CHAPTER 1. INTRODUCTION

1.1. BACKGROUND OF RESTORATION STUDY REPORT

Over a century of water development in the San Joaquin River basin has contributed to the economic growth of the region, state, and nation through many industries, most notably agriculture. Water development has regulated flows; confined the river system with levees; constructed flood bypass structures; drained and cleared riparian floodplains and wetlands for agricultural, gravel mining and urban uses; and lowered the water table through groundwater pumping. These changes to the river ecosystem have decreased the quantity, diversity, and connectivity of native floodplain habitats along the lower San Joaquin River. These habitat changes have caused a general reduction in wildlife populations and impairment of wildlife movement, and specifically resulted in the extirpation of all anadromous salmonids on the San Joaquin River.

As a result of the cumulative habitat changes resulting from the diversion of natural streamflows in the upper San Joaquin River, a coalition of environmental organizations led by the Natural Resources Defense Council (NRDC) filed suit against the U.S. Bureau of Reclamation. The Friant Water Users Authority (Friant), a joint powers authority under the Central Valley Project (CVP) of the U.S. Bureau of Reclamation, intervened in the suit. After several court proceedings, the NRDC and Friant obtained a stay and entered into settlement agreement negotiations. One component of this settlement agreement process is to develop a San Joaquin River Restoration Study Report (Restoration Study). The parties also developed a Mutual Goals Statement, as follows:

> *"The mutual goals of the parties is to expeditiously evaluate and implement, on a mutually acceptable basis, instream and related measures that will restore natural ecological functions and hydrologic and geomorphologic processes of the San Joaquin River below Friant Dam to a level that restores and maintains fish populations in good condition, including but not limited to naturally reproducing, self-sustaining populations of Chinook salmon. It is further the mutual goal of the parties to accomplish these restoration goals while not adversely impacting the overall sufficiency, reliability and cost of water supplies to Central Valley Project Friant Division water users.*

The intent of the Restoration Study is to develop up to three strategies that will achieve the objectives set forth in the Mutual Goals Statement. Parallel to the Restoration Study development is a corresponding Water Supply Study, which investigates various water supply strategies that will enable implementation of the Restoration Study strategies and minimize adverse impacts to water supply. Once both studies are completed, they will be integrated into a single plan (Figure 1-1). The integrated plan will be part of the underpinnings of the settlement agreement.

1.2. RESTORATION STUDY SCOPE OF WORK

The April 2000 Scope of Work for the San Joaquin River Restoration Study organizes the Study as follows:

- Task 1. Summarize Historical and Existing Conditions. Summarize historical conditions and processes along the San Joaquin River for various geomorphic, vegetative, and biotic indicators; summarize how these conditions have changed over time; and summarize available information to develop the Restoration Study Report.
- Task 2. Analyze Opportunities and Constraints. Analyze opportunities and constraints on restoration activities imposed by human infrastructure, land use, and other programs affecting the San Joaquin River.

