Delta-Estuary
California's Inland Coast
A Public Trust Report

Prepared for the

California State Lands Commission

May 1991

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Errata Sheet June 6, 1991

Pg. xi	East Bay Regional Park District
Pg. 5	. . . move to open the way for the traveller to pass. . .
Pg. 33	At this point, the South Bay Aqueduct branches out from the California Aqueduct. The California Aqueduct continues southward to deliver water to the San Joaquin Valley and Southern California.
Pg. 42	. . . high flow through the Delta into the Bay.
	During periods of low inflow and high water diversion, water flow reverses and is pulled back upstream along the channel of the San Joaquin as well as the Old and Middle Rivers. When exports. . .

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Acknowledgements

California State Lands Commission

Leo T. McCarthy, *Lieutenant Governor, Chairman*
Gray Davis, *State Controller*
Thomas W. Hayes, *Director of Finance*

Charles Warren, *Executive Officer*

Elizabeth Patterson, *Delta Project Director*
Division of Environmental Planning and Management

Dwight E. Sanders, *Chief, Division of Environmental Planning and Management*

Contributors:
Division of Environmental Planning and Management
Mary Bergen, PhD.
Daniel Gorfain
Jacques Graber
Diana Jacobs, PhD.
Kirk Walker

Claire Goldstene, *Executive Fellow*

Dan Cato, *Student Assistant*

Lisa Lloyd, *Secretary*

Kent Dedrick, PhD., *Research Program Specialist*

Curtis Fossum, *Sr. Staff Counsel*
Jan Stevens, *Supervising Deputy Attorney General*

Jeanne Gunther, *Sr. Graphic Artist*
Ruth Odlin, *Sr. Geological Drafting Technician*
Kathy Ross, *Sr. Graphic Artist*

Gala Argent, *Editor*

Bob Walker, *Cover Photograph*

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Glossary of Acronyms

ABAG	Association of Bay Area Governments
AOR	Assembly Office of Research
ARB	Air Resources Board
BCDC	San Francisco Bay Conservation and Development Commission
BMP	Best Management Practices
BOR	Bureau of Reclamation
CALTRANS	California Department of Transportation
CCC	California Coastal Commission
CCMP	Comprehensive Conservation Management Plan
CDMG	California Division of Mines and Geology
CEQA	California Environmental Quality Act
COE	Army Corps of Engineers
CVP	Central Valley Project
CVRWQCB	Central Valley Regional Water Quality Control Board
DAPC	Delta Advisory Planning Council
DDT	dichloro-diphenyl-trichloroethane
DFG	Department of Fish and Game
DOC	Department of Conservation
DOHS	Department of Health Services
DPR	Department of Parks and Recreation
DWR	Department of Water Resources
EBMUD	East Bay Municipal Utility District
EBRP	East Bay Regional Parks
EC	electrical conductivity
EC	Energy Commission
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FDA	Food and Drug Administration

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FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
GHC	Geologic Heat Center
HCB	hexachlorobenzane
LAFCO	Local Agency Formation Commission
MAF	million acre-feet
MTC	Metropolitan Transportation Commission
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
OES	Office of Emergency Services
OPR	Office of Planning and Research
OSR	Office of Secretary for Resources
PAH	polynuclear aromatic hydrocarbons
RB	State Reclamation Board
RCD	Resource Conservation District
S&O	Swamp and Overflowed Lands
SARPCG	Sacramento Area Regional Planning Council of Governments
SCC	State Coastal Conservancy
SCPR	Sacramento County Parks and Recreation
SCS	U.S. Soil Conservation Service
SFEP	San Francisco Estuary Project
SFRWQCB	San Francisco Regional Water Quality Control Board
SLC	State Lands Commission
SMUD	Sacramento Municipal Utility District
SOHP	State Office of Historic Preservation
STR	Status and Trends Report
SWP	State Water Project
SWRCB	State Water Resources Control Board
TBT	tributyltin
THMP	trihalomethane
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
WCB	Wildlife Conservation Board

Foreword

This Commission report has two purposes: 1) to mark the status of the public trust resources in California's great Delta region and the likely future of those resources if present trends continue; and 2) to identify and underscore the importance of the Delta, in the context of the Environmental Protection Agency's current San Francisco Estuary Project.

This status and trends review of the Delta's public trust resources is intended to provide guidance to the State Lands Commission and other governmental agencies whose activities are concerned with or affect public trust values. This report also examines the accomplishments and failures of the public and private sector agencies and organizations whose activities influence or control the fate of the Delta.

The public's right to use California's waterways for navigation, fishing, boating, recreation and other water-oriented activities is protected by the common law doctrine of the public trust. Historically, the doctrine has referred to the basic right of the public to use California's water resources to engage in "commerce, navigation, and fisheries." More recently, the doctrine has been broadened to include the right to swim, boat, and engage in other forms of recreation and to preserve lands as habitat in their natural state.

The public trust doctrine was described by the California Supreme Court in its historic *National Audubon* decision as "... an affirmation of the duty of the state to protect the people's common heritage of streams, lakes, marshlands and tidelands, surrendering the right of protection only in rare cases when the abandonment of that right is consistent with the purposes of the trust." The court was stating the Justinian rule of law accepted universally among civilized nations; a recognition that there are certain resources common to humankind, and that among them are "the air, running water, the sea and consequently the shores of the sea."

Audubon also stated the principle that the state has "an affirmative duty to take the public trust into account in the planning and allocation of water resources, and to protect public trust uses whenever feasible."

Few places in California show the need for public trust protection more than the Delta. Much of the Delta, once the home of immense elk herds, innumerable flocks of geese and ducks, and one of the largest salmon runs on the West Coast, has been diked by levees and drained. Encroaching housing developments bear witness to the increasing attractiveness of the area to residents of the mushrooming San Francisco Bay and Central Valley communities.

The Delta's waterways are among the most important in the State. They serve as the source of invaluable water supplies, at least in part, for two-thirds of the state's population and much of California's agricultural production. However, the traditional values of navigation, fishing and recreation are threatened by the competing demands of the federal and state water projects and urban growth. If further irreparable harm to Public Trust resources is to be avoided, steps need to be taken now to recognize the trust values threatened and the measures that need to be undertaken to protect them.

The importance of maintaining irreplaceable public trust resources was eloquently expressed by the Oregon Court of Appeals:

> *The severe restriction upon the power of the state as trustee to modify water resources is predicated not only upon the importance of the public use of such waters and lands, but upon the exhaustible and irreplaceable nature of the resources and its fundamental importance to our society and to our environment. These resources, after all, can only be spent once. Therefore, the law has historically and consistently recognized that rivers and estuaries once destroyed or diminished may never be restored to the public and, accordingly, has required the highest degree of protection from the public trustee.* Morse v. Oregon Div. of State Lands, (1979).

The State Lands Commission was established in 1938 to hold title to and manage some 4 million acres of land held in trust for the people of California. These lands—consisting of offshore coastal and tidelands and all navigable rivers, streams and lakes, known as sovereign lands—became state property when California joined the Union in 1850. Also in 1850, the United States granted "swamp and overflowed lands" to California. The land was surveyed by federal and state surveyors and by 1871 determined to include over two million acres. Much of the "swamp and overflowed" land was sold or "patented" to private citizens for the purpose of agricultural reclamation. A line was drawn around the Delta for future state determination if these islands were swamp and overflowed land, tide and submerged lands or uplands. It is this original "lowlands boundary" that became the statutorily defined Delta. The "swamp-land" which was sold during a 30-year period also included both navigable tidelands and submerged lands--lands which were to be held in the public trust.

Today, by law, these lands, and the overlying waterways, must be administered by the State Lands Commission for the benefit of the public. Because the Commission holds them in trust, they cannot be sold and must be used for water-dependent or water-oriented purposes such as navigation, boating, recreation, fishing, natural habitat and ecological preservation. In managing these sovereign lands under applicable trust principles, the Commission seeks to assume a stewardship role.

This report consists of an Executive Summary with Findings and Conclusions, a description of the Delta's geologic, hydrologic, biologic and cultural history and the public trust uses that are dependent on these resources, and a survey of the institutions and entities that manage its resources. A bibliography provides source documentation and as well as a literature "guide" for further readings.

A literature review and survey of the Delta—California's Inland Coast—conducted by State Lands staff, was made possible by generous contributions of time and information from several agencies. The San Francisco Estuary Project's reports provided an invaluable literature review, which contributed to leads for primary research, and comprehensive summaries of critical estuarine issues. East Bay Regional Parks District provided recreation background information and insights into the recreational planning process. The Department of Water Resources provided "data layers" for use in graphics prepared by the Center for Environmental Design Research, University of California at Berkeley, and responses to staff's questions. State agencies contacted include the Resources Agency, the Department of Conservation, the Department of Fish and Game, the Department of Parks and Recreation, the Bay Conservation and Development Commission; federal agencies include the Fish and Wildlife Service, Department of Agriculture Soil Conservation Service, Environmental Protection Agency, Bureau of Reclamation and the Army Corps of Engineers; private non-profit organizations contacted include the Bay Institute, Save the Bay, Planning and Conservation League, Sierra Club and the Nature Conservancy. While grateful for such assistance, the staff of the State Lands Commission acknowledges and accepts its responsibility for the contents of this report.

Executive Summary

The Chronicles of George C. Yount describe the Delta,

> *It [Benicia] was nothing more than a wide and extended lawn, exuberant in wild oats and a place for wild beasts to lie down in — the deer, antelope and noble elk held quiet and undisturbed possession of all that wide domain, from San Pablo Bay to Sutter's Fort. . . The above named animals were numerous beyond all parallel — In herds of many hundreds, they might be met, so tame that they would hardly move to open they way for the traveller to pass — They were seen lying, grazing, in immense herds, on the sunny side of every hill, and their young, like lambs were frolicking in all directions — The wild geese, and every species of waterfowl darkened the surface of every bay, and firth, and upon the land, in flocks of millions, they wandered in quest of insects, and cropping the wild oats which grew there in richest abundance — When disturbed, they arose to fly, the sound of their wings was like that of distant thunder — It was literally a land of plenty, and such a climate as no other land can boast of. . .*

The Delta is part of the San Francisco Bay/Delta Estuary and is delineated by Section 12220 of the State Water Code (Figure 1) which describes the estuarine environment as "a coastal water body where ocean water is diluted by outflowing fresh water."

Juan Batiste de Anza on his 1776 overland expedition from Monterey reached the Carquinez Strait hills and became the first European to sight the immense expanse of tules, islands, and waterways of the Sacramento-San Joaquin Delta.

The abundant game and fish de Anza and other early visitors found contributed significantly to the settlement of the West Coast and the Bay. The rich and varied wildlife resources of San Francisco Bay and the Delta were important constituents of the area's growth and economy.

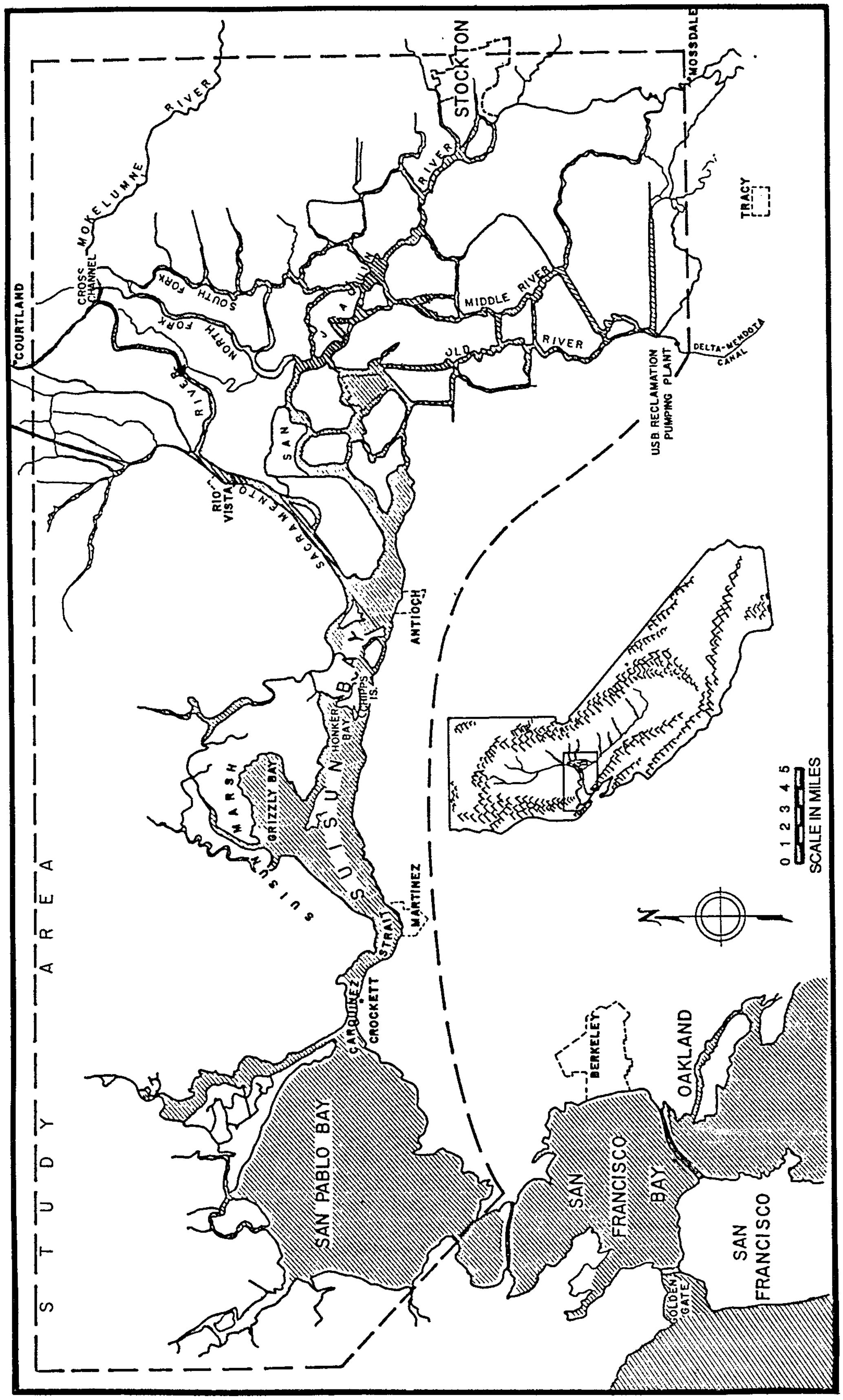

Figure 1. San Francisco Bay and Delta Estuary

Figure 1.

The Delta was a vast marshland habitat for wildlife so abundant that explorers became poets when describing the skies darkened with waterfowl and birds, the waters "boiling" with fish, and its fur-bearing inhabitants. Since 1850, the landscape of the Delta has changed dramatically. Lands converted to agriculture, ports and harbors, and large metropolitan areas, both surrounding and far removed, depend on and use the Delta as a source of both water and land to meet their special needs.

Today, the Delta's existing wetlands and seasonally flooded fields represent more than 25 percent of the statewide total of such habitat and regularly harbor about 10 percent of the waterfowl of the Pacific Flyway, a bird migration corridor stretching from the southern tip of South America to Alaska and protected by the *Migratory Bird Protection Act*. However, recent census figures show the migrating waterfowl populations have plummeted by more than 5 million in a little over a decade. Fisheries, waterfowl, bird, animal and plant populations are rapidly declining or nearly gone. The tule elk no longer forage in the marshes. Of the 29 kinds of indigenous fish, one is extinct, one is extirpated and 10 are on the Department of Fish and Game's Species of Special Concern list which means that they are threatened with extinction.

The evidence is compelling that the historic values and living resources of the Sacramento-San Joaquin Delta are at peril and that current trends in water management and land use could reduce the Delta to little more than a sterile water transfer "station" and flood control facility.

The state's fisheries, waterfowl and wildlife are public trust resources. They are dependent on the 700 miles of Delta waterways, the 1,100 miles of inland coast and the 350,000 acres of reclaimed marshland that is presently used for agriculture.

Other public trust resources include recreation, public access and navigation. Recreation includes fishing, boating, hiking and sightseeing. The recreational experience is intimately dependent on the quality of the living resources of the Delta and access to it. However, public access is restricted and in numerous cases is being aggressively denied. The public, for the most part, can access the Delta only through a few public marinas and two state parks.

While navigation, both commercial and recreational, is a public trust resource, its practice may intrude on other such resources. Commercial navigation on today's scale requires channel dredging, which unless undertaken responsibly, can be environmentally destructive. Recreational boating contributes to levee erosion and demand for more marinas.

An adopted, comprehensive resource conservation management program to balance all these resources does not exist. Without such a program, the fisheries and the waterfowl of the Delta, as well

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as other public trust values, remain at risk. Without responsible stewardship, the Delta will be described not by its flora and fauna, but by its waterworks, ship channels and dense urban marinas.

Information on the Delta is acknowledged by the Environmental Protection Agency to be sparse and limited, yet millions of dollars have been spent by federal and state agencies to "study" the Delta. Some of these studies have been by the sponsors of the two huge water transfer systems that use the Delta as a point for such transfer. These studies have sought to assure that such transfers would not result in further declines in fisheries populations. Other studies have documented the area's wildlife habitat and recreational resources. But most studies have been directed toward the engineering of water diversion programs: how much water can be diverted; how water quality in light of such diversions can be maintained or improved. This professional hydrologic work has contributed little to a comprehensive understanding of the biological diversity of the California's inland coast dependent as it is on tides, floods and inflows of fresh water.

California's Inland Coast

The Delta has been described as a "reversed delta" with the enclosed bay at the mouth and the deltaic formation inland. (See Figure 2.) It provides nutrients and influences food sources that contribute to the adjacent bays and marine resources. It is subject to tidal action and has the geomorphology, vegetation and hydrologic elements typical of an estuary. Thus the Delta is an inland coastal environment.

The outlook of the San Francisco Estuary Project is illustrative:

> *As defined in the [Water Quality] Act, the estuarine zone extends to the upstream reach of tidal influence or the historical limit of anadromous fish runs, whichever is greater. The estuarine zone of the San Francisco Estuary extends well into the upper reaches of streams in the Central Valley where fish such as salmon and steelhead trout spawned in the past* (Section 320, Clean Water Act, as amended).

This inland coast is a 1,153 square mile triangular region at the confluence of the Sacramento-San Joaquin River system in the heart of California. Within this triangle are vital public trust resources: commercial navigation that depends on dredged deep water channels to the Ports of Sacramento and Stockton; recreational boating that includes vessels from canoes to yachts using sloughs and channels and over 130 private and public marinas; public access that while limited by private property claims and prohibitions still provides an unparalleled opportunity to walk miles of estuarine

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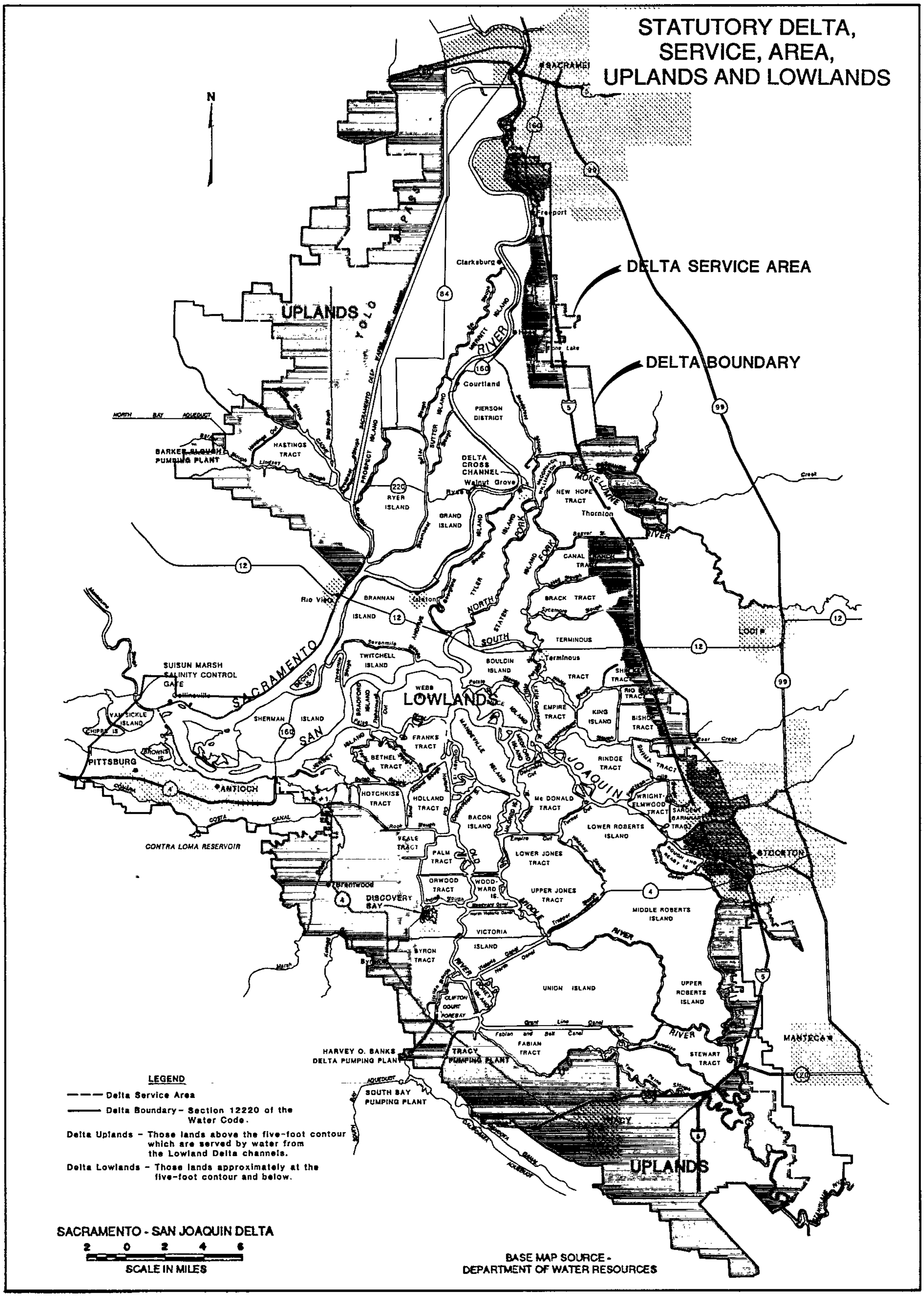
STATUTORY DELTA, SERVICE, AREA, UPLANDS AND LOWLANDS
DELTA SERVICE AREA
DELTA BOUNDARY
UPLANDS
LOWLANDS
UPLANDS
LEGEND
Delta Service Area
Delta Boundary - Section 12220 of the Water Code.
Delta Uplands - Those lands above the five-foot contour which are served by water from the Lowland Delta channels.
Delta Lowlands - Those lands approximately at the five-foot contour and below.
SACRAMENTO - SAN JOAQUIN DELTA
SCALE IN MILES
BASE MAP SOURCE - DEPARTMENT OF WATER RESOURCES

Figure 2.

riparian "coast" to view marshes and wetlands; fisheries without which the Delta would loose its major recreational attraction and through which all Central Valley salmon and other anadromous fish must travel to reach their riverine spawning grounds; over 550,000 acres of open space providing relief from the urban scape and habitat for the Pacific Flyway waterfowl and resident birds and animals.

The region is within one hour of the major population centers of the San Francisco Bay area, and is bordered by the major cities of Sacramento and Stockton and smaller, rural cities such as Rio Vista, Walnut Grove, and Galt. These cities are within five counties: Sacramento, San Joaquin, Contra Costa, Yolo and Solano. Over 6 million people in these cities and counties rely on the Delta for its open space, and other public trust amenities.

Over 700 miles of interconnected waterways flow around 57 major leveed reclaimed islands and tracts, and approximately 800 unleveed islands. The Delta's 50,000 surface acres of water is one of the largest bodies of protected cruising water in the western United States. Its two major rivers contribute to about 42 percent of the estimated natural water runoff of the State.

Approximately 1,100 miles of artificial levees protect the 700,000 acres of "reclaimed" marshland and uplands. Some of these levees are 25 feet high and reach 200 feet at the base. Some are over 100 years old. This report describes the pre-levee conditions of the delta, the reclamation projects that have claimed over 500,000 acres of former marshland and tidal wetlands and geologic hazards associated with these aging levees.

Presently, agriculture is the Delta's primary industry. About 350,000 acres of the Delta's intensely cultivated and highly erodible peat soil produce crops worth over $400 million annually. Agricultural practices, behind the protective levees, have contributed to subsidence which has caused land formerly at or within two feet of sea level to sink up to 25 feet below sea level. If flooded, such lands would be deeper than most of San Francisco Bay.

Although agricultural land use is responsible for the conversion of at least 350,000 acres of marshland and wetlands, this land still provides habitat and food for the Pacific Flyway migratory birds. Agricultural land use also provides foraging and nesting for resident birds.

Fisheries in the Delta have three "historic" phases. The diversity and abundance of fish species once existing in the Delta, as indicated by fish remains found in an Indian midden, are no longer. A number of species are gone or nearly gone. The thicktail chub is extinct, and the Sacramento perch has been extirpated. Their decline and disappearance are probably due to the loss of tule beds and other submerged, rooted vegetation required for spawning and rearing habitat.

Commercial fisheries make up the second phase. At the turn of the century the Delta had more than 25 operating canneries. There were canneries for salmon, steelhead, sturgeon, perch, striped bass and American shad. Even the now-extinct thicktail chub was available in fish markets.

The third phase records the continuing decline of indigenous fish—the salmon, steelhead trout, sturgeon and delta smelt—and of introduced species including the striped bass and shad. At present, populations of Delta fisheries are at an all time low and certain species, such as the Delta smelt, may also become extinct.

The estuary ecosystem of California's inland coast is a valuable resource; it provides primary productivity within its remaining spawning and nursery habitat. Remaining wetlands vegetation protects the Delta shoreline, traps suspended sediments and transforms water quality pollutants by physical, chemical and biological means, thus providing natural water treatment. Riparian vegetation protects river banks from erosion, shades the sloughs and channels, a fact important for young fish species' survival, and offers essential corridors to aerial, terrestrial, and aquatic wildlife of all types.

At an earlier time, Native Americans used the resources of the Delta without depleting its fish, mammal or bird populations. The prehistoric and historic sites to be found in the Delta are instructive to this and future generations about the cultural and social aspects of the Delta. Historic towns are archives of extensive cultural resources. George Shima "Potato King," the wealthiest Japanese man in California in the early 1900s, made his fortune in the Delta and maintained a home on Bacon Island. Shipwrecks are the visible narrative of the history of public trust resources, telling of early exploitation, transportation to the gold country and the ruin of water-borne commerce because of hydraulic gold mining and its sedimentation of waterways.

The promise of Delta recreational opportunities has not been realized. Past efforts to do so were unsuccessful; current efforts are isolated and, in many instances, inconsistent. While the East Bay Regional Parks District seeks public access for shoreline recreational development in eastern Contra Costa County, in other areas public access may be restricted because of locally approved shoreline development projects. Throughout the Delta, riparian corridors which could provide hundreds of miles of coastal trail opportunities are under siege by levee "maintenance and restoration" work and by such channel management practices as "riprapping."

Effects of Human Activity on Delta Resources

Beginning in the 1850s and completed by the 1930s, extensive reclamation efforts such as draining and diking transformed the Delta. These transformations were followed by the major water diversions which now supply fresh water to over two-thirds of the state.

The amount and timing of fresh water that flows in streams and rivers of the San Francisco estuary determines the biological productivity of both freshwater and downstream saline habitats and regulates the life cycles of many of the Estuary's organisms. Thus, the loss of fresh water to the ecosystem by diversion decreases freshwater flow through the Delta and increases salt water intrusion from San Francisco Bay, adversely affecting Delta fisheries.

While draining, diking and water diversions have taken their toll, emerging land-use trends are adding to the region's stress. These trends show development to accommodate the area's rapid population growth will occur away from the existing city centers of population and along the major highway transportation corridors between the San Francisco Bay Area and Sacramento and throughout the Delta. Such uses in the Delta involve the conversion of rural areas or wetlands to one of three urban land uses: residential, commercial/light industrial or heavy industrial. Over 4,000 acres of wetlands, stream environments and diked historic wetlands are projected to be lost, based on approved county general plans.

Agencies, Policies and Programs That Affect the Delta

The *California Environmental Quality Act (CEQA)* is the state's basic charter for protecting the environment and provides a major tool through environmental impact reports for examining significant impacts of state and local projects. The Sacramento-San Joaquin Delta is identified in CEQA as a specific area of sensitive, significant resources, thus triggering CEQA review where projects are proposed. CEQA is limited in application to specific projects and is ill equipped, by itself, to provide the comprehensive protection the Delta deserves.

The Delta is affected by the planning and management decisions of numerous governmental agencies—local, regional, state and federal. These agencies make decisions affecting the Delta in response to programs and policies that are frequently inconsistent, often conflicting and certainly inadequate and inefficient.

Delta land-use is determined primarily by local cities and the counties of Contra Costa, Solano, Yolo, Sacramento and San Joaquin. State law has strengthened the planning and regulatory capabilities of local governments by requiring that local governments prepare comprehensive general plans and that all local ordinances, development plans and activities be consistent with those plans. Each locality must also undertake the CEQA environmental review process. There are no state or regional provisions to resolve conflicts or inconsistencies between local, state or regional plans. Thus, there are no clear, consolidated state-wide policies on Delta land-use issues.

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The state agencies with important roles are:

- Department of Water Resources (DWR) manages the transport of water and construction of water facilities in the Delta. It is responsible for the State Water Project (SWP), which includes the Clifton Court Forebay storage facility in the Delta and pumping facilities. The amount of water diverted is restricted by 1981 permits until the "indirect impacts" of these facilities are mitigated. In 1986, DWR and the Department of Fish and Game signed an agreement, containing Article VII, to mitigate for "direct losses" of striped bass, chinook salmon and steelhead trout due to the SWP pumping plant. DWR's proposed North and South Delta Water Management Programs which will increase the capacity of the SWP and will require channel widening, levee construction and barrier structures, rely on future mitigation measures to be determined in the Article VII process.

- The State Reclamation Board exercises responsibilities for flood management including levee projects and other channel flood control projects.

- Local Reclamation Districts receive subvention funds from the state to "repair and maintain" the levees, often without streambed alteration agreements from the Department of Fish and Game, nor permits from the State Lands Commission or the Army Corps of Engineers. These permits are customarily required when there is construction in the "waters" or in tidal areas or where construction results in fill within these areas.

- The Department of Fish and Game (DFG) is the principal agency charged with protection of the state's fish and wildlife resources. Under the Fish and Game Code DFG, among its many responsibilities, regulates hunting and fishing. DFG has participated in the Interagency Ecological Study Program to "study and monitor" fisheries in the Delta to "assure" that the water management programs do not significantly harm the fisheries. The striped bass is used as an indicator species by DFG and its population is considered a measurement of the "health" of the Delta. Presently, the striped bass index is the lowest since the measurement began.

- The State and Regional Water Resources Control boards administer California's system of water rights and are responsible for setting water quality standards in the inland surface waters, enclosed bays and estuaries and for developing Basin

Plans for the Delta which include salinity and flows standards. The SWRCB reviews applications for the diversion of water from the Delta or its tributaries to determine the effect of the proposal on the quantity and quality of the water, and the resultant effect on other uses of water in the Delta. The state and regional boards review all proposed activities in the Delta that require federal grants, licenses or permits to determine the effect of the proposed action on water quality.

- The State Lands Commission (SLC) administers policies established by the legislature and the courts for the management and protection of sovereign lands received from the federal government upon its entry into the Union. These lands include the beds of all naturally navigable waterways, tide and submerged lands, and swamp and overflow lands. These sovereign lands can only be used for public trust purposes consistent with provisions of the public trust. The SLC has permitting authority for all proposed projects on waterways and review responsibility of upland activity that may affect these sovereign lands and waterways. The right to preserve the public trust in tidelands and known historic waterways, even though obscured by subsequent treatment of land, has given the state considerable authority to regulate the appropriate use of these lands.

The federal role in the Delta is dominated by the following:

- The Bureau of Reclamation operates the Central Valley Project. The 1986 Coordinated Operating Agreement between the Central Valley Project and the State Water Project, provides among other water allocations, a commitment of about 2.3 million acre-feet from both projects during a critical water supply period. During the last five drought years, all agricultural contracts have received 100 percent allotments.

- U.S. Fish and Wildlife Service (FWS) is the natural resource trustee for migratory birds, certain anadromous fish, endangered species and certain federally managed water resources. The FWS participates in the *Central Valley Habitat Joint Venture*, a group of private organizations and public agencies, to solve habitat problems in the Pacific Flyway. Conservation easements and fee title acquisitions in the North Central Valley Wildlife Management Area are proposed by this agency as a major program to restore and maintain the diversity, distribution and abundance of waterfowl.

- The *San Francisco Estuary Project* under the *Clean Water Act* is a five-year program to develop by November 1992 a Comprehensive Conservation Management Plan (CCMP) to protect and improve water quality and to enhance living resources of the San Francisco Bay-Delta Estuary. The Sponsoring agencies are the U.S. Environmental Protection Agency, the State Water Resources Control Board, and the Central Valley and San Francisco Bay Regional Water Quality Control boards. Regulatory authority for the CCMP implementation is limited to federal legislation.

- The Army Corps of Engineers (COE) is the principal federal agency involved in regulation of wetlands, and shares a lead role with the EPA in preventing degradation and destruction of "waters of the U.S." The COE is probably the most influential public agency regulating estuary wetlands because of its permit powers and project responsibilities for port maintenance dredging, deep water channel construction, levee construction, flood control, dam construction and shore stabilization, among others.

Private programs and initiatives in the Delta include waterfowl habitat acquisition by duck clubs, land managers (farmers) consulting with conservation organizations and governmental agencies for better management of their land in order to provide habitat for waterfowl and migrating, as well as resident, birds. Public interest groups are also active in the region. The Nature Conservancy pursues acquisition of lands for wetland and riparian restoration. The Solano Open Space and Land Trust acquires and manages land within the Delta for wetlands and riparian protection and restoration. The Planning and Conservation League was responsible for the language in the levee protection subvention program that provides for no net loss of habitat.

Legislative findings, declarations and regulations for protecting the Delta's values include the following:

> *The Legislature finds and declares that the people of the state have a primary interest in the conservation, control, and utilization of the water resources of the state, and that the quality of all the waters of the state shall be protected for use and enjoyment by the people of the state...further finds and declares...that the state must be prepared to exercise its full power and jurisdiction to protect the quality of waters in the state from degradation...that the waters of the state are increasingly influenced by interbasin water development projects and other statewide considerations;...and that the*

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statewide program for water quality control can be most effectively administered regionally, within a framework of statewide coordination and policy. California Water Code, Section 13000.

The Legislature further finds and declares it to be necessary for the general public health and welfare that facilities for the storage, conservation or regulation of water be constructed in a manner consistent with the full utilization of their potential for the enhancement of fish and wildlife and to meet recreational needs.

The Legislature further finds and declares...that recreation and enhancement of fish and wildlife resources are among the purposes of state water projects; that the acquisition of real property for such purposes be planned and initiated concurrently with and as a part of the land acquisition program for other purposes of state water projects; and that facilities for such purposes be ready and available for public use when each state water project having a potential for such uses is completed. California Water Code, Section 13000.

*The Legislature hereby finds and declares that the delta is endowed with many invaluable and unique resources and that these resources are of major statewide significance. The Legislature further finds and declares that the delta's uniqueness is particularly characterized by its hundreds of miles of meandering waterways and the many islands adjacent thereto, that in order to preserve the delta's invaluable resources, which include highly productive agriculture, recreational assets, and wildlife environment, the physical characteristics of the delta should be preserved essentially in their present form....*California Water Code Section 12981.

The Legislature further finds and declares that in order to enhance the general public health and welfare it is necessary that all flood control and watershed protection projects be designed, constructed, and operated so as to realize their full potential for the enhancement of the state's fish and wildlife resources and to provide recreational opportunities to the general public. California Water Code, Section 12841.

The Legislature finds and declares that the establishment of enforceable standards for the maintenance and operation of levees, channels, and other flood control works of a project or plan authorized or adopted by the Reclamation Board is *necessary to provide effective and uniform flood protection to the people of the state, and to insure that the maintenance and operation of such works will not adversely affect the vital interests of the people of the state in fish and wildlife, recreation, and the preservation and enhancement of the natural environment.* Stats 1970 chapter 804, section 2.

The board shall establish and enforce standards for the maintenance and operation of levees, channels...including but not limited to standards for encroachment construction, vegetation and erosion control measures. In adopting such standards, the board shall give full consideration to fish and wildlife, recreation and environmental factors. Any violation of such adopted standards without the permission of the board is a public nuisance.... California Water Code, Section 8608.

However, despite these legislative pronouncements, damage to wildlife and its habitat continues to occur with many more species threatened with the finality of extinction, public access continues to be denied to public waterways and recreational facilities continue to be restricted. Unfortunately, no comprehensive planning or review of the decisions affecting the Delta complement the Legislature's intentions.

Findings and Conclusions

Public Access

- There are 600 miles of protected waterways in the Delta whose use is extensive, but largely unplanned and uncoordinated among recreational jurisdictions, local government, state and federal agencies.
- Water diversion facilities and levee maintenance have failed to mitigate their adverse effects on the Delta's natural beauty, meandering waterways and abundant fish and wildlife populations.
- Existing state park facilities are filled to capacity during peak season; several park projects authorized in the mid-1970s have not been built.
- Many regions in the Delta have been identified as recreational areas, but most of them lack sufficient facilities and many are not accessible to the public.
- Unregulated recreational overuse within growing urban development directly affects fish and wildlife populations and habitat as well as increasing conflicts with farmers and reclamation districts in rural areas.

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Conclusions

The promise of a Delta recreation master plan and coordinated implementation and activities has not been met. Because of land development pressure, not only is there an increasing demand for recreational facilities in the Delta but also public access may be further restricted, a repeat of the coastal access problems that California faced prior to the Coastal Act. In the meanwhile, the natural resource values are diminished because of water diversion and transport or lost because of water facilities construction and maintenance. A coordinated planning and management effort to maintain recreation, accommodate growth and avoid or mitigate adverse impacts on resource values should be considered.

Navigation

- The Ports of Stockton and Sacramento are primarily agricultural commodities ports. At least 70 percent of Delta export shipping consists of rice, wheat, logs, wood chips, sulphur, gypsum, nitrogenous fertilizer and coke.
- Port growth is dependent upon channel deepening. Current channel depths can accommodate only 30 percent of all ocean going vessels.
- Maintenance dredging is essential to commercial navigation. The Army Corps of Engineers maintains ship channels. Dredging and disposal of dredged material temporarily increases turbidity, smothers benthic communities at or near disposal sites, and may affect the behavior and physiology of fish and other organisms.

Conclusions

A Delta port long-term management strategy is needed to eliminate unnecessary dredging activities, provide environmentally sensitive spoils disposal sites and balance shipping market development with water quality and fisheries needs so that sensitive environmental resources are protected.

Fisheries

- Ninety-two percent of the original Delta wetlands have been converted to farmland. Wetland and marshland losses are matched by extinction of fish species, extirpation of mammals and significant reduction in waterfowl populations.

- The Delta smelt is found only in the California Delta. The decline in its population is so acute that it is a federal candidate for listing as an endangered species. However, the State Fish and Game Commission declined to list the smelt as an endangered species preferring to "coordinate" with the DWR and other related agencies in a program of further study and monitoring.

- All Central Valley salmonids migrate through the Delta to upstream spawning beds. Because of the timing of different runs of salmon, juvenile salmon can be found in the estuary during all months of the year. The Sacramento River winter-run chinook salmon is now a state-endangered and federal-threatened species, and the spring-run is a probable candidate for listing as well. The San Joaquin River spring-run is extinct.

- In 1990, the population of striped bass, a species selected by the Department of Fish and Game as an indicator of the "health" of the Delta, reached an all-time low.

- Concentrations of several pollutants in Estuary waters exceed State water quality objectives. Concentrations of some pollutants in animal tissues exceed international standards or guidelines for the protection of aquatic life. The major sources of pollutants are urban and nonurban runoff, discharges from municipal wastewater treatment plants and industrial facilities, and dredging related activities.

- Samples of fish taken from the San Joaquin River near Vernalis have elevated concentrations of pesticides. Chlordane, DDT and toxaphene commonly exceed the guideline concentrations recommended by the National Academy of Science and on occasion exceed Federal Drug Administration action levels.

- Water quality in the Sacramento River is affected seasonally by rice field herbicides. Mining wastes in its upper portion are a significant source of the cadmium and copper found in the lower Sacramento River and Delta. Drainage water is at times toxic to test organisms; downstream toxicity from the Colusa Drain has been measured in the Sacramento River as far south as Rio Vista.

- Freshwater exports from the Delta have had a significant impact on the environment, in part because of huge pumping plants in the south Delta. An average of 50 percent of Delta outflow is presently diverted. Diversions are not distributed evenly between years or season. Diversions and altered flow regime have modified circulation and water quality, reduced biological productivity and increased mortality in many species.

- The federal Central Valley Project and the State Water Project divert nearly 10 million acre-feet of water from the Estuary watershed. Eighty-five percent of this water is used by agriculture and 15 percent is used by municipal, industrial and other consumers.

- The Central Valley Project and State Water Project plan to increase diversions from the Delta by a combined total of 3.3 million acre-feet. This will require modifying Delta channels and increasing reservoir storage capacity.

Conclusions

State and federal programs developed for fisheries and wetland protection have been inadequate to halt the loss and degradation of each. In noted instances, water quality standards are not adequate to maintain healthy fisheries. Water transport has dictated biological and fisheries management. Unproven fisheries management programs are proposed as mitigation for additional water management plans and facilities.

Open Space and Wildlife Habitat

- Despite massive changes which have occurred, including alteration of the environment and major shifts in plant and animal species, the Delta still functions as an ecosystem.

- The Delta is part of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. An estuary is the region where fresh water of a stream or river meets tidal ocean water. Estuaries are among the richest and most productive ecosystems on earth; their diverse natural habitats are capable of supporting an astonishing array of living resources.

- Impacts and threats to Delta biological resources include: direct loss or injury to species, such as entrainment by water pumping facilities, hunting, fishing or poisoning by pollution; loss or damage to habitats, such as urbanization of open space, clearing of riparian habitat from levees or shifts in water salinity; and introductions of new species which out-compete or consume native species.

- Urban development is encroaching into the Delta lowlands; upland development contributes to loading of pollutants in effluent and runoff. Continued expansion threatens to destroy and degrade valuable agricultural land and wetlands, and to increase water pollution to water.

Conclusions

Land and water use decisions hold the key to restoring and protecting the Delta. How the land will be used for highways, housing, agriculture or other uses will determine the nature and extent of resulting environmental impacts.

Agricultural lands can serve multiple functions, especially as seasonal wetlands. Conversion of these lands to urban uses would further degrade the Pacific Flyway habitat. Flood control measures which are needed to accomodate urbanization include filling lowland areas and levee reconstruction which destroy habitat areas. Although not all Delta farmlands are suitable for intensive agricultural production they are valuable as open space.

