications must also include a work plan. 25% of the project cost must come from local sources, and 40% of the matching funds must be in cash.	Grants provide 75% matching funds for projects.	California Department of Conservation http://www.con-srv.ca.gov/dlrp-/RCD/index.htm

Table D-1. Summary of Conservation Options for Landowners, continued

Program	Purpose	Term	Eligibility	Requirements	Incentives	Agency and Website
Buffer Strips						
Conservation Reserve Program	to establish long-term vegetation conserving on farmland	10 to 15 years	Landowner must have owned the land for at least 1 year and the land must have been used for agricultural production for 2 of the 5 most recent crop years.	Land must be devoted to environmental practices such as filter strips, riparian buffers, grass waterways, shelter belts, wellhead protection areas, or other similar practices.	Annual payment based on rents for similar lands. For restoration of wetlands, the program pays a one time incentive of 25% of the cost in addition to the 50% cost share to establish wetland vegetation.	Farm Service Agency http://www.fsa-.usda.gov/daf-p/cepd/crp.htm
Incentives Programs						
Environment-al Quality Incentives Program	provides technical, financial, and educational assistance to farmers and ranchers who face serious threats to soil, water, and related natural resources in national priority areas.	5 to 10 years	Limited to landowners engaged in livestock or agricultural production, except for owners of large confined livestock operations.	A conservation plan must be produced for the property and address natural resource concerns.	Cost sharing up to 75% of the cost for certain conservation practices to improve and maintain the health of natural resources in the area and payment up to 3 years to perform land management practices. Incentives are capped at $10,000 per person per year and $50,000 for the length of the contract.	NRCS http://www.nh-q.nrcs.usda.go-v/OPA/FB96OP-A/eqipfact.html
Wildlife Habitat Incentives Program	provides both technical and cost share payments to help establish and improve fish and wildlife habitat	5 to 10 years	Landowner must agree to prepare and implement a wildlife habitat development plan.	All lands are eligible except for federal lands, and lands currently enrolled in conservation programs.	NRCS provides technical assistance and pays 75% of the cost of installing wildlife improvements.	NRCS http://www.nh-q.nrcs.usda.go-v/OPA/FB96OP-A/WhipFact.ht-ml

Federal programs sponsored by the USDA Natural Resources Conservation Service (NRCS)

Wetlands Reserve Program

The Wetlands Reserve Program (WRP) provides financial incentives to landowners to restore wetlands on private property by retiring marginal agricultural lands. The WRP was authorized by the Food Security Act of 1985 and was amended by the 1990 and 1996 Farm Bills. Funding for WRP comes from the Commodity Credit Corporation and is administered by the NRCS in consultation with Farm Service Agency (FSA) and other federal agencies. Prior to enrolling in the program, the landowner must have owned the land for a minimum of one year. Land eligible for WRP must be restorable and suitable for wildlife and can include previously restored wetlands enrolled in the Conservation Reserve Program (CRP). Ineligible lands include: wetlands converted to cropland or pasture after December 1985, timber stands established under a CRP contract, federal lands, and lands in which conditions make restoration infeasible. WRP participants either sell conservation easements or enter into cost-share agreements with the USDA to protect wetlands. Riparian projects funded under this program emphasize stabilization of stream corridors, expansion of floodplains, and improving water quality benefits, as well as providing flood relief, wildlife habitat, and potential educational and research activities. The program offers landowners the option of entering a permanent easement (which also pays 100 percent of the cost restoring the wetland), 30-year easement, or restoration cost-share agreements. Although the latter two are usually only partially funded (the 30 year easement pays 75 percent of the permanent easement and the cost share agreement pays 75 percent of the cost of restoration of the wetland) by the NRCS, landowners are encouraged to find partnerships with other agencies or private conservation organizations to provide additional assistance for easement payment or restoration costs to make up the difference, thereby reducing costs for the landowner and increasing involvement of local groups.

