SACRAMENTO / SAN JOAQUIN

DELTA WILDLIFE HABITAT PROTECTION & RESTORATION PLAN

CALIFORNIA DEPARTMENT OF FISH & GAME / U.S. FISH & WILDLIFE SERVICE

DECEMBER, 1980

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PROLOGUE

To most observers traveling across the Sacramento-San Joaquin Delta for the first time, the region appears to be a vast plain, interrupted by occasional clusters of farm buildings and intersected by levees and sloughs and the erector set bridges which cross the Delta's waterways. The waterways themselves seem always in danger of spilling out of their containing levees to "reclaim" the flat land below which was once their natural floodplain. And in fact they do so sporadically.

As the land appears flat, so does the sky above it – a metallic grey in the winter – stretching west to Mt. Diablo and framed along its lower edge by single or clustered trees and by bands of tule along the minor sloughs. The flat quality in summer is the shimmer of midday heat reflected off the land and water surface, which prompts the casual visitor to hurry to another destination or find shelter.

But there are other qualities which add a third dimension to the apparent flatness of the Delta, qualities which are known to long-time residents and to visitors who are fortunate enough to have discovered the "inner" Delta. This is the Delta of the quiet overhung backwater slough, of the luminous breaking of a morning tule fog by the winter sun burning weakly to dispel the mist clinging to the land. It is also the Delta of wind and of waves battering against fragile levees, and of great flocks of geese and ducks seeking food and shelter in shallow flooded grain fields behind the levees.

To these inhabitants and visitors, the Delta has its own retreats as well as challenges. It is a region of land and water which seems strangely isolated from its urban fringe and from the industrious Bay which it so profoundly influences.

- *For more than a hundred years, farmers have seen the Delta as a reclaimed lowland containing some of California's most fertile peat and mineral agricultural soils.*
- *For a fisherman, its 700 miles of meandering waterways provide an abundance of fish and other aquatic life.*
- *For a large part of the Central Valley, San Francisco Bay Area, and Southern California, the Delta represents one of the world's more elaborate "natural" water conveyance systems.*
- *For industrial and commercial navigation interests, the Delta is a deep water transportation corridor with direct access between the Pacific trade routes and the Sacramento and Stockton inland ports.*
- *For thousands of recreationists, it is a labyrinth of quiet sloughs and backwaters providing hundreds of square miles of water surface for speed boating, water skiing, and shoreline recreation.*
- *For 225 species of resident and migratory birds, including a large wintering waterfowl population, and for many other forms of wildlife the Delta provides a habitat critical to their survival.*

***The Sacramento-San Joaquin Delta Wildlife Habitat Protection and Restoration Plan** documents the wildlife resources which have given to the Delta many of its evident and subtle qualities, which in fact have contributed to its historic agricultural and more recent recreational economic bases, and which are now threatened by the human users and beneficiaries of these resources.*

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SUMMARY AND RECOMMENDATIONS

SUMMARY

The Sacramento-San Joaquin Delta occupies the strategic position of convergence of waters draining more than half of California. The 1,100 square mile inland delta shaped by these waters is a complex of sloughs and reclaimed alluvial and peat islands which bear limited resemblance to the tidelands, swamps, and overflow lands that made much of the area inaccessible to humans 130 years ago. It is difficult now to imagine that panorama of tangled riparian vegetation and tule marshes which provided rich habitat for the fish and wildlife of Central California.

Levees created the framework for lands and waterways that could be used in other ways. With the reclamation of much of the Delta came an important new identity – that of an agricultural center, a recreational playground, and a growing urban complex.

No one wishes to turn back the Delta clock. It is significant, however, that we have come to expect the Delta to have a certain appearance, and that is disappearing, along with the habitats and the fish and wildlife themselves that have been an integral part of that appearance. The loss has occurred in increments; we can now perceive the cumulative effect of all the small losses and can predict that future losses will occur unless we anticipate and act to prevent them.

The protection, enhancement, and restoration of Delta fish and wildlife and their habitats are among the primary goals of the U.S. Fish and Wildlife Service and California Department of Fish and Game. Their means to achieve these goals have been reinforced in recent years by a series of State and federal governmental directives for protection of wetlands, endangered species, migratory birds, and significant resource areas in general – and for protection in particular of the San Francisco Bay-Suisun Marsh-Delta ecosystem.

The Delta has not had the same coordinated level of protection as either the Bay or Suisun Marsh. The independent spirit which prompted people to settle and farm the Delta against difficult odds also guides them in their activities and many political decisions. In addition, the resources of the Delta, particularly the waters which flow through it, have attracted the interests of many public agencies and private commercial enterprises. As a result, there has been limited overall policy and inconsistent implementation of what common policies do exist.

The year-long study which culminated in this report and plan was undertaken by U.S. Fish and Wildlife Service and the California Department of Fish and Game, the agencies charged with protecting fish and wildlife resources. The principal objective of the study was to seek more effective ways to protect and enhance the wildlife resources of the Delta and to investigate and suggest various means of restoring some of those resources which have disappeared in recent decades.

The plan has another important objective: to present the policies and position of the Department of Fish and Game and the Fish and Wildlife Service with respect to protecting wildlife resources of the Delta.

The means to achieving these objectives take two forms in this plan – documentation of the natural resources of the Delta, the human developments which affect them, and review of the technical aspects of enhancing and restoring them; and analysis of the institutions and governmental bodies which have a specific interest or regulatory role in the Delta and suggested options for better coordinating these interests and providing more effective protection of habitats.

The Plan is presented in two parts. Part I presents an overview of the resources, their values, the problems which interfere with optimal wildlife habitat conditions, some of the compelling social and economic bases for conflict, and suggested options or solutions. The first part also projects future conditions, depicting habitat

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distribution under two possible scenarios. Part II describes the habitat resources in detail – the habitat types, the significant natural resource areas and habitat complexes, the fish and wildlife which inhabit the Delta, and those species which are rare or endangered by human activities.

The uses and activities which place wildlife in the Delta in greatest jeopardy are current levee maintenance practices, uncontrolled recreational use, and conversion of lands to urban developments. A variety of lesser activities also contribute incrementally to degradation or loss of habitats. Pumping and conveyance of water along with export have had the greatest impact on fish resources in the Delta. This relationship is the subject of many other studies and is not central to the purposes of this document.

This study explores many techniques and courses of action to prevent further damage to habitats from occurring, discusses ways to maintain the valuable habitats that have become dependent on agricultural practices, and suggests methods to restore habitats which once were prevalent. Among these options, the Fish and Wildlife Service and the Department of Fish and Game have selected eight proposals to recommend as both feasible and effective courses of action.

RECOMMENDATIONS

The California Department of Fish and Game and the United States Fish and Wildlife Service recommend that:

1. **Legislation be enacted to require local govenments of the Delta to develop, adopt, and implement "Local Delta Programs."**

   The Suisun Marsh Act of 1976, which established a "Local Protection Program" for the marsh, stands as a model of the type of planning and ordinance coverage that is required as a minimum to achieve a coherent and consistent approach to regional planning in a sensitive resource area. This model can be adapted for use in the Delta. At the same time, this recommendation enables local governments to assume the leadership in Delta resource management without the intrusion of a new State agency. The Sacramento and Stockton Port Districts should be included in the process of plan development. Any legislative proposal would be developed in consultation with the Delta Advisory Planning Council (DAPC).

2. **An "Office of Delta Coordination" be established within the Resources Agency.**

   The coast, San Francisco Bay, and Lake Tahoe have State agencies designed to provide an overview function. The Delta is not even monitored by a full-time staff person. The proposed office would not constitute a new level of government. Rather, it is an expanded function of an existing agency whose member departments share many involvements in the Delta already. The office would review all plans, projects, and studies proposed for the Delta by other State agencies. It would also monitor the implementation of the proposed "Local Delta Programs" (see Recommendation 1) and the issuance of Corps

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Section 10/404 permits. A coordinating function was called for in the 1976 *Delta Master Recreation Plan* (which recommended a permit coordinator) and the *Delta Action Plan* (which recommended a "Delta Permit Forum").

3. **Local governments of the Delta adopt the significant resource areas identified in the Plan as part of the open space/conservation elements of their general plans and protect such areas with appropriate zoning.**

   The inclusion of such areas in the local planning and zoning process would provide a local inventory, data base, and means of protecting such areas. Local initiative thus would preclude the need for State or federal intervention when planned or proposed land uses threatened significant resource areas. Many of these significant areas are mapped at a large scale in the Corps of Engineers' *Delta Environmental Atlas* (See Chapter 1). The Atlas should serve as an essential companion document for all resource planners using this Plan.

4. **The existing classification of State lands in the Sacramento-San Joaquin Delta be reevaluated for possible upward reclassification to better protect areas possessing significant environmental values as identified in this report, pursuant to the provisions of the California Administrative Code, Title 2, Division 3, Section 2957 (a) and (b).**

   The information contained in this report on significant Delta fish and wildlife habitats and resource areas should provide the basis for a more exacting identification of parcels to be classed for restricted use, limited use, or multiple use. The evaluation and reclassification process should include DAPC.

5. **The State Lands Commission seek funds and legislative directive to substantiate State ownership of lands in the Delta.**

   The Delta has not received the degree of attention given by the State Lands Commission to the coast and San Francisco Bay. As a result, State park projects have languished and private-public land ownership conflicts have become highly controversial. A clearly defined program for systematic investigation of Delta title issues and site-specific problems should be developed by the State Lands Commission, preferably with legislative policy guidance and funding.

6. **The Department of Water Resources and Corps of Engineers revise levee design criteria and maintenance manuals in accordance with guidelines for levee vegetation management contained in this report.**

   Two principal factors which govern the construction and maintenance of Delta levees are their function as flood control structures and the costs of maintaining them. It has been demonstrated in numerous pilot projects and studies, however, that certain amounts and types of vegetation and habitat are compatible with engineering standards, where levees have sufficient structural integrity. Until guidelines reflect more sensitive environmental standards, Corps project levees (15% of the Delta levees) and direct agreement levees (10%) will continue to be generally barren in spite of their physical ability to support vegetation.

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7. **The Army Corps of Engineers seek to obtain "administrative law" procedures to expeditiously prosecute violations of its permit authority.**

   Permit violators now must be prosecuted through the office of the U.S. Attorney and the courts. This is a cumbersome procedure that should be avoided, if possible, especially on "less significant" infractions. An administrative law process would make it feasible to prosecute lesser violations as is now done by the U.S. Coast Guard. Such procedures would result in better compliance with permit conditions. The procedure would also encourage the Corps to place appropriate conditions on permits with the anticipation of easier and more efficient enforcement.

8. **Determine feasibility of publically acquiring a Delta island for marsh and/or riparian restoration purposes.**

   A problem exists in providing suitable spoil disposal sites for the channel dredging that occurs in the Delta. It is also recognized that marshland habitat, once dominant throughout the Delta, has been vastly diminished. Agricultural operations in some locations have become marginally economic for a variety of reasons. And, finally, Delta Islands are becoming increasingly subject to flooding by virtue of subsidence and levee failure. The acquisition from a willing seller and development of all or portions of an island for a spoil disposal site and ultimately a marsh or riparian forest would address all four of these issues. Upon rehabilitation of the levees, spoils could be deposited until the proper elevations are reached to allow marsh development.

IMPLEMENTATION

The Delta Wildlife Plan is a statement of policy of the Department of Fish and Game and Fish and Wildlife Service for carrying out their responsibilities in protecting Delta wildlife resources. It will guide both agencies in responding to other State, federal, and local agencies' proposals for land use changes and other projects in the Delta. And it will serve as a guide for seeking changes in present laws, policies, plans, and procedures for the improvement of Delta wildlife habitat conditions.

While this document is presented as a "Plan," it is not directly implementable by the Department or the Service. Neither agency has land use planning authority in the sense of enforceable county or city plans, nor authority to issue land use permits. However, both the Service and the Department are committed to working toward implementation of these recommendations – at federal and State levels as appropriate, and with local governments, public interest groups, and individuals who share the concerns expressed in this report.

Not all of these recommendations can be implemented easily, especially in the absence of direct DFG and FWS regulatory authority. However, as an expression of need and response, this Plan and its recommendations will provide guidance to all who value the Delta's natural resources and who choose to study the report carefully, use it in planning and policy making, and apply its principles in the day-to-day decisions which help to shape the future Delta. The recommendations will only be as effective as the support of the public interests and individuals whose voices can be heard.

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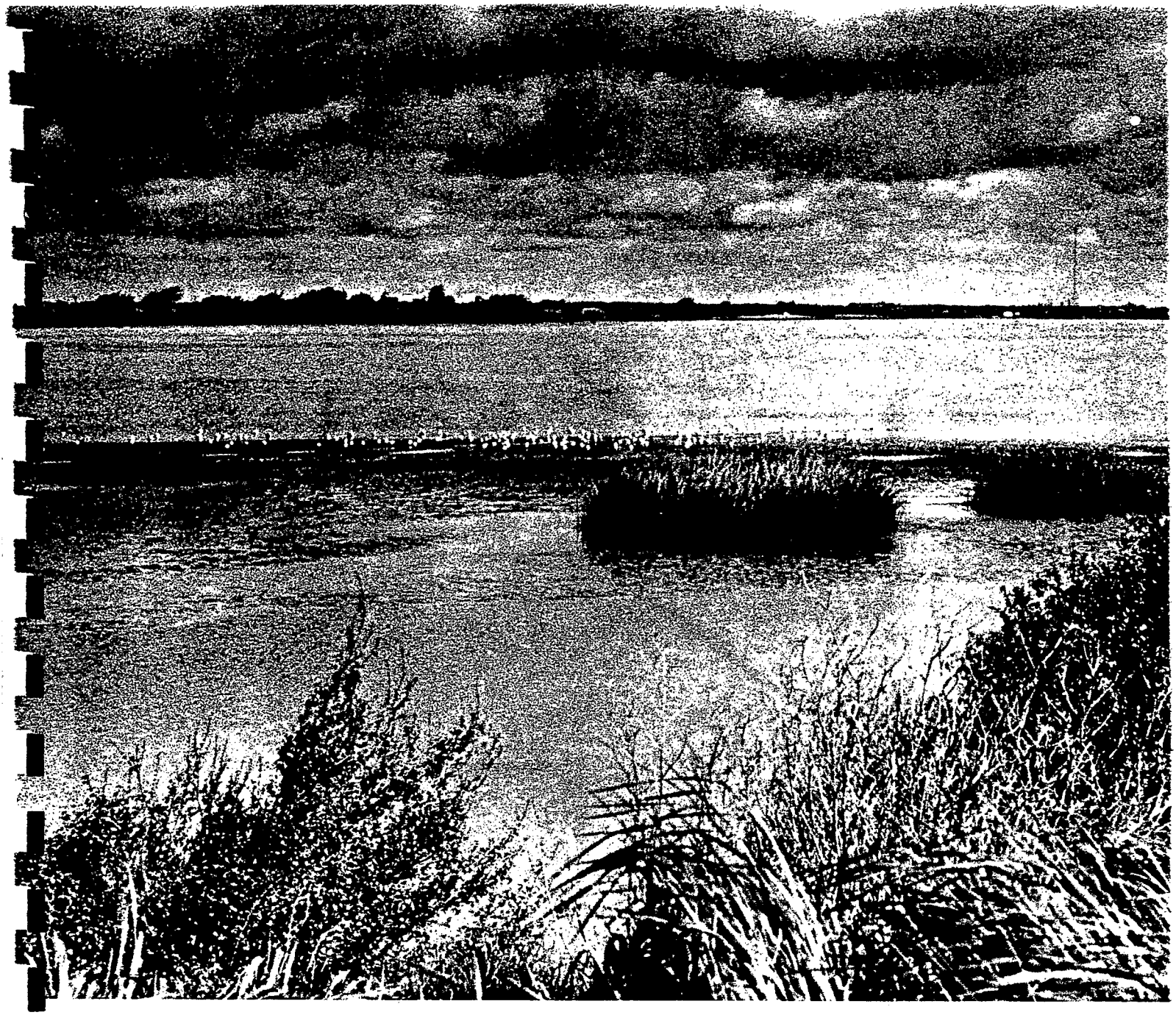
PART I: STATUS REPORT AND PLAN



Introduction

1

The Sacramento-San Joaquin Delta Habitat Protection and Restoration Plan addresses that region of central California where the major California rivers – the Sacramento and San Joaquin – along with the Mokelumne and Cosumnes and other tributaries converge, forming an inland, 1,150 ± square mile delta-like network of sloughs and islands roughly 50 miles northeast of San Francisco (Figure 1). The Delta, as it is commonly called, is separated geographically from the San Francisco Bay by the hills of the Coast Range on the west; on the east it is bounded by the outwash plains of the Sierra Nevada foothills. To the north and south there are no topographic features to define its limits, although the

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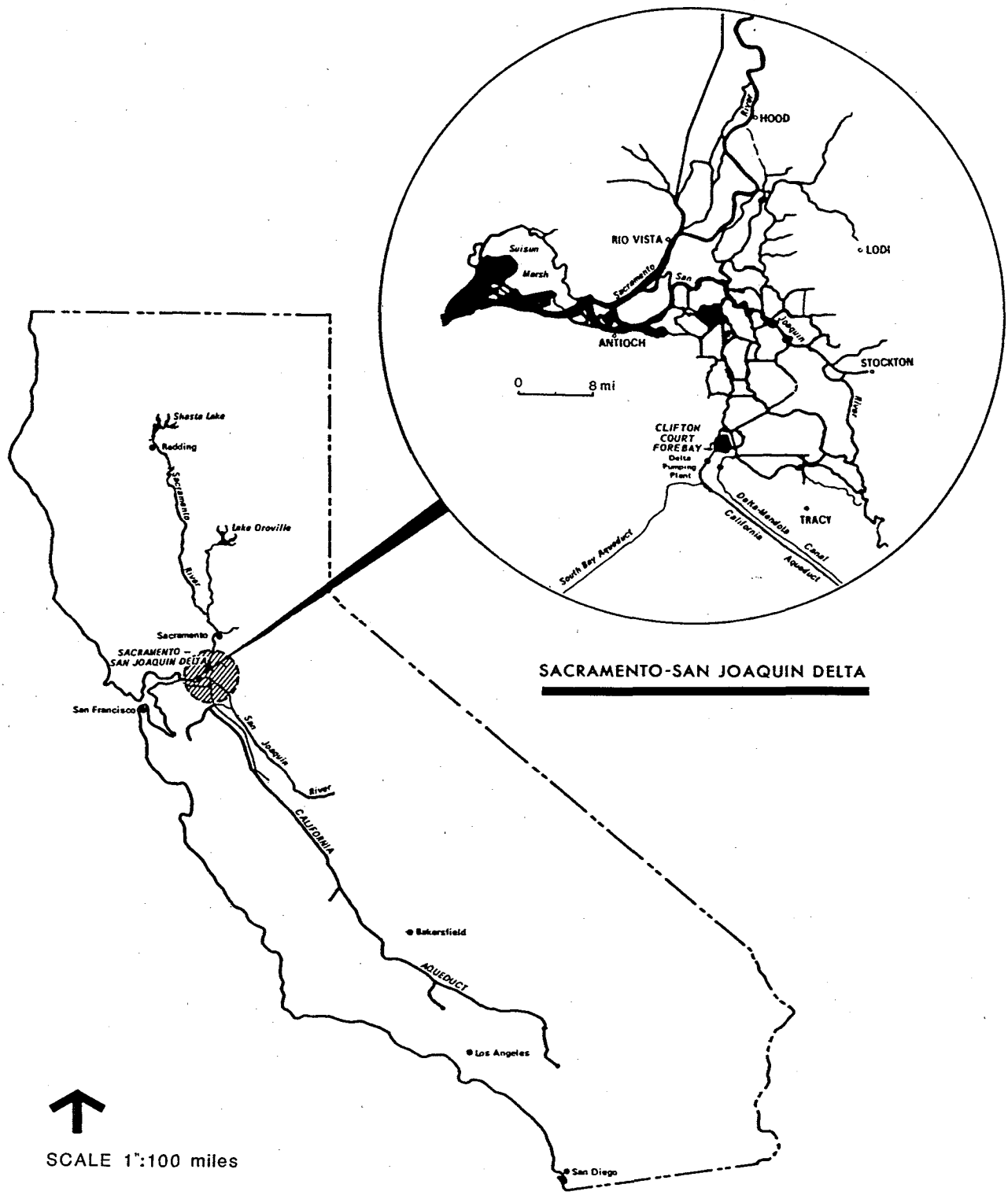

FIGURE 1
Regional Location

cities of Sacramento and Tracy coincide with the approximate northern and southern extremities of the marshes and overflow lands which characterized most of the region before its reclamation.

The physical extent of the existing Delta has been defined by a number of somewhat arbitrary boundaries. The most common definition is the statutory or "Legal Delta" (Water Code Sec. 12220).

Functionally, the Delta is a part of the larger San Francisco Bay-Delta ecosystem, linked by the fresh water which flows out of the Delta into the Bay and by the tidal influence which extends from the Bay up to most reaches of the Delta waterways. A long salinity gradient through the Carquinez Strait and Suisun Bay defines both the linkage and the transition between the Bay and the Delta. Any study of one, to be complete, must include, or at least acknowledge, the other.

The study area for the Habitat Plan generally corresponds to the "Legal Delta." The legal boundary was extended to encompass two supplementary areas where future urban and industrial expansion is likely to encroach on habitat resources. These include: a portion of the Montezuma Hills in Solano County along the west bank of the Sacramento River between Collinsville and Rio Vista; and lands lying to the south of Sacramento and east of the Western Pacific railroad to the vicinity of Freeport. While the Legal Delta encompasses 1,153 square miles, or 738,000 acres, the slightly larger study area Delta totals 1,183 square miles, or 747,120 acres (Figure 2).

This Wildlife Habitat Plan, covering the Sacramento-San Joaquin Delta, is the second of two parts in a comprehensive habitat protection and restoration plan which now covers the San Francisco Bay and Suisun Marsh and adjacent waters, and the Sacramento-San Joaquin Delta. The completion of this Plan will contribute to a better understandng of the effects of human activities in the Delta on wildlife resources both there and in the ecosystem as a whole.

The present Plan represents the culmination of a year-long study of wildlife habitats in the Delta. The study was undertaken by the United States Fish and Wildlife Service (FWS) and the California Department of Fish and Game (DFG), whose responsibility it is to protect and maintain these resources. These agencies act in accordance with the policies and provisions of a variety of federal and State laws, including the *Fish and Wildlife Coordination Act,* the *Migratory Bird Treaty Act,* the *National Environmental Policy Act* (NEPA), the *Clean Water Act,* the *California Environmental Quality Act* (CEQA), and other policies, regulations, and guidelines contained in federal and State codes (See Chapter 3).

NEED FOR THE PLAN: THE ISSUES

The Delta reveals perennial conflicts between the needs of humans and the needs of wildlife. Situated in the middle of the Central Valley, the Delta occupies a key position on the Pacific Flyway, which is the major migratory route used annually by west coast waterfowl and other birds.

Originally the Delta was one of the most significant waterfowl areas in the state and probably in the entire western U.S. Reclamation of this area created fertile farmland, but while doing so, it also destroyed the extensive marshland habitat that was of great value to these birds. Flooded agricultural fields duplicate to some extent the functional values of the marshes and seasonally flooded backswamps of the pre-reclamation Delta. Thus, the habitat that currently exists continues to be of importance. The continued existence of the extensive agricultural habitats depends in part on the continuation of land use and management practices which are governed by economic and other constraints and generally do not regard wildlife habitat as a primary or in some cases even a compatible objective.

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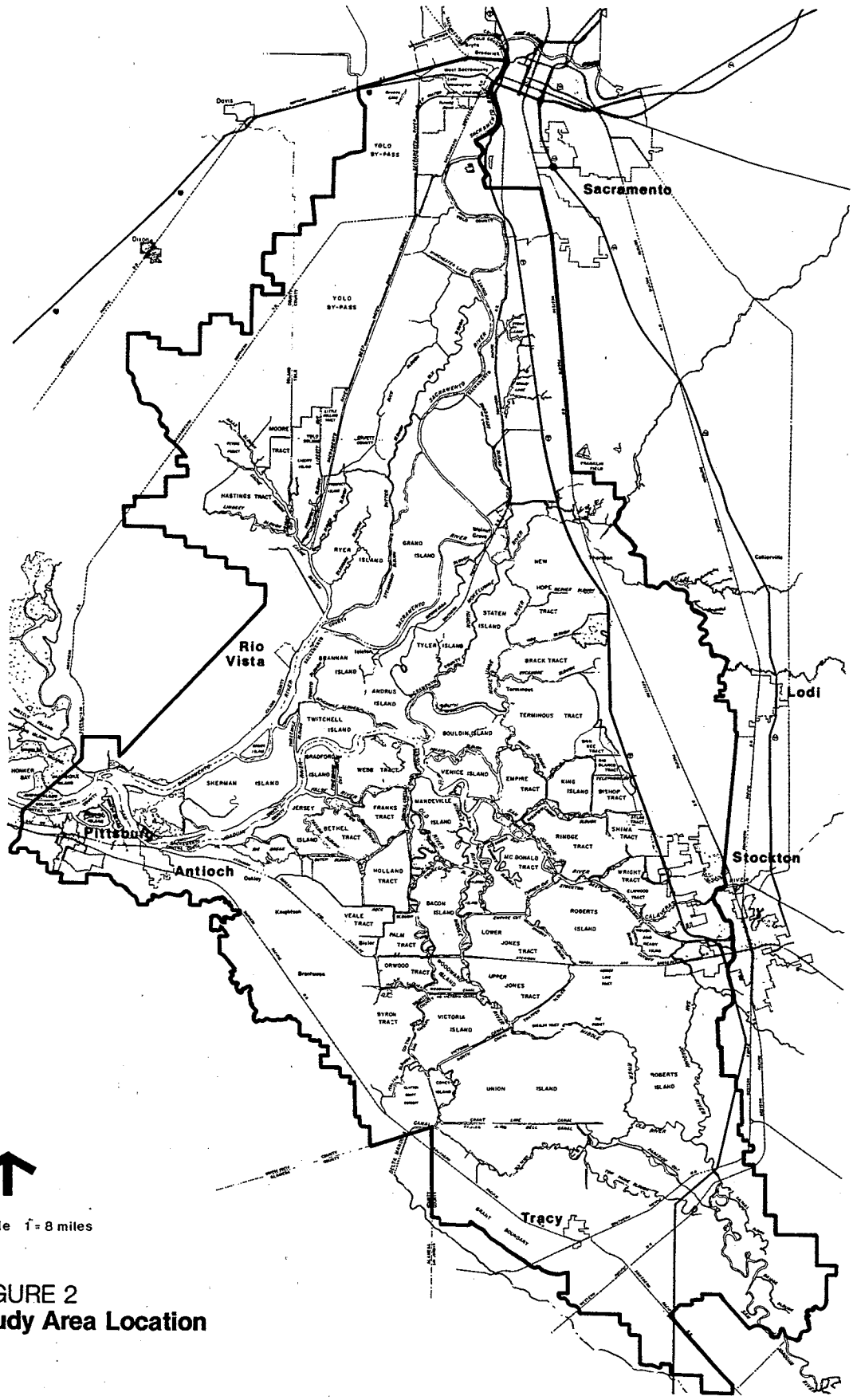


FIGURE 2
Study Area Location

Agricultural habitats are dependent also on the levee system which reclamation created. Today, maintenance practices to protect the levees continue to affect much of the Delta's riparian habitat and related wildlife populations. The most dramatic habitat changes in the Delta in recent years have resulted from deliberate removal of this vegetation, a practice which continues in spite of protests for two decades.

Other human needs and activities conflict with the wildlife habitats which indirectly serve as human amenities. Expanding settlements have directly displaced or compromised the natural conditions of riparian forests on historic floodplains of the peripheral Delta, or they have encroached onto agricultural lands, thus displacing areas of wildlife habitat. Popular recreation facilities and activities have either destroyed, damaged, or disturbed marshes and riparian vegetation, or have necessitated structural reinforcement of levees at the expense of vegetation.

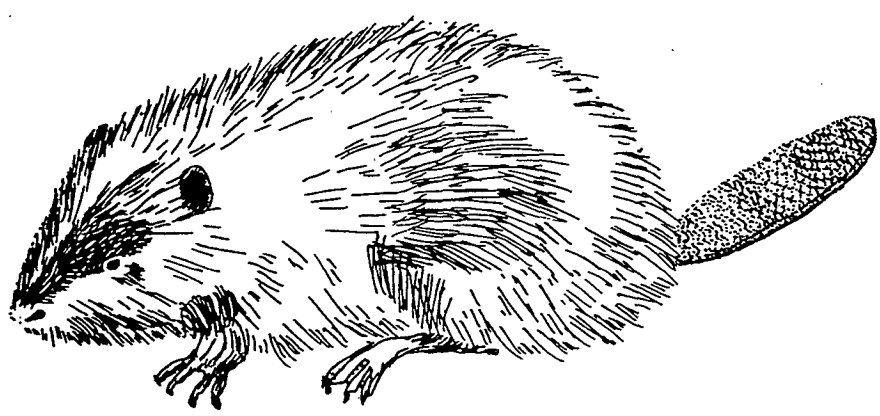
Freshwater and brackish marshes are tempting sites for marinas and other recreational development. Few pristine tidal marshes now remain except for those on channel islands, and these may be the only freshwater tidal marshes in California. Channel islands themselves are numerous but enjoy little protection from use as recreation sites and as dredging borrow-areas for levee repair. Dredging required to create the Stockton Deep Water Ship Channel eliminated all or portions of many channel tule islands and their habitat.

The Delta is also the keystone of the Sacramento-San Joaquin River system. The habitat that supports anadromous and resident fishes has been severely degraded by reverse flows and by increased water velocities from water pumping and transfer.

The many previous studies and planning efforts which form the working base for this Plan reveal these characteristic and related issues, evident for more than two decades as three recurring themes with variations. These issues, which are more fully analyzed in later sections of this Plan, now present a new urgency as major plans and proposals confront the Delta:

- the effects on fish and wildlife resources of present and proposed land and water uses, such as urban encroachment, recreational expansion, and intensified navigation;
- the need for protection of habitats or habitat complexes of special value which are either vastly reduced in area and occurrence, or are particularly sensitive to human incursions; and
- basic conflicts in the primary objectives of the various agencies which exercise authority in the Delta and which must respond to different interests and accomplish different functions.

The emphasis of this report – and of the Plan – is on water dependent and water related wildlife habitats and the human developments and activities which affect them. Aquatic and fish habitats do not receive emphasis, nor does the Plan consider the effects of water diversion, conveyance, or export systems on aquatic habitat. These developments, along with fish and fisheries, are the object of many past and ongoing studies. They constitute a specialized resource management problem.



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GOALS AND OBJECTIVES

The overall goals of the Delta Habitat Plan are directed to the continued existence of habitat resources in the Delta:

- **PROTECT AND IMPROVE IMPORTANT WILDLIFE HABITATS, ESPECIALLY WETLAND AND RIPARIAN TYPES.**
- **IMPROVE THE VARIETY OF HABITATS AND, WHERE THERE ARE DEFICIENCIES, INCREASE BOTH HABITATS AND WILDLIFE DIVERSITY AND NUMBERS.**
- **MAINTAIN HABITATS OF ALL ENDANGERED SPECIES OF PLANTS AND ANIMALS, AND GIVE SPECIAL ATTENTION TO THOSE HABITATS OF RARE AND THREATENED SPECIES.**
- **INFORM THE PUBLIC OF THE MAGNITUDE OF THE PROBLEMS THAT THREATEN IMPORTANT WILDLIFE RESOURCES IN THE DELTA, AND PROPOSE MECHANISMS FOR BETTER COOPERATION AMONG LOCAL GOVERNMENTS AND BETWEEN THEM AND STATE AND FEDERAL AGENCIES IN MAINTAINING DELTA HABITATS.**

The Delta habitat planning study was designed to fulfill several objectives necessary to achieve these goals:

1. **To present a statement of policy, programs, and intent of the California Department of Fish and Game and the U.S. Fish and Wildlife Service as they apply to the Sacramento-San Joaquin Delta.**

   Criticism has been levied against DFG and FWS for their failure to formulate and consistently act on the basis of a predictable body of policies concerning wildlife resources of the Delta. This Plan provides that opportunity. The two agencies intend to work toward implementing their recommendations and furthering their interest in protecting and restoring wildlife habitats in the Delta.

2. **To bring together into one document existing data, other information, and recommendations pertaining to wildlife habitats in the Delta.**

   Over the past few decades, numerous agencies have been involved in the management of land and water resources in the Delta. This has precipitated many specialized investigations of Delta habitats, such as in the *Ecological Studies of the Sacramento-San Joaquin Delta* (Skinner, 1972), environmental impact studies in connection with the Peripheral Canal, the Baldwin-Stockton and Sacramento Deep Water Ship Channels, the Sacramento-San Joaquin Basin Water Quality Control Plan, multiagency monitoring of freshwater outflow in the Bay-Delta system, the Corps of Engineers' *Delta Levee Investigation* and *Environmental Atlas*, and many others which are discussed and referenced in this report. There was an obvious need for a comprehensive overview and description of Delta wildlife resources, their relationship to the forces of change in the Delta, and their long-term protection and restoration.