There is no regional land use planning for the Delta. Local land use decisions remain uncoordinated and tend to ignore the protection of the Delta's Public Trust values.

Future developments in the Delta should be carefully planned and managed. Such developments should be consistent with the sovereign interests of the State and its responsibility, as expressed in the State Supreme Court's *National Audubon* decision to protect Public Trust resources. Within this doctrine are also found the public's access rights to its waterways, the use of these waterways for fishing and navigation, and the protection of wildlife and its habitat, marine and the other estuarine resources of California's inland coast.

C-038124

C-038125

The Delta's Formation

1

The Delta was formed during the last 10,000 years when a rapid rise in sea level following the last Ice Age inundated the alluvial valley of the Sacramento River (Atwater, 1979). For the last 6,000 years, the rate of rise has been roughly the same rate as measured over the last 130 years. Thus, the estuary has continued to expand.

Today the Delta encompasses 1,153 square miles. It is comprised of a 1,100 mile "coast line" and 700-mile-long network of channels and sloughs which surround 57 islands (Resources Agency, 1976). The Delta is fed by freshwater flows from the southbound Sacramento River, the northbound San Joaquin River and, to a lesser extent, by the Cosumnes, Mokelumne, Stanislaus, Tuolumne and Merced Rivers, which flow from the Sierra Nevada mountains.

The Central Valley was, and remains, the source of most of the freshwater flows. An historic natural inflow hydrograph would depict two "peak" flow periods: winter rainstorms and spring runoff due to snowmelt. Peak winter flows probably conveyed the most sediment into the Estuary.

In its natural state, the Estuary experienced flooding from winter flood flows and high tides. These infrequent high flood flows on the Sacramento River would overtop the natural levees, filling the floodplain basins; downstream the overflow of the Sacramento levees would tend to inundate the tidal marshes in the San Joaquin Delta by a few feet. High tides from storm surges coupled with spring tides could raise water levels to more than three feet above the marshplain level for several hours.

C-038127

The Delta's Climate

2

The importance of climate and its affects on environmental conditions in the Delta is notable. Near twilight, after a hot summer's day in most adjacent communities, there is almost always a cooling westerly, the "Delta Breeze," which can result in a drop in temperature of as much as 30 degrees Fahrenheit in two or three hours. The maritime influence is clearly dominant in winter as well, for the Pacific Ocean is the birthplace of all storms that provide almost all of the water for the Delta watershed.

The Delta's climate is influenced also by both coastal and inland characteristics. The climate of inland central California is characterized by hot, dry summers and cool wet winters. The climate of the coast, however, is distinguished by the dominating influence of the Pacific Ocean and thus has relatively warmer winters and cooler, foggy summers with a small annual temperature range.

Within the Delta watershed, precipitation varies greatly with the wettest areas receiving about 60 inches of rain and the driest areas receiving 10 inches. Wide variations also occur seasonally and from year to year, affecting freshwater flow patterns, fish and wildlife habitat and hydrology.

The prevailing winds in the Bay area during summer are from the west and northwest, reinforced by an inland movement of air caused by the solar heating of the air masses in the Central Valley. This heating effect is greatest during the day and causes a marked diurnal, as well as a seasonal, pattern in wind speed. When winter storm centers pass to the south, the winds can be from the east or southeast.

These prevailing winds from the west and northwest are strongest close to the gap at Carquinez Strait. In the Delta, such winds often blow continuously day and night, and are generally from west southwest. At Sacramento, such winds are more variable throughout the day, weak and southerly until about noon, when a somewhat stronger flow commences from the southwest. The summer flow at Stockton is also strongest in the afternoon, and throughout the day generally blows from the west northwest.

The typically strong summer winds of afternoons and winter storms wield significant force on the area's surfaces. Prevailing winds can generate basin-wide circulation that is superimposed upon tidal circulation. Wind generated waves resuspend sediment, oxygenate the water and by mixing water in this shallow environment, disperse dissolved and particulate matter, and organisms, throughout the estuary (Conomos, 1985).

The Delta is transitional between the coastal and inland extremes. The effects of the local topography and the continuous interaction of maritime and continental air masses provides a varied climate.

The Delta's Waters

3

The Sacramento-San Joaquin Delta lies at the confluence of the Sacramento and San Joaquin Rivers. It is the largest inland delta, its waters flow through the largest brackish water marsh, and it is part of the largest estuary on the west coast of North America. (Cohen, 1990). By virtue of its topography, productive waters and shelter, the Delta has developed as a center for fishing, shipping and recreational boating.

A variety of uses of the Delta have altered the Delta's character. Two-thirds of the state's water supply is carried by rivers and streams in northern California, while two-thirds of its use is south of Sacramento. (See Figure 3.) Water is transferred from the north to the south through the Delta, where huge state and federal pumping plants move it on its journey southward. Increasing awareness of the link between water diversions and the health of the Delta have prompted much debate over how the beneficial uses of its waters should be prioritized.

Dredging affects water quality and Delta hydraulics. Maintaining and enlarging shipping channels by dredging results in flow alterations; levee reconstruction and flood control programs affect waterways; and accommodation of a growing population may lead to the deterioration of water quality as greater volumes of waste water are discharged into the estuary.

Water quality in the Delta depends on the quality and quantity of water flowing into the Delta from the Sacramento and San Joaquin Rivers and other source streams as well as on the tidal intrusion of salt water from Suisun Bay. Water quality of source streams, tidal intrusion and mixing patterns are, in turn, dependent on water flow. Thus, water quality and flows in the Delta are integrally connected.

During the past six decades, competition for the use of the Delta's scarce water resources has increased rapidly. The nature and extent of water exports from the Delta to urban and agricultural consumers have substantially altered its hydraulics and adversely affected its ecology, threatening the continued existence of populations of several species which have historically inhabited the area.

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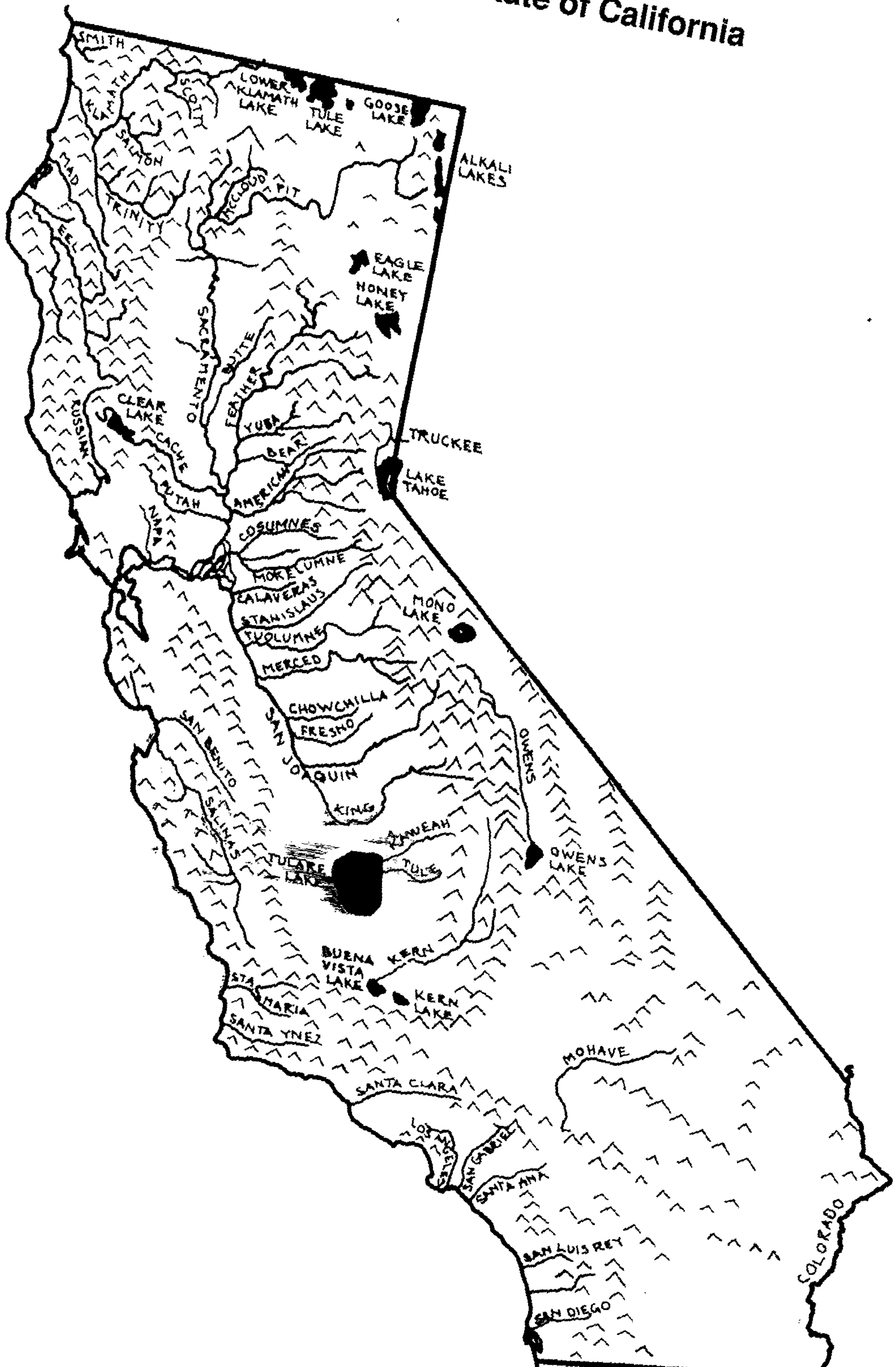
Figure 3.

State of California



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Historic Modifications and Development

The Delta has been significantly altered by human activity since Gold Rush days. As the Gold Rush began to wane, farmers were lured to the area by the fine silt and deep peat soils laid down by centuries of river floods and marsh growth. Between 1860 and 1930, the vast majority of the Delta's 350,000 acres of freshwater marsh were diked off and planted with food crops (Cohen, 1990).

Hydraulic mining in the Sierra foothills between 1853 and 1884 resulted in the washing of almost 1 billion cubic yards of sediment into the rivers (a bathtub has a capacity of about one cubic yard), draining the Gold Country before it was stopped by a Federal court injunction (Cohen, 1990). Sand and cobbles clogged the river beds, raising them by as much as 20 feet. The finer materials were carried downstream and deposited in the Delta and northern portion of the Bay, causing extensive shoaling and flooding, obliterating fish breeding grounds and creating new tidal marsh.

Levee Construction

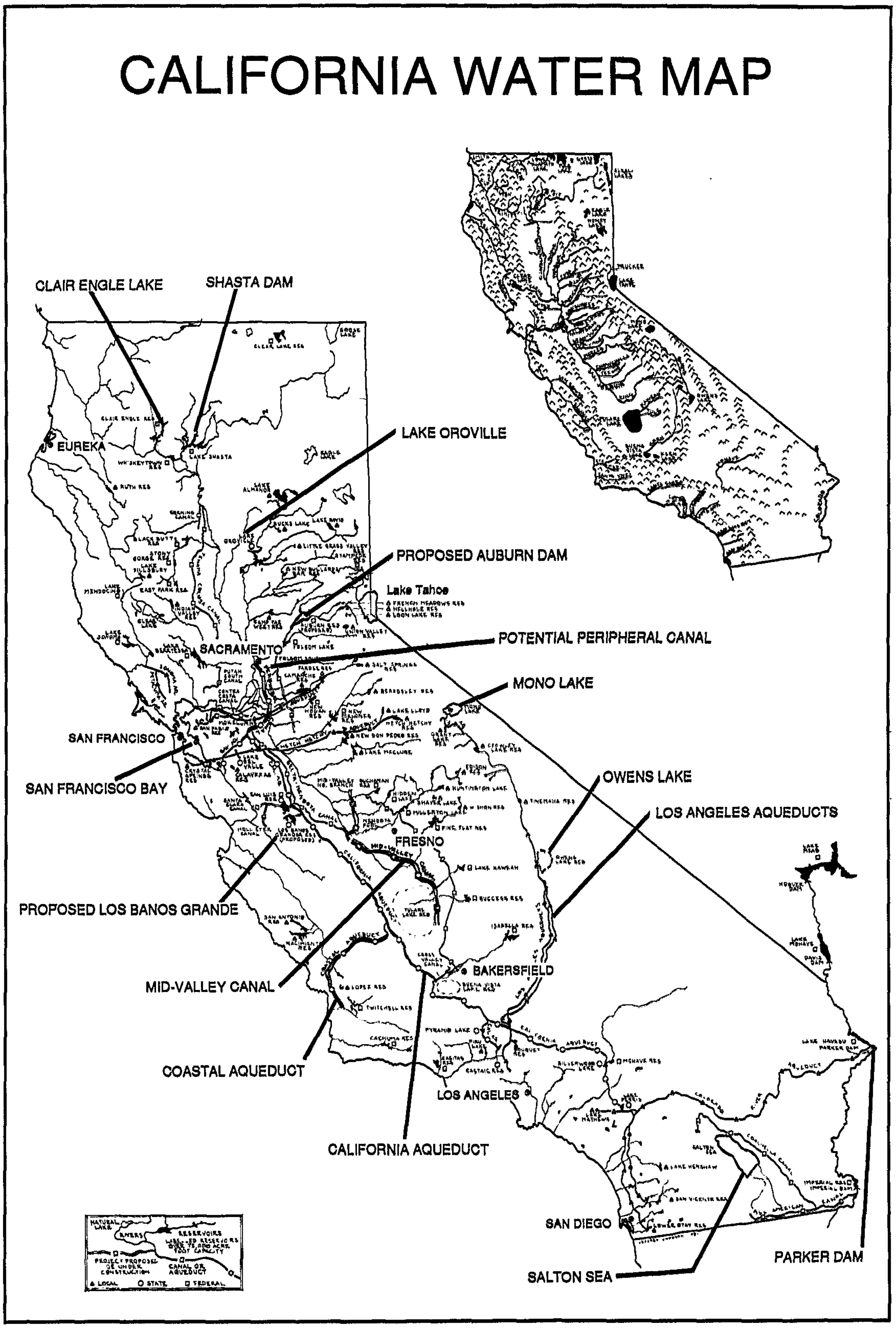
The existing Delta levee system was constructed by farmers out of the tidal marshlands, draining substantial habitat used by the abundant wildlife. Almost all of the historical tidal marshes have been leveed for agriculture, duck clubs or urban use. This loss of the tidal prism in the Delta has caused most of the remaining major slough channels to fill with silt. Maintenance dredging is necessary to maintain navigation. There are approximately 1,100 miles of levees, diking some 500,000 acres of farmland in the Delta. Many of these levees were not engineered to withstand high flood levels and other forces of nature.

Federal and State Water Projects

The principal freshwater diversions from the Delta are accomplished by the State Water Project (SWP) and the federal Central Valley Project (CVP) exports and, to a much lesser but notable extent, by the Contra Costa County Water District into the Contra Costa Canal (Figure 4). The SWP is operated by the State Department of Water Resources (DWR). The CVP is operated by the U.S. Department of the Interior's Bureau of Reclamation (BOR). Water for export is pumped from southern Delta channels into the California Aqueduct, the South Bay Aqueduct, the Delta-Mendota Canal and the Contra Costa Canal.

The SWP and CVP are required to maintain sufficient water in the Delta to ensure water quality at levels established by the State Water Resources Control Board (SWRCB) in Decision 1485 as a

Figure 4.



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condition of their water rights permits. The 1986 *Racanelli* decision held that the SWRCB must set water quality standards to protect fish and wildlife. Controversial Water Board hearings since 1978 have been unable to establish water flows and water quality standards. The EPA has testified that the 1978 standards are inadequate.

In addition to regulating flows, the state and federal projects divert large volumes of fresh water from the Delta and its tributaries. More than 7,000 permitted diversions remove water from the watershed and the Delta. These diversions range from a few cubic feet per second (cfs) at small farm diversions to an average annual rate of 7,000 cfs at the massive CVP and SWP pumps in the south Delta.

The Central Valley Project

The die of the Delta's future was cast when, in 1937, Congress authorized construction of the CVP, following the failure of a state bond measure to fund the project. It was to be and has become a large water project whose primary purpose is to store and transfer water in 20 reservoirs and through 500 miles of canals and other facilities within the Sacramento, Trinity, American and San Joaquin river basins. The Bureau of Reclamation goals were to bring "cheap" water to develop the Sacramento and San Joaquin valleys for small farms to "promote family farming." Estimated farm development was planned for over 6,000 farms, but records indicate only 214 land units are being billed for water (Assembly Concurrent Resolution 191, 1976). Other project functions include urban water supply, water quality maintenance, flood control, power generation, recreation, and fish and wildlife enhancement (DWR, 1988).

The CVP's key features are Lake Shasta and Shasta Dam on the Sacramento River, constructed in 1944. The 4.5 million acre-feet of water stored here is first used to generate power as it flows into the natural channel of the Sacramento River toward the Delta. This flow is supplemented by water from Clair Engle Lake on the Trinity River through the Trinity diversion.

Twenty miles east of Sacramento, American River water is stored in Folsom Lake, which can store up to one million acre-feet, for use in the Folsom-South service area and for release into the Sacramento River upstream of the Delta.

Thirty miles south of Sacramento, at the north edge of the Delta, the Delta Cross Channel serves as a controlled diversion channel between the Sacramento and Mokelumne rivers. In conjunction with Georgiana Slough, it directs Sacramento River water across the Delta to the Rock Slough intake of the Contra Costa Canal and to the export pumps near Tracy. Six pumps at the Tracy Pumping Plant lift as much as 4,600 cubic feet of water per second 197 feet into the Delta-Mendota Canal which delivers the water to the lower San Joaquin Valley.

C-038134

About 60 miles south of the Delta, between the Delta and the Mendota Pool, is the San Luis Dam and Reservoir. This facility was constructed as a joint federal/state storage facility. Water diverted from the Delta in the Delta-Mendota Canal and the California Aqueduct is pumped into San Luis Reservoir during winter and early spring for release to service areas during summer and fall.

The recently completed San Felipe project provides approximately 200,000 acre-feet of water from the San Luis Reservoir to coastal counties via a system of tunnels, pipelines and pumping stations. Project planning also includes water supplies for Santa Cruz and Monterey counties.

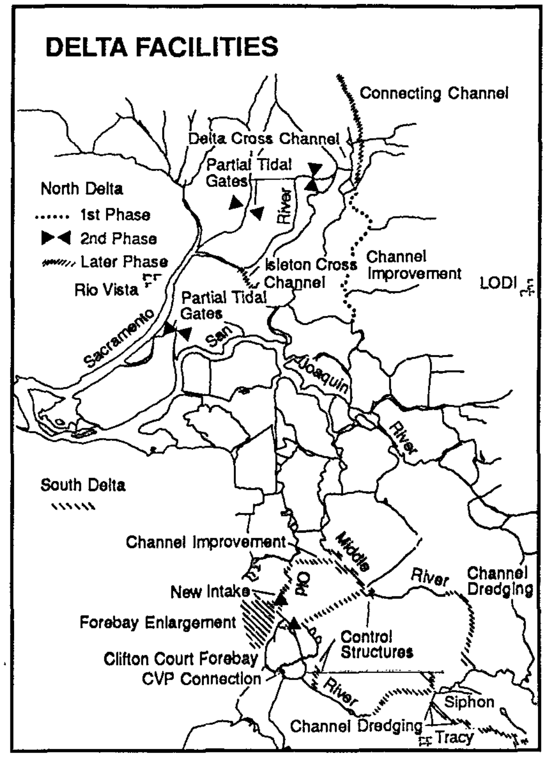

Figure 5.

The State Water Project

The SWP, authorized by the 1959 Burns-Porter Act, is a water storage and delivery system of reservoirs, aqueducts, powerplants and pumping plants (Figure 5). It extends for more than 600 miles, two-thirds the length of California, from Plumas County in the north to Riverside County in the south. The project's main purpose is to transport water to meet its water contracts with water districts in Northern California, the San Francisco Bay Area, the San Joaquin Valley and Southern California.

All costs for water development, operations and maintenance, fish and wildlife preservation (mitigation) and power are stipulated by the Burns-Porter Act to be repaid to the state with interest by the water supply contractors. Costs for flood control are paid by the federal government. Costs for recreation and fish and wildlife are paid by the state. Twenty-five million dollars annually from the state's tidelands oil revenues help retire the state's bonds for Project construction (PRC 6217 (b)). To date, despite contract specifications, only a fraction of total project and interest costs have been paid back by the contractors.

The State has contracts to deliver up to 4.2 million acre-feet a year to 30 public agencies. Various methods are used to ascertain how much water is delivered by the SWP. According to DWR's rule

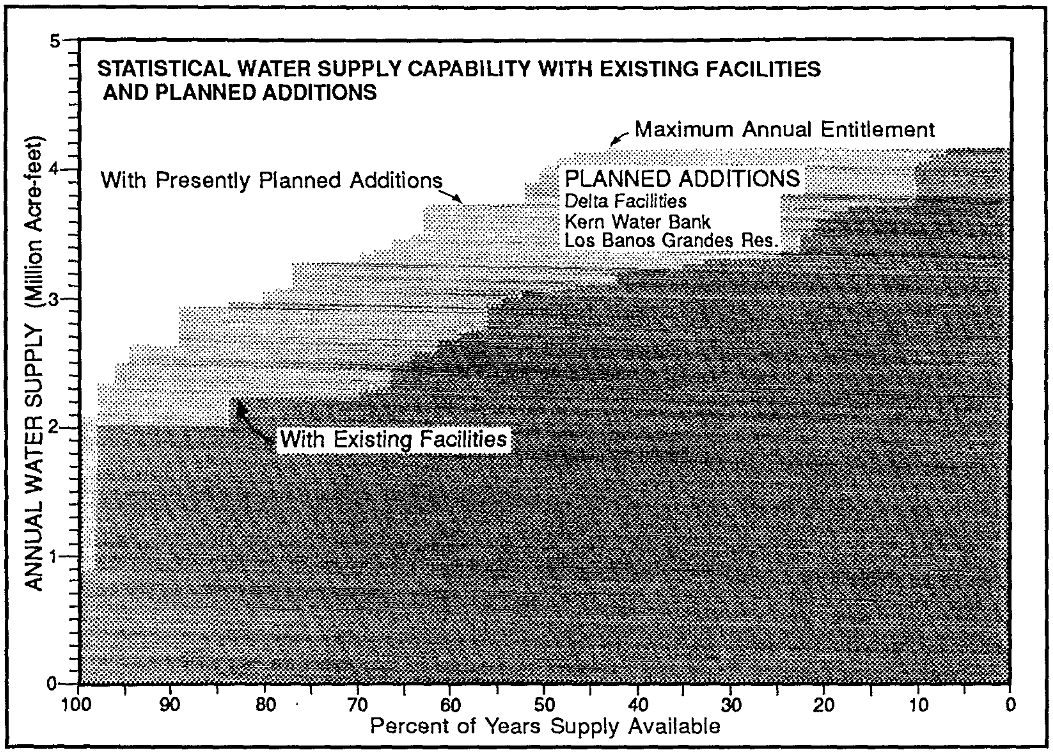

Figure 6.

curve (Figure 6), the project now delivers only 2.4 MAF annually. Other means of measurement suggest that more water actually has been delivered, even over recent drought years. Approximately 54 percent of this water is used to irrigate farmland and 46 percent to meet the needs of the state's growing population (San Francisco Estuary Project, 1991). More than two-thirds of all Californians and over 600,000 acres of irrigated farmland receive at least part of their water supply from the SWP.

Lake Oroville is the SWP's principal storage facility with a capacity of 3.54 million acre-feet. Water from the reservoir "flows" through an underground hydroelectric power plant, through the Thermalito Afterbay, down the Feather River into the Sacramento River and then through the Delta's channel network.

Near the northern edge of the Delta is the recently completed North Bay Aqueduct which diverts water to Napa and Solano Counties. At the southern edge of the Delta, 15 miles southwest of Stockton and 10 miles northeast of Tracy, are the Clifton Court Forebay, John E. Skinner Delta Fish Protective Facility, and the Harvey O. Banks Delta Pumping Plant and its intake channel.

Clifton Court Forebay facility has a capacity of 28,700 acre-feet, providing storage capacity and operational flexibility to regulate water for the Banks Pumping Plant; seven pumps are designed to lift up to 6,400 cubic feet per second into the California Aqueduct. At this point, the South Bay Aqueduct branches and delivers water to

San Joaquin Valley and Southern California.

The Bureau of Reclamation engineers proposed a fresh water Delta bypass project known as the Peripheral Canal. This canal was to divert Sacramento River water just south of Sacramento and transport it to the pumps for delivery to San Joaquin agricultural users and urban users further to the south. It was also supposed to release water into the Delta at strategic points for salinity control and fish and wildlife needs. After two decades of considerable legislative study and much debate, and the perceived inability of the project to meet water flow and quality standards, the state's voters rejected the canal in the1982 referendum election. Legislation proposing by-pass project variations and water quality legislation to revive the canal is introduced in almost every legislative session.

Delta flows come from winter rains and spring runoff. Regulated flows also come from reservoir releases in the summer and fall. Delta flows are not only necessary for the needs of fish and wildlife, but are essential in repelling the intrusion of salt water from San Francisco Bay. Current demands on Delta flows come from the SWP, agricultural interests in the Delta, and urban and industrial water users. Water district demands for quality water, especially during dry climate periods, compete with fisheries and other Delta wildlife needs.

Diversions within and upstream from the region also impact the Delta. About 1,800 agricultural diversions within the Delta divert about 960,000 acre-feet annually. None of these diversions are screened to prevent impacts on fish and their eggs and larvae resulting in significant losses. Upstream diversions account for a loss of 9 million acre-feet, about one-third of the Delta's annual inflow, of water that would otherwise flow through the Delta.

Coordinated Operation Agreement

In 1986, increasing concern about conditions in the Delta and the need for coordinated water transport led to DWR and the federal Bureau of Reclamation reaching a Coordinated Operation Agreement, formally committing to work together to "sustain water flows during dry periods so that Delta salinity standards are met." The 1986 agreement also provides a process for incorporating the new water quality standards scheduled to be adopted by the SWRCB in 1991. The agreement requires that the parties negotiate a contract for the SWP to transport water for the federal project through the California Aqueduct, and for the federal project to sell an equal amount of water to the SWP, subject to Congressional review and approval. The federal government has participated in funding the state-constructed facilities related to the management of the Suisun Marsh.

C-038137

Water Contracts

Thirty public agencies have long-term water supply contracts with the SWP for an ultimate firm yield of 4.2 million acre-feet a year. Firm yield is defined as the dependable annual water supply that could be made available in all years, without exceeding shortages in agricultural deliveries during droughts. These contracts run until 2035. Originally, it was estimated that all contractors would need their maximum entitlement by about 1990. While this held true for agricultural contractors, slower population growth and increased conservation measures, and the continued availability of Colorado River water in excess of anticipated amounts, now indicate that maximum entitlement deliveries for urban contractors will not be needed until after 2010 (DWR, 1988).

However, contractor requests for water exceed dependable supplies. Therefore, current operation and deliveries are based on a probability, or risk analysis. This approach has resulted in shortages in drier years.

In four drought years all CVP contracts were met by BOR, resulting in extreme shortages for the fifth drought year, 1991. The long-term average annual supply from existing facilities is estimated at 2.9 million acre-feet with project buildout at 3.7 million.

SWP Facilities Plans

The SWP has been a phased project. Construction began in 1957 with the Delta Cross Channel between the Sacramento and Mokelumne rivers. The first water deliveries were made in 1962 from the partially completed South Bay Aqueduct. In 1963, work began on the California Aqueduct with the first water deliveries to the San Joaquin Valley in 1968.

While early project stages emphasized flood control and water deliveries to areas identified as having "high water demand," most construction in the 1970s centered on the initially deferred pumping units, power plants, enlarging or extending aqueduct reaches, and facilities needed to protect water quality in Suisun Marsh. Some later projects, such as the gate on Montezuma Slough, were constructed with the intent to address adverse effects on Suisun Bay created by earlier project phases.

The project currently delivers 2.4 million acre-feet annually, but plans exist to expand that amount to 4.2 million acre-feet. In the 1990s, development is expected to focus on facilities authorized to convey water to coastal San Luis Obispo and Santa Barbara counties and to further augment SWP water supply capability (DWR, 1988). This development includes: completion of the installation of four additional pumps which would raise pumping capacity from 6,400 to 10,300 cfs; the South Delta Water Management Plan which calls for barriers and channel widening and deepening to allow for more

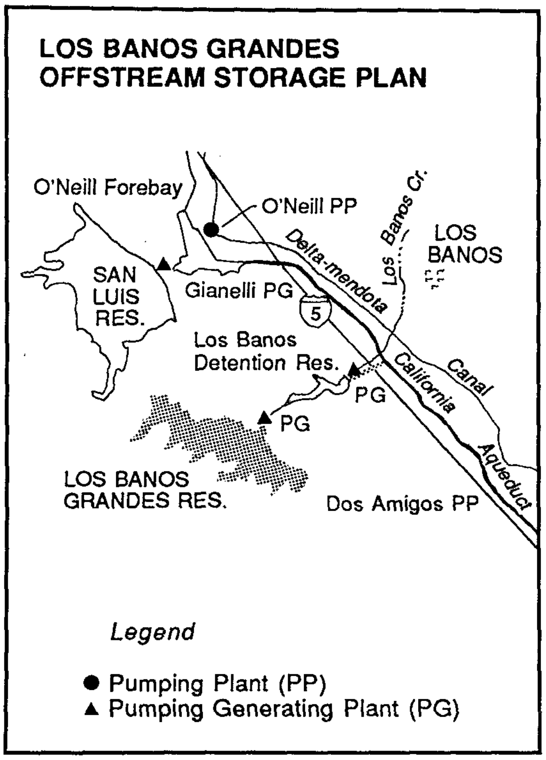

Figure 7.

water to reach the pumps; the North Delta Water Management Plan which provides for channel widening and deepening; the construction of the 3,000-acre Clifton Court Forebay increased capacity; and the Los Banos Grandes storage facility to be constructed south of the Delta (Figure 7). The stated purposes of these projects is to improve water quality for commercial fisheries and game waterfowl, to reduce reverse flows, and to facilitate further water exports for agricultural and urban consumers.

This water management approach replicates the efforts in Suisun Marsh which, while outside the statutory Delta, is instructive of water management accomplishments in the Delta. The Suisun Marsh Agreement sets water quality standards for the designated marsh within limited biological criteria. The Department of Fish and Game (DFG) acknowledges that these standards may not be adequate for protecting the most sensitive resources in Suisun Marsh.

Delta Hydraulics and the San Francisco Bay

Delta hydrodynamics must be considered in developing solutions to issues of sustaining and restoring fisheries, water quality and other uses of the Delta's limited fresh water resources. Delta hydraulics are influenced by freshwater inflow from tributary streams, Pacific Ocean tides, water uses in and exports from the Delta, and morphology—the configuration and geometry of Delta channels.

Morphology and Tidal Action

The amount of water in Delta channels varies each day within the limits of the ebb and flow of the tide. Water levels in the channels cannot decrease significantly below low tide levels because inflow caused by higher water levels in Suisun Bay will make up the difference. Suisun Bay water is quite saline and brackish (DWR, 1986).

An enormous volume of salt water moves back and forth within the Bay-Delta Estuary each day. Its tidal prism averages

1,250,000 acre-feet or nearly one-fourth its total volume. In contrast, its average daily fresh water inflow is 50,000 to 60,000 acre-feet. Water carried into the San Francisco Bay Estuary by the tides is split about equally between its northern and southern reaches, but their tidal patterns are very different. In the northern reach the tidal range is 4.3 feet at Suisun Bay and 3.0 feet in Sacramento, compared to 5.6 feet at the Golden Gate. In contrast, in the nearly enclosed basin of the southern reach, the tidal range is 8.5 feet. In the northern reach, river flow can change radically from year to year, but averages 14 million acre-feet, about 50 percent of the total runoff to the system. The remainder is diverted for agricultural and urban use. The salinity gradient in this reach is typically vertical and more apparent in winter and in wet years when it can extend for many miles within the northern reach. Tides can push the "mixing zone" for salt and fresh water up and down the Estuary two to six miles each day.

Freshwater Inflow and Exports

Since about 95 percent of the inflow to the Estuary occurs as runoff, the amount of precipitation in the Central Valley watershed determines the potential flow of fresh water into the Delta (Williams, et al., 1988). With the exception of wet years, flows into and out of the Delta are completely controlled by reservoir releases and export pumping in the summer and fall. As indicated above, annual Delta outflow has been reduced by about 50 percent from the estimated natural flow (Williams, et al., 1988). The spring low peak has been eliminated. Further decreases in flows will occur following the completion of the previously discussed water development in the watershed.

Seasonal flow changes are more pronounced than annual flow changes. For instance, an 85 percent reduction in the spring flows now occurs in dry years, and low spring flows that formerly only occurred in the dry 10 percent of years now occur about 75 percent of the time (Williams Fishbain, 1987 <u>in</u> Williams, 1988). These spring diversions have a particularly devastating impact on the area's biological resources (see Chapter 5).

This diverted and exported water now accounts for 48 percent of the state's total net water use of 34.2 million acre-feet (MAF) and 51 percent of the state's total water supply (DWR, 1983).

Within the Delta, almost all water use is agricultural; 500,000 acres are irrigated and produce corn, grain, tomatoes, alfalfa, pasture, sugar beets, safflower and asparagus (SWRCB, 1988).

Of the 1985 7.4 MAF of water carried by Central Valley Project water, 2.79 MAF are from the Delta. Ninety-four percent of the CVP water was used to irrigate 2.8 million acres of farmland of which 1.2 million acres were in the San Joaquin Valley. Urban and industrial consumers use the remainder (DWR, 1990).

While CVP water is mostly used for agriculture, the State Water Project delivers approximately 1.1 MAF to municipal, industrial and other consumers (SWRCB, 1987). Agriculture uses 1.3 MAF or 54 percent of the 2.4 MAF to grow crops on 445,000 acres in the San Joaquin Valley and other areas. The largest SWP contractor is Metropolitan Water District of Southern California.

Thus, of the water delivered by the SWP and CVP in 1985, 85 percent was used by agriculture and the remainder to urban, industrial and other users.

Water Quality

Water in the Delta is a mixture of waters from the Sacramento and San Joaquin Rivers and other source streams as well as water from San Francisco Bay. The relative contribution of each source to the mixture depends on the source amounts and on flow patterns within the Delta.

Each source of water has its own particular characteristics, such as salinity and nutrient content. Each source contains pollutants from point and non-point sources. As water from different sources mix, water quality changes. Water quality in the Delta is a complicated amalgam of water flow and discharges into and through the Delta, the water quality of source water, water use within the Delta and diversions which remove water from the Delta or alter flow patterns.

High Flows and Low Water Diversions

During periods of high river flow and low water diversions, water flows down the San Joaquin, Old and Middle Rivers and the Sacramento Rivers through the Delta to the sea (Figure 8). With high flow and high water diversion, water from the San Joaquin River is pulled west and south (upstream) through Old and Middle River to Clifton Court Forebay (Figure 9). A portion of the Sacramento River flows through the Cross Delta Channel and Georgiana Slough into the distributaries of the Mokelumne River; Sacramento River water also enters the central Delta through Three-mile Slough. Thus, most of the water flowing through the western Delta is from the Sacramento River; water flowing through the central and south Delta is from the San Joaquin River as well as from the Sacramento and Mokelumne Rivers. Water from the San Joaquin River flows into the Bay only when river flow exceeds water exports.

Low Flow and High Water Diversions

Water exports and diversions have decreased the frequency of

Figure 8. Water flows in the Delta with high flow and no water export. From the State Water Resources Control Board, 1990a.

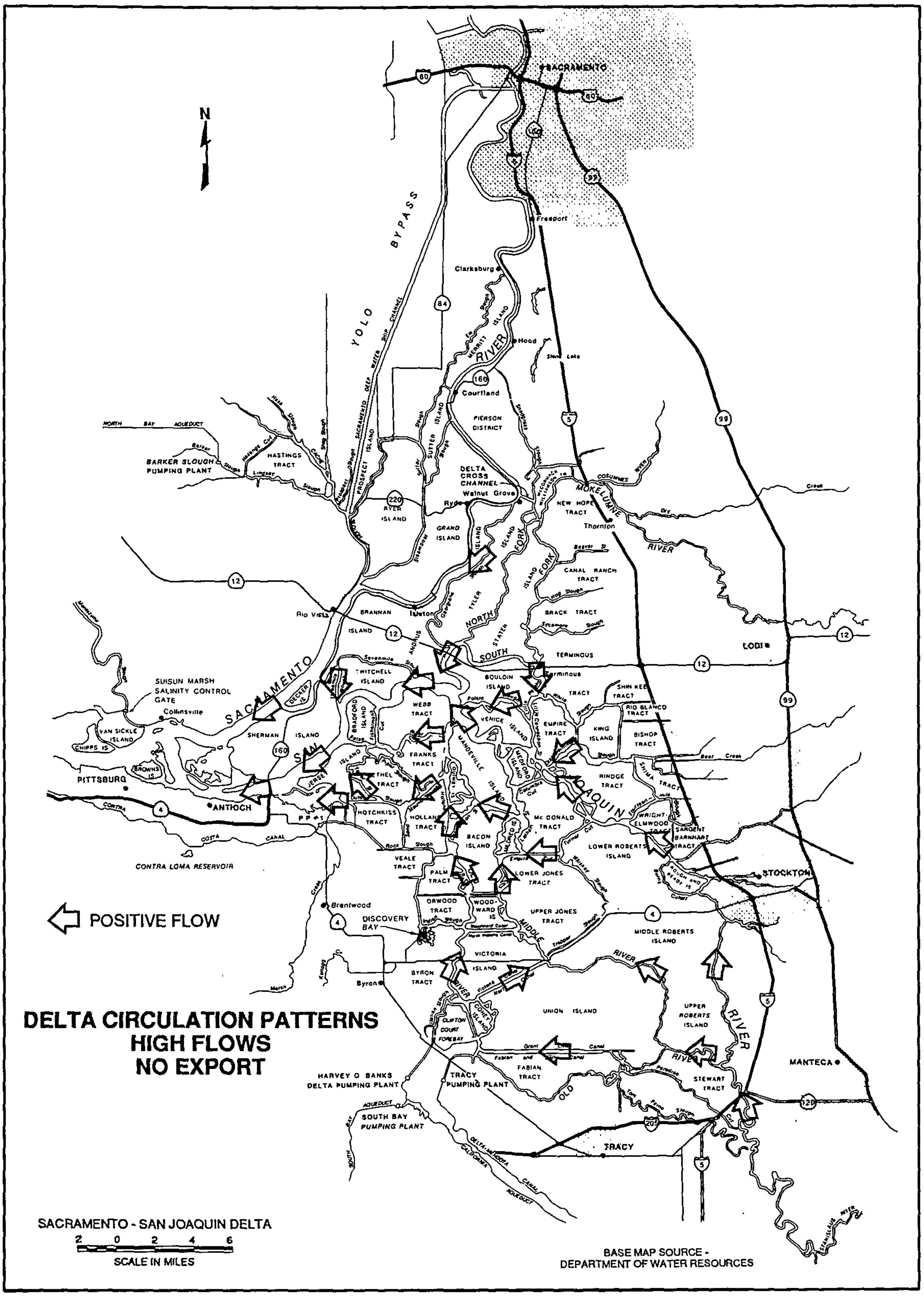

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Figure 9. Water flows in the Delta with high flow and high water export. From the State Water Resources Control Board, 1990a.