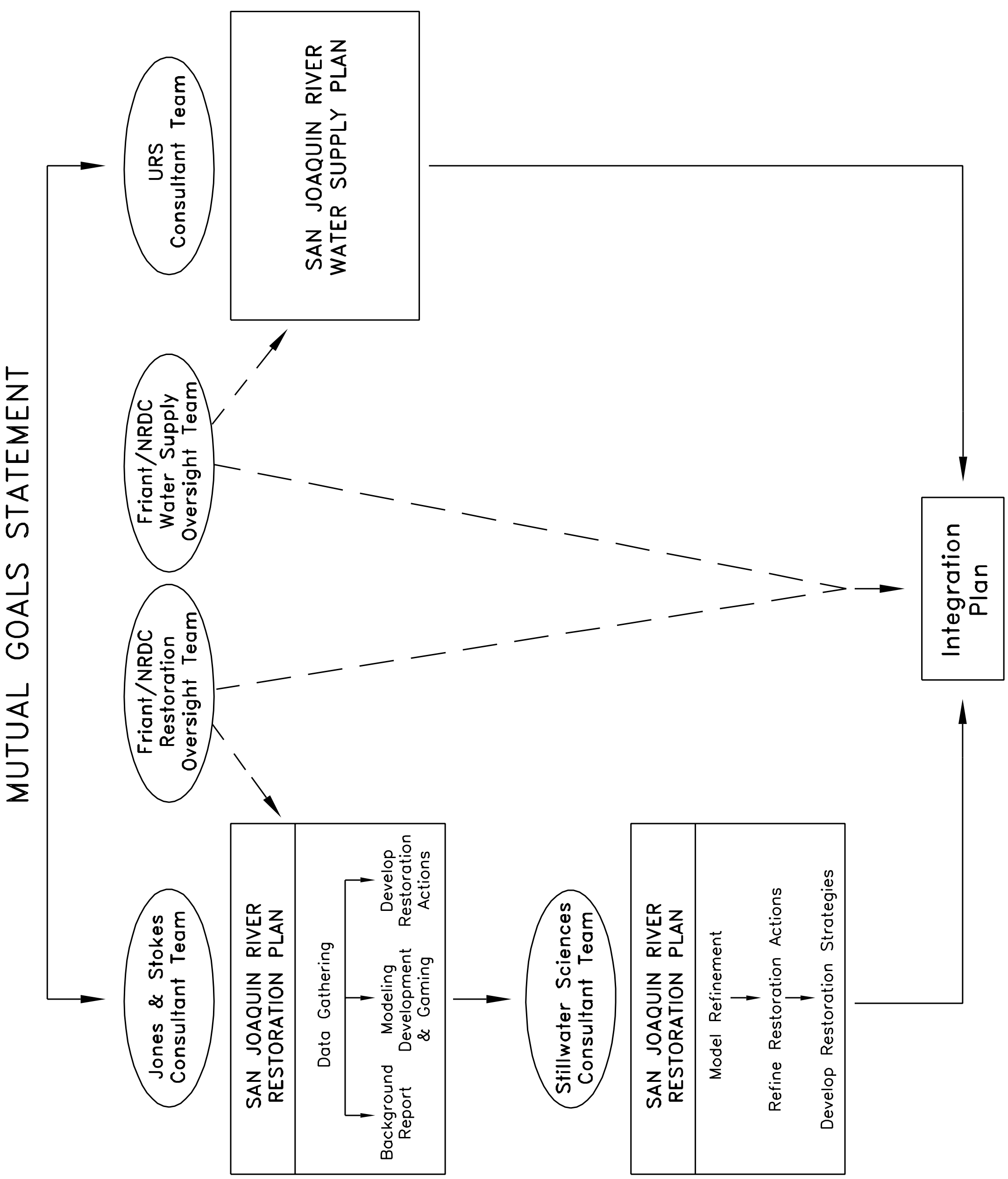


Figure 1-1. The general governing process outlined for development of the Restoration Plan, as defined by the NRDC v. Patterson settlement.

- Task 3. Detailed Description of the Restoration Goal. Evaluate historical and existing conditions in Task 1 and the opportunities and constraints in Task 2, then refine the quantitative objectives for the Restoration Study.
- Task 4. Develop Conceptual Models and Hypotheses. Based on historical and existing conditions and review of recent scientific literature, develop conceptual models of ecological and physical processes for the San Joaquin River, and develop hypotheses which support restoration objectives developed in Task 3.
- Task 5. Quantify Ecosystem Linkages. Identify and quantify linkages between desired environmental conditions and the modifications in flow or habitat necessary to produce these conditions.
- Task 6. Develop List of Potential Restoration Actions. Develop a wide list of possible restoration actions, based on quantitative linkages between desired effects and corresponding modification. Then for each potential restoration action, document the benefit of the action towards achieving the restoration objectives; the anticipated time of achievement; the geographic location, scale, or magnitude of the action; the approximate cost of the action; and water volume required.
- Task 7. Prioritize Restoration Actions. Develop criteria that prioritize actions or groups of actions that best achieve restoration objectives, and evaluate the actions or groups of actions based on the prioritization criteria.
- Task 8. Develop Wide Range of Restoration Strategies: Bundle individual restoration actions into 3 to 5 restoration strategies that achieve the common restoration goal, but encompass a diversity of approaches to achieve that goal.
- Task 9. Refine Restoration Strategies. Based on input from the Restoration Study Oversight Team, refine Task 8 strategies into 2 to 3 final restoration strategies that include details on cost, benefits, constraints, timeline, water and land requirements, and non-flow restoration actions.

The Task 9 restoration strategies will be integrated with the Water Supply Study to develop a final restoration strategy for the Settlement Agreement. Several modifications to this scope of work have occurred since April 2000; however, changes to the scope of work related to this Background Study have been minimal, and can be found in Contract Modification #3 (August 31, 2001).

1.3. OBJECTIVES OF BACKGROUND STUDY

This Background Report is intended to be a stand-alone document that summarizes information generated in Tasks 1, 2, and 4, which will provide a foundation for Restoration Strategy development as part of the Restoration Study effort. In this Background Report, we expend a significant amount of effort on 1) describing the historical conditions and processes of the San Joaquin River, and 2) describing the evolution of these historical conditions and processes to the present. A question commonly asked in similar restoration planning efforts is "Why spend time evaluating the past, when restoration should really focus on the future?" The answer is that by knowing how a river used to function in a healthy condition, we can develop and evaluate restoration measures that best achieve future restoration objectives. In other words, knowing how the river is "broken" gives us tremendous insight on how to fix it. To this end, we focus our analysis on the following:

- How the San Joaquin River used to function as a backdrop to evaluating how contemporary physical and ecological factors limit populations of the fish species and other populations of concern identified in Tasks 1, 2, 3, and 4;

- Hypotheses on the physical and ecological processes and conditions necessary to restore the restoration subcomponents listed above (or identified in Task 3);
- Key linkages between potential management interventions and ecosystem responses that need to be quantified to efficiently scale the management intervention and expert recommendations on the best methods for quantifying those linkages;
- Additional information needs, competing hypotheses, and important uncertainties and disagreements on the hypothetical restoration intervention necessary and recommendations for testing these hypotheses to reduced uncertainty.

1.4. PHYSIOGRAPHIC AND ECOLOGICAL SETTING

The San Joaquin basin setting is briefly described to provide context for the evaluations and analyses in this Background Report. Additional detail can be found in subsequent chapters.

1.4.1. Ecological Functions

We now recognize that ecological systems (ecosystems) are composed of more that just a collection of biological communities. Ecosystems manifest relationships of interdependence and competition among organisms, are driven by variable inputs of energy and nutrients, and are manipulated by humans, all of which result in a high level of complexity and internal structure. Contemporary river ecology has embraced this realization, and restoration efforts are now increasingly adopting a broader, more holistic ecosystem-based approach to conservation and restoration efforts that attempt to improve geomorphic and hydrologic functions of the river (Ligon et al. 1995; Stanford et al. 1996). According to this approach, by restoring the physical structure and processes within the river corridor, we can initiate biotic responses that will eventually support a diverse, resilient assemblage of native plants and animals.

Restoring natural physical processes to the river channel and floodplain offers the basis for successful ecological function within the ecosystem. Ecological process such as floodplain inundation, sediment supply and transport dynamics, and variability in streamflow patterns determine the physical and chemical habitat quality, quantity, structure, and connectivity in river-riparian-floodplain ecosystems. Species abundance, distribution, composition, and trophic structure are directly related to these attributes (Figure 1-2).