3. **To provide a better understanding of wildlife use of Delta terrestrial and wetland habitats, and the relationship of habitats to adjacent land and water uses.**

   Prior to 1978, only fishes and their aquatic habitats had been thoroughly documented. At that time the Corps of Engineers undertook an inventory and mapping of habitat types, using vegetation and floristics as a basis for classification. This work resulted in the *Delta Environmental Atlas* (COE, 1979a). Little work of a comprehensive nature has ever been done to document bird and mammal use of Delta habitats.

   The lack of field data in terrestrial and wetland habitats has hampered the understanding of effects of developed uses on wildlife in Delta habitats, even though it has been apparent that as certain habitats have diminished in size, so have their wildlife inhabitants diminished in numbers. The Delta Habitat Plan and study provided the opportunity to fill gaps in the record of wildlife use (see Chapter 6).

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4. **To provide an analysis of the functions and effectiveness of regulatory and other governmental agencies in protecting habitat in the Delta: their purview, ecological objectives, and regulatory powers; gaps in implementation and conflicts between regulatory objectives; means of cost sharing, and the legislative means and planning tools needed for more effective protection of natural resources in the Delta.**

   Five counties and seven incorporated cities, and numerous State and federal agencies exercise regulatory and other types of authority in the Delta, but there is a conspicuous absence of effective regional coordination. This lack of regional cohesion is reinforced by a tradition of political independence and local distrust of State and federal interference.

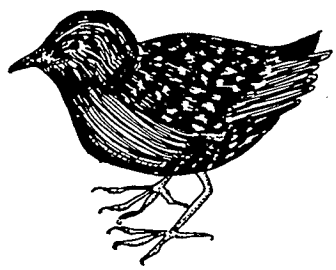
   Nevertheless, there are common and useful threads of environmental and natural resource protection, of varying strengths, which have the potential for connecting the policies of local plans with the legislated authorities and policies of FWS, DFG, COE, Department of Water Resources (DWR), and other public resource agencies.

   This Plan will assist in obtaining consensus among local and other entities as to the value of the natural resources within their jurisdictions and the most effective means of guaranteeing their survival.

5. **To provide habitat protection concepts, to outline problems and means for enhancement and restoration of wetlands, vegetation of levees and other areas capable of habitat improvement, and to recommend management guidelines for environmental review of ongoing and future development.**

   If the Delta is to regain some of the wildlife habitat and aesthetic qualities which have been lost, most dramatically over the past two decades, it will be necessary to implement restorative programs and at the same time modify present resource management practices. Studies going back to the 1960's suggest that vegetating levees is feasible and that design features can be incorporated into levee reconstruction which are conducive to natural reestablishment of riparian vegetation. Habitats can be created in dredge spoil deposits, and marshes can be created through controlled flooding of subsided lands.

   Each of these programs carries with it major technical or environmental problems. The Plan reviews the problems and findings of past and current studies and pilot programs and suggests specific solutions or conceptual approaches. It also provides a basis for future design of comprehensive management plans, for example for nongame birds using marsh or riparian habitats, or for waterfowl using Delta tule marshes and agricultural habitats (see Chapter 6).



6. **To compare alternative scenarios for the next two decades as a predictive tool for evaluating cumulative impacts of development on habitats and significant natural resources.**

   Incremental effects of piecemeal development or change are generally not perceived until they accumulate and become obvious. In the 1940's and 1950's, such was the case with Delta levees, whose gradual stripping became dramatically apparent and the focus of attention in the early 1960's. The scenarios presented in this plan provide a view of alternative fates of Delta habitats and resources (See Chapter 5).

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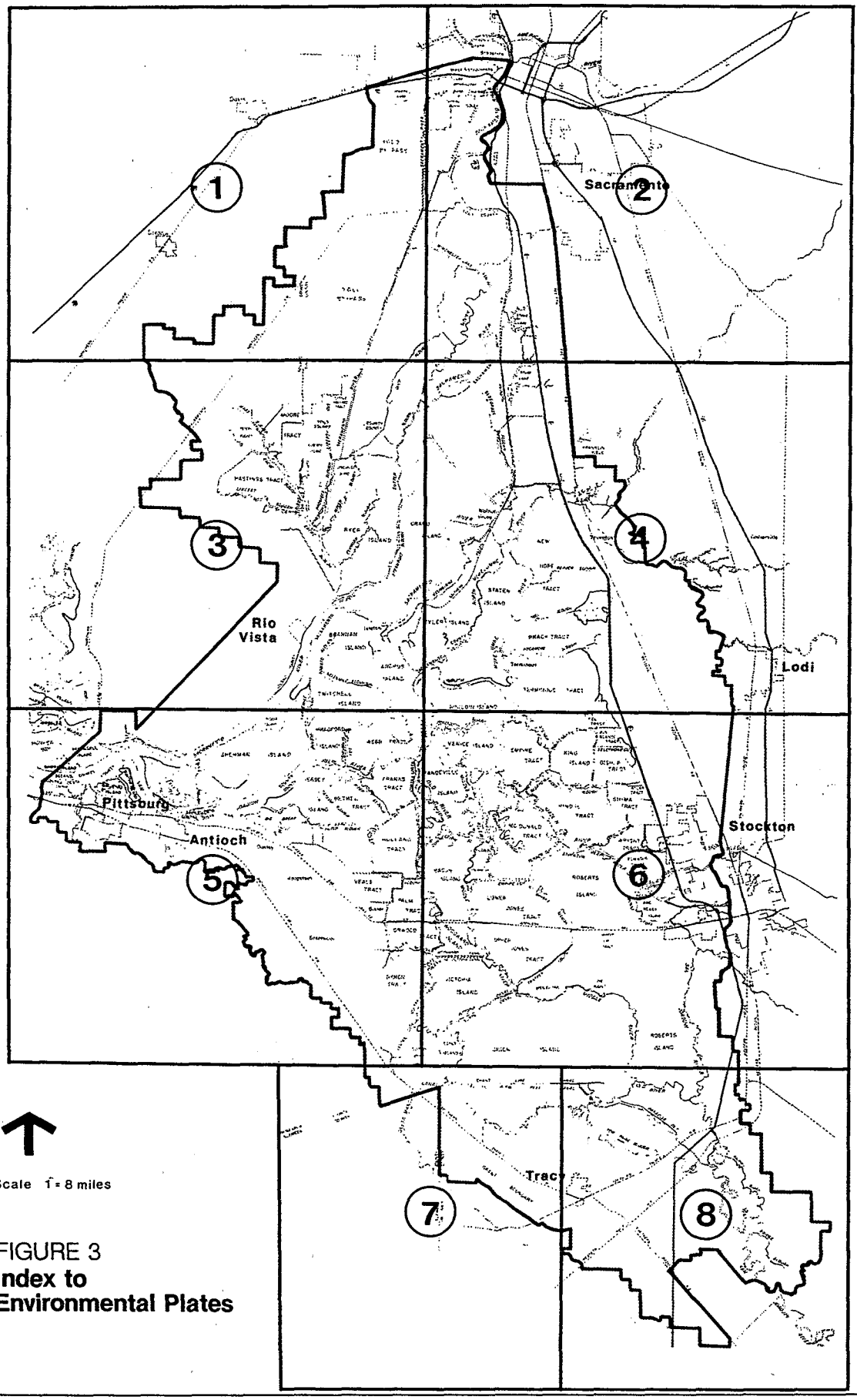

Scale 1" = 8 miles

FIGURE 3
Index to Environmental Plates

The *U.S. Army Corps of Engineers Sacramento-San Joaquin Delta Environmental Atlas* (COE, 1979a) is an essential companion to this Plan. The Atlas documents the most recent technical investigation and mapping of the Delta, displaying at a scale of 1:12,000 separate land use and habitat maps on orthomosaic aerial photographs. The year-long project is the only comprehensive habitat mapping of the Delta. This Habitat Plan is intended to be used in close conjunction with the photo maps of the Environmental Atlas, which were the primary reference for the Habitat Plan maps.

The principal original work which the Atlas contributes to Delta resource information is the delineation and classification of Delta wetland habitats, using the system developed by FWS for wetlands of the United States (Cowardin *et al.*, 1979). This system is explained in Chapter 6.

The Atlas maps use vegetation, physical, and hydrologic features to classify habitat type. The Atlas does not focus on wildlife use of habitats, although a comprehensive list of fish and wildlife is presented in the Atlas, based on a variety of sources of information. In contrast, the Delta Habitat Plan effort gathered original information on wildlife use of the Delta, complementing the Atlas' original work on vegetation.

Protection and Restoration of San Francisco Bay Fish and Wildlife Habitat (1979) is a study for the Bay, parallel to the Delta Plan, undertaken in 1978-79 by U.S. Fish and Wildlife Service and California Department of Fish and Game. The planning study had essentially the same objectives and study program as the Delta Habitat Plan, with the significant difference that the San Francisco Bay Plan contains its own mapping (1:24,000) of the habitats within the Bay shoreline study area. Like the Corps' Environmental Atlas, the basis for habitat mapping is the FWS Wetlands Classification System (Cowardin *et al.*, 1979). Although the San Francisco Bay map scale is half that of the Atlas Delta maps, the use of a common classification system now provides complete standardized habitat mapping of the San Francisco Bay-Delta System. The Delta Habitat Plan adapted portions of the San Francisco Bay Habitat Plan governmental analysis and options section, to the extent that these were applicable.

Use in Local Planning Process

The Delta Habitat Plan is intended to be used as a tool by local county and city governments in advance and current planning and the environmental review of plans and projects. In conjunction with General Plan preparation, this Plan will provide guidance for reevaluating and revising local policies, particularly those which concern open space and conservation, recreation, and environmental resource management in general. The Plan provides both regional data and a regional context for formulating or revising these policies, addressing the conditions and concerns which are common to all those jurisdictions which share Delta lands and other resources.

In addition, local General Plan land use maps can adapt the descriptions and mapped delineation of existing habitat resources within their jurisdictions, using this Plan in conjunction with the larger scale COE Atlas maps. Also adaptable are the mapped delineations of Significant Natural Resource Areas, including locations of rare, threatened, and endangered species. The mapped projection of areas of potential habitat enhancement and restoration (Chapter 5), can serve as guidance for defining "reserve" areas, for future possible extension of wildlife habitat and scenic areas, agriculture, or recreation sites.

The Plan further suggests courses of action for implementing natural resource policies at a local level. These include:

— defining special standards and criteria for planned development in resource areas;
— developing special resource protection designations or zoning districts;
— specifying the nature and location of habitats to be protected under ordinances; and
— allocating the costs of protecting resources through density transfer, tax incentives, acquisition, or other means.

In reviewing current planning and projects, local planning staffs and commissions can use information in the Delta Habitat Plan to evaluate the appropriateness of land use proposals and permit applications with respect to:

— wildlife and scenic resources;
— adjacent land uses; and
— overall distribution of natural resources and competing needs within the boundaries of the jurisdiction.

The Plan suggests several bases for assigning values to habitat (below) and describes the relative value of different habitats to wildlife (Chapter 6). This evaluation should assist decision makers in weighing the many competing demands on Delta resources and taking action on specific development proposals which impinge on habitat and aesthetic resources.

One of the most immediate uses of this Habitat Plan, used in conjunction with Corps Atlas maps, is in the local review and processing of plans and projects which fall under the *California Environmental Quality Act* (CEQA). Specifically, the information in the Plan can be incorporated by reference or summarized in initial studies and environmental impact reports, thus avoiding duplication of effort and reducing the cost of environmental processing. Proposed and alternative development sites can be evaluated for their potential impacts on significant natural resources and habitats of rare and endangered species. The cumulative impacts of developments on wildlife resources can be projected by calculating the extent of existing habitats in the jurisdiction and anticipating the loss or damage to those habitats which is forecast in the Development Scenario (Chapter 5). Habitat management and restoration information in Chapter 4 can be used to design or suggest mitigation or compensation requirements for loss of or damage to habitats,and to specify conditions of approval.

ALTERNATIVE APPROACHES TO EVALUATING DELTA WILDLIFE RESOURCES

Not everyone is convinced that the continued existence of fish and wildlife for their own sake is sufficient justification for plans and programs developed primarily in their behalf, at the expense of other uses. Historically, in the Delta human needs have received higher priority in the management of resources than have fish and wildlife, and they have received political and financial support accordingly.

Various approaches can be used to assess the value to both humans and wildlife of natural resources such as the marsh, riparian, and other habitats of the Delta. They generally support the contention that these resources deserve protection and enhancement and warrant investment of public or private funds toward their protection. If decisions regarding use of the Delta's resources are to reflect a variety of human values and needs as well as ecological conditions and political realities in the Delta, it is apparent that more than one approach to evaluating natural resources must be applied. A short description of various methods for accomplishing this are outlined below.

- An *energy evaluation* of Delta habitats would view habitat as part of an ecosystem and human life support system and assign a dollar value to net energy produced in calories per unit of dry weight and area (Gosselink *et al.*, 1974). While this approach assumes that the ultimate objective of society is to maximize energy production - a somewhat restricted view - it is useful in evaluating the Delta ecosystem.

  For example, tules are among the most productive plants in the Delta in terms of annual production of net food energy. Unfortunately we do not have measured evidence of direct use of tule marsh plant detritus by fish and wildlife to permit quantifying this contribution. It is theoretically possible, however, to quantify the contribution of peat soils formed from tule marsh to agricultural production in the Delta.

- The *economic approach* to valuing natural habitats analyzes the many uses to humans of habitat in terms of "user days" and direct and support dollars spent by Delta "consumers." There are numerous obvious uses of Delta aquatic, marsh, and riparian habitats in particular: hunting and fishing; flood protection; recreation and associated activities, such as observing nature, boating, and hiking; environmental education, scientific research, and other information gathering; and sediment entrapment and water quality "treatment."

  These benefits, which San Francisco Bay-Delta fish and wildlife resources produce, are equivalent to hundreds of millions of dollars annually and have been historically undervalued (USFWS, 1979b). If the economic approach were applied accurately in the Delta, many of its natural resources could compete effectively with other land and water uses. Only recently have fish and wildlife begun to be recognized as economically significant "appropriative uses" for California's water resources.

- The measurement of the *social values* of certain unique features of the Delta is more problematic. It is difficult, if not impossible, to assign a dollar value to the preservation of an endangered species or even the maintenance of common species of high public interest. Nevertheless, society has come to place certain nonmonetary values upon these resources and has directed governmental agencies through various laws and directives to ensure their preservation.

- *Ecological values* of habitats directly or indirectly benefit humans, but are of most immediate, demonstrable importance to fish and wildlife. These are described in Chapter 6 in connection with individual habitat types and their use by fish and wildlife.

CHALLENGES FOR THE FUTURE DELTA

The Delta was once an ecological treasure chest. The values inherent in that metaphor diminished with reclamation and almost ended with the institution of a flood control philosophy that required removal of all vegetation, a philosophy that persists in spite of two decades of attempts at reversal. The wildlife values of the region today are still significant, but pale in comparison to the historic Delta and the potential future Delta which this Plan envisions. Correcting and reversing wildlife losses is especially difficult in the Delta because of the complexity and interrelationships of land and water, of resource uses, and of the multilevel governmental regulations affecting them.

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This Plan can be the vehicle to channel governmental actions toward the goal of enhancing the Delta, but its implementation will require close attention and difficult political decisions. Completion of any of the recommended actions in this Plan will be an improvement of today's Delta, which is largely an agricultural prairie, intercut with channeled, stone-lined waterways, and dotted with an occasional green oasis of valuable wildlife habitat.

Tomorrow, this agricultural region could be protected and fringed along all its water courses with trees that provide shade and wildlife habitat, reduce wind erosion, and enhance scenic values. The great majority of levees could be covered with riparian shrubs and trees, with marsh vegetation on the waterside berms, providing essential cover and resting, nesting, and feeding habitat for many of the Delta's wildlife species. The back of the levees could be covered with grass and sufficient tree and shrub vegetation for habitat, but still permit inspection and ready access during emergencies.

Substantial stands of riparian woodland could be scattered around the Delta, perhaps located next to re-created marshes, so that the combined habitats could restore a diversity and density of wildlife now absent from many areas. Channel tule islands would continue to be vital habitat areas, expanded where feasible by the deposition of dredge spoils on subsided, flooded lands.

Recreation would also be benefited by the improvements in natural scenery and the increased numbers of wildlife available for viewing and, where appropriate, hunting.

The Sacramento-San Joaquin Delta has the potential of again being one of the most productive and valuable wildlife resource regions in California, in a manner which protects and enhances both the agricultural and recreational industries. The Delta can never be restored to its natural, historic condition nor necessarily should it be, but it can support a variety of compatible multiple-purpose uses that benefit all the people of California.

Natural and Human Resources

2

Fish and wildlife habitats of the Delta are a product of both historical and ongoing natural processes and of the relatively recent influences of human developments and activities. These two generally opposing influences are particularly apparent in the shaping of the land, vegetation, human, and other biotic communities of the Sacramento-San Joaquin Delta, where natural processes strive toward their own kind of "reclamation" of the land. Water always was and will continue to be the primary "owner" and shaper of the Delta, and most habitats in the Delta were formed by water processes.

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Chapter 2 reviews the relatively recent history of the Delta during which the most dramatic changes brought about by human settlement have taken place. The Chapter goes on to describe:

- the physical setting and natural processes which influence Delta fish and wildlife habitats and populations;
- the habitat resources as they are presently distributed (summarized from more detailed descriptions in Part II);
- human development and the principal human activities which form the social and economic base of the Delta; and
- the impacts which these activities have had and will continue to have on fish and wildlife resources unless steps are taken to protect these resources more effectively.

HISTORICAL BACKGROUND

The pristine Delta prior to 1850 was largely a tidal marshland of about 400,000 acres, surrounded by 200,000 to 300,000 acres of slightly higher lands and shallow backswamps behind natural alluvial levees (Thompson, 1957). Most of the land was close to mean sea level, with the highest points of land no more than 10 or 15 feet above that level. Flooding of the backswamps was frequent; in the spring virtually all of the Delta became a vast inland lake, covered by high tides and runoff from the great watershed of the Sacramento and San Joaquin Rivers (Figure 4).

Floodwaters deposited nutrient-rich sediments and detritus on Delta lowlands, contributing to their high biological productivity. Often described as the "Everglades of the West", this rich area was covered with dense tules, willows, and cottonwoods, which, along with adjacent higher vegetation, teemed with more than 250 species of birds and mammals. The Delta was one of the most significant areas of waterfowl concentration in the state, supporting ducks, geese, swans, and other waterfowl in great numbers during winter migration. In addition to many furbearers, such as river otter, bobcat, and grizzly bear, great herds of antelope, tule elk, and deer were present in and around the Delta.

Perhaps as many as 30,000 Indians originally inhabited the Delta. An expedition led by Pedro Feges and Fray Juan Crespi in 1772 resulted in the first documented account of the area by Europeans (Thompson, 1957). Spanish padres led mission-siting parties in the late 1700's, and several battles were fought between the Spanish missionaries and Indians, many of whom fled to the Delta from the Spanish-controlled San Francisco area. The Delta Indian population was essentially eliminated in the summer of 1833 by an introduced pestilence. In 1852, the census of San Joaquin County listed only 370 Indians and by 1870 the once extensive population had been reduced to five.

The abundant Delta wildlife populations were not greatly affected by European intrusion until the mid and late 1800's. Trappers began to exploit the vast numbers of beaver, mink, and otter in the 1830's. By 1856, these furbearer populations were almost exhausted. The great herds of elk and antelope were largely elminated by 1880 through hunting and habitat destruction. Several eastern fish species were introduced to the Delta during this period (1870's), and of these striped bass, American shad, black bass, and white catfish were highly successful (Skinner, 1972).

Reclamation

Johann Sutter had settled near the Sacramento River in 1839. Sutter's Fort became the heart of activity during the early settlement of the Delta and Sierra Nevada. Gold was discovered at Sutter's Mill in 1848, and the resulting gold rush was to change the character of the Delta forever (DAPC, 1976b). Soon after the onset of the gold rush, reclamation of the swamp and marshlands along the Delta waterways began. Many disappointed gold seekers had turned to farming to satisfy the rising demand for food by the gold rush population. When the Federal Swamp and Overflow Act of 1850 was passed, the title to Delta lands passed to the State of California, which proved to be a major impetus in furthering Delta reclamation. Individuals wishing to reclaim Delta swamplands were able to purchase land for as little as one dollar per acre.

Levee building and reclamation of Delta lands altered irreversibly the physical appearance and function of the area. The first levee is believed to have been built in 1852 on Merritt Island (Thompson, 1957). These and other early "shoestring" levees were built by hand by Chinese laborers, or by Fresno scrapers drawn by mules or horses. They were low earthen mounds, confined to peripheral higher-lying marshlands and built from blocks of tule sod removed from the island interiors. Flooding of the early levees was a frequent problem, and from the outset subsidence of the reclaimed islands contributed to the flooding problem.

By 1880, approximately 100,000 acres of land had been reclaimed. Higher and more substantial levees were built in the 1890's by clamshell dredges, which form an important chapter of their own in the history of the Delta up to the present time (Dutra, pers. comm.). These levees were set back from the riverbank with wide berms between the riverbank and the levee toe (DWR, 1961). By 1900, half the Delta (250,000 ± acres) had been reclaimed, and by 1930, Delta reclamation was essentially complete, with the formation of 60 major islands covering about 450,000 acres.

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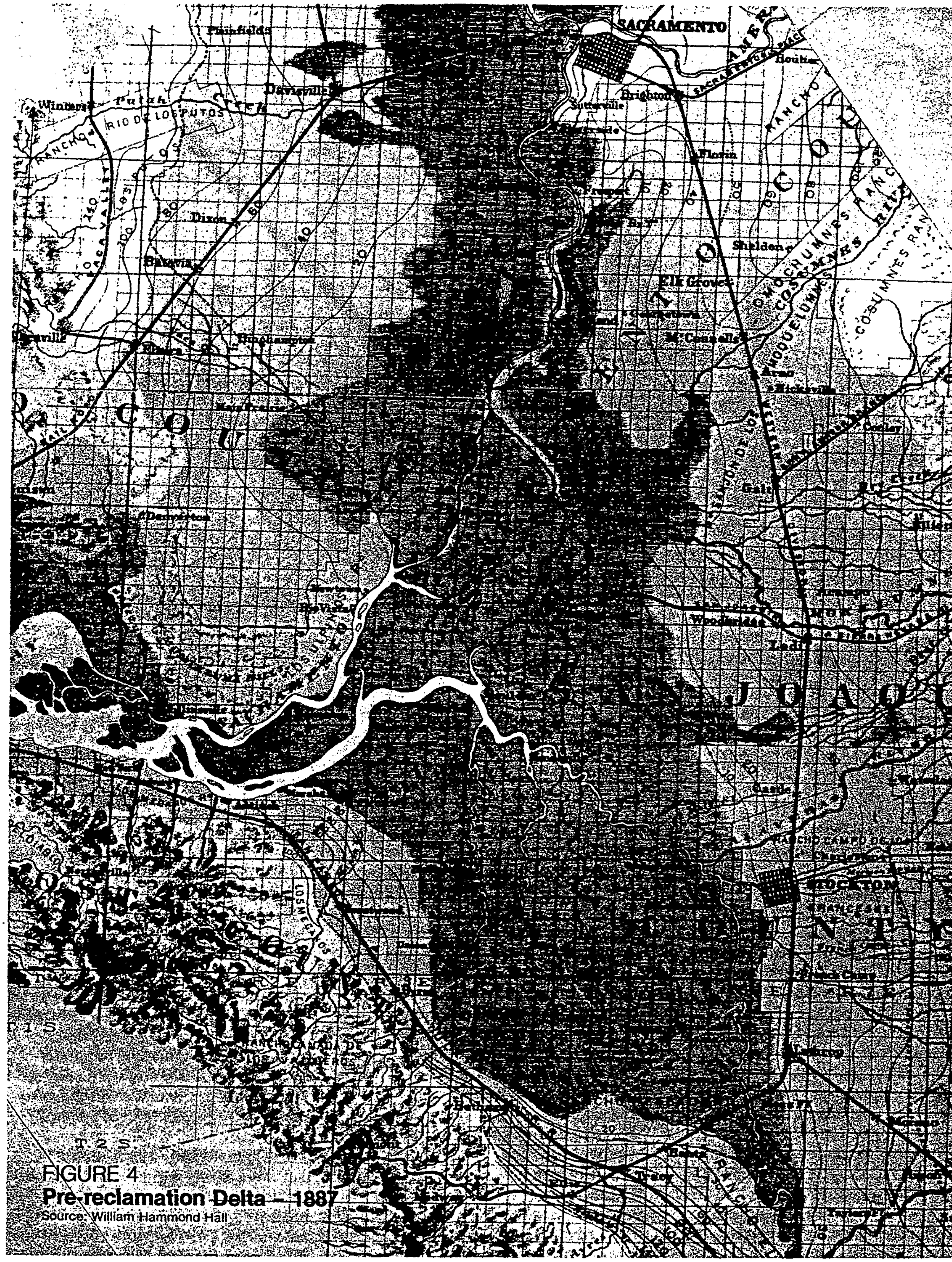
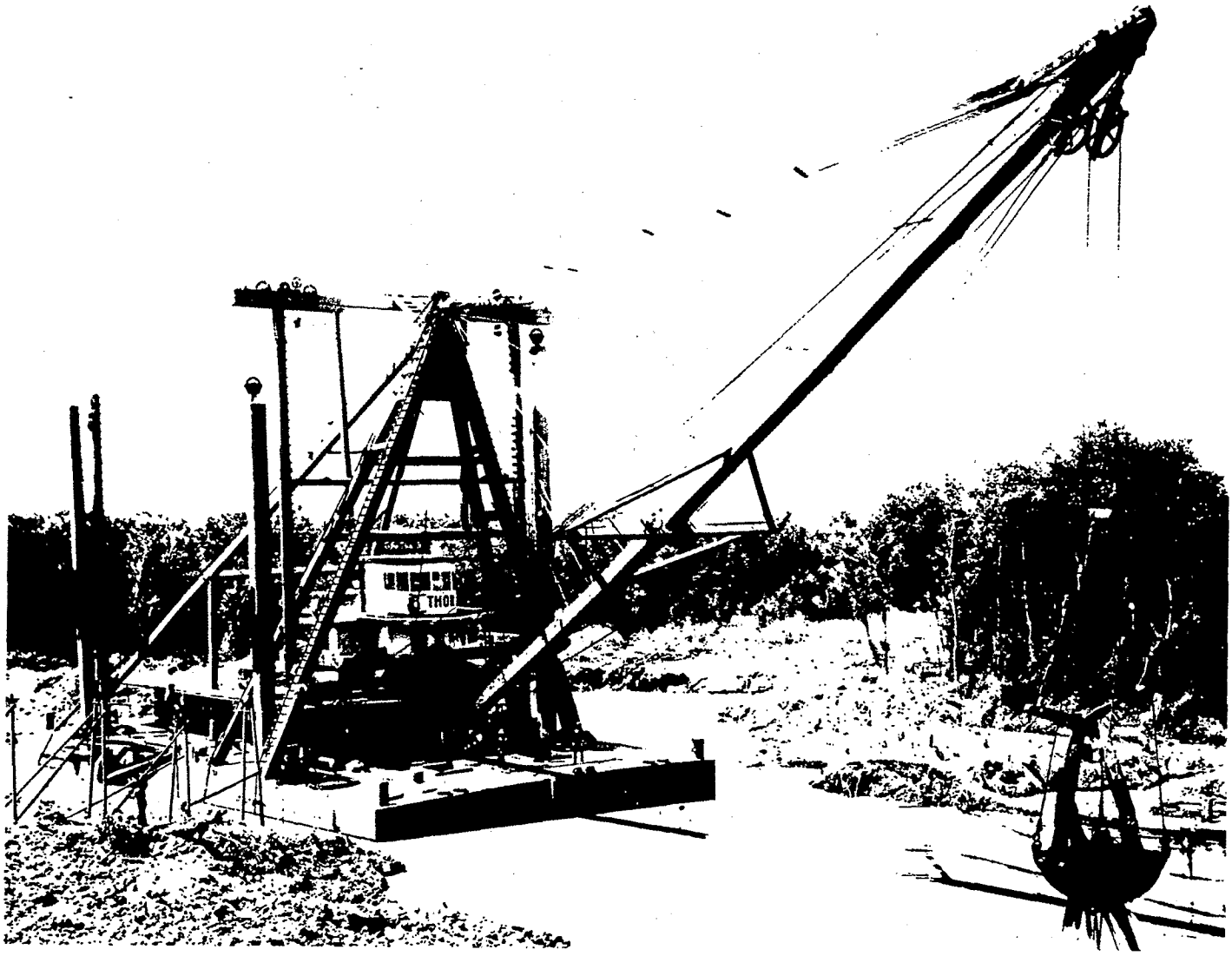


FIGURE 4
Pre-reclamation Delta – 1887
Source: William Hammond Hall



Waterway Problems

During the gold mining era of the late 1800's, hydraulic (placer) mining practices caused millions of cubic yards of sediment and debris to be washed through Delta rivers and streams into San Francisco Bay. A heavy sediment layer settled on the channel bottoms of Delta waterways, raising their bottom elevation by as much as 15 feet. Consequently, the levees had to be raised to prevent flooding (Whitlow *et al.,* 1979). By the 1890's, sedimentation and debris from mining activities had greatly narrowed channels and diminished the tidal basin in the Delta (DAPC, 1976b). The Sacramento River was dredged between 1913 and 1924 to alleviate the problem, and a channel opened through to the river mouth allowed natural scour to largely restore normal streambed levels (OPR, 1976).

Salinity intrusion from San Francisco Bay has long been a problem, particularly in the western Delta. Early records show that salinity intrusion occurred in some years long before extensive development of the Delta (DAPC, 1975). But as reclamation and diversions increased, the invasion of saline water from the west became more frequent and extensive. In 1931, the maximum intrusion of saline water occurred, and an estimated 74% of the Delta water supply was rendered unusable (ASWPA, 1976).

Many other problems were plaguing the Delta waterways. Summer outflows had decreased as a result of reclamation to agricultural uses, and extensive groundwater withdrawals throughout the San Joaquin Valley had already created a demand by the early 1900's for imported irrigation water (OPR, 1979). Flooding incidence increased as more levees were constructed. Levee building and reclamation occurred not only in the Delta, but to the north and south along both the Sacramento and San Joaquin Rivers. Loss of floodplains and marshlands, particularly along the Sacramento, decreased the natural flooding and water retention capacity of the riverine and floodplain system. The tidal prism of the Delta had been reduced to 10% of its original extent. Winter flooding was aggravated as greater amounts of floodwater were confined to the main river system, creating hydrostatic pressure on the levee system.

Development of Water Systems

The systems which were developed to manage the flow and flooding regime are now an integral part of the Delta ecosystem. The Central Valley Project (CVP) was passed by the State and sub-

sequently funded and built by the federal government in 1933, in part to relieve the problems of Delta waterways, but primarily to utilize water more fully. Dams, reservoirs, and other structures were built to store more of the water entering Delta tributaries. Salinity control was not then a primary objective.

Shasta Dam, the most prominent of the upstream storage reservoirs, was completed in 1949, and in August, 1951, the pumping station at Tracy in the southern Delta began delivering Sacramento River and Delta water to the Delta-Mendota Canal and the upper San Joaquin Valley.

By the 1950's, the need became apparent for more extensive flood control and additional water for irrigation and urban use, especially in southern California. The State Water Project (SWP) Oroville Dam and Reservoir was fully authorized in 1959 by the Burns-Porter Act. The Delta Protection Act, passed in the same year, obliged the state to provide salinity control and an adequate water supply for Delta water users. The State Water Project (SWP) was implemented in stages throughout the 1960's and now carries water from the Sacramento River and the Delta into the southern San Joaquin Valley and ultimately to the Los Angeles area. MacDiarmid (1972) provides a thorough historic review of the State and federal projects.

Much attention has been focused on the Delta in the past two decades, fortunately moving toward greater interagency cooperation. But the Delta, as the "water wheel" for the major part of the state, continues to be at the center of north-south controversy over the allocation of State water and its conveyance through either the natural waterways of the Delta or through a long-planned peripheral canal. The Delta is still the subject of many unresolved differences concerning management of its resources (See also Chapter 2, below).