Farmland Protection Program

The Farmland Protection Program (FPP) allows farmers to keep their land in agriculture and protect farmland from conversion to nonagricultural uses. The FPP was authorized by the 1996 Farm Bill and is financed through the Commodity Credit Corporation. Funds are distributed by the NRCS. The program provides matching funds for local, state or tribal entities with existing farmland protection programs to purchase conservation easements to preserve land for agricultural uses. State, tribal and local governments are required to provide at least 50% of the fair market value of the interest they are acquiring. Funds can be used to purchase easements on prime, unique or other productive soils. Eligible farmland must be threatened by development and located next to agricultural infrastructure and markets to ensure future viability. All lands enrolled in the program must develop a conservation plan, which encourages good stewardship. Landowners must agree to keep their land in agriculture and retain all rights to use the property for agricultural purposes. The program requires a minimum conservation easement terms of 30 years, although priority is given to perpetual easements.

Emergency Watershed Protection

The Emergency Watershed Protection (EWP) program helps protect property threatened by natural disasters such as floods, hurricanes, tornadoes, and wildfires. In many cases, EWP provides funding to property threatened by excessive erosion and flooding, and can include stabilizing riverbanks, restoring riparian vegetation, and preserving floodplain habitat. EWP was authorized by the Agricultural Credit Act of 1978 and the 1996 Farm Bill and is administered through NRCS. EWP is designed to assist more than one landowner facing a common hazard. A local agency or tribal entity sponsor is required for eligibility under the EWP program.

Examples of traditional projects funded by EWP include: removing debris from streams, road culverts, and bridges; reshaping and protecting eroded banks; correcting damaged drainage facilities; repairing levees and structures; restoring vegetation; and purchasing floodplain easements. Projects must be sponsored by a political subdivision of a state, such as a city, county, improvement district, or conservation district. Public and private landowners are eligible for assistance, but must be represented by a project sponsor. EWP funds cannot be used to improve the level of protection above the pre-disaster condition or correct problems that existed before the disaster. EWP funds cannot be used to fund maintenance work, repair structures installed by another federal agency, or build structures that do not reduce hazards. EWP projects must: reduce threats to life and property, benefit more than one person, represent the least expensive alternative, be economically justifiable, improve the environment, and utilize sound engineering principals. EWP provides up to 75 percent of the funds needed to restore the natural function of the watershed and the sponsor of the project pays the remaining 25 percent. Applications must be submitted within 10 days after the natural disaster for exigency situations and within 60 days for nonexigency situations.

The Federal Agricultural Improvement and Reform Act of 1996 amended the EWP to include the purchase of floodplain easements as emergency measures. Floodplain easements are important conservation tools that restore, protect, maintain, and enhance the functions of the floodplain. Undeveloped floodplains conserve fish and wildlife habitat, improve water quality, retain flood water, recharge ground water, and preserve open space, reduce long-term federal disaster assistance, and safeguard lives and property. EWP funds can be used to purchase easements on floodplains that have been impaired within the last 12 months or that have a history of flooding. The terms of the easements are permanent and the landowner must grant authority to NRCS to restore and enhance the floodplain. The landowner receives either a rate established by the NRCS state conservationist, a value based on a market appraisal analysis, or the landowner's offer as an easement payment. EWP funds can pay up to 100 percent of the cost to restore floodplain functionality and 75 percent of the cost to remove buildings. Landowners retain the rights to control access and undeveloped recreation, such as hunting and fishing. Additionally, the landowner may obtain authorization from NRCS to engage in other activities, such as timber harvest, growing hay, or grazing. However, NRCS determines the amount, timing, intensity, and duration of any compatible uses.

For both options, sponsor's application must include a letter signed by an official of the sponsoring organization and should include information on the nature, location, and scope of the problem.

For more information on NRCS programs, contact:

Merced Service Center
2135 Wardrobe Ave. Ste C
Merced, CA 95340-6445
(209) 722-4119
(209) 725-2964 fax

Los Banos Service Center
745 J St.
Los Banos, CA 93635-4317
(209) 826-5770
(209) 826-7052 fax

State programs sponsored by the California Department of Conservation

California Land Conservation Act of 1965 (Williamson Act)
The California Land Conservation Act, commonly known as the Williamson Act, allows landowners to enter into contracts with local governments (cities and counties) to keep their land in agriculture or open space use for a 10-year period, which is renewed annually. The landowners receive property tax benefits by entering into these contracts. Eligible land must be designated by the city or county as an agricultural preserve, scenic highway corridor, or wildlife habitat area, or it must be actively used for the three years immediately preceding the beginning of the contract as a saltpond, managed wetland, or recreational or open space area.