Aquatic food webs depend on physical processes within the river channel. Primary (algal) production within the river channel often requires scouring flows to provide surfaces for colonization. Algal mats provide nutrients and habitat for macroinvertebrates and have been shown to be important for macroinvertebrate species diversity (Power 1990). Invertebrate production within the channel and along the floodplain provides food sources for salmonids, as well as other native fishes, and emerging insects provide prey for birds and bats foraging along the river corridor. The nutrient cycle is completed during salmon spawning when carcasses decay and return nutrients to the river, where they can be taken up by primary producers.

A healthy riparian ecosystem also depends on hydrologic and fluvial geomorphic processes, such as inundation regimes and sediment deposition patterns within the river corridor. Supporting a diverse riparian corridor is important because riparian zones provide the interface between terrestrial and aquatic habitats and food webs and are widely recognized as centers of biodiversity and corridors of dispersal for plants and animals within the landscape (e.g., Gregory et al. 1991; Stanford et al. 1996). Riparian forests filter nutrients and agricultural chemicals from runoff; stabilize channel banks; and provide leaf litter for aquatic food webs, large woody debris and overhead cover for fish, and nesting

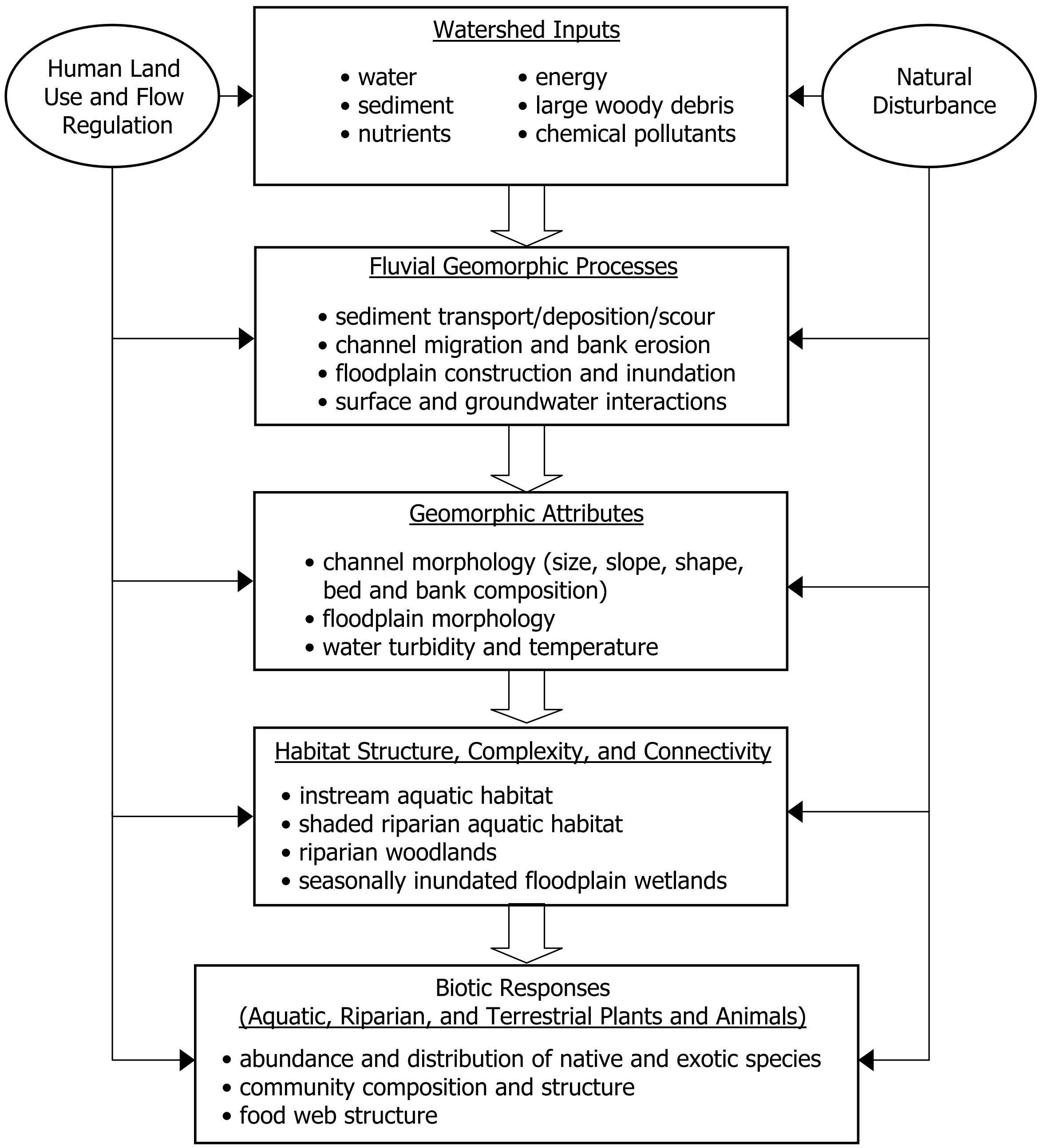


Figure 1-2. A simplified conceptual model of the physical and ecological linkages in alluvial river-floodplain systems.

and roosting habitat and migratory corridors for birds and mammals. Some birds and bats in particular forage over the river corridor and require specific habitat elements along the channel. In addition, over time, successional processes along the floodplain can alter the vegetation composition, and leaf litter from pioneer species can provide nutrients to the floodplain soils, creating suitable habitats for a greater diversity of species.

Non-native species are usually beneficiaries of disturbed ecosystems, and the San Joaquin River is no exception. Restoring more natural hydrologic and fluvial geomorphic conditions often has the added benefit of supporting a shift from non-native species back to healthy ecosystems and food webs dominated by native species.