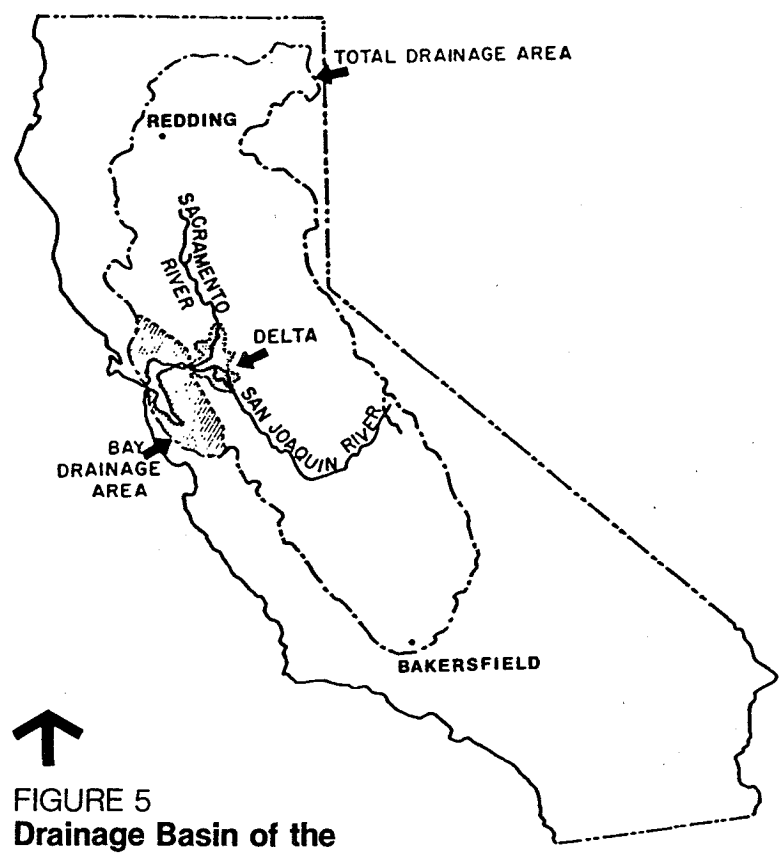


FIGURE 5
Drainage Basin of the San Francisco Bay-Delta System

PHYSICAL SETTING OF THE DELTA

Climate

The climate of the Delta is relatively mild, with a long growing season during which most farmers are able to plant and harvest two or three crops. Like most of California, the overall climate is Mediterranean, with hot dry summers, and cool moist winters. Winter rains are often interspersed with periods of dense, low-lying ground fog, known locally as tule fog. Average annual rainfall is 18 inches in the eastern and central parts of the Delta, and 12 inches in the southern part. The local rainfall is supplemented by continually available irrigation water from the surrounding waterways.

Average temperatures in the Delta are 45 to 50 °F from December to March and 75 °F from June to September, with high temperatures exceeding 100 °F and lows dropping to 30 °F. The year-round average is approximately 60 °F. Water temperatures range from 43 to 82 °F. During spring and summer afternoons, winds from the ocean enter the Delta through Carquinez Strait. Between April and September these cooling breezes become quite strong, reaching up to 50 mph. During the winters land breezes prevail, blowing in the opposite direction.

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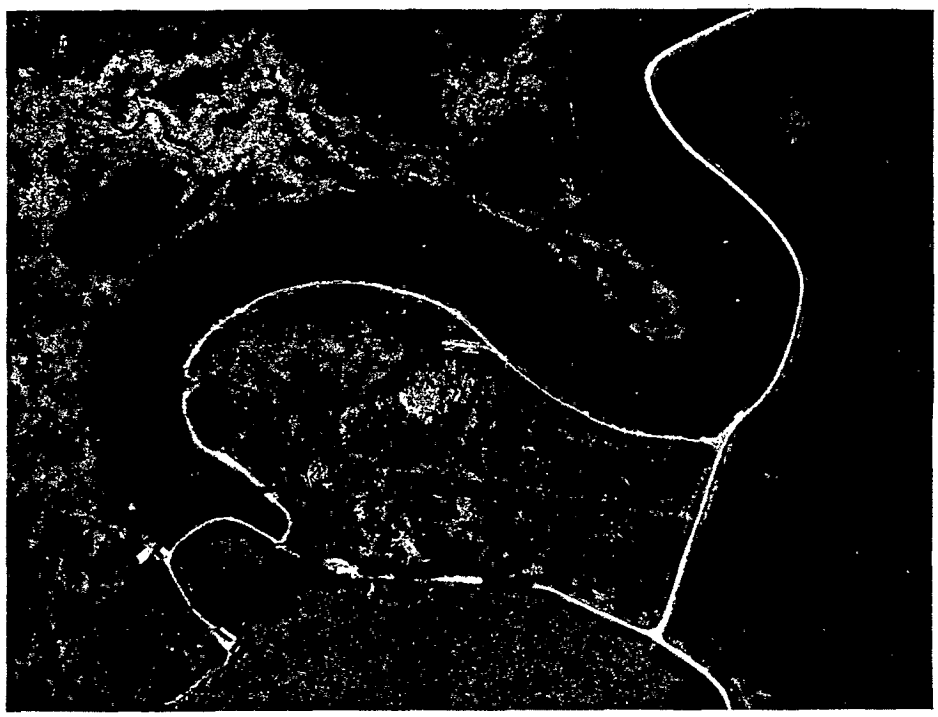

Soils and Topography

Peat soils, derived from ancestral tule marshes and mineral-rich alluvial soils deposited by rivers entering the Delta, occupy most of the level, low-lying central part of the Delta. Mineral soils, derived from weathered rock and deposited on the lower slopes of the surrounding valley plains, predominate on the periphery of the Delta. Organic soils, transitional soils, and mineral soils make up the 500,000± acres of agricultural lands in the Delta.

While the original elevation of this area was close to MSL, except for a few high spots that reached 10 to 15 feet above MSL, the elevation of Delta lands now ranges from +5 to −20 feet, with an average elevation around 10 to 15 feet below MSL. Removal of sod for early levee building, drying and subsequent shrinking of peat soils, wind erosion, natural oxidation, and intentional and accidental burning have all contributed to the subsidence, which continues at an estimated rate of 2 to 3 inches each year (OPR, 1979; Whitlow *et al.*, 1979) (See Chapter 4).

Man-made levees ring all of the major and many of the minor islands and line the banks of waterways and overflow channels throughout the Delta. The 886 islets and islands, of which 60 are major leveed islands, or tracts, cover about 450,000 acres. While the first constructed levees were only a few feet high, levee settlement, land subsidence, channel modification, increased wave action from motorboat wakes, and other factors have required major reinforcement of the original levees. Today Delta levees are a prominent feature of the landscape; some stand 25 feet high and reach 200 feet across at the base (See Chapter 4).

Hydrology

The Delta is unlike the classical triangular alluvial fan formed where the tidal mouth of a river meets the open water of an ocean or bay. Instead, California's Delta is an inland triangular network of waterways formed from the rising of sea level through the Carquinez Strait about 6,000 years ago to meet the alluvial fans of the Sacramento, San Joaquin, Cosumnes, Mokelumne, and Calaveras Rivers and smaller tributary streams (Figure 5).

Despite constriction at its western Carquinez outlet and isolation from the ocean, the Delta deserves its name for two reasons. First, under pristine conditions (pre-1850) it possessed landforms - distributaries bordered by natural levees and separated by tidal wetlands -that are typical of many classic deltas. Second, where inundated by historic floods, it formed a body of relatively motionless tidal water into which tributaries flowed (Atwater *et al.*, 1979).

The streams and rivers that flow together to form the Delta drain a 61,200-square mile watershed of the Central Valley of California, which represents around 37% of the State's land area and carries between 40 and 50% of the natural runoff of all of California (OPR, 1979). With diversions, the average annual flow for this drainage basin has been estimated at 27,000,000 acre-feet, or almost 9 trillion gallons (Stevens and Chadwick, 1979). Roughly 85% of the water reaching the Delta comes from the Sacramento River, 12% from the San Joaquin River, and 3% from the streams and sloughs to the east (OPR, 1979).

The many waterways of the Delta come together near Antioch and flow west through Suisun Bay and the Carquinez Strait to San Pablo and San Francisco Bays, and eventually through the Golden Gate into the Pacific Ocean. As a component of the San Francisco Bay-Delta ecosystem, the Delta is part of the largest estuary on the Pacific Coast (USFWS, 1977).

Within the Delta are roughly 50,000 acres of water, of which 39,000 acres are tidal. The legal Delta has 700 miles of waterways, lined with 1,062 miles of levees, while the study area Delta has 725 miles of waterways and 1,141 miles of levees.

The open waters and waterways of the Delta have been and continue to be a prominent and important component of the ecosystem. In addition to providing essential aquatic habitat, the channels are avenues for floodwaters. They provide irrigation and export water and receive and carry off treated and untreated wastes from many different sources. They are heavily used by commercial ships and recreational boaters, bathers, anglers, hunters, and others.

Before the extensive system of levees was built, winter and spring floods spread over the backswamps and floodplains. Since the reclamation of the Delta, virtually every island has flooded at least once. The most recent floods - Brannan-Andrus Islands in 1972, and Webb, Holland, and Jones Tracts in 1980 - demonstrate that flooding can occur in both dry and wet seasons. The most extensive wetlands in the Delta today are seasonally flooded agricultural fields, the total acreage of which depends on weather, crop, and prevailing irrigation practices.

Tides

As is typical for the Pacific coast, the waters of the Delta rise and fall on two unequal high tides and two unequal low tides each day. The Delta is tidal throughout, but the time and range of tides varies from place to place. In San Francisco Bay, the average diurnal tidal range is 5.7 feet; at Collinsville, the western-most point of the Delta, the range is somewhat less, at 4.3 feet. Tidal range decreases with distance from San Francisco Bay and the Golden Gate. At Sacramento, the range is 2.9 feet, and at Mossdale Wye, between Tracy and Manteca, the range is 2.4 feet (ACWA, 1976)(Table 1).

Timing of the tidal ebb and flow in the Delta lags behind San Francisco Bay tides. The actual lag differs with location, but generally increases with distance from San Francisco Bay so that upstream tidal points in the Delta may lag behind Golden Gate tides by as much as 10 hours (ACWA, 1976).

Water Quality

Various factors, including seasonal and annual fluctuations, affect the quality of water in the Delta. Tidal mixing keeps Delta waters generally turbid throughout the year. Tubidity increases during the winter and spring, when water from the Sacramento and San Joaquin Rivers is heavily laden with sediment. Disolved oxygen (DO) in Delta waters varies with local conditions. DO is decreased by low flows, high temperatures, municipal, industrial, and agricultural discharges, and dredging activities (DMRP, 1976) and is increased by phytoplankton and algae photosynthesis. Excess growth (blooms) can create the opposite problem of high biological oxygen demand (BOD).

Salinity in the Delta is determined by the balance between freshwater outflows and saline tidal inflows from San Francisco Bay. The average total dissolved solids concentration of Sacramento River waters in the Delta is around 100 parts per million (ppm) TDS. In the San Joaquin River, agricultural return waters and low flows cause average concentrations to increase to about 400 ppm TDS. Streams entering from the east side average only 50 ppm TDS (ACWA, 1976).

TABLE 1 **Tide Elevations at Delta Points**

Stage	Elevation, in feet, USGS datum				
	Collinsville: (a)	Venice Island: (b)	Sacramento: (c)	Stockton:	Mossdale (d)
Maximum flood stage	6.6	7.2	30.3	7.3	24.4
Mean high high tide	3.4	3.6	4.9	3.7	3.2
Mean half tide	1.3	1.8	3.4	1.6	1.9
Mean low low tide	-0.9	0.0	2.0	-0.6	0.8

(a) Lower (western) end of Delta.
(b) Mid-Delta area.
(c) Northern end of Delta.
(d) Southern end of Delta.

Source: Association of California Water Agencies, 1976

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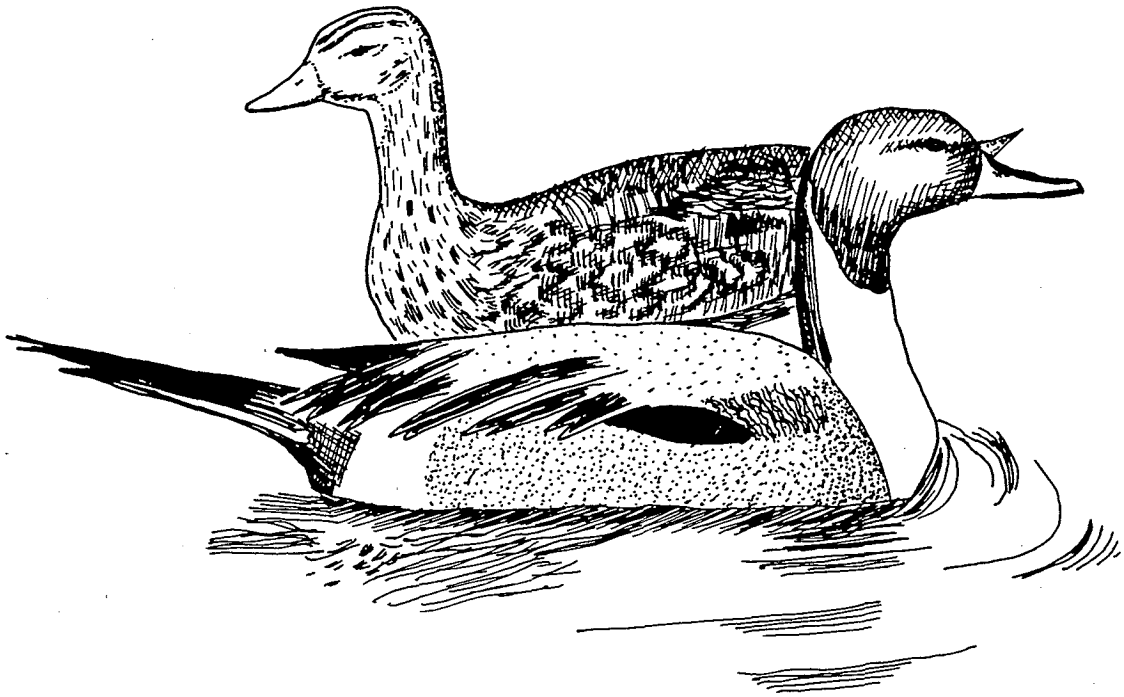

Functions of Freshwater Outflow

Delta freshwater outflows are of biological significance to downstream ecosystems in Suisun Marsh, San Pablo Bay, San Francisco Bay, and even the continental shelf. Before reclamation, winter and spring flows would overtop the natural riverbank levees and deposit nutrient-rich sediments and detritus on the backswamps and floodplains of the Delta. The nutrient output from these areas was undoubtedly a significant input to downstream ecosystems, although no estimate has been made of their loss or the resulting effects. Local agricultural return water continues to carry some nutrients out to Delta channels.

Delta freshwater outflows also contribute to the formation and location of the "entrapment zone" in the vicinity of the Suisun Bay. The approximately 30-mile long salinity gradient, or salt wedge, is formed as fresh water from the Delta flows out over denser saline inflows from the Pacific Ocean. The circulation pattern in the entrapment zone creates accumulations of suspended detritus, other nutrients, plankton, fish and invertebrate larvae, and other organisms, and the area is an important nursery for a large number of fishes, including striped bass (Stevens and Chadwick, 1979).

Freshwater outflows are an important factor in maintaining water quality within the Delta and the salinity regimes of Suisun Marsh, which supports an abundance of foodplant species of great value to large concentrations of waterfowl during migration and wintering periods. Increases in salinity would change the vegetation composition to less desirable foodplant species and reduce or eliminate some of the most valuable waterfowl habitats in California.

Freshwater outflow is important to anadromous fish like the striped bass, American shad, sturgeon, steelhead, and salmon seeking spawning sites, and in regulating the development and distribution of several of these fishes' eggs and larvae.

Delta outflows, particularly during the winter flood stage, are thought to have a significant influence on flushing in San Francisco Bay, especially in the sluggishly circulating southern extremities. The extent to which these outflows actually affect Bay flushing and their corresponding influence on Bay ecosystem functioning are not well understood but are the subject of ongoing studies under the Interagency Ecological Studies Program and U.S.G.S., and the recently authorized Delta Outflow-San Francisco Bay Study (DFG, 1980) and San Francisco Bay-Delta Aquatic Habitat Program (SWRCB, 1980).

Water quality standards for the Delta are established by the State Water Resources Control Board (SWRCB) through conditions in water rights permits and in Basin water quality plans. (See Chapter 3: SWRCB)

FISH AND WILDLIFE RESOURCES

The Delta occupies an important position in California and the Central Valley for fish and wildlife. It lies in a strategic location not only on the Pacific Flyway, the major migratory route for birds in the western United States, but also at the convergence of the Sacramento and San Joaquin River system, with its associated anadromous and resident fisheries. Even though large areas of the Delta no longer offer the marshland habitat which once covered up to 400,000 acres, a large number and diversity of fish and wildlife populations inhabit the Delta for all or part of the year.

The vast tidal marsh of the ancestral Delta was one of the most significant areas of waterfowl concentration in California. Reclamation eliminated much of the former waterfowl habitat, gradually converting it into the complex system of managed channel and slough aquatic habitats, leveed riparian corridors, extensive cultivated agricultural habitats, occasional remnants of riparian forests, and urban habitats which together now characterize the area.

Winter-flooded agricultural fields - principally corn and other grains -

provide extensive seasonal wetlands. Along with the other principal wetlands which comprise Central Valley waterfowl habitat, the Delta is important wintering habitat for 60% of the waterfowl that use the Pacific Flyway, and for 91% of all waterfowl that winter in California (USFWS, 1977). The Central Valley waterfowl poplation moves around among valley wetland habitats in response to available food. Roughly 10% of this population makes extensive winter use of the Delta (USFWS, 1977), and in excess of one million waterfowl are frequently in the Delta at one time.

Fall and mid-winter survey data (1973-1977) indicate that Delta flooded fields and adjacent unflooded lands are among the most important of all Pacific Flyway habitats for whistling swans (38,000 birds, or 73% of the Central Valley population); white-fronted geese (65,000 birds, or 34% of the Central Valley population); pintails (370,000 birds, or 12% of the Central Valley population); and other waterfowl (USFWS, 1977).

The principal habitat functions of Delta (and Central Valley) wetlands, whether seasonal or permanent, are to provide wintering waterfowl with food and resting space for fall and winter months; to provide temporary habitat for birds wintering elsewhere to the south; and to provide habitat for all water-related wildlife.

The Delta is also the hub of the Sacramento-San Joaquin River system and San Francisco Bay-Delta estuary, which contain 91 species of fish, almost 70% of the total number of species found in California. Seventeen of these species are found only in this system, and 11 species of native and introduced anadromous fish (roughly 50% of California's anadromous fish population) are directly affected by conditions in the Delta (Moyle, 1976). These include striped bass, king and silver salmon, white and green sturgeon, and other important game fish. Delta fisheries have been profoundly influenced by water management and by introduction of nonnative species, which have outcompeted many native fish.

While waterfowl and fish may be the most conspicuous animal inhabitants of the Delta, many other wildlife groups and species depend on the mosaic of habitats that the "managed" Delta provides.

Distribution of Fish and Wildlife Habitats

The variety of wildlife habitats which comprise the Delta are distinguished primarily by their vegetation and by the presence and periodicity of water. Their extent and distribution vary somewhat according to season, year, and the method of classification.

Acreages, given in Table 2 and below, are adapted from the COE *Environmental Atlas* and must be considered approximate. A detailed description of habitats and their value to wildlife is presented in Chapter 6, and detailed maps of habitat types are found in the COE *Atlas*. Plates A1-8 present generalized distributions of the principal habitat categories: freshwater marshland and riparian vegetation; channels and open water; agriculture and upland; and urban. Important areas for migratory and wintering waterfowl are overlaid on agricultural habitats.

TABLE 2 **Table of Habitat Types and Area**

Habitat Type	Approximate Acres
Freshwater and Brackish Marsh	9,000-11,000
Channels, Open Water, Dead-end Sloughs, and Lakes (including submerged islands)	52,000
Tideflats	minimal
Riparian Woodland	2,700
Riparian Shrub-brush (including Brushy Riprap)	4,300
Agriculture	520,000
Upland	44,000
Urban	31,800

Adopted from COE Environmental Atlas (1979)

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Freshwater and Brackish Marsh

Today, out of the 358,400 or more acres of tidal marshes and swamps which once covered the Delta only 5,210 acres of "pristine" wetland area remain (Atwater, 1979) (Figure 19, Chapter 6).

Estimates of the present extent of both tidal and nontidal freshwater and brackish marshland vary from 9,000 acres to 11,000 acres, most of which are freshwater. Much of the tidal marsh consists of narrow bands and pockets of tules, predominantly, along the margins of larger islands and in sediment accumulations along the base of many miles of levees. Larger sediment deposits in channel meanders have formed tule islands, and where additional sediments have established higher elevations, woody vegetation forms a dense thicket of willows and similar species. Generally, channel islands are habitat complexes, with marsh vegetation reflecting elevation and extent of inundation. Undisturbed, undiked peat island marshes, once widespread, are now scarce.

Nontidal marshes are associated with lakes or standing water in low elevations behind levees. These are now small remnants of the "backswamp," overflow lands (seasonal floodplains) which once covered large expanses behind natural berms and levees. The Stone Lakes basin offers a good example of nontidal marshes in a complex which also includes open water and riparian forest. Both tidal and nontidal marshes demonstrate high biological productivity and are significant as vestiges of the "pristine" Delta.

The density of vegetation in tule marshes determines their use by wildlife. Dispersed stands are used by shorebirds, and denser stands provide shelter for rails and marsh wrens. Muskrat and beaver depend on these marshes for food and shelter. Given sufficient areas of marsh and open water, beavers would be less likely to use levees as lodge sites, thus endangering levee stability.

Tide flats occur in small areas only in the western Delta. They are generally backed by brackish tidal marsh, but also exist as shallow areas of sandy sediment deposition where the Sacramento and San Joaquin Rivers broaden at their convergence. They provide habitat for shorebirds which is otherwise limited in the Delta.

Riparian

Riparian habitat, as a term, encompasses at least two distinct vegetation types which occur singly or in combination in the Delta: riparian woodland, or forest, and riparian shrub-brush. Riparian woodland has been estimated to cover from as little as 173 acres, a restricted definition which only includes large trees in wet meadows or along watercourses, to 2,700 acres, which would include more diverse woody vegetation on levees and berms along waterways. Riparian shrub-brush, characterized by small willows and other low woody and herbaceous vegetation, covers about 4,300 acres.

True riparian forests, consisting of stands of large cottonwoods, sycamores, white alders, and valley oaks were never as prevalent in the central and western Delta as in other adjacent parts of the Central Valley. They occupied areas of higher alluvial mineral soils which were the historic floodplains of the San Joaquin, Cosumnes, Mokelumne, and Sacramento Rivers around the periphery of the Delta. Remnants of the formerly extensive Central Valley riparian forests do exist in the Delta: along the upper Mokelumne River, Cosumnes River, at Bidwell Park on the San Joaquin River, and on larger channel islands. Throughout the Delta and Central Valley, much of this resource has been diminished by agricultural clearing and indirectly by exclusion of seasonal flood flows.

Mature riparian woodlands offer the most diverse habitat resources for birds and other wildlife in the Delta. Their value is made even more significant by their limited distribution and by the added resources which they provide to wildlife in adjacent habitats.

Riparian shrub-brush is more prevalent in the Delta than woodland on levees along watercourses, and better able to recover following its removal. Left without disturbance, this vegetation would eventually succeed to a wooded community with typical riparian trees, a condition which could not have occurred in the central Delta peat lands before the introduction of levees standing above the mean tide level. The frequency and severity of vegetation removal, however, not only precludes further habitat development but has replaced much of the riparian shrub habitat with seasonal grass and weedy annuals.

Although the structural diversity and specialized niches in riparian shrub-brush are fewer than in woodland, the thickets in this habitat are heavily used by wildlife, in the absence of similar cover in open agricultural lands. Riparian shrub-brush is one of the most significant Delta habitats for maintenance of many species of common birds and mamals. Some riprapped banks have been allowed to develop brushy vegetation; wildlife use is less than in unriprapped situations, although the vegetation offers some supporting habitat.

Channels and Open Water

Estimates of open water area in the Delta range from 47,000 to 52,000 acres. Slightly under 80% is tidal, the remainder made up of lakes, ponds, and nontidal sloughs. The most prominent bodies of tidal open water are the channels which comprise the network of the Sacramento and San Joaquin Rivers and tributaries. They range in width from a mile in the vicinity of the rivers' convergence to a few hundred feet and carry fairly strong tidal currents and flow velocities induced by pumping in the southern Delta. Among their other habitat functions, they serve as migratory corridors and nursery areas for anadromous fish which are the base for recreational fishing.

Dead-end channels in the eastern Delta are represented by Beaver, Hog, and Sycamore Sloughs. Because they are quiet backwaters, they provide essential habitat for native resident fish species. Their importance as habitat is based on several factors: high velocity water flowing toward Delta pumps does not go through these channels; the flood risk of eroded levees is reduced, and thus the presence of vegetation poses less hazard to levee maintenance; the absence of frequent fast through boat traffic reduces

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this common cause of levee erosion; and these side channels are less visited by recreationists, thus limiting the inevitable impact on wildlife of human intrusion.

A third kind of tidal open water habitat in the Delta is represented by flooded, submerged islands or portions of islands. Franks Tract, Big Break, and Clifton Court Forebay were flooded either intentionally (Clifton Court) or accidentally and left without repair of levees. (Other islands which flooded in 1980 are being "re-claimed" by pump-out). Habitat conditions and inhabitants are comparable to other tidal open waters.

Nontidal bodies of water were formed either as trapped, formerly tidal sloughs and old overflow channels in the floodplain, or as part of marshes lying behind levees. These two kinds of lakes in the Delta are represented by nontidal sloughs, such as Trapper Slough, and by the Stone Lakes and the shallow Headreach Island Lake. Habitat conditions in nontidal lakes are similar to those in dead-end tidal sloughs: the absence of flow permits an extensive floating plant community to develop along with good habitat for resident fish.

Sewage oxidation ponds should also be recognized as a "nontidal open water habitat." These year-round ponds in Stockton and Lodi are used heavily during migration and winter months by shorebirds and waterfowl.

Channel Islands

The cumulative acreage of large and small channel islands has not been computed, but they constitute one of the most significant habitat resources (Chapters 6 and 7) and one of the most threatened in the Delta. Channel islands present a wide array of physiographic types, from small marshy patches to diverse habitats with some combination of wooded upland, dredge spoils, shrubs, open grassy areas, lakes, and marshland. Islands in the smaller sloughs in the San Joaquin River and Chipps Island are examples of the diverse conditions. The value of wildlife habitat on these islands varies in direct proportion to the freedom from human disturbance afforded by their isolation.

Agricultural Habitats

The most extensive habitat complex in the Delta is that which agriculture provides. Estimates of overall agricultural areas range from 400,000 to 500,000+ acres. Not all types of agriculture are equally useful as habitat. The acreage planted to various crops varies from year to year except for orchard and vineyard, which are fairly stable. Land use figures from 1978 showed the following relative acreages (COE, 1979a):

Crop	Acreage	Percent of Total Delta
Field crops	314,169	46.2%
Pasture	95,405	14.0%
Truck & berry crops	77,755	11.4%
Orchard crops	24,671	3.6%
Vineyard	3,333	0.5%
Fallow land	5,185	0.8%
Total Agriculture	520,518	76.6%

While fields under active cultivation have only limited wildlife value, fall and winter flooded and unflooded corn and grain fields (field crops) and uncultivated ruderal fields (fallow land) have significant habitat value. Orchards and vineyards also are used more by wildlife than fields under active cultivation.

Fields flooded seasonally for leaching or to attract waterfowl substitute in part for the many acres of pre-reclamation wintering habitat. Unflooded corn and grain fields and permanent pasture are also important winter feeding and resting habitats for waterfowl and provide year-round cover and food as well.

Pasture can be considered either an "agricultural" or, more generally, an "upland" habitat. The pastureland which surrounds much of the eastern Delta dead-end sloughs attracts one of the most important concentrations of sandhill cranes in California. Other permanent pasture which is not regularly mowed or cultivated functions as year-round rather than seasonal habitat. Agricultural lands or border lands which are either untended or temporarily fallow tend to revert to a semi-natural state. These ruderal lands provide important wildlife cover in an otherwise intensively managed area.

Upland

Upland habitats occur both within and surrounding the Delta and cover about 44,000 acres. The diversity of habitat types includes some pasturelands, other grazing lands, oak savannah, and a miscellany of man-made conditions, such as "grassy riprap."

Most stands of oak savannah are remnants of a once-extensive community that occurred on the higher peripheral Delta and throughout the Central Valley. Much of the former expanse has been converted to agricultural or urban uses. The few remnant stands are attractive for parks or residential development, and are growing under cultivated conditions which are inimical to replenishment of valley oaks by natural reproduction. Several other specialized upland habitats, present in the study area, are discussed below: Significant Natural Resource Areas.

Urban

Urban habitats, which are associated with about 31,800 acres of urban land uses, have developed around and within the Delta along with the spread of human settlements. As with typical urban landscaping, introduced trees and shrubs in Delta town centers provide habitat for common "backyard" birds and also for pest mammal species.

Significant Natural Resource Areas

In many locations in the Delta remnants of relatively natural, if not pristine, habitat still remain on isolated channel islands, along a few waterways less used for recreation or navigation, or in quiet, dead-end sloughs. A total of 66 such sites were identified as "Significant Natural Resource Areas" in the *Delta Action Plan* (DAPC, 1966a). These were largely repeated in the *Delta Environmental Atlas,* although some of the specific resource sites were combined into habitat complexes (COE, 1979a). This Plan adds several sites, and describes 49 areas in Chapter 7. Most of them are mapped in detail in the COE Atlas, and generally mapped in Plates B1-8 and C1-8.

Most of the significant habitats in the Delta are water-related. However, the upland habitats on the Delta margins contain a few specific areas which are valuable because of their rarity. The Antioch Dunes are the last remnants of the Delta dune system, and support two endangered plants and an endangered butterfly population that are found nowhere else. Vernal pools on the northwest (near Rio Vista) and southwest (near Byron) Delta margins are also surviving examples of a once more widely distributed habitat type. The highly specialized plants found only in vernal pool habitats include two endangered species.

The rare, threatened, and endangered species of plants and animals that occur in the Delta region are listed and mapped in Chapter 7, along with a number of plants for which there is concern. The animals include the bald eagle, peregrine falcon, Aleutian Canada goose, salt marsh harvest mouse, San Joaquin kit fox, Lange's metalmark butterfly, thicktail chub (endangered and possibly extinct), California black rail, giant garter snake, and Delta green ground beetle.

Plants include Colusa grass, Crampton's orcuttia, Antioch Dunes evening primrose, and Contra Costa Crampton's orcuttia, Antioch dunes evening primrose, and Contra Costa wallflower (endangered); lilaeopsis (rare); and slough thistle, Delta coyote thistle, California hibiscus, caper-fruited tropidocarpum, Bolander water hemlock, Contra Costa baeria, and legenere (species of concern).

HUMAN DEVELOPMENT

The present human-inhabited Delta represents the almost inevitable outgrowth and consequence of events, activities, and settlements which have been in evidence since before the turn of the century. In some respects, the Delta appears not to have changed in 100 years. Differences between 1880 and 1980 reveal primarily the accelerated rate of development and intensity of human use which has characterized much of the Delta in recent decades.

The single most dramatic human action which modified Delta fish and wildlife habitats was reclamation. The second major action which has had significant influence in the Delta is the conveyance and diversion of water from upstream sources through miles of waterways, and export for diverse and often distant consumers. Other developments and uses have followed a logical sequence revolving around two major activities: farming and urban settlement, each with its closely allied facilities and land and water uses.

Managed Water and Flood Control System

Water management, particularly the export of water, is not central to this Plan. However, an investigation of human influences on Delta wildlife habitat should begin by recognizing the Delta's role as California's "water wheel," and the need to manage volume and quality of water.

Inflows, Withdrawals, and Outflows

Physical changes brought about by human manipulation of the Sacramento and San Joaquin River systems have profoundly affected the inflow, outflow, and distribution of flows within the Delta. The average annual natural inflow that once reached the Delta and San Francisco Bay (27,000,000 acre-feet, or almost 9 trillion gallons) has been greatly reduced by upstream diversions, local withdrawals, and export to the south. In the period 1922-1924, the annual inflow averaged 19,794,000 acre-feet, a 27% reduction; the current average annual flow now reaching the ocean is roughly 50% of the original inflow (Stevens and Chadwick, 1979).

These inflows, especially from the Sacramento River, are regulated by upstream storage and flood control reservoirs. Regulation serves to reduce winter flooding and augment summer flows, offsetting in part the loss of natural floodplain functions which occurred through leveeing and reclamation. Controlled releases of upstream water also help to repel the intrusion of saline waters into the Delta during summer low flow periods or following major floods, such as the Brannan and Andrus flood of June, 1972.

In addition to upstream and local users, roughly 25% of the state land area and 67% of the state population are served, at least in part, by water exported from the Delta (OPR, 1979). The exact amount exported depends on the state-wide pattern of rainfall and demand during any given period, but in most years the CVP and SWP divert 30% to 40% of the inflow. With local consumption, diversions from the Delta have exceeded 80% of the inflow (Stevens and Chadwick, 1979; OPR, 1979).

The amount and distribution of present freshwater flows in the Delta depend on these inflows, exports, and local withdrawals. Near Walnut Grove, both the Delta Cross Channel and Georgiana Slough divert waters east and south from the Sacramento River to Snodgrass Slough, the Mokelumne River, and the San Joaquin River. The Delta Cross Channel can be closed off and is operated to maintain channel flows as well as to facilitate exports to the southern Delta export pumps. Other substantial withdrawals for central California export are made by the Contra Costa Canal, South Bay Aqueduct, and Vallejo pipeline. The proposed North Bay Aqueduct would also export water out of the northwestern Delta.

Concept of a Peripheral Canal

Most of the Delta inflow comes from the Sacramento River in the north. Operation of the storage reservoir and pumping facility for the export systems in the southwestern Delta pulls in Sacramento River water, causing reversal of flow in channels in the southern and western Delta and increasing current velocities in the eastern and central Delta. These reverse flows and increased velocities disrupt the behavior and movements of anadromous fish, their larvae, and food organisms, and have caused significant damage to Delta fisheries.