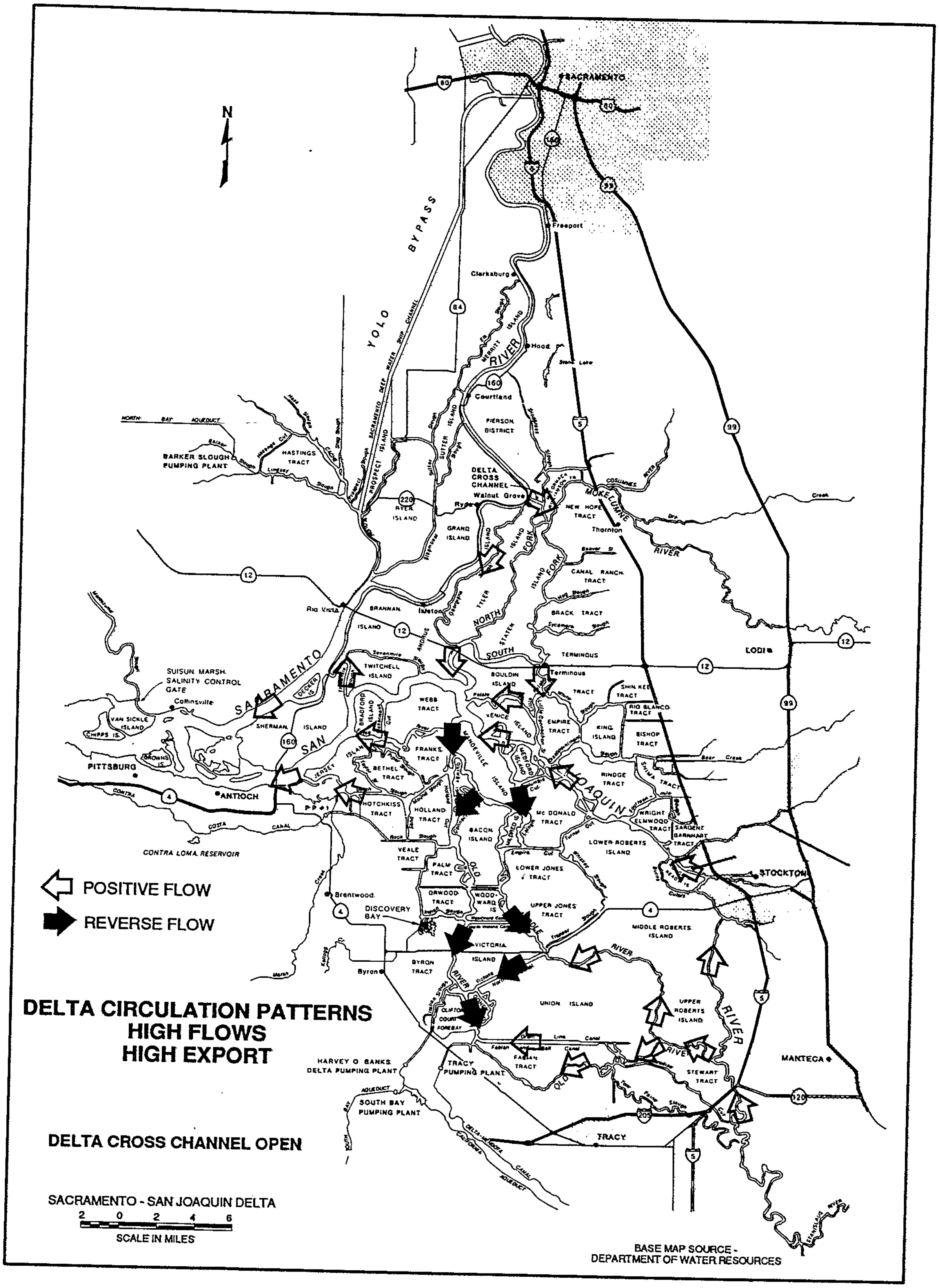

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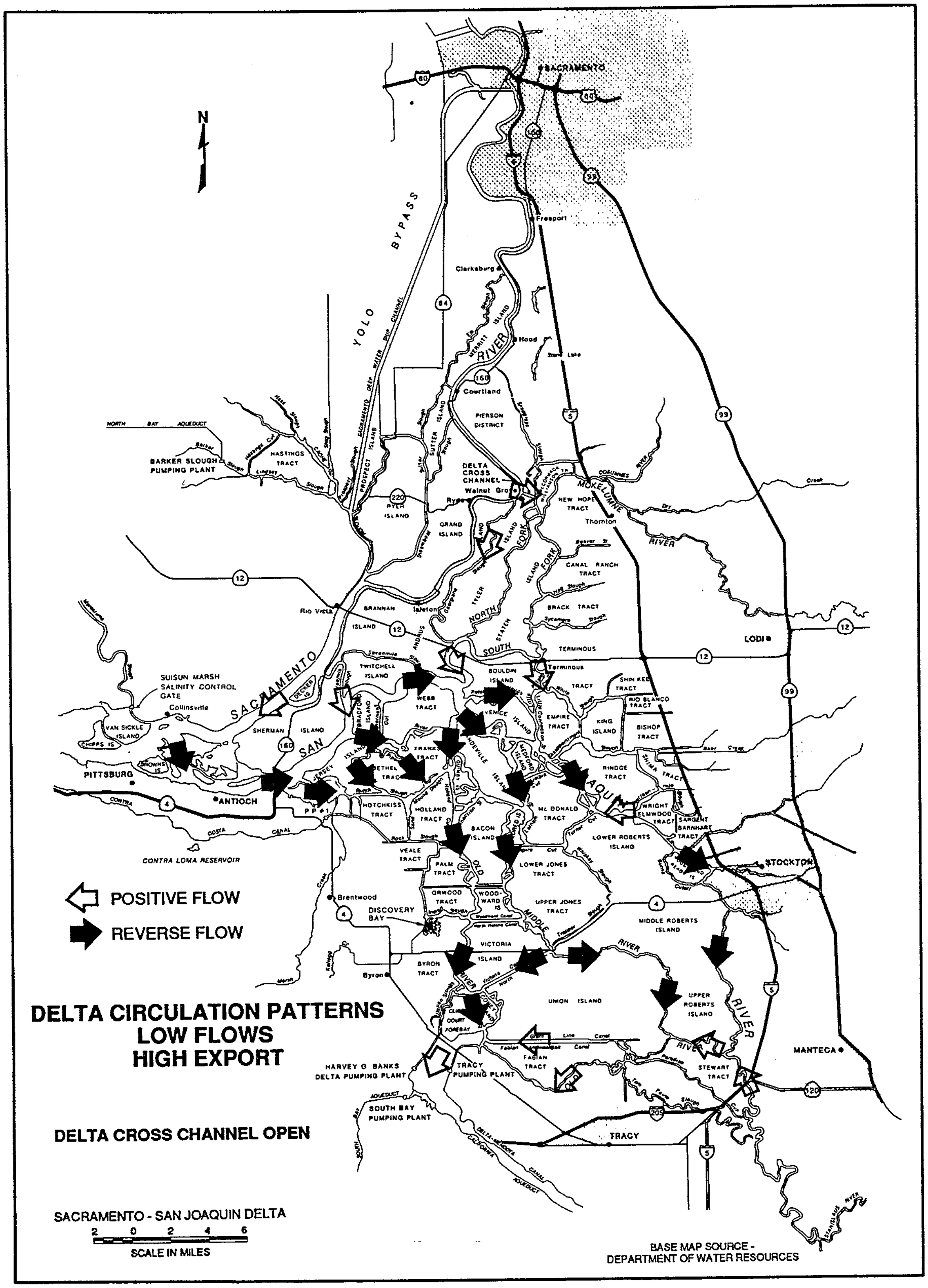
Figure 10. Water flows in the Delta with low flow and high water export. From the State Water Resources Control Board, 1990a.



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exports are sufficiently high, the flow along the lower San Joaquin River between Jersey Point and Antioch also reverses, carrying a mixture of water from Suisun Bay and the Sacramento River back into the central Delta (Figure 10).

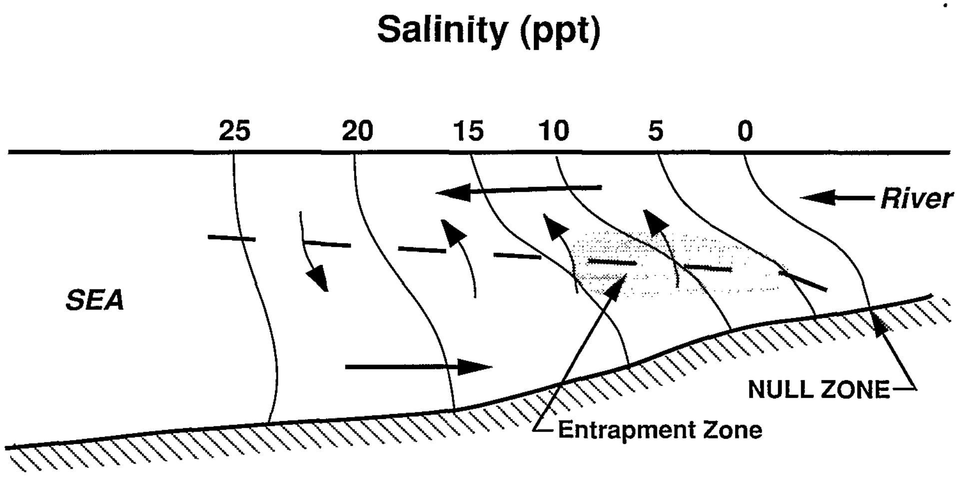

Figure 11. Conceptual Diagram of Circulation and Position of the Entrapment Zone of a partially mixed estuary. From State Water Resources Control Board, 1990a.

"Null" or Entrapment Zone

The point at which freshwater flowing from the Delta meets saline water from San Francisco Bay is called the null or entrapment zone (Figure 11). It is here that downstream river currents meet and offset upstream bottom currents from the Bay. Low current velocities in the null zone create high settling rates, concentrating suspended sediments. The location of the entrapment zone varies in relation to the discharge rate of fresh water from the Delta and the tidal cycle. With high freshwater flows, the entrapment zone is located downstream of Suisun Bay (Figure 12). With low flows, the entrapment migrates into the western Delta, sometimes as far as Jersey Island. Each day the entrapment zone also oscillates up and downstream with the tide, moving from three to 10 kilometers, depending on the magnitude of the tidal cycle.

The relationship between electrical conductivity (EC)—a measure of salinity—and the relationship between flow in the Sacramento and San Joaquin Rivers and at Jersey Point in the western Delta in the water years 1984 to 1988 are illustrated in Figure 13. Flow is considerably higher in the Sacramento River (10 to 60 cubic feet per second) than in the San Joaquin River (five to 24 cubic feet per second). EC is higher in the San Joaquin River (100 to 1300 Us/cm) than in the Sacramento River (70 to 220 Us/cm). In the western

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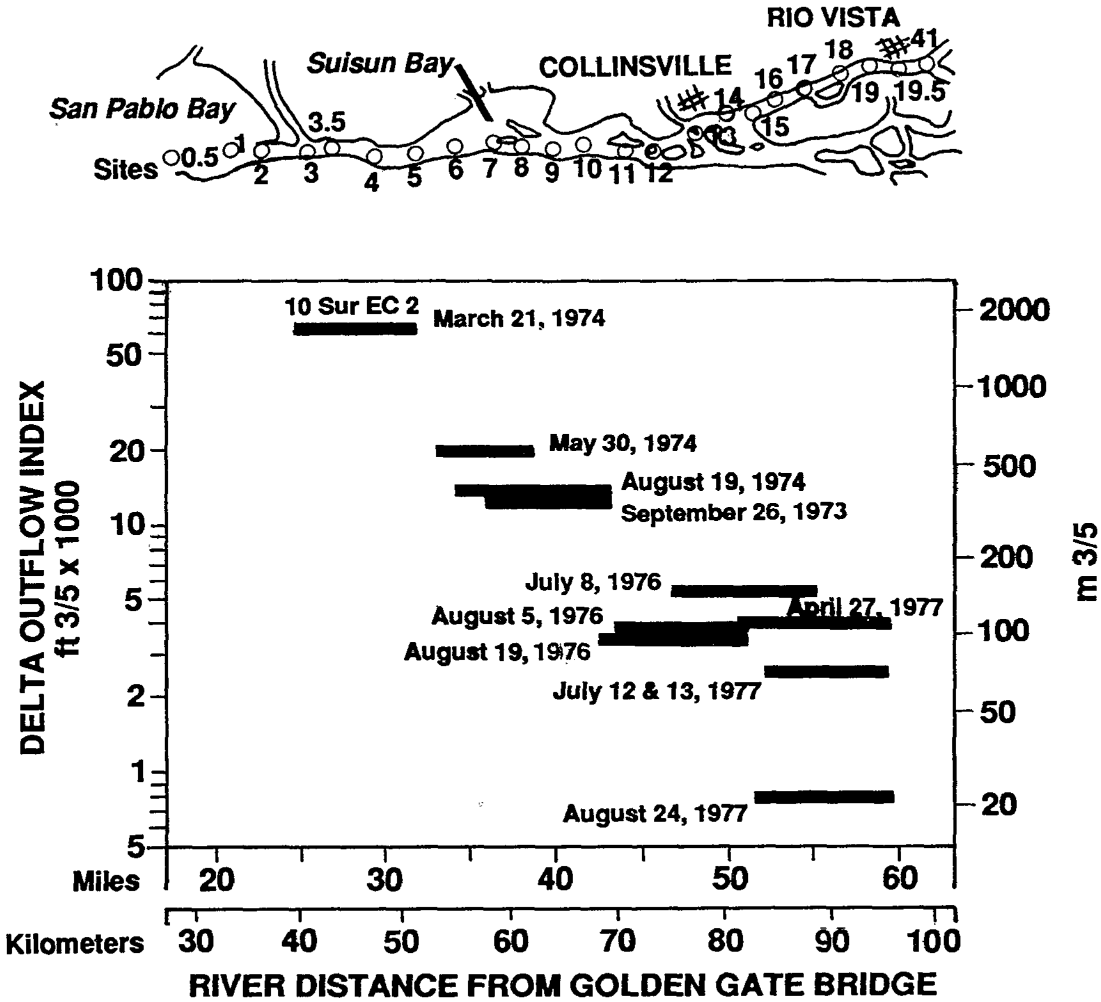


Figure 12. Estimated High Slack Tide Locations of the Entrapment Zone in the San Francisco Bay-Delta based on the 2-10 millimho/cm EC (1-6%) range at various Delta Outflows. From Arthur and Ball, 1979.

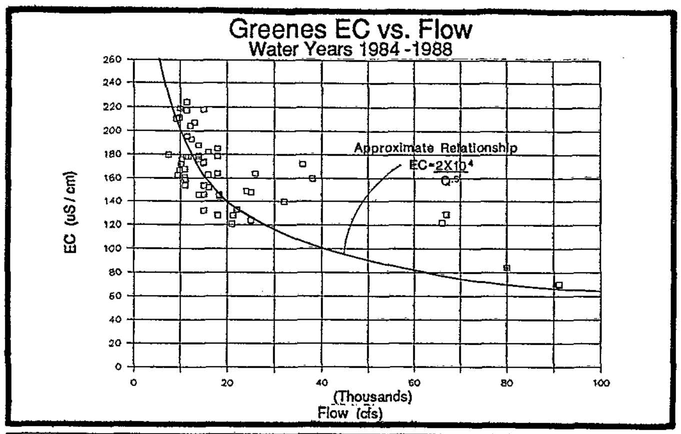
Delta, when flow was downstream (positive), EC ranged from 100 to 250 Us/cm. When flow was upstream, EC ranged from 300 to 2400. The higher EC is indicative of saltwater intrusion.

Sacramento River Water Quality

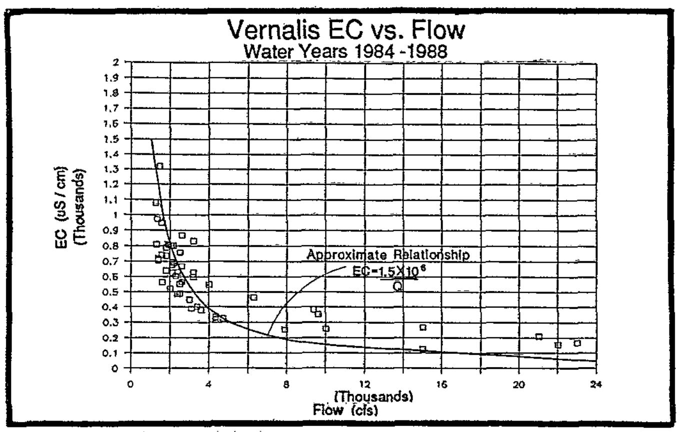
The Sacramento River contributes 85 percent of the inflow to the Delta. Water quality in the Sacramento is generally good. However, in May and June, agricultural drainage may constitute 30 percent of the flow (Gunther, et. al., 1987).

Drainage water is, at times, toxic to test organisms. Monitoring from 1986 to 1989 has consistently demonstrated that, in May and June, water in the Colusa Drain is toxic. Downstream toxicity from

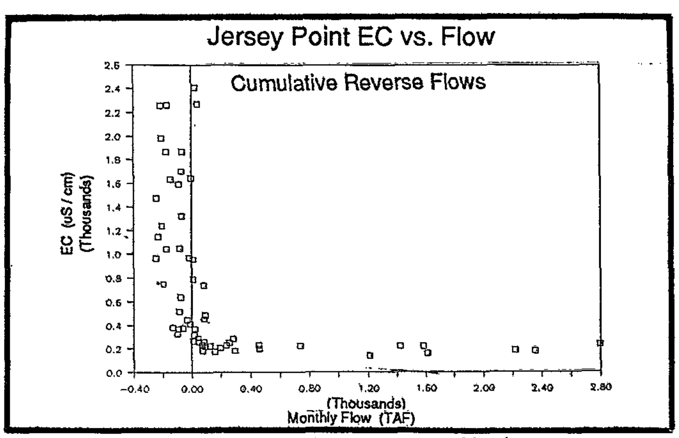
Figure 13. Relationship between monthly average EC and Monthly Flow in the Sacramento and San Joaquin Rivers and at Jersey Point ED HAMP 1984-1988 Data. From Jones and Stokes, 1990.



SACRAMENTO RIVER



SAN JOAQUIN RIVER



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the Colusa Drain has been measured in the Sacramento River as far south as Rio Vista (Foe and Connor, 1989). In 1988 the toxicity was caused by the release of the pesticides carbofuran and methyl parathion from rice fields. In 1989, toxicity was caused by carbofuran, methyl parathion and malathion. The source of malathion is unknown.

It has been suggested that pesticides from rice fields are a contributing factor in the decline of the striped bass. Approximately 50 to 65 percent of the eggs produced each year are spawned from about May 10 to June 12 in the Sacramento River between the cities of Colusa and Sacramento. Thus, there is a spatial and temporal relationship between spawning and toxicity in the river.

Studies by the Department of Fish and Game (DFG) show an accelerated decline in survival of the larvae of striped bass, starting in 1977. It is probable that multiple factors are affecting striped bass (See The Delta's Flora and Fauna). Between 1977 and 1979 the Sacramento Valley rice industry shifted from long- to short-stem rice cultivation, with a concomitant increase in the number of acres of rice cultivated and the number and pounds of pesticides applied. A correlation between the pounds of methyl parathion applied to rice fields divided by the average daily May flow rate of the Sacramento River at the "I" Street Bridge is statistically significant ($P<0.01$); the correlation accounts for 42 percent of the difference between the predicted and observed numbers of bass from 1970 to 1986 (Foe and Connor, 1989).

Other pollutants, including heavy metals, chlorinated hydrocarbons (DDT and PCB) and petrochemicals, may be contributing to the decline of the striped bass. Monocyclic aromatic hydrocarbons (e.g., benzene, toluene), alicyclic hexanes and DDT in livers and ovaries of prespawning striped bass have been associated with egg resorbtion (taken back into the tissue), abnormal egg maturation and egg death (Setzler-Hamilton, et al, 1988). Skeletal abnormalities have been correlated with high body burdens of trace elements, particularly mercury, selenium, zinc and chromium (Interagency Ecological Study Program, 1987).

Drainage from mine wastes in the upper Sacramento River are a significant source of heavy metals, particularly in the area from Shasta Dam to Red Bluff (SWRCB, 1990c). Elevated levels of chromium, cadmium, copper, nickel and zinc are found in fish collected near Keswick (SWRCB, 1990d). Mine drainage contributes cadmium, copper and chromium to the lower Sacramento River and the Delta (SWRCB, 1990b). Elevated levels of cadmium and chromium have been measured in fish collected in the Sacramento River near Hood. Between 1978 and 1984 concentrations of mercury, from historical gold mining, exceeded the Median International Standard for Trace Elements (SWRCB, 1990d).

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The use of the pesticides DDT, HCB and chlordane have been banned in California, DDT in 1971, HCB in 1976 and chlordane in 1988. Toxaphene is no longer registered in California. Use, as measured by pounds registered, has declined from 1,025,098 pounds in 1978 to 647 pounds in 1987. Dactyl is a pre-emergence herbicide, commonly used on crops such as broccoli and onions. Chlorpyrifos, an insecticide sold as Dursban, Lorsban and Stipend, has extensive urban and agricultural use.

Pesticides have also been detected in fish collected from the lower Sacramento River. DDT, toxaphene and chlordane in fish collected near Hood sometimes exceed the guideline concentration recommended by the National Academy of Science. Hexachlorobenzene (HCB) has also been detected at high levels. One sample of fish from Rio Vista showed elevated levels of dacthal and chlorpyrifos.

San Joaquin River Water Quality

The San Joaquin River contributes 10 percent of the inflow to the Delta. The river is more saline than the Sacramento and carries higher concentrations of several constituents, including nitrates, selenium, nickel, manganese and boron. The concentration of salts, selenium and other constituents is highest just downstream of the confluence of Salt and Mud Slough with the San Joaquin River; concentrations decrease upstream and downstream of this area (California Regional Water Quality Control Board, Central Valley Region, 1991). Salt and Mud Slough are the major sources of subsurface agricultural drainage to the San Joaquin River.

Agricultural drainage comprises a significant portion of the flow in the San Joaquin River during the irrigation season and, occasionally, in January and February following flushing of agricultural water from duck clubs (SWRCB, 1990b). Bioassays have shown periodic toxicity in the river (SWRCB, 1990c), sometimes with high mortality over many miles (Foe, 1989; 1990a,b). Tests conducted in April, 1990, for instance, showed significant mortality to test organisms in 78 river miles from Fremont Ford Park to Maze Road. Two pesticides, diazinon and carbofuran, were detected at levels that can cause toxicity. In 36 miles of the San Joaquin River, diazinon exceeded EPA's recommended criteria by a factor of 82-170; carbofuran exceeded the Central Valley Regional Water Quality Control Board's performance goal by a factor of 1-2. (Foe, 1990b).

Samples of fish taken from the San Joaquin River near Vernalis have elevated concentrations of pesticides. Chlordane, DDT and toxaphene commonly exceed the guideline concentration recommended by the National Academy of Science and, on occasion, exceed FDA action levels. Hexachlorobenzene is regularly detected (SWRCB, 1990d).

Urban Runoff Pollution

Urban runoff, particularly from Sacramento and Stockton, undoubtedly contribute pollutants to the Sacramento and San Joaquin Rivers; however, little is known about the temporal and spatial effect of urban runoff in the area. One study in Sacramento (Montoya, 1987) detected polynuclear aromatic hydrocarbons (PAHs) at high levels. Copper, lead, zinc, cadmium and chromium in runoff water and sediments often exceeded the U.S. EPA water quality criteria for protection of freshwater aquatic organisms. Exhaust fumes, tire wear and crankcase oil from automobiles are known to contribute PAHs and metals to urban runoff.

Point-Source Pollution

The primary point-source discharges in the Delta are shown in Table 1. Sacramento Regional Waste Treatment Plant (RWTP) and Stockton Sewage Treatment Plant are the largest sewage treatment plants discharging to the Delta. There are no large industrial discharges in the Delta. There is one power plant that uses Delta water for cooling. Two oil terminals, three paper processors, four oil production facilities and several manufacturing facilities discharge to the Delta.

Table 1. Municipal and Industrial Outfalls in the Delta (after Gunther, et. al., 1987).

Discharger	Industry	Segment of the Estuary Receiving Waste	Avg. Flow 1984-1986 (millions L d)
Sacramento RWTP	Delta POTW	North Delta	508
Stockton STP	Delta POTW	Central Delta	109
Lodi White Slough WPCP	Delta POTW	North Delta	19
West Sacramento STP	Delta POTW	North Delta	14
Tracy	Delta POTW	South Delta	14
Davis STP	Delta POTW	North Delta	12
Rio Vista WTP	Delta POTW	Central Delta	2
Central CCSD #19	Delta POTW	Central Delta	1
Walnut Grove WTP	Delta POTW	North Delta	0.4a
PGE: Contra Costa	Power Plant	Central Delta	
Shell Oil (West Sacramento)	Oil Terminal	North Delta	
Tosco Corp.	Oil Terminal	North Delta	
Allied Energy	Oil Production	Central Delta	
Int'l Oil and Gas	Oil Production	Central Delta	
John Pestana Family	Oil Production	Central Delta	
Termo	Oil Production	Central Delta	
Crown Zellerbach	Paper	Central Delta	
Fibreboard	Paper	Central Delta	
Pacific Paperboard	Paper	Central Delta	
Discovery Bay	Lagoon	Central Delta	
Mohawk Rubber	Rubber	Central Delta	
Sacramento River Water TP	Water Treatment	North Delta	
Sharpe Army Depot	Depot	South Delta	
Union Carbide: Linde Div.	Gases	Central Delta	

a Reclaims wastewater in the summer. Wet season flows averaged over the entire year.

Since monitoring data has not been compiled, it is not possible to determine the amount of heavy metals and other constituents entering the Delta from point sources. Information in Gunther, et al. (1987) shows that, between 1984 and 1986, the Sacramento RWTP contributed 25 percent of the lead discharged to the Delta by the eight largest publicly owned treatment plants. The Sacramento RWTP was also a significant source of copper and chromium from 1984 to 1986 and silver in 1985 and 1986. There is no information on the contribution of the Stockton sewage treatment plant.

Non-Point Source Pollution—Agricultural Drainage

In the Delta, more than 1,800 siphons divert water for crop and livestock production. Water also seeps onto the islands from surrounding channels. The collected water is then pumped back into Delta channels. Evaporation and water use by plants (evapotranspiration) concentrate salt on the islands; return water therefore typically has concentrations of two to five times more salt than source water. The water also accumulates organic compounds from the decay of vegetation and oxidation of the Delta's peat soils as well as nutrients (nitrates and sulfates) from fertilizers.

Organic Components

The organic content of the water is important because it is related to the formation of carcinogenic compounds, such as chloroform and bromoform, during chlorination of drinking water. These compounds are collectively known as trihalomethanes. Trihalomethane formation potential (THMP) is a measure of the amount of trihalomethanes that will be formed during disinfection of drinking water. As shown in Table 2, THMP in agricultural return water is 200 to 500 percent higher than in water from the Sacramento and San Joaquin rivers. THMP in water from Suisun Bay is approximately twice that of water from the rivers. THMP in Suisun Bay, however, differs from THMP in the Delta and the rivers because the water in Suisun Bay has seawater containing high levels of bromides. The bromides combine with the organic matter to form brominated trihalomethanes. Brominated compounds may be more difficult to remove during water treatment and may have more serious health effects than chlorinated compounds (Jones and Stokes, 1990).

Pesticides from Delta Activities

Pesticides are generally not detected in return water, except for small amounts of atrazine, simazine and 2,4-D (Jones and Stokes,

Table 2. Average water quality as measured in IDHAMP Delta Agricultural Drainage Samples as compared to Delta inflows for 1983-1988. Data as represented in Table 3C-17 and 3C-23 in Jones & Stokes (1990).

Location	EC (uS/cm)	THMFP (ppb)	SO4 (ppm)	NO3 (ppm)
Delta inflows				
	165	302	11	
Sacramento River	592	494	95	
San Joaquin River	7,953			
San Francisco Bay		890	348	
Suisun Bay (Mallard Island)				
Island agricultural drains				
	1,374	2,950	114	
Empire	501	2,372	81	
Bouldin	488	2,205	47	
Tyler	902	1,850	86	
Rindge	880	1,822	132	
Egbert	759	1,619	83	
Brannan	791	1,537	42	
Terminous	439	1,489	47	
Grand	1,315	1,315	101	
Upper Jones	711	1,153	31	10
Kings	966	854	93	6
Mossdale	1,976	804	230	10
Pescadero	684	801	61	4
Prospect	578	773	35	4
Natomas	894	707	37	5
Rioblanco				

1990). However, pesticides have been detected in sediments and fish in the Delta (Jones and Stokes, 1990, p. 3C-13). Relatively few samples of fish tissues have been taken in the Delta proper, but two out of three samples of fish taken in Paradise Cut near Tracy show contamination with chlordane, DDT, toxaphene, and hexachlorobenzene; one sample had elevated levels of chlorpyrifos. One sample taken near Twitchell Island had elevated levels of chlordane and PCB. Fish taken in Old River had elevated levels of arsenic (SWRCB, 1990d).

Dredging

Dredging to maintain ship channels and access to ports and marinas as well as to repair and maintain levees in the Delta may further affect water quality in the region. However, except for maintenance dredging of the Sacramento River and Stockton Deep Water Ship Channels, records are not kept on dredging activity in the Delta. Dredging may remove shoal areas, create turbidity and resuspend toxics, if present. There is essentially no information available about sediment contamination in the Delta, but samples from Mormon Slough, in the southern Delta, and from the Stockton Ship Channel

Table 3. PAH and PCB concentrations in surficial (top 1-5 cm) sediments from the San Francisco Estuary (San Francisco Estuary Project, 1990).

Compound Class	Location	Concentration in sediment ug g-1 dry wt.	ug g-1 organic carbon
PAHs (Total)	Islais Creek	129	36,300
	India Basin	69.7	23,200
	Port of Stockton	47.5	26,500
	Mormon Channel	73.5	24,400
	Mormon Slough	1.4	1, 600
PCBs (Total)	Islais Creek	0.45	125
	India Basin	0.78	259
	Port of Stockton	12.6	7,020
	Mormon Channel	17.8	5,913
	Mormon Slough	7.1	8,060

(Table 3) showed some of the highest levels of PAHs and PCBs measured on the Pacific coast (San Francisco Estuary Project, 1990).

Other Unknowns

Another unknown, but potentially important, water quality problem in the Delta is tributyltin (TBT), an organic tin compound used in antifouling paints on boat hulls. TBT is extremely toxic and can cause growth abnormalities in molluscs and other organisms. It also has a high potential for bioaccumulation. TBT is mostly used on boats used in marine waters, but sampling in the Delta (Table 4) has shown the presence of TBT in sediments. Water in several marinas exceeded the U.S. EPA criteria (26 ng/l) for protection of freshwater aquatic organisms, sometimes by more than a factor of 10. Commercial and recreational vessels discharge sewage and grey water into both the Delta and Bay.

The area downstream from the Delta is heavily industrialized. Three refineries, four chemical plants, a steel processing plant, and two power plants discharge to Suisun Bay and the Carquinez Strait (Table 5). The refineries are a significant source of selenium, while the U.S. Steel plant is a significant source of chromium (Gunther, et al., 1987). There is also substantial oil tanker and other ship traffic through this area which creates the potential for oil or hazardous waste spills that could adversely affect Delta resources.

Table 4. Butyltin in Delta Water (ng/l) and sediment (ng/kg). From Richard & Lillebo (1988).

LOCATION	1* SAMPLE #	2* TYPE	4* TBT	DBT	MBT	flora	3* Presence of fauna
Sacramento Turning Basin	1	W	4	14	8	Y	?
	1	S	tr.	tr.	1,300	Y	?
Isleton,	1	W	210	21	8	N	?
Oxbow Marina	2	W	250	13	3	N	?
	1	S	7,000	2,500	11,000	N	?
Stockton Water	1	W	51	27	10	N	N
Front Yacht Club	2	W	51	42	22	N	N
Near Turning Basin							
	1	S	3,300	2,000	20,000	N	N
Stockton,	1	W	23	3	5	Y	?
Paradise Point	2	W	17	2	4	Y	?
	3	W	n.d.	4	5	Y	?
	4	W	6	3	25	Y	?
	1	S	n.d.	n.d.	n.d.	Y	?
Stockton,	1	W	n.d.	n.d.	n.d.	Y	Y
Tower Park	2	W	n.d.	n.d.	n.d.	Y	Y
	3	W	n.d.	tr.	tr.	Y	Y
Bethel Island	1	W	17	3	8	Y	?
Yacht Sales	2	W	13	7	8	Y	?
	1	S	3,800	4,100	28,000	Y	?
Stockton	1	W	170	27	6	Y	?
Village West	2	W	120	18	19	Y	?
	1	S	13,000	12,000	30,000	Y	?
Rio Vista	1	W	130	10	6	Y	?
Delta Marina	2	W	51	14	5	Y	?
	1	S	5,500	8,800	16,000	Y	?
Stockton,	1	W	60	8	5	Y	?
Ladds Marina	2	W	62	16	13	Y	?
	1	S	23,000	21,000	60,000	Y	?
Tiki Lagoon	1	W	n.d.	n.d.	3	Y	?
Resort Launch Ramp	2	W	11	4	4	Y	?
	1	S	n.d.	3,700	2,000	Y	?

Footnotes:
1. Two or more samples taken at a site are not duplicates or replicates and should be considered separately (i.e. should not be averaged).
2. W = water; S = sediment
3. Y = yes; N = no; ? = not observed
4. n.d. = not detected; tr. = trace

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Table 5. Municipal and Industrial Outfalls in Suisun Bay and Carquinez Straits (after Gunther, et al, 1987).

Discharger	Industry	Segment of the Estuary Receiving Waste	Suisun Bay Avg. Flow 1984-1986 (millions L d)
Central Contra Costa SD	Delta POTW	Suisun Bay	146
Delta Diablo SD	Delta POTW	Suisun Bay	36
Fairfield-Suisun SD	Delta POTW	Suisun Bay	36
Benicia WTP	Delta POTW	Suisun Bay	9
Mountain View SD	Delta POTW	Suisun Bay	5
United States Steel	Large Indust.	Suisun Bay	75.7
General Chemical	Large Indust.	Suisun Bay	4.2
C & H Sugar (E002)	Large Indust.	Carquinez Straits	3.8
Dow Chemical	Large Indust.	Suisun Bay	1.5
Stauffer Chemical, Martinez	Large Indust.	Carquinez Straits	0.4
PGE: Avon	Power Plant	Suisun Bay	
PGE: Martinez	Power Plant	Suisun Bay	
PGE: Pittsburg	Power Plant	Suisun Bay	
Wickland Oil	Oil Terminal	Carquinez Straits	
Shell Oil Company	Chemical	Suisun Bay	
C & H Sugar	Sugar	Carquinez Straits	
Hysol/Dexter	Adhesives	Suisun Bay	
IT Corporation	Hazardous Waste		

The Delta's Structure

4

The Delta, California's inland coast, lies along the western margin of the Central Valley. Geologists suggest that this valley was formed in the basin of a large sea between 175 million to 25 million years ago. Extensive sedimentation, global climate change and the geologic processes that raise mountains all helped create the Delta. At that time, an island mountain chain lay to the west of a continental margin presently occupied by the Sierra Nevada (Atwater, 1982).

Rapid mountain uplifting along this ancestral coastline created great volumes of erosional material. This material migrated westward, filling the basin. This sedimentation created an environment for the formation of rich hydrocarbon gas deposits and the building of flat land, or peneplain.

As this shallow basin was filling to form the ancestral valley floor, mountain building to the west began and continued to the Miocene, between 26 to 5 million years ago. This activity formed the present Coast Range.

The Sierra Mountain chain continued to build, simultaneously depositing material across the peneplain forming the new valley floor. Deposits of non-marine sediments in the valley mark this event.

Cycles of glacial advances, melting and retreating created events of high water runoff which established the early river drainage systems through the Central Valley. This river and stream drainage continues presently. With lower relative sea levels, the prehistoric streams flowed westerly through a narrow valley and into the ocean. This valley was inundated repeatedly, ultimately forming the inner bays and the San Francisco Bay. The advancing waters created the proper conditions for Delta formation (Figure 14) (Thompson, 1982).

Cyclic river flooding helped contribute material along the stream channels forming natural levees. These levees formed around islands which created environments for tule marsh.

The high concentrations of tules in the wetlands environment promoted deposition of plant debris to create peat soil. These thousands of years of accumulations continued until the 1850s, creating deposits reaching 50 feet at the greatest depths. The constant flooding of the Delta kept these materials from decomposing and compressing dramatically, so the islands maintained a relatively stable surface elevation—roughly low tide level.

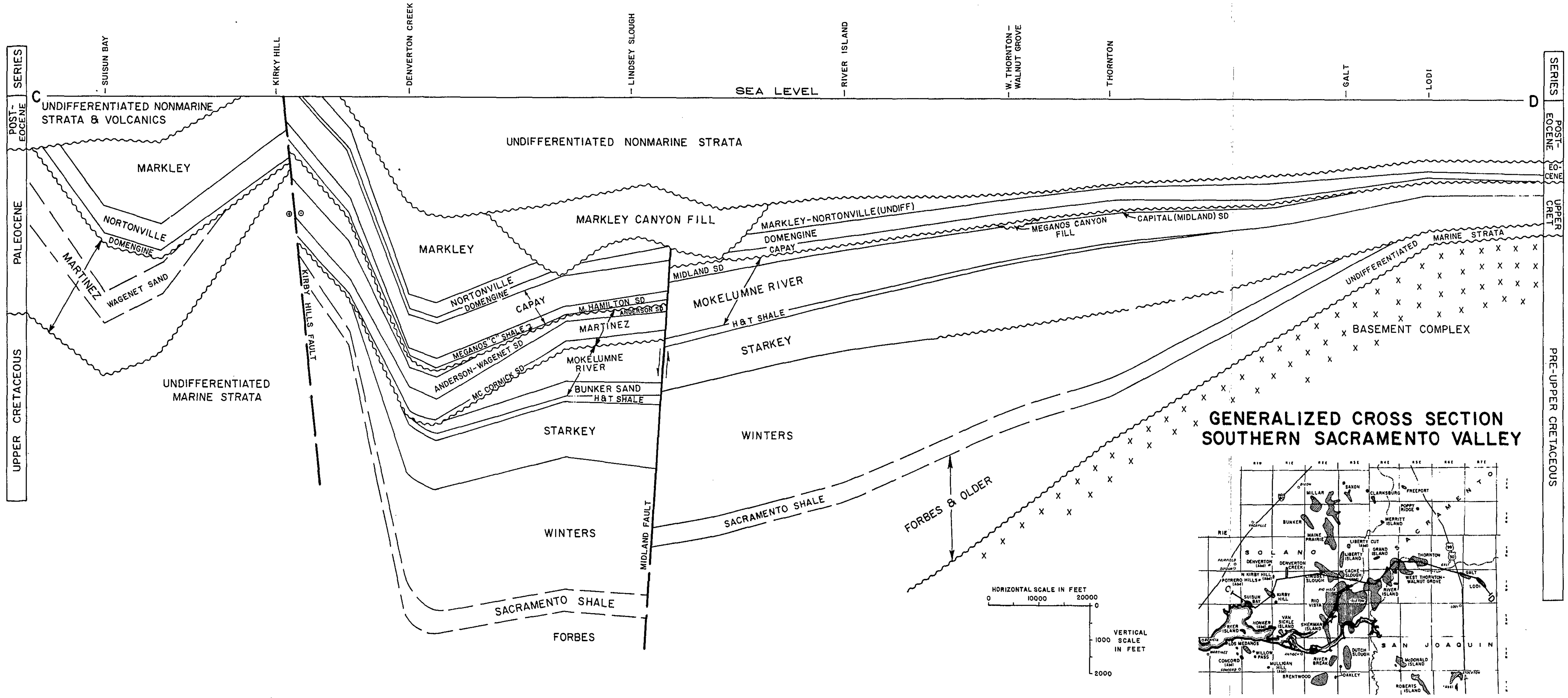
The Delta, prior to the Europeans, had evolved geologically and hydrologically with a network of slow-moving river channels dependent on and influenced by the confluence of the two major rivers, the Sacramento and San Joaquin and the subordinate streams—the Mokelumne, Calaveras, and Cosumnes rivers.

Major land features included low natural levees rising about five feet above sea level flanking each major channel. The natural islands in the Delta were much as they are at present in their basic configurations. These islands were dished with a lower center which was often flooded and filled with tules. The levees formed a raised "lip" around the perimeter of the natural islands. It is upon these existing islands that settlement brought on the construction of artificial levees in the 1850s.

With the arrival of Europeans and Americans, alterations of the historic Delta began. The shallow dish-like islands became sites of reclamation and agricultural use. The early levees were low structures built around the perimeters of the natural islands with manual labor.

Extensive hydraulic gold mining, beginning in around 1850, contributed destructive sediment loads to the major northern California rivers which consequently carried this material into the Delta. This increased sedimentation in the Delta caused flooding of the region. By 1856 serious impacts on navigation and farming in the northern portions of the Delta were evident. The mining debris ultimately raised river beds higher than the surrounding "uplands." To prevent continued flooding, levees of increasing height were constructed. After many attempts at solving the debris problems, farmers appealed to the California Supreme Court which in 1884 ruled that hydraulic mining had created a public nuisance to public waterways and private farmland and upheld an action to enjoin its continuance. In 1884, hydraulic mining was banned. By this time, an estimated 800 million cubic yards of tailings had been released from mining sites.

Since the 1850s, the Delta's land form has been extensively altered by humans. The flow of the major rivers has been primarily controlled by the water export projects (see Delta's Waters). This has stopped the flood periods which brought new sediments along the whole river network and to the Delta. The regenerative soil replenishment cycle associated with this flooding ceased. The flooding of the island interiors which kept the tule marshes alive was stopped with levee building and flood control. As a consequence, the tule marshes are no longer flooded or reproduced. Succeeding tules have not replaced those that died in previous years. When the island soil levels could no longer maintain their equilibrium, subsidence began.


SERIES
POST-EOCENE
PALEOCENE
UPPER CRETACEOUS
SUISUN BAY
KIRKY HILL
DENVERTON CREEK
LINDSEY SLOUGH
RIVER ISLAND
W. THORNTON - WALNUT GROVE
THORNTON
GALT
LODI
C
D
SEA LEVEL
UNDIFFERENTIATED NONMARINE STRATA & VOLCANICS
MARKLEY
NORTONVILLE
DOMENGINE
MARTINEZ
WAGENET SAND
UNDIFFERENTIATED MARINE STRATA
KIRBY HILLS FAULT
UNDIFFERENTIATED NONMARINE STRATA
MARKLEY CANYON FILL
MARKLEY
NORTONVILLE
DOMENGINE
CAPAY
M. HAMILTON SD
ANDERSON SD
MEGANOS "C" SHALE
ANDERSON-WAGENET SD
MC CORMICK SD
MARTINEZ
MOKELUMNE RIVER
BUNKER SAND
H&T SHALE
STARKEY
WINTERS
SACRAMENTO SHALE
FORBES
MIDLAND FAULT
MARKLEY-NORTONVILLE (UNDIFF)
DOMENGINE
CAPAY
MIDLAND SD
MOKELUMNE RIVER
H&T SHALE
STARKEY
WINTERS
SACRAMENTO SHALE
FORBES & OLDER
MEGANOS CANYON FILL
CAPITAL (MIDLAND) SD
UNDIFFERENTIATED MARINE STRATA
BASEMENT COMPLEX
POST-EOCENE
EO-CENE
UPPER CRET
PRE-UPPER CRETACEOUS
GENERALIZED CROSS SECTION
SOUTHERN SACRAMENTO VALLEY
HORIZONTAL SCALE IN FEET
0
10000
20000
VERTICAL SCALE IN FEET
1000
2000
SOLANO
SACRAMENTO
SAN JOAQUIN

Soil

The Delta is valued for its soils. These soils range from a variety of mineral alluvial fan deposits around the periphery of the Delta to rich organic peats in the central Delta.

The soils pattern in the Delta is dominated by silts, clays, silty clays and sandy soils. Well drained loams, sandy loams and clay loams are found surrounding the Delta. These soils are usually level to strongly sloping, forming the rolling hills on the periphery of the Delta (U.S. Department of Agriculture, 1977).

The organic-based peaty soils are located further in the Delta's midst. Shallower peats 10 to 20 feet thick are found along the north central Delta from Walnut Grove south to Brannan Island and Staten Island. Peats over 20 feet deep are found south of Seven Mile Slough to Franks Tract and Bacon Island. Jersey Island and Bacon Island have shallower peat deposits (Figure 15). Prior to farming, the continual regeneration of plant populations and tidal flooding helped to maintain constant elevations with no subsidence in the wetlands.

The Montezuma Hills immediately west of the town of Rio Vista are the only high relief feature close to the Delta. These hills are composed of steep rolling slopes with narrow gullies. Surface vegetation consists mainly of grasses with some stands of oaks. The soils are composed of uncemented fine-grained sands, silts and clays, pebbly sand and gravels (U.S. Department of Agriculture, 1977).

Sandy soils commonly accompany the fluvial channels of the main waterways: the Sacramento, San Joaquin, Mokelumne, and Cosumnes Rivers. These low-sloping to near-level soils are not as susceptible to rainwash erosion as the steeper regions. They were within the cyclic flood zones prior to levee construction but are now cut off by the extensive levee system today.