1.4.2. Watershed Characteristics and Hydrology

The San Joaquin River and Sacramento River are the two largest rivers in the Central Valley; the Sacramento River drains the northern portion of the valley and the San Joaquin River drains the south (Figure 1-2). The San Joaquin River originates in the highest peaks in the Sierra Nevada Mountains above 11,000 ft, and flows down to sea level at the delta. Where the San Joaquin River leaves the Sierra Nevada foothills at Friant, the watershed area is 1,676 mi^2, and the watershed area near the delta at Vernalis is 13,536 mi^2. Precipitation in the watershed is variable and depends on watershed elevation, ranging from as little as 6 inches/year on the valley floor, to as much as 70 inches/year at higher elevations of the Sierra Nevada. Precipitation above the 4,000 ft to 5,000 ft elevation is primarily snowfall, and its melting dominates the unimpaired streamflow hydrology on the river.

Snowmelt runoff generates a majority of the flow volume from the watershed. Unimpaired snowmelt peak flows at Friant ranged from 3,500 cubic feet per second (cfs) to over 30,000 cfs, with typical values in the 10,000 cfs to 15,000 cfs range. Winter rain-on-snow events contributed much larger floods than the snowmelt peak flows, sometimes exceeding 95,000 cfs (e.g., 1997 flood inflows, 1862 flood). While the snowmelt peaks likely played a less important channel-forming role than the winter rain-on-snow events, the snowmelt runoff period was probably the most important biological hydrograph component. The spring snowmelt hydrograph caused prolonged periods of overbank inundation, creating vast floodplain and wetland habitat that supported large populations of fish and wildlife.

A unique aspect of the San Joaquin River's hydrology was the interaction between the San Joaquin River and the Tulare Basin during flood flows. Historically, flood flows likely drained from the San Joaquin River into Tulare Basin when Tulare Lake was at a moderate to low elevation, and when Tulare Lake was higher and/or the Kings River was at high flow, flood flows from the Tulare Basin drained into the San Joaquin River at Mendota. This flood flow contribution from the Kings River still occurs, but the contribution of flood flows from the San Joaquin River to Tulare Lake is rare. For baseflows, historical accounts suggest that the shallow groundwater and artesian springs substantially augmented summer and fall baseflows to the lower San Joaquin River (Grunskey 1929). These historical accounts also describe the San Joaquin River as susceptible to floods and droughts, with droughts being more severe than those experienced in the Sacramento River basin. San Joaquin basin droughts were most likely more severe because the San Joaquin River groundwater contribution was less than the comparable contribution of springs and shallow groundwater in the Sacramento River and its tributaries.

Contemporary hydrology is dominated by irrigation storage, irrigation delivery, and flood control releases. Irrigation and flood control has virtually eliminated all traces of the natural flow regime, with the periodic exception of flood control releases. Reach 1 has a constant baseflow to provide for riparian water rights (50 cfs to 300 cfs), Reach 3 has releases for downstream diversion at Sack Dam (200 to 500 cfs), and lower Reach 4B and Reach 5 receive varying amounts of agricultural return flows. Reach 2 and 4 are usually perennially dry. Even though the Friant Dam outlet works can release up to 16,000 cfs, contemporary flood control restrictions limit releases to less than 8,000 cfs. Larger releases can still occur during very large storm events that encroach into the flood control space behind Friant Dam, as occurred in 1997 when 60,300 cfs was released (ACOE 1999). Further impacting this loss of surface water to the river is the groundwater pumping in downstream reaches of the river. Groundwater pumping has eliminated most of the historic groundwater contribution to the river, and in most reaches, shifted the river from gaining flows from groundwater contribution to losing flows due to infiltration into the depressed shallow groundwater table.

1.4.3. Geology and Geomorphology

The geomorphology of the San Joaquin River is strongly influenced by the underlying geology of the Sierra Nevada Mountains, the Coast Range, and the San Joaquin Valley. Because aquatic and terrestrial habitats are created and maintained by geomorphic and geologic processes, the geologic and geomorphic context is an important consideration in restoration efforts (Figure 1-2). The upper San Joaquin River watershed originates in the Sierra Nevada, and the underlying geology is dominated by crystalline igneous rocks (granite and quartzites). The young age and rapid uplift of the Sierra Nevada, combined with repeated periods of glaciation, resulted in steep, deeply incised river canyons. Sediment yield is low, and combined with the high sediment transport capacity in the canyon, the channel morphology is dominated by bedrock with very little sediment storage.

Tectonic uplift of the Sierra Nevada range, subsidence of the San Joaquin Valley, and surface erosion of the watershed are the dominant natural forces that control the San Joaquin River's morphology between the foothills and the delta. As the river exits the Sierra Nevada foothills, gradient and confinement decrease, and alluvial sediment storage increases. The river quickly transforms to an alluvial channel, with a meandering alternate bar morphology in most reaches. The Coast Range bounds the lower San Joaquin River from the west, and alluvial fans from the Coast Range tend to keep the San Joaquin River in the central axis of the Central Valley. Tectonically driven subsidence rates are approximately 0.25 mm/yr, and this subsidence is partially counterbalanced by sediment deposition of alluvial fans from the San Joaquin River and tributaries draining from the Sierra Nevada and Coast Range (Janda 1965). Recent groundwater pumping has rapidly increased this natural subsidence rate (Bull and Miller 1975), with the elevations of some areas west of Mendota decreasing by over 25 feet. Stream gradient is very low in all reaches, with steeper reaches in the foothills less than 0.1 percent, and remaining reaches less than 0.05 percent. This low slope results in a relatively short 35-mile gravel bedded reach downstream of Friant Dam, while the remaining 230 miles are sand-bedded.