Construction and operation of an isolated transfer facility has been proposed for many years as one means of facilitating the export of water to the SWP and CVP while at the same time eliminating such problems as reverse flows and high current velocities. The Peripheral Canal was conceived as the most likely project to divert water from the north Delta and transport it around the eastern periphery to the pumping facility at Clifton Court Forebay near Byron for export to the south (See also Chapter 5: Relationship of the Peripheral Canal to the Future Delta).

Other less costly options for delivering export water to the pumps which at the same time counter salinity intrusion have been studied, including a salinity barrier in the vicinity of Chipps Island and Carquinez Strait. These were rejected because of their adverse impacts on the Delta fishery resources. A range of nonstructural alternatives to the Peripheral Canal are also under study. These include reducing exports, conservation, water pricing reform, and groundwater management (NMFS, 1980).

Agricultural Uses

Agricultural irrigation and the periodic flooding of fields for leaching of accumulated salts, pest control, or wildlife habitat management create the most significant demands within the Delta for water withdrawals. The amounts of water used locally vary with the types of crops being grown, the time of year, the weather, and other factors. Average annual withdrawals for agricultural purposes, including seepage as well as pumped water, have been estimated at 980,000 acre-feet, most of which is used in the summer (June-September) (ACWA, 1976). Because most agricultural lands in the Delta are below sea level, constant subsurface seepage requires continual drainage and pumping through an elaborate system of ditches and siphons to maintain a desirable water table elevation in the island interiors (See Chapter 4).

TABLE 3 **Population of Delta Counties**

COUNTY	1960 1/	1970 1/	1975 1/	1980 2/
Contra Costa	409,030	555,805	583,400	646,100
Sacramento	502,778	634,190	687,300	776,700
San Joaquin	249,989	289,564	298,000	325,000
Solano	134,597	171,815	185,100	227,900
Yolo	65,727	91,788	100,500	111,000

Sources: 1/ Department of Finance, Population Research Unit. Census data.

2/ e-150 projection

Flood Control Projects

Authorized flood control projects affect the Delta in varying degree. These projects, summarized below, are usually constructed by the federal government in concert with local and State agencies. Environmental aspects are coordinated with Department of Fish and Game and Fish and Wildlife Service.

- *Sacramento River Flood Control Project.* First authorized in 1917, the project includes a series of levees, overflow weirs, leveed bypass floodways, pumping plants, and enlarged channels both north and south of Sacramento. The major work has been completed.

- *Sacramento River Bank Protection Project.* This project also extends north and south of Sacramento, involving mainly the addition of riprap (rocking) to project levees from bank erosion. Riverside recreation facilities are also provided at selected locations.

- *Morrison Creek Stream Group Flood Control Project.* A reservoir would be built on streams which feed the ecologically important Beach and Stone Lakes Basin in Sacramento County. Levees (26 miles) and "channel improvements" (66 miles) would lead to a 7,800-acre flood-retardation basin in the Stone Lakes area. The basin is an integral part of the project plan, and would be purchased by the Federal Government for use as a National Wildlife Refuge and for recreation in addition to its basic flood control purpose. Preconstruction planning was funded and began in fiscal 1980.

- *Lower San Joaquin River and Tributary Flood Control Project.* This work involved constructing or improving levees, removing snags, and riprapping streambanks. The major work has been completed.

Urban Centers and Population Growth

While land use patterns in the Delta have not changed drastically since the end of reclamation in the 1930's, and agriculture continues to dominate, considerable urban growth is apparent in and around the region. The population of the Delta was estimated to be about 250,000 in 1976 (Resources Agency, 1976). Population figures from 1960 through 1980 for the five Delta counties, Contra Costa, Sacramento, San Joaquin, Solano, and Yolo, reveal that they are, for the most part, undergoing continued growth (Table 3). Figure 15, Chapter 5, shows the present urban pattern in the Delta as well as the currently authorized urban growth areas.

No major cities are located entirely within the Delta; however, Delta boundaries touch upon Sacramento and include a large portion of Stockton. Smaller incorporated cities within the Delta include Antioch, Pittsburg, Isleton, and Rio Vista, as well as about ten unincorporated towns and villages. It is possible that new developments like Discovery Bay might expand into communities. To the west, the Delta opens into San Francisco Bay and the heavily populated Bay Area.

Agriculture

The Delta is one of the most fertile areas in the United States, and about 91% is zoned for agriculture. The 500,000 ± acres of agricultural land are composed of peat, organic sediments, and alluvium. Crops produced in the Delta fall into four main categories: field crops, truck crops, fruits and nuts, and forage crops. Historically, the Delta has been noted for its asparagus, potatoes, celery, and other varied truck crops. Recently, greater emphasis has been placed on field crops — corn, milo, grain, and hay. A grape and wine industry is growing, especially in the Lodi area.

Among these types, field crops provide the greatest benefit to wildlife, particularly migrating waterfowl. In recent years, the acreages devoted to raising truck crops have decreased considerably and been replaced by field crops. While

the crop patterns have varied with the agricultural economics of the periods, the percentage of area cropped has remained fairly stable, at about 75% of total land (ACWA, 1976).

The major issues which face Delta agriculture and indirectly influence maintenance of wildlife habitat are discussed in Chapter 4. Among these are the determination of crop selection, economic farming and levee management practices, and general viability of maintaining lands in agricultural production. Behind these lie a number of persistent problems:

- *Land Tenure.* With increasing absentee landlords, there is less concern with maintaining the high original fertility. As a result, the land is "mined" without consideration for maintaining its fertility.

- *Drainage and Subsidence.* Lowering of the land surface in the islands has increased the hydraulic pressure from the surrounding channels, with a corresponding increase in seepage and costs for drainage pumping, and in risk of levee failure (See Chapter 4).

- *Soil Salinity.* Frequent leaching is required to maintain suitable growing conditions for salt-tolerant crops. As the lands subside, the cost of maintaining the quality of soils increases (see Chapter 4).

- *Fertility Problems.* Although peat is rich in nitrogen, other nutrient problems are often inherent in peat soils. Phosphorous and zinc deficiencies are typical, and potassium deficiency is apparent in a number of locations.

- *Transportation.* Movement of produce can be difficult because of the limited roadway system and increasing costs of shipping.

- *Labor Problems.* In recent years, agricultural labor has played a significant role in the determination of types of crops within the Delta. Labor-intensive crops are being displaced by capital-intensive crops, *e.g.* asparagus by corn (ACWA, 1976).

- *Recreation.* Increasing trespass and vandalism by recreationists throughout the Delta are causing crop damage and losses.

- *Water Costs.* The free use of Delta water may be changed by the Legislature in the future to offset costs of export pumping.

Transportation Facilities

The major road system is Interstate 5, which flanks the eastern Delta between Stockton and Sacramento. Although it is the principal north-south interstate route in the western United States, the missing Delta link was not completed until October, 1979. Other freeways outside the region provide easy access for visitors from all areas.

Only two state highways traverse the Delta from east to west: Highway 4, from Stockton to Antioch in the south Delta; and Highway 12, through the central Delta from Highway 99 through Rio Vista to Fairfield. From north to south, State Highway 113 links Interstate 80 with Highway 12 west of Rio Vista, and the Sacramento River Road (Highway 160) traverses the length of the Delta from Sacramento to Antioch. Several railroad lines cross the Delta, owned by the Atchison, Topeka and Santa Fe, Southern Pacific, and Western Pacific Railroads.

Two deep water channels bring ocean-going vessels to the Ports of Sacramento and Stockton. The Sacramento River Deep Water Ship Channel Project extends from Suisun Bay to Sacramento. The channel was formed by widening and deepening the natural channel of the Sacramento River and Cache Slough, and by excavating a new channel from a point 6 miles upstream from Rio Vista to Lake Washington at the northern terminus of the project in Sacramento. The project includes a harbor and turning basin at Lake Washington, and a connecting barge canal with navigation lock from the harbor to the Sacramento River. Commodities requiring both deep and shallow-draft vessels are moved on these waterways.

A feasibility study of deepening the existing 30-foot channel was begun by the U.S. Army Corps of Engineers in 1970, followed by a Draft Environmental Impact Statement in 1979. A final feasibility report was scheduled for release in summer, 1980. Some questions which are being resolved are the project's potential to increase salinity intrusion into the Delta, and mitigation of adverse impacts of spoil disposal. Modeling studies following authorization are anticipated in a Memorandum of Agreement between COE and DWR.

The 40-mile-long Stockton Deep Water Ship Channel and the Port of Stockton were both completed in 1933. Between Antioch and the Port of Stockton, the ship channel generally follows the route of the San Joaquin River, except where bends in the river required the channel to be straightened by cutting the tips off the larger islands and bisecting some smaller ones. In 1965, deepening of the navigation channels between the Golden Gate and the Port of Stockton was authorized by the Congress. The port facilities at Stockton handle conventional general cargo in both foreign and domestic trade and local LASH barge service between Stockton and the Port of San Francisco.

The Stockton Deep Water Ship Channel Project is part of the overall John F. Baldwin Channel, and provides for the deepening of the existing channel to 35 feet. Dredged material removed for channel deepening would be disposed of at several sites along the ship channel and be used for both habitat restoration and public recreation (COE, 1980). The proposed cutoff through False River, included in the authorized plan, has been deleted from the project as too expensive and environmentally damaging compared to the river route. The project was authorized by Congress in 1965, and construction was begun in 1971, with rock bank protection placed at six locations damaged by wave wash.

However, work has been temporarily suspended pending completion of planning studies and resolution of complex environmental problems.

Dredging

Dredging and dredge disposal sites are essential to maintaining the two deep-draft channels. Each year, the U.S. Army Corps of Engineers dredges about one million cubic yards of sediment from the Sacramento and San Joaquin Rivers. Material is unloaded at disposal sites in the region. Periodic dredging is also required for maintenance of marinas, for levee repair, and for construction of new marinas. Deepening the Sacramento and San Joaquin Rivers from 30 to 35 feet will require removal of 30 million and 12 million cubic yards, respectively.

The most common method of dredging is by side-draft, long-boom clamshell dredges, which have been operating in the Delta for many decades. Hydraulic suction dredging is used for large-scale channel-deepening projects.

Industry

Industrial areas have grown up in several concentrated areas on the periphery of the Delta, proximate to transporation and available water for cooling or other operations.

- *Contra Costa County.* The Pittsburg-Antioch area is part of an industrial corridor which extends almost unbroken along the west and south shores of San Pablo and Suisun Bays from the City of Richmond through Antioch. Industries located there (about 65) include steel, chemical, rubber, paper and fiberboard, glass, food, building material, and raw material processing facilities. Major electrical power plants also are located in the area, and six major oil refining facilities are sited along the Contra Costa County shoreline.

- *East Yolo.* Most industries in the northern part of the Delta are situated across the river from Sacramento City, in the East Yolo portion of Yolo County. About 2,000 acres in East Yolo are zoned for heavy and light industry, with more than 20 square miles of potential industrial land south of the Port of Sacramento and east and adjacent to the Sacramento Deep Water Ship Channel. The East Yolo General Plan (1976) calls for phased industrial and residential development on most of this land. About 20 manufacturing plants are located in the East Yolo area, including facilities for food processing and manufacture of wood, paper, and metal products. The Port of Sacramento is a major industry. Several trucking terminals are associated with it.

- *Solano County: Collinsville-Montezuma Hills.* A large industrial complex has been proposed in the County of Solano in the Collinsville-Montezuma Hills area, along the Sacramento River in southeastern Solano County. A PG&E coal-fired power plant has been approved for this area.

- *Stockton.* About 3,000 acres within the city limits are zoned for light and heavy industry, much of it around the Port. Manufacturing concerns in the greater Stockton area produce laminated glass, machinery, paper products, asbestos, cement products, steel-fabricated forms, food products, and ships and boats.

- *Tracy.* Roughly 1,000 acres within the City of Tracy are zoned for industry. Seven manufacturing plants are located in the City; goods produced include processed foods, aggregates, wood products, glass containers, processed sugar, reinforced paper, and business forms.

- *Lodi.* Lodi has more than 600 acres zoned for industry, and about 90 manufacturing plants are located in the area. Leading classes of products are concrete mix and piping, metal products, meats, canned fruits and vegetables, tire molds, cereals, and sportswear.

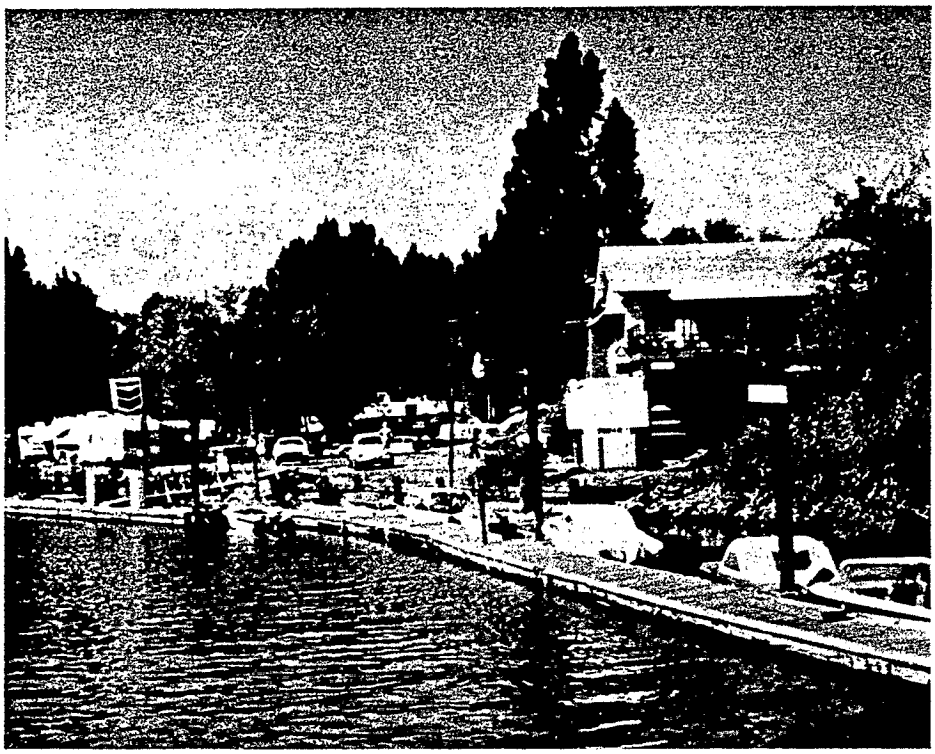
- *Rio Vista.* Four manufacturing concerns producing farm equipment, refuse containers, and natural gas are located near Rio Vista. Nonmanufacturing concerns include businesses engaged in road construction, gas and oil well drilling and maintenance, and dredging.

Agriculture-Related Industry

Agriculture-related industry can include agriculture service facilities (machinery repair shops, *etc.*), facilities to process raw agricultural products (canneries, grain elevators, *etc.*), as well as facilities to manufacture products used in agricultural production, such as fertilizer and farm machinery.

Most jurisdictions allow some agricultural industry in agricultural zones. In most cases, however, the types of industries allowed are severely restricted, and a conditional use permit is required. Usually no such uses are allowed on lands designated as "Agricultural Preserves" or "Permanent Agriculture," in order to maintain the maximum amount of land in agricultural production.

Sacramento County has developed planning standards for permitting certain agriculture-related industries to be located in rural, agricultural portions of the County, provided wastewater disposal is on land. Such uses include: fruit and vegetable canneries, slaughter and packing houses, poultry processors, breweries, malt plants, wet corn mills, beet and cane sugar refineries, wineries, distilleries, and dairy processors. One attempt to build at a sensitive Delta location was rejected, and only one area has been approved to date in Sacramento County for such a use, just beyond the Delta planning area near Elk Grove.



Recreational Uses and Developments

The Delta is, and will continue to be, a popular recreation area. It is close to major metropolitan areas, parts of it are readily accessible, and it contains one of the largest recreational waterway complexes in the western United States. Temperate climate allows almost year-round use, but the major recreation season extends from before Memorial Day through the first week of September. These factors, along with the attractive setting and the excellent sport fishery, are responsible for the Delta's constantly growing popularity and the demand there for a wide variety of recreational services.

Recreation in the Delta can be grouped into water-dependent and land-dependent uses. Boating is the major water-dependent activity and most recreational activities relate to it. The exceptions are: car touring, bank fishing, camping, swimming, picnicking, hunting, hiking, and sightseeing/photography. Fishing from banks and boats accounts for over 60% of all activity (Resources Agency, 1976).

About 140 marinas and related facilities in the region offer a variety of services and supplies, such as boat docking and repair facilities, restaurants, grocery stores, equipment rentals, and overnight accommodations (cabins, trailers, motels, and camping sites).

Mobile home subdivisions are being developed at marinas, largely for weekend and summer use. They typically include such facilities and services as community parks, swimming pools, adjacent restaurants and bars, ample auto parking, landscaping and lawn maintenance, and frequently sewer lines. These trailer and mobile home parks for vacationer/semi-permanent residents are also becoming places of primary residence. The largest example is at Terminous, San Joaquin County, which is a non-conforming use under present zoning (Keranen, pers. comm.).

Public facilities and parks are still of minimal significance in actual land and water area in the Delta. Existing facilities include:

- Brannan Island State Recreation Area
- Clifton Court Forebay
- Franks Tract and Little Franks Tract
- Two bank fishing sites and one fishing pier (Antioch) developed by the Wildlife Conservation Board (WCB)
- Hogback Island Park (5 acres), jointly constructed by the Corps of Engineers and the State as part of the Sacramento River Bank Protection Project. Similar features have been constructed on Georgiana Slough and at Garcia Bend.
- Lower Sherman Island Wildlife Management Area; WCB boat ramp
- South Spud Island County Park, San Joaquin County
- Clarksburg boat ramp — WCB
- Oak Grove Regional Park, at intersection of I-5 and Eight Mile Road

A recreation area on Roberts Island is proposed as part of the Stockton Ship Channel improvements, and on Sandy Beach as part of the Sacramento River Ship Channel improvements. Several parks which were authorized in the Delta have been eliminated or delayed for budgetary or political reasons. The Delta Meadows Park (Sacramento County) was authorized in 1954, but still has not been acquired due to the State Lands Division's difficulty in determining existing State ownership. The Cosumnes State Park (Sacramento County) was authorized in 1974 and deleted from the budget in 1977.

Older River Islands State Park (San Joaquin County) was authorized in 1954. The money that had been budgeted was transferred for use in development of Durham Ferry State Recreation Area, downstream of Durham Ferry Road on the east side of the San Joaquin River. The State recently approved the development plan for that site. Channel Island State Park (Sacramento and San Joaquin Counties) was authorized in 1974, but lingers until State-ownership questions are resolved.

The popularity of the Delta for recreation depends heavily on the maintenance of fish and wildlife habitat, in part because vegetation and wildlife confer on the Delta its characteristic aesthetic quality, in part because vegetation provides shelter to boaters and other recreationists, and in part because the habitats sustain fish and game which are caught and consumed as an essential part of the recreational experience.

Mining, Harvesting, and Extraction of Delta Resources

A variety of consumptive uses occur in the Delta which have less impact on habitats than the preceding developments:

- *Commercial Fishing.* The only significant commercial fishery within the Delta today is for crayfish. A small carp and splittail fishery also exists. The commercial taking of striped bass was halted in 1937, and the taking of salmon ended in 1957. However, up to 80% of the total California commerical salmon fishery in coastal waters is dependent on the Bay-Delta estuary for production of the resource. The crayfish catch is almost entirely frozen and shipped to Scandinavia. Excessive harvesting of crayfish led to passage in 1975 of a new law allowing the Fish and Game Commission to set regulations (Section 8491, Fish and Game Code).

- *Gas and Oil Production.* The Delta natural gas reservoir, one of the largest in the nation, makes natural gas a resource of regional and national importance. Thiry-five operating fields are located in the five Delta counties, with major fields around the Rio Vista area. Cumulative production of gas from the Delta fields now stands at about 4.1 trillion cubic feet, with gas reserves estimated to be about 1.5 trillion cubic feet at the end of 1974, compared with a reserve of 5.8 trillion cubic feet throughout the State. Delta fields can probably produce until the turn of the century. Some of the abandoned fields are being used to store imported gas. At the present time, one producing oil field is located near Brentwood in Contra Costa County.

- *Peat and Lime Mining.* Peat is mined at a few locations in the Delta (*e.g.*, Franks Tract in Contra Costa County), chiefly for horticultural purposes. Another product, lime (for sugar processing), is mined at two locations: near Tracy and Clarksburg.

- *Sand and Gravel Extraction.* Sand and gravel have been mined to a limited extent in the Delta, near Byron, Tracy, Antioch, and in Putah Creek, Yolo County. Outright loss of habitat is the principal potential environmental impact of such operations. Reclamation of excavated areas requires long-term rehabilitation plans.

IMPACTS OF LAND AND WATER USES ON DELTA HABITAT

It is unjust to attribute the entire loss or destruction of fish and wildlife habitat in the Delta to any one of these many land and water uses or to past developments which have at the same time made the Delta a desirable place for diverse human activities. Each actitivity could be analyzed to determine precisely what its impacts on habitat are and have been, and to what degree. It would be necessary also to assess the impacts of activities outside the Delta but within its large watershed. Some of the principal impacts on fish and wildlife resources are summarized below.

Water Development. Most investigations of adverse impacts have concerned water development and management in relation to the hydrodynamics of the Bay-Delta system. These investigations have been motivated largely by the economics of altering the Delta environment and by the need to solve specific engineering or environmental problems, such as:

- arresting landward saltwater intrusions;

- defining levels to which freshwater discharges can be economically reduced without harmful ecological (and economic) effects, and defining flushing flows for the Bay;

- defining dispersal characteristics of receiving waters for inflow of sewage and other pollutants; and

- defining the standards and design specifications needed for confining flood and tidal flows to leveed waterways through the reclaimed Delta.

While we have a limited understanding of some of the complexities of the Bay-Delta ecosystem, we do know from observations that major fish and wildlife losses in the Delta have resulted from changes in hydrography by impoundments and diversions, some of them long before pumping and export began; and from changes brought about specifically by pumping and export.

Urban Development. The most significant direct impacts of urban development on habitat have been those associated with reduction in the availability of land for habitat through gradual conversion of open habitat lands to developed uses, and changes to natural vegetation through its deliberate removal or abuse. For example, subdivisions such as Discovery Bay and Bethel Island are an emerging threat to open space and wildlife habitat on the Delta islands. They could become a major concern in the future if the levee system is upgraded to 100-year flood protection, thereby encouraging intensified land use. The trend toward subdivisions spreading outwards from major cities in the peripheral Delta is also apparent (See also Chapter 5).

Indirect impacts on adjacent lands and waters are an inevitable by-product as human activities intensify in growing urban areas. These are the result of many minor and major actions such as extending community support systems like water and disposing of urban waste products. For example, changes in Delta water quality have occurred in the past through pollution from a variety of industrial and municipal waste discharges. Fortunately many of these pollutant sources are being brought under control.

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Industrial Development. The relationships between industrial activity and quality of fish and wildlife habitat are many and diverse. The most obvious include encroachment on shoreline areas by industrial facilities, accidental discharge of petroleum or other contaminants into aquatic habitats, disruption of adjacent habitats by human activities, discharge of water process or cooling water into receiving water, discharge of biostimulants such as fibers, changes to local hydrology, *etc.* Industrial uses are not necessarily incompatible with maintenance of adjacent habitat, except where there is outright conversion of lands supporting wildlife habitat to industry as a developed use of the land.

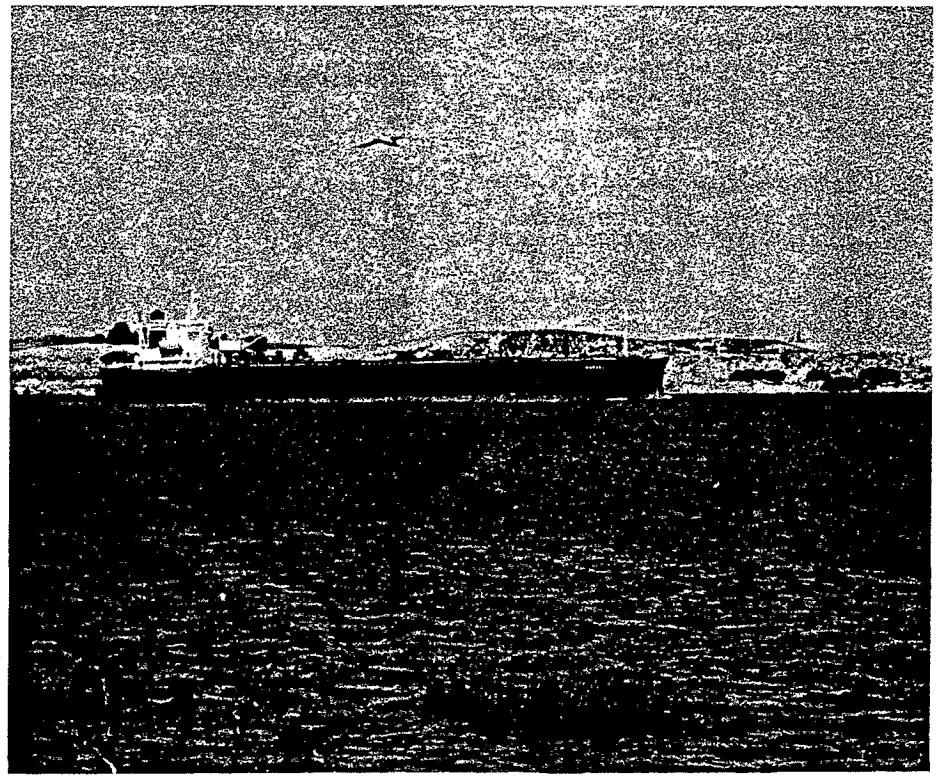
Agriculture-Related Industry. The effects of agriculture-related industry on habitats are similar to those associated with other industrial activities. However, inland locations and lesser dependence on water make agriculture-related industry less threatening to Delta aquatic and shoreline habitats. Waste products are also likely to be disposed of more effectively.

Navigation and Dredging. Changes in the use of Delta waters from natural aquatic habitats to locales for intense human commercial and recreational activities have had a significant effect on both aquatic, marsh, and riparian wildlife habitats. Transportation by water has a greater potential effect on fish and wildlife habitat in the Delta than modes of land transport. Commercial navigation carries with it the risk of accident and potential discharge of toxic materials or other contaminants. In addition, availability of convenient water transportation may encourage industrial expansion into the lands which are presently undeveloped.

Dredging has been an essential and continual activity in the Delta. Levee construction, repair, and maintenance depend on dredging, and shipping and flood control channels were constructed and must be deepened and maintained by dredging. Environmental impacts of clamshell dredging, the most common type of dredging on aquatic habitat, are generally local and short-term, although sediments are dispersed throughout the water column for the duration of activity. Hydraulic suction dredging, used for large projects, increases turbidity only at the bottom. In both cases, bottom (benthic) mud-dwelling communities are destroyed for varying periods of time. Recent studies have shown that for periodically disturbed benthic communities, such as those in ship channels, recovery from deepening may take as little as 3 months. Disturbances to stable, undisturbed benthic communities could require up to two years for full recovery (COE, 1980b).

Several other types of impacts can be attributed to dredging and channel deepening projects:

- Land disposal and storage of hydraulic suction dredge spoils poses some environmental problems, due to the fluid nature of the material. The drying time for spoils is one to two years, during which the material is confined by levees (COE, 1979b) and essentially unusable.
- Dredging in the Delta has had an impact on small channel islands, which serve as convenient "borrow" areas for emergency levee repair.
- Increasing channel depth by dredging may lengthen the longitudinal mixing zone of saline and fresh water, causing slight increases in dry-season and dry-year salinities in the far western Delta.



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Recreational Facilities and Activities. Ironically, recreational facilities and activities, which are enhanced by the presence of vegetation and fish and wildlife habitat, bear a large share of the responsibility for past and present destruction of or damage to vegetation and habitat in the Delta. Uncontrolled intensive recreational use presents the most serious threat to the habitat values of channel islands, through both disturbance to wildlife activity and modification of habitat conditions by vegetation removal and wave erosion of islands from excessive boat wakes. The loss can be attributed to several causes:

- the spread of living areas and other facilities associated with marinas over levees and other land areas, to the detriment of habitat;
- encroachment of many individually minor but cumulatively major structures into waterways and shorelines;
- conversion of biologically productive wetland habitat to less productive open water marina basins;
- cumulative damage to marsh and riparian vegetation on otherwise isolated islands by boaters' recreational use of islands; and
- levee-eroding waves from the wake of larger boats, which necessitate replacement of vegetation by rock revetment. Recreational boat wake has been a significant contributor to levee damage in the past few decades.

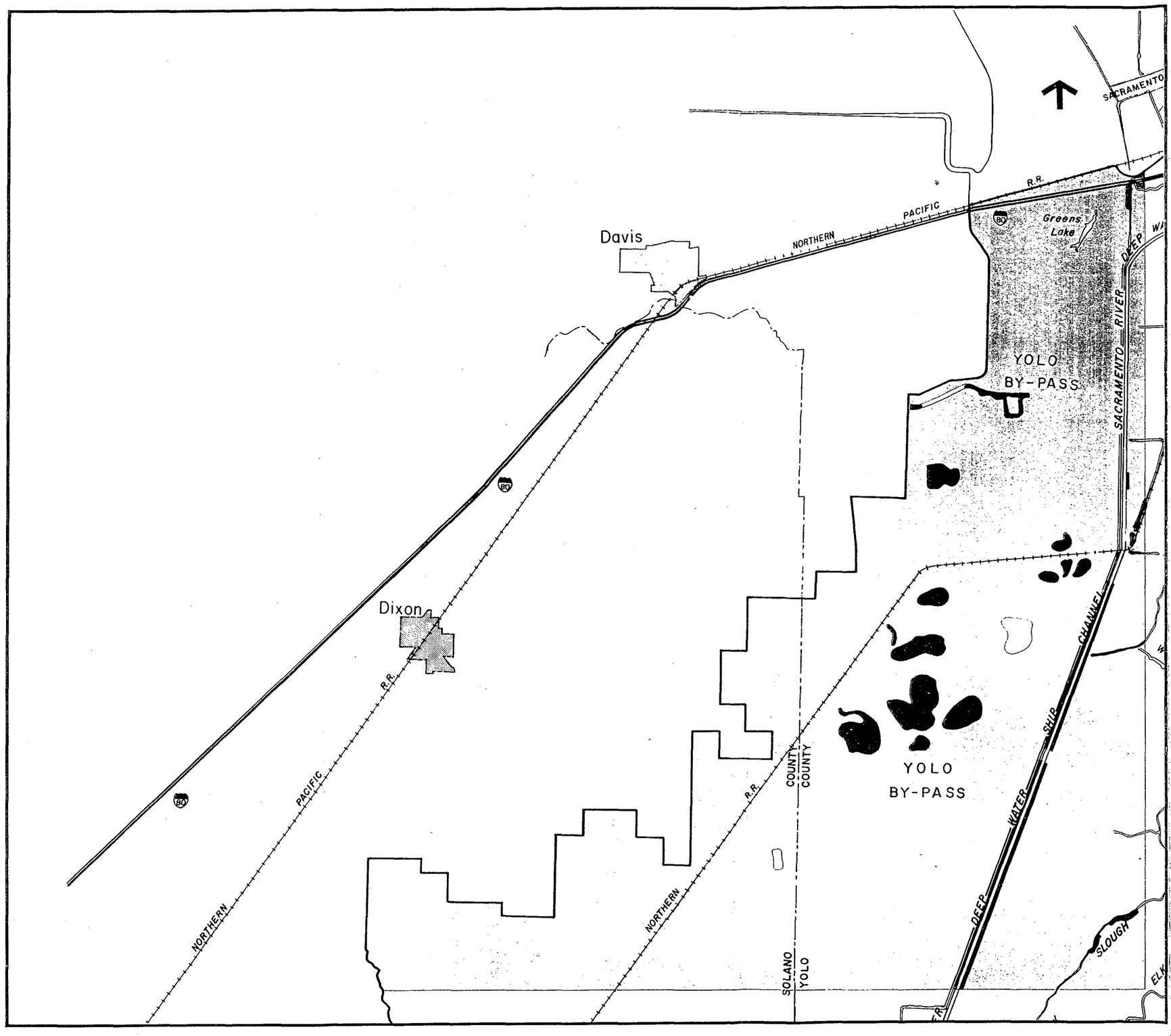
Other adverse environmental effects of recreation on habitats that have been observed include (DRMP, 1976):

— noise and activity which frightens sensitive wildlife species;
— trampling and destruction of vegetation;
— occasional vandalism and animal destruction;
— litter accumulations which can injure fish and wildlife;
— occasional uncontrolled fires (including peat) from campfires, careless smokers, ORVs, and arsonists; and
— localized and increased traffic and air pollution into natural areas.

Agriculture. The relationship between agriculture and wildlife habitat is discussed in detail in Chapter 4. In general, the maintenance of agriculture as the predominant land use in the Delta can be regarded as significant in the protection of certain kinds of wildlife, notably waterfowl. Other habitats have not fared as well under prevailing farming practices. Water quality has also been affected by contaminants pumped out into Delta waterways with irrigation tailwater and floodwaters used for leaching out salts. The specific effects have not been assessed.