California Farmland Conservancy Program
The California Farmland Conservancy Program (CFCP), formerly known as the Agricultural Land Stewardship Program, provides funding for projects which use and support agricultural conservation easements between landowners and government agencies. Easements funded by the CFCP must be of a size and nature suitable for viable commercial agriculture. Although private landowners cannot directly apply for funding under the CFCP, individuals may contact eligible applicants (land trusts, cities, counties, or qualified non-profit organizations) to determine whether their property is consistent with the goals and objectives of the sponsoring entity. Agricultural conservation easements can provide income and property and estate tax benefits. The first use of the CFCP in Merced County was in February of 2000. The CFCP (along with matched funds from the USDA's FPP) issued grants to the American Farmland Trust to purchase a permanent agricultural conservation easement on the O.Z. Ranch, south of Delhi.

Resource Conservation District Assistance Program
In an effort to preserve open space and agricultural areas within the state, the California Department of Conservation's Division of Land Resource Protection provides grants to California's 103 Resource Conservation Districts (RCDs) to help fund conservation and preservation activities. RCDs implement projects on public and private lands to conserve, restore, enhance and manage various land use areas including wildlife, wetland, agricultural, open space, recreational, and forest habitats. Like the CFCP, assistance is provided to the RCD, and local landowners can contact the RCD for applications submitted on their behalf. The East Merced RCD services Merced County.

Conservation Reserve Program
The Conservation Reserve Program (CRP) was authorized by the Food Security Act of 1985 and is implemented by the Commodity Credit Corporation through FSA. The NRCS, Cooperative State Research and Education Extension Service, state forestry agencies, and local soil and water conservation districts provide program support. The CRP provides annual rental payments, incentive payments, and cost-share assistance to establish buffers on eligible land. The program encourages farmers to plant buffers to improve soil, water, and wildlife. Eligibility for this program requires that land must have been planted with a crop for two of the last five crop years and the land must have been in the same ownership for at least one year. Certain marginal pasturelands are also eligible if they are enrolled in the Water Bank Program. The following additional requirements must be met

for land to be eligible for CRP incentives: an erosion index of eight or highly erodable land, the property is a cropped wetland, the property is subject to scour and erosion, the property is located in a national or state CRP priority area, and the land is cropland associated with adjacent non-cropped wetlands. Additionally, the landowner must convert the land covered under the program to filter strips, riparian buffers, grass waterways, shelter belts, or wellhead protection areas. Although enrollment is continuous and noncompetitive, contracts are ranked and selected based on an environmental benefits index. Rental rates are calculated based upon the productivity of soils within each county and the average rent paid for local cropland over the pervious three years. Currently a sign-up incentive is available of $100 to $150/acre for certain buffer practices and an additional incentive covers 40 percent of the installation cost. Incentives are also available for other conservation practices including a 40 percent cost-share incentive for field windbreaks, grassed waterways, filter strips, and riparian buffers. A 10 percent cost-share incentive is available for land located within a wellhead protection zone. The USDA pays an additional 50 percent of the cost to establish a riparian buffer. The terms of the contract last between 10 to 15 years.

Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) was established by the 1996 Farm Bill and provides technical, financial, and educational assistance to farmers and ranchers who face serious threats to soil, water, and related natural resources in national priority areas. EQIP includes four former USDA conservation programs: the Agricultural Conservation Program, Water Quality Incentive Program, Great Plains Conservation Program, and the Colorado River Basin Salinity Control Program. Funding for EQIP comes from the Commodity Credit Corporation and is administered by NRCS. Eligible land uses include cropland, rangeland, pasture, forestland, and other farm or ranch lands. Confined livestock operations are not eligible for cost-share assistance for animal waste storage or treatment facilities. Funds can be used to install or implement structural, vegetative, and management practices. Eligible lands are identified by a localized conservation effort that is facilitated by the local conservation district. A conservation plan is developed through a collaborative process that includes: the local conservation district, NRCS, Farm Service Agency, Cooperative State Research, Education, and Extension Service, other federal and state agencies, local agencies, and community members interested in natural resource conservation. All EQIP projects must be carried out according to site-specific conservation plans. Applications are accepted throughout the year and are then ranked based on the environmental benefit that they will provide. Funded applications maximize the environmental benefit per dollar spent. The program covers up to 75 percent of the cost associated with implementing grassed waterways, filter strips, manure management facilities, capping abandoned wells, and other practices that improve or maintain the health of natural resources. Additionally, incentive payments are made to encourage land manage-

Photo/Stillwater Sciences

ment practices such as nutrient management, manure management, integrated pest management, irrigation management, and wildlife habitat management. EQIP contacts provide incentive payments and cost sharing for 5 to 10 years. Cost-share and incentive payments are limited to $10,000 per person per year and $50,000 for the length of the contract.