1.4.4. Biota

The Central Valley is a unique place; its high degree of productivity and habitat diversity is rarely found anywhere else in the world. This productivity and diversity resulted in large numbers and a diversity of plants and animals. Before land and water development, riparian vegetation between Friant and Gravelly Ford was dominated by sycamore, cottonwood, willow and alder, and was confined between bluffs and terraces. Once the river left the confinement of the foothills and terraces at Gravelly Ford, riparian vegetation and wetlands extended laterally downstream to Mendota. Vegetation within the San Joaquin River floodway downstream of Mendota was historically dominated by tule marsh, which thrived under periods of prolonged inundation from snowmelt runoff, flow contribution from the Tulare Basin, artesian springs, and shallow groundwater contribution. Tule marsh was fringed with riparian vegetation along the river margins, and by grasslands, desert saltbush, and Frankenia in alkaline upland areas (summarized in Preston 1981).

The San Joaquin River corridor and adjoining grasslands once supported large herds of elk and pronghorn antelope, grizzly bear, and other terrestrial species (summarized in Preston 1981). Floodplains and seasonal wetlands supported large numbers of waterfowl, beaver and the river supported salmon populations numbering in the tens of thousands to hundreds of thousands (summarized in Yoshiyama 1999). While the river corridor still supports large numbers of wildlife relative to today's numbers, several species are now extinct or have been extirpated from the San Joaquin River corridor. Populations of remaining species are much smaller than those occurring before land and water development.

1.4.5. Anthropology

The San Joaquin River has been a focal point for human use for thousands of years prior to European immigration. The Yokut people historically inhabited the Tulare Basin and southern San Joaquin River basin, congregating along the riverbanks to take advantage of the river's extraordinary resources. Salmon were an important dietary staple, as were other plants and animals found along the river. With the coming of the Spanish in the late 1700s, and of the Americans in during the gold rush after 1849, the Yokuts and other Native Americans were displaced from their ancestral lands, and land use along the river quickly changed from hunting and gathering to more intensive uses. Navigation, livestock grazing, and seasonal grain crops were the primary land and river uses through the late 1800s. With the increasing irrigation came a rapid agricultural expansion along the river corridor, with the agricultural economy dominating the regional economy. The agricultural economy continues to dominate, although urban and suburban areas along the river are expanding.

1.5. STUDY AREA

The San Joaquin River is bounded by the Sierra Nevada on the east and Coast Ranges on the west; its southern boundary is on divide between the Tulare Lake basin, and its northern boundary is the Delta near Stockton (Figure 1-3). The San Joaquin River Restoration Study area includes approximately 150 miles of the San Joaquin River from Friant Dam at the upstream end near the town of Friant, to the confluence with the Merced River at the downstream end (Figure 1-3). The river flows to the north of the metropolitan area of Fresno, then passes near the communities of Biola, Mendota, Firebaugh, Dos Palos, and Los Banos, within the counties of Fresno, Madera, and Merced (Figure 1-4). As defined in the April 2000 Scope of Work, the study area's width was to correspond with the pre-Friant Dam 100-year floodway. However, this definition of study area width is not explicitly delineated in this report because the inundation area of the pre-Friant Dam 100-year floodway has not been conducted. Instead, we have defined the study area's width based on estimates of unimpaired riparian and wetland areas, derived from other studies that assessed historical sources, soils, and vegetation conditions (Figure 1-5). Certain information downstream of the Merced River confluence is presented and discussed in this Background Report due to its relevance restoration efforts (e.g., delta pumps, water quality); however, this downstream reach is generally considered outside the study area of the Restoration Study and Background Report.

Within this 148-mile section of the San Joaquin River from Friant Dam to the Merced River confluence, the river passes through several reaches differentiated by their geomorphology and resulting channel morphology, and by their human-imposed infrastructure along the river. Therefore, the river has been subdivided into five primary reaches that exhibit similar flows, geomorphology, and channel morphology (Figure 1-3). Reach boundaries, infrastructure, and landmarks are listed in Table 1-1, and each of the five reaches is briefly described below.