* * * *

In retrospect, we can acknowledge our ability to change the environment of the Delta through looking at the present accumulation of individual effects of the past decades, and hope to have the foresight to predict - and possibly to avoid - the damaging effects of incremental actions now and in the future.



Existing Habitat

- Freshwater Marshland and Riparian Vegetation
- Channels and Open Water
- Agriculture and Upland
- Urban
- Important Areas for Migratory and Wintering Waterfowl
- Study Area Boundary

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

Existing Habitat

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **A-1**

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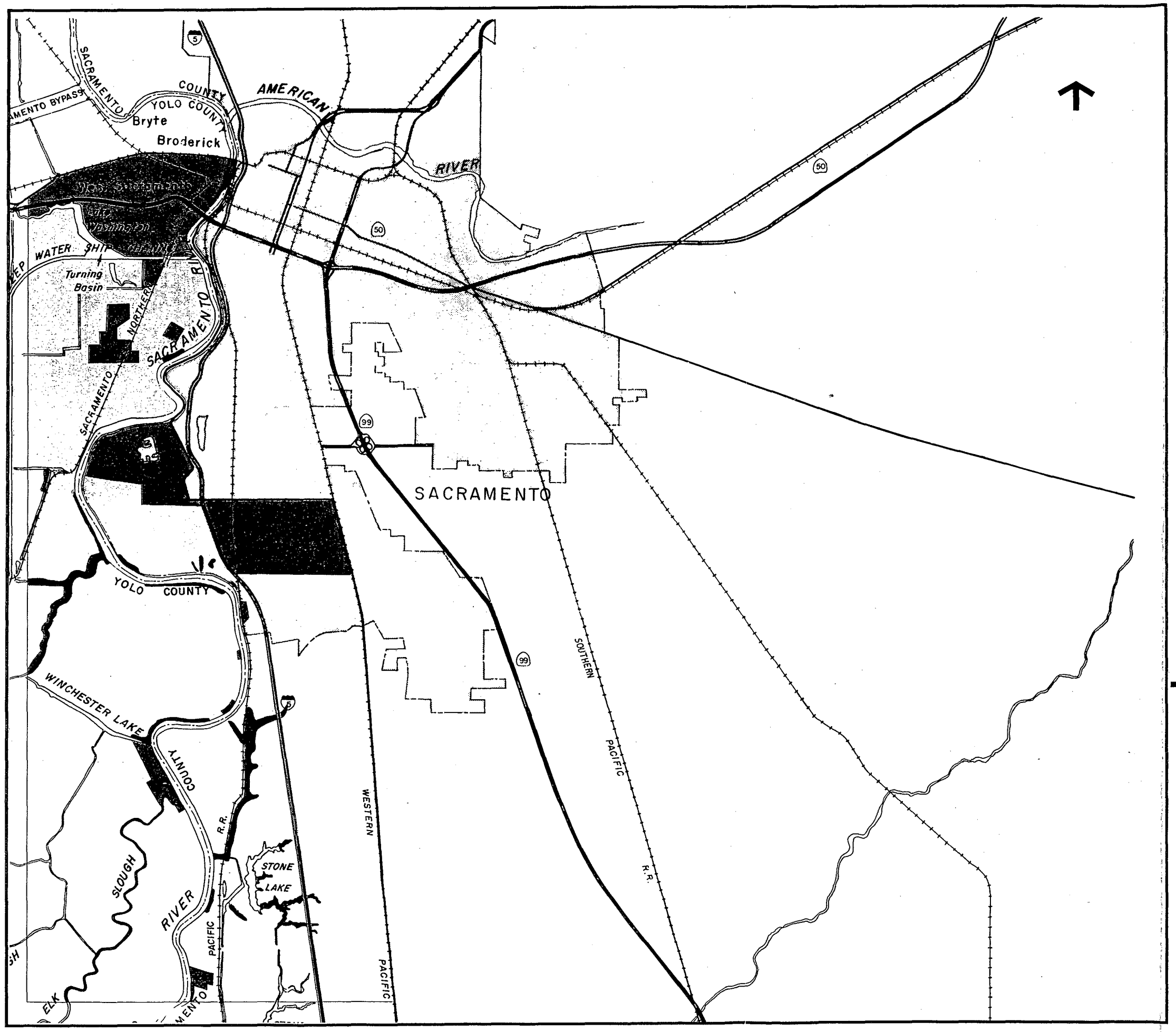


Existing Habitat

- Freshwater Marshland and Riparian Vegetation
- Channels and Open Water
- Agriculture and Upland
- Urban
- Important Areas for Migratory and Wintering Waterfowl
- Study Area Boundary

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

Existing Habitat

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

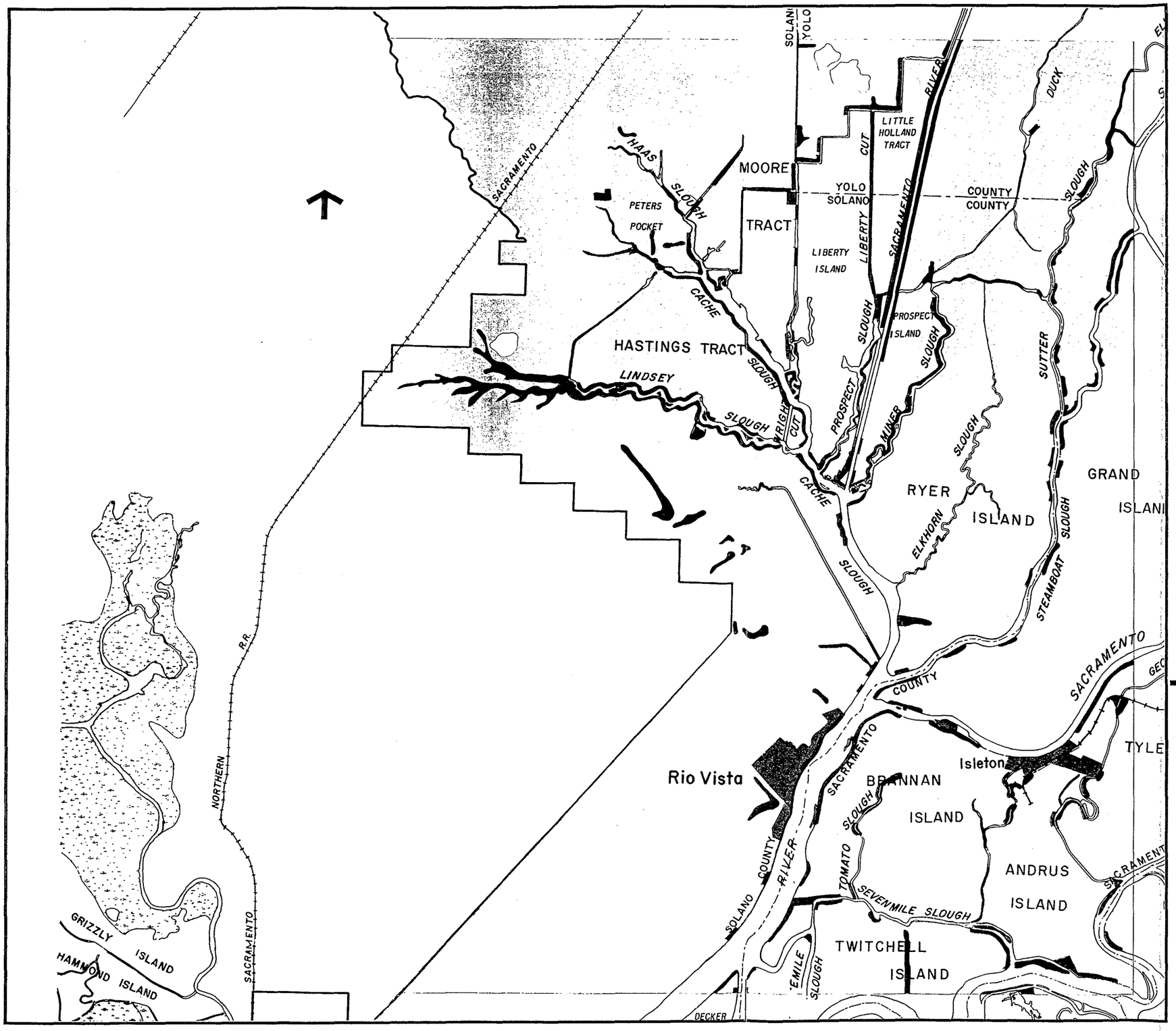
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **A-2**

C-056239

C—056239



Existing Habitat

- Freshwater Marshland and Riparian Vegetation
- Channels and Open Water
- Agriculture and Upland
- Urban
- Important Areas for Migratory and Wintering Waterfowl
- Study Area Boundary

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

Existing Habitat

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

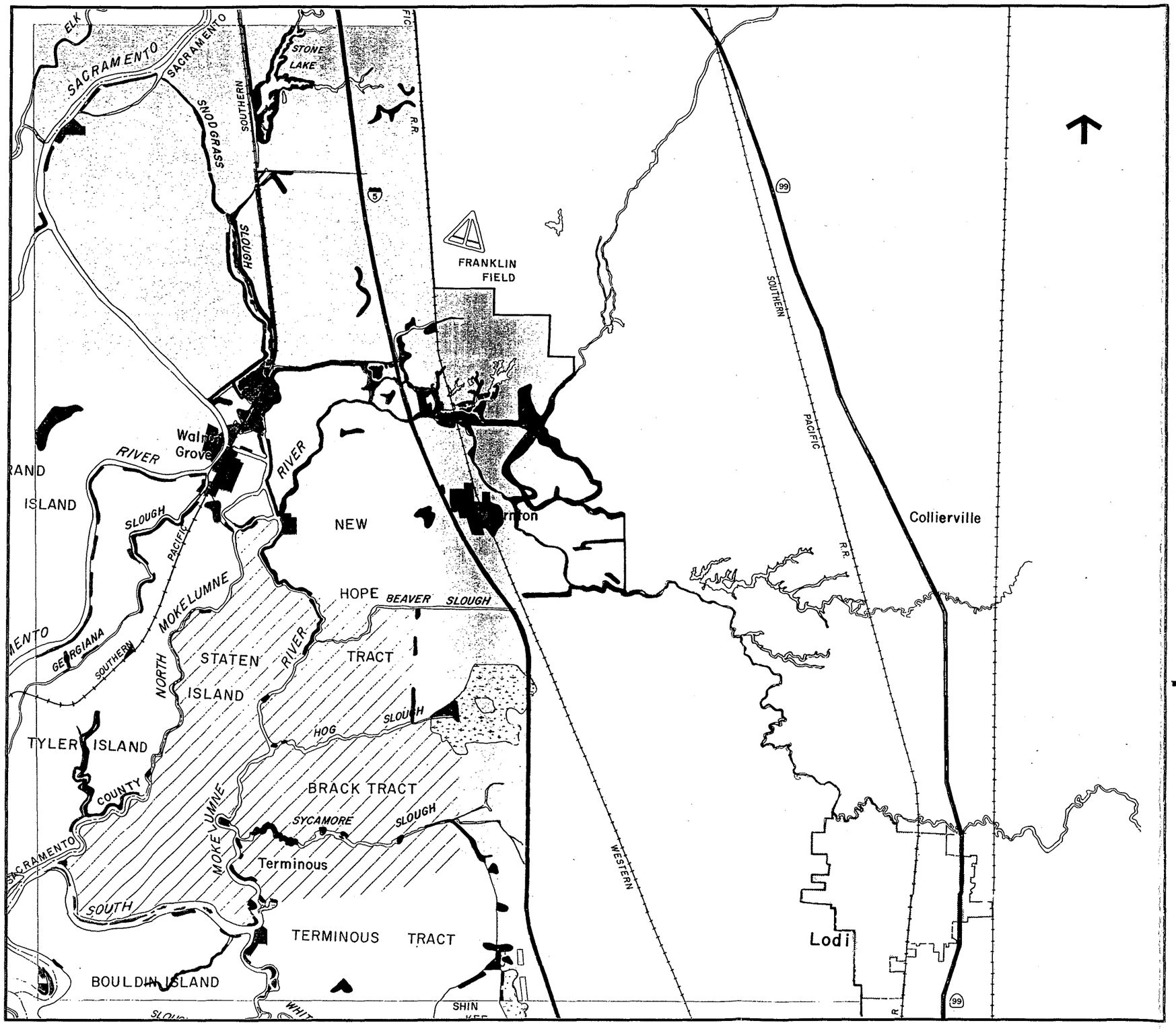
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **A-3**

C-056240

C-056240



Existing Habitat

- Freshwater Marshland and Riparian Vegetation
- Channels and Open Water
- Agriculture and Upland
- Urban
- Important Areas for Migratory and Wintering Waterfowl
- Study Area Boundary

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

Existing Habitat

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

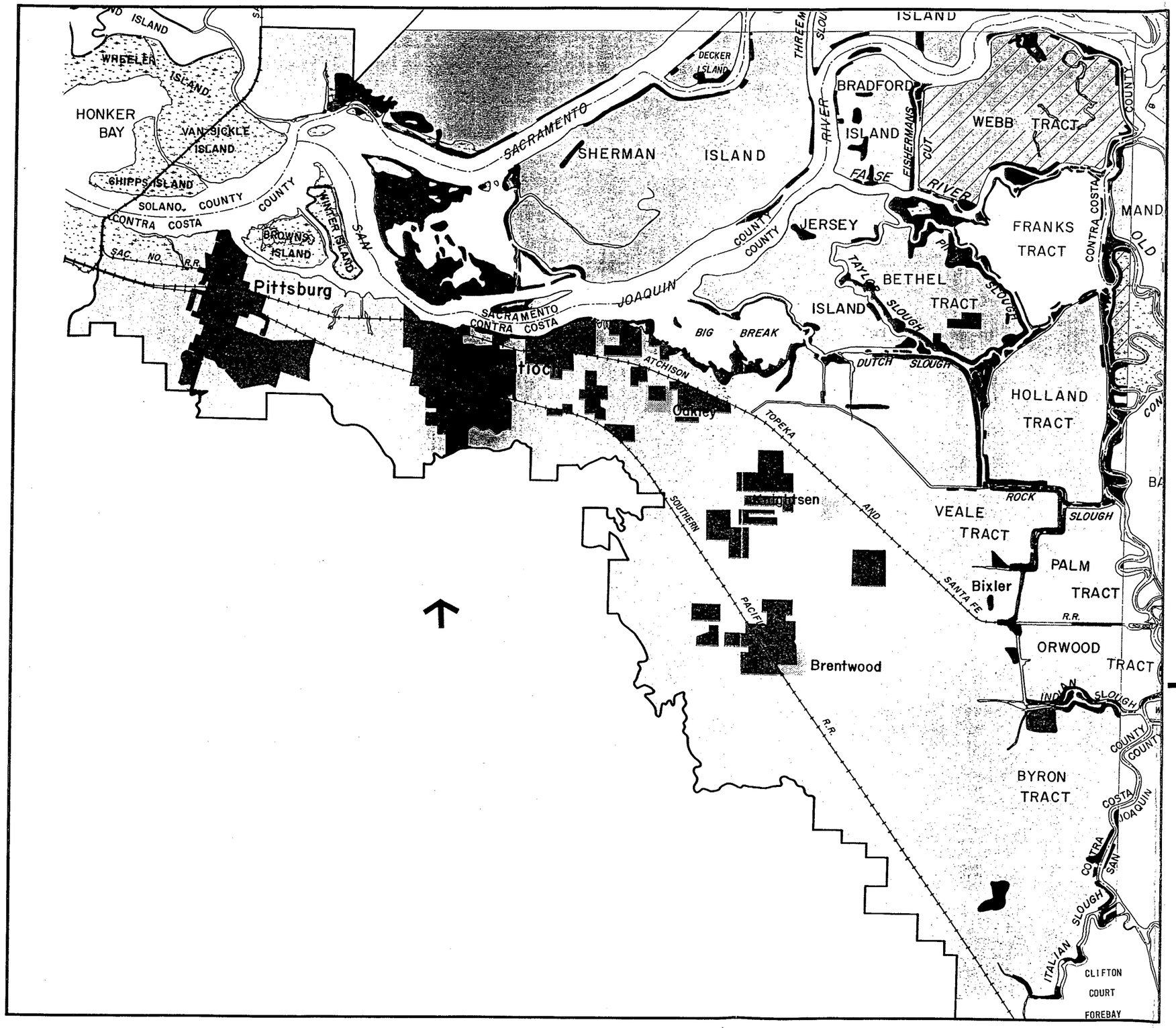
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **A-4**

C-056241

C-056241



Existing Habitat

- Freshwater Marshland and Riparian Vegetation
- Channels and Open Water
- Agriculture and Upland
- Urban
- Important Areas for Migratory and Wintering Waterfowl
- Study Area Boundary

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

Existing Habitat

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

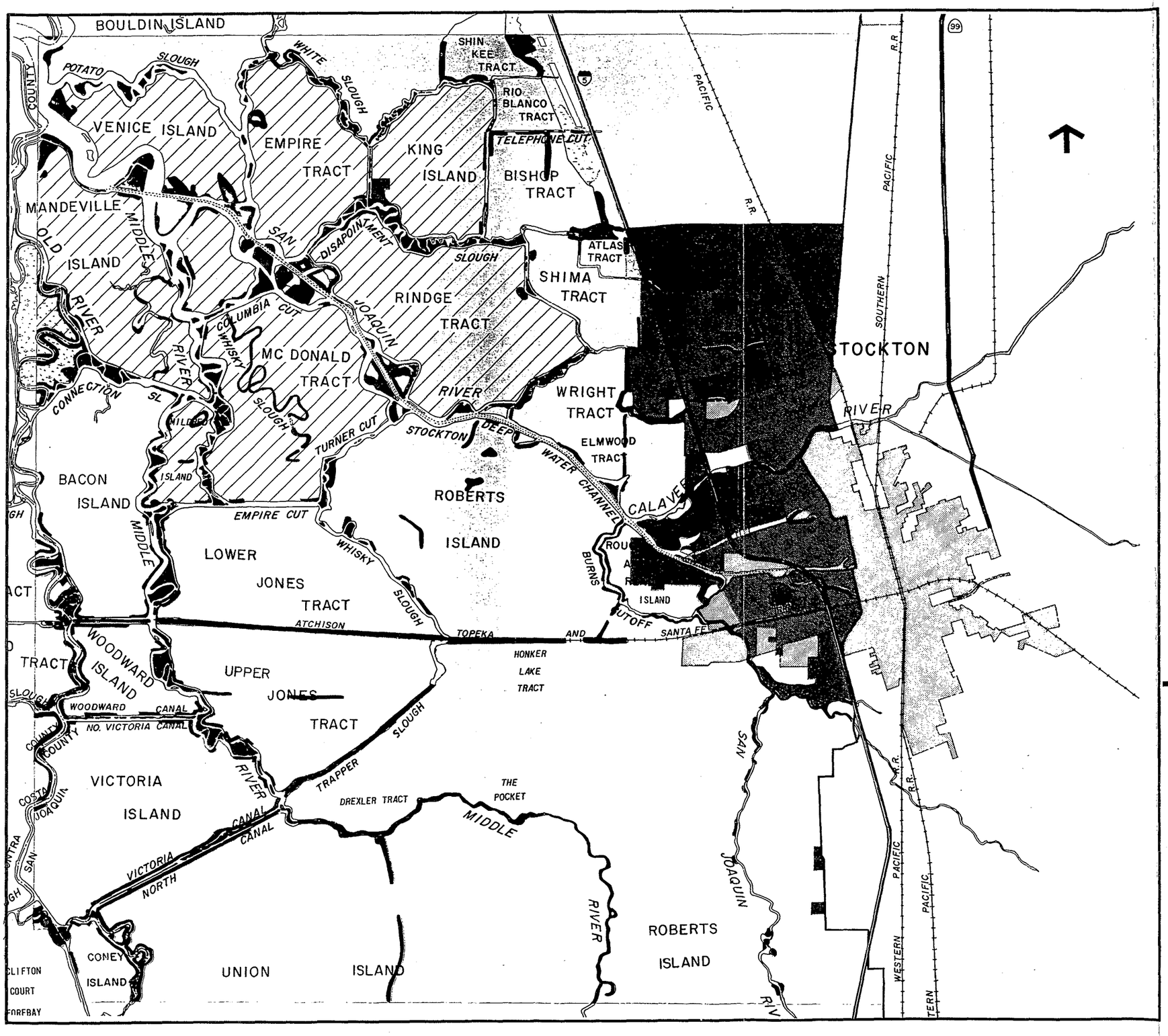
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **A-5**

C-056242

C-056242



Existing Habitat

- Freshwater Marshland and Riparian Vegetation
- Channels and Open Water
- Agriculture and Upland
- Urban
- Important Areas for Migratory and Wintering Waterfowl
- Study Area Boundary

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

Existing Habitat

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **A-6**

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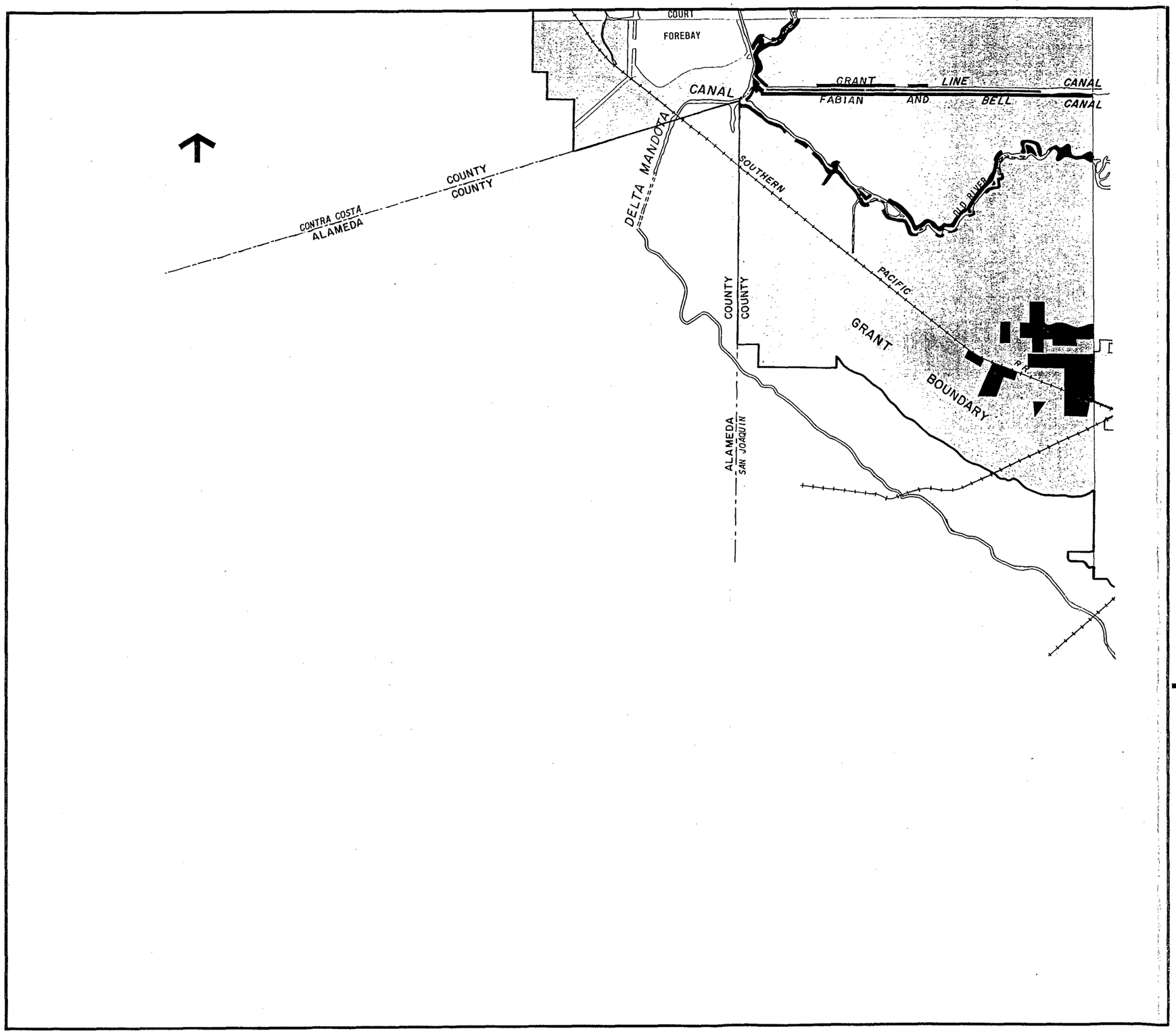

Existing Habitat

- Freshwater Marshland and Riparian Vegetation
- Channels and Open Water
- Agriculture and Upland
- Urban
- Important Areas for Migratory and Wintering Waterfowl
- Study Area Boundary

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

Existing Habitat

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **A-7**

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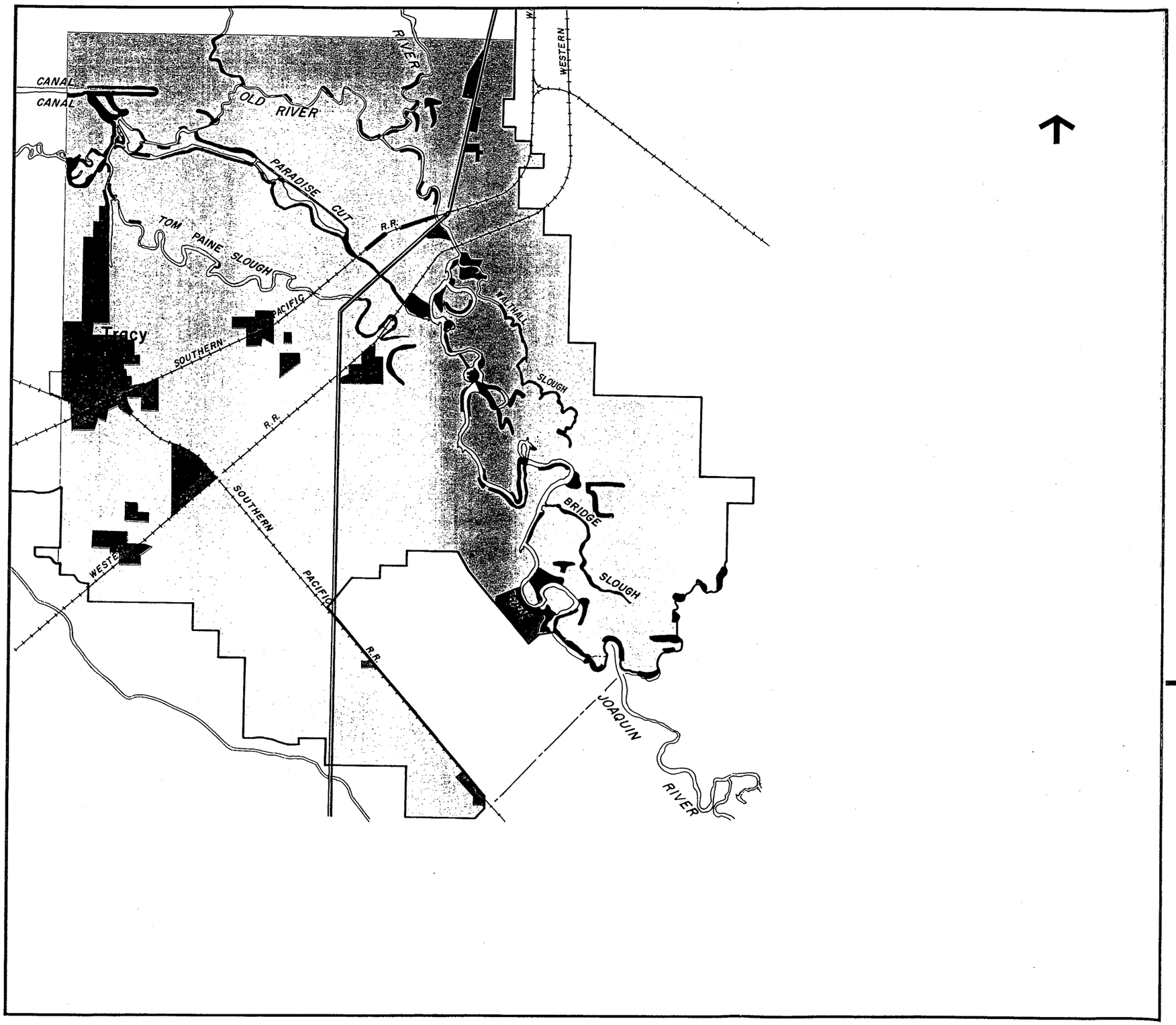

Existing Habitat

- Freshwater Marshland and Riparian Vegetation
- Channels and Open Water
- Agriculture and Upland
- Urban
- Important Areas for Migratory and Wintering Waterfowl
- Study Area Boundary

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

Existing Habitat

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **A-8**

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Laws, Programs, and Activities Affecting Delta Wildlife Habitat

3

Chapter 3 presents an analysis of the various agencies and many governmental activities which influence, directly or indirectly, natural resources of the Delta. Three basic questions guide the analysis:

- Are existing laws, regulations, policies, and practices effective in guiding resource use in the Delta?
- Are the principal agencies charged with protecting fish and wildlife, DFG and FWS, effective in guiding resource use and the decision-making processes at all levels which control that use?

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TABLE 4 Legal and Policy Framework Pertaining to the Delta

LEGISLATED POLICIES AND DIRECTIVES

State of California

- Davis-Dolwig Act of 1961
- California Environmental Quality Act of 1970
- Delta Levee Maintenance Fund, 1973
- Z'berg Project Levee Vegetation Maintenance Fund
- Fish and Game Code, Section 1600
- California Endangered Species Act of 1973
- Senate Concurrent Resolution No. 28, 1978
- Nejedly-Mobley Delta Levees Act of 1976
- Keene-Nejedly Wetlands Preservation Act of 1976

Federal Government

- River and Harbors Act of 1899
- Fish and Wildlife Coordination Act
- National Environmental Policy Act of 1969
- Clean Water Act of 1977
- Endangered Species Act of 1973
- Federal Water Project Recreation Act
- Land and Water Conservation Fund Act

EXECUTIVE ORDERS AND AGENCY REGULATIONS

State of California

- Decision 1485, August 1978, SWRCB
- Governor's Executive Order B-39-77,

Federal Government

- Principles and Standards for Planning Water and Related Land Resources
- Presidential Executive Order No. 11988, Floodplain Management
- Presidential Executive Order No. 11990, Protection of Wetlands
- U.S. Fish and Wildlife Service Guidelines for Review of Fish and Wildlife Aspects of Proposals In or Affecting Navigable Waters. December, 1975.
- Regulatory Programs of the U.S. Army Corps of Engineers
- Regulatory Program of EPA in Navigable Waters

State-Federal

- Four-Agency (DFG, USFWS, DWR, WPRS [Water and Power Resources Service] Memorandum of Agreement

INTERNAL POLICIES AND GUIDELINES

State of California

- California Fish and Wildlife Plan, 1966
- California Fish and Game Commission Resolution, February 9, 1973
- DFG Position on Delta Fishery Protection by a Delta Water Facility, November 29, 1975
- DFG Position on Delta and Suisun Marsh Wildlife Conservation by a Delta Water Facility, November, 1975
- Delta Waterways Use Program, Delta Master Recreation Plan, 1976
- Resources Agency Policy for Preservation of Wetland in Perpetuity, 1977

Federal Government

- Concept Plan for Waterfowl Wintering Habitat Preservation

- Are the criteria for evaluating resource use appropriate, and are there feasible and enforceable means to avoid or minimize future losses and restore habitat?

A fourth question underlies the latter part of the analysis:

- What major and minor changes to the existing body of laws, regulations, policies, and agency practices are possible and can be considered as potential means to improve habitat protection, assuming additional protection is necessary?

In response to these questions both general and specific solutions can be offered. This chapter presents general suggestions. More detailed options for future consideration are presented in Appendix C. Several possible courses of action are specifically recommended for implementation by the Department of Fish and Game and the U.S. Fish and Wildlife Service for the Delta. These are presented as recommendations (see Summary and Recommendations).

LAWS, PROGRAMS, & ACTIVITIES

A number of state and federal natural resource-related laws, regulations, and guidelines form the loosely coordinated legal and policy framework now in effect for the Delta, affecting in varying degree all levels of government. Table 4 summarizes these "directives." A fuller discussion is found in Appendix A.

Local Governments

Land Use Regulations

Land use management begins with general plans prepared by local governments. General plans are implemented by local zoning ordinances which regulate the use of lands within the local governments' jurisdictions. If a project as proposed does not comply with the zoning regulations, the project may be modified to comply. Alternatively, a variance, or exception to the law, may be granted or the area may be rezoned. Variances and rezoning, however, must still conform to the general plan. The general plan may also be amended to accommodate the project, but revisions are allowed only three times a year with full public notice and environmental impact review.

Once a project's compliance with the zoning ordinance has been established and the permit application along with appropriate environmental documents has been approved, the local government must issue a building permit for the proposed project. For use permits, conditions can be attached, based on results of environmental review, to mitigate possible impacts.

To evaluate land use and zoning in the Delta, the planning departments of all five counties comprising the Delta were contacted and their general plans reviewed. Although nine incorporated cities are at least partially in the Delta, their influence over wildlife habitat is minimal. Therefore, only limited review of their general plan documents was conducted.