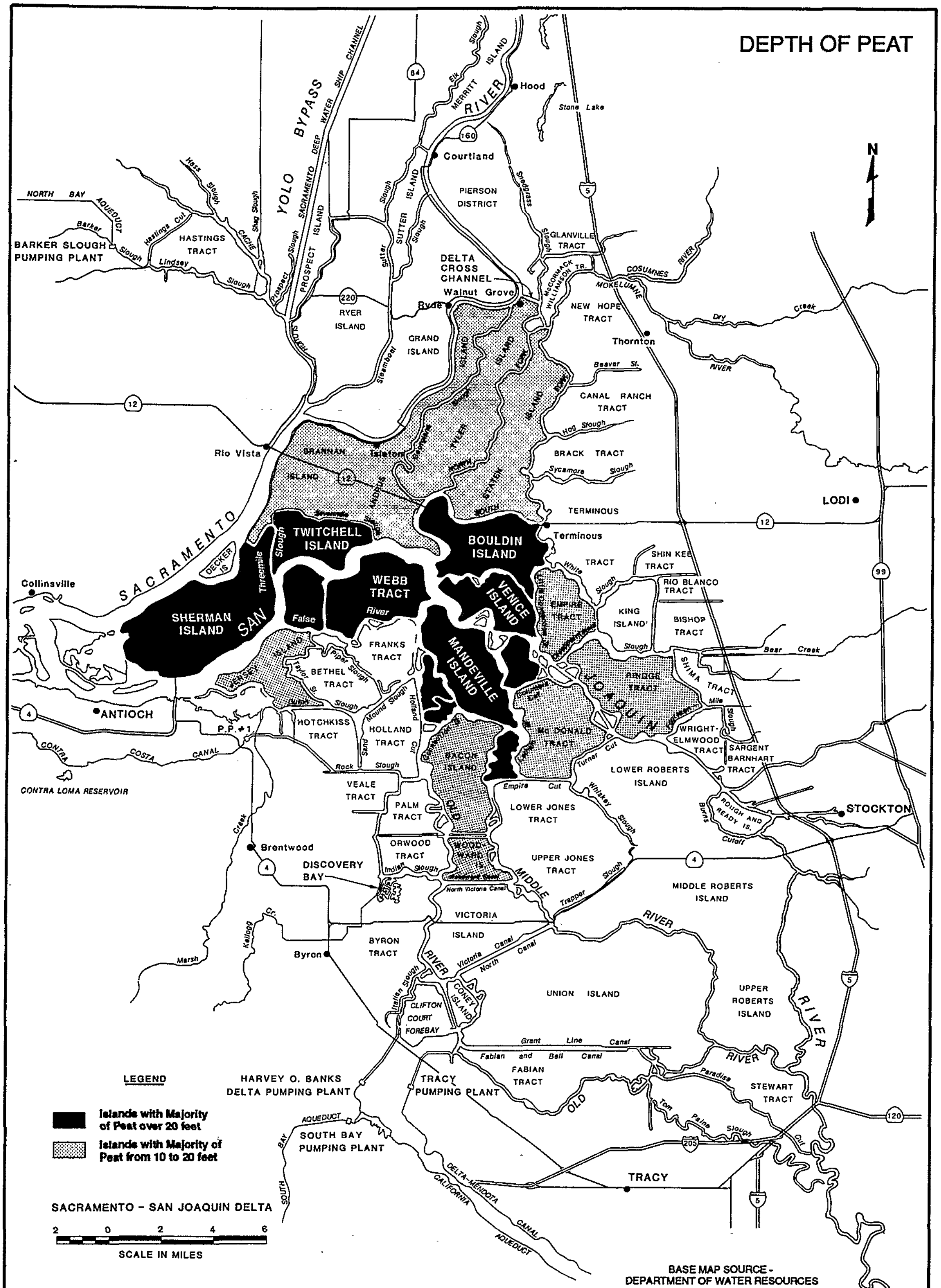
Other sources of sediment deposits are from human activity. Reclamation plans, navigational needs require dredging; construction and, as previously indicated, mining activities have added to the sedimentary history. Most of these sediments were deposited between 1913 and 1927 (Jones, 1942; Thompson, 1957).

Soil Erosion and Subsidence

The Delta, since the beginnings of its reclamation, has been used for agriculture. Intensive cultivation has precipitated extensive depletion of the soil resource through erosion and oxidation.

Oxidation of the peat soils on the majority of the islands is causing subsidence of the foundations under the levees and the levees themselves. This causes uneven settling and further weakening of the levees. Exposure of the peat soils to the air has resulted in high oxidation of the peat at the rate of three inches annually (DWR,

Figure 15.



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1980). Some parts of the Delta have lost 25 feet of depth. This loss can extend another 20 to 30 feet if steps are not undertaken to reduce the impact (California Legislature, 1982). Some peat loss is attributed to compaction (compressing of the material either by agricultural machinery or its own weight), to wind erosion and to the burning of peat material as a result of crop burning. Ultimately, oxidation makes up to 50 percent of bulk loss in peat soils (Stephens, Spier, 1969).

The majority of soil loss, both in mineral soil regimes as well as in the organic soil, or peat, regimes, is attributable to human activity, including farmland management, urbanization construction covering soil with structures and exposing soil to wind or water erosion.

Efforts at soil conservation are being adopted including best management practices: planting cover crops to reduce exposed soil, eliminating burning of crop stubble and soil amendments to replenish organic matter. Another step aimed at reducing loss of peat soils caused by oxidation is the temporary raising of field water tables during the winter fallow period.

Flooding

Throughout the Delta's history, levee breaches and island floodings have occurred. In succeeding years, though, the costs of reclaiming flooded islands are outstripping the value, as determined by existing institutional programs, of the islands themselves. Flooding has occurred at over 25 of the islands during the past 50 years (Figure 16) (California Legislature, 1982; Burke, 1980).

More recently, flooding occurred at Frank's Tract (1938) which was never reclaimed because of repeated flooding and the high costs of reclamation. In total, six islands flooded in 1938. In 1955, seven islands flooded, all were reclaimed. In 1969, Twitchell and Sherman Islands flooded. In 1972, Brannan/Andrus Island flooded, inundating the town of Isleton. Webb, Holland, Prospect and Deadhorse tracts flooded in 1980. Lower Jones and Upper Jones tracts flooded in late 1980. All these islands were reclaimed.

Venice Island and McDonald tract and some smaller areas flooded in 1982, Mildred Island, Bradford Island in 1983, Tyler Island and New Hope went under in 1986 along with smaller islands (Figure 17).

Flooding is a natural phenomenon. Early farmers took advantage of flooding by allowing high water to flood fields and then to drain through breaks in the low levees. However, controlling floods has been institutionalized through federal and state programs. Any return to the earlier system or allowing controlled flooding has all but been eliminated because of severe soil subsidence, encroaching urban development on the flood plain and water diversion programs.

It is feared that levee failure will result in a "domino effect" that could result in a succession of islands flooding, threatening the

Figure 16.

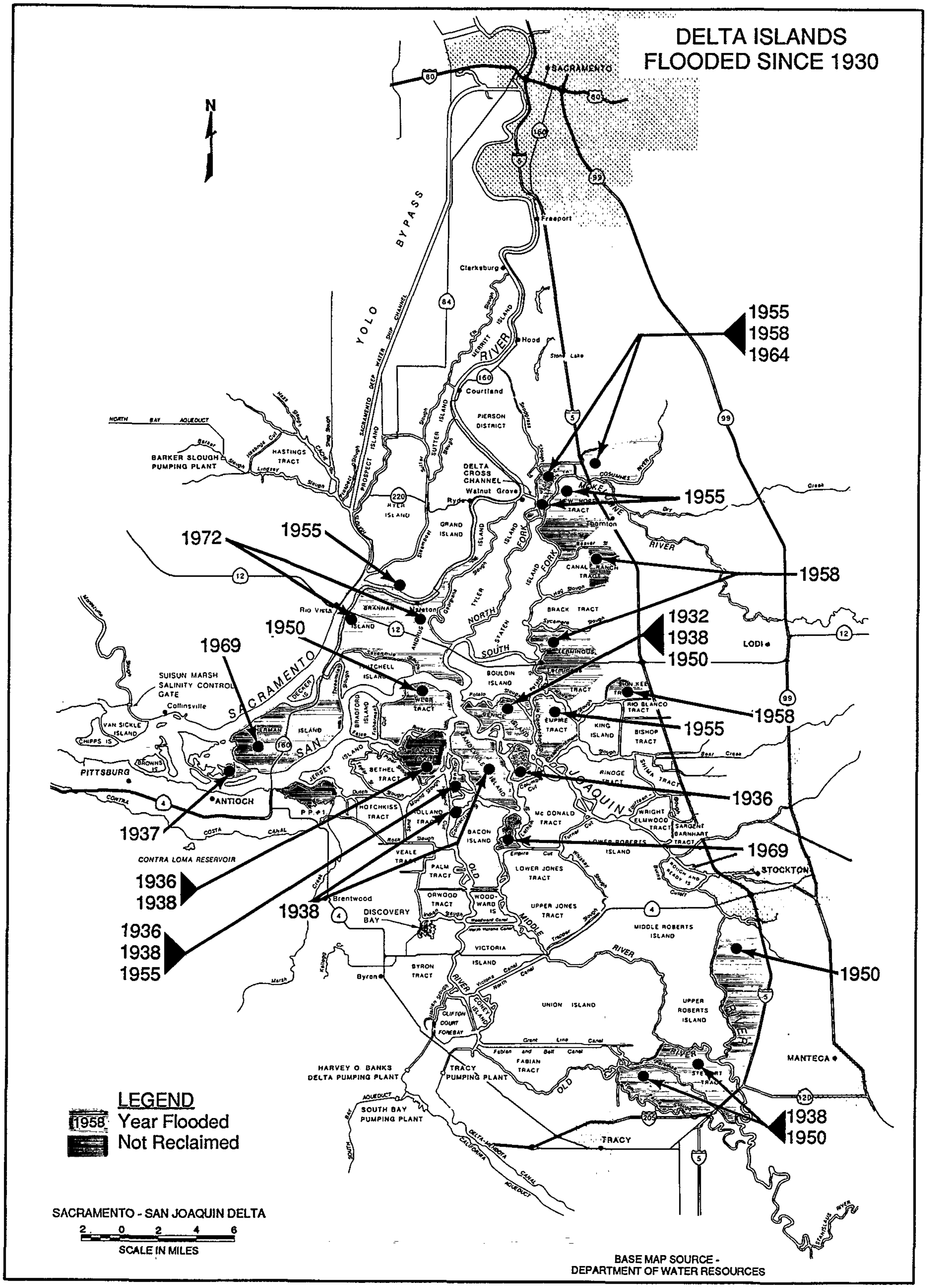

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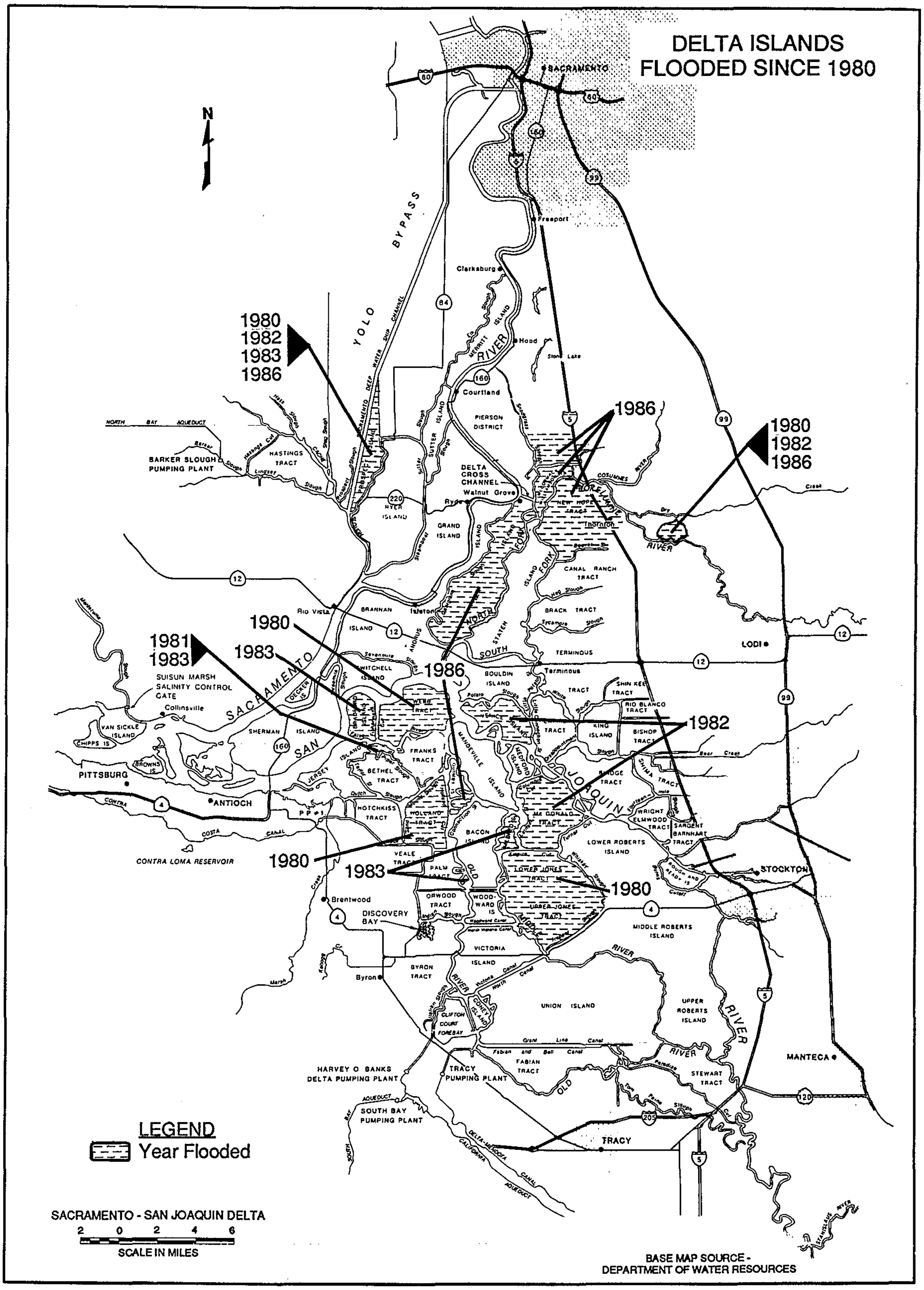
Figure 17.



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integrity of remaining islands in the Delta. Total loss of reclaimed islands could create an "inland sea" which would cause many environmental problems. In addition, levee age and structural characteristics make the Delta vulnerable to seismic events, a significant danger which, until recently, has not been extensively studied.

Seismicity and Faults

Although there are no active major faults in the Delta region, seismicity and faulting are geologic events with wide-reaching impacts — the 1989 Loma Prieta earthquake affected areas 70 miles away. An inventory of significant faults outside the geographic boundaries of the Delta follows:

The Sacramento-San Joaquin Delta system is located approximately 60 miles from the San Andreas Fault which passes in a northwesterly orientation along the California Coast Ranges. It passes under the San Francisco metropolitan area, making landfall again at Bolinas Lagoon in Marin County. This right lateral strike slip fault, where lateral movement follows along the length of the fault, has been the source of significant seismicity and is capable of shocks greater than magnitude eight (Richter Scale).

Diverging slightly from the San Andreas Fault is the Sunol-Calaveras Fault. This fracture passes along the eastern slope of the East Bay Hills striking northeasterly toward the Carquinez Strait. Westerly of this fault is located the Hayward Fault. This feature follows the west side of the East Bay Hills continuing northwesterly into San Pablo Bay. This fault is believed to continue across the Bay emerging at Sears Point and connecting with the Tolay Fault. It is felt the Hayward Fault is a prime candidate for future seismic events (CDMG Spec Pubs. G1, 1982).

A very complex matrix of fault fractures lies westerly of and roughly parallel to Interstate 5. This complex crosses the eastern most bays of the San Pablo Bay/Suisun Bay arm. The Green Valley Fault is part of this series of faults.

Branching more northerly from this fault series is a complex of parallel faults which are inferred to pass under the west end of the Delta. These faults are interpreted as continuing north westerly of Sacramento.

The next recognized series of faults is a roughly 10 mile wide belt of northwest trending faults located approximately 30 miles east of Sacramento. Seismicity of these faults varies greatly in known and potential magnitudes. Several of these recognized fault systems have established records of seismicity. A greater portion of these faults have no current history of seismicity; some faults are inactive while others may have not released stresses yet.

The San Andreas and Hayward Faults are considered primary sites for large magnitude earthquakes (GHC Bulletin, Fall 1989). The

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Loma Prieta earthquake of magnitude 7.1 was considered too distant to impact the Delta, but a similar magnitude tremor either farther north on the San Andreas Fault or along the Hayward Fault could impact Delta levees. An acceleration of 0.15g may liquify soils in the Delta upon which many levees are constructed. The Loma Prieta earthquake produced accelerations between 0.18 to 0.29 g. Distance may have attenuated the shocks before reaching the Delta.

Though it is inconclusive, levee damage might have occurred as a result of the 1906 San Francisco earthquake. In 1907, the first flood season in the Delta immediately following that quake, 53 of the 60 major islands within the Delta flooded (U.S. Bureau of Reclamation, 1964).

The 1983 Coalinga earthquake might have caused levee damage at Webb Tract. Some damage may also have been caused by seismicity in the Morgan Hill earthquake of April 24, 1984 (Table 6).

Proximal to the Delta is the Antioch Fault which has demonstrated recent displacement by offsetting railroad tracks crossing the fault. DWR cut a trench across this fault confirming the fault's movement. This fault may be associated with faulting along the northwest flank of the Montezuma Hills (Burke, Kelley, 1973). Another fault is inferred along the east flank of the Montezuma Hills (Reiche, 1950), but data as to its true seismic role is inconclusive.

A normal fault is also believed to be situated in the vicinity of Sherman Island (Shileman, 1971). Data on this feature is also inconclusive.

Studies of seismic epicenter location and orientation of levees in relation to the epicenter have shed light on how this relationship may affect the chance of survival for levees. The study shows the levee axis may play an important part in shock effects. Levees in which seismic movement strikes broadside may be more susceptible to collapse than when shocks are more axial (Figure 18) (DWR, 1985).

In addition, the unconsolidated structure of both the foundation substrate upon which the levees are built as well as the material in the levees themselves is susceptible to the cyclic loads (earthquake shaking) as well as the static compressional loads and sideward shear loads exerted by high water (hydrostatic pressure) forces.

A change in the practice of using unconsolidated silts, sands, muds and peat soil materials commonly extracted from dredging will be required to reduce levee susceptibility. Supplementary levee protection and reinforcement will be needed to improve levee strength. The subsidence of island floors will have to be controlled to reduce the side loads caused by relative high water channels pressing against unsupported levees where islands are below sea level.

Stemming from the renewed awareness of the potential damage that could result from earthquake, new studies are being conducted on the seismic vulnerability in the Delta. No formal programs have been developed, but a compilation of information begin-

Table 6.

Earthquake Related Damage, Sacramento-San Joaquin Delta						
Map No.	Epicenter	Date	Magni-tude	Delta Island or Tract	Distance to epicenter in miles	Damage
1	Coyote Lake	8-06-79	5.9	Mandeville	65	A 500-foot section of the west levee moved landward several feet. It was noticed independently by two people, and first seen minutes after the earthquake.
2	Livermore	1-24-80	5.9	Bacon	15	A 250-foot land-side rotational slip-out dropped several feet. This damage was cited by the 1980 DWR Delta seismicity hazards report as possible earthquake related damage.
3				Empire	20	A 200-foot land-side rotational slip-out dropped 6 inches. It was reported by a local resident and a DWR employee.
4	Coalinga	5-02-83	6.7	Webb	150	A 500-foot crack opened along levee crown up to 5 feet wide. Four or five land-side rotational slip-outs caused a bulldozer to fall off levee. Several eyewitnesses were present.
5				Webb	150	The "Garratt Well," an abandoned artesian well, and the site of seepage for many years, stopped flowing. This claim is supported by DWR photographs taken both before and after the earthquake.
6				Venice	150	A 500-foot crack opened on land-side toe of levee and dropped from several inches to over 2 feet. The damage was noticed minutes after the earthquake.
7				Venice	150	An area of persistent seepage into a drainage ditch for many years. The seepage stopped after the earthquake.
8				Venice	150	Several cracks opened at the site of the 1982 levee break. One crack was 400 feet long and 10 to 20 feet deep; another crack had water pouring out of it.
9				Venice	150	A 1000-foot crack ran along the levee toe. It was up to 3 feet wide and 10 to 15 feet deep.
10				Venice	150	At this site 14 wooden pilings popped up in a field that had been mowed the day before. The tops of the pilings were evenly 9 feet above the ground surface. The pilings were the foundations of an abandoned horse barn.
11				King	160	The concrete floor of a shed cracked for a length of 25 feet and settled about 8 inches.
12	Pittsburg	6-05-83	3.6	Webb	15	Several minor cracks were noticed at the Coalinga damage area. These cracks were at right angles to those produced by the Coalinga earthquake.
13	Morgan Hill	4-24-84	6.2	Webb	60	Six parallel cracks one inch wide and 75 feet long were noticed minutes after the earthquake. They were not present the day before the earthquake.
14				Webb	60	A 25-foor long crack one inch wide was noticed the same time as site no. 13.
15				Venice	60	A pre-existing 25-foot long crack lengthened 75 feet and the land side of levee dropped 2 inches. This site was inspected by the island caretaker and DWR employees before and after the earthquake.

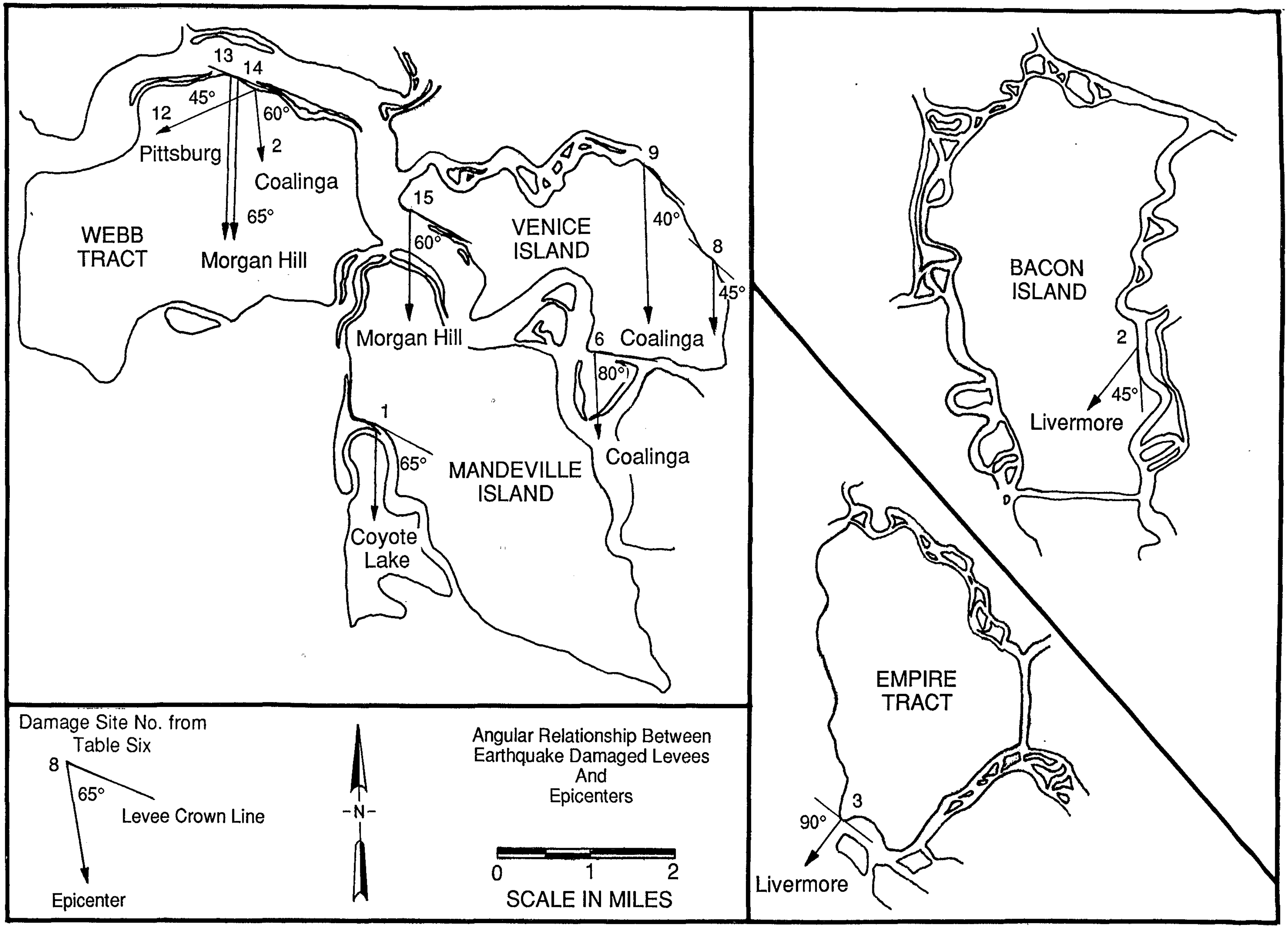

Figure 18. Angular relationship between earthquake damaged levees and epicenters, Sacramento-San Joaquin Delta. Numbers represent damage sites, Table 6.

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ning with interpretations of impact from the 1906 San Francisco earthquake has been ongoing. Preliminary research has shown a possible correlation between earthquakes and levee failures and research is continuing in this subject.

Land Reclamation

The "reclamation" of the Delta, described here as levee construction and draining of the numerous naturally occurring marsh islands which were interlaced by tidally influenced fresh water rivers flowing primarily out of the Sierra Nevada, had its beginnings even before California became a state.

History of Levee Construction

In the 1850s small landowners tried, with little success, to build levees by hand around their own holdings. These early individual efforts were undertaken either with "Fresnos"—scrapers drawn by horses—or manual labor. Levees rose only three to five feet above the islands' surface. Reclamation efforts were uncoordinated and hesitating as the farmers developing these lands were unsure of their legal ownership.

The first artificial levees were constructed on Merritt Island around 1852 by Chinese laborers. Increased demand for navigation and flood control, coupled with advances in dredging technology, such as the clamshell dredge in 1879, led to the fully mechanized construction of taller, wider levees at an accelerated pace. New machinery allowed construction of artificial channels or "cuts" which altered the water flow through the Delta and created linear drainages instead of the natural meandering channels. By 1900 nearly 50 percent of lands had been reclaimed and essentially all Delta islands were reclaimed by 1930.

To further land reclamation, the 1850 Swampland Act granted swamp and overflow (S&O) land title to states with conditions that the proceeds from sales of these lands would go toward reclamation. An 1856 statute authorized the sale of swamp and overflow lands at one dollar per acre for a maximum of 320 acres. By 1859 the acreage limit was raised to 640 acres. The California legislation in the 1850s relied on the individual farmer's abilities and provided no centralized policies or supervision of the reclamation efforts.

Not until 1861 was the enormous problem of flood control and reclamation confronted by the California legislature. Laws were enacted creating a new type of governmental entity, an independent and centralized State Board of Swamp Land Commissioners, to oversee flood and reclamation efforts statewide. The Commission was responsible for the creation of simultaneously authorized recla-

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mation districts as well as for providing the engineering expertise for the improvements to be constructed by the districts. These districts were the first "special districts," the progenitors of all California special districts—school, fire, water and resource conservation.

The uniqueness of the reclamation districts is found in their landowner-controlled quasi-governmental nature. Unlike other one-person one-vote districts, reclamation districts voting continues to be based on the value of property owned by each member landowner—one-dollar one-vote.

The independent Commission's engineers were overconfident in their ability to control both the elements and the districts. The property owners, the "governing board" of the reclamation districts, were given the power to tax lands lying within district boundaries. However, they often refused to tax themselves or refused to pay the tax, resulting in underfunded projects. The experiment in centralized control was soon abandoned.

In 1866, the legislature turned over state control to local boards of supervisors. The supervisors were to use their popularly elected county surveyor as their engineering expert in approving reclamation plans. This system lasted only two years.

In 1868 virtual total control was turned over to the property owner districts. The state, county surveyors and boards of supervisors had little or no role in the process. Furthermore, the acreage limitation was lifted and the purchase price of S&O land ($1/acre) made refundable. Within three years, millions of acres were conveyed by the state, one-half million in the Delta alone. The new legislation also lifted the acreage ban and often hundreds of thousands of acres were held under single ownership. The era of swamp land monopoly and fraud had begun. In 1895, the local reclamation districts were authorized to float bonds. This basic *laissez faire* system of local autonomy by landowners has continued from 1868 to the present.

In 1911, the State Reclamation Board was created with responsibilities to review and approve local district reclamation plans involving the Sacramento River and its tributaries, but it was given no control or jurisdiction over the internal operations of the districts.

In the heyday of the reclamation district, from 1905 to 1920, almost all of the islands present today took shape, as did the major levees along the Feather, Bear, Sacramento, American and San Joaquin Rivers. Levees built as part of the Federal Flood Control Project are considered project levees and maintained to federal standards, those maintained and constructed by island land owners and private interests are non-project levees.

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Function of Levees

Levees were originally constructed to drain the marshland for agricultural production and to prevent the natural tidal action and occasional flooding. But over time levee functions have expanded. Today, levees provide flood protection for towns, cities, agricultural lands, gas wells and utilities. Levees have roads, serve as recreation areas, provide public access—although usually restricted—and, with vegetation, provide habitat for wildlife. Levees are also used to protect water quality by concentrating flows in channels and controlling salt water intrusion, and they help to maintain channels of navigation.

The patchwork of levees are classified into three types:

a. Project Levees (15 percent of Delta total). These levees are maintained at federal standards for flood control. Local reclamation districts under the State Reclamation Board within the Department of Water Resources maintain the levees and inspect and report on their maintenance. A portion of project levees along the west side of the Sacramento River Deep Water Channel are maintained directly by the federal government. These levees are the most strictly maintained.

b. Direct Agreement (10 percent of Delta total). Built as part of a navigation project or repaired by the federal government following damage, these levees are built and maintained according to less stringent standards than project levees. Nonfederal entities maintain these levees. The State Reclamation Board has no jurisdiction. The U.S. Army Corps of Engineers maintains the slope while local agencies (Port of Stockton for example) maintain their integrity or condition.

c. Non-Project Levees (75 percent of Delta total). Constructed by private interests, these structures follow no set standards for design or maintenance. These levees show the greatest variation in condition and design. Some reclamation districts maintain higher standards than required, for example, Bethel Island.

Problems

The variation in levee types and levels of maintenance is cause for concern for levee integrity. The problem of soil subsidence on the islands is a significant factor of levee maintenance. Oxidation, erosion, burning and compaction have caused peat soils to subside to 25 feet below sea level, with soil loss and compaction averaging two to

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three inches per year. The elevation drop is thought to be causing a change in the lateral loads of water against the levees, making them vulnerable to breaching. Water pressure is producing leaks under the levees on to the islands. Wind-wave action, water velocity due to pumping, and boat wakes contribute further to levee maintenance problems.

With this increase in hydrostatic pressure imbalance on the levees, there is concern that there are and will be more incidents of levee failure. The use of channel material to build the levees can cause additional problems. This material is composed of highly water-saturated, unconsolidated clays, muds or silts and is not a reliable medium for constructing structures put under extreme loads or stresses. It is also potentially vulnerable to liquefaction during seismic events.

Levees are susceptible to seismic hazards. The aging levees built on and with poor material may not survive the effects of an earthquake. As stated, the possible impact of seismicity is under study to determine ways to reduce the danger. Several options are currently being studied to reduce this problem.

Most of the Delta islands have been flooded over the past 100 years, raising questions about the effectiveness of levees as flood control mechanisms. The construction of dams and reservoirs upstream has alleviated some of the problem, but flooding is still caused by increased hydrostatic pressure on the levees from lowering ground water levels in the island interior as a result of land subsidence. The diversion and transportation of Delta water to CVP facilities in 1951 and SWP facilities in 1968 has added to the demand for levee reconstruction and maintenance.

Non-project levees are less stable than project levees because of poor foundation material, insufficient height and cross section, erosion and inadequate maintenance. These levees are more vulnerable to failure. Levees have been stripped of vegetation for maintenance purposes, eliminating a source of habitat for local wildlife. Many non-project levees are located in the central Delta and have high peat soil concentrations which erode and subside easily, and where increased water pressure causes fractures. Recently, better agricultural practices are being used to conserve and protect soil resources from erosion and steps are being taken to reduce the loss of peat soils caused by oxidation. If one Delta island is flooded and the levees destroyed, the levees on adjacent islands are more vulnerable because of the increased water pressure. Levees restrict and constrain the natural system of Delta waterways, creating artificial conditions that produce complex problems.

C-038171

Levee Protection Programs

Delta Flood Protection Act, "SB-34"

The Delta Flood Protection Act of 1988 (SB-34) increased the financial assistance to Delta reclamation districts maintaining non-project levees. The legislation contains provisions for local districts to pay the first $1,000 for each mile of levee maintenance and rehabilitation, and the state to pay up to 75 percent (up form 50 percent) of the cost exceeding $1000 per mile. The legislation contains a new Delta Flood Protection Fund of $6 million annually for 10 years for special flood control projects, and $6 million annually to the Levee Subventions Program, of which approximately $5.3 million is used for direct levee activities and habitat mitigation (Johannis 1/30). SB 34 also provides that DFG approve all mitigation plans to determine no net loss of habitat.

A recent 1991 Senate Agriculture and Water Resources Committee hearing revealed a lack of agency coordination, failure to monitor projects, virtually no mitigation program for riparian and wildlife habitat and lack of staffing for DFG to effectively participate as provided in the legislation. There is also controversy regarding the permitting process and an overall lack of detailed procedures and requirements for the individual reclamation districts.

Others

The California Legislature, in 1973, passed SB-541 (Way) which provided some financial asistance to local entities for levee maintenance. In 1976 the California Legislature passed SB 1390, the Nejedly-Mobley Delta Levees Act, which carried out the recommendations of DWR Bulletin No. 192 for improvement of Levees surrounding portions of fifty-five Delta islands and tracts. Expenditures authorized by the Way Bill And the Nejedly-Mobley Bill amounted to one million dollars.

C-038172

The Delta's Flora and Fauna

5

The Delta is a part of the San Francisco Bay/Delta Estuary. Estuaries are among the world's richest and most productive ecosystems. The meeting of fresh water from the land with salt water from the ocean in shallow embayments supports high rates of primary and secondary productivity, as evidenced by the abundance of fish, shellfish, birds, and other living resources which characterize estuaries.

The Delta, California's inland coast, is linked to the San Francisco Estuary by the narrow physical constriction of the waters of the Sacramento and San Joaquin Rivers near Collinsville. Ecologically, the Delta is distinct from most of the rest of the Estuary in that it is essentially a freshwater system.

The area's early abundance of fish, shellfish and wildlife contributed to its attractiveness to Native Americans as a place to live and to the exploration and settlement of the area by European fur traders.

Historic and Present Delta

The historic Delta has been described as consisting of numerous low islands of tule marshes, intersected by miles of river and distributary channels and dead-end sloughs. The lowland marshes and waterways were surrounded by slightly higher seasonal flood plain grasslands and oak savannah.

An ecosystem is a particular assemblage of living species in a particular environment, linked by significant interactions among and between the living resources and their environment. The Delta landscape unit, in its historic condition, was an exceptional ecosystem.

Prior to human intervention, the central Delta region was covered by a vast freshwater marsh inundated with each high tide. These tidal marshlands were separated into "tule islands" by many channels and sloughs. Large rivers and streams, entering the Delta region on the north, east, and south created waterways which were bordered by extensive stands of riparian forest growing on naturally deposited levees. The higher ground of the natural levees prevented some overland flood waters from draining into the rivers and created non-tidal marshes and seasonal wetlands in the outer Delta lands.

The marsh and riparian vegetation mosaic was surrounded by and intermixed with grasslands, oak woodlands and the continuation of riparian forests upstream on the rivers.

The extent of the marshes, riparian forests and other habitat types in the Delta as it existed prior to statehood is not precisely known. From reviews of early maps, old diaries, other accounts of the region and knowledge of landform and vegetation ecology, it is possible to characterize the historic condition of the approximately 700,000 acres in the Delta. The heart of the Delta was covered by about 350,000 acres of tidal freshwater marsh, crisscrossed by many waterways, including dead-end sloughs. The outer Delta was 200,000 to 300,000 acres of extensive riparian woodlands on natural alluvial levees, non-tidal marshes or seasonal wetlands, and some upland grasslands and woodlands (Atwater et al, 1979; Nichols and Wright, 1971; Thompson 1957).

In the early 19th century, Delta marshes, forests, grasslands and waterways were habitat to more than 250 species of birds and mammals (Madrone, 1980). The region yielded millions of waterfowl and shorebirds, and abundant antelope, tule elk, furbearing mammals and fish. The natural bounty of the ecosystem was evidenced by the large activity in fur trade, market hunting and the commercial fishing industries which rapidly grew up in the Delta with increasing European settlement.

In the late 1800s and early 1900s, exploitation of fish and wildlife resources peaked, causing severe declines and even local extinctions (extirpations) for many species. Laws which essentially eliminated commercial hunting and fishing and which controlled recreational harvest were eventually enacted to protect remaining resources (Skinner, 1962).

Despite the massive changes that have occurred, the Delta still functions as an ecosystem, albeit a drastically altered and intensely managed one.

Delta Ecosystem Structure and Function

In estuaries, sunlight in warm shallow waters and nutrients from the river and ocean encourage the growth of phytoplankton (microscopic, free-floating plants), attached algae and marsh vegetation. Plants within marshes and other types of vegetation also provide physical structures for cover for fish, birds and mammals. This primary productivity from green plants supports zooplankton (tiny animals), other invertebrates and many birds and mammals. In complicated food webs, smaller organisms are eaten by larger fish and other vertebrates, which themselves in turn may be consumed by humans.

The most important environmental factors affecting biological systems in the Delta, like in all estuarine systems, have to do with its waters—especially circulation, temperature, salinity and their temporal and spacial variations. As indicated, the major determinants of Delta water characteristics at any point in time are the tides, river inflows and export of water from the Delta.

Saline water from the ocean tides meets freshwater flows from the rivers, creating particular patterns of water circulation. At the upper end of the ocean salinity, at about one to six parts per thousand (ocean seawater is 30-33 parts per thousand), incoming and outgoing currents on the bottom tend to cancel each other out; this area is called the "null zone." The null zone creates a region where suspended nutrients tend to accumulate, as do phytoplankton, zooplankton, and eggs and larvae of many fish. This "entrapment zone," just downstream of the null zone, is the site of much biological activity (Arthur and Ball, 1979).

The location of the entrapment zone is determined by the amount of freshwater flow through and out the Delta. With very high flows the entrapment zone is in San Pablo Bay or the Carquinez Straits, with moderate flows it is in Suisun Bay, and with low flows it moves upstream into the lower Sacramento River (Arthur and Ball, 1979). When the entrapment zone is located in the warm, shallow waters of Suisun Bay during spring, summer and fall, it appears that planktonic food chain dynamics are most favorable for many Delta fish species. When the entrapment zone is further inland in narrow river channels with cooler temperature and decreased residence time, ecosystem productivity is diminished.

Delta Plants and Animals

See Figure 19, DELTA BIOLOGY, page 75.

Plants

The base of all ecosystem food chains is the producers, the green plants which capture the sun's energy in photosynthesis and convert it to biomass. In the Delta, the chief producers are phytoplankton, primarily diatoms. Phytoplankton numbers in the system are the result of production within the Delta and some input from upstream sources. Production is dependent upon a complex of different factors including: "residence time," or speed of passage, of channel waters; nutrient concentrations; sunlight; consumption by animals; and toxic substances (Herbold and Moyle, 1989).

The Delta's marshes are also sites of important primary production. The tules, bulrushes, reeds, and cattails which dominate in the freshwater tidal marsh commonly grow fifteen feet tall. Delta marshes may have the largest above-ground standing biomass of any

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tidal marshes in North America (Atwater et al, 1979). Riparian forests, dominated by deciduous trees and shrubs, are also characterized by extremely high biomass production (Holstein, 1984).

A diverse and abundant animal community is dependent upon the Delta's primary production, ranging from microscopic zooplankton and mud-dwelling clams and worms, to large fish, birds and mammals.

Delta agricultural fields are also important producers of biomass, not only for obvious commodity values, but for wildlife as well. During the winter, large numbers of waterfowl and shorebirds forage on the Delta agricultural lands, especially row crops, pastures and fallow fields.

Invertebrates

Largely unseen or unnoticed, invertebrate animals nonetheless are critically important as food for many of the major fish and wildlife resources of the Delta. In the water, the major zooplankton of importance as food for Delta fish are the copepod *Eurytemora* and Opossum shrimp, *Neomysis* (Herbold and Moyle, 1989).

Although over 80 species of benthic invertebrates have been noted in the Delta, only five species dominate, including the introduced Asiatic clam (*Corbicula*). The Delta also supports a healthy population of signal crayfish, introduced to the Delta in 1898, and now yielding a commercial harvest of 500,000 lbs/year (Herbold and Moyle, 1989).

Riparian vegetation, supports abundant insects in the canopy, leaf litter, and tree and shrub bark. These insects are important food for resident and migratory songbird populations (Gaines, 1977).

Fish

Perhaps no other group of species in the Delta indicates the degree to which the ecosystem has been modified by modern humans than the fish fauna. Of the 29 fish taxa (kinds) which were native to the Delta, 10 are considered DFG Species of Special Concern (Moyle, et al., 1989).

Figure 20 shows the relative prehistoric abundance of fish species in the Delta, as indicated by fish remains found in an Indian midden in the north Delta (Schulz and Simons, 1973). Today, these species are gone or nearly gone from the Delta. The thicktail chub is extinct, and the Sacramento perch has been extirpated from the Delta. The Sacramento splittail is considered a California Fish Species of Special Concern - Category Two, and the Hitch has declined in abundance in the Delta (Moyle, 1976; Moyle, et al., 1989).