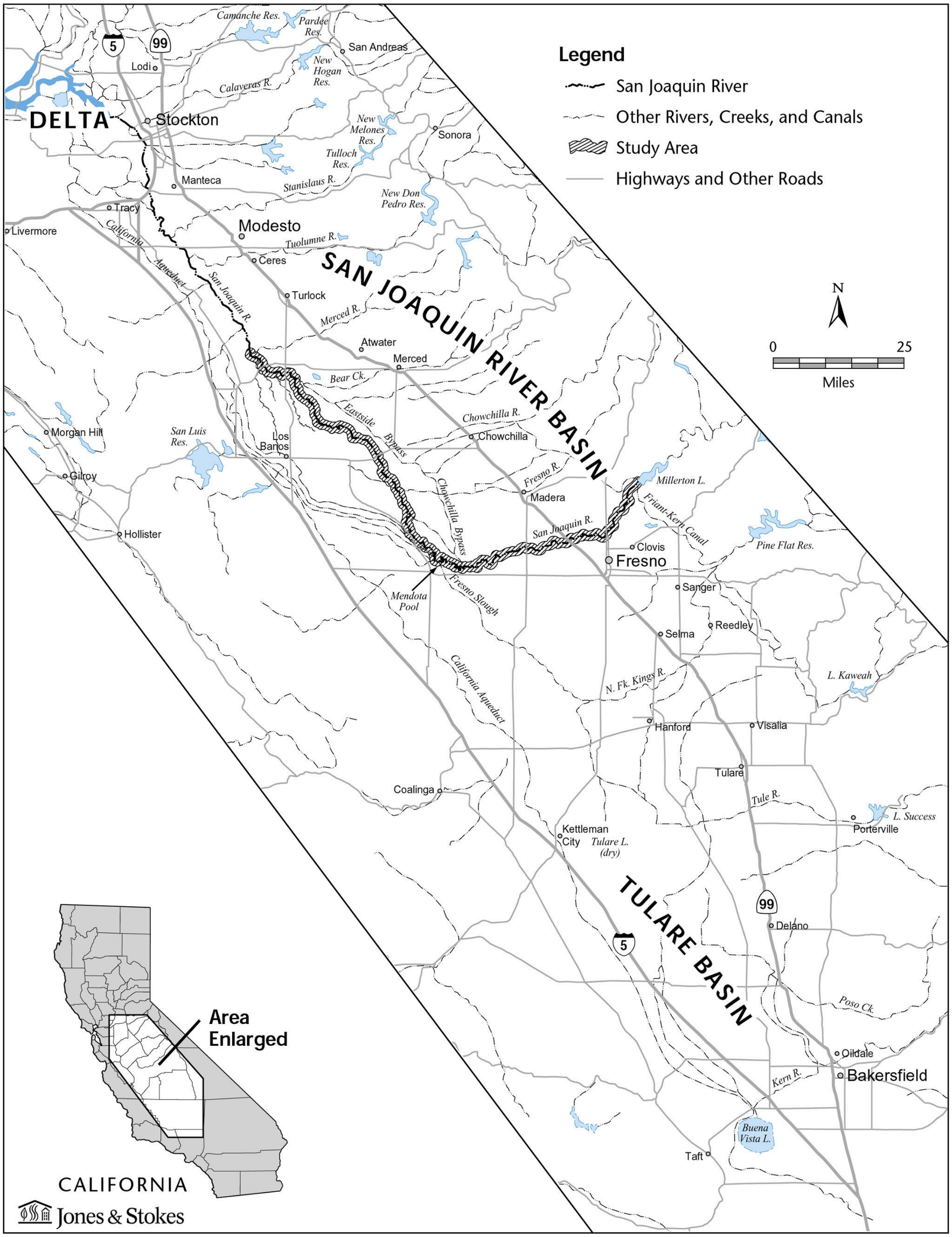


Figure 1-3. Location of the study area for the San Joaquin River Restoration Plan.