General Plans. Local development policies, objectives, and standards are contained in the elements of the local general plan, mandated by State law under Government Code, Section 65000 *et seq*.

General plan elements which most affect protection and/or preservation of wildlife habitats are contained in the land use, open space, and conservation elements:

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

- 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 (Section 65560, Governmental Code).

All the Delta counties have adopted policies within the conservation and open space elements of their general plans or special area plans for the conservation of wildlife habitats. Policies addressing habitat protection vary significantly, often simply stating that wildlife resources (in general terms) should be protected, without providing precise guidelines and action programs.

Zoning Ordinances. Since 1971, State law has required that the adopted zoning ordinance and map must be consistent with the general plan and that every city and county adopt an open space zoning ordinance consistent with the open space element. This has not yet been fully implemented, either in the Delta or Statewide. For example, a land use designation of "River Conservation Zone" might be established on general plan maps, but not be matched by a zoning district to implement and enforce the concept.

About 91% of the Delta is zoned for agricultural use (DAPC, 1976a), which in itself provides wildlife benefits. However, any zoning can be changed in the face of development pressures. More effective than zoning in restraining urban growth in the Delta has been the level of flood protection provided by most levees, which is insufficient for urban development (see Chapter 4).

Even most agricultural zoning allows for certain uses that can have specific impacts on wildlife habitat. For instance, if a use permit is issued, agricultural zoning can sometimes allow a cannery or a marina to be constructed on a portion of the land. And, it is obvious that when a vegetated wildlife habitat is included in agricultural zoning, there is nothing to prevent the landowner from cutting down trees and brush for conversion of lands to farming uses, unless they are wetlands.

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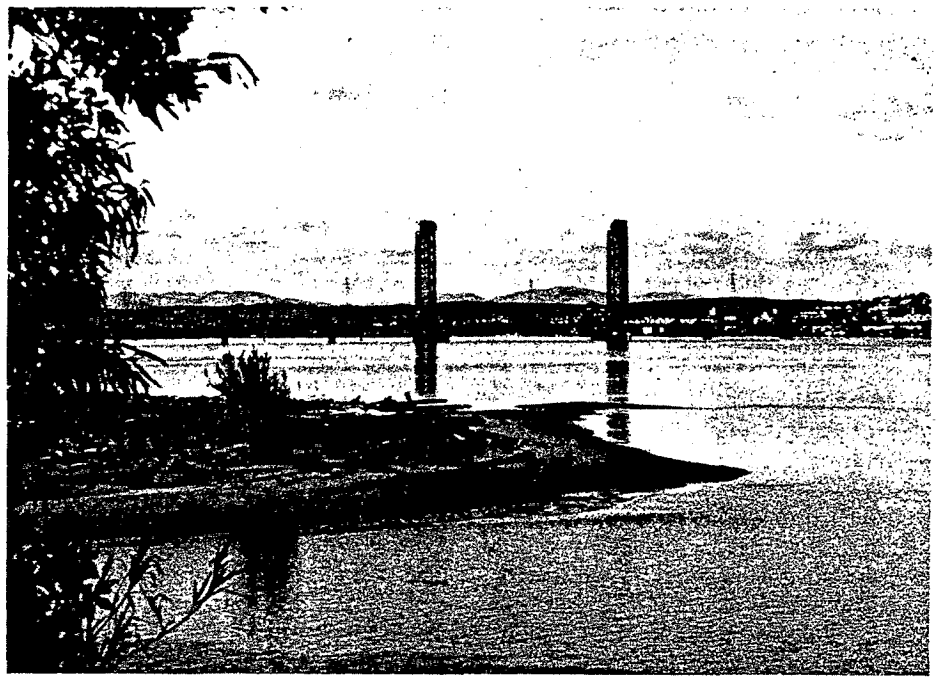

Today, there are still no comprehensive local governmental zoning tools in the Delta area that can be applied effectively against the alteration of significant resource areas.

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. Local governments are required by State law to deny tentative or final maps for developments which require subdivision of land, if the finding is made that the design of the subdivision and proposed improvements are likely to cause substantial environmental damage or substantial injury to fish or wildlife in their habitats, or that the proposed subdivision is not consistent with the general plan and specific plan elements. However, the *State Subdivision Map Act* does not clearly define either the habitats that are addressed by the Act or the studies necessary to ascertain impacts (DFG, 1979). In general, local governments have not incorporated adequate criteria or habitat descriptions into their subdivision ordinances to implement the State law.

Environmental Review Process. The *National Environmental Policy Act* (NEPA) and *California Environmental Quality Act* (CEQA) require that projects which may have a significant effect on the environment and which involve discretionary governmental action be subject to an environmental review process. The Environmental Impact Report (EIR) and Environmental Impact Statement (EIS) are the major devices used by State and federal governmental agencies, respectively, to investigate the environmental impacts of proposed projects where significant impacts and public controversy are recognized.

In California, federal environmental review is required if a federal permit is sought (*e.g.* a Corps permit under Section 10, *River and Harbors Act*), if construction is proposed on federal lands or within the jurisdiction of a federal agency, or if federal funding is involved. CEQA review enters into local planning for all projects which are either discretionary or not exempt under a variety of categories specified in the Act. For non-exempt projects, a brief initial study determines the presence and possible significance of impacts. The EIR, when required, examines the significant issues in detail.

The EIR/EIS frequently occurs too late in the planning process to permit the sponsor to fully evaluate alternatives which may be economically and environmentally more acceptable. New guidelines and regulations have corrected this problem somewhat. The process requires incorporation of mitigation measures into most projects.

A major constraint to the effectiveness of the impact assessment process statewide has been the lack of officially recognized significant resource area inventories that can be used to influence project siting and design. Since 1976, the Delta has had such an inventory, but whether such areas will be protected after they have been identified through the environmental assessment process depends upon general plan policies and implementing zoning ordinances.

Permit Controls. Local permits are often believed to provide the ultimate control over land use, but this is not entirely true. Most permits are merely "ministerial"; that is, the project sponsor need only prove that the building, zoning, and health requirements have been met and thereafter will automatically receive the needed permits. Conditional use permits, however, can be required for certain types of developments and can include special conditions, such as design review and standards. Such ordinances typically refer only to the retention of "significant vegetation" or wildlife habitat in the most general terms.

Other Local and Special Purpose Agencies

Influence over habitat also comes from other local agencies. The county agricultural commissioner issues permits for herbicide spraying to remove levee vegetation, although environmental concerns rarely influence the decision. Burning of the vegetation must coincide with approved "burn days" identified by the Air Pollution Control District. Burning sometimes must also be approved by local fire departments.

In the Delta there are about 80 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.

Another agency which can influence growth patterns is the Local Agency Formation Commission (LAFCO), which is responsible for reviewing annexation proposals. Although not an urgent problem at present in the Delta, additions of rural land to urban centers can occur in the fringe areas. Any such future decisions should include review of fish and wildlife protection policies of the jurisdictions in the proposed annexation area.

Two other special purpose agencies or special districts in the Delta are the Sacramento-Yolo Port District and the Stockton Port District. Although both ports are instrumental in advancing the major deep water channel projects (see Chapter 5), neither has a master plan identifying environmental considerations and wildlife habitat areas to be protected in their areas of influence. Such plans are especially important in that both of these districts have the ability to operate outside of local land use regulations.

Three counties - San Joaquin, Sacramento, and Contra Costa - maintain Sheriff Department boat patrol of waterways. Their principal function, besides general law enforcement and response to emergencies, is enforcement of boat speed limits where posted and in the vicinity of docks. Personnel are insufficient to be effective in controlling boat speed.

State Government

The primary state agencies affecting Delta wildlife habitat are: Office of the Secretary for Resources; Department of Fish and Game; State Lands Commission and Division; the Reclamation Board; and the Department of Water Resources. Others of importance are: State Water Resources Control Board; Central Valley Regional Water Quality Control Board; the Department of Parks and Recreation; the Office of Planning and Research; the Department of Boating and Waterways; and the Office of Emergency Services.

Office of the Secretary for Resources

The State Resources Agency 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* (DMRP, revised 1976). The Agency also responds to State Clearinghouse notices on public agency and subdivision projects. In addition, the Agency evaluates environmental impact documents for State Lands Division permits and leases. In each evaluation, the Resource Agency considers existing State policy, programs, and plans. Responses to permit applications are considered by the Corps of Engineers, the State Lands Division, and by other permit-issuing agencies.

The Agency's basic policy document for the Delta is the *Delta Master Recreation Plan*, including the Delta Waterways Use Program, which "zones" the channels into "Natural Areas," "Scenic Areas," and "Multiple Use Areas" (See Chapter 1 and Appendix B). The DMRP refers to earlier editions (1966; 1973) by observing:

> "Many of the recommendations in the plans have not been put into effect. In part, this can be attributed to the fragmented mechanisms responsible for carrying out the overall policy, the difficulty of determining the State's interest and ownership of tidal lands in the Delta, and the difficulty of obtaining sufficient funds to implement the recommendations."

The same conclusion can be made following the 1976 report. Coordination is still absent. At present there is no full-time staff person to provide an ongoing overview of all the resource and environmental problems in the Delta. An aide to the Resources Secretary includes the Delta as one in a long series of assignments. The 1976 DMRP proposed that a permit coordinator position be established, while the *Delta Action Plan* (DAPC, 1976a) proposed a "Delta Permit Forum" to streamline development review. This function has never been established. Even today there are Delta related studies and projects being conducted without the awareness of politically affected or interested parties.

In the absence of codification of the Delta Waterways Use Program, standards for waterways construction have been irregularly applied, even though the Corps of Engineers uses the program as a guide to issuing its permits. The 1976 DMRP recommended codification and determination of the "feasibility of establishing enforceable standards for restricted wake zones to protect sensitive ecological resources."

Also important to the Delta is the "Resources Agency Policy for Preservation of Wetlands in Perpetuity" (September 19, 1977), which guides other departments, boards, and commissions of the Agency and requires that they "will not authorize or approve projects that fill or otherwise harm or destroy coastal, estuarine, or inland wetlands." Exceptions to the policy may be granted if:

1. the proposed project is "water dependent or an essential transportation, water conveyance, or utility project";
2. there is no feasible, less environmentally damaging alternative location;
3. the public trust is not affected; and
4. adequate compensation is part of the project.

This policy is applied only by the Resources Agency at present.

Department of Fish & Game

Plan and Policy Base. Prior to this Delta Habitat Plan, the Department has had no specific published Delta Plan or policy. The *Delta Master Recreation Plan* strongly reflects DFG positions and needs, and the *California Fish and Wildlife Plan* (1966, now in revision for a 1981 release) states the following overall department objectives:

1. to maintain all species of fish and wildlife for their intrinsic and ecological values as well as for their direct benefits to man;

2. to provide diversified recreational use of fish and wildlife;

3. to provide for an economic contribution of fish and wildlife in the best interest of the people of the state; and,

4. to provide for scientific and educational use of fish and wildlife.

The *Keene-Nejedly California Wetlands Preservation Act* of 1976 (Appendix A) states that there "is need for an affirmative and sustained public policy and program directed at their (wetlands) preservation, restoration, and enhancement, in order that such wetlands shall continue in perpetuity..." Such a policy is found in the 1977 Resources Agency Policy for Preservation of Wetlands in Perpetuity, and has been furthered by Senate Concurrent Resolution 28 (Appendix A), which DFG has begun to implement by the preparation of a Statewide wetlands plan.

DFG Delta Study Activities. The DFG has carried out ecological research and management study programs concerning the Delta for many years. From 1961 to 1971, DFG and DWR conducted the cooperative Delta Fish and Wildlife Protection Study. Ecological studies continued under an Interagency Memorandum of Agreement (July 13, 1970) involving DFG, DWR, USFWS, and WPRS. The purpose of the agreement was to gain a thorough understanding of the ecology of the San Francisco Bay-Delta Estuary. Studies generally focus on anadromous fish, water quality, fish facilities, and Suisun Marsh. Ecological aspects of various water transfer proposals have been the object of intensive research, including the Peripheral Canal concept. DFG maintains a field office in Stockton for the conduct of their part of the Delta Study program. Annual reports of findings, *viz. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary,* have been produced through 1978.

DFG Regulatory Activities. Two DFG regional offices (Reg. 3: Yountville; Reg. 2: Rancho Cordova) service the Delta, among other areas. In addition to programs for the preservation and protection of fish and wildlife habitat, the Department of Fish and Game has specific regulatory responsibilities in the Delta. The Department enforces fishing, hunting, and trapping regulations and laws, including screening of water diversions (Sections 5980-6100, Fish and Game Code). It is responsible for the licensing of private pheasant clubs and shares in the enforcement of trespass and litter laws. The Department also has authority to regulate hunting and to conduct wildlife management programs on Lower Sherman Island and in the White Slough Wildlife Area, at present the only two DFG managed sites in the Delta.

Under the authority of Sections 1601 -1603 of the Fish and Game Code, the Department also has some control over any physical changes that require the alteration of stream beds or banks. Proposed works are reviewed by the Department for their impact on fish and wildlife. If an agreement on mitigation of adverse effects cannot be reached between the applicant and the Department, the decision is placed before an arbitration panel. This process has been applied to bank rocking (riprap) in the Delta, but is not broad enough to allow negotiation on the removal of riparian vegetation above rocking and on project levees and adjacent lands along the riverbank, where federal standards apply.

Project Review and Impact Assessment/Mitigation. DFG personnel are regularly involved in review and comment on all forms of development-related processes: State Lands permits and leases; EIRs/EISs; Corps of Engineers Section 10 and 404 permits; RWQCB Section 402 (NPDES) permits; and water project developments under the *Davis-Dolwig Act* (see Appendix A).

The Department consistently advocates the maintenance of existing fish and wildlife resources. If this cannot be satisfactorily accomplished, either project denial or approval with mitigative measures is recommended.

DFG and the State Lands Commission Permit Process: DFG has an opportunity to comment on SLC permits at both the design and project stage. Potential objections to small, relatively non-controversial projects are ascertained from DFG by the SLC staff. Comments are solicited either in verbal or written form from the regional office of DFG.

DFG and the Corps Permit Process: The federal *Fish and Wildlife Coordination Act* requires the Corps to seek comments from the "head of the agency exercising administration over the wildlife resources of the particular state" where the project is located. Through the observance of the *Delta Master Recreation Plan* policies and specific DFG/ Resources Agency comments, wildlife habitat is usually well considered in this permit process.

DFG receives the Corps' public notice via the Resources Agency. DFG comment on the project may require field checks and review by the regional DFG office and supporting environmental information to determine the magnitude of potential impacts. The DFG regional office then determines if

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there are important concerns that need to be addressed and assesses the need for mitigation of impacts. Before a permit is granted, DFG will work with the Corps, if requested, in evaluating specific mitigation measures. This review procedure is one of the most effective in which DFG (and FWS) participate. In the Delta, levee reconstruction and other Section 10 projects are investigated fairly thoroughly by the Department.

DFG and the EIR/EIS Review Process: EIR/EIS documents processed through the State or federal A-95 clearinghouse follow DFG review procedures described and evaluated in the report *An Evaluation of the California Department of Fish and Game Environmental Review Process* (VTN, 1977). The *California Environmental Quality Act* (CEQA) defines the Delta as an area of critical environmental sensitivity (Sec. 15161.6) and requires that all environmental documents on the Delta be submitted to the State Clearinghouse. Once determination of the adequacy of an environmental document (EIR/EIS) is made, DFG can cause projects to be revised or terminated only if it can convince decision-makers to do so (DFG, 1979).

DFG and Local Government Land Use Regulation: DFG and FWS usually become involved in local land use and zoning activities only when requested to by local government or other interested agencies.

Increased problems of personnel shortage, largely imposed by the recent initiatives limiting governmental activities and spending, restrict DFG from responding quickly and thoroughly to all environmental review and comment opportunities. Too often, important projects are identified too late for DFG to comment in early planning stages or to have any influence in the review process, or they are not identified at all. "No comment" by DFG appears to indicate lack of interest or lack of objection to the proposed project, when in fact it may indicate lack of time or personnel.

State Lands Commission and Division

Public Trust Lands. The State Lands Commission (SLC) has been designated by the Legislature, pursuant to the Public Resources Code Section 6301, as the State agency having exclusive jurisdiction over all ungranted sovereign tide and submerged lands and the beds of navigable lakes and streams, Statewide. The jurisdiction over these lands, which the State owns in a trustee capacity for all the people of the State, involves not only the statutory responsibilities in the Public Resources Code and specific Constitutional limitations of Article X, Sections 3 and 4 and Article I, Section 25, but the Common Law Public Trust for Commerce, Navigation, Fisheries, and other Public Purposes. (Marks *v.* Whitney, 6 C. 3d 251 (1971))

The goal of the Commission's leasing and management policy is to optimize the use of the land under its jurisdiction in the Statewide public interest consistent with environmental protection and enhancement. To the greatest extent possible, the management of State lands by the Commission is influenced by the concept of multiple land uses.

The Commission authorizes and sets fees at public hearings for the use of State lands. Equitable fair market value rental and royalty rates are assessed for use of State lands and resources. Because the uses of State lands and resources are as varied as the character of the lands themselves, the Commission has developed different approaches to setting rental rates for various types of projects in order to guarantee a fair value for the use of State lands and resources (Fukushima, pers. comm.).

The authority to sell, lease, or otherwise encumber the tidelands and submerged lands of the State in the public's behalf passed to the State Lands Commission in the 1930's, when there was pressure to develop waterfront land for commerce. More recent legislation, however, requires the Commission also to consider environmental effects. State Lands Commission permits, except those for private recreational piers, provide some revenue to the State and are valid for from 5 to 49 years. Removal of the structures when the permit has expired is required only where the State owns the land in fee. Consequently, title inventory is made to determine the extent of State fee-owned lands, and to determine the applicants authority to acquire these areas (Resources Agency, 1976).

In the SLC permit application process there are informal meetings with the applicant and DFG to discuss possible project impacts and mitigation or compensation procedures. DFG advises the SLC on selection of parcels of land that could be used for the compensation. The SLC advises DFG regarding title clearance. Conflicts of land classifications, environmental constraints, and ownership are resolved through the SLC public hearing process.

"The Commission may not approve any application affecting lands designated as environmentally significant without finding that adequate provisions have been made for the permanent protection of such lands or that the granting of the application will have no significant effect upon said characteristics." (Sec. 2962, Article II, California Administrative Code, Title 2, Division 3).

Significant Land Inventory. In 1970 the Commission was directed by the legislature to inventory, identify, classify, and protect "environmentally significant" lands under its control (Sections 6370 to 6377, Public Resources Code). In 1975 a document was released showing State lands classified as: "restricted use" (where public use must be minimized to preserve the natural environment); "limited use" (where one or more significant environmental values are present); and "multiple use" (areas which are less susceptible to environmental degradation but do possess values).

The scale of the report's maps was so small as to be of limited practical value; however, a more detailed map at a scale of 1" = 2 miles is available. The inventory process is being resumed to revise outdated and insufficient information.

There are obvious parallels in the Delta between this program and the Delta Waterways Use Program. Both have similar resource use classes or zones:

Delta Waterways Use Program	SLC Significant Land Inventory
Multiple Use	Multiple use
Scenic Area	Limited Use
Natural Area	Restricted Area

The State Lands Commission's adoption of the Waterways Use Program would add a higher level of authority to the DMRP program.

A major problem in the Delta is the continuing uncertainty of the degree of State ownership of tidal lands and lands behind levees. To research even a single channel island can require several months. At present only two State Lands staff persons are conducting this work. Even the authorized Delta Channel Islands State Park has not been implemented due to SLC inability to provide the necessary staff time.

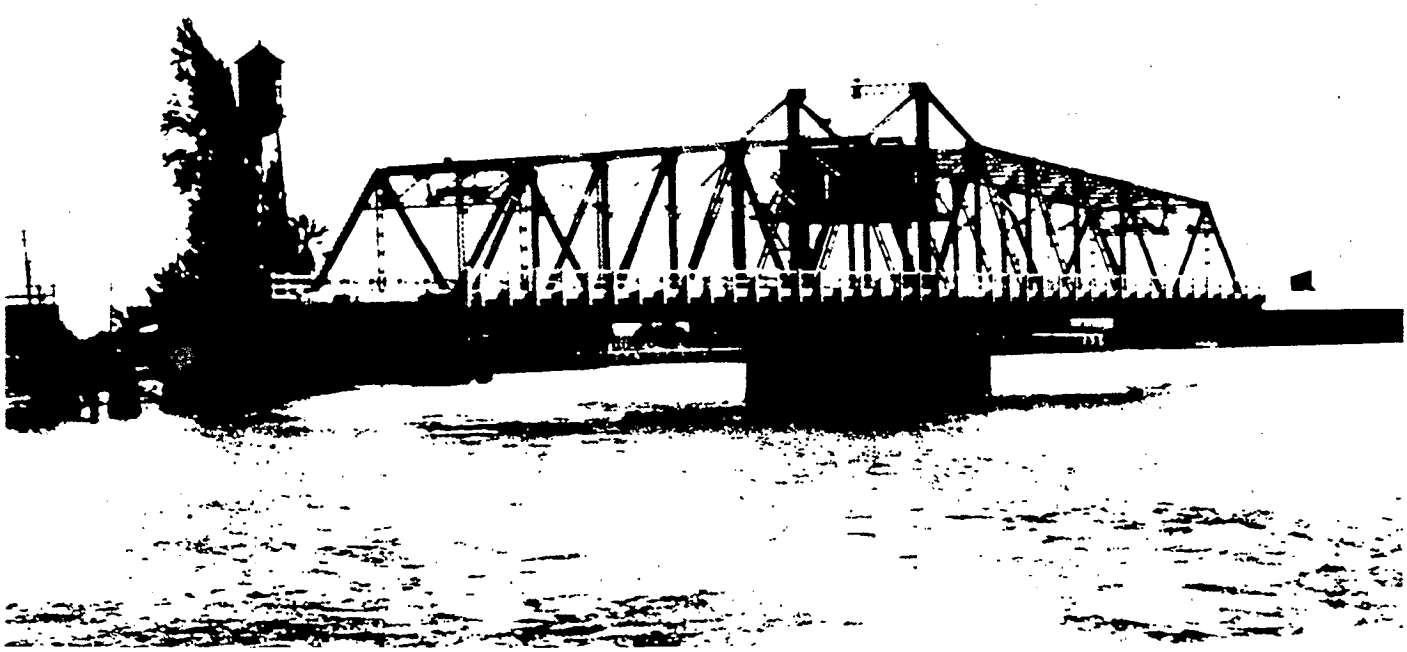
State Reclamation Board

The Reclamation Board's primary function is to participate with the federal government in the completion of federal levee and channel flood control projects. This involves providing project assurances and acquiring lands and rights-of-way for the projects. Another important function of the Board is to insure the integrity of the federally constructed levee and channel flood control systems in the Central Valley.

The Board's principal regulatory activities in the Delta have consisted of the review of any works that would have an impact on the project levees or channels. Works include – but are not limited to – marinas, gas pipelines, aerial and underground communication facilities, bridges, docks, platforms, pumps, stairways, and plantings on the levee. Approval must be obtained prior to construction. Each order contains technical conditions, which assure that the proposed work will not adversely affect the flood control works.

The Board requires the submittal of an application for approval of plans for any work affecting project levees or channels in the Delta. Since most of the Delta, especially the interior Delta, is serviced by private or local levees, and since works in this area do not as a rule affect project works, the Board exercises relatively little permit jurisdiction in the Delta.

This review authority came into a state of uncertainty with the 1977 decision at the Superior Court level holding the State of California liable for damage incurred during the Brannan-Andrus Island flood of 1972. Liability was premised on a finding of Board responsibility for advice given regarding the maintenance of a private levee. The Attorney General advised the Board to no longer accept general private levee



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work applications. Applications are accepted for work on private levees only where the work could have an impact on project levees. This policy is consistent with the appellate court reversal in 1979 of the lower court decision. The Board has ceased to issue permits or to approve plans for work over which its authority is merely advisory.

Dept. of Water Resources

The Department of Water Resources (DWR) is responsible for water supply development and delivery for the State. DWR's major concern is the delivery of water through the State Water Project's pumping facilities near Clifton Court Forebay near Tracy. Since 1959, DWR has been authorized to construct a "Delta Water Facility" - better known as the Peripheral Canal or one of its alternatives - but chose to secure specific enabling legislation to resolve a multitude of related problems (SB 200, 1980) (See Chapters 2 and 5).

DWR has been an active participant in the *Ecological Study Program for the Sacramento-San Joaquin Estuary*, since 1961 with DFG alone, and since 1970 as one of four cooperating agencies. The Delta Environmental Advisory Committee (DEAC) was formed by DWR in 1973 to assist the Department in improving its understanding of environmental concerns related to water development and the Sacramento-San Joaquin River Delta. The Committee's five major categories of concern were: 1) Delta outflow; 2) Delta transfer facilities; 3) the Suisun Marsh; 4) North Coast Rivers; and 5) Delta levees. DEAC provided valuable analyses and position papers on those five subjects to the Department (DEAC, 1977).

An important DWR interest in the Delta is its proposed levee improvement program detailed in Bulletin No. 192 (1975). DWR has proposed improvement of 310 miles of levees that surround portions of 55 islands or tracts in the Delta. Slightly more than 45 miles of levee would be improved to 100-year protection, which is considered adequate protection for urban uses. The remaining 265 miles of levee would be improved to provide 50-year protection, adequate for agricultural land use. The plan also provides for recreation facilities, improved roads, and enhancement of the environment. There would be 50 recreation access sites, of which 40 would be for fishing access. The remaining 10 would include launching ramps, parking areas, picnic facilities, freshwater supply, and sanitary facilities. The preliminary estimated capital cost of the project in 1974 was $128 million, to be shared by federal, State, and local governments (see also Chapter 4).

In 1976 the *Mobley-Nejedly Levees Act* (Public Resources Code, Section 12225) adopted this plan by reference and authorized a pilot levee program, which has not been implemented. DWR has been cooperating with the Army Corps of Engineers in a joint *Delta Levee Investigation* (see below, COE).

In conjunction with this investigation, the *Delta Outdoor Recreation Survey* was conducted and completed in March, 1980. Results of this survey will provide the basis for selecting recreation development sites and determining public recreation needs in the Delta.

State Water Resources Control Board and the Regional Water Quality Control Board

The Central Valley Regional Water Quality Control Board acts as an agent of the State Water Resources Control Board and the Environmental Protection Agency. It issues waste discharge control permits authorized under both the State's *Porter-Cologne Act* and the federal *Clean Water Act*, which allows EPA to transfer to the State is "National Pollutant discharge Elimination System" authority (NPDES permits, Section 402, *Clean Water Act*). These permits are the primary means of implementing the Regional (Central Valley) Water Quality Control Plan (1974), which, along with both Acts, establishes substantial protection of fish and wildlife. DFG/FWS receive and review notices of application for NPDES permits.

Both regional and State water boards participate in the federal and State grant funding process for wastewater treatment and disposal facilities. DFG/FWS can comment on these projects by receipt of federal A-95 notifications (see Glossary) and EIR/EISs.

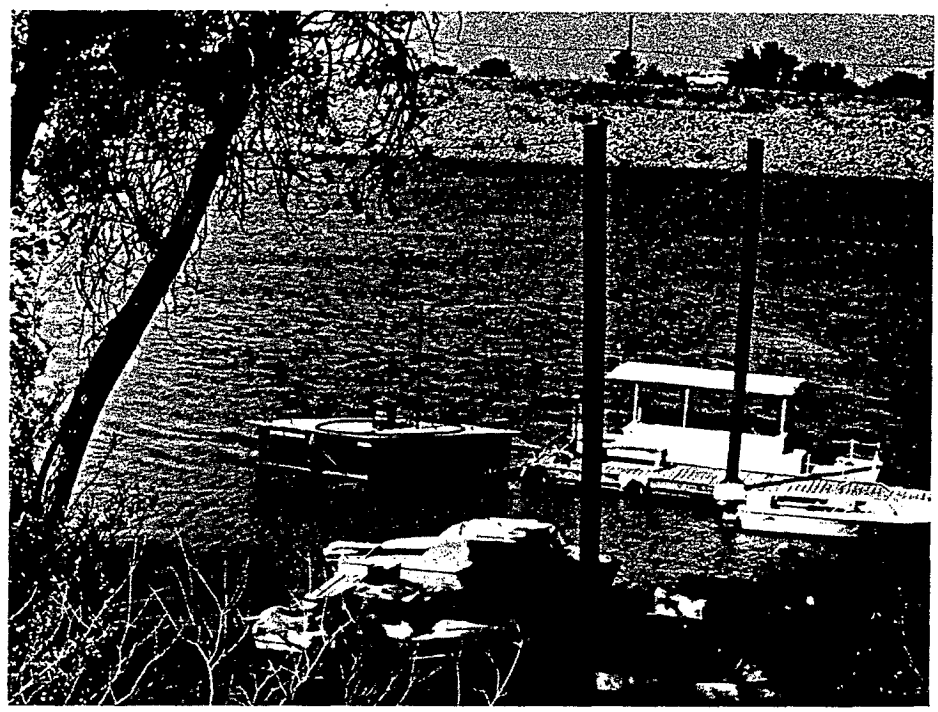
The State Board, acting in a quasi-judicial function, also reviews applications for the diversion of water from the Delta or its tributaries in order to determine the effect of the proposal on the quantity and quality of water, and the resultant effect on other uses of water in the Delta. Permits for diversion and storage of water may include special conditions that require a specific water quality and quantity.

The 1971 Water Rights Decision 1379 established water quality criteria for the Delta, particularly for salinity. These criteria, essentially unchanged, were included in the 1975 RWQCB San Francisco and Central Valley Basin Plans. Revised standards adopted in 1976 under the Basin Plans became the basis for terms and conditions for operation of the State Water Project and federal Central Valley Project in Decision 1485. D-1485 standards and criteria are far more complex than their predecessors, taking into account the differing water quality requirements of water-year types and types of beneficial uses (SWRCB, 1979). The Central Valley Project has not made a long-term commitment to comply with these standards. However, the federal government has agreed on a year-to-year basis to meet the standards.

The State Board is also chiefly responsible for implementing Section 208 of the *Clean Water Act*, the mandate to control "nonpoint" pollution - that is, those pollutants which do not reach waterways through specific discharge pipes (such as agricultural discharges and urban runoff). In the Delta area, two 208 planning agencies - the Association of Bay Area Governments (ABAG) and the Sacramento Regional Area Planning Commission - have prepared plans which emphasize erosion control through maintenance of vegetation along waterways. This program can provide an important vehicle to give much higher emphasis to the

preservation of riparian vegetation to resist streambank erosion and to filter overland runoff. In addition the 208 program can be used to develop new marshes near population centers to receive urban runoff and provide natural filtration at a minimum public cost.

A recent study of aquatic habitats in the Delta and San Francisco Bay has been initiated by the State Board with 208 funds. The two-year study will result in a management program for coordinating, monitoring, and applying research concerning pollutant effects in Delta and Bay waters.



Office of Planning & Research

The Office of Planning and Research (OPR) is in the Office of the Governor. OPR has no regulatory authority but has substantial influence in guiding administration policy and in providing guidance to local governments.

OPR has the capability to assist in developing specific planning tools, such as model general plan policies for fish and wildlife habitat protection and model programs and ordinances to implement these policies. Model ordinances which might apply in the Delta would include: density transfer ordinances; resource conservation overlay districts; floodway protection zoning districts; drainage ordinances; and subdivision ordinances as they apply to fish and wildlife habitat.

The Office has several primary functions: to provide guidance in formulating and implementing State planning law; to offer permit assistance to local governments and private and public applicants; to function as clearinghouse of CEQA documents (EIR/EISs); and to recommend policy for Statewide planning.

In addition, OPR has a limited role in monitoring local conformance with planning law to ensure that local plans and zoning are compatible, especially regarding open space (Section 65910, Government Code).

Dept. of Parks & Recreation

DPR, the primary State agency responsible for preserving significant examples of the State's landscape, cultural heritage, and recreational areas, has been able to implement only a single project in the Delta, the Brannan Island State Recreation Area. Several parks have been authorized by the Legislature; two (Old River and Cosumnes) were later dropped from the budget as local opposition and delay reduced their viability. Two more projects - Delta Meadows and the Channel Islands - remain stalemated, apparently because of the inability of the State Lands Commission to complete title determinations.

Protection of fish and wildlife habitat in the Delta is not necessarily furthered by the authorization of parks, because of the potential impact of park recreation on habitat, levees, and farming. The two authorized areas include significant habitat which would be established as "natural preserves."

Dept. of Boating & Waterways

The Department of Boating and Waterways (previously Navigation and Ocean Development) is oriented primarily toward boating. Interest in using some channel islands for boat mooring facilities led to a recommendation in the 1976 *Delta Master Recreation Plan* that the department should develop a program to acquire selected nonleveed channel islands in "scenic" and "multiple use" waterways for boater-destination anchorages. If such a program were to be developed, DFG/FWS would participate in site identification and impact and mitigation analysis.

Also of potential importance to the Department would be the development of restricted wake zones, which could be posted and enforced in sensitive habitat areas. The *Delta Master Recreation Plan* includes the recommendation that appropriate standards be codified in the Harbors and Navigation Code, with joint local government-department efforts to establish these areas. At present the DMRP suggests that the criterion for identifying an illegal wake would be the sighting of a "white water " impact on the area in question, thereby giving police officers and boaters a readily visible standard.