The Sacramento perch, thicktail chub and Sacramento splittail

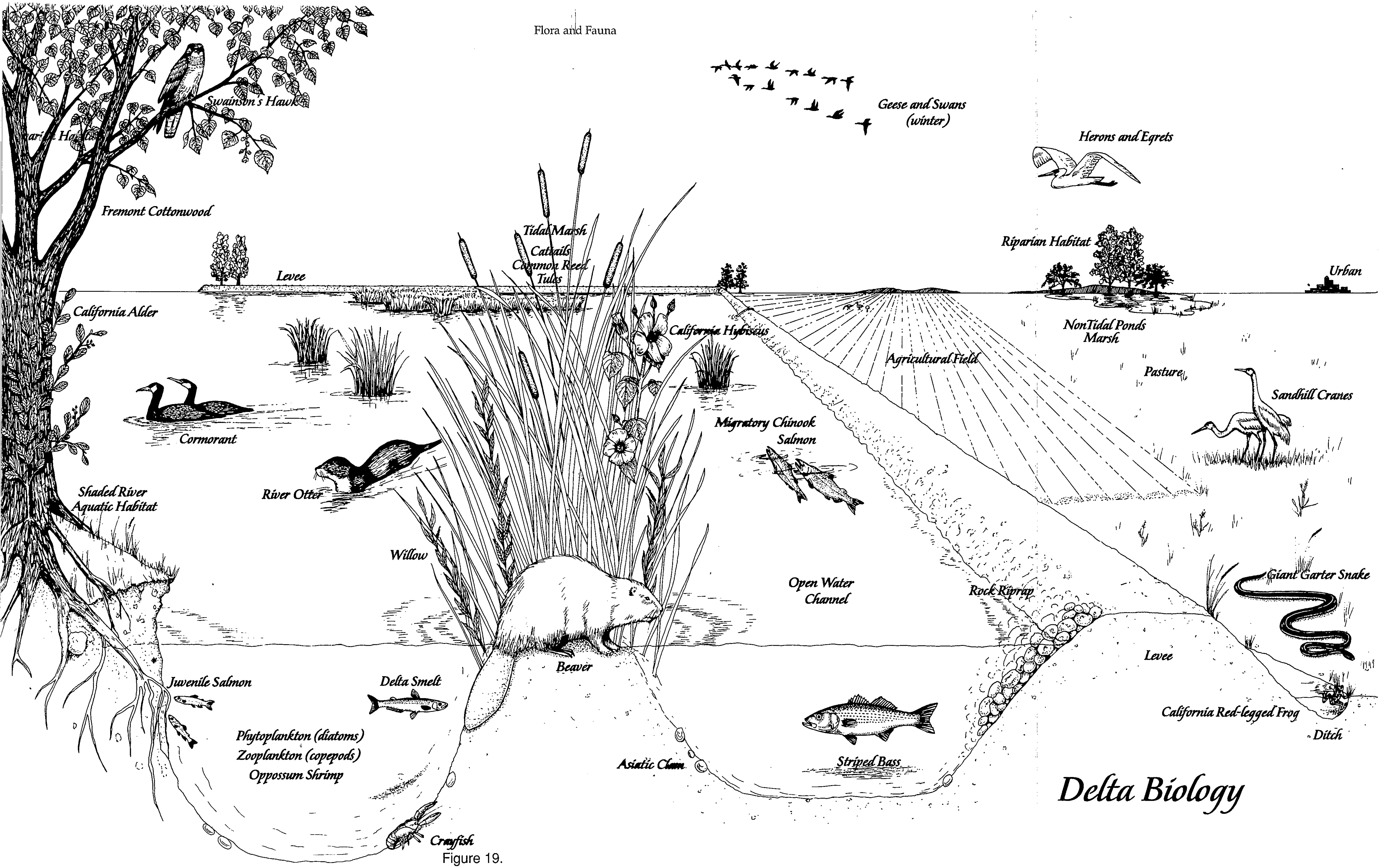
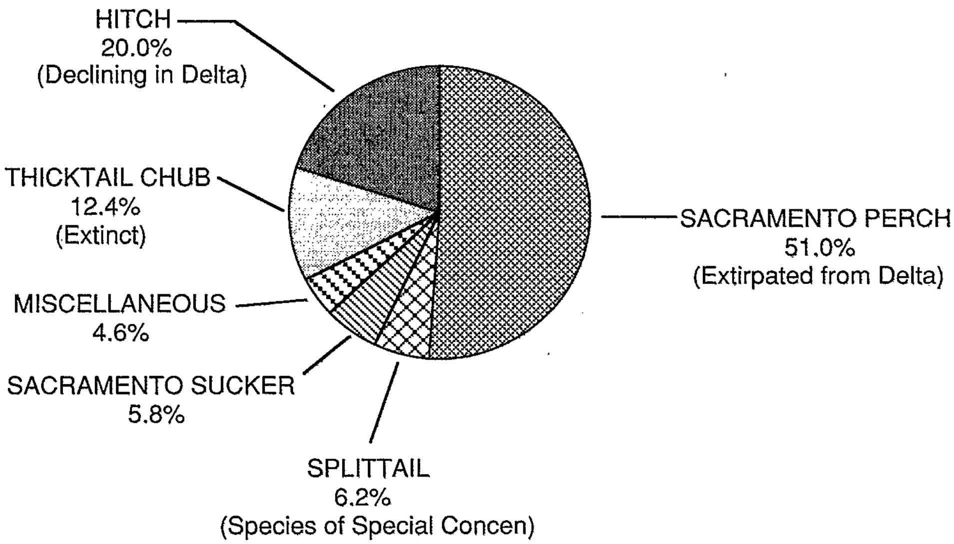

Swainson's Hawk
Fremont Cottonwood
Levee
Tidal Marsh
Cattails
Common Reed
Tules
California Alder
California Hybiscus
Cormorant
River Otter
Shaded River
Aquatic Habitat
Willow
Migratory Chinook
Salmon
Open Water
Channel
Beaver
Juvenile Salmon
Delta Smelt
Phytoplankton (diatoms)
Zooplankton (copepods)
Oppossum Shrimp
Asiatic Clam
Striped Bass
Crayfish
Geese and Swans
(winter)
Herons and Egrets
Riparian Habitat
Urban
NonTidal Ponds
Marsh
Agricultural Field
Pasture
Sandhill Cranes
Rock Riprap
Giant Garter Snake
Levee
California Red-legged Frog
Ditch
Delta Biology

Figure 19.

Figure 20. Relative prehistoric fish abundance in the Delta. From Schulz and Simons (1973).



can tolerate well brackish and warm water conditions found in valley sloughs, lakes and ponds. Their disappearance and decline is apparently due to the loss of tule beds and other submerged, rooted vegetation required for spawning and rearing habitat (Moyle, 1976).

There were also a number of commercial fisheries in the Delta including salmon, steelhead, sturgeon, perch, striped bass and American shad. Even the extinct thicktail chub was once available in San Francisco fish markets (Miller, 1963 in Moyle 1976). At the turn of the century, the Delta had more than 25 canneries operating (California Water Atlas, 1979). Soon after the commercial fisheries peaked, fish stocks began declining, particularly the larger fish such as salmon, sturgeon and striped bass . Ultimately, most commercial fishing was banned (Skinner, 1962).

Delta waterways now support 28 different types of native fish, including resident and anadromous kinds. Anadromous species migrate upstream to spawn in the fresh waters of the river systems, then return as young to the salt waters of the Bay and Pacific Ocean (Table 7). Resident forms include the Delta smelt, the longfin smelt, and the Sacramento splittail. Native anadromous fish include steelhead, four different runs of chinook salmon, and two species of sturgeon (Table 8).

The Delta smelt is found only in the California Delta. It spawns in submerged vegetation in freshwater, then the tiny larvae drift downstream to the entrapment zone, feeding on zooplankton, primarily copepods. Most of population is replaced every year (Moyle et al, 1989; Wang, 1986). In recent years, numbers have drastically declined and it is now a federal candidate for listing. It was also a state candidate for listing, but in August 1990, the Fish and Game Commission declined to list, and instead directed DFG to collaborate with DWR on a variety of studies dealing with impacts and possible restoration measures.

The smelt's abundance has declined as Delta exports have increased, but other factors such as toxics, changes in food sources and the invasion of a new species of clam from Asia (*Potamocorbula*) may also be contributing. The petition to include the smelt on the state list cited high enough freshwater flow through the Delta to keep the entrapment zone located in Suisun Bay during March, April, May and June in most years as the only way of keeping it from extinction.

The Sacramento splittail, like the Delta smelt, is endemic to the Central Valley. This species was once much more widespread, but now is principally found in the Delta and is considered a Species of Special Concern (Moyle, et al., 1989). It requires flooded vegetation for spawning (Moyle, et al., 1989). The population is directly correlated with patterns of Delta outflow, probably because of increased availability of spawning habitat in high flow years (Daniels and Moyle, 1983 in Moyle, et al., 1989).

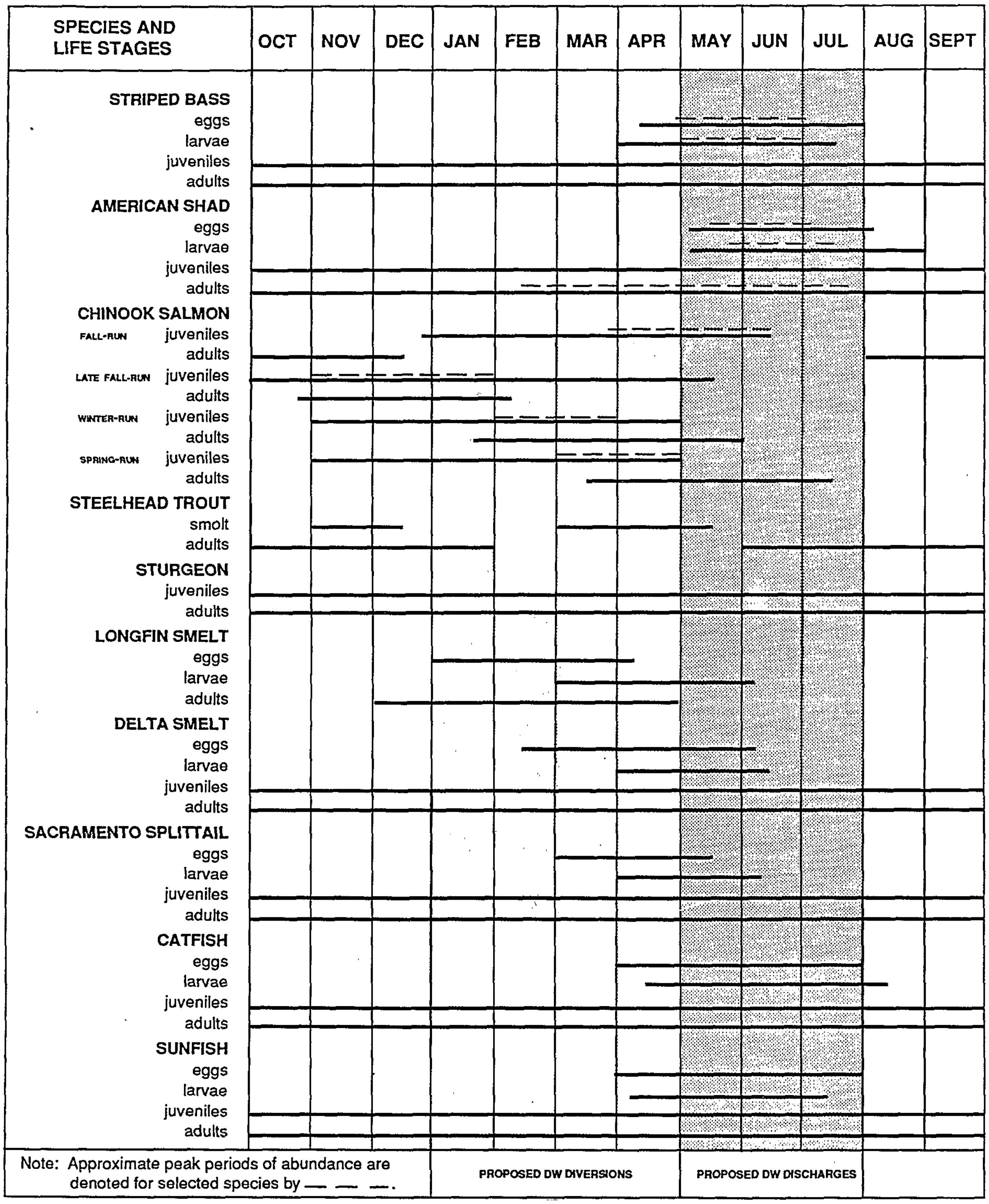
The Longfin smelt spawns in freshwater in the Delta and rivers such as lower Sacramento River. The young drift down to Suisun and San Pablo Bays, so it is sometimes considered anadromous (Wang, 1986). Like the Delta smelt, it feeds on zooplankton, primarily *Neomysis* (Moyle, 1976). Adults are abundant and are important prey for striped bass (Interagency Ecological Study Group, 1987). Longfin smelt abundances are closely correlated with Delta outflow from February to September (Stevens and Miller, 1983 in Herbold and Moyle, 1989).

All Central Valley salmonids, salmon and steelhead, must find their way through the Delta on their migration to upstream river spawning beds, finding the correct stream odor gradient to "home-in" on (Reynolds, et al., 1990). The Delta is also of major importance to young salmonids on their outward migration to the ocean. Because of the timing of different runs of salmon, juvenile salmon can be found in the Estuary during all months of the year. Smaller fry may spend a month or more rearing in Delta channels. Larger young ready to make the transition into salt water, called smolts, may pass through the Delta in one to two weeks (USFWS, 1987).

Recent salmon runs in the Central Valley have been averaging 272,000 adult fish, most of which (88 percent) were the fall-run in the Sacramento River. Steelhead runs in the Central Valley have been about 35,000, almost entirely from the Sacramento River system. The chinook salmon production in the San Joaquin system, once numbering 300,000, is down to a few thousand.

In 1991, after five years of drought, indications are that even Sacramento River system salmonid populations have

Table 7. Source: Jones & Stokes Associates, 1990.



APPROXIMATE TEMPORAL OCCURRENCE OF FISH SPECIES IN THE DELTA BY LIFE STAGE

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Table 8.

Abundance of the fish of the Sacramento-San Joaquin Delta

R=resident, A=anadromous, N=nonresident visitor, M=euryhaline marine

Common name	Scientific name	Abundance	Native (N) Introduced (I)
Pacific lamprey	*Entosphenus tridentatus*	Common (A)	N
River lamprey	*Lampetra ayresi*	Uncommon (A)	N
White sturgeon	*Acipenser transmontanus*	Common (A)	N
Green sturgeon	*Acipenser medirostris*	Uncommon (A)	N
American shad	*Alosa sapidissima*	Common (A)	I
Threadfin shad	*Dorosoma petenense*	Abundant (R)	I
Brown trout (sea-run)	*Salmo trutta*	Rare (A)	I
Steelhead	*Oncorhynchus mykiss*	Common (A)	N
Pink salmon	*Oncorhynchus gorbuscha*	Occasional (A)	N
Coho salmon	*Oncorhynchus kisutch*	Rare (A)	N
Chinook salmon-4 runs	*Oncorhynchus tshawytscha*	Common (A)	N
Chum salmon	*Oncorhynchus keta*	Occasional (A)	N
Sockeye salmon	*Oncorhynchus nerka*	Occasional (A)	N
Longfin smelt	*Spirinchus thaleichthys*	Common (A-R)	N
Delta smelt	*Hypomesus transpacificus*	Common (R)	N
Thicktail chub	*Gila crassicauda*	Extinct	N
Hitch	*Lavinia exilicauda*	Common (R)	N
California roach	*Hesperoleucus symmetricus*	Rare (N)	N
Sacramento blackfish	*Orthodon microlepidotus*	Common (R)	N
Splittail	*Pogonichthys macrolepidotus*	Common (R)	N
Hardhead	*Mylopharodon conocephalus*	Uncommon (N)	N
Sacramento squawfish	*Ptychocheilus grandis*	Common (R)	N
Fathead minnow	*Pimephales promelas*	Occasional (R)	I
Golden shiner	*Notemigonus crysoleucas*	Common (R)	I
Goldfish	*Carassius auratus*	Common (R)	I
Carp	*Cyprinus carpio*	Abundant (R)	I
Sacramento sucker	*Catostomus occidentalis*	Common (R)	N
Black bullhead	*Ictalurus melas*	Common (R)	I
Yellow bullhead	*Ictalurus natalis*	Rare (R)	I
Brown bullhead	*Ictalurus nebulosus*	Common (R)	I
White catfish	*Ictalurus catus*	Abundant (R)	I
Channel catfish	*Ictalurus punctatus*	Common (R)	I
Blue catfish	*Ictalurus furcatis*	Rare (R)	I
Inland silversides	*Menidia beryllina*	Abundant (R)	I
Mosquitofish	*Gambusia affinis*	Common (A-R)	I
Striped bass	*Morone saxatilis*	Abundant (R)	I
Sacramento perch	*Archoplites interruptus*	Extirpated	N
Bluegill	*Lepomis machrochirus*	Common (R)	I
Redear sunfish	*Lepomis microlophus*	Uncommon (R)	I
Green sunfish	*Lepomis cyanellus*	Common (R)	I
Warmouth	*Lepomis gulosus*	Uncommon (R)	I
White crappie	*Poxomis annularis*	Common (R)	I
Black crappie	*Pomoxis nigromaculatus*	Uncommon (R)	I
Largemouth bass	*Micropterus salmoides*	Common (R)	I
Smallmouth bass	*Micropterus dolomieui*	Uncommon (R)	I
Bigscale logperch	*Percina macroplepida*	Common (R)	I
Yellow perch	*Perca flavescens*	Extirpated	I
Tule perch	*Hysterocarpus traski*	Common (R)	N
Yellowfin goby	*Acanthogobius flavimanus*	Common (R)	I
Staghorn sculpin	*Leptocottus armatus*	Common (M)	N
Starry flounder	*Platichthys stellatus*	Common (M)	N
Rainwater killfish	*Lucania parva*	Rare (R)	I
Prickly sculpin	*Cottus asper*	Common (R)	N
Threespine stickleback	*Gasterosteus aculeatus*	Uncommon (R)	N
Chameleon goby	*Tridentiger trigoncephalus*	Common (R)	I

From Herbold and Moyle 1979

dropped catastrophically. Ocean commercial and sport salmon fisheries allocations for this year have been cut drastically by the Pacific Fisheries Management Council.

The Sacramento River winter-run salmon is now a state-endangered and federal-threatened species, and the spring-run is a probable candidate for listing as well. The San Joaquin River spring-run is extinct.

There are 28 non-native species of fish found in the Delta (Herbold and Moyle, 1989). In fact, the most abundant species found now in the Delta are all introduced species: Threadfin shad, carp, white catfish, inland silversides, and striped bass (Herbold and Moyle, 1989). American shad was introduced in 1871, and striped bass, about 1879-82. Both species established themselves quickly after introduction and supported large commercial fisheries. Commercial fishing for these species has now been banned, but they remain as important sport fisheries, especially the striped bass.

The striped bass has gained much notoriety as an indicator of the health of the Delta because of its resource value and sensitivity to changes in the Estuary. (Interagency Ecological Study Program, 1987).

Most stripers spawn in the Sacramento River, some quite high upstream of the Delta. Young fish rear up to three years in the Delta. When very small, they feed on zooplankton, preferring Eurytemora copepods. As they grow, prey size shifts to larger organisms such as Neomysis.

DFG's Striped Bass Index

The Index over the last five years is not encouraging:

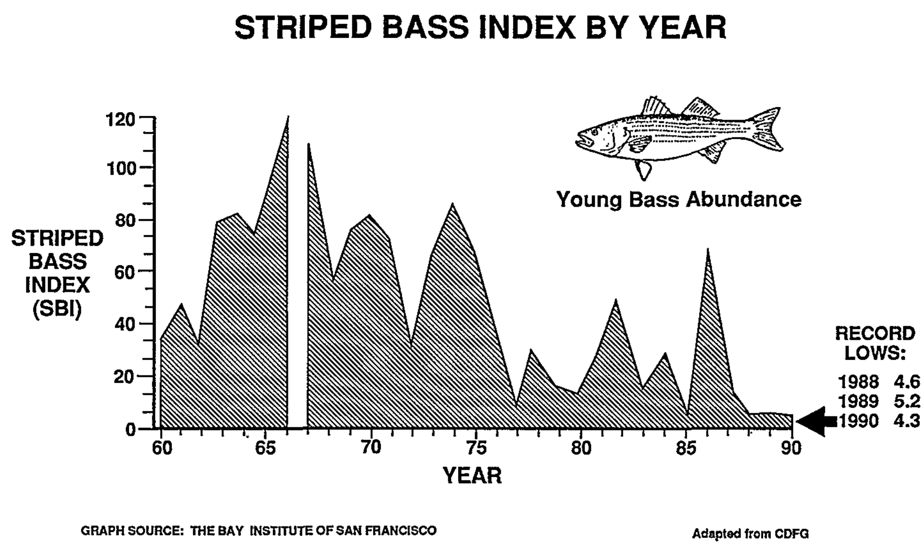
'86 - 64.9
'87 - 12.6
'88 - 4.6
'89 - 5.1
'90 - 4.3

In recent years, (Figure 21) striped bass numbers have severely declined. Adult striped bass are now one-third of former levels. DFG's Striped Bass Index (38mm) in 1990 was an all-time low at 4.3. Before the 1976-77 drought the average was 66; after 1977, the average has been 22; the highest since beginning of sampling in 1959 was 117, in 1965. Many factors are considered responsible for the striped bass decline; two of the most important factors appear to be reduced freshwater outflow and increased diversions since the 1970s (Stevens, et al., 1989).

Vertebrate Wildlife

The Delta vertebrate wildlife fauna - amphibians, reptiles,

Figure 21.



birds, and mammals- is diverse, with 300 species of native and introduced species. Almost 40 native species are species of concern, with 10 designated as state or federal threatened or endangered species. Complete listings of wildlife species for the Delta, along with indications of their habitat usage, relative abundance, and legal status can be found in Madrone Associates (1980), Rollins (1977), Herbold and Moyle (1989), and the forthcoming Wetlands and Wildlife Status and Trend Reports of the San Francisco Estuary Project.

Waterfowl

In the past, the Delta was a major nesting area for dabbling ducks, species which prefer to feed in shallow waters on aquatic vegetation and invertebrates. It also was one of the most significant areas for wintering migratory waterfowl, including ducks, geese and swans (USFWS, 1978).

Today with 95 percent of the marsh converted to agriculture, the Delta supports very little waterfowl nesting. However, the agricultural lands which replaced the marshes are still very important for wintering waterfowl, supporting 10 percent of the entire state's overwintering population (Rollins, 1977).

The hundreds of thousands of acres in agricultural fields are particularly valuable for geese and swans, which prefer to feed by grazing. The Delta is the most important swan wintering ground in the Pacific Flyway (USFWS, 1978). At times, approximately 75 percent of the Tundra (Whistling) Swans in the Pacific Flyway are found in the Delta (Madrone, 1980). The concentration of Tundra Swans wintering in the Delta is second only to that in Chesapeake Bay (Bellrose, 1980).

The Delta is also important for geese, especially Greater white-fronted geese, and "white" geese, which include Ross' and snow geese. The Aleutian Canada goose, a state and federal endangered species, uses the Delta as a stopover on the way to its main wintering ground in the San Joaquin Valley (Madrone, 1980). However, small numbers overwinter in the Delta (Woolington, et al., in Herbold and Moyle, 1989).

Northern Pintail ducks are the most abundant wintering species in the Delta. Numbers in the Delta represent 10 percent of the Central Valley and 7.5 percent of the Pacific Flyway Pintail populations. Pintails concentrate on flooded agricultural fields and also move between other areas in the Central Valley and the Suisun Marsh. Mallards are the second most abundant duck species in the Delta, but are far less abundant than pintails (Herbold and Moyle, 1989).

Other Bird Species of Interest

The Delta is also important as wintering ground for the Greater sandhill crane, which concentrates in the thousands in flooded fields of the eastern and northern Delta (Rollins, 1977). In recent years, an estimated two-thirds of the Central Valley population uses the Delta during mid-winter (Pogson, 1988).

The Swainson's hawk, a state threatened raptor species, breeds in the Delta. Preferred habitat consists of tall trees for nesting and perching with proximity to open fields which support small rodents for prey. Historically this habitat was provided by the tall cottonwoods, sycamores, oaks and tree willows of riparian forests adjacent to native grasslands. Much of the Central Valley riparian forests are gone, and grasslands have been converted to agriculture.

The Delta reclaimed marshes, which are now pastureland or alfalfa fields, support abundant rodent populations. The highest breeding density of Swainson's hawk in the Central Valley is found in the region between Sacramento and Stockton, encompassing the eastern Delta (Estep, 1989).

Mammals

The once abundant mammalian fauna in the Delta is now dominated by species which can tolerate proximity to human populations, such as skunk, raccoon, opossum and ground squirrels, and aquatic species such as beaver, muskrat, mink and river otters. Muskrats, beaver and mink are trapped commercially in the Delta (Herbold and Moyle, 1989).

Beavers and muskrat eat a variety of aquatic, marsh and riparian plants, and construct nests of vegetation or dig burrows in banks. Burrowing into Delta levees by these species and by ground squirrels is considered a serious threat to levee stability by maintenance authorities (Herbold and Moyle, 1989).

Mink and river otters are carnivores, preying on fish, shellfish and sometimes small mammals and birds. These aquatic mammals, as well as the beaver and muskrat, are limited in the Delta by the availability of natural riparian and wetland vegetation in proximity to waterways (Herbold and Moyle, 1989).

Reptiles and Amphibians

Most Delta amphibian species are dependent on marsh, riparian and small pond and pool habitats. The loss of these habitats from land-use conversions has been devastating to native amphibian populations such as the increasingly rare California tiger salamander and the western spadefoot toad. The California red-legged frog was formerly very abundant in the Delta but habitat loss, massive commercial harvesting in the past, and competition and predation by introduced species has resulted in the near extirpation of this species from the Delta (Herbold and Moyle, 1989).

The Giant garter snake, found in marsh and riparian vegetation adjacent to ditches, ponds, sloughs and other bodies of water, is a state-listed threatened species found in the Delta.

Delta Habitats

Habitats are particular environments associated with particular plant and animal communities. Estuarine ecosystems have varied habitats, from tidal marshes to riverine forests. Table 9 lists, in broad categories, the different habitats found in the Delta and estimates of their extent.

Habitats usually do not stand alone as functioning systems. Most Delta animals, whether terrestrial or aquatic, depend on more than one habitat. For example, the Swainson's hawk depends on grasslands and open fields for foraging but riparian trees for nesting and perching. Also, most resident native fish species spawn or rear in the submerged vegetation of marshes or on the edge of riparian habitat, but live as adults in open waters. The following habitats discussion is primarily based on information from Madrone (1980).

Agricultural lands in the Delta region include row crops, pasture, fallow lands and some orchards and vineyards. The present-day Delta is mostly farmlands, which comprise over 86 percent of the dry land surface area. The wildlife habitat value of these lands depends on agricultural practices including flooding regimes, pesticide and herbicide applications and tillage.

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TABLE 9. Delta habitat types.

Current habitat types	ACREAGE Nearest 1000 AC.	Rel %
Agriculture *	531,000	78%
Channels and Other Open Water	53,000	8
Tidal (46,000)		
River, tributary channels		
Dead-end channels		
Submerged islands *		
Non-tidal lakes and ponds (7,000)		
Upland	44,000	6
Oak woodland/savannah		
Grassland (Vernal Pools)		
Urban *	32,000	5
Freshwater Marsh	12,000	2
Tidal (11,000)		
Non-tidal (1,000)		
Riparian Habitat	7,000	1
Woodland/Forest (4,000)		
Shrub-Brush (3,000)		
TOTAL ACREAGE	679,000	100

* Not present pre-statehood
Based on COE Mapping in 1979, Madrone 1980

The farmed wetlands of the Delta are critically important habitat for wintering waterbirds including shorebirds, geese, swans, ducks and sandhill cranes, supporting 10 percent of all waterfowl wintering in the state. During the winter, many fields are flooded with shallow water, enhancing their value to ducks, geese and swans (Madrone, 1980; Rollins, 1977). Much Delta farm acreage is in corn, which has particularly good forage value for geese and swans (USFWS, 1978).

The value of Delta agricultural lands to waterfowl is closely tied to cropping and flooding patterns, which can vary from year to year (USFWS, 1978). Since corn is sensitive to salinity, during low Delta outflow other more saline tolerant crops are planted. Also, during drought years, flooding of fields is decreased.

Open fields have large populations of small animals such as rodents, reptiles and amphibians providing opportunities for raptor foraging. Nonflooded fields and pastures are also habitat for pheasant, quail and doves.

Channels and Other Open Water habitat values depend upon the exposure to tides, current velocities, location in the Delta, depth to the bottom, width of the waterbody, salinity and other physical and chemical characteristics of the waterbody.

Most open-water aquatic habitat in the Delta is tidal, rising and falling with two tide cycles each day. The Delta water is fresh, dominated by river inflow. However, with very low Delta outflow, western Delta salinity can reach six parts per thousand.

Major open-water food web species are phytoplankton, zooplankton and fish. Bottom sands and muds support high numbers of benthic (bottom dwelling) species, dominated presently by the Asiatic clam (Corbicula). In lakes, ponds and quiet sloughs, aquatic plants such as the duckweed and non-native water hyacinth can form dense floating mats during the growing season. Open water habitats are also used by a number of bird species which feed on aquatic invertebrates and fish, such as diving ducks and grebes, and waterfowl such as mallards and wood ducks which feed on submerged aquatic plants .

Lakes and ponds such as Stone Lake near Sacramento, the sewage treatment ponds in Stockton and Clifton Court Forebay, support simple invertebrate communities and also invertebrates such as opossum shrimp, crayfish. Some lakes with riparian vegetation, like Beach and Stone lakes near Sacramento, also support large numbers of waterfowl.

Upland habitats are found mainly on the edge of the Delta, and consist primarily of grasslands with some remnants of oak woodland and savannah (grassland with scattered trees). Native perennial grass species and abundant spring wildflowers have been replaced by European annual grass and weed species.

The Antioch Dunes at the western edge of the Delta is a unique natural community. This tiny remnant of sand dunes on the southern bank of the San Joaquin River contains a number of endangered species including two wildflowers and Lange's metalmark butterfly.

Rare vernal pools are found within grassland areas near Byron and at the Jepson Prairie near Dixon. Vernal pools are small grass- and wildflower-dominated ecosystems associated with shallow seasonal pools, submerged in the winter but dry throughout the summer. Specialized and unique species of plants and invertebrates have adapted to the wet and dry cycles. These fragile pools have been destroyed by grazing, cultivation or other development activities. More than 200 plant species, 91 percent of which are California natives, occur in vernal pools statewide (Holland, 1976). The remaining Delta vernal pools support a number of rare, threatened or en-

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dangered plants, as well as the federally-listed threatened insect, the Delta green ground beetle.

Freshwater Marshes in the Delta are both tidal and non-tidal. Tidal marshes, once the most widespread habitat in the Delta, are now restricted to remnant patches. "Tule islands" or "berm islands," as these patches are often called, are principally found in Delta channels where the area between levees is wide enough or where substrates are deposited high enough for tules and reeds to survive. There are also remnant non-tidal marshlands found in the interior of Delta Islands and in the Stones Lakes complex of the north Delta.

Delta tidal marshes, with at least 40 different plant species, have a higher plant diversity than the more saline tidal marshes of the brackish Suisun Bay or the salt marshes of San Pablo and San Francisco bays. However, Delta vegetation, both in current and historic tidal marshes, is dominated by only five species: tules, bulrush, cattails, common reed, and arroyo willow (Atwater, et al., 1979).

Tidal marshes are important for many birds and mammals, including sensitive species such as the Black rail and Giant garter snake. Tules and reeds provide food and cover for native fish species and aquatic mammals such as beaver and muskrat. The Delta's wetlands are valuable assets—providing food-web support, fish and wildlife habitat, recreational opportunities, water quality improvement and erosion control. Land reclamation has claimed 90 percent of the Delta's original wetlands.

Riparian Habitat is tree-dominated woodlands and forest, or shrub/brush, made up of deciduous woody species.

Dominant species in the overstory include cottonwood, sycamore, valley oak and tree willow, which may reach heights of 100 feet. Understory or shorter species include white alder, shrub willows, elderberry, ash and box elder. Blackberries and wild grape are common ground cover or vines.

Riparian woody species can survive seasonal, but not permanent, flooding. They are found on slightly higher ground of natural levees or other areas of sediment deposition in river floodplains. Riparian habitat is commonly found on the banks of waterways, including on those man-made levees which are not kept artificially cleared. Riparian vegetation is also supported in the interior of some Delta islands.

Because of the dense and diverse canopy structure, and abundant leaf and invertebrate biomass production, riparian habitat is used by more vertebrate wildlife, 107 species, than any other Delta habitat type (Madrone, 1980). Species diversity and population numbers of resident and migratory birds are especially high in Central Valley riparian habitats (Gaines, 1977).

In addition, woody roots and branches overhanging or extending into the water make up a special type of habitat called "shaded riverine aquatic cover" with important values to terrestrial and aquatic animals, especially fish (DeHaven, 1989).

Raptors (birds of prey), and herons and egrets, seek height and nest or perch on riparian or woodland trees.

In the Central Valley as a whole, more than 90 percent of the riparian forests are gone. They were cleared historically for firewood, agriculture and levee building. Urban development and traditional levee maintenance practices are causing further losses.

Impacts to Biological Resources

The Bay-Delta ecosystem is one of the most altered estuaries in the world, especially considering the number of different kinds of changes which have occurred (Nichols et al, 1986). Further impacts to the ecosystem continue today.

Impacts and threats to Delta biological resources include: direct loss or injury to species, such as entrainment by water pumping facilities, hunting, fishing, or poisoning by pollution; loss or damage to habitats, such as urbanization of open space, clearing of riparian habitat from levees, or shifts in water salinity; and introductions of new species which out-compete or consume native species.

The results of this anthropogenic modification in the Delta include severe declines in species populations and habitat. Some species or habitats have disappeared altogether or are present in such low amounts they are threatened with extinction (Table 10). At stake is the natural biological diversity of the system and its ability to support many ecological benefits which human society values for economic, scientific, or aesthetic reasons.

Land Use Changes

The most significant land use change in the Delta was the reclamation of tidal marsh to agricultural land. By 1930, 350,000 acres of tidal marsh were gone. This resulted in alterations to the hydrodynamics of the system, and major reductions in the abundance and kinds of waterfowl, resident fish and other animals which once were plentiful in the Delta.

Today, additional major impacts would be felt from any conversion of Delta agricultural lands to urban uses. Migratory waterfowl and other waterbirds such as sandhill cranes, herons, egrets or shorebirds and the threatened Swainson's hawk would all suffer with any further loss or damage to the existing character of Delta farmlands.

Changes from corn or other desirable agricultural crops to those less desirable, or reductions in the amount of shallow flooding of fields would reduce the carrying capacity of the land to support

Table 10.

DELTA SPECIAL STATUS SPECIES

ANIMALS

Species	Status	Habitat in Delta
MAMMALS:		
Riparian Brush Rabbit	FC,CSC	Rip
Salt Marsh Harvest Mouse	FE,SE	Mrsh (salt - W Delta only)
San Joaquin Pocket Mouse	FC	Grass
San Joaquin Kit Fox	FE,SE	Grass(SW edge of Delta)
BIRDS:		
Common Loon	CSC	Open water (rare visitor)
American White Pelican	CSC	Open water
Double-crested Cormorant	CSC	Open water; Mrsh
Least Bittern	CSC	Mrsh; Agr
White-faced Ibis	FC,CSC	Mrsh; Agr
Aleutian Canada Goose	FE	Mrsh; Agr esp. flooded
Fulvous Whistling Duck	FC,CSC	Mrsh (rare visitor)
Northern Harrier	CSC	Mrsh; Agr; grass
Sharp-shinned Hawk	CSC	Rip; Mrsh; Agr; grass
Cooper's Hawk	CSC	Rip; Mrsh; Agr; grass
Swainson's hawk	ST	Rip; grass; Agr
Golden Eagle	CSC	(rare visitor)
Bald Eagle	FE,SE	(rare visitor)
Merlin	CSC	Mrsh; grass
Prairie Falcon	CSC	(rare visitor)
American Peregrine Falcon	FE,SE	(rare visitor)
Greater Sandhill Crane	ST	Grass, Agr esp. flooded
California Black Rail	FC,ST	Tidal Mrsh
Long-billed Curlew	FC	Grass, Agr
Burrowing Owl	CSC	Grass; Agr
Long-eared Owl	CSC	Rip
Short-eared Owl	CSC	Mrsh; grass; Agr
Willow Flycatcher	SE	Mrsh; Rip
Vermillion Flycatcher	CSC	(rare visitor)
Purple Martin	CSC	Urban
Saltmarsh Common Yellowthroat	FC,CSC	Tidal Mrsh (W Delta?)
Yellow Warbler	CSC	Rip & oak woodlands; urban
Suisun Marsh Song Sparrow	FC,CSC	Tidal Mrsh (W Delta?)
Tricolored Blackbird	FC	Mrsh
REPTILES:		
Southwestern Pond Turtle	FC, CSC	Mrsh, Rip.
California Horned Lizard	CSC	Grass (SW Delta)
Giant garter snake	FC,ST	Mrsh; Rip
AMPHIBIANS:		
California Tiger Salamander	FC,CSC	Vernal pools; other aquat.
California Red-legged Frog	FC, CSC	Mrsh; Rip
Foothill Yellow-legged Frog	CSC	Mrsh; Rip
FISH:		
River Lamprey	CSC	Anadromous
Spring-run Chinook Salmon	CSC	Anadromous
Winter-run Chinook Salmon	FT,SE	Anadromous
Coho Salmon	CSC	Anadromous
Pink Salmon	CSC	Anadromous
Delta Smelt	FC,CSC	Resident
Thicktail chub	Extinct	Was resident
Sacramento Splittail	FC, CSC	Resident
Hardhead	CSC	Resident
Sacramento Perch	FC,CSC	Was resident, extirp. in Delta
INSECTS:		
Delta Green Ground Beetle	FT	Vernal pools(Jepson Prairie)
Valley Elderberry Longhorn Beetle	FT	Rip
Lange's Metalmark Butterfly	FE	Antioch Dunes

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Table 10, continued.

PLANTS

Species	Status	Habitat in Delta
Aster chilensis var. *lentus* Suisun aster	FC	Mrsh; Rip
Cirsium crassicaule Slough thistle	FC	Mrsh, Rip
Cirsium hydrophilum v. *hydrophyllum* Suisun thistle	FC	Tidal Mrsh(Brack.- W Delta?)
Cordylanthus mollis ssp. *mollis* Soft bird's beak	FC,SR	Mrsh (Salt, Brack.- W Delta?)
Cordylanthus palmatus Palmate bird's beak	FE,SE	Grass (Alkali sink)
Eryngium racemosum Delta button celery	FC,SE	Rip
Erysimum capitatum v. *angustifolium* Contra Cost Wallflower	FE,SE	Antioch Dunes
Hibiscus californicus California hibiscus	FC	Rip; Mrsh
Lasthenia conjugens Contra Costa Goldfields	FC	Vernal pools; grass
Lathyrus jepsonii ssp. *jepsonii* Delta tule pea	FC	Rip; Mrsh
Legenere limosa Legenere	FC	Vernal pools
Lilaeopsis masonii Mason's lilaeopsis	FC,SR	Mrsh; Rip
Neostapfia colusiana Colusa grass	FC,SE	Vernal pools
Oenothera deltoides var. *howellii* Antioch Dunes evening primrose	FE,SE	Vernal pools
Orcuttia tenuis Slender orcutt grass	FC,SE	Vernal pools
Orcuttia viscida Sacramento orcutt grass	FC,SE	Vernal pools
Plagiobothyrus hystriculus Bearded popcornflower	FC	Vernal pools
Tropidocarpum capparideum Caper-fruited tropidocarpum	FC	Grass (extinct?)
Tuctoria mucronata Solano grass	SE,FE	Vernal pools

FE - Federally-listed as endangered
FT - Federally-listed as threatened
FC - Federal candidate for listing

SR - State-listed as rare
ST - State-listed as threatened
SE - State-listed as endangered
CSC - California state species of special concern

Agr - Agricultural lands
Mrsh - Marsh, freshwater unless otherwise noted as salt or brackish
Grass - Grassland
Rip - Riparian scrub and woodland

existing wildlife.

The clearing of levees for maintenance or placement of rock revetment results in a severe loss of riparian and shaded riverine aquatic habitat. Studies by the U.S. Fish and Wildlife Service (DeHaven and Weinrich, 1988) indicate that less than 15 percent of Delta waterway banks have shaded riverine aquatic cover. Furthermore, distribution of heavily-vegetated bank habitat is very spotty; many islands have little or no such cover left and are surrounded by rocked channels.

Although state law requires no net loss of habitat for levee maintenance or repair, loss continues and few proven alternatives are utilized. There is a serious conflict between perceived needs for levee security and the continuing loss of extremely valuable fish, wildlife and sensitive plant habitat. It is asserted by engineers that woody vegetation can be detrimental to levee slope stability as a result of trees toppling during high water or by large woody roots weakening internal soil structure. Visibility for safety inspection is another concern with heavily vegetated slopes. Little or no conclusive data exists which either supports or refutes these contentions in the Delta. However, it is agreed that most levees in the Delta are of poor construction and are vulnerable to collapse.

Mitigation efforts include the Corps of Engineers' geotechnical studies on levee stability, which may lead to increasing tolerance to woody vegetation in rock revetment. In addition, the Corps, in coordination with the State Reclamation Board, the State Lands Commission, the Department of Fish and Game, and the U.S. Fish and Wildlife Service, is constructing experimental mitigation berms in the Steamboat Slough and the Sacramento River to attempt to replace shaded riverine aquatic cover without threatening levee security.

Freshwater Diversions

Freshwater exports from the Delta have had a significant impact on the environment. Huge pumping plants in the south Delta divert an average of 50 percent of Delta outflow. However, this figure does not indicate the true extent of effects felt by the Delta ecosystem. Diversions are not distributed evenly between years or season; in dry years and in spring diversions may be as much as 85 percent of outflow (Williams, 1989). Fresh water is also pumped into Delta agricultural fields for consumption within the system.

One of the major impacts from the SWP and CVP Delta pumping plants and from agricultural intake pipes is the loss of aquatic species by entrainment or impingement. Fish screens and fish salvage operations at the SWP and CVP pumps cannot avoid significant fisheries losses. In addition, most agricultural siphon pipes are inadequately, or not, screened.

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It is estimated that hundreds of millions of young striped bass are lost due to pumping plants, including direct loss of unscreenable eggs and larvae, mortality at screens of larger fish and loss in salvage transport. The total result has been calculated as a one half to two-thirds reduction in catch due to CVP and SWP pumping (Interagency Ecological Study Program, 1987).

Export diversions affect water quality characteristics such as temperature, oxygen and salinity. Also affected are the location of the null zone, channel flow directions, channel flow velocities, and water residence time. All of these in turn affect phytoplankton and zooplankton distribution and abundance. Fish species which have planktonic eggs or larvae, or which feed on plankton, are ultimately affected with such changes to the aquatic system. Young salmonids do not survive in water with low oxygen and high temperatures.

Reverse flows in many Delta channels due to SWP and CVP pumping affect migratory species such as salmon and steelhead. Reverse flows confuse adult salmonids migrating upstream, resulting in delayed passage or straying from the proper home stream (Reynolds, 1990). The consequences of pumping plant operation are even more dire for young salmonids. It is estimated that up to 50 percent of the outmigrant young salmonids are lost to stress and increased predation because they are drawn into the Delta Cross-channel on their sea-ward travel path (USFWS, 1987).

Most of the historic salmonid spawning and rearing grounds have been blocked off, destroyed or degraded by the construction of water supply and flood control dams well upstream of the Delta. Hatcheries in the Central Valley, built to mitigate the impacts of water development projects, fall well short of desired hatchery production levels because of ecological, genetic, engineering, and funding problems. The hatcheries on the Feather, American, and Mokelumne truck their production of juvenile salmonids past the recognized Delta hazards to be released at Rio Vista or the Carquinez Straits.

Waterway modification

Dredging, as discussed in Chapter 7 of this report, can affect biological resources in a number of ways. Dredging and disposal of dredged material can directly disturb or destroy marsh, riparian and aquatic habitats (Madrone, 1980). Dredging also contributes to turbidity in the water column. This is generally short-term and localized. Toxic substances may be resuspended by dredging.

Waterway alterations could potentially have major effects on water flows and circulation patterns. Deepening of the Stockton and Sacramento River ship channels could result in salinity intruding further into the Delta (See Nichols letter, Appendix 3, SFEP STR on Dredging and Waterway Modification in the San Francisco Estuary, 1990).

Flooding

Levee breaks in the Delta can occur due to structural failure or erosion, the danger of which increases with high tides, winter storm runoff or earthquakes. Levees are seriously threatened by sea level rise, particularly if it is accelerated by global warming. (SFEP STR on Dredging and Waterway Modification in the San Francisco Estuary, 1990).