Local Resources for Landowner Conservation

California Department of Conservation
Division of Land Resource Protection
801 K Street, MS 13-71
Sacramento, CA 95814-3528
Phone: (916) 324-0850
Fax: (916) 327-3430
Email: dlrp@consrv.ca.gov

USDA Farm Service Agency
Merced Service Center
2135 Wardrobe Ave. Ste C
Merced, CA 95340-6445
(209) 722-4119
(209) 725-2964 fax

East Merced RCD
Merced Service Center
2135 Wardrobe Ave. Ste C
Merced, CA 95340-6445
(530) 756-2387

California Dept of Forestry and Fire Protection
California Forest Stewardship Program
PO Box 944246
Sacramento, CA 94244-2460
Jeffrey Calvert
(916) 653-8286
jeffrey_calvert@fire.ca.gov

Wildlife Habitat Incentives Program

The Wildlife Habitat Incentives Program (WHIP) provides both technical assistance and cost-share payment to establish and improve fish and wildlife habitat. WHIP was authorized by the 1996 Farm Bill and is administered through the NRCS. All land is eligible for incentives from WHIP except for federal land; land enrolled in the Water Bank Program, Conservation Reserve Program, Wetlands Reserve Program, or other similar programs; land subject to the Emergency Watershed Protection Program; or land that the USDA determines is unlikely to improve the quality of wildlife habitat. Additionally, WHIP funds cannot be used for mitigation or on converted wetlands. Landowners or land managers agree to prepare and implement a wildlife habitat development plan. The NRCS offers technical assistance to help participants prepare the plan in consultation with the local conservation district. The plan lists the participant's goals for improving wildlife habitat, the practices used, and a schedule for installing them, and details the steps necessary to maintain the improved habitat for the life of the project. WHIP funds are distributed to states based on state wildlife habitat priorities, which are developed through a locally led process that identifies wildlife resource needs. Under the terms of the contract, the participant agrees to install and maintain habitat improvements and allow the NRCS to monitor the effectiveness of the improvements. The USDA provides technical assistance and pays up to 75 percent of the cost of installing the habitat improvements. The participant can also explore additional funding from cooperating state wildlife agencies and nonprofit or private organizations. The USDA and the participant enter into a contract that lasts from 5 to 10 years.

APPENDIX E
Biotechnical Erosion Control


Photo/International Erosion Control Association

Biotechnical methods are designed to protect streambanks and control erosion while providing or enhancing habitat value. Biotechnical erosion control methods use a combination of vegetative and structural materials that function together in mutually reinforcing or complimentary ways to protect slopes and streambanks and control erosion. Biotechnical methods incorporate vegetation, living and/or dead, in ways that mitigate or prevent erosion, protect erosion control structural components, and provide favorable site conditions for the establishment of a permanent vegetative cover.

Conventional methods of streambank stabilization and erosion control such as riprap, concrete lining, and gabion baskets often have negative effects on geomorphic processes and aquatic and terrestrial habitats. Biotechnical methods, on the other hand, incorporate tree plantings, boulders, rootwads, or other structures that can improve instream habitat complexity and, once vegetation has matured, can shade the stream and provide habitat for birds and other species. Biotechnical methods are considered especially appropriate for environmentally sensitive areas such as parks, woodlands, riparian areas, and scenic corridors where aesthetics, wildlife habitat, or native planting may be critical. Biotechnical methods are generally more cost-effective than conventional methods, especially when long-term maintenance and repair are factored in because they are designed to be strong initially and grow stronger as the vegetation becomes established. In addition, it is often easier to obtain environmental clearance and necessary permits for erosion control projects that incorporate biotechnical and habitat enhancing elements in their design.