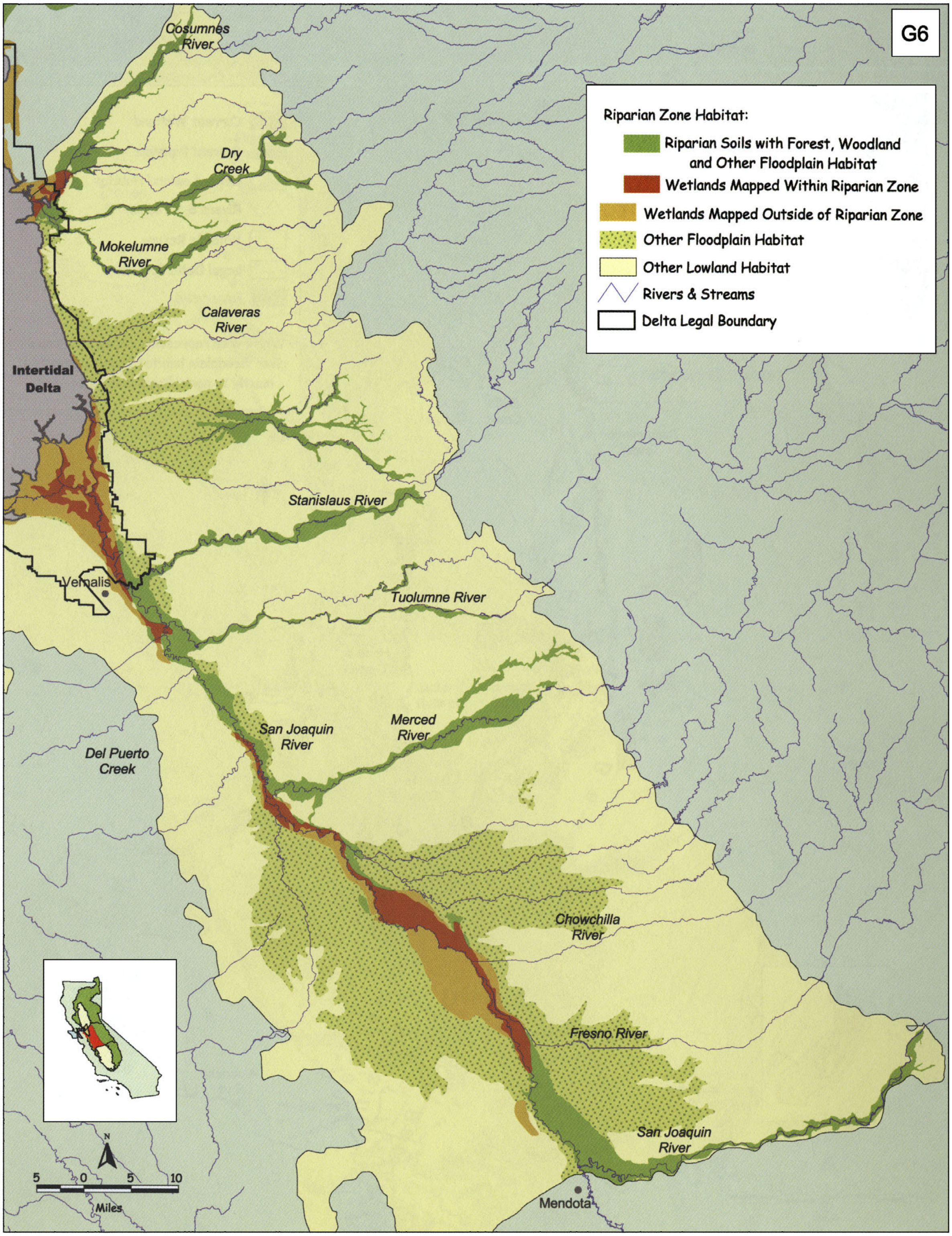
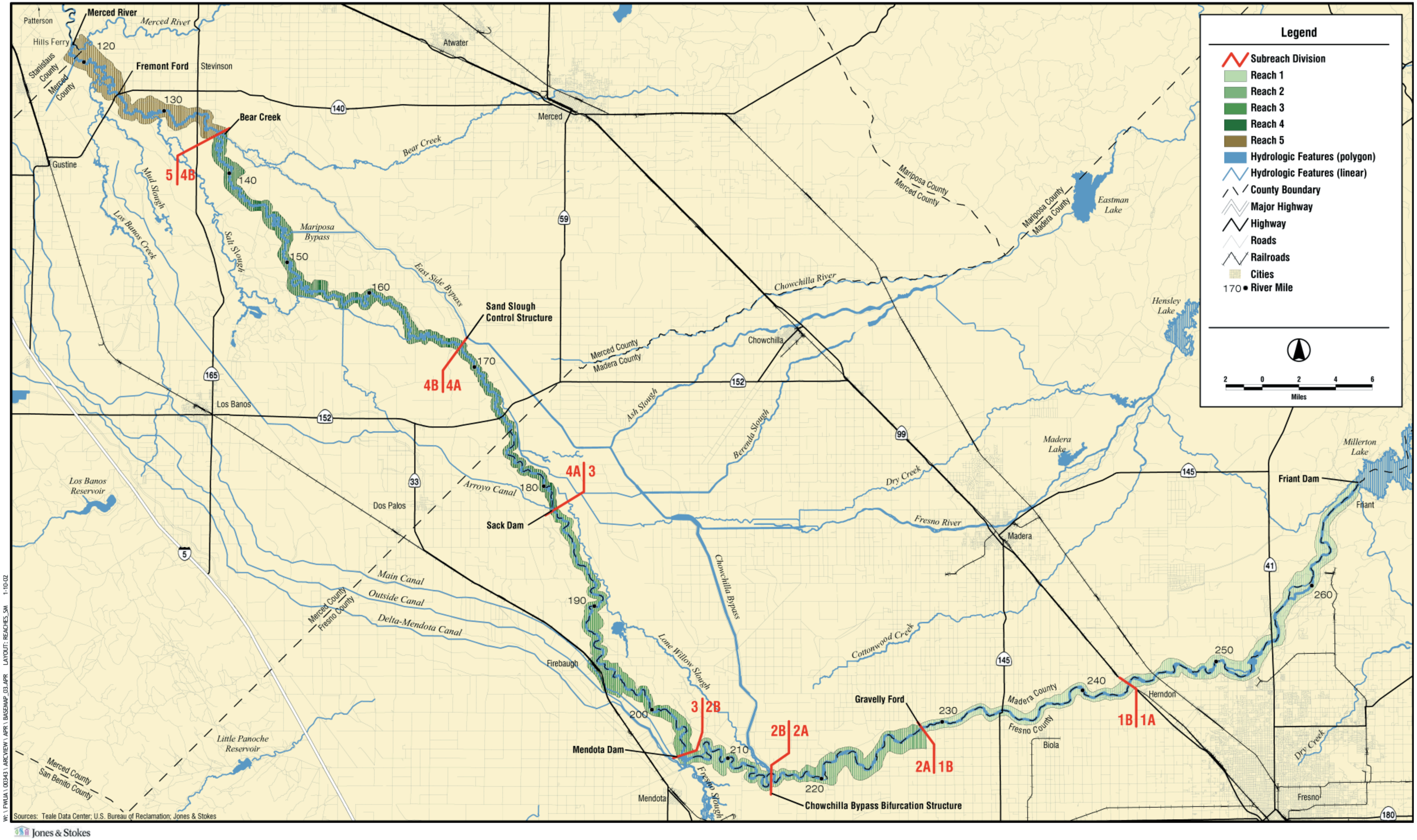


Figure 1-4. Estimated historical extent of the San Joaquin River and floodplain ecosystem, based on evaluation of soil characteristics (from The Bay Institute, 1998).



Jones & Stokes

Figure 1-5. Study area for the San Joaquin River Restoration Plan, showing the reach and sub-reach boundaries.

Table 1-1. River mile boundaries of five reaches, infrastructure, and selected landmarks within the study reach.

	Landmark	River Mile
REACH 1		*267.5 to 229.0*
	Friant Dam	267.5
	North Fork Road Bridge	266.8
	Cobb Island Bridge	259.0
	State Route 41 (Lanes Bridge)	255.2
	Scout Island Bend	250.0
	ATSF Railroad Bridge	245.0
	State Route 99	243.2
	Southern Pacific Railroad	243.2
	State Route 145 Bridge (Skaggs Bridge)	234.1
	Gravelly Ford	229.0
REACH 2		*229.0 to 204.8*
	Gravelly Ford	229.0
	Upstream Limit of Right Bank Levee	227.0
	Upstream Limit of Left Bank Levee	225.0
	Chowchilla Bypass Control Structure	216.1
	Mendota Dam	204.8
REACH 3		*204.8 to 182.0*
	Mendota Dam	204.8
	Avenue 7.5 Bridge (Firebaugh)	195.2
	Sack Dam	182.0
REACH 4		*182.0 to 135.8*
	Sack Dam	182.0
	State Route 152 Bridge	173.9
	Sand Slough Control Structure	168.5
	Mariposa Slough Control Structure	168.4
	Turner Island Road Bridge	157.2
	Mariposa Bypass confluence	147.2
	Bear Creek/Eastside Bypass confluence	135.8
REACH 5		*135.8 to 118.0*
	Bear Creek/Eastside Bypass confluence	135.8
	State Route 165 Bridge (Lander Avenue)	132.9
	Salt Slough confluence	127.7
	State Route 140 Bridge (Fremont Ford)	125.1
	Mud Slough confluence	121.2
	Merced River confluence (Hills Ferry Bridge)	118.0