If Delta levees broke and islands were flooded permanently, as happened in Franks Tract, agricultural land would be replaced by open water habitat. Depending upon the timing, amount of land flooded and response of upstream reservoir operators, saline waters may intrude significantly into the Delta. Valuable wintering habitat for swans, geese, dabbling ducks and shorebirds would be lost.

The area of aquatic habitat would be expanded, but significantly altered. Because the islands have subsided up to 25 feet, flooding would result in water depths too deep for marsh vegetation to be established. Wind-wave erosion would probably take out most remaining tidal marsh and riparian vegetation and result in a vast "inland sea." The fate of fish species that need submerged vegetation for spawning, rearing or adult habitat would probably be extinction. Riparian and marsh wildlife would also disappear.

Current Delta levee management programs are not protecting ecosystem values. While levee maintenance practices and riprap placement significantly degrade habitat values, loss of levee integrity on a large scale might result in ecosystem collapse. Alternative methods for levee maintenance or reconstruction could provide greater protection for the ecosystem.

Species Introductions

Since the settlement of the Delta by Europeans, there have been many new species of plants and animals introduced to the ecosystem. Some of the new species were transplanted on purpose, such as the striped bass, American shad, and crayfish. Most of the exotic species have been inadvertently brought to the Delta, such as annual grasses and weeds from the Mediterranean, and the Asiatic clam, Corbicula.

Exotic plants, in the absence of normal controls from their place of origin, may spread rapidly, out-competing native plants and degrading the habitat value for native animals. In the Delta, False-bamboo, Arundo donax, is a giant cane grass which grows aggressively in dense clumps on levees and banks. It can choke out native riparian or marsh vegetation species. Chunks may break off during floods, uprooting large holes in levees. Water hyacinth is a large

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floating aquatic weed. In the south Delta, it forms dense mats over waterways, impeding navigation and clogging water pumps.

International shipping has been responsible for many new species of invertebrates throughout the San Francisco Estuary. In the Delta, two new species of zooplankton, both copepods, were introduced in the late 1970s (Herbold and Moyle, 1989). There has also been a decline in the native copepod, Eurytemora, which is the preferred prey for young fish. This decline may be due a competitive disadvantage by the native species (Interagency Ecological Study Program, 1987).

In 1986 a new clam from Asia, Potamocorbula, was discovered in the Suisun Bay. It has now spread to San Francisco and San Pablo bays, and the western Delta. This species is a filter-feeder and is capable of consuming enormous amounts of phytoplankton. It may cause significant changes in phytoplankton and zooplankton in the Estuary, especially in Suisun Bay (See Nichols 1990 - Interagency Newsletter June 1990).

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The Delta's History

6

Over the course of thousands of years, until this century, human activity and the actual Delta environment have interacted symbiotically. The Delta's natural resources drew early inhabitants to the area and caused cultural adaptations in their means of dealing with those resources. Likewise, prehistoric and historic cultural phenomena have modified the Delta's natural environment.

These changes in cultural and natural resources provide information important to our understanding of early California culture. The Delta is a window to the past of the seminal periods that identify California to the rest of the world.

Human History in the Delta

California was peopled from the North between 12,000 and 20,000 years ago at the end of the last Ice Age. The wandering tribes found and settled in one of the most productive area's on the continent. It is estimated that, at one time, some 30,000 individuals lived in the areas surrounding the Delta (SFEP State of the Estuary, 1991).

These people from the north initially shared the Hokan language, a "tool kit" and a set of cultural traditions. Groups of families were separated by distance, as some people moved east and south. These groups became more individualistic with time, creating their own languages, housing styles and basketry. But the different groups continued to trade ideas, traditions and goods among themselves. For instance, throughout California young girls had similar adolescence ceremonies while the men gathered in sweathouses. The groups held in common that it was forbidden to talk of the dead, that baskets were more important than pottery, that the atlatl, or spear-thrower, was used instead of the bow and arrow and that tribal warfare was unknown.

A warmer and drier climate developed about 4,000 years ago leaving a vast Central Valley marsh where lakes had been. New people from eastern Washington and Oregon and western Idaho migrated to the warmer environment.

The new language group, known as Penutian, occupied non-

Hokan territory in the San Francisco Bay and the Delta. These two groups, through sharing and trading, mingled traditions including that of the shamans who began to take their power from the intangible spirits of places.

The new people of the "Windmiller Tradition," residents of the Bay and vast Delta marshlands, developed different lifestyles. By 1500 A.D. there were enough differences in the Bay and Delta group, the ancestral Miwok and Yokut, that the Europeans considered them different branches of the same tribes.

By the time of this European contact the tribes occupying the Delta had fairly defined territories, although there was some overlap where different cultures met. Archaeological evidence indicates there was considerable trade between the cultures and little, if any, warfare. Most of the Delta was occupied by the Eastern, or Plains, Miwok. They inhabited the lower reaches of the Mokelumne and Cosumnes rivers and both banks of the Sacramento River from Rio Vista to Freeport.

The Bay Miwok, or Saclan, lived in the eastern portions of Contra Costa county from Walnut Creek eastward to Sherman Island. South of these tribes were the Northern Valley Yokuts, whose territory extended to the ridge-line separating the Calaveras and Mokelumne River drainage and to the crest of the Mount Diablo range. North and west of the Miwok tribes lived the Patwin, from Benicia, around Suisun Bay, east of the Montezuma Hills and east of the Yolo drains and sinks of Putah Creek (Figure 22).

VILLAGE / TRIBELET —— LOCATIONS

I. SOUTHERN MAIDU (NISENAN)

1. Sama (?)
2. Momal
3. Yalisumni
4. Pusune
5. Totola

II. RIVER WINTUM (PATWIN)

6. Tolenas
7. Ululato
8. Liwai

III. BAY MIWOK (SACLAN)

9. Chupcan
10. Julpan
11. Ompin
12. Anizumne
13. Bolbon

IV. PLAINS MIWOK

14. Quenemsia
15. Junizumne
16. Chucumne
17. Ochehamne
18. Chupumne
19. Gualacomne
20. Hualpumne
21. Tanquimne
22. Cosomne
23. Newachumne
24. Sotolomne
25. Locolomne
26. Seguamne
27. Muquelemne

V. NORTHERN VALLEY YOKUT

28. Yachik (Chulamni)
29. Wane (Chulamni)
30. Pescadero (Jalalon)

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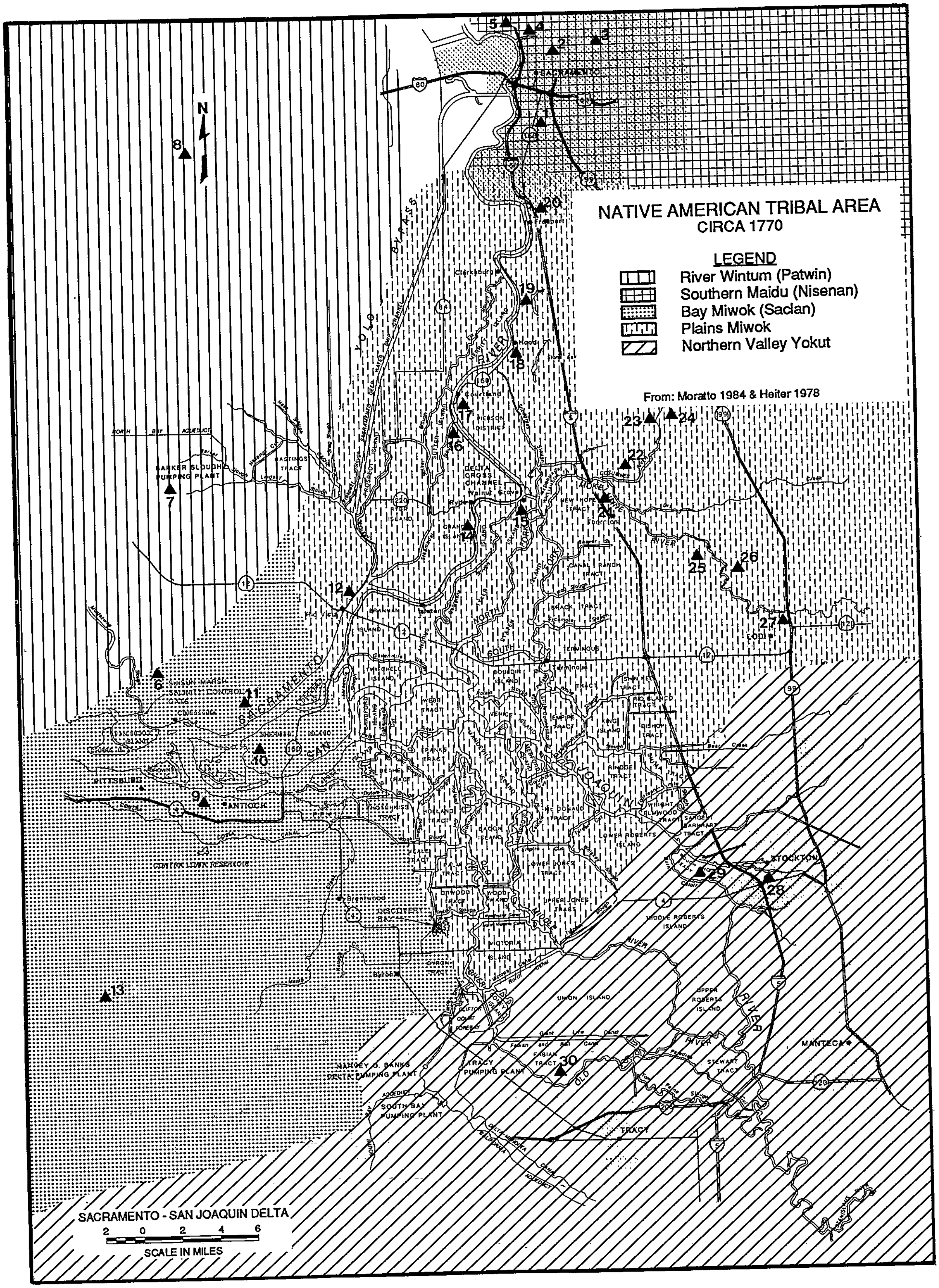
Figure 22.



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The early European exploration and use of the Delta waterways began slowly. In 1772, Father Juan Crespi and Don Pedro Fages from the vantage of the Mt. Diablo summit described the confluence of what are now called the Sacramento and San Joaquin Rivers. Explorers sailing in small boats, frigata, from the new Presidio in San Francisco reached the mouth of the Sacramento (New Rogue) in 1776. Lieutenant Moraga, in 1808, ascended the river to the mouth of the Feather River which he called "Sacramento." On his return he crossed overland from the Sutter Buttes to Stony Creek on the Sacramento, which he then named the "Jesus Maria," thinking it a different river.

Larger vessels began exploration in 1811 when Fathers Abella and Fortini journeyed up the "northern river of San Francisco" to explore the mouth of the San Joaquin. The Spanish Fathers and soldiers in 1820 explored Montezuma slough, the Sacramento as far as present day Redding and along the southern edge of the Delta to where Stockton later developed.

The Russian Captain Kotzebue sailed up the Sacramento in 1824. The British navy sent H.M.S. *Sulphur* in 1837 which produced the oldest surviving chart of the lower Sacramento. The American Jedediah Smith walked the upper Sacramento in 1828 thinking this was the legendary Buenaventura flowing west from the Rocky Mountains to the Pacific.

British and French trappers appeared in the Delta by 1820 taking their pelts to Yerba Buena Cove and other trading centers. A few Delta place names, such as French Camp, remain to indicate their presence. During this period, the area saw a large decline in furbearing animals, such as the beaver and otter.

The Hudson Bay Company's John Work, in 1832, traveled the Sacramento. Members of the Company's party brought malaria to the wetlands of the Valley exposing the native inhabitants. Within four years over 75 percent of the Patwin were dead, the Bay Miwok disappeared, and the Plains Miwok lost over 80 percent of their people. Other European diseases—smallpox, mumps, measles, influenza and syphilis—also decimated Indian populations.

River commerce developed between the new settlements of John Marsh at the foot of Mt. Diablo (1837), John Sutter at New Helvetia (1841), Juan Pena and Juan Vaca at Lagoon Valley (Fairfield, 1842), the Berryessa brothers at Cache Creek (1843), Charles M. Weber at French Camp (1844), and Stockton.

The Sacramento River had more traffic than the San Joaquin because of the upriver settlements by Peter Lassen, John Bidwell, William Knight and the Wolfskill clan. The sailing launch, Sacramento, part of the Sutter purchase of Ft. Ross in 1841, was the first to provide regular service between New Helvetia and Yerba Buena, now Sacramento and San Francisco. The round trip usually took two weeks.

Ocean-going sailing ships that regularly docked at Sacramento and Stockton were replaced by steam power. The "steam era" began in the summer of 1847 with the Russian bark *Nasednich's* "general cargo" delivery at Yerba Buena. This cargo was the 37 foot long steamboat, the Sitka or "Little Sitka" consigned to the merchant William Leidesdorff. The *Sitka* steamed upriver for six days to New Helvetia—on the return trip an oxcart beat the steamer to Benicia.

The steamboat trade flourished with the Gold Rush and the Delta became the main traffic corridor from San Francisco to Sacramento for prospective miners and camp followers (Figure 23). Large eastern sidewheelers began from New York and Boston, stopped in southern ports, the West Indies and Rio to load more coal (or wood), sail through the Straits of Magellan and up the Pacific coast to San Francisco. Despite the odds these ships arrived in useful condition.

Smaller steamers were shipped on windjammers to San Francisco and assembled on beaches. The *Lady Washington* was the first steamboat on the American River in 1849, but sank on a return trip from Coloma by hitting a snag. The ship was raised and sailed as the *Ohio*. The *Pioneer*, built in Benicia, began the San Francisco to Sacramento run in 1849. The *Senator*, a famous Boston to New Brunswick liner began regular service to Sacramento in the same year. Within three months the *California, Sarah, Commodore Preble, General Warren* and *Governor Dana* were competing. The *New World, S.B. Wheeler* and the *Cornelia* competed on the San Joaquin to Stockton run.

High profits encouraged more boats and shipping companies, resulting in lowered fares and profits. The *Senator's* initial $30 for one-way trips dropped to $1 a trip by 1850. There were then 203 vessels on the rivers. The "fastest boat on the river" could claim higher prices. Ramming was a frequent device to eliminate the competition. To maintain profits and reduce sinking, the major boat owners in 1854 formed the California Steam Navigation Company, creating an effective monopoly on river traffic through the 1930s.

Sedimentation and siltation from hydraulic gold mining ruined the rivers for the larger boats. The 1861, 1862, 1875 and 1878 floods carried sand, mud and tailings from the upper reaches of the rivers to farmlands, fisheries of the Feather, American, Bear and Sacramento rivers. Steamboat Slough averaged 12 feet deep in 1853. In 1879 it was only five feet deep, and it was closed to the steamboats. The Sacramento lost 15 feet of depth and Suisun Bay was virtually filled in. By the time hydraulic mining was declared illegal in 1884, it was too late for deep draft navigation of the region's waterways.

Early settlers in the Delta avoided the marshes and grazed cattle on the upland grasses. Chinese workers finished with the railroad work and disappointed miners saw the Delta's potential for farmland. Crude levees were built by hand and were followed by the first land schemes and private development in the mid 1860s. These early efforts were destroyed in the great flood of the 1890s (Figure 24).

Figure 23.

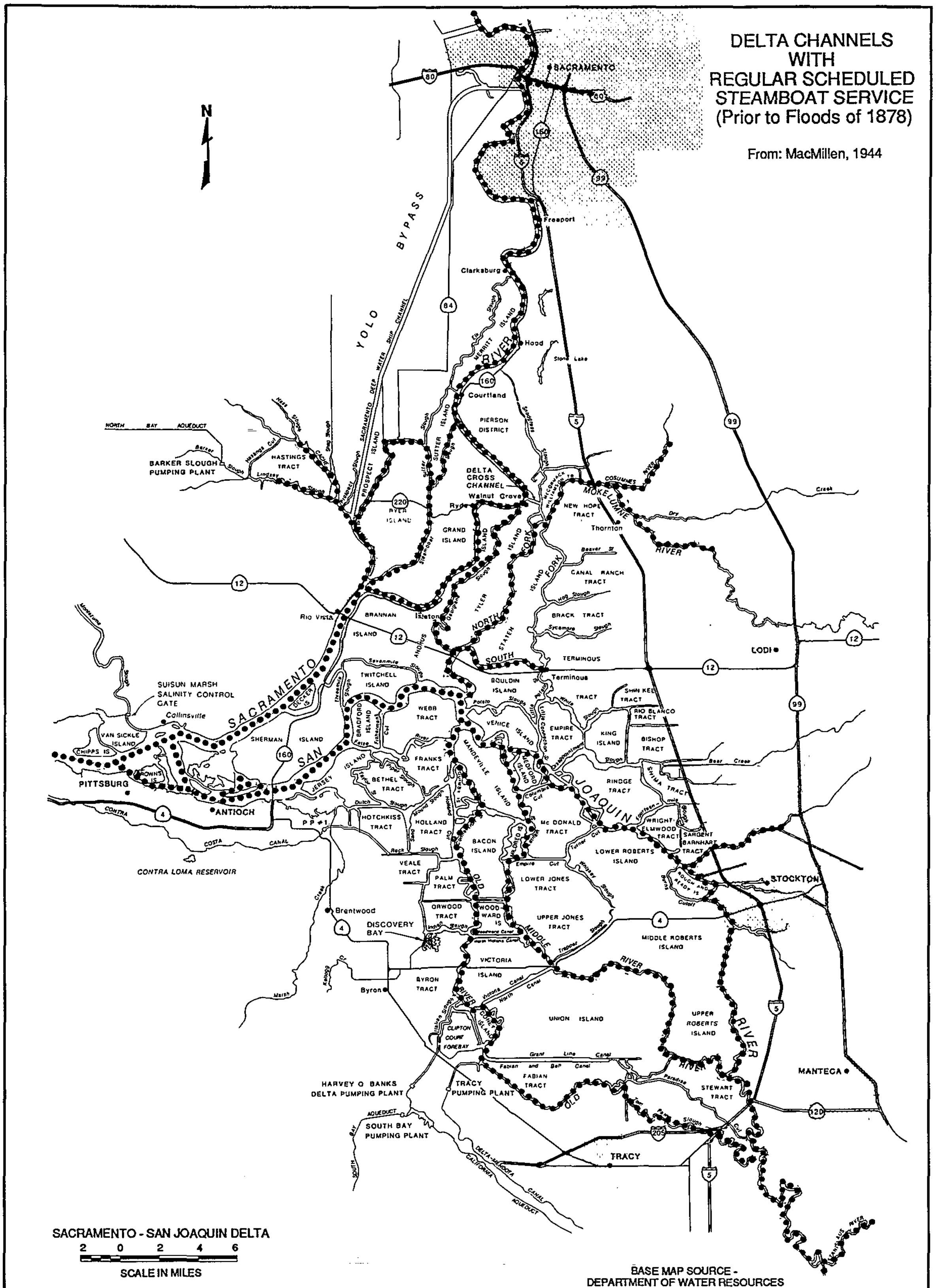

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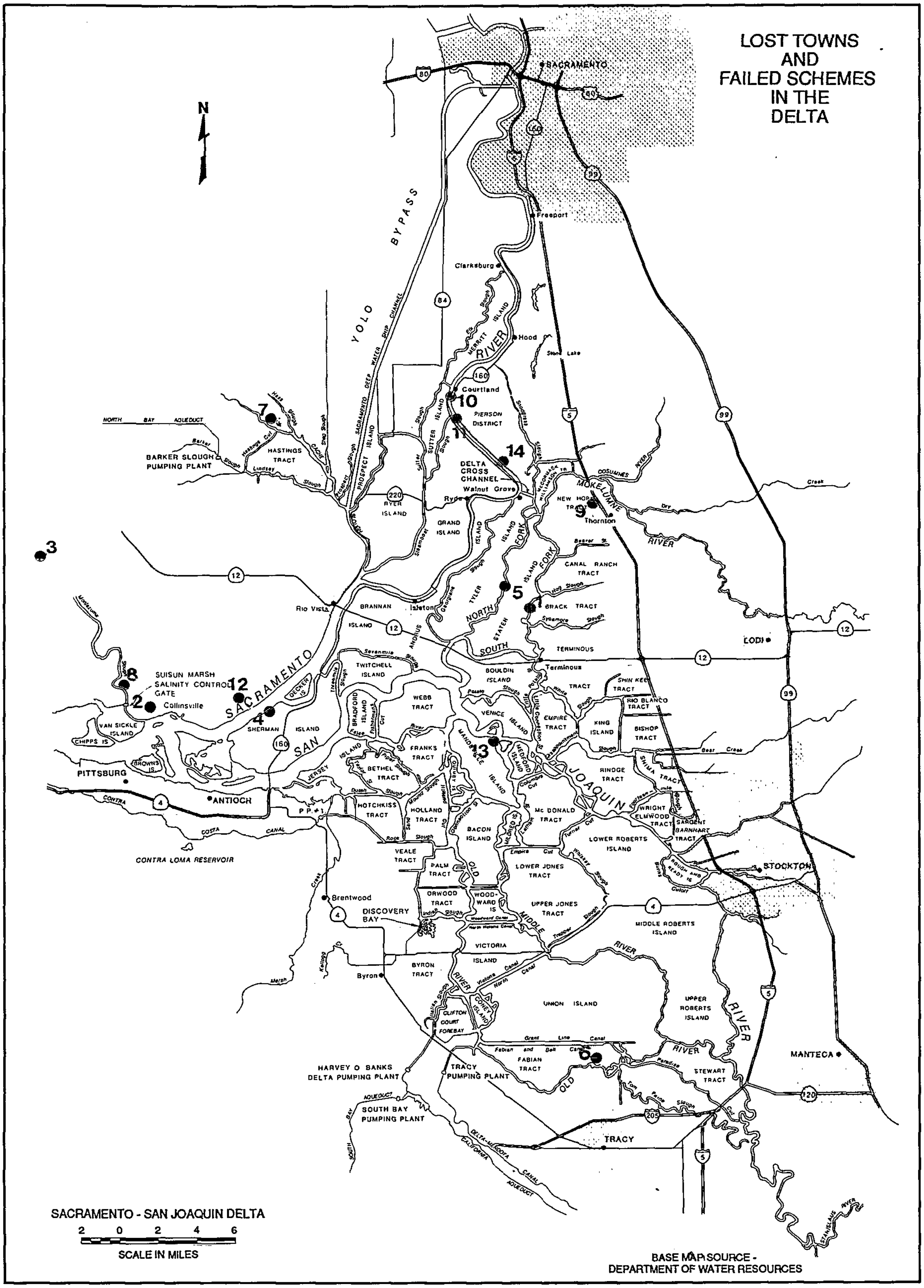
Figure 24.



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From Figure 24.

Lost Towns

1. **Brach's Landing** - Development scheme that no one subscribed to; now misspelled Brack Tract.

2. **Collinsville** - Old Italian commercial fishing port wiped out by the crash of fish species following the floods of 1878.

3. **Denverton** - Faded away when the railroad went to Fairfield.

4. **Emmaton** - Flooded out and never rebuilt.

5. **Hagginsville** - People just moved away.

6. **Holt** - Steamers stopped coming.

7. **Maine Prairie** - Railroad bypassed town.

8. **Montezuma** - Mormon community collapsed in religious dissension. Failed again as Stanislaus City.

9. **Mokelumne City** - Flooded out in 1862 and never rebuilt.

10. **Onisho** - Need for local Indian chief, people drifted away.

11. **Paintersville** - River became too shallow for streamers.

12. **Toland's Landing** - People moved away.

13. **Venice** - Development founded on the belief Stockton was about silt up. The few subscribers drifted away when Stockton survived.

14. **Vordon** - People moved away. Also known as Trask's Landing.

Power dredges and reclamation districts appeared at the turn of the century, leading to permanent settlements.

As the number of people and farms grew the small, shallow-draft steamboat took over where the bigger boats could no longer go. Every slough had landings from which anyone could flag down a steamer. Using combinations of the rivers and sloughs boats could travel over 600 miles on California's inland waterways, from Fresno to Red Bluff, without ever leaving fresh water.

By the 1860s, more than 160,000, half of the state's population, lived within the Estuary drainage. After World War II the area's growing population began using the Delta for recreation. The channels, riparian vegetation and excellent fishing made the Delta a boater's paradise. Marinas, fueling docks, restaurants and bait shops were built to service this recreation.

From 1950 to 1975 the area retained its rural character, but large-scale residential and commercial development began to replace the farms on the lands around the Bay. Until recently there has been little growth pressure on the Delta. However, the early settlers, the Delta farmers and the rural residents are now being replaced by suburban waterfront development.

Cultural Resources of the Delta

Traces of the oldest inhabitants of the Delta are buried in the sediments. The "Windmiller" sites, dating from 500 BC back to 3000 BC, have been excavated from as much as 20 feet below present ground levels.

The Miwok-era sites are mostly gone because their culture focused on a cycle of different camps throughout the year, moving from one seasonal food resource to another. The main camps of the tribelets tended to be close to the natural levees, on rises that protected them from flooding. These were the same sites that early European settlers took over when they arrived, so many of the Miwok village sites were built over in the Mexican or Anglo period. Smaller temporary hunting or fishing camps are still found occasionally during construction projects, but it is unlikely that major village sites still exist.

There are two major classes of historic resources: shipwrecks in the water and old homesites and abandoned towns on the land (Figure 25).

Effects of Human Activity on Cultural Resources

Delta development activities that threaten cultural resources are divided into waterway projects, upland projects that cover significant acreage and corridor projects for roads and utilities.

Waterway projects include dredging channels, dredging material for levee repair, driving pilings for docks or other structures and marina construction. Each of these activities can destroy historic resources, especially shipwrecks. The shipwrecks range from simple barges to sidewheel steamers or large sailing vessels, such as the *La Grange* recently surveyed off the Sacramento waterfront.

Major upland projects that affect prehistoric sites include housing developments, shopping centers, office complexes and industrial sites. Even if a site is protected from excavation by burial and covering with a parking lot, it has become unavailable both to the archaeologist for study and to the descendants of the original inhabitants.

Historic sites with remains of buildings, railway embankments, old trash dumps and rusting equipment may be vulnerable to the vibration of heavy equipment in the area. Development can affect the value of the sites and can cause increased vandalism of prehistoric and historic sites.

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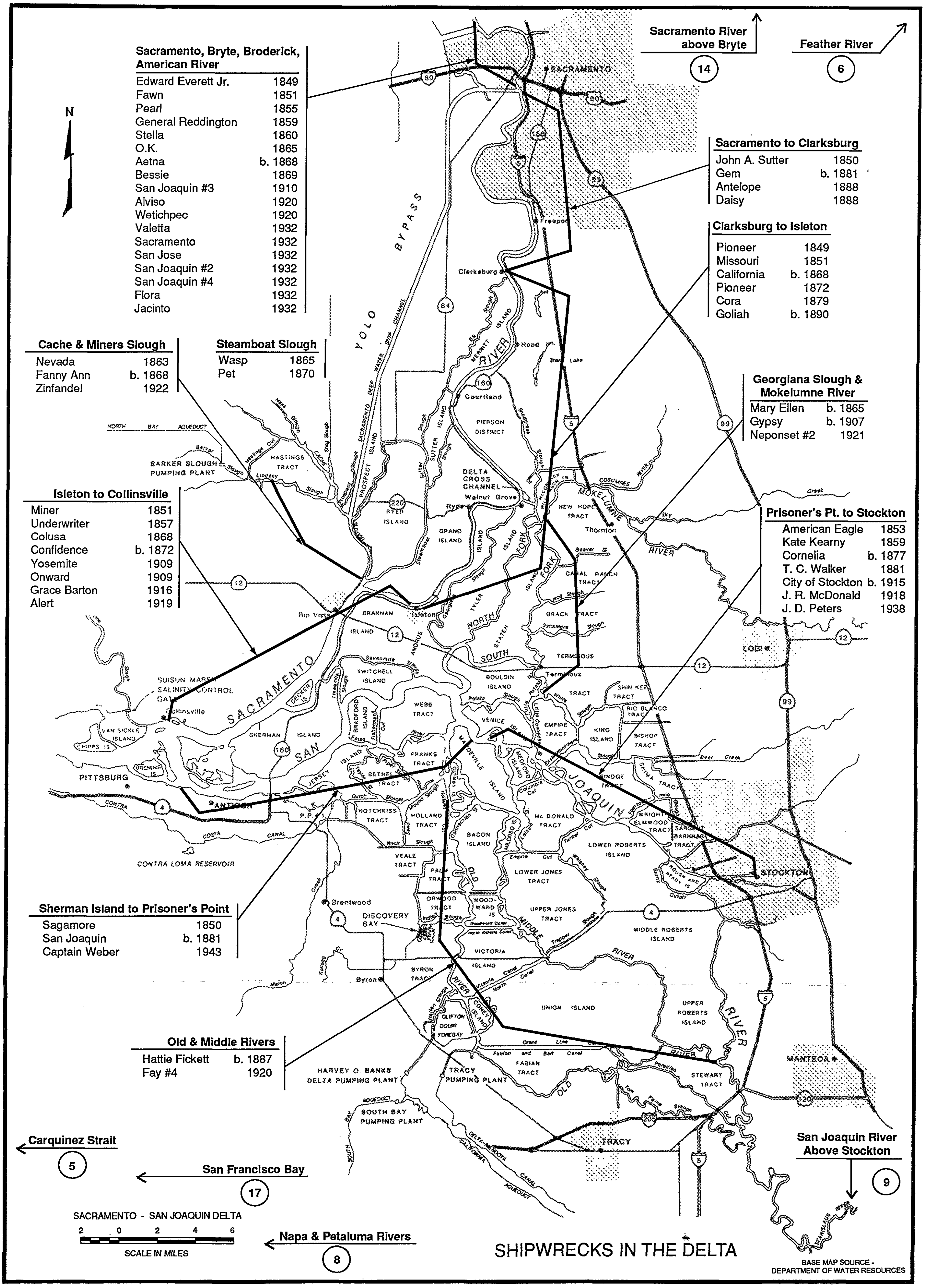

SHIPWRECKS IN THE DELTA

The Delta's Public Trust Values

7

Public Access and Recreational Resources

The Delta lends itself to increasing recreational use because of its aesthetic beauty, wildlife, unique waterway system and temperate climate which encourages year-round recreation. The Delta's close proximity to major population centers also contributes to its growing popularity. Recreation in the Delta, mostly water-oriented, currently exceeds 12 million user days annually (California Legislature, 1982) and is expected to rise, particularly with increasing populations in the surrounding counties (DPR, 1988). Difficulties related to Delta recreation include the lack of appropriate public facilities, limited access to recreation sites and minimal coordination between recreational jurisdictions (Madrone, 1980).

The 1976 *Recreation Master Plan* predicted that visitor-day demands from 1975 to 2000 would increase dramatically, possibly doubling, especially if new public facilities were constructed. None of the recommendations in the report have been implemented to date, and there is no updated quantitative information on Delta-wide recreation. State, local and privately managed recreation areas have witnessed a relatively steady increase in attendance which has intensified in recent years (Resources Agency, 1976; DPR at Brannan Island). Visitors to Brannan Island State Recreation Area have consistently increased over the past five years, and park facilities are usually filled to capacity. Although the Delta Meadows Recreation Area has limited public facilities, it also shows a steady increase in attendance (Table 11).Though there are many regions in the Delta that may be identified as recreational areas, most of them lack sufficient facilities and many are not publicly accessible. There are more than five times as many commercial facilities than public; the vast majority are marinas. Current public facilities are listed in Table 12. East Bay Regional Park District (EBRPD) is currently negotiating to establish a 93-acre open space site at Big Break, and has proposed in their 1989 Master Plan the expansion of existing, and the creation of new, bicycle and pedestrian trails in the outskirts of the Delta area (Mikklsen, 10/90). EBRPD also has money from the passage of

Table 11.

RECREATION ATTENDANCE

Attendance Record-Brannan Island State Recreation Area
Numbers of visitors per year

1974	134,248
1975	129,890
1976	145,963
1977	72,910
1978	174,722
1979	170,247
1980	169,376
1981	168,841
1982	173,260
1983	159,824
1984	181,504
1985	191,169
1986	191,668
1987	213,294
1988	220,872

Delta Meadows Recreation Area-Attendance
Numbers of visitors per fiscal year

1986/87	1,494
1987/88	1,946
1988/89	3,228
1989/90	3,748

Source: California Department of Parks and Recreation, Brannan Island.

Measure AA in 1988 for a proposed Delta shorelines project, but no specific plan has yet been adopted (Mikklsen, 3/91). DWR and DFG are proposing to convert Sherman Island to a wildlife/wetland management area, increasing habitat areas and providing both land and water access for recreation users.

Both the *1976 Delta Action Plan* and *1976 Delta Master Recreation Plan* proposed numerous projects to improve recreational opportunities and address the lack of recreation facilities in the Delta. The two plans recommended adoption of the Delta Waterways Use Program, the creation of parkways, trails and "boating trails," and the acquisition of land to be developed as parks, recreation areas or wildlife refuges. Other planning projects include implementing Brannan Island General Plan and Franks Tract Recreation Area.

Several park projects have been authorized for construction in the Delta but have not been built. The Cosumnes State Park was authorized in 1974 and deleted from the budget in 1977. The Nature Conservancy currently owns natural preserve land along the Cosumnes River and plans to open the area to hiking and walking (Unkle, 12/90). Older River Islands State Park was authorized in 1954, but the money budgeted for its construction was transferred for use in development of Durham Ferry Road. Channel Island State

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Table 12.

PUBLIC RECREATION FACILITIES

Name	Maintenance	Facilities
Brannan Island State Recreation Area	State Department of Parks and Recreation (DPR)	land and water access; launch ramp, swimming beach, campsites, picnic areas, parking, restrooms, interpretive center
Clifton Court Forebay	Department of Water Resources and Department of Fish and Game	land access; parking, only portion of reservoir available for fishing, need special permit
Franks Tract and Little Franks Tract	DPR	water access only; few facilities
Antioch fishing sites and one fishing pier	City of Antioch	land and water access; pier, parking, restrooms
Hogback Park	Sacramento County Parks and Recreation (SCPR)	land and water access; launch ramps, guest dock, picnic area, parking, restrooms
Lower Sherman Island	SCPR	land and water access; launch ramp, parking, restrooms
South Spud Island County Park	San Joaquin County Parks Department	water access only; undeveloped natural reserve, water related activities only
Clarksburg Boat Ramp	Yolo County Parks Department	land and water access; launch ramp, unpaved parking, restrooms
Oak Grove Regional Park	San Joaquin County Parks Department	land access; lake, picnic area, dock, nature trails, interpretive center
Delta Meadows	DPR	land and water access; few facilities
Rio Vista Public Launch Ramp	City of Rio Vista	land and water access; parking, launch ramp
Rio Vista riverbank	City of Rio Vista	land and water access; pier, barbecue pits, parking
Sandy Beach Park	Solano County Parks Department	land and water access; campsites, showers, picnic areas, parking, beach area, paved roads
Borrow Ponds	Department of Water Resources	land access; fishing ponds as part of undeveloped Peripheral Canal right-of-way
Buckley Cove Marina Park	City of Stockton	land and water access; water frontage, fishing, berths, launch lanes, parking, restrooms, gas & repair services, snack bar, playgrounds, organized recreational programs
Fritz Grupe Park	City of Stockton	land and water access; water frontage, fishing, picnic area, parking, bicycle racks, playing fields, restrooms, organized recreational programs
Mandeville Tip Park	Port of Stockton	water access only; boat dock, picnic area, restrooms
Channel I-5 boat ramp park	City of Stockton	land and water access; dock, launch lanes, sailing, low speed boating, picnic area, restrooms
Louis Park	City of Stockton	land and water access; water frontage, bank fishing, dock, launch lanes, boating, parking, bicycle racks, picnic areas, playing fields, restrooms, gas & repair services, snack bar, organized recreational activities
Dos Reis County Park	San Joaquin County Parks Department	land and water access; water frontage, launch ramp, water activities
Mossdale Crossing Park	San Joaquin County Parks Department	land and water access; launch ramp, parking, restrooms
Georgiana Slough Fishing Access	SCPR	land and water access; parking, launch ramp, restrooms
Cliff House Fishing Access	SCPR	land and water access; parking, restrooms

Park was also authorized in 1974, but state-ownership questions requiring resolution delayed the project indefinitely.

Uses Described

Recreation in the Delta involves both passive and active activities related to both water and land. Passive recreation includes fishing, bird watching, photography, picnicking, hiking and nature study. Much of Delta recreation is water oriented, and many recreation areas are only accessible by water, limiting their potential use.

Active, water-oriented recreational activities include boating, boat fishing, swimming, water skiing, sailing and canoeing. Boating popularity has risen in recent years. The combined vessel registration in the six-county Delta area as of September 1990 was 147,015, and many boats are trailered in to Delta launches. There are approximately 100 marinas providing 12,700 berths located throughout the Delta region (Figure 26) (Draft SFEP State of the Estuary, 1991). Many are private and not available to the majority of boaters or have a small launching capacity.

Access to land-based recreation is limited to a few roads. See Figure 27 for those areas accessible. Major land oriented recreational activities include camping, hunting, channel bank fishing, bird watching, hiking, sightseeing, outdoor sports, bicycling, car touring, picnicking and horse back riding. There have been numerous projects proposed to encourage the historic restoration of Delta towns, but current programs to preserve and interpret the Delta's historic and cultural resources are inadequate.

Recreation activity and related services ranks as the third industry in the Delta, following agriculture and natural gas exploration. Recreation use supports a variety of services and supplies, including boat docking and repair facilities, restaurants, grocery stores, equipment rentals and overnight accommodations (cabins, trailers, motels, and camping sites). Recreational use will continue to grow with population growth. The amount of growth is dependent on resolving use conflicts with agriculture and wildlife habitat.

Effects On Recreation Uses, Potential Uses and Resources

Recreationists are attracted to the Delta's natural beauty, with its meandering waterways and fish and wildlife populations. Physical alterations in the region affect the natural setting as well as the recreation experience. Natural occurrences, such as drought, affect the interest in and availability of recreation and damage native habitat areas. The drought, combined with water transport for state and federal water projects, has also reduced freshwater flow into the Delta, diminishing the fish population available for recreation.

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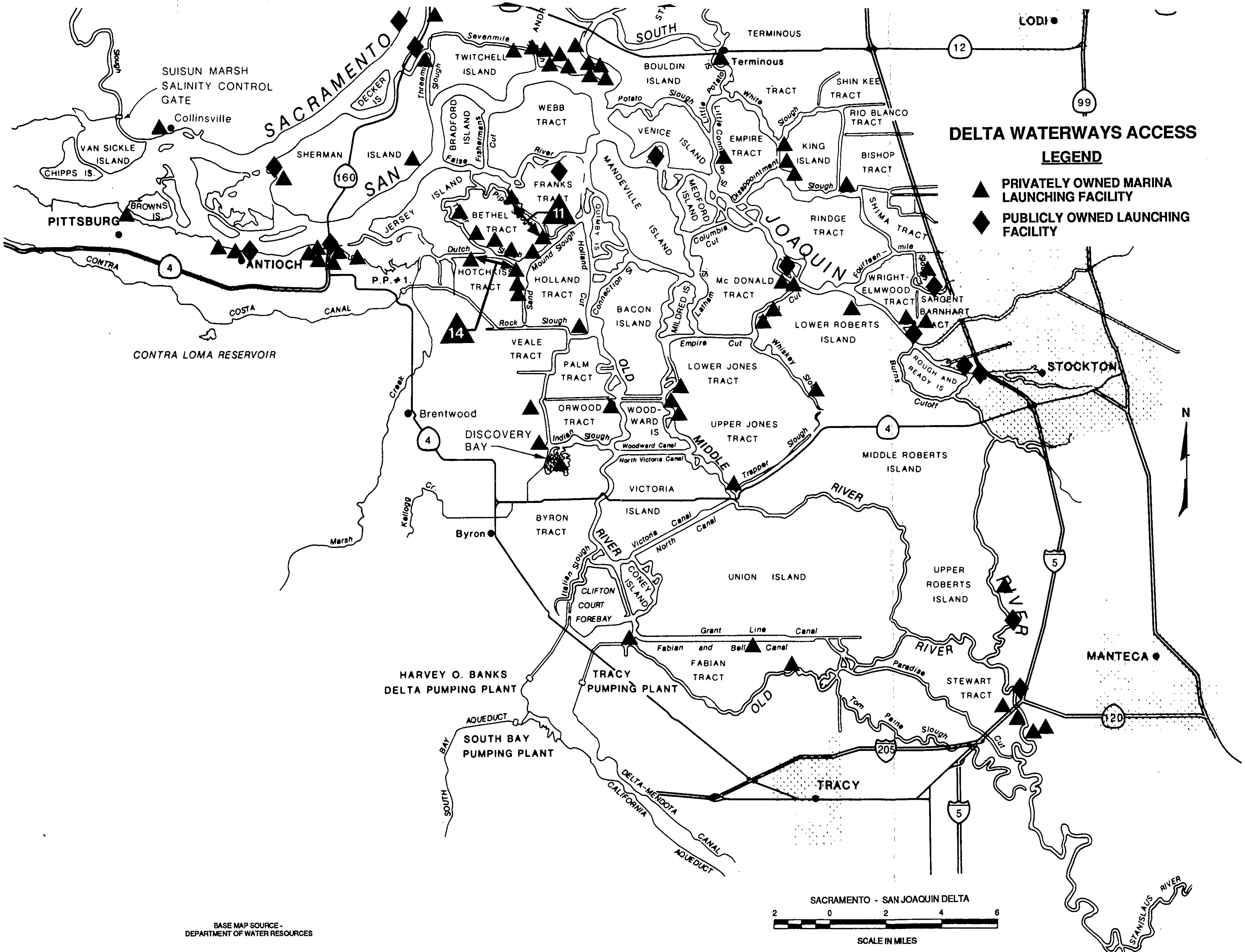


BASE MAP SOURCE - DEPARTMENT OF WATER RESOURCES

Figure 26.