This appendix presents a sample of biotechnical techniques that represents a range of implementation effort and cost. The descriptions in this appendix are not meant to function as instructions for project construction but rather to inform the reader of some of the methods available and associated costs. Those interested in learning more about biotechnical methods or implementing a biotechnical erosion control project on their property should contact their local Resource Conservation District or local erosion control specialist to determine which techniques are best suited for the site, which permits may be required, and the costs of implementation.

This appendix was compiled from information taken from manuals, books, and references that document biotechnical methods of slope and streambank protection and erosion control. Primary sources for this appendix are McCullah (1999), Gore (1985), and Flosi et al. (1998).

Seeding and Mulching

Seeding and mulching of disturbed areas are among the simplest and least expensive biotechnical methods to prevent or control erosion.


Photo/International Erosion Control Association

Seeding

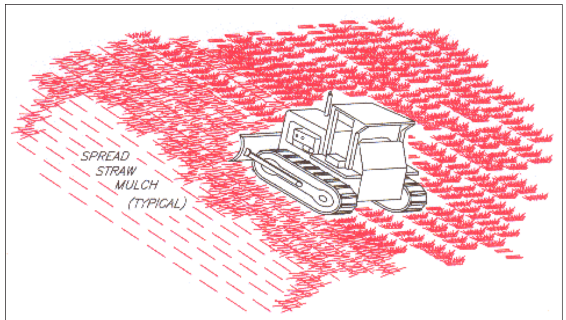
Seeding disturbed areas with native perennial grasses provides a permanent vegetative cover that prevents soil erosion by raindrop impact, reduces sheet and rill erosion, and stabilizes slopes and channels. Native perennial grasses and legumes provide a fibrous root network, which stabilizes the soil while improving wildlife habitat and aesthetics. Seeding is an appropriate method for graded or cleared areas, or in combination with manufactured erosion control products (see Section 2 of this appendix). The proper seed mixture is critical to the success of seeding as an erosion control method. Long-lived, climatically adapted perennial, annual, and legume species that require minimal fertilization, irrigation, and mowing should be used. For small sites that are difficult to access, seeds can be sown by hand. For large sites, which are easily accessible by vehicle, a truck-mounted hydroseeder (pictured at left) can be used to apply a slurry of seeds and fertilizer. At some sites, roughening of the soil surface may be required to increase seed collection and encourage establishment. Appropriate equipment, ranging from hand rakes to bulldozers, depending on the size of the site, can be used to roughen the soil. Consult a local plant materials specialist, erosion control specialist, or Resource Conservation District for the appropriate seed blend for the project site, planting season and rate of application.


Photo/Southern California Hydroseed and Hydromulch, Inc.

Cost: $2,500–$7,000/acre depending on application method.

Mulching

Mulching is the application of a protective layer of straw or other suitable material on top of the soil surface to protect bare or recently seeded areas from raindrop impact or sheet and rill erosion by increasing infiltration, conserving moisture, and preventing soil compaction. Mulch provides temporary erosion control until a permanent vegetative cover is established. Straw is a commonly used mulching material because of its low cost, but other materials such as wood chips and bark can also be used. Clean straw should be used to limit the introduction of non-native or noxious plant species to the site. Native grass straw should be used for environmentally sensitive sites. Straw mulch should be evenly distributed by hand or machine to a depth of 2–4 inches. One bale of straw covers approximately 1,000 ft^2. Sites exposed to high winds require anchoring the straw with a bulldozer to enhance the effects of the mulch (pictured at right). It should be noted that over-applying mulch, especially hydromulch, can result in poor germination of seeds. *Cost: $800–$1,000/acre.*



Drawing/John McCullah, *Salix* Applied Earthcare

Erosion Control Products

Numerous manufactured products are available that can be installed alone or in combination with seeding and mulching to control erosion or stabilize banks. Erosion control blankets and cellular confinement systems (or geocells) are two examples of these products.

Erosion control blankets

Erosion control blankets come in rolls, are generally made from straw, coconut fiber, or synthetic material that is enveloped in plastic or biodegradable netting, and serve the same function as mulching. The blankets can be used on steep slopes, stream banks, or highly erosive soils where mulch anchoring is necessary but not feasible. Erosion control blankets are most effective when installed after seeding, but can provide effective erosion control for at least one season if used alone. Erosion control blankets are installed by anchoring the top edge of the blanket at the crest of the slope with u-shaped wire staples and soil (pictures at right). Next, the blanket is unrolled down the slope and anchored with staples at manufacturer-specified intervals. The installed blanket can be perforated with small, widely spaced holes and planted with grass plugs. The manufacturer's instructions should always be followed during installation, and an erosion control specialist or Resource Conservation District should be consulted to be sure erosion control blankets are suitable for the project site.