Office of Emergency Services

The Office of Emergency Services provides assistance to local governments in preparing for and responding to disasters. OES operates primarily under

the *Disaster Assistance Act* (Public Law 93-288). Local governments must request aid from the State following a disaster to initiate OES involvement. OES personnel will assess the severity of the disaster, decide how to respond to the situation, and coordinate the aid and recovery programs. If State resources are not sufficient to respond to a disaster, OES can ask the governor to apply for federal assistance.

OES responds to various types of disasters but is primarily concerned with flooding in the Delta region. Although OES is only able to respond to disasters after they occur, the office has an interest in preventive measures. The condition of levees in the Delta and methods of financing maintenance and repair work are important issues to OES.

Federal Government

The primary federal agencies affecting Delta fish and wildlife habitat are: Corps of Engineers, Fish and Wildlife Service, and Water and Power Resources Service (previously Bureau of Reclamation). Others of importance are: Environmental Protection Agency, National Marine Fisheries Service, Coast Guard, Soil Conservation Service, and Federal Emergency Management Agency.

Army Corps of Engineers

The Corps of Engineers is the single potentially most influential agency in the Delta with its permit powers and project responsibilities, which include maintenance dredging, deep water channel construction, levee construction, and emergency flood control.

Permit Program. The legislative authorities behind the Corps' permit program are:

- Section 9-10, *River and Harbor Act* of 1899 - regulates the diking, filling, and placement of structures in navigable waterways.
- Section 404, *Clean Water Act* - regulates disposal of dredge and fill materials in the "waters of the United States." This phrase has been judicially and administratively interpreted to include all streams to their "headwaters" (5 cubic feet of water flow per second), lakes over 10 acres, and all contiguous wetlands, including those above the ordinary high water mark.

The 1899 law originally had the intent of protecting waterway navigability by regulating: construction of any structures in and/or over the water; excavation or deposition of materials; or other activities affecting the course, location, condition, or capacity of such navigable waterways. In the early 1970's, this law was also given an environmental perspective based on court interpretation of NEPA.

Section 404 of the *Clean Water Act* calls for regulating the deposition of dredged and fill material in all waters of the United States, and all wetlands adjacent or contiguous. This authority extends shoreward to the plane of mean high water in tidal waters and the ordinary high water mark in nontidal waters.

All saline, brackish, or freshwater wetlands (characterized by prevalence of vegetation that requires saturated soil conditions) which are adjacent to navigable waters are subject to Corps jurisdiction under this Section. The exercise of authority over lands behind dikes varies from one Corps District to another. It is significant that the San Francisco District exercises both Section 10 and Section 404 authority in the San Francisco Bay diked lands , while the Sacramento District exercises only Section 404 in Delta diked lands. The reason that a major part of the Delta (which falls well below MHW but is seasonally flooded) is excluded from Corps jurisdiction is the Corps' position that the low elevation is a result largely of human activities rather than natural processes. In the Corps' view most of the Delta reclaimed lands are not considered "historic navigable waters." In addition, since there is debate over whether woody riparian vegetation adjacent to Delta waterways constitutes "wetlands," the Sacramento District does not exercise Section 404 jurisdiction in such areas.

The Corps' practice is to issue public notices on proposed projects and invite comments from all interested parties. The Corps can deny permits to those applicants whose projects are determined not to be in the public interest. Generally, Corps permits will not be issued in those instances where required State or local authorizations have been denied.

The Corps' policies for evaluating permit applications were established in 1979 in 33 CFR 321-329. Generally these policies state that permits will be issued or denied based on evaluation of probable impact of the proposed activity and its intended use on the public interest. This requires a careful weighing of "all those factors which become relevant in each particular case. The benefit...must be balanced against its reasonably foreseeable detriments." Further, the decision should reflect the national concern for both protection and utilization of important resources, considering conservation, economics, aesthetics, general environmental concerns, historic values, fish and wildlife values, flood damage prevention, land use, navigation, recreation, water supply, water quality, energy needs, safety, food production, and, in general, the needs and welfare of the people.

General criteria which are considered in the evaluation of every application include:

1. extent of the public and private need for the proposed structure or work;
2. alternative locations and methods to accomplish the objective of the proposed structure or work;
3. the extent and permanence of the beneficial and/or detrimental effects on the public and private uses to which the area is suited; and
4. the probable impact of each proposal in relation to the cumulative effect created by other existing and anticipated structures or work in the general area.

In the same regulations it is recognized that wetlands are vital areas and that minor changes can have a cumulative effect from numerous piecemeal changes, leading to a major impairment of the wetland resources. The regulations require that no permit will be granted unless the District Engineer concludes that the benefits outweigh the damage to the wetlands resources, and the proposed alteration is necessary to realize those benefits. The evaluation particularly considers degree of dependency on the aquatic environment, justification for the project's location in the wetland, and availability of alternative sites.

The determination of when minor changes have an adverse cumulative impact is a difficult technical issue which requires additional definition by FWS. For example, the cumulative impact of piers along a shoreline is not now well understood and requires research.

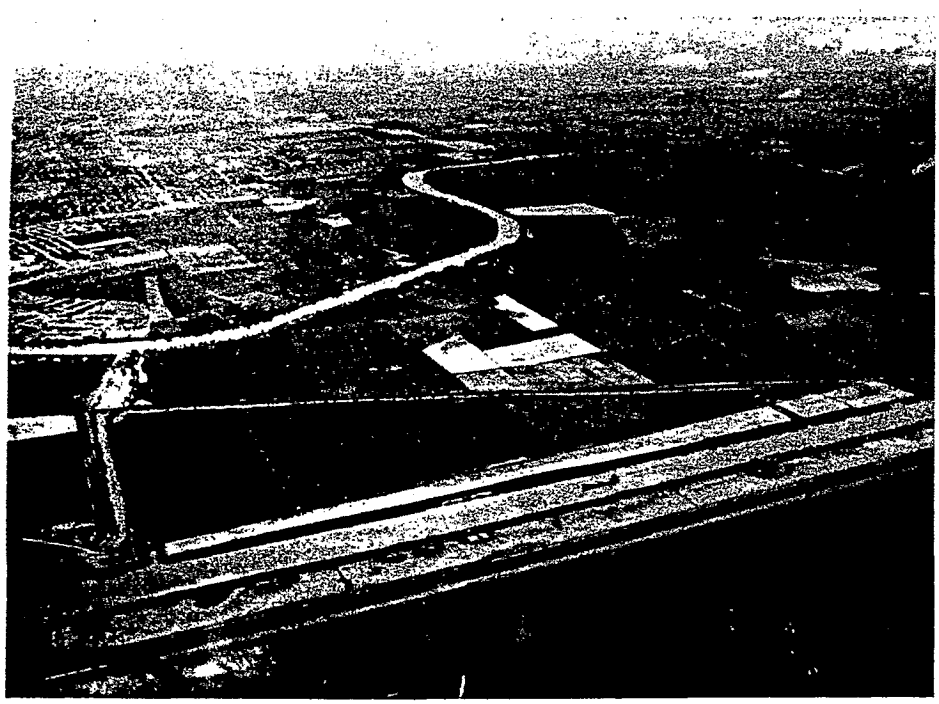
In general, the administration of this permitting process is effective in the Delta, and well-coordinated with FWS and DFG. However, the process fails to assess cumulative biological impacts and is not always effective in enforcement of permit conditions. Court prosecution is required for non-compliance. An administrative law process would make it feasible to readily prosecute lesser violations, as is now done by the U.S. Coast Guard, and would improve full compliance with permit conditions (DFG, 1979).

Levee Maintenance. In addition to its regulatory role, the Corps, as the construction agency for flood control and shipping channel projects in the Delta, requires that the project levees be maintained in accordance with specific standards. Maintenance of Corps project levees is the responsibility of the State Reclamation Board, which in turn passes this responsibility on to local reclamation districts or to other legally constructed maintaining agencies. The Corps, however, maintains some levees along the Stockton Ship Channel in order to protect these levees from ship wave wash erosion. Maintenance of levees repaired or replaced by the Corps under emergency authorities is the responsibility of the appropriate local agencies or individuals (Resources Agency, 1976).

The basic authority for levee maintenance by the Corps is found in Title 33 of the Code of Federal Regulations and is further detailed in two Sacramento district documents, entitled *Standard Operation and Maintenance Manual for the Sacramento River Control Project* (1959) and *...For the Lower San Joaquin River Levees, Lower San Joaquin River and Tributaries Project, California* (1960). Corps levee maintenance standards are felt to be overly stringent, causing the unnecessary removal of riparian vegetation from levees and riverbanks (see Chapter 4).

In the Sacramento-San Joaquin Delta Levee Investigation, begun in 1975, the Corps of Engineers has been studying means to improve the Delta's nonproject levees. Alternatives have been presented for public review, and a final document is expected to be released in 1982. The State Department of Water Resources is cooperating with the study (see above, DWR; and Chapter 4).

Both the Corps of Engineers and FWS are guided by the U.S. Water Resources Council's Principles and Standards (1978) in their planning, evaluation, and regulatory roles in the Delta. The Principles and Standards calls for evaluation of federally sponsored water-related projects using four accounts: the National Economic Development (NED) account, which forms part of the basis for the Development Scenario in this Plan (Chapter 5); the Environmental Quality (EQ) account, which is the basis for the Enhancement Scenario (Chapter 5); the Social Well-Being (SWB) account, whose objective is self-evident; and the Regional Development account, which also is a partial basis for the Delta Development Scenario. FWS tends to foster the EQ account and the Corps is required to conduct cost-benefit comparison of all proposed projects (*e.g.* Delta Levee Investigation alternatives) in terms of all four accounts.



Fish & Wildlife Service

The *Fish and Wildlife Coordination Act* of 1958, the *Estuary Protection Act* of 1968, and the *National Environmental Policy Act* of 1969 are a few of the authorities under which the U.S. Fish and Wildlife Service operates. This agency's basic responsibilities concern migratory birds, anadromous fish, and

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endangered species. In addition, under the *Fish and Wildlife Coordination Act* the FWS reviews federally permitted, funded, and constructed projects with the goal of protecting, preserving, improving, and where possible restoring the fish, wildlife, and natural values of waters and related wetlands.

Project and Permit Review. The Coordination Act mandates that any department or agency of the United States, or any public or private agency under federal permit, license, or funding, proposing to modify any stream or other body of water, shall first consult with the Fish and Wildlife Service to determine the effects of the proposed projects on fish and wildlife resources.

In conjunction with the Corps' Section 10 and Section 404 Permit Program, the Service investigates, reviews, and provides ecological advice and technical assistance to applicants for federal permits and other developments in or affecting navigable waters.

A Memorandum of Understanding between the Departments of the Army and Interior has defined the coordination process, which was further established in the Code of Federal Regulations in 1975, and modified in "Review of Fish and Wildlife Aspects of Proposals in or Affecting Navigable Waters" (40 CFR 55810-55824, May, 1979).

This Army-Interior Memorandum of Understanding provides that when the FWS has unresolved objections to a project at the time the Corps' District Engineer makes a determination to grant a permit, the FWS can insist that the issue be referred to higher authority within the Interior and Army Departments, up to the secretarial level in Washington if necessary. This rarely occurs. Applicants will accept mitigation conditions in preference to the time delay (DFG, 1979). Monitoring of permit conditions is variable, generally due to time constraints, and enforcement must be left to the Corps.

Resource Inventory and Evaluation. An important function of FWS is research and resource inventory. Among its research activities, FWS has developed the *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin *et al.*, 1979). To aid in implementing provisions of the *Clean Water Act* (1977), FWS is conducting a National Wetlands Inventory. Another important research/planning effort by FWS that is facilitating resource protection solutions is the Habitat Evaluation Procedure (HEP), a methodology in development since 1974, which is designed to standardize means of quantifying fish and wildlife habitat values to assess losses. The system is useful in the evaluation of project sites and plans and in estimating the number of acres, under different levels of management, that will be necessary as mitigation to offset the fish and wildlife "values" lost through project implementation (Schamberger, 1979). FWS also is a participating agency in the *Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary.*

Another important FWS function is acquisition and management of National Wildlife Refuge areas, such as in the San Francisco Bay. FWS is also a land acquisition agency through the National Migratory Bird Conservation Program. A higher level of wetland purchase by FWS is forecast in its *Framework Plan for Migratory Waterfowl, Central Valley, California* (1979).

Water and Power Resources Service

Previously known as the U.S. Bureau of Reclamation, the U.S. Water and Power Resources Service is the federal equivalent to the State Department of Water Resources. In addition to operating the pumping plant in the Southern Delta for the Central Valley Project, the Service operates the Delta Cross Channel, which is designed to move Sacramento River water for in-channel flow toward the pumps. The Service's role is further represented through their participation in and contribution of funds to the *Interagency Ecological Study Program* in the Delta.

Environmental Protection Agency

EPA's role with respect to fish and wildlife habitat in the Delta is primarily one of oversight and monitoring of permits affecting water quality. The *Clean Water Act* allows states, which meet minimum standards, to issue the permits for the National Pollution Discharge Elimination System (NPDES, as established in Section 402 of the Act). These permits are issued by the Regional Water Quality Control Board as an agent for the SWRCB and EPA.

The Army Corps of Engineers issues Section 404 permits for placement of dredged and fill material in navigable waters. Since water quality is involved, EPA reserves the option of intervening in this process. The Regional Administrator receives Public Notices from the Corps and reviews and comments on permit applications, retaining veto power.

NOAA and the National Marine Fisheries Service

A part of the National Oceanic and Atmospheric Administration in the U.S. Department of Commerce, the National Marine Fisheries Service (NMFS) has no direct permitting authority. Under authorities similar to those which guide FWS, NMFS reviews federally initiated or federally licensed or permitted projects which have the potential of altering aquatic environments and thereby impacting the biological resources which depend upon those habitats. Habitats may include existing or potentially restorable spawning areas, rearing areas, food-producing areas, or other areas necessary for the survival of marine estuarine, or anadromous resources.

The water-dependence of the proposed activities is a positive consideration in determining project approval. Where habitat/resource damages can be compensated, conditions are recommended which would incorporate in projects the means to eliminate or minimize adverse environmental impacts, to compensate for unavoidable adverse environmental impacts, and to assure that post-project habitat value shall be equal to or greater than pre-project value.

The NMFS acts to protect Delta habitats by commenting on Corps public notices for particular projects. NMFS is particularly concerned about impacts on anadromous fish by the State Water Project and Central Valley Project and proposed new diversions, such as the North Bay Aqueduct and Stockton Delta diversion. The agency has taken an official position of not supporting the Peripheral Canal (see Chapter 5).

NOAA also administers the *Coastal Zone Management Act*. The Estuarine Sanctuaries Program, one component of the Act, affords protection through acquisition of selected estuaries throughout the nation's coastal areas. For a variety of reasons, the Delta is expressly excluded as a potential candidate in California.

Coast Guard

The Coast Guard has four major programs that affect the Delta. One program provides aids to navigation through the maintenance and operation of lights, buoys, and other warning or signal devices to mark the channels of the Sacramento and San Joaquin Rivers.

The second program involves regulation of the construction, modification, and operation of bridges.

Through the third program, which involves boating safety, the Coast Guard provides a search and rescue service, information about safe boating, enforces boating safety regulations, and issues permits for boat races and parades.

A fourth role of increasing importance is the Coast Guard's control over spills of pollutants such as oil in Delta and Bay waters. The Coast Guard requires and enforces contingency clean-up plans for accidental spills.

The Coast Guard also will comment on the Corps' public notices regarding pollution and navigation matters.

Soil Conservation Service

The Soil Conservation Service in the Department of Agriculture is involved in soil analysis and erosion control, provision of technical assistance to farmers, river basin surveys, and small watershed projects (under PL83-566). These "PL-566 Projects" have often included stream channelization. No such projects are presently pending in the Delta.

Federal Emergency Management Agency

The Federal Emergency Management Agency can provide assistance to the State in the event of a major disaster. FEMA responds to a disaster at the request of the governor. FEMA personnel review damage to an area and present findings to the national office. The President must determine whether or not to declare a federal disaster. If an area is eligible for federal assistance, funds are made available based on an assessment of damages to the area. FEMA operates under the Disaster Assistance Act (Public Law 93-288).

The Federal Emergency Management Agency is designed to respond to an actual disaster. However, the recurrence of disasters over a period of years in particular areas such as the Delta has led to the development of a new policy. Hazard mitigation and floodplain management plans must be formulated within 180 days for areas which have been declared federal disaster areas and received federal assistance. These plans must consider all hazards, not just the one which created the disaster.

OPPORTUNITIES FOR MODIFYING GOVERNMENTAL ACTIVITIES, PROGRAMS, & LAWS

The analysis of existing governmental procedures presented in the prior section was designed to ascertain how the systems of resource management function now in the Delta and how responsive they are to the protection and maintenance of wildlife habitat. The analysis reveals a number of general and specific problems that fall into the following areas:

- Need for local governments to become more effective resource managers through the variety of means available to them;
- need for overall State policy for the Delta, which is codified and implemented consistently;
- need for better coordination among the many and complex agencies and of the responsibilities which they carry out in the Delta;
- need for higher levels of personnel and funding for the tasks which agencies must fulfill in managing the Delta's resources, implementing policies, and enforcing regulations, and means of allocating costs fairly;
- need to resolve many specific problems such as degree of ownership of tidal lands and present inadequacies in DFG and FWS role in resource protection, and to devise better tools to aid in effective inventory and protection of significant and sensitive natural resource areas in the Delta.

This section presents general suggestions for possible actions which should be considered in order to provide better protection, maintenance, and possible restoration of wildlife habitats. These are summarized and presented as specific options, or courses of action, which could affect all levels of government, from local to federal. Since these would all require further study, they are presented in Appendix C.

Suggested Improvements to Local Government Protection of Delta Habitats

Local governments have available to them an array of planning instruments (general plans; zoning ordinances; *etc.*) and tools (technical data; review procedures) for protection and management

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of natural resources. Their influence over these resources in the Delta is constrained in part by policy priorities, in part by an inadequate body of policies and implementing means, and in part by inconsistency in applying policies and regulations. Some of these constraints could be overcome by a comprehensive approach to protecting Delta resources.

For local governments to become effective resource managers, several major provisions should be added to or improved in the local planning and permit processes:

1. **inventory of significant resource areas with specific general plan policy protections and inclusion of the inventory in the open space or conservation elements;**

2. **better defined local subdivision ordinances to require:**
   - **habitat impact and mitigation assessment;**
   - **open space dedication of habitat areas;**
   - **performance bonds for development within wetland areas; and**
   - **denial of tentative and final maps for projects shown to have potential significant adverse impact on the environment and for which mitigation measures are not adequate;**

3. **effective use of conditional use permits, the most common tool which local government currently has to protect habitat from the impact of development;**

4. **incorporation of the intent and guidelines of CEQA into local codes, including subdivision ordinance, so that eventaully CEQA becomes integral rather than external to local environmental review;**

5. **use of an implementing "overlay" zoning district to protect significant areas, such as a "resource management district," or a "floodplain conservation district," to replace existing zoning. All alterations in these areas would be subject to the issuance of a conditional use permit, with clearly stated criteria and requirements for habitat protection and mitigation for damaged or lost areas;**

6. **use of a Planned Development (PD) District or a Specific Plan (Government Code Section 65450-65553) to guide major projects (such as marinas or subdivisions) which are to be built in or near a sensitive resource area;**

7. **efficient mechanism for obtaining guidance from DFG or FWS in placing conditions on use permits and formulating other planning tools which may be applied to habitat protection.**

8. **codification of a density transfer system to permit the transfer of development density from environmentally sensitive parcels to areas where higher density is more appropriate. The system allows property owners to recoup the value of a site that is under restrictive controls by transferring site development rights to other less restricted areas. This tool also permits governments to protect significant resource areas without having to purchase them or diminish overall development potential for the owner.**

A higher level of local government resource management in the Delta will not be achieved simply by accomplishing piecemeal changes in laws and processes. A high degree of consistency in intent, technique, and tools is required among the five counties. Precedents exist for achieving this consistency while retaining traditional local governmental roles in land use regulation. There are two models in the State for achieving greater policy and regulatory consistency among local governments:

- The Local Coastal Program (LCP), established in the *Coastal Act* of 1976.

- The Local Protection Program (LPP), for the *Suisun Marsh Preservation Act* of 1976.

The "LPP" offers the better example of a thorough resource management program (including a general plan element and several ordinances prepared by Solano County), which has applicability to the Delta. Such legislation can and should be sought for the Delta (see Recommendations).

Problems and Solutions for Policy and Coordination in the Delta

The analysis in this chapter has described the State's basic policy framework for the Delta as contained in the *Delta Master Recreation Plan* and Delta Waterways Use Program. Two problems are inherent in the failure to implement these policies and programs. The first is the absence of codification, particularly of the Waterways Use Program, so that policies might be applied with greater consistency. And the second is the fragmented mechanisms responsible for carrying out the overall policy.

This latter problem is further elaborated in The Solano County *Resource Conservation and Open Space Plan,* Phase II (1973), which states the following about the Delta:

> "To conclude that such important resources (as the water and land areas of the Sacramento-San Joaquin Delta) are primarily the responsibility of other levels of government would be an oversimplification and an understatement of the complexities and challenges involved. In truth, the responsibility is inter-governmental, involving city

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and county governments, special districts, regional agencies, and the state and federal government. Responsibility also rests with the private sector – the landowner, the farmer, the sportsman, the commercial and industrial operators, whose activities often are in competition for the use and management of limited and scarce resources."

The Solano document further states:

"There is a clear need for collaboration as well as cooperation among local, regional, state, federal and private programs for the management of natural resources. Policy conflicts are inherent in differing legislation, in somewhat different objectives, and in attempts to meet the growing demand for the use of resources. Often, there are competing demands for the use of resources by sister agencies operating in the resource management field, as well as competing demands among various levels of government, between government and the private sector, and within the private sector."

One of the most critical areas where a much higher degree of coordinated governmental activity is needed is in management of Delta levees. Chapter 4 examines concepts to guide DFG, Reclamation Board, USFWS, and Corps of Engineers in updating the standards of project levees and applying them to the forthcoming Delta levee improvement program.

The cooperative approach to researching Delta problems has occurred to some degree in the Delta. The DFG/DWR *Delta Fish and Wildlife Protection Study*, the *Interagency Ecological Study Program*, and the *Delta Levee Investigation* are indications of State and federal cooperation in examining natural resource problems and arriving at joint solutions. Offsetting this cooperation is the failure of federal interests to agree fully to carry out the State's water quality standards. At the local level, the Delta Advisory Planning Council's effort at coordinating local governments produced the highly useful but as yet only partially implemented DAPC Plan (1976).

There are several approaches to resolving the dual problems of overall policy and coordination:

1. **State policy expressed in the *Delta Master Recreation Plan* and Delta Waterways Use Program should be codified following thorough public review as the basic framework for a consistent and coordinated approach for resource planning in the Delta.**

2. **Some form of "Delta clearinghouse" should be established within an existing agency, such as the Resources Agency or Office of Planning and Research. A Delta clearinghouse could be identified as the "Office of Delta Planning and Coordination," with functions to be clearly defined. The Resources Secretary could ensure that all State, federal, and local agencies send Delta-related documents, including permit applications and all environmental documents, to this office for review and entry into a regional data system.**

3. **The Secretary for Resources could also take a leadership role in convening a temporary task force of federal, State, and local agencies to examine major unresolved issues in the Delta, at a minimum:**

   - **inability of the State Lands Division to conduct State lands determinations in the Delta;**
   - **current lack of Reclamation Board activity in the Delta;**
   - **relationship of subsided lands to future levee and/or wetland restoration;**
   - **potential for legislation recommended in this Plan.**

Funding and Allocation of Costs of Resource Protection

A perennial problem in the Delta, and elsewhere in California, is shortage of public staff and funds to implement policy and enforce regulations, such as boat speeds and trespass onto private lands. The more acute problem is that of allocating the high costs of levee maintenance, which is the most frequent excuse for gross (rather than selective) levee maintenance practices.

The 1977 report of the Delta Environmental Advisory Committee (DEAC) states that Delta levees will continue to be important:

"Delta channels will still (be needed) to convey the water to the Delta farmers and to the Bay. The loss of Delta levees would make that conveyance much less efficient and would require far higher outflow from the Delta to repel salinity... Equally significant is the recognition that maintaining Delta levees in an engineering and ecologically sound manner is necessary for the preservation of Delta agriculture, fish, wildlife, and recreation. That, and not the protection of water quality destined for export, has been the reason for past public contributions to Delta levee maintenance."

It is critical that a determination be made that all those who benefit from levees should contribute to future maintenance and improvement programs:

1. **Beneficiaries of water "destined for export" should contribute to the future levee improvement program, which the flooding of 1980 has shown to be so vitally needed. A "Delta Levee Restoration Fund," using revenue from an annual small surcharge on the cost of each acre-foot of water exported from the Delta by the SWP and CVP, would offer one equitable solution.**

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2. **Another partial solution to sharing costs of levee maintenance among beneficiaries would consist of imposing small user fees for various recreational facilities.**

Other Problems and Possible Solutions

State ownership. The continuing uncertainty of the degree of State ownership of tidal lands is a major problem in the Delta. Legislative funding and directives are necessary to resolve this stalemate. Until proper State claims to ownership have been asserted, areas such as the Channel Islands will continue to be altered and appropriated for nonwildlife habitat uses. High priority should be given to the designated State Park islands and those islands that are coming under development pressures. Each island which is found to be State-owned land could thereafter be designated an Ecological Reserve, requiring at least a minimum level of management by DFG.

The inventory process recently reopened by State Lands Commission (SLC) should merge with the parallel program of DFG and include those significant resource areas listed in this document, which are State-owned lands in the present SLC official inventory. Thereafter, development proposals could be conditioned to protect these areas. The proposed "Office of Delta Planning and Coordination" could accomplish this function.

Waterways Use Program. Administratively, the Waterways Use Program could be improved by overlaying the three waterway zones on the Corps' *Delta Environmental Atlas* 1:12,000 photo maps. This would overcome the scale deficiencies of the present 1:126,720 map of those zones. Distribution should be to all concerned federal, State, and local agencies.

Effectiveness of DFG and FWS role. The preceding analysis of governmental agencies reveals that the DFG and FWS are generally successful in their protection of fish and wildlife habitats through their participation in the Corps and other federal and State agency permit application reviews. While DFG and FWS presently provide fish and wildlife resource data when commenting on EIRs, EIR review usually comes late in the site review process and comments may be completely disregarded. A number of problems hamper their effectiveness, especially in conjunction with local government planning and permitting processes:

- The absence of direct regulatory authority in commenting on local planning and EIRs;
- The reluctance of the Corps to issue permits with conditions;
- Uncoordinated institutional arrangements causing the late or nonexistent entry of DFG and FWS into the local planning process;
- Lack of feedback (following comment) to evaluate the success or usefulness of comments.

DFG and FWS involvement is needed in both early project stages and advance planning:

1. **DFG and FWS could assist in formulation of natural resource policy and design of implementing ordinances and programs of local government as well as those of State and federal agencies with particular interest in the Delta.**
2. **Both DFG and FWS should formulate specific standards and criteria for fish and wildlife habitat protection to serve as guidelines for local governments to use in their own review procedures and plans.**
3. **The involvement of both agencies could be facilitated by an "Office of Delta Planning and Coordination" for more timely response to specific requests for review and comment.**

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Habitat Protection and Restoration

4

State, federal, and to an extent local agencies are seeking an economic and ecological balance between competing Delta resource uses. Practical ways do exist for preventing further losses and protecting and enhancing widlife habitat. Further, there are both technical and regulatory/governmental means to restore some habitats that have been damaged, as well as to create new habitats to compensate in part for situations where habitat no longer exists or has been reduced from its former extent.

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Chapter 4 explores technical problems and feasibility, and suggests guidelines for protecting, restoring, or otherwise improving wildlife habitat in the Delta:

- as a major component of levee construction and maintenance programs, compatible with flood control objectives;
- as an important objective compatible with agricultural practices;
- as one of the options in ultimate disposition of subsided islands;
- as an integral part of dredge material disposal; and
- as a component of various State and local plans and programs for protecting significant resource areas and managing habitat.

LEVEES AS HABITAT: PROBLEMS AND POSSIBILITIES

The man-made separation of land and water, and the development of uses which for the most part are mutually exclusive, underlie all other attributes and activities in the Delta, whether of humans or of wildlife. This separation is the primary function of levees in the Delta and the primary objective in their management. Construction and maintenance of the levee system are the most influential factors which have shaped and now in part determine the presence, type, and condition of fish and wildlife habitat in the Delta. The manner in which levees and their vegetation are managed, particularly where land surface and water meet to form potential marshes and riparian corridors, is central to this Wildlife Habitat Plan and a key to maintaining habitat resources in the Delta.

Problems of Stability, Subsidence, and Erosion

Maintaining the levee system involves four primary and related problems:

— foundation conditions and construction materials;

— land subsidence;

— erosion; and

— the influence of vegetation and animals on levee stability.

A fifth problem concerns the design standards and maintenance practices which have been developed as means of solving the other four problems but which, in fact, have created further problems.

Foundation Conditions and Construction Materials

Except in the peripheral areas, where sandy silts are more common, or along the main channels of the Sacramento and San Joaquin Rivers, where river sands are available, Delta levees are built on and constructed of locally available peats and silts. Most have been built up over the years with material from adjacent channels, by the use of side-draft long-boom clamshell dredges. Consolidation of the soft foundation material requires periodic dredging and widening and raising of levees to keep pace with settlement.

It is almost impossible to separate problems associated with construction from those associated with maintenance, since the initial construction conditions have required that levees be constantly maintained and rebuilt. While the peat soils of the Delta are excellent for growing crops, they lack stability as a construction material. Stability is further jeopardized by absence of protective waterside berms or by the loss of such berms where they originally existed (see Figure 11).

The problem of levee instability exists throughout the Delta but is most critical in the deep peat areas of the central and western Delta. Levee instability has become more serious in recent years with higher levees and increased hydrostatic pressures resulting from the subsidence of the islands (see below). Many of the private levees, which constitute 75% of the total 1,100 miles of levees, are in serious condition, due mainly to the materials of construction, their original design, and their age.

Subsidence

Islands which were at or near sea level prior to reclamation are now as much as 20 feet below sea level as a result of decomposition of the peat soils, wind erosion, burning of the soil (no longer practiced), water erosion, compaction by heavy farm machinery, and geological subsidence due to natural gas extraction and groundwater removal. Some geologists believe there is also a general subsidence of the Delta area along local faults, but this is probably insignificant in the short time periods considered here (Shlemon and Begg, 1975).

As long as the water table is maintained below the ground surface, subsidence will continue until nearly all of the organic matter in the peat has decayed or blown away. The process has continued until the thickness of peat is only two to three feet above mineral soils on lands near the margins of the Delta. The current rate of subsidence is around two to three inches per year (Figure 6).

Along with the loss and subsidence of the peat farmlands in the island and tract interiors, the surrounding levees themselves are also subsiding as their peat foundations dry and shrink. Newer levees subside at a greater rate than the older ones, which have generally reached the end of consolidation. As the levees subside, additional measures must be taken to increase or maintain their height to prevent overtopping by normal high waters. The problem of levee subsidence is only partially offset by resultant strengthening of the levee through consolidation and compaction of soils (COE, 1975).

As the subsidence of the lands on the interior continues and the difference between levels of the water in the channels and the islands increases, additional

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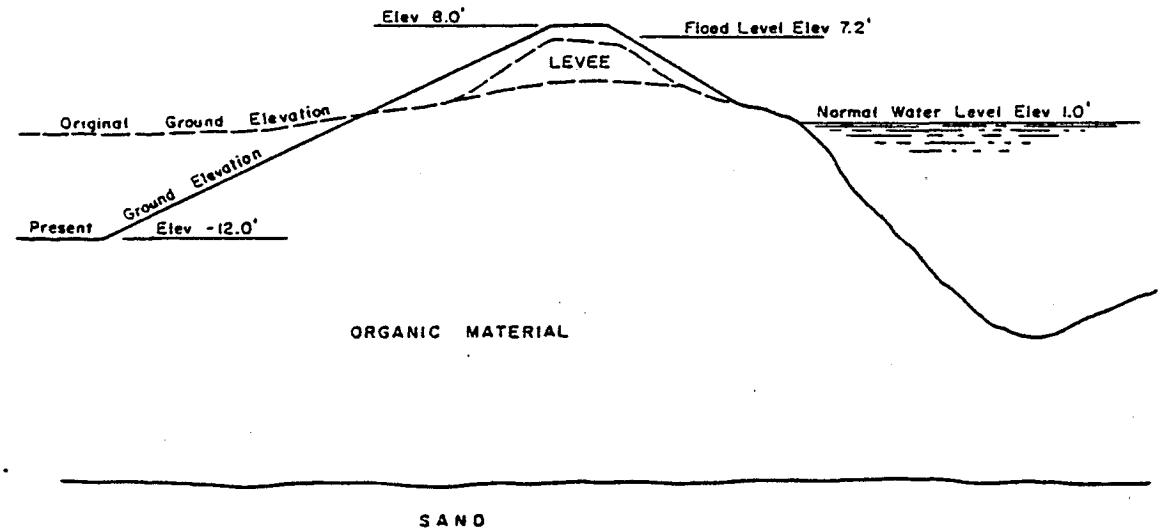


FIGURE 6
Subsided Island: Past and Present Ground Elevations

hydrostatic pressure on the outer dike adds to levee instability, increasing both maintenance costs and the likelihood of levee failure.