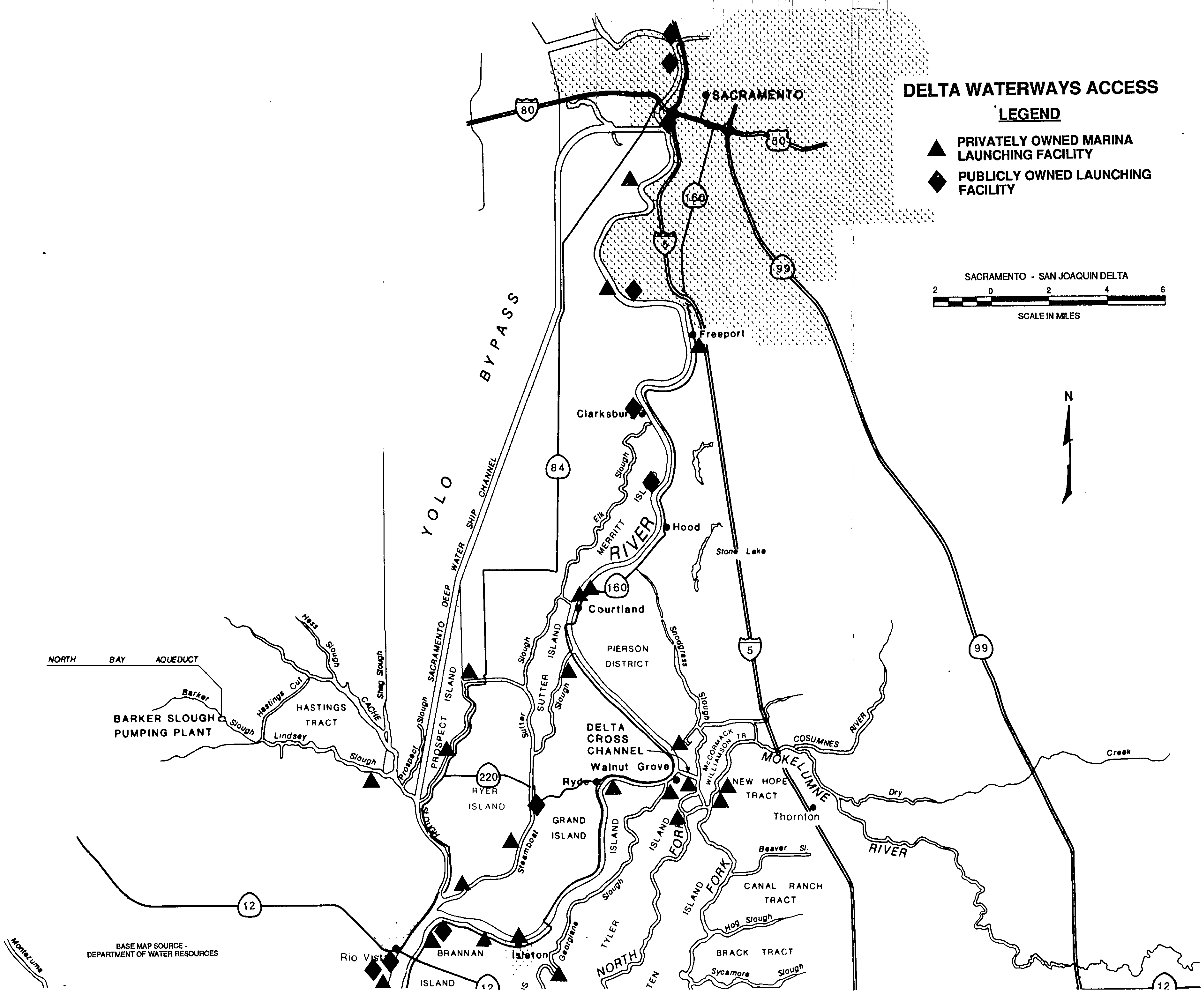
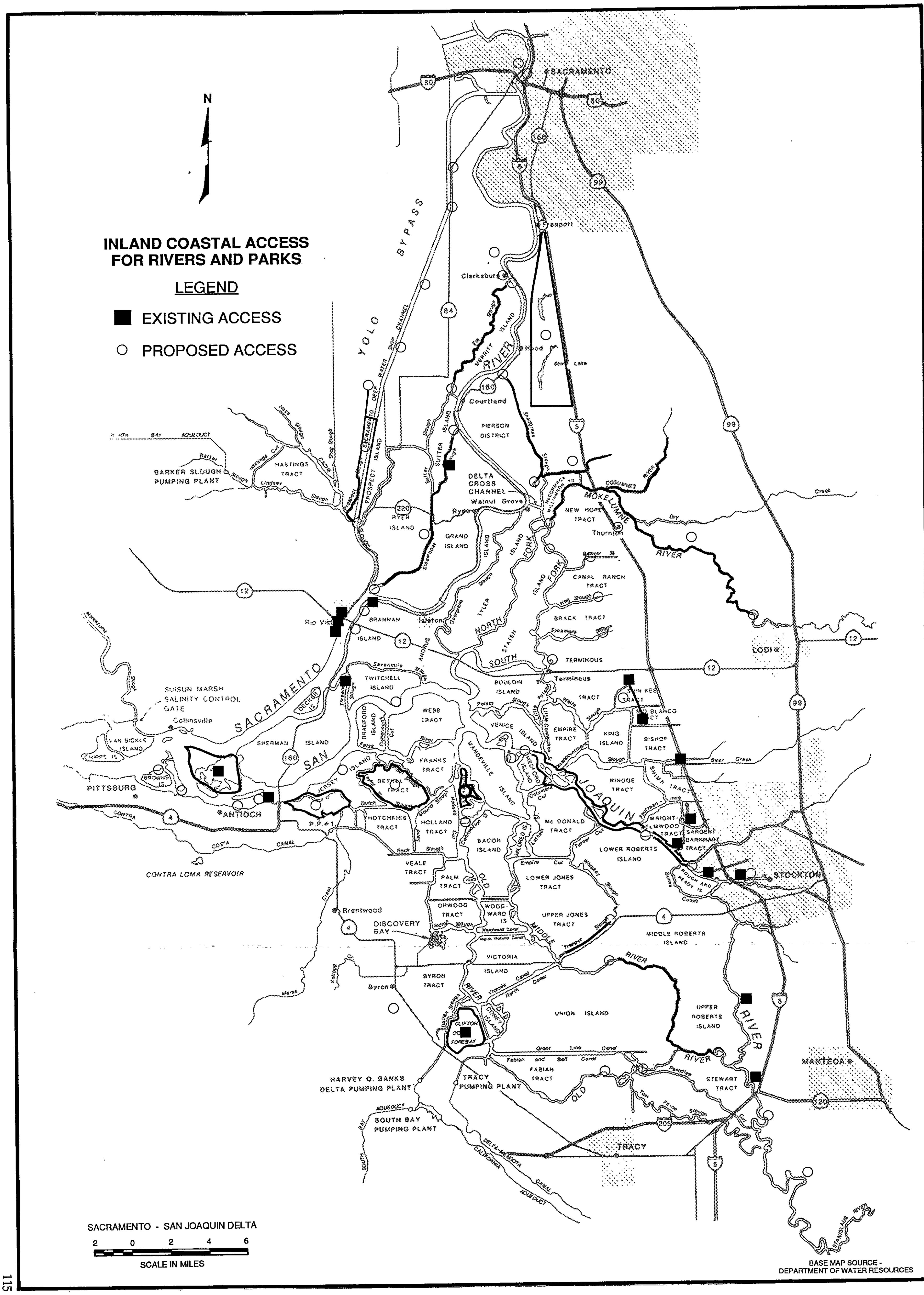

DELTA WATERWAYS ACCESS
LEGEND
PRIVATELY OWNED MARINA LAUNCHING FACILITY
PUBLICLY OWNED LAUNCHING FACILITY
SACRAMENTO - SAN JOAQUIN DELTA
SCALE IN MILES
N
SACRAMENTO
Freeport
Clarksburg
Hood
Stone Lake
Courtland
PIERSON DISTRICT
DELTA CROSS CHANNEL
Walnut Grove
Ryde
NEW HOPE TRACT
Thornton
GRAND ISLAND
RYER ISLAND
HASTINGS TRACT
BARKER SLOUGH PUMPING PLANT
NORTH BAY AQUEDUCT
YOLO BYPASS
SACRAMENTO DEEP WATER SHIP CHANNEL
PROSPECT ISLAND
SUTTER ISLAND
MERRITT ISL
RIVER
MOKELUMNE
COSUMNES RIVER
CANAL RANCH TRACT
BRACK TRACT
BRANNAN ISLAND
Isleton
Rio Vista
TYLER ISLAND
NORTH FORK
BASE MAP SOURCE - DEPARTMENT OF WATER RESOURCES

Figure 27.



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Artificially produced changes also alter the attractiveness of Delta recreation. Water diversions alter the natural water flows along Delta waterways. A combination of decreased inflow to the Delta because of upstream diversions, controlled through-Delta flows, and net reductions in Delta outflow because of local use and export, have resulted in flow reversals and intrusions of salt water. These practices affect the quantity and distribution of fish and wildlife.

The conversion of Delta lands to agricultural use has changed the natural waterway system and contributed to water quality and quantity problems that injure Delta fish and wildlife. Levee construction to protect agricultural fields has altered the natural environment and shape of waterways, and pesticide use on agricultural crops has polluted Delta waterways because of surface run-off from treated fields. The effects of these farming practices on water-dependent wildlife is significant and reduces recreational opportunities and the natural integrity of the Delta.

Sustaining fish and wildlife habitat is necessary to preserve recreational interest. The majority of Delta levees are non-project, and are maintained privately or by local reclamation districts. Few levees are maintained to preserve levee vegetation (Resources Agency, 1976). Because most levees are constructed from peat soil, they are particularly sensitive to the erosion from boat wakes and increased water velocity caused by water diversion and irrigation pumping. The practices of stripping levees of vegetation to monitor or improve levee stability, and of riprapping eliminate significant wildlife habitat, and affect aesthetics and animal activity which are attractive to recreationists.

Land-use conflicts are of primary concern to farmers, reclamation districts and recreationists. Open space for recreation purposes is competing with agricultural use demands and pressures for residential and commercial development. The loss of agricultural lands to expanding urban development decreases open space, reduces areas for wildlife, and limits potential historic restoration. For instance, Rio Vista recently annexed 2,400 acres for a housing development which is expected to increase the population at a relatively steady pace over the next 20 years—from 3,470 to 16,700 by 2005. Delta counties and cities are experiencing growth that, even if tempered, will significantly increase the human population of the region. Although there is a recognition of a need for open space in these proposed developments, such significant growth at current trends will likely have substantial negative effects on an area as fragile as the Delta.

Despite access problems, this growing urban population is recreating in the Delta. Rising fuel costs make the Delta an attractive alternative to travel for recreational opportunities. The numbers of residents and non-residents recreating in the Delta is steadily increasing. This increasing use is consistent with a 1980 DFG report that

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noted, "With rising transportation costs, the large populations of recreationists in nearby urban centers may seek a closer playground than Tahoe or the Coast. Recreational use of the Delta can only increase" (Madrone, 5-8, 1980). With transportation costs continuing to rise and expected increasing population growth, this trend will likely intensify in the immediate future.

Effects of Human Activities

Restriction of Public Access

A significant problem with recreation in the Delta is a lack of public access to many areas. There are few roads and bridges in the Delta region because of high building and maintenance costs and the difficulty of road construction on peat levees. Many recreation areas are accessible only by water. Further, many levees and roadways are privately owned, and trespass problems create conflicts between visitors and residents. Recreationists may drive on public roads that parallel some of the public waterways, but they often must trespass on private lands to gain access to the waterway (Resources Agency, 1976). There are also insufficient levee recreation facilities and parking sites. There is concern, however, that improving vehicular access to and in the Delta would likely increase development pressures in the region.

Economic Effects

Recreation in the Delta is a growth industry, but is dependent on improved public access and resolving conflicts with land-use practices. A Department of Parks and Recreation study is currently being conducted to assess the economic impact of Brannan Island State Park on the region, and is expected to substantiate what is generally agreed upon, that recreational activity generates substantial dollars for the local Delta economy (report due out in September, 1991).

Decline in Availability and Quality of Recreational Opportunities

Threats to fish and wildlife populations in the Delta decrease the availability and quality of recreation. Maintenance of habitat areas for fish and wildlife, including wetland and riparian areas, is important to the remaining fish and wildlife species. These habitat areas are being lost to particular levee maintenance methods that remove native vegetation, to land-use practices such as artificial structures in waterways and riparian habitat areas, and to the loss of agricultural land to urban uses.

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The natural beauty and wildlife variety of the Delta environment attracts recreationists to the area, but that same interest may potentially harm the natural environment. The environmental impact of a growing number of recreationists with insufficient facilities to accommodate them is anything but beneficial. Unregulated recreational overuse directly affects fish and wildlife populations and habitat, as well as exacerbating sanitation and litter problems. Expanded boating on Delta waterways is commonly cited as a primary cause of levee erosion because of wakes, triggering a chain reaction that increases subsidence, affects water quality, damages riparian habitat and diminishes the Delta's uniqueness.

Competing Recreational Uses

Many problems with Delta recreation result from competing recreational uses, especially along waterways. The *Delta Recreation Master Plan* noted that, "Recreational use of the Delta's waterways is essentially unplanned and unregulated." Common complaints from Delta recreationists participating in an outdoor recreation survey included concern about the dangers of high speed boating and overcrowding. Conflicting types of activities spoil the recreation experience of many visitors, and some activities threaten public safety and private property.

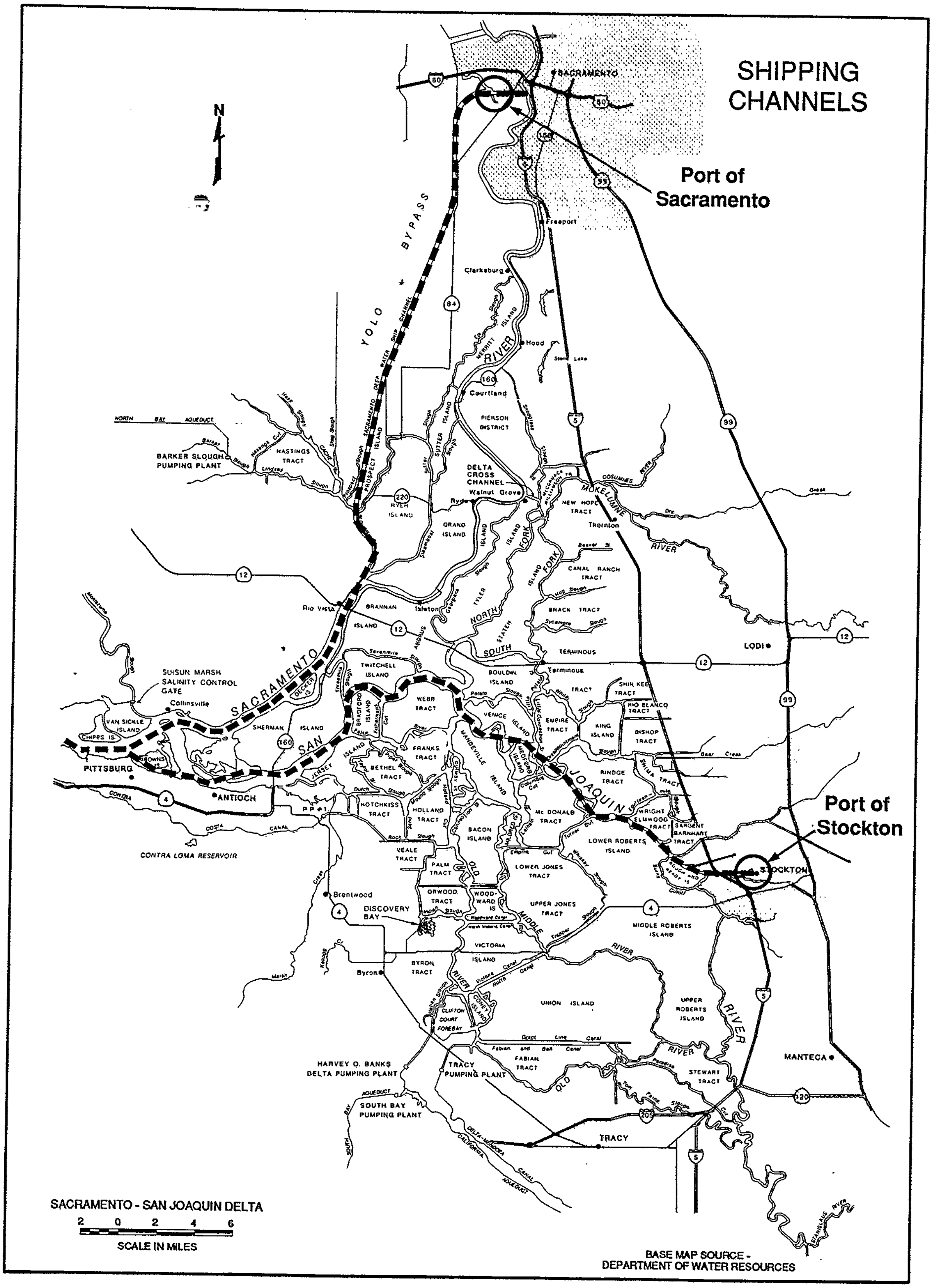
Waterway Uses

Delta ports have been important elements in the agricultural economy of the San Joaquin Valley. The ports of Sacramento and Stockton rely on the Delta rivers and ship channels (Figure 28).

1840s to 1946

Commercial shipping began explosively in the Delta with the discovery of gold in California. In 1849, over 100,000 gold seekers came to the state. The only efficient way of supplying the new arrivals was shipping through the Delta to the Sacramento River. "It is almost impossible to appreciate the role played by the Sacramento River in the economic life to the Sacramento Valley and the Mother Lode prior to the building to the railroads. All goods, after long, four month voyages via Cape Horn, were unloaded in San Francisco and then moved upriver to Sacramento and other river towns. While goods and passengers did travel by land, it was both expensive and uncomfortable. It was the river communities that served as the centers of both settlement and trade." (SLC, 1988).

Between 1853-1878, shipping on the lower Sacramento was significantly altered by the affects of hydraulic mining, limiting



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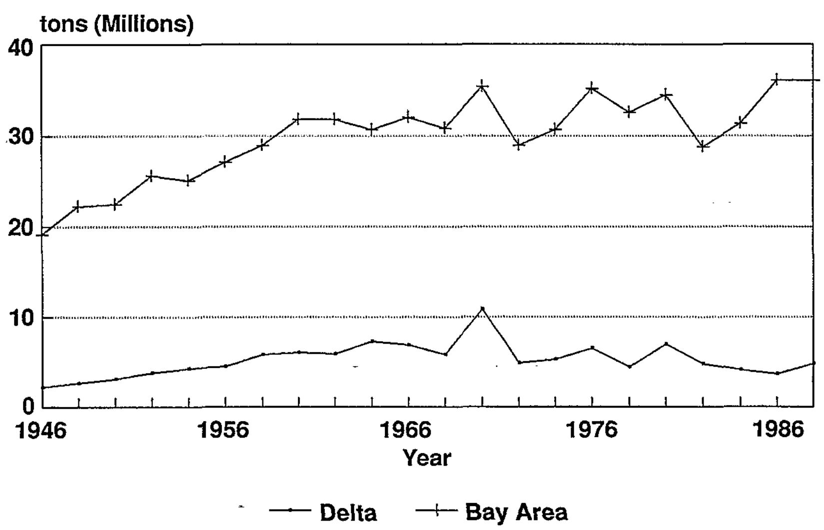
shipping. As mentioned previously, Steamboat Slough was filled in from a depth of 12 feet in 1853 to a mere five feet in 1879. The bed of the Sacramento River at Sacramento had risen 15 feet, and Suisun Bay had virtually been filled. The weight of the ships that could travel on the Sacramento in the early 1860s was reduced by two-thirds by 1873 because of this sediment deposition.

1946 to 1988

Commercial shipping in the Delta increased steadily between 1946 and 1964 with a small slip in 1962 (Figure 29). Since 1964, there has been a downward trend in tonnage per year shipped from the Delta, with some significant exceptions: 1970 was a landmark year for Delta shipping with over 11 million tons being shipped, accounting for over 30 percent of all Bay area shipping; in 1976 and 1981 there were also significant surges in the quantity of goods shipped. These surges can be attributed, in large part, to yearly fluctuations in the shipments of agricultural products, such as rice, wheat and wood products.

Figure 29. The data in this graph is charted biyearly and reflects total tons shipped from the Delta v. Bay Area. The Delta is defined by all traffic shipped on the Sacramento and San Joaquin Rivers. The Bay Area is defined by the Delta, the Port of San Francisco, the Port of Oakland and the Port of Richmond.

Bay Area v. Delta Shipping
1946-1988



Source: Army Corps of Engineers

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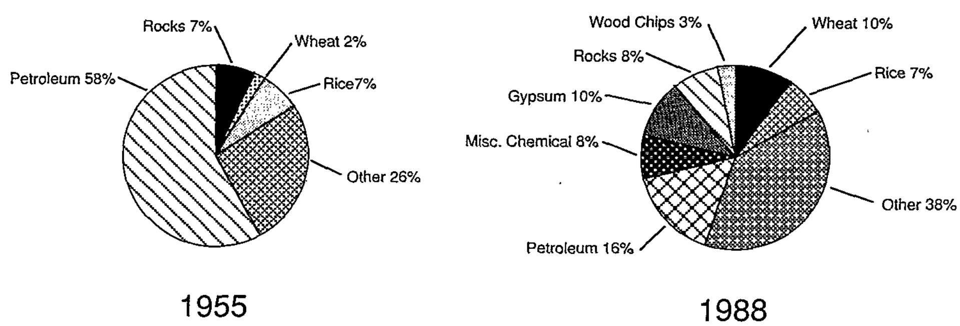
The diversity of shipping composition has changed significantly since the 1950s. As Figure 30 shows, the amount of petroleum shipped in the Delta has been reduced from 58 percent of total yearly tonnage in 1955 to seven percent of total yearly tonnage in 1988. The significant role petroleum used to play as cargo in Delta shipping has been replaced by a variety of other goods from gypsum to wood chips. Note specifically the difference in "other" goods shipped, which changed from 26 percent of total tonnage in 1955 to 40 percent of total tonnage in 1988. This trend of diversification has lead to a slight increase in the variability in short-term shipping tonnage, because more goods are subject to large yearly variations in the amounts shipped. But in the long-term diversification has provided stability, cushioning the loss of shipping markets for petroleum.

Figure 30. In these pie charts total tonnages are approximately equal.

Comparison of Shipping 1955 & 1988



Source: Army Corps of Engineers

A key issue in analyzing commercial shipping in the Delta is the significance of the tonnages given. In this report, significance will be judged by using three percentages: first, the percentage of total Bay area shipping that moves through the Delta; second, the percentage of total Bay area shipping that moves through Delta with petroleum tonnage excluded from calculations; third, in the next section, percentages of specific commodities shipped in the Delta relative to total Bay area shipments of those commodities.

In 1986, the percentage of Bay area tonnage coming from the Delta hit a 40-year low with the Delta accounting for only 10 percent of Bay area shipping. The significance of the Delta in these figures may be understated since petroleum shipments are included in these figures. The mass of petroleum weights percentages, and since very little petroleum is now shipped in the Delta the percentages are weighted against the Delta, making it seem less significant.

Waterway Functions and Uses

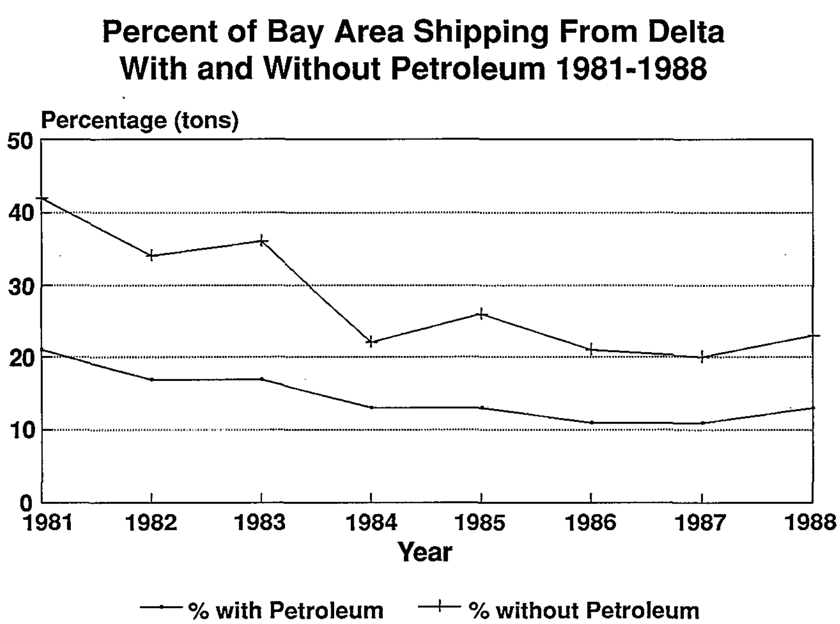
Current and Future Trends

Between 1981 and 1986 commercial shipping in the Delta declined. The composition of shipments in the Delta during the 1980s has stayed relatively constant, with a few goods such as gypsum and logs gaining in importance. The importance specific commodities play in shipping from the Delta can vary from year to year, with certain commodities like rice, fertilizer and coke staying relatively constant.

Data compiled from the Army Corp of Engineer's *Waterborne Commerce of the United States* confirms the perception that the ports of Sacramento and Stockton are primarily agricultural ports. Relative to Bay area shipping, at least 70 percent of the following eight goods were shipped from the Delta in the 1980s: rice, wheat, logs, wood chips, sulphur, gypsum, nitrogeneous fertilizer and coke.

Delta shipping relative to total Bay area shipping is addressed in Figure 31. In 1981 the Delta accounted for 21 percent of all Bay area shipping, and 42 percent of all non-petroleum shipments. In 1986 and 1987 the Delta accounted for only 11 percent of total shipping and 20 percent of all non-petroleum shipments.

Figure 31.



Source: Army Corps of Engineers

But figures based solely on weight tell only part of the story when judging significance. The diversification of a port and the importance of its goods to production processes relative to weight are also important. For example, one ton of electrical components is relatively more important to Bay area industry than one ton of crushed rock, though in weight based calculations they are considered equally. Port diversification and the relative importance of the goods shipped to production processes should be considered in addition to the total tonnage of goods shipped.

In the Bay area, the Port of Oakland is the most significant non-petroleum port. With its deep draft channels (65 feet), its proximity to relatively cheap rail transport and advanced loading and unloading machinery, the port was able to ship 147 classes of commodities for a total of 10 million tons in 1988. In that year, the Port of Richmond shipped 86 classes of commodities for a total of 19 million tons, 15.5 million tons of which were petroleum. The Port of San Francisco shipped 136 classes of commodities for a total of 2.3 million tons in 1988.

The Delta ports, Sacramento and Stockton, shipped approximately 75 to 80 different classes of commodities for a total of 4.7 million tons. From these figures it can be seen that the Delta plays a significant role in Bay area shipping, and though the ports of Sacramento and Stockton lack the diversity of other Bay area ports, they do play crucial roles in the agricultural economy of the Central Valley. California "growers produce two times more fresh vegetables than consumed in the state, five times more fresh fruits, 10 times more rice, and 30 times more almonds and walnuts. . . . Without the international market, 'California's ranchers and growers would find it difficult to sell all they produce of the domestic market.'" (Pahl, 1983).

The Future of Shipping in the Delta

Shipping activity is expected to increase in the Delta in the 1990s. This assumption is based on an analysis in the *Sacramento River Deepwater Ship Channel General Design Memorandum, Appendix A* and *Final Supplemental EIS*, regarding the deepening of the channel. It states, "Navigation benefits derived from deepening the channel from 30 feet to 35 feet are the result of transportation savings from the movement of cargo on larger ocean-going vessels with their inherent economies of scale, reduction in delays due to tides, reduction of present light-loading practices, and movement of project induced tonnage. These transportation savings would accrue to companies shipping through the Port of Sacramento and to new industries which will locate adjacent to the channel in the future." An annual report from the Port of Sacramento states that currently only 30 percent of all ocean going vessels can reach the port. After deepening the channel it is estimated that about 70 percent of all ocean going vessels will be able to moor at the Port of Sacramento.

Commercial Waterway Issues

Physical Changes

Changes in channel depth and width affect ship movements within the Delta. These changes occur primarily because of dredging but also can be the result of erosion, sedimentation and climate change. Dredging affects channel depth and width more substantially than any other single phenomenon. Over the past century, hundreds of millions of cubic yards of soil have been dredged from the Delta to facilitate commercial shipping. In order to carve out the artificial stretch of the Sacramento Deepwater Channel alone, 340 million cubic yards of soil were dredged, enough to cover the city of San Francisco six feet deep. Other projects, such as the dredging of the Stockton Deepwater Channel, dredging of other commercial channels and maintenance dredging have required the removal of several hundred million additional cubic yards of soil.

Erosion and sedimentation also have a significant effect on channel depth, hence the need for maintenance dredging. Because no recent sediment budget analysis has been calculated for the system, it is difficult to determine how much new sedimentation is occurring. It can be assumed that sedimentation rates are substantially higher than they were prior to human development of the region because of accelerated upland erosion due to logging, grazing and farming and the loss of sediment-trapping tidal and floodplain wetlands. The deepening of shipping channels also induces the need for more frequent dredging: the deeper a channel is dredged the slower the water moves within it, allowing more sediment deposition. This increased sediment loading requires more "routine" dredging to maintain channel depth.

Sea-level rise can also have a significant effect on Delta shipping. The primary affect of this would be the deepening of ship channels. Secondary effects include increased storm surges which could flood ports and collapse already unstable levees within the Delta, as happened in 1983, altering the hydrodynamics of the entire area. In planning for the Delta's future, it is crucial that the potential effects of rising sea-level be taken into consideration.

Problems which affect the production capacity of agriculture and the timber industry also have the potential to significantly affect shipping in the Delta. The current problems within California agriculture, including the loss of farmland to urbanization, drought and salinization of farmland have the potential to reduce aggregate crop yields and therefore reduce shipments of crops such as rice and wheat. Similarly, the current excesses within the state's logging industry may also affect long-term yields, reducing potential exports of wood chips and logs.

Economic Changes

Competition from the Ports of Oakland, Richmond and San Francisco, and competition from rail transport affect shipping from the Delta. A larger economy of scale is available to the Bay ports because their deeper channels can accept larger ocean-going vessels than the Delta. The result of this is that a higher volume of non-agricultural goods are shipped out of the Bay area at a cheaper price than the Delta ports can offer.

Highly competitive Bay ports can also have a beneficial effect on Delta ports. Both the Port of Sacramento and the Port of Stockton are highly accessible to both the interstate highway and rail systems. The Port of Sacramento is currently developing its potential as an intermediary between these systems and the high-volume container traffic that moves through Oakland. By downloading containers from rail and truck to steamships which sail to Oakland and load their cargoes onto ocean-going vessels, the Port of Sacramento provides a cheaper more efficient method of transport than direct movement to Oakland over congested area freeways and rail lines. A continued increase in container traffic through Oakland and possibly San Francisco can only benefit Sacramento's role as an intermediary.

Changes in costs for rail transportation can also affect the demand for shipping from the Delta. Deregulation of American railroads in the 1980s has made it cheaper in many cases to move commodities across country by rail than to ship them through the Panama Canal. Changes in the costs of rail transport in the future will have an impact on shipping from the Delta. It should also be noted that the costs of both rail and truck transport affect the amount of goods received by Delta ports. Cheaper railroad or trucking costs could have the complementary effect of bringing more goods to the Delta ports to be exported.

Factors which cause agriculture in the Central Valley to become more or less profitable will also have an affect on commercial shipping in the Delta. These factors include urbanization of agricultural land, energy/petroleum costs, and crop prices. Urbanization of, and near, agricultural lands poses several major problems: it increases air pollution which reduces crop yields; it reduces the amount of land under production which can potentially reduce aggregate yields; it increases the pressure for further development and therefore increases the opportunity cost of farming; and it increases the transportation costs of moving agricultural goods from more distant fields to distribution centers (i.e. the Ports of Stockton and Sacramento). All of these problems reduce the profitability of farming by increasing costs. At some point these forces, left unattended, will cause crop yields and farm exports to decrease. As *The Functions of Bay area Farmland: Background Report #2*, a report published by the People for Open Space Farmlands Conservation Project, states, "If farmland removal persists at a high rate, the viability of related services and processing activities will be threatened at a certain 'threshold' point, which varies for different activities. The loss of these related activities would in turn make it more difficult economically to maintain remaining farmland." These compounding loses will undoubtedly affect export agriculture and shipping if they cause crop yields to decline.

Other factors which affect the profitability of farming and therefore the volume of agricultural exports are petroleum and world crop prices. As was seen during the 1970s, increased petroleum prices can drastically affect the profitability of farming. The "farm crisis" of the 1980s can in part be attributed to the increased cost of farming in the 1970s.

American farming is extremely energy intensive, requiring large amounts of machinery, fertilizer and pesticides. Current increases in energy costs, as well as future variation in energy costs and federal subsidies, will affect the choices of farmers, and therefore the amount of agricultural crops exported.

World crop prices affect farming decisions in a similar manner as other factors which affect profitability. Simply stated, increased crop prices induce more production and export, decreased prices induce less production and export.

Political Changes

National, state and local politics have the potential to induce many of the physical and economic changes mentioned previously. National legislation led to the creation of the Sacramento and Stockton deep water channels and the deregulation of the railroads; state legislation guides and limits development on agricultural lands by enacting laws such as CEQA and the Williamson Act; and local planning policies determine the importance of farmland to communities and the rigorousness with which CEQA and other related laws are observed.

National trade policies have a further effect on which crops are grown for export. For example, the recent lifting of trade barriers against the USSR and the extension of $1 billion in guaranteed loans for food may cause Central Valley farmers to grow more wheat which would be shipped to the USSR through the Ports of Sacramento and Stockton.

Trade policies affecting log exports to Japan could affect exports from the Delta. Currently, public interest groups are trying to get the federal government to limit log exports from California. Proposition 130, in the 1990 election, is an example of the effort to limit such exports.

National policies toward endangered species, specifically the Northern Spotted Owl and possibly the Marbled Murrelet, could

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result in reduced rates of logging in old growth forests and leave fewer logs available for export to Japan.

Limiting or loosening of regulations regarding the length of ships allowed in California shipping channels would make ports like Oakland and San Francisco more competitive because of the larger economies of scale that would be available to them, while the Delta would be less competitive with its narrower channels that could not accept the larger ships. Limiting length would cause lower volumes per shipment from the Delta, increasing costs.

Effects of Human Activities

Waterway Dredging

Most of the Estuary is shallow; without dredging, shipping within current parameters in the Estuary would cease. There are three types of dredging which occur in the Delta: maintenance, construction and commercial. Maintenance dredging is performed to maintain channel depth in commercial shipping channels and around marinas. Maintenance dredging requires environmental assessment on its impacts to water quality, habitat and spoil deposition. It is normally the least harmful form of dredging and is generally done only as needed.

Construction dredging is performed to build new and deepen existing channels. The major construction dredging project currently being performed in the Delta is the deepening of the Sacramento Deep Water channel. The completion of this project is scheduled for the early 1990s. Construction dredging can be very harmful to the environment when performed in channels, (see Water Quality and Flora and Fauna) and an environmental assessment under CEQA and/or NEPA is required.

Commercial dredging of sands for building materials is new in the Delta. Normally these projects occur in the San Francisco Bay, but with the public's increasing sensitivity to such projects, commercial dredging is moving into the Delta and the Eel river region. A very large commercial dredging project involving millions of cubic yards of material is being planned near Rio Vista. Such projects are monitored for environmental impacts because of their potential to destroy biological habitat, increase saltwater intrusion and sedimentation and degrade water quality.

In addition to the process of dredging, the placement of dredge materials is closely monitored in the dredging permit process. Dredge material deposition has the potential to cover and destroy biological habitat, and contain toxic substances which can bioaccumulate in the surrounding ecosystem.

Port Facilities—Sacramento

The Port of Sacramento is involved primarily in shipping bulk commodities such as, rice, wheat, fertilizers, wood chips, and logs. It has extensive facilities for making bulk shipments and the port has an outside storage capacity of 650,000 tons.

The Port of Sacramento's general cargo facilities include 86,900 square feet of enclosed general cargo space, and two 45-ton gantry cranes for moving cargoes, such as, logs, automobiles and containers.

Other facilities include the Port of Sacramento's "Seaway Center." The concept for the Seaway Center is for the port to serve as a feeder port for the Ports of San Francisco and Oakland. A feeder port is a port which accepts containers from trucks and rail and "feeds" them by barge and small ship to the central container receiving Ports of Oakland and San Francisco.

The Seaway Center also has Foreign Trade Zone status. This status allows goods to be manipulated on port property without tariffs being assessed. As an annual report published by the port states, "The Seaway Center Foreign Trade Zone [is] attractive to importers with special needs. Deferral of payments, entry inspection, manipulation, processing, and reexporting of merchandise are a few of the benefits." (Port of Sacramento, 1990). Foreign Trade Zone status is imparted on the port by the federal government.

Port Facilities—Stockton

The Port of Stockton has a more diverse array of shipping facilities than does Sacramento. The port handles fairly large volumes of general, dry bulk and liquid bulk cargoes. It also has a variety of storage facilities.

General cargo shipping from the Port of Stockton, either in or out of containers, involves agricultural commodities such as baled cotton, bagged wheat, almonds, and steel in a variety of forms (i.e. beams, coils, scrap), dry well cargoes and liquid bulk products. A large amount of petroleum is shipped by pipeline from Concord. Jet fuel is also shipped by pipeline to Merced Air Force Base.

Land Use

The Delta provides approximately 6 million residents and notable number of visitors with substantial economic, recreational and aesthetic benefits. The many benefits that the Delta provides make it a resource of invaluable treasures.

Over 75 percent of the nation's population resides within 50 miles of a coastline and many of the country's 92 significant estuaries are under increasing pressure from population growth and development. Pollutant loads and loss of habitats are closely linked with population density (SFEP, Draft State of the Estuary, 1991).

All Delta uses depend on its qualities and state of health. Coexisting Delta uses include recreation, fisheries and wildlife. Conflicting uses include urban development, water diversion and other uses that degrade Delta resources.

Land use has a direct impact on the Delta's ability to function as a dynamic natural and economic resource. The preceding chapters have identified: the hydrologic changes as the result of levee construction to claim marshland for agriculture; the soil erosion and subsidence that result from agricultural practices leading to the costly maintenance of levees; the flood control measures that interfere with the natural cycle of nutrient replenishment and instream flows; and the water facilities, barriers, cut channels and off-site storage that divert the Delta's very essence—water—out of the region.

These direct and indirect land-use impacts continue and future land-use activities threaten its biological condition. The San Francisco Estuary Project's *Status and Trends Report on Land Use and Population* (1990) chronicles the historic changes in population and land use in California and the Bay-Delta Estuary from the Mission era through 1975. It notes that the Delta region, including the Bay area, have experienced change that shows a future trend of additional, significant economic and population growth and land-use change and intensification.

During the 1980s, California's population grew to 29 million people. The Estuary area has added one-half million people every five years. The nine-county San Francisco Bay area's population increased approximately 14 percent to just over 6 million people, surpassing the Philadelphia metropolitan area in population and becoming the fourth most populated metropolitan area in the country. The Sacramento area, which had one of the nation's highest growth rates, added approximately one-quarter of its 1.38 million population in the 1980s. The three-county Delta area provides about 750,000 jobs, many in the agricultural sector. The economic and population growth will continue in the 1990s with significant land-use change and intensification of urbanization.

Sources and Documentation

This chapter relies on the comprehensive and thorough analysis by the San Francisco Estuary Project land-use studies. Much of the analysis is based on work carried out in the University of California's Berkeley Spatial Information Systems Laboratory. The State Lands Commission is working directly with the Berkeley Laboratory for adding "data layers" in the geographic information system (GIS). These data layers (existing land use, wetland area, geomor-

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phology) combined with land-use changes for which the GIS is programmed to provide analysis is a useful tool which relates to geographic features and, in particular, land-use restraints and land-use change.

Existing Land Use Patterns

Previous chapters have identified the patchwork of low-lying islands and adjacent lands in the Delta. The eastern and southern portion of San Joaquin County, the majority of Yolo County and most of Sacramento County lie within the flat portions of the Central Valley.

The "Delta's History" chapter described the area's early, turn of the century, settlement schemes and later successful rural development which spread evenly over the Delta islands. However, in recent decades that pattern has shifted dramatically as the original urban centers grew rapidly and their economies diversified. What were once essentially agriculture service centers are now becoming full-fledged suburban communities. These newly flourishing communities have benefitted from their location not along waterways, but rather along major interstate and state highways.

Unlike the Bay area with its geographic constraints, Delta communities have sprawled across the flat topography at relatively low building densities. The Delta current populations are mostly in unincorporated areas. In contrast, 60 percent of Yolo County's population and households are in the two major cities of Woodland and Davis.

Delta counties, in contrast to the Bay area, form a region not as self contained as the Bay area. New development and concentration of Delta county communities has been driven by connections with the growing job centers in the Bay Region. Few natural barriers or strong land-use management plans exist to cope with the substantial development pressures from surrounding areas.

Land Uses

The Estuary Project analyzed land-use categories that include rural/open space, intensive agriculture, residential, commercial/light industry and heavy industry. These upland uses were chosen for impact analysis. However, there is no breakdown of land-use categories specifically for the Delta territories (Figure 32).

The California Assembly Office of Research's (AOR) *Delta Dilemma* conducted a land-use survey in 1981 which included land ownership in the Delta. Boundary lines used to define these precise areas closely coincide with the statutorily defined Delta lowlands. These lands are generally less than five feet elevation above mean sea level and consume water derived from Delta channels by

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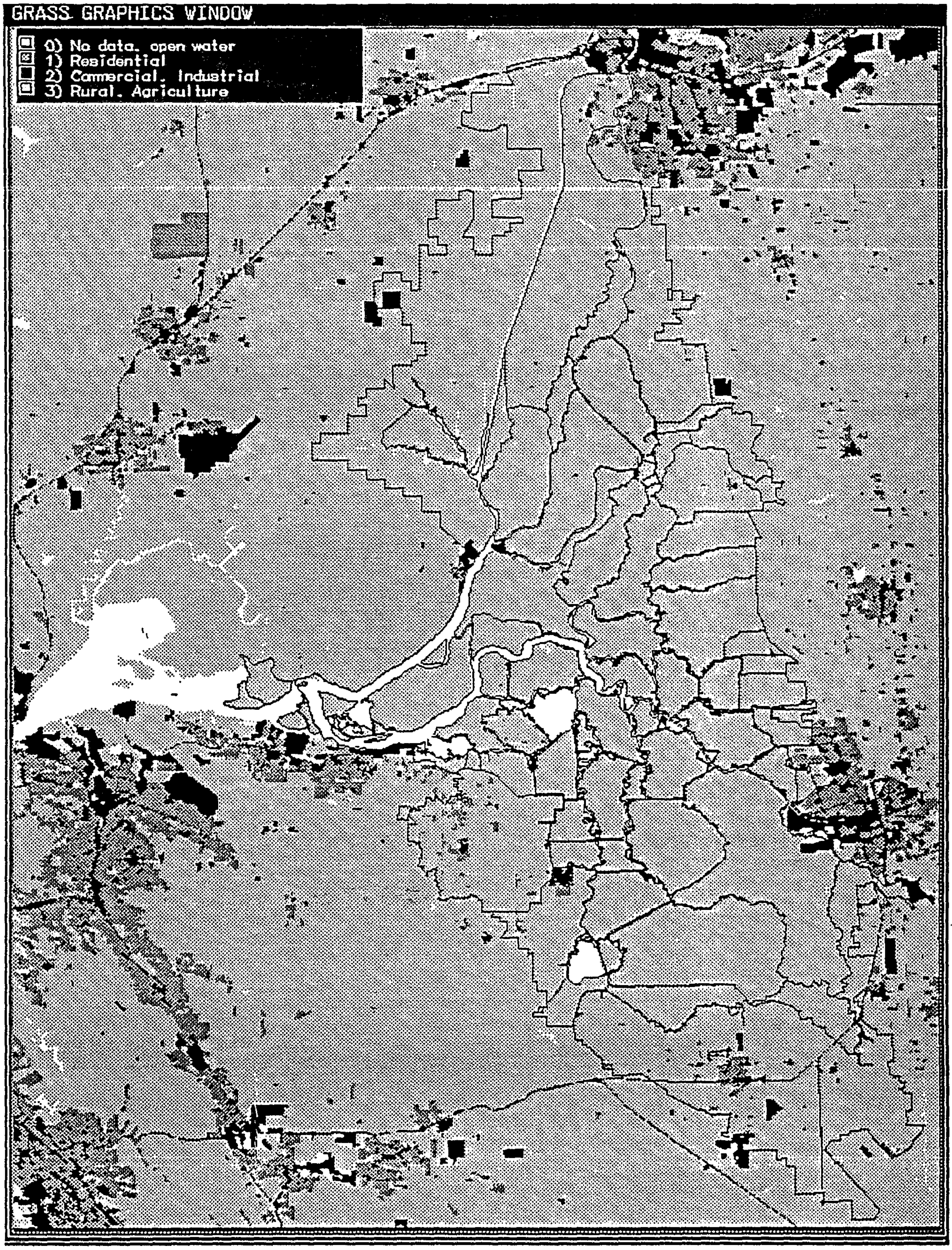

Figure 32. Land Use. University of California Spatial Information Systems Laboratory. April 1991.