Photo/International Erosion Control Association

Cost: $3,000–$7,000/acre.

Geocells

Cellular confinement systems, or geocells, are three-dimensional, 4–8-inch deep, honeycomb earth-retaining structures used to permanently stabilize soil and slopes. When vegetated or filled with rock, geocells can be used as a flexible channel lin-

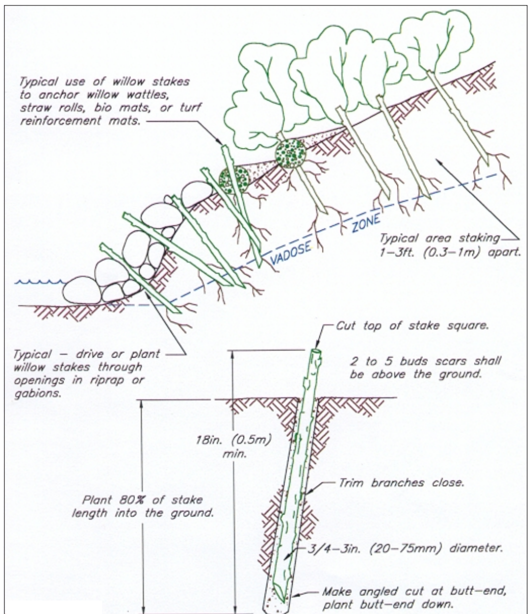

Photo/International Erosion Control Association

ing or as an earth retaining system. The expandable polypropylene honeycomb-shaped cells confine topsoil, protect and reinforce plant roots, and permit natural subsurface drainage. Installation of geocells requires grading the site surface, laying the geocells so that the top of the cells are flush or slightly lower than the adjacent terrain, anchoring cells, and backfilling the cells with topsoil (pictured at left). After backfilling the cells with topsoil, the cells can be seeded or planted.

Cost (depending on type of material): as high as $50,000/acre

Live Plant Staking

Live plant cuttings can be planted to provide cost efficient and effective erosion control and streambank stabilization. Live plant stakes can be used to buttress small soil slips and slumps, armor active headcuts and eroding gullies, anchor and enhance erosion control products, and stabilize stream banks where water is flowing parallel to the bank. The root system of established plant cuttings creates a root mat that reinforces and binds soil particles, while the foliage creates habitat and improves aesthetics.



Drawing/John McCullah, *Salix* Applied Earthcare

Willows are generally the preferred species for live stakes, although any plant that roots from cuttings can be used. Cottonwood and dogwoods are also suitable for live stakes. Willow sources are often available on-site for use as cuttings in riparian areas. If willows, or other appropriate species, are not available on-site, live plant staking may not be a cost-effective method of erosion control.

Willow stakes should be harvested and planted when the plant is dormant. Live, healthy wood that is reasonably straight and at least two years old is most suitable for live stake cuttings. Cuts should be clean, without split ends, and stakes should be approximately ¾ inch in diameter and 18 inches long (pictured at right). Cutting the stake at an angle on the bottom and bluntly on the top makes planting easier and insures that cuttings are planted correctly, with buds up. Branches should be trimmed from the cutting as closely as possible. Trimming terminal buds redirects the plant's energy to root growth, but should not be done with cottonwood cuttings. Cuttings should be planted on the day they are cut, or soaked in water until the day they are planted. Soaking willow cuttings for 5–7 days significantly increases their survival rate, but they must be planted the same day they are removed from water. To plant the cuttings, use an iron stake or bar to make a pilot hole in the soil, and then place the cutting in the hole with approximately 80% of the cutting in contact with the soil, and at least 2 buds or bud scars above the soil level, and lastly, tamp the soil around the cutting (without scaring or scraping the cutting) to insure good contact with the soil.

Cost: 1 hour of work for every 22–54 square feet, including preparation.