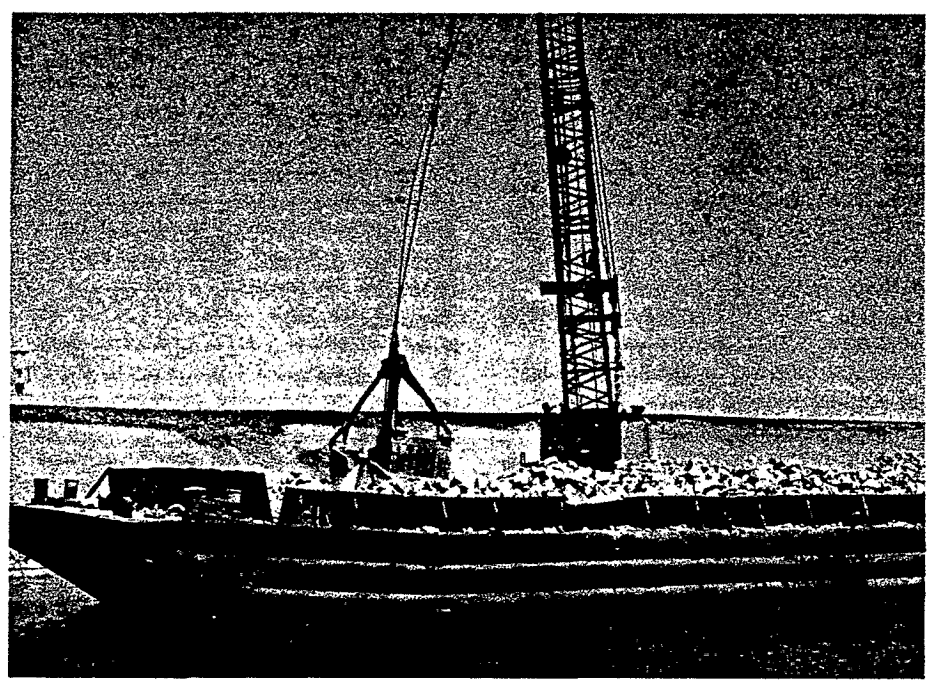
Erosion

Low-lying narrow linear islands — tule berms — were originally left in many places in front of the levees following construction by the dredges. These protective tule berms are gradually disappearing, primarily from repeated dredging and subsequent erosion, leaving the levees throughout the Delta exposed to direct attack from tidal and flood currents and from wind- and boat-generated waves. While these are all major causes of erosion, increased use of the Delta waters in recent years by recreational boaters has greatly accelerated erosion from wave wash in areas of heavy use (DMRP, 1976).

The impact and erosive effects of currents, wind waves, and boat wake waves vary greatly with each slough in response to its configuration, orientation to the wind, width, and recreational use (Limerinos and Smith, 1975). Accordingly, the need to use structural means of bank protection — typically rock revetment, or riprap — varies also with the location and use. In certain places the placement of protective rock itself can create a critical loading condition on an unstable foundation (Whitlow *et al.*, 1979).

While the necessity for rock riprap to stabilize levees and prevent erosion may be questioned, Delta levee maintenance districts are in agreement that riprap is the best solution to erosion, and that vegetation complicates levee maintenance. Where wind and boat waves and currents are a persistent problem, riprap generally is placed up to the flood level. Opinion to the contrary holds that rock may be needed only up to the normal high waterline, or in some cases not needed at all if engineering criteria such as for adequate cross section are met.

It is possible that "rocking" can be avoided in smaller channels with lower current velocities and on the inner curves of channel bends, where erosion is less severe. However, the main reason riprap is not used in many places is its high cost. Typically, material dredged from the channel bottom or from residues from island leveling is used to patch eroded areas or heighten the levee, often smothering tules at the water line.



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Influence of Vegetation and Animals

Early Delta farmers used trees and other vegetation on their levees for stability (Stewart, pers. comm.). The roots of brushy vegetation served to hold sand material levees together. In addition, alfalfa, Bermuda grass, and willows were planted to stabilize levees (Thompson, 1957).

Even with strong evidence that vegetation is an effective means of controlling stream bank erosion (Keown *et al.*, 1977), uncontrolled levee vegetation in the Delta presents a potential hazard. Trees with extensive root systems, while stabilizing soils, also provide paths for the piping of water, which can lead to levee failure. Trees with shallow root systems, on the other hand, are subject to wind-throw, taking large chunks of the levee with them in their fall. Any kind of dense foliage or undergrowth obscures the visibility of the levee face from easy inspection and is a hindrance in emergency flood actions.

Opinions vary concerning the influence of vegetation on erosion and levee stability. Vegetation is considered a hazard during flood flows, increasing friction and reducing a channel's hydraulic cross section. Vegetation near the waterline collects debris which may direct flows into the levee. In addition, tules tend to cause eddy currents during high flows in Delta channels. The currents encroach between the stands of tules, causing considerable erosion.

Conversely, it is felt that vegetation at the water's edge reduces current velocity, thus retarding erosion (Parsons, 1963, in Whitlow *et al.*, 1979). Tules have contributed to stability, where foundation, construction material, and levee cross section were adequate, by providing a natural breakwater on berms or on the waterface toes of levees. By retarding erosion, levee vegetation prevents loss of soils and in fact can encourage soil deposition from backwater flows. Studies have also shown that above the tidal fluctuation zone, grasses and other groundcovers have worked well to control erosion, even during a forty-day, high-stage flood flow (DWR, 1967).

Conflicts between maintaining levees for flood control and permitting wildlife habitat on levees are inevitable. Some animals pose a threat to levee stability. As with vegetation, the degree of threat varies with the location and species and with differing opinions and observations.

The major deterrent to permitting vegetation on levees is that it attracts animals whose colonies and burrows weaken the levees and tend to induce water piping. It has long been assumed that brushy vegetation encourages ground squirrels and impairs visual detection of their colonies. Recent evidence indicates that frequent stripping, burning, mowing, grazing, or other practices which create large areas of sparse vegetation actually encourage rather than discourage ground squirrel infestations, while gradual revegetation suppresses populations. Correspondingly, increased cover for hiding and perching would encourage natural predators of the ground squirrels, gophers, and other rodent pests (JMI, 1978a) (Figure 7). It must also be recognized that certain plant species provide food for ground squirrels. Approaches to biological management of ground squirrel colonies are under study (see DWR, below).

The burrows of beavers and muskrats are also a problem. In an undisturbed setting, these animals construct lodges in marshlands and dig burrows in riverside berms where food is plentiful and they are relatively isolated from predatory animals. Banks may also be used, but are generally a less secure location. In the Delta, available habitat for these animals is scarce, and while they do use marshlands and berms to the extent they are available, they also burrow into unriprapped banks.

Beaver burrows weaken levees and are believed to be a prime cause of levee failure, but no systematic assessment of the actual extent of levee burrowing or its effect on levee stability has been done. An increase in marshland and riverside berm habitat, where suitable food is more plentiful and predator isolation more effective than on channel levees, would encourage beavers to use habitat other than levees for burrowing. Limited low-level rocking at and below the waterline would also discourage burrowing.

Design Standards and Maintenance Practices

There are three categories of levees in the Delta today (Figure 8):

- Project levees (15% of the total of 1,100 miles) are part of federal flood control projects and are maintained by local districts and the State to federal standards.
- Direct agreement levees, as defined in this plan, were constructed as part of a COE navigation project or were rebuilt by the federal government after a flood; these are also maintained locally to federal standards and comprise 10% of the total mileage. Other "direct agreements" between the State or federal government and local landowners or reclamation districts apply to construction and maintenance of levees in the Delta, with varying sets of conditions attached. A major portion of private levees have been worked on under such agreements at some point in their history.
- Private (non-project) levees are maintained by landowners or local reclamation districts and make up 75% of the Delta levees.

Except in the case of project and Corps direct agreement levees, little attempt has been made to design or construct levees to a consistent set of engineering standards. Typical freeboard ranges from a few inches to one or two feet with narrow crests. Slopes originally constructed to the natural angle of repose of the available dredged material have been cut to a near-vertical bank by dredging or by wave erosion where protection by natural island berms or rock revetment is absent. Landward slopes are continually changing, in part as a result of interior land subsidence, and in part because persistent discing of the landward side causes levee material to move

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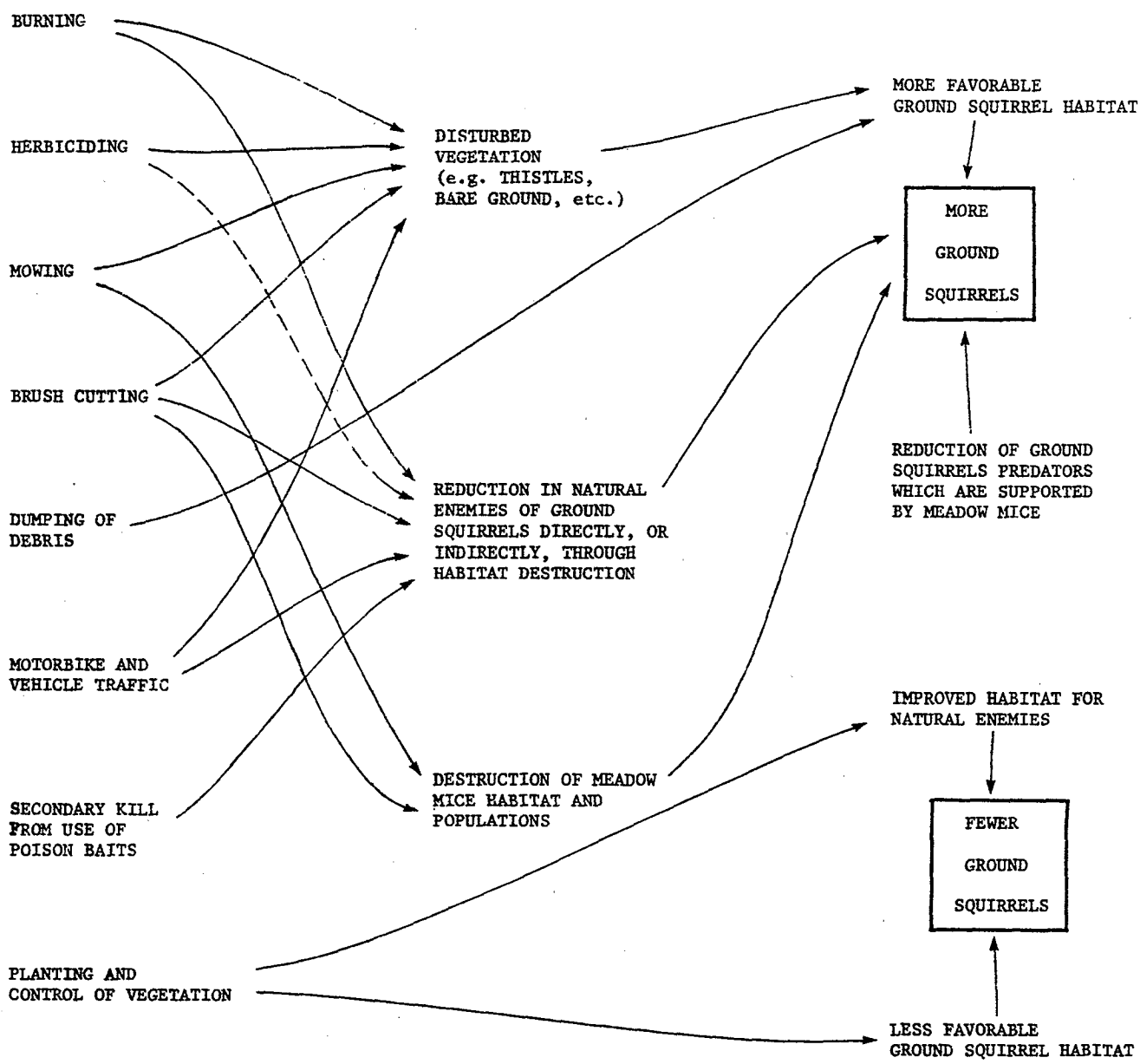

FIGURE 7
A Relationship Diagram Indicating Key and Presumptive Connections Between Variables that Affect Ground Squirrel Populations

Adapted from: John Muir Institute, 1978.

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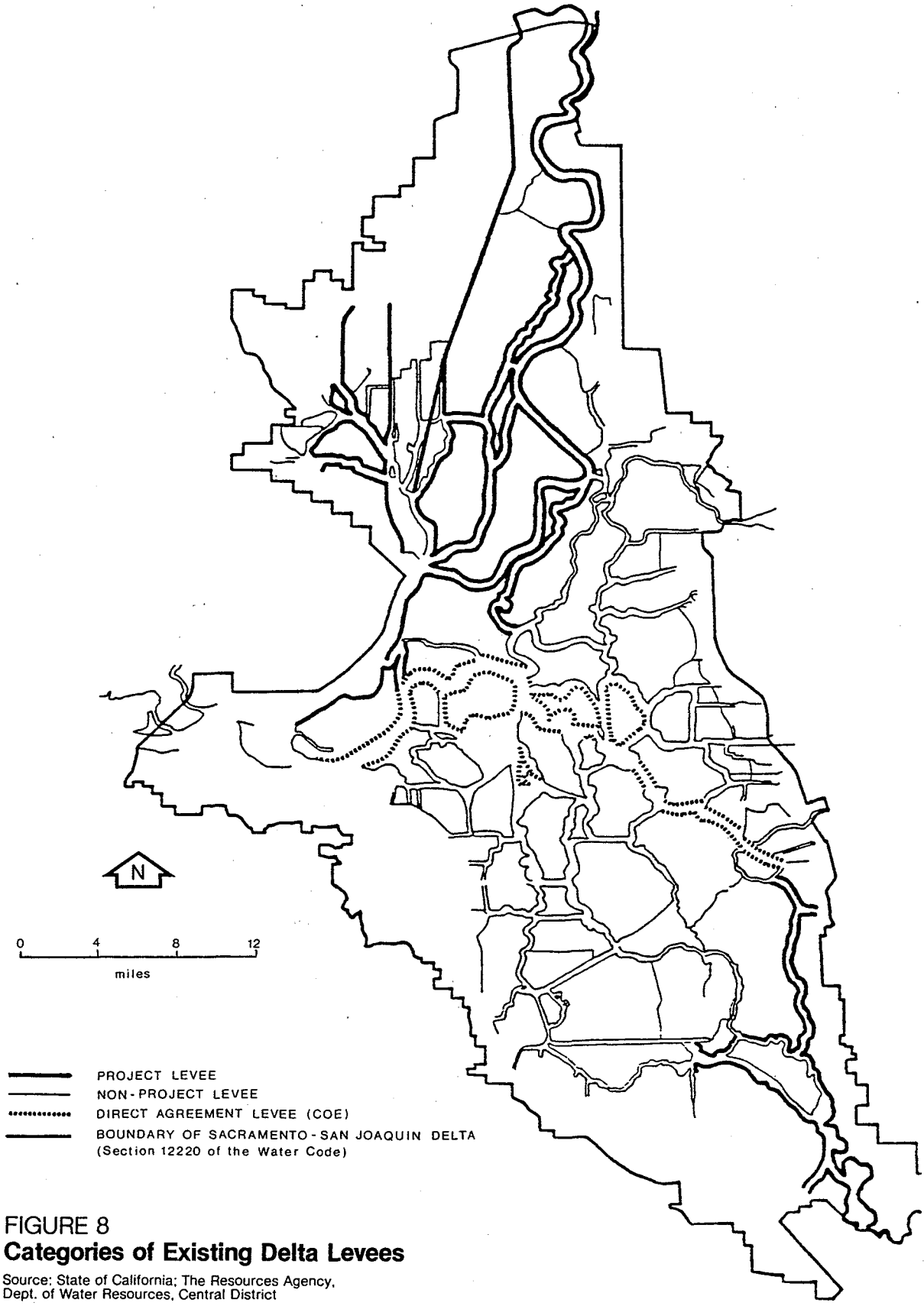

FIGURE 8
Categories of Existing Delta Levees

Source: State of California; The Resources Agency, Dept. of Water Resources, Central District

toe-ward, that is downslope, thus flattening the land face slope.

Vegetation cover on the Delta levees varies in character, depending on the location and maintenance. Some have barren slopes, while others may be covered with tules and willows, brush, grass, or trees. "Good" maintenance practices (DWR, 1967) prevail on the project levees and on certain islands, *e.g.* Bethel Island, but in general, routine maintenance work on private levees is either minimal, or seemingly excessive on levees of poor quality construction materials. Maintenance practices are directed entirely toward flood prevention and are generally detrimental to good wildlife habitat conditions.

Typical levee maintenance practices have had and continue to have a devastating effect on riparian vegetation and associated wildlife. On project and Corps direct agreement levees, vegetation is removed to facilitate inspection, to prevent weakening by tree roots and burrowing animals, and to reduce fire hazard in summer. Federal regulations require removal of "wild growth" and mowing of grasses and weeds. Spraying of herbicides and burning of vegetation are also used to facilitate inspection.

On private levees the principal reason for removing riparian vegetation is lack of money for alternative treatments. Most reclamation districts apply their limited funds in areas of critical erosion. The most cost-effective repair method is to strip off all vegetation, reshape the levees, and add stone or concrete revetment to guard against further erosion. Consideration of long-term preventive action or of environmental needs varies significantly from one island to another, and from one landowner to another.

Many current practices which are used on all types of levees have undesirable side effects. The application of herbicides on waterward slopes to remove all vegetation leads to accelerated erosion from waves and flood flows. Discing and mowing machines, also used to control vegetation, cause tire damage to levee slopes, which can lead to further erosion. Discing and mowing also encourage ground squirrel infestations.

In spite of considerable progress in research and experimentation on levee vegetation and levee pest control over the past two decades, levees which have been stripped, burned, and riprapped still present a common spectre of barrenness in many parts of the Delta. This condition points up the need for major restoration of vegetation associated with levees.

Managing Levees for Multiple Use

Delta levees were constructed to "reclaim" land from a natural floodplain and have been maintained ever since for the primary purpose of flood control. According to the Department of Water Resources' guidelines for levee maintenance, the properly maintained levee in the 1960s had the following characteristics:

- section clear of all brush, trees, encroachments, and other obstructions;
- a levee crown slightly rounded to provide unform drainage; and
- levee slopes uniform in shape and slope, without mounds, holes, or other irregularities.

Guidelines recommended annual burning, use of herbicides, dragging of levee slopes to remove woody vegetation, use of soil sterilants, and various rodent extermination methods.

Growing public awareness of loss of riparian vegetation and tule marshes in the Delta, coupled with increasing recreational use, brought the problem of levee construction and maintenance practices to legislative attention in 1961. It was apparent that levees offered other important uses and amenities besides flood control, notably recreation, aesthetics, and wildlife habitat.

Recreation and Aesthetics. There is no question that recreation in the Delta is enhanced by the presence of ample riparian and fringe marsh vegetation on levees and berms. In addition to providing a scenic backdrop and shade for other activities, riparian vegetation contributes to aquatic habitats which maintain sport fish populations, and it plays an important supporting habitat role in maintenance of pheasant and other game bird populations for hunters in adjacent agricultural lands. Unfortunately, the same natural features which attract recreationists are also threatened by their activities.

Wildlife Habitat. Riparian vegetation associated with levees is a critical habitat in the Delta in its own right and because it makes other habitats more useful by providing cover (Figure 9) (See also Chapter 6). Riparian vegetation plays a key role in sustaining a great variety and density of migratory and resident fish and wildlife.

It is apparent that not all levees can be managed for multiple uses and that the concept is more appropriately applied to the system as a whole. For example, physical limitations or exposure would preclude some areas or levee segments from recreational use; other areas where levees are structually sound provide potential recreation sites, preferably away from sensitive resource areas. Still others have been identified as supporting valuable natural resources and should be managed with wildlife habitat (and aesthetics) as a primary objective, compatible with flood control.

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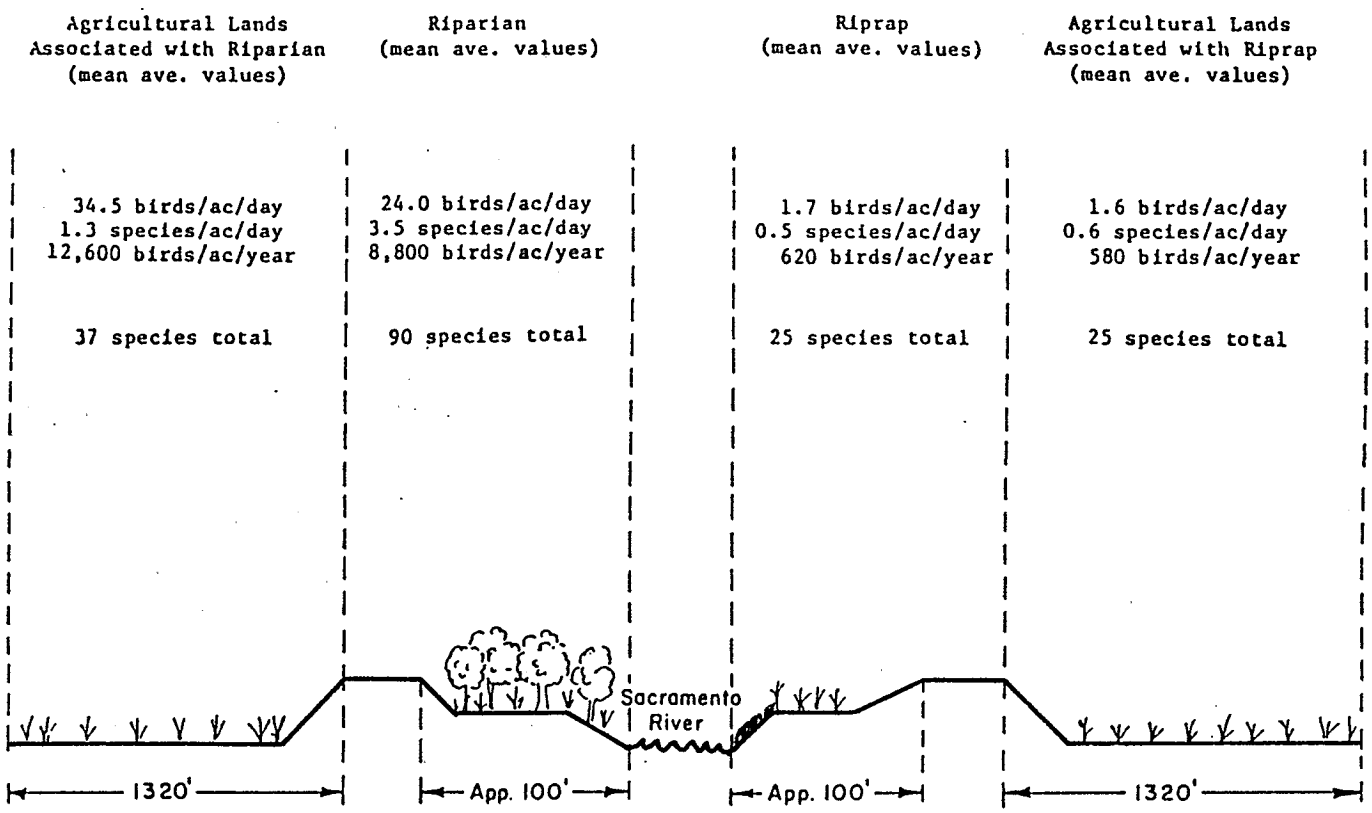
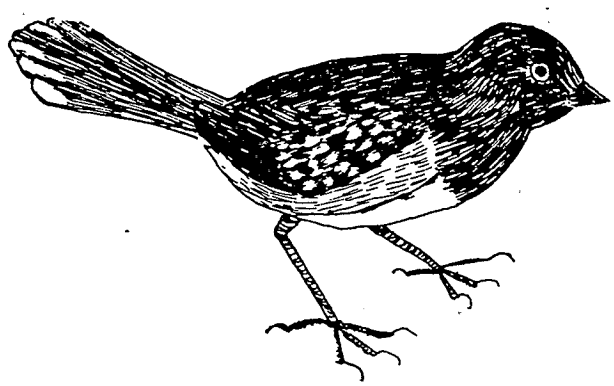


FIGURE 9
A Comparison of Bird Use on Four Different Habitat Types

Source: United States Fish and Wildlife Service, 1976.



Agencies and Programs for Management of Levees and Vegetation

The principal agencies which have the responsibility for construction, inspection, maintenance, and/or regulation of levees in the Delta are the U.S. Army Corps of Engineers (Sacramento District), Department of Water Resources, State Reclamation Board, and the many local reclamation and levee districts that actually accomplish most of the maintenance of private and project levees. The U.S. Fish and Wildlife Service, National Marine Fisheries Service, and the California Department of Fish and Game serve in an advisory environmental role, reviewing plans and permit applications and providing guidelines for project levees.

The COE Manual is the primary basis for standards that are operative in construction and maintenance of project and direct agreement levees. Private levees are subject to neither standards nor environmental review, except to the extent that new construction would require a COE permit (See Chapter 3). Notwithstanding the obvious prevalence of denuded, riprapped levees, all of the agencies have either conducted or participated in studies or specific levee programs since the 1960's which recognize vegetation and wildlife habitat as an important component of multiple-purpose levee construction and maintenance.

Army Corps of Engineers

For many years the Corps of Engineers has been active in the Sacramento-San Joaquin Delta — historically with regard to navigation and flood control projects and permits to work in navigable waters, and more recently with regard to recreation, preservation of environmental resources, and water quality management (See also Chapter 3). Studies of the Sacramento-San Joaquin Delta region were authorized by the U.S. Congress as early as 1948, discontinued during the fifties, and resumed in 1962 at the request of the State of California. A plan proposing levee rehabilitation to the 50-year flood level met mixed response in 1966, and the studies were again discontinued, to be resumed in late 1975. The State's delineation of levee policy in 1973[1] reaffirmed State interest in Delta levees, and this was further reinforced in 1975 by Bulletin 192 and in 1976 by adoption of a policy to preserve the levee system[2] (See Chapter 4 below).

As a consequence of the these legislative events, a joint Corps/DWR investigation is being conducted: *The Sacramento-San Joaquin Delta Levee Investigation.* October 1982 is the target date for completion of a draft feasibility report. An interim COE report outlines a range of alternatives which generally seek to fulfill both recreational and environmental objectives along with the central objective of flood protection (COE, 1979b). DWR has also prepared interim reports, on an annual basis, for the State legislature.

The alternatives under consideration provide varying levels of vegetation and habitat protection or enhancement — actually restoration, since reconstruction of levees initially would remove most existing vegetation but selectively introduce new vegetation, depending on location and mode of construction.

In addition to four basic alternative plans and variations in mode of construction, level of flood protection, and amount of freeboard, the investigation evaluates an Environmental Quality (EQ) Plan which has as its goal "maximum environmental benefits, unconstrained by monetary requirements" (See also Chapters 3 [COE] and 5). The EQ Plan contains specific recommendations for protection or enhancement of vegetation and habitat which include:

- prohibiting the plowing of levee slopes;
- control of both burning and application of herbicides along levees and berms;
- modification of flood control maintenance practices to retain vegetation on levees and berms wherever possible;
- where new setback levees are constructed, planting of riparian vegetation on the remnants of the old levee, which becomes a berm, and breaching the old levee to allow the formation of backmarshes between old and new levees (Figure 10); and
- prohibiting incompatible development on the waterside of levees in areas having significant riparian or wetland values (COE, 1979b).

The outcome of the Corps/DWR levee investigation and the recommended alternative plan or plans cannot be anticipated. It seems likely that cost-benefit analysis will not support the EQ Plan in its entirety, but rather may permit certain elements only to be incorporated. These might include limited vegetation, modification of current maintenance practices, concentration of recreational facilities away from sensitive habitat areas, and, in highly scenic locations, use of set-back levee construction instead of standard stage-construction with riprap (Figure 10).

In planning Corps projects with EQ measures, some manner of cost sharing is normally required, determined by the most apparent use or policy requirement. For example, if use is closest to recreation, then 50% nonfederal cost sharing would be expected, and so on.

The Corps' most active involvement in Delta levee management has been in conjunction with maintaining and planning for expansion of the Sacramento and Stockton Deep Water Ship Channels. Their principal flood control project has been the Sacramento River Bank Protection Project, which extends to Collinsville in the Delta. The Project was authorized in 1960 to provide protection for the existing levee system of the Sacramento River. The first of two phases was completed in 1975, and the second is underway in specific locations.

In its first Phase, the Project constructed bank protection north and south of Sacramento, primarily by mechanically sloping the river bank or

1. State of California. Senate Bill No. 541
2. Senate Bill No. 1390

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berm and facing it with a stone revetment. Some riparian vegetation was saved; however, much valuable riparian fish and wildlife habitat was destroyed. The shade canopy of woody plants and other shoreline vegetation and snags were replaced with a nearly uniform riprapped, sloped surface. Annual maintenance practices, carried out by local reclamation and levee districts, have further damaged shoreline vegetation. Planning for Phase II has had active involvement by FWS, DFG, and the State Reclamation Board in order to obtain better protection of existing vegetation and mitigation for losses.

Some changes in regulatory and planning attitudes are apparent. The Corps' biannual review of California projects (COE, 1979d) says of its Sacramento River Bank Program:

> "Bank protection work requires construction activity that can adversely affect wildlife habitat and the natural beauty of a particular riparian area. To minimize these effects, trees, shrubs, and other vegetation are preserved where practicable and scarred construction sites are reseeded or replanted... Bank protection work is performed in a manner that insures preservation of riverfront aesthetics and wildlife habitat."

Many would disagree that the Corps' work has had this end result. For some time to come, the occasional retention of vegetation on levees will be due primarily to the high cost of selective removal or to oversight.

The Corps has also initiated or participated in pilot programs to test vegetation species and methods on levees. The Corps' Monument Bend test planting was reported by DWR. The study was carried out to determine which of 16 species of trees and shrubs would survive best in a test planting on a substantial levee berm along two miles of the Sacramento River. The five species showing highest survival were the Arizona ash (*Fraxinus velutina*), Japanese zelkova (*Zelkova serrata*), honey locust (*Gleditsia triacanthos inermis*), western catalpa (*Catalpa speciosa*), and coast beefwood (*Causarina stricta*). The evidence of reproduction of the planted species and natural colonization by native wood species and other plantings on the site was encouraging in a riprapped, flood-prone area (Whitlow *et al.*,1979). The Corps believes that this test planting demonstrates effectively that vegetation can be planted on selected levees to improve both appearance and wildlife habitat (Kindel, pers. comm.).

Department of Water Resources

The interests of DWR in flood control and levee management in the Delta are many and complex. These are summarized in Chapter 3. Specifically, under State law, DWR cooperates with the Reclamation Board (below) to provide maintenance of project levees in those cases where it is not performed by local reclamation or levee districts.

The informal policy of DWR with regard to levees emphasizes that proper habitat is needed throughout the Delta and that reasonable amounts of vegetation must be provided to maintain an ecological balance, with major emphasis given to species native to the Delta. However, habitat must be considered in conjunction with other related and often conflicting uses and resources (DWR, 1980).

Following the Sherman Island levee failure in 1969, DWR was directed by the California legislature to study problems relating to the Delta levees and recommend solutions and a course of action (See also Chapter 3). Bulletin 192 — *Plan for Improvement of Delta Levees* (DWR, 1975) — presented to the legislature a plan calling not only for improvement of flood control but also for a well-defined levee vegetation program, to include planting of trees, shrubs, and grasses on the waterside between the top of riprap (1½ feet above mean high water level) and the crown. Where possible, natural vegetation would be retained if there were no interference with flood control capability. Boat speed limits in some channels could reduce the need for riprap.

The objective of restoring and improving wildlife habitat through a planting program was supported by aesthetic objectives and illustrated by typical sections of vegetated levees (Figure 11). "Desirable trees and shrubs such as oaks and crepe myrtles would be retained by selectively clearing the dead, diseased, or unwanted types of vegetation. While more expensive than total clearing of the levee slope, selective clearing would be justified in order to retain desirable native vegetation" (DWR, 1975).

The plan indicated that recreational benefits would accrue from improved fish and wildlife habitat and from aesthetically pleasing levee vegetative plantings. Furthermore, in construction-related dredging operations every effort would be made to protect Delta water quality and fisheries, and dredging would be limited to seasons of the year approved by State and federal fish and wildlife and water quality agencies.

In 1976, the legislature directed DWR to prepare detailed plans and specifications for the improvement of levees in the Delta and report on its recommendations, which would cover not only construction and flood control, but also land use, zoning, recreation, fish and wildlife habitat, and aesthetic values. Cost sharing would be an important consideration. This study is the *Delta Levee Investigation*, now being conducted jointly with the Corps of Engineers. DWR will report to the legislature in 1982.

The Department of Water Resources sponsored and/or participated in two levee pilot planting programs in the 1960's, the first known as the *Pilot Levee Maintenance Study* (1963-1967, DWR Bulletin 167), and the second near Monument