Table 13. County Acreage (Land Use).
Source: AOR Delta Dilemma.

County	Total Acreage	% of Total
Contra Costa	38,120.8	11.4
Sacramento	91,142.5	27.2
San Joaquin	109,449.6	32.7
Solano	58,931.2	17.6
Yolo	37,333.2	11.1
TOTAL	334,977.3	100.0

subirrigation or surface application. County acreage figures are given in Table 13. Several general observation were made:

1. Land ownership in Contra Costa, Sacramento, San Joaquin, and Solano Counties were heavily concentrated among the large landowners (i.e. those with at least 500 acres). In contrast, the vast majority of landowners in Yolo County fall into the 50- to 499-acre category.

2. Average parcel size tended to be larger in Contra Costa (213 acres) San Joaquin (237 acres) and Solano (232 acres) counties than in Sacramento (162 acres) or Yolo (105 acres) counties.

3. Large landowners are relatively "few" in number (about 160), but hold more than 60 percent of the acreage in the study area.

Thus the following land use description is generalized and not quantified:

Rural/Open Space

This category includes many types of open or partially developed lands which are a small component of the area's open lands. Sub-categories include: publicly owned parks and watersheds; privately held lands in extensive agriculture (primarily grazing); rural estates (ranchettes) with one unit on a parcel of one to 40 acres of land; and other small private holdings on lands that are difficult to develop.

In general, the Delta region has significantly less publicly owned parkland than the Bay area, where public parks serve a denser population. For instance, in Sacramento County and City, most parks are located along the American River and in San Joaquin County, most regional parks are associated with waterway access.

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Extensive Agriculture

Unlike the Bay area, where nearly two million agricultural acres are grazing land, most Delta farmland is intensive agriculture. There is major dairy farming around Galt and Elk Grove in Sacramento County. Other grazing in the Delta is limited in the adjacent ridgelands areas.

Intensive Agriculture

As noted, intensive agriculture is the predominant land use in the Delta. The flat topography and excellent soils, combined with riparian water supplies and water from government water projects, produce an agricultural cornucopia. DWR estimated the value of Delta farm products to be nearly $375 million in 1987.

Residential/Commercial/Light Industry/Heavy Industry

Delta residential density has been low until recently. Contra Costa County's Discovery Bay developed with a density range of 9.6 to 15.8 dwelling units per acre; Stockton's Grupe project has a density of 3.5 to 4 dwelling units per acre.

Significant concentrations of heavy industry are in Stockton, Sacramento, Pittsburg and Antioch. These locations developed earlier as shipping ports. Later, with the railroads, processing plants and refineries developed.

Changes in Development Pattern

As a result of Proposition 13, local governments have been actively pursuing land uses which generate greater sales tax revenue. (See Figure 33.)These uses include office, industrial and commercial development. Housing developments are generally avoided because they are perceived as requiring more services and providing less revenues than sales-generating developments. These fiscally driven development decisions have created a job/housing imbalance.

The urban area's disinclination to provide for and approve new housing pushes new housing developments to the region's fringes, converting agricultural lands and encroaching on wetlands and riparian habitats. This ancillary housing growth pressure in the Delta has increased substantially in the last decade. Table 14 depicts the population figures for Delta cities in 1980 and 1990, showing a decade of growth. County populations for 1989 and projections to 2000 are shown in Table 15.

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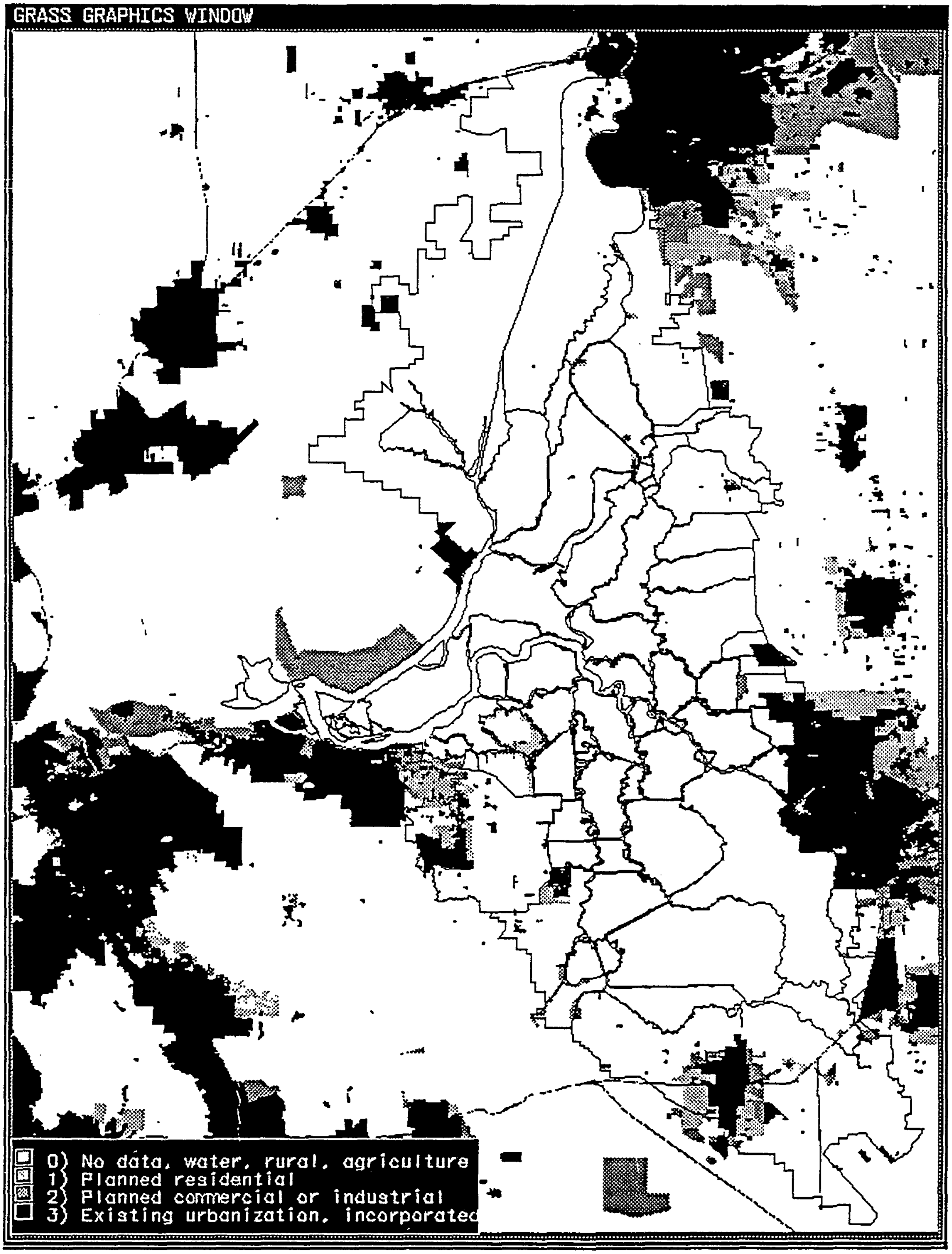

Figure 33. Planned Development. University of California Spatial Information Systems Laboratory. April 1991,

Table 14. Delta City Population Figures.
Source: Department of Finance. *California Statistical Abstract - 1990,* Homer, Edith R., Editor
California Cities, Towns & Counties - 1990

CITY	1980	1990/a
Antioch	42,683	62,000
Brentwood	4,434	7,050
Isleton	914	920
Pittsburg	33,034	45,650
Rio Vista	3,142	3,470
Ripon	3,509	7,425
Ross	2,801	2,740
Sacramento	275,741	346,600
Stockton	149,779	195,200
Tracy	18,428	32,700
West Sacramento	n/a	27,350

Table 15. Delta County Population Figures.
Source: Department of Finance. *California Statistical Abstract - 1990,* Homer, Edith R., Editor
California Cities, Towns & Counties - 1990

COUNTY	1989	2000 - PROJECTED
Alameda	1,261,500	1,330,245
Contra Costa	790,000	876,000
Sacramento	1,007,300	1,186,600
San Joaquin	464,900	513,600
Solano	330,200	397,230
Yolo	136,200	158,780

Trends and Conclusions

Existing economic opportunities and perceived quality of life will continue to attract people to the Delta region at a moderately high rate. New development to accommodate this growth will occur away from city centers and along major highway transportation corridors.

The wetlands that provide "water treatment" and a buffer for a potentially rising sea level continue to be adversely affected by development.

Land-use change and intensification in the Delta will involve conversion of land currently in intensive agricultural, rural or wetland land use to urban uses.

Current county plans will result in changes including 936 acres of wetlands that would be eliminated or modified; 1,596 acres of Delta stream environment areas and 430 acres of Suisun Bay stream environment areas would be eliminated or modified. Approximately 1,800 acres of diked Delta lowlands would be eliminated. See Figure 34 for existing wetlands and stream environments.

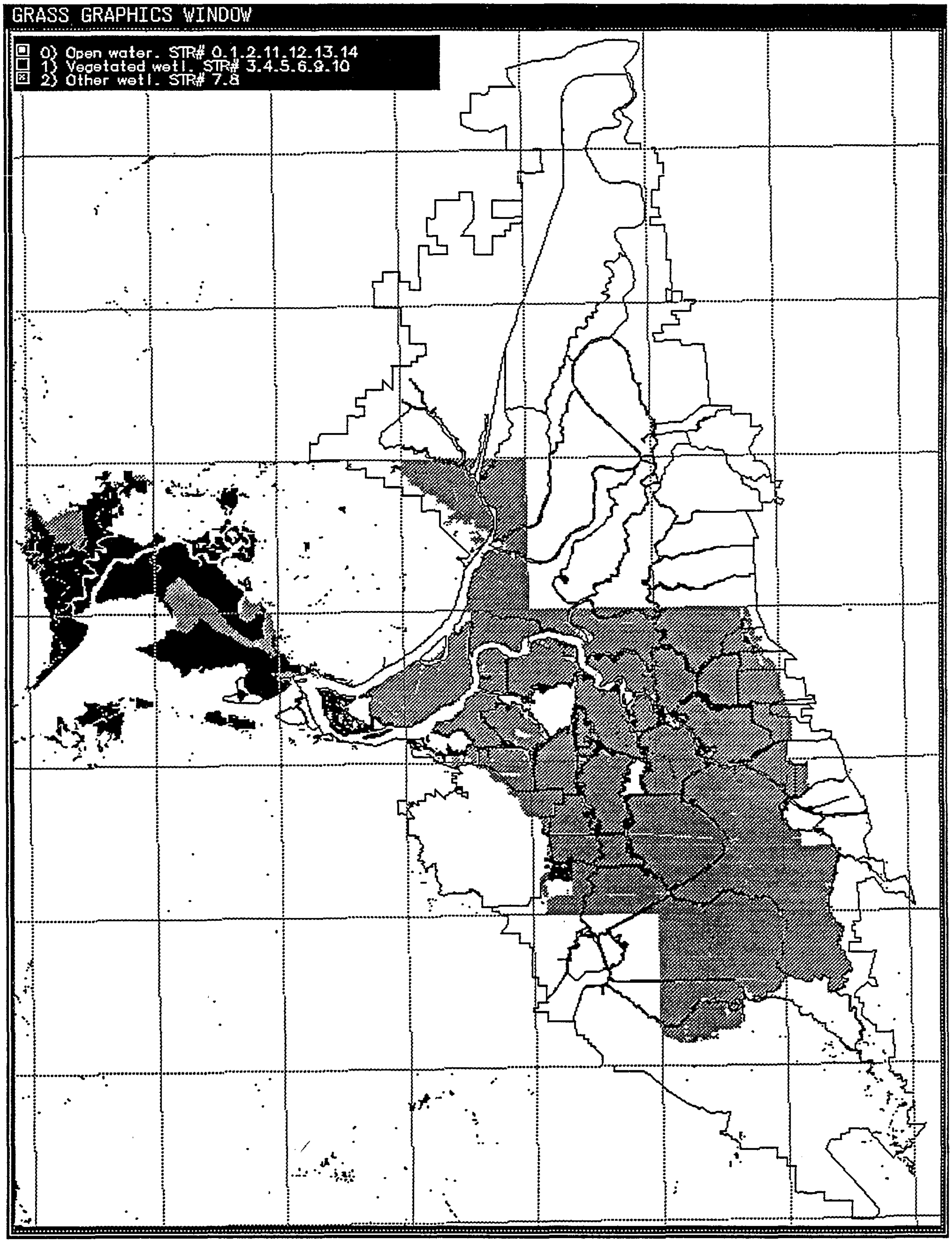

Figure 34. Wetlands. University of California Spatial Information Systems Laboratory. April 1991.

State and federal agencies affect Delta land-use planning indirectly through specific programs such as diking, water diversion, recreation, and state and federal highways.

State law requires that each city and county prepare a comprehensive general plan and all local ordinances, development plans, zoning laws, and infrastructure financing must be consistent with those plans. These plans, while largely in a localized context, are subject to the California Environmental Quality Act. Within this state-mandated planning process, there are presently no provisions to resolve conflicts or inconsistencies between local, state or regional plans. There is no consolidated statewide policy on land-use issues.

Community participation has increased in the planning process However, such participation has addressed local, rather than regional or resources, needs.

The Delta has been identified as a multifaceted region—a recreational resource for major metropolitan areas; a waterfowl refuge; a water transport system; a commercial navigation system; and a land-use resource for residential development. Planning for these uses has not, thus far, addressed the Delta's environmental carrying capacity for attendant marinas, or for residential, commercial and industrial land uses.

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The Delta's Programs and Policies: Gaps and Overlaps

8

Existing government programs and policies act separately or indirectly to manage water quality or quantity, fisheries, endangered habitats, navigation, public access, recreation, and general land use. There is no comprehensive policy or structured approach to managing these resources. At present there is, in fact, no management structure by which an integrated policy, if one existed, could be implemented.

The following is a summary of the federal, state and local institutions, agencies, regulations, and policies that illustrate the institutional infrastructure presently governing the Delta and its public trust resources. Portions of the material in this chapter have been exerpted from a *preliminary draft* report currently being prepared under the auspices of the San Francisco Estuary Project. Staff of the Commission acknowledge the preliminary nature of the report and assume full responsibility for the accuracy of such excerpts. (See Table 16 for a listing of relevant state and federal legislation.)

The Federal Role

Department of Agriculture

U.S. Soil Conservation Service (SCS)

SCS provides technical assistance in the conservation, development and productive use of nation's soil, water, and related resources. SCS is staff to the Local Resource Conservation Districts (California special districts).

SCS administers the *Water Bank Program* with assistance from the Agricultural Stabilization and Conservation Service and other agencies. The objectives of the program are to preserve, restore and improve habitat in important migratory waterfowl nesting and breeding areas and to benefit other wildlife resources. Landowners with eligible wetlands may enter into agreements to receive annual payments for conserving land as wetlands.

SCS participates in the *1985 Farm Bill (Amended 1990)* with the objective to retire farm lands that have identified soil and water problems; landowners with eligible lands may enter into agreements to receive annual payments. The 1990 Farm Bill provides "perpetual conservation easements" under the Wetland Reserve Program. Final regulations have not been approved, but it is likely that only agricultural lands which have been classified as "prior converted wetlands" would be eligible. Also being considered for inclusion are adjacent existing wetlands and uplands if they add to the value of the wetland complex.

Department of Commerce

National Oceanic and Atmospheric Administration (NOAA)

NOAA is the Federal government's primary source of data and information on problems of the ocean and the atmosphere.

NOAA's activities include providing information on resources of the Estuary; performing assessments, research and synthesis/prediction; monitoring of ambient levels of pollutants in the sediment and water column; research effects of pollution on the Estuary habitats, organisms, and subsequent effects on human health.

NOAA administers the *Coastal Zone Management Act (amended 1990)* whose purposes are to enhance the effectiveness of the CZMA of 1972 by increasing understanding of the coastal environment and expanding the ability of State coastal zone management programs to address coastal environmental problems; emphasizes controlling land use activities which result in non-point pollution of coastal waters, and of anticipating sea level rise; provides procedure for state inland coastal boundaries to be modified to extent necessary to control the land and water uses that have a significant impact on coastal waters of the state.

NOAA funding under the act assisted California in the coastal plan development, identifying critical areas within the coastal zone, including wetlands, designating appropriate uses, and establishing state and local programs to regulate coastal land use. Other grants have been awarded for carrying out parts of the California Coastal Plan and San Francisco Bay Plan.

Federally funded projects and projects on federal lands must be consistent with the State Coastal Zone Management Program; Section 404 (Clean Water Act) permit actions must also be consistent with the CZMA programs.

NOAA administers the *National Estuarine Research Reserve System (NERRS)* which provides estuarine site acquisition for research and education.

National Marine Fisheries Service (NMFS)

NMFS's mission is to conserve, manage and develop living marine resources and to promote the continued utilization of these resources for the nation's benefit.

Department of Defense

Army Corps of Engineers (COE)

The COE's mission is to develop, control, maintain and conserve the nation's waterways and wetlands. The COE is the principal federal agency involved in the regulation of wetlands, and shares a lead role with the EPA in preventing degradation and destruction of "waters of the U.S." (most freshwater, wetlands, estuaries and coastal waters within the territorial limits). The COE provides engineering and construction services to both military and civilian projects including: levee systems, ports, flood control projects, shipping channels and shoreline erosion control projects.

The COE has authority through *Section 404 (Clean Water Act),* and *Section 10 (Rivers and Harbors Act).*

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Department of Health and Human Services

Food and Drug Administration (FDA)

FDA sets and enforces allowable levels of toxics in food, controls fish catches transported between states and monitors catches in federal waters.

Department of the Interior

Bureau of Reclamation (BOR)

The BOR constructs and maintains federal water development (reclamation) projects for irrigation water services, municipal and industrial water supply, hydroelectric power generation, water quality improvement, wind power, fish and wildlife enhancement, outdoor recreation, and river regulation and control.

The BOR operates the Central Valley Project. BOR is signatory to the Coordinated Operating Agreement between the *Central Valley Project* and *State Water Project* (1986):

> Provides that both the CVP and SWP are subject to water quality standards and export decisions taken from SWRCB Water Rights Decision 1485. Provides for CVP/SWP proportional splits of 75/25 responsibility for meeting in-basin use from stored water releases and 55/45 for capture and export of excess flow. Agreement requires a commitment of about 2.3 million acre-feet from both projects during a critical water supply period.

BOR funds and participates in the *Interagency Ecological Study Program.*

U.S. Geologic Survey (USGS)

USGS provides geologic, topographic and hydrologic information that contributes to the management of resources. USGS collects data on a routine basis to determine quantity, quality and use of surface and groundwater; conducts water resources appraisals describing the consequences of alternative plans for developing land and water resources; researches hydraulics and hydrology; and coordinates all federal water data acquisition.

U.S. Fish and Wildlife Service (USFWS)

USFWS does not have direct permit authority; it is, however, responsible for protecting and conserving fishes, wildlife (birds and most mammals) and their habitats for the benefit of the public. USFWS is the natural resource trustee for: migratory birds, certain anadromous fish, endangered species and certain federally managed water resources.

Fish and Wildlife Coordination Act (1958): USFWS reviews Corps permit applications (404 program) and federally permitted or constructed projects in or near wetlands with the goal of protecting and restoring the fish and wildlife values.

North American Waterfowl Management Plan (1986), signed by United States and Canada (endorsed by Mexico), provides a broad framework for waterfowl conservation and management in North America through year 2000. This plan seeks to restore and maintain the diversity, distribution and abundance of waterfowl that occurred from 1970 to 1979 by solving habitat problems with a focus on seven priority habitat areas. The Central Valley including the Delta is one of these areas. *The Central Valley Habitat Joint Venture* (Joint Venture) is a group of private organizations and public agencies which have agreed to pool their resources to solve habitat problems in the Central Valley.

Conservation easement and fee title acquisitions in the North Central Valley Wildlife Management Area are proposed as a major USFWS program contributing to the Joint Venture.

The Migratory Bird Conservation Act of 1929 (16 U.S.C. 715) authorizes the USFWS to acquire lands for conservation of migratory waterfowl and the *Fish and Wildlife Act of 1956* authorizes the acquisition of lands for wildlife refuges.

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The Emergency Wetland Resources Act of 1986 authorizes the Secretary of Interior to acquire wetlands, and the *North American Wetland Conservation Act of 1989* authorizes acquisition of wetlands to implement the North American Waterfowl Management Plan.

Funding for the *Migratory Bird Conservation Act* comes from the migratory Bird Conservation Fund, derived primarily from the sale of federal duck stamps. Funding for both the Fish and Wildlife Act and the Emergency Wetland Resources Act come from the Land and Water Conservation Fund, which is from revenues derived primarily from offshore oil and gas leasing. The North American Wetland Conservation Act authorizes appropriations as well as earmarked proceeds from migratory bird fines and accrued interest from Pittman-Robertson funds to implement the Management Plan.

The proposed management plan identifies delineated, unprotected natural wetlands and adjacent restoration potential south of Sacramento in the Stone Lakes and Cosumnes River corridors.

USFWS manages the *San Francisco National Wildlife Refuge Complex* and is the lead agency on the Stone Lakes Refuge proposal.

USFWS's programs includes fish and wildlife conservation: technical assistance on wildlife management to federal, state and local agencies; migratory birds: acquires areas for management and protection of migratory birds; wetlands conservation: provides funds for wetlands acquisition; conserves estuarine areas under the *Estuarine Areas Act (PL 90-454)*; conducts *National Wetland Inventory* and insures compliance with *NEPA*.

Under provision of the *Refuge Revenue Sharing Act (Public Law 95-469)* payments are made to counties to offset tax revenue lost as a result of fee title acquisition of private property for refuge establishment.

Department of Transportation

U.S. Coast Guard

The U.S. Coast Guard enforces federal fisheries laws; promotes navigation and boating safety; aids vessels in distress; and protects ports, waterways, and shoreside facilities. The Guard is the primary enforcement agency for ocean disposal activities and assists COE in monitoring the activities of disposal barges in the Estuary. The Guard has increasing control over spills of pollutants and requires and enforces contingency clean-up plans for accidental spills.

Executive Branch

Environmental Protection Agency (EPA)

EPA was established to protect, maintain, restore and enhance environmental quality and human health through the regulation of activities that have potentially harmful effects on air, water and land resources. EPA exercises authority through the *National Pollution Discharge Elimination System (NPDES), National Pretreament Program, Ocean Dumping/Dredging and Fill,* and has delegated to states the authority to certify that permitted actions are consistent with the state's water quality objectives under the *Clean Water Act.*

Under the *Clean Water Act*, the *San Francisco Estuary Project* is in the third year of a five-year program to develop a Comprehensive Conservation Management Plan. Program purposes are to protect and improve water quality and to enhance the living resources of the Estuary.

Council on Environmental Quality (CEQ)

The CEQ reviews Environmental Impact Statements, promulgates regulations including NEPA, and mediates interagency disputes for major federal actions significantly affecting environmental quality.

National Environmental Policy Act (NEPA) - 1969

NEPA provides for preparation of reports evaluating the potential environmental impact for facilities constructed by the federal government or its licensees or for facilities funded by the federal government or subject to federal approval. Proposed construction of recreation facilities that fall under federal jurisdiction are subject to NEPA. NEPA provides for the consideration of historic resources in order to "preserve important historic, cultural, and natural aspects of our national heritage, and to maintain, wherever possible, an environment that supports diversity and a variety of individual choice" (42 U.S.C.A. Sec. 4331).

Federal Emergency Management Agency (FEMA)

FEMA provides assistance to state in the event of a major disaster. Disaster insurance is available to local government that has flood control ordinance with FEMA approved standards including levees.

The State Role:

Department of Transportation (CALTRANS)

CALTRANS plans, designs and builds state highway system.

Environmental Protection Agency

Air Resources Board (ARB)

ARB's mission is to control air pollution and improve air quality throughout California. Its primary responsibility is to control motor vehicle pollution and oversee the activities of 14 local air pollution districts which regulate industrial sources of air pollution.

The ARB established air quality standards, researches pollution problems, monitors air quality, inventories major sources of air pollution and regulates agricultural burning.

Integrated Waste Management Board

The waste Board approves local waste management programs.

State Water Resources Control Board (SWRCB)

SWRCB administers California's system of water rights and controls water quality. Authority is delegated to Regional Water Quality Control Boards for implementation of *Clean Water Act* and *Porter-Cologne Act* provisions.

The SWRCB develops control strategies for non-point pollution sources and management plans. *Assessment Reports* identify categories of non-point source pollution, identify surface water bodies that would not attain water quality standards without non-point source controls, describe the development of "best management practices" (BMP) for control of non-point sources, and review existing control programs.

The SWRCB is charged with establishing water quality standards for the Central Valley Project and the State Water Project. The SWRCB reviews applications for the diversion of water from the Delta or its tributaries to determine the effect of the proposal on the quantity and quality of the water, and the resultant effect on other uses of water in the Delta. The SWRCB is also chiefly responsible for implementing section 208 of the *Clean Water Act*, the mandate to control "non-point" pollution. The State and Regional Water Quality Control boards review all proposed activities in the Delta that require federal grants, licenses or permits to determine the effect of the proposed action on water quality.

Regional Water Quality Control Boards

Regional Boards act as agents of the State Water Resources Control Board and the Environmental Protection Agency, issuing waste discharge permits.

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San Francisco - SFRWQCB jurisdiction includes the watershed of the Bay downstream of Chipps Island. The Board prohibits the disposal of material from major new work dredging projects at existing disposal sites, sets annual and monthly limits on the amounts disposed at each site, and prohibits disposal at certain times when a potential exists for conflict with other beneficial uses.

Central Valley - CVRWQCB jurisdiction includes the Delta from Chipps Island east and the Central Valley.

Resources Agency

San Francisco Bay Conservation and Development Commission (BCDC)

BCDC is authorized by the *McAteer-Petris Act* to analyze, plan and regulate San Francisco Bay and its shoreline. It implements the *San Francisco Bay Plan* and the *Suisun Marsh Protection Plan*, and regulates filling and dredging in the Bay, its sloughs and marshes, certain creeks and tributaries. BCDC jurisdiction is the Bay and within 100 feet of shoreline. The *Bay Plan* is subject to CZMA consistency review as a component of California's Coastal Plan which is administered by BCDC.

Suisun Marsh Preservation Act was enacted in 1977 to establish policies and programs in the Suisun Marsh Protection Plan. Local governments and districts prepare Local Protection Programs (LPPs) to bring their policies and ordinances into conformity with the provisions of the act.

California Coastal Commission (CCC)

1976 Coastal Protection Act provides that the Commission protect marine and coastal resources, promote coastal conservation, regulate coastal development and perform as the designated coastal zone management agency. The commission aids local planning efforts concerned with land use and water development, public access, natural resources, off-shore oil development, agriculture, and issues affecting the coastal zone; the commission has permitting authority for land use.

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Department of Boating and Waterways

This department is responsible for state activities related to ocean and coastal engineering. It spends money for recreational harbor development and grants money for boat launching facilities.

Department of Conservation (DOC)

DOC's programs include mining and geology, recycling, land resources protection, and oil and gas. It issues *Oil, Gas and Geothermal Well Permits.*

DOC's programs address soil conservation, particularly as it relates to land use. The DOC administers the Williamson Act on agricultural lands and maintains a task force to evaluate the progress of the Act. DOC's *Important Farmland Mapping* program provides information on conversion of these lands to other uses. DOC administers the *Surface Mining and Reclamation Act* which requires reclamation of mined lands to alternate uses such as range and forage.

Department of Fish and Game (DFG)

The Fish and Game Commission sets policy for DFG. DFG has legislative authority to preserve, protect and manage California's fish, game and native plants, without respect to their economic value. DFG administers provisions of the state *Endangered Species Act*. DFG is responsible for wildlife management, collecting and managing data for waterfowl and nongame wildlife, disease research, wetlands enhancement, habitat development and management on 76 designated state-owned Wildlife Areas, Ecological Reserves and other public lands.

DFG *Stream or Lake Alteration Agreements* are required for activities that result in changes in natural conditions in streams, lakes channels or crossings.

Wildlife Conservation Board (WCB)

This Board acquires land, develops recreation facilities and public access to natural sites and investigates areas to determine suitability for wildlife production, preservation and recreation.

Department of Parks and Recreation (DPR)

The DPR mission is to acquire, develop and interpret recreational resources throughout the state for the use and enjoyment of all people.

DPR prepares resource management portions of general plans for each state park, and carries out resource mitigation plans after construction of recreational facilities.

Department of Water Resources (DWR)

DWR's mission is to evaluate current and projected needs for water and development programs and assure the best use of the resource; to protect the public through water quality improvement, flood control and dam safety programs; and to assist local water agencies with funds, expertise and technical support to improve their water delivery systems.

DWR issues permits for activities involving dams or reservoirs.

DWR is responsible for the State Water Project with pumping facilities near Clifton Court Forebay. DWR, as authorized by *Delta Flood Protection Act of 1988 (SB 34)* is involved in a levee improvement program for flood protection which overlaps the North Delta Water Management Plans for widening channels. The South Delta Water Management and the Los Banos Grandes projects which include channel widening and water storage facilities are being considered.

DWR represents the state in U.S. Army Corps of Engineers and Bureau of Reclamation flood control and water development projects. Projects are being considered that include channel widening and water storage facilities.

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State Reclamation Board (RB)

Administratively part of DWR, this Board exercises responsibilities for flood management on the Sacramento and San Joaquin Rivers and their tributaries, and participates with the federal government in the completion of federal levee and channel flood control projects.

The Board pays for maintenance of reclamation and flood control districts levees through the Delta Subvention Program (SB 34). The Board issues a *Development Permit.*

Energy Commission (EC)

The EC ensures that needed energy facilities are sited in an expeditious and environmentally acceptable manner.

State Coastal Conservancy (SCC)

The Conservancy acquires, restores, provides access to, enhances and sells lands to solve land-use problems. Conservancy programs include agricultural preservation, restoration (lot consolidation and transfer of development rights), urban waterfront restoration, resource enhancement, site reservation and public access development. The Conservancy provides technical assistance to local governments and non-profit land conservation organizations.

State Lands Commission (SLC)

The SLC administers policies established by the Legislature and the State Lands Commission for the management and protection of lands which the state has received from the federal government upon its entry into the Union. Such lands include the beds of all naturally navigable waterways such as major rivers, streams and lakes; tide and submerged lands which extend from the mean high tide line seaward to the three-mile limit; swamp and overflow lands; vacant state school lands; and granted lands. The state holds its sovereign lands in trust and they can no longer be sold. The Commission manages the resources in a manner consistent with the public trust values for fisheries, navigation, public access, recreation and wildlife habitat and open space.

Commission requires a *Land Use Lease or Permit, Dredging Permit or Mineral Extraction Lease* for activities on all its lands and functions as a CEQA Lead, Responsible and/or Trustee Agency.

Health and Welfare Agency (Department of Health Services - DOHS)

DOHS finds and prevents pollution of public water supply and promotes other environmental health issues.

Governor's Office

State Office of Historic Preservation (SOHP)

National Historic Preservation Act (NHPA) 1966 established the *National Register of Historic Places*, Advisory Councils on Historic Preservation, State Historic Preservation Offices and Grants-in-Aid programs. *Section 106* requires that all federal agencies consult with the Advisory Council prior to undertaking any action that would affect a property on or eligible for the National Register. It established regulations that encourage coordination of agency cultural resource compliance.

American Indian Religious Freedom Act recognizes that Native American religious practices, sacred sites and objects have not been properly protected under other statutes. It establishes as national policy that such traditional practices and beliefs, as well as sites, including right of access, and the use of sacred objects, shall be protected and preserved.

Archaeological Resources Protection (ARP) 1979 intent is to enhance preservation and protection of archaeological resources on public and Indian lands. Its primary emphasis is on a federal permitting process in order to control the disturbance and investigation of archaeological sites on these lands.

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Office of Planning and Research (OPR)

OPR has no regulatory authority, but has substantial influence in guiding administration policy and in providing guidance to local governments. Administers the State Clearing House for CEQA documents. OPR is responsible for preparing planning reports to the governor.

The *California Environmental Act (CEQA)* (1970), patterned after NEPA, sets the state's basic charter for protection of the environment. Its policies include preventing the elimination of fish and wildlife populations. The Sacramento-San Joaquin Delta is listed as having regional and state-wide significance; wetlands and riparian lands are defined as significant. Impacts must be mitigated to a level of insignificance (or a finding of overriding consideration) and there must be a mitigation monitoring plan to ensure effective mitigation measures.

Office of Emergency Services (OES)

OES provides assistance to local governments in preparing for and responding to disasters, such as flooding.

Office of the Secretary of Resources (OSR)

Secretary directs the State Resources Agency which functions as an "umbrella" agency, setting major resource policy for the state and overseeing programs of agency departments including Water Resources, Fish and Game and Coastal Commission. The agency evaluates CEQA documents for consideration of existing state policy, programs, and plans and coordinates all state agency comments on applications for Corps permits in the Delta. These comments indicate whether the application conforms with the Waterways Use Plan and Shoreline criteria of the *Delta Master Recreation Plan.*

The Agency's basic policy document for the Delta is the *Recreation Plan* with areas designated as "Natural, Scenic, Multiple Use Area."

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Local Government

Regional Planning

Association of Bay Area Governments (ABAG)

ABAG provides technical planning assistance to member governments and develops comprehensive planning programs in the areas of transportation, housing, water quality, land use and air quality. ABAG has no land use regulatory authority.

Sacramento Area Regional Planning Council of Governments (SARPCG)

SARPCG is advisory agencies to local governments including Delta Counties and acts as area wide clearinghouse for federal grants within its region.

Metropolitan Transportation Commission

MTC is responsible for comprehensive transportation plan for the nine-county Bay Area. The plan includes mass transit, highway, bikeway, airport and seaport activities. MTC is the central review agency for all Bay area jurisdictions seeking federal and/or state transportation funds.

Local Agency Formation Commission (LAFCO)

LAFCOs coordinates and approves changes in local government boundaries by authority of the *Knox-Cortese Act;* LAFCOs have authority over all cities and special districts requesting changes in geographic or public service boundaries; establishes "spheres of influence" for cities and districts.

Delta Advisory Planning Council (DAPC)

Although DAPC, composed of representatives from each of the Delta counties, is an advisory board and does not have specific regulatory authority, it has issued reports on Delta issues,including recreation. The most comprehensive report was the *1976 Delta Action Plan.*

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Districts

Resource Conservation Districts are authorized by *Division 9 of California Public Resources Code* to assist the state in conserving soil and water resources on farm, range, urban and timber lands. The districts provide assistance to landowners and government agencies to prevent soil erosion, control runoff, stabilize soils and protect water quality. Districts receive technical assistance from the USDA Soil Conservation Service. Each district prepares a long-range plan for lands within its boundaries.

Suisun Resource Conservation District manages diked wetlands of the Suisun Marsh to maximize migratory waterfowl, and prepares water and vegetation management plans for the Marsh in cooperation with duck club owners.

Delta RCDs: Suisun, Contra Costa, Alameda, San Joaquin, Lower Cosumnes, and Yolo.

Open Space and Park Districts acquire and preserve open space lands, and manage wildlife, recreation and stock animals.

East Bay Regional Park District (EBRP) owns over 60,000 acres of land within the Estuary watershed area. EBRP district is developing recreational plans for Delta shorelines.

Municipal Utility Districts treat and dispose of sewage. East Bay MUD also serves 1.1 million people with water from Sierra watershed (Mokelumne River) transported in pipes across the Delta. EBMUD has access to American River water with in-stream protection.

Sacramento Utility District (SMUD).

Water Districts in the Delta are: North Delta, Contra Costa County Water Agency, Central Delta Water Agency, East Contra Costa Irrigation District, Byron-Bethany Irrigation District and South Delta Water Agency.

Port Authority Districts are Sacramento and Stockton. Both ports are instrumental in advancing the major deep water channel projects. Both of these districts have the ability to operate outside of local land-use regulations.

Reclamation Districts were the first special districts established by law. There are 108 reclamation districts which are responsible for levee maintenance. These special districts are formed and supported by the landowners of the area protected by the levees. Except for maintenance of Corps project and direct agreement levees, they are subject to limited state and federal flood maintenance and environmental requirements and virtually no local planning regulations. When state subsidy funds are used, or if construction activities on private levees require a Corps permit, environmental conditions can be imposed.

Local Jurisdictional Planning Authority

Local governments (Counties and Cities) are required (*Government Code, Section 65000 et seq.*) to have a general plan with mandated elements including open space/conservation, safety, land use, circulation. There are no regional requirements for plan consistency between the six counties and 10 cities.

The general plan land-use element delineates the general distribution, location, and extent of local development patterns and land use.

The conservation element addresses the "conservation, development, and utilization of natural resources, including water and its hydraulic force, forests, soils, rivers, and other waters, harbors, fisheries, wildlife, minerals, and other natural resources."

The open-space element defines provisions for open space for the preservation of natural resources, the managed production of resources, outdoor recreation, and public health and safety.

C-038253

Zoning Ordinances.

State law requires that the adopted zoning ordinance and map must be consistent with the general plan. There are no comprehensive local governmental zoning tools in the Delta area that can be applied effectively against the alteration of significant resource areas.

Subdivision Ordinance Controls.

The *State Subdivision Map Act* requires that a subdivision map be reviewed and approved by the appropriate local government for all projects creating five or more parcels of land or condominiums. Maps may be denied if a finding is made that the subdivision and proposed improvements are likely to cause substantial environmental damage. In general, local governments must incorporate adequate criteria or habitat descriptions into their subdivision ordinances to implement the state law. The *Subdivision Map Act* (Section 66478.1) requires public access to rivers to be provided by the subdivision.

Private and Local Programs

Duck Clubs own a vast majority of Central Valley and Suisun wetlands and manage these areas for waterfowl. Ducks Unlimited is participating in the Joint Venture program.

The California Waterfowl Association, The Nature Conservancy, Trust for Public Land, Solano County Farmlands and Open Space Foundation, and Audubon Society have acquired sensitive lands for preservation and restoration.

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Table 16.

LIST OF KEY LEGISLATION

Federal

Swamp and Overflowed Lands Act of 1850 (USCA Title 43, §§981 et seq.)
Rivers and Harbors Act of 1899 (30 Stat.1112) as amended (USCA Title 33, §§1371 et seq.)
Migratory Bird Treat Act of 1918 (PL86-732)(USCA Title 16, §§703 et seq.)
Migratory Bird Conservation Act of 1929 (PL87-812)(USCA Title 16, §§715 et seq.)
Land and Water Conservation Fund Act of 1965 (USCA Title 16, §§460 et seq.)
National Environmental Policy Act of 1969 (USCA Title 42, §§4321 et seq.)
Water Bank Fund of 1970 (USCA Title 16, §§1301 et seq.)
Federal Water Pollution Control Act 1972 (Clean Water Act) as amended (USCA Title 33,§§1251 et seq.)
Coastal Zone Management Act of 1972 and 1990 (USCA Title 16, §§1451 et seq.)
Endangered Species Act of 1973 (USCA Title 16, §§1531 et seq.)
Salmon and Steelhead Conservation and Enhancement Act of 1980 (USCA Title 16, §§3301 et seq.)
Food and Security Act of 1985 (USCA Title 7, §§1281 nt)
North American Waterfowl Management Plan of 1986
Emergency Wetlands Resources Act of 1986 (USCA Title 16, §§3901 et seq.)
North American Wetlands Conservation Act of 1989 (USCA Title 16, §§4410 et seq.)
Food Security Act of 1990 (Farm Bill) (Public Law 101-624)
Federal Water Pollution Control Act amendments of 1991 (anticipated)

State Legislation

Public Trust Doctrine (Common Law, also see People v. California Fish Co. 166 Cal.3d. 251; Marks v. Whitney, 6 Cal.3d. 251; Nat'l Audubon Society v. Superior Court, 33 Cal.3d. 419)
Swamp and Overflowed Lands Act of 1858 (Ch. 235, Stats. 1858) amended (Pub. Res. Code §§ 7501 et seq.)
Reclamation and Segregation Act of 1861 (Ch. 352, Stats. 1861)
State Water Commission Act of 1913 (Water Code § 1000 et seq.)
Davis-Dolwig Act of 1961 (Water Code §§ 11900-11925)
McAteer Petris Act of 1965 (Gov. Code §§ 66600 et seq.)
Land Conservation (Williamson) Act of 1965 and subsequent acts (Gov. Code §§ 51200-51295)
Water Quality Control (Porter-Cologne) Act of 1969 (Water Code §§ 13000 et seq.)
Environmental Quality Act of 1970 (Pub. Res. Code §§ 21000 et seq.)
California Endangered Species Act of 1973 (Fish & Game Code §§ 2050 et seq.)
Levee Maintenance Fund Act of 1973 (Water Code §§ 12980 et seq.)
Native Species Conservation and Enhancement Act of 1974 (Fish & Game Code §§ 1750 et seq.)
Subdivision Map Act of 1975 (Gov. Code §§ 66410 et seq.)
Coastal Act of 1976 (Pub. Res. Code §§ 3000 et seq.)
Wetlands Preservation Act of 1976 (Pub. Res. Code §§ 5810-5818)
Sacramento-San Joaquin Delta Levees Act of 1976 (Water Code §§ 12225 et seq.)
Suisun Marsh Preservation Act of 1977 (Pub. Res. Code §§ 29000-29612)
Kapiloff Land Bank Act of 1982 (Pub. Res. Code §§ 8600-8633)
Fish and Wildlife Habitat Enhancement Act of 1984 (Fish & Game Code §§ 2600-2651)
Delta Flood Protection Act of 1988 (Water Code §§ 12300 et seq.)

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