Native Material Revetment

Native material revetment is a viable alternative to riprap armoring or gabion type structures to protect streambanks from erosion while providing instream and overhead cover for fish. Native material revetment combines mature tree rootwads and logs with stones or boulders (preferably a locally occurring rock type) and live plant material to armor streambanks and provide a natural looking stabilization structure. The rootwads and boulders increase instream habitat complexity and, once established, willow stakes provide shading of the stream and habitat for birds and terrestrial wildlife. In addition, rootwads create scour pools, which serve as important hiding and resting areas for native fish.

Natural material revetments are most effective when used in river systems where these types of structures occur naturally. The channel morphology and stream type of the project site should be studied to determine if native material revetment will produce the desired effect.

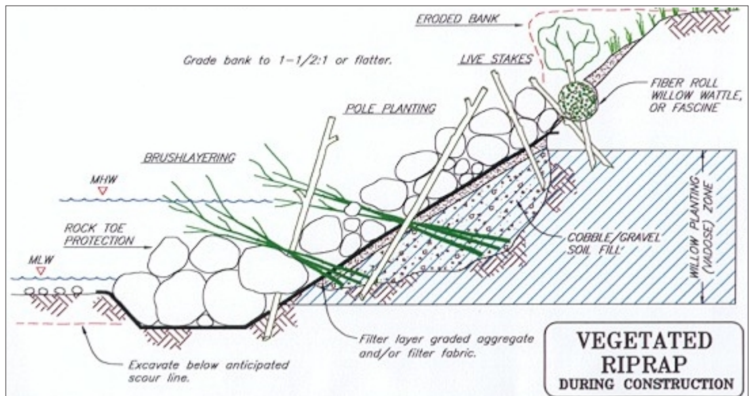
A typical revetment structure includes a large log, a rootwad with at least 6.5 feet of trunk still attached to anchor the rootwad into the bank, boulders or quarry rock of appropriate size and weight for site flow velocities and slope, a filter layer of graded aggregate or filter fabric under the boulders to prevent washout of native soil, and willow cuttings for the live vegetation component. A backhoe or excavator is used to set a "footer" log into a trench excavated below the channel thalwag, running roughly parallel with the bank. A second log with the rootwad attached is set on top of the footer log diagonally forming an "X", with the root wad pointing upstream into the flow and the butt end of the log lying downstream 45–60 degrees. The butt end of the root wad should be set in an excavated trench into the bank. Large boulders and willow stakes are used to secure the rootwad. The willow stakes should be imbedded into the soil to a depth of 1 – 1.6 feet between rocks during construction. The stake ends should extend 1.6 feet above the rock surface and lie at on oblique angle downstream. The lowest stakes in the riprap should be below the level of the mean summer flow and well wedged among the rocks to prevent wash-out.

Cost: approximately 1 hour of heavy equipment use/structure, plus quarry rock. Rootwads and footer logs depend on availability.

Vegetated Riprap

Rock riprap is a common and effective method of streambank protection, but it can be washed out if the river scours the bank and it can degrade habitat value. Bank revetment, such as vegetated riprap, could increase bank erosion downstream and threaten downstream properties or unprotected banks. Riprap can take many years to become vegetated if revegetation is not incorporated during riprap installation. Vegetated riprap is appropriate whenever there is a need to install riprap, but where enhancing aesthetics and habitat is desired. The roots of woody vegetation prevents soil loss from behind the rocks, and helps armor the rock to the bank increasing the rocks' lift-off resistance. In addition, vegetation can slow water velocities along the bank, encouraging sediment deposition. Studies have shown that vegetated riprap fails at a much lower rate than unvegetated riprap (McCullah 1999).

The primary materials for vegetated riprap include quarry stone, a filter layer under the quarry stone of either graded aggregate or filter fabric, and live willow stakes long enough to reach through the quarry stone and into native soil (pictured at right). The willow stakes are imbedded into the soil to a depth of 1–1.6 feet between rocks during construction. Rocks need to be placed, not end-dumped, onto the bank in order to avoid damaging the willow stakes. The stake ends should extend 1.6 feet above the rock surface and should lie at on oblique angle downstream. The lowest stakes in the riprap should be below the level of the mean summer flow and wedged among the rocks to prevent wash-out.



Drawing/John McCullah, *Salix* Applied Earthcare

Cost: similar to traditional riprap construction plus approximately 10% for labor and equipment time to place the rock and install the cuttings.

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