1.5.1. Reach 1—River Mile 267.5 to River Mile 229.0

Reach 1 begins at Friant Dam, where the San Joaquin River exits the Sierra Nevada foothills and enters the Central Valley floor. The downstream end is defined at Gravelly Ford because this point defines the historical transition between gravel and sand bedded reaches. Reach 1 is gravel bedded, of moderate slope, and is confined by bluffs and terraces. Reach 1 is divided into two subreaches; Subreach 1A extends from Friant Dam to State Route 99, is the steepest portion of Reach 1, and is confined by bluffs. Subreach 1B begins at State Route 99 and extends downstream to Gravelly Ford, and this reach's gradient is much lower, is confined by terraces, and contains the contemporary transition from gravel bedded to sand bedded. Gravel mining and agriculture is the primary land use in this reach.

1.5.2. Reach 2—RM 229.0 to RM 204.8

Reach 2 is entirely sand bedded, and meanders across the Pleistocene alluvial fan of the San Joaquin River between Gravelly Ford and Mendota Dam. The confining terraces end at Gravelly Ford, and mark the beginning of the San Joaquin River alluvial fan. The downstream boundary at Mendota Dam also marks the location where the river intersects the north-south axis of the valley, and where slope decreases. Reach 2 is divided into two subreaches. Subreach 2A begins at Gravelly Ford and extends downstream to the Chowchilla Bypass Bifurcation Structure. Subreach 2B extends from the bifurcation structure downstream to Mendota Dam. Both subreaches have confining levees protecting agriculture land uses in the reach.

1.5.3. Reach 3—RM 204.8 to RM 182.0

Reach 3 is sand bedded and meandering, and is different from other reaches because it contains perennial flows of up to 600 cfs, due to water deliveries from the Delta Mendota Canal, through the San Joaquin River channel, and to the Sack Dam diversion into Arroyo Canal. No unique subreaches are delineated within Reach 3. Agriculture is the primary land use in this reach, and the river is confined by local dikes and canals on both banks.

1.5.4. Reach 4—RM 182.0 to RM 135.8

Reach 4 is sand bedded and meandering, and is usually dewatered due to the diversion at Sack Dam. Reach 4 is divided into two subreaches. Subreach 4A extends from Sack Dam downstream to the Sand Slough Control Structure. The flows in this subreach are usually negligible due to the Sack Dam diversion, but periodically flood control flows are conveyed such that a channel is defined through the reach. Subreach 4B begins at the Sand Slough Control Structure and extends downstream to the confluence with Bear Creek and the Eastside Bypass, The upstream portion of Subreach 4B no longer conveys flows because the Sand Slough Control Structure diverts all flows into the bypass system. As a result, the channel in the upstream portion of Subreach 4B is poorly defined, filled with dense vegetation, and in some cases, Subreach 4B is plugged with fill material. Agriculture is the primary land use in the entire reach. In Subreach 4A, the left bank (west side) of the river is bounded by the Poso and Riverside canals, and the right bank (east side) is confined by local dikes. In Subreach 4B, the river is no longer bounded by canals, but is confined by small local dikes downstream to the confluence with the Mariposa Bypass at the San Luis National Wildlife Refuge. Project levees begin at the Mariposa Bypass and continue downstream on both banks.

1.5.5. Reach 5—RM 135.8 to RM 118.0

Reach 5 is sand bedded and meandering, and flows continuously due to agricultural return flows. No subreaches were delineated within Reach 5. Reach 5 is bounded on the left bank by Project levees downstream to the Salt Slough confluence and on the right bank to the Merced River confluence.

1.6. REPORT ORGANIZATION AND AUDIENCE

1.6.1. Report Organization Principles

The Background Report is organized into chapters based on an interpretation of subtasks in the Scope of Work. To communicate the information required to support the development of the Restoration Study, the Background Report chapters are organized to discuss: 1) the physical and chemical underpinnings of the San Joaquin River ecosystem (Chapters 2-6), 2) the biota that inhabit the San Joaquin River corridor (Chapters 7-9), then 3) the human aspects of the San Joaquin River (Chapters 10-12). The chapters following the introductory Chapter 1 are as follows:

- Chapter 2: Surface Water Hydrology
- Chapter 3: Channel Processes and Form
- Chapter 4: Groundwater Hydrology
- Chapter 5: Water-Related Infrastructure, Flood Control, and Diversions
- Chapter 6: Water Quality and Temperature
- Chapter 7: Fish Resources
- Chapter 8: Vegetation Communities
- Chapter 9: Special-Status Species;
- Chapter 10: Land Use and Ownership
- Chapter 11: Social and Cultural Factors
- Chapter 12: Other Programs, and Downstream Opportunities and Constraints

1.6.2. Audience

The San Joaquin River Restoration Study process contains considerable participation from stakeholders with technical understanding of the issues. Therefore, this Background Report is written as a technical document, but also attempts to simplify and summarize concepts for a non-technical audience within reasonable constraints. The chapters contain technical terminology that reflect the level of science and expertise applied in the course of this study, but attempts have been made to present the analysis in lay terms to inform decision-makers and persons with a general environmental background. Finally, to ensure appropriate context, a comprehensive glossary is not included; but important terms are defined in the body of the text where applicable.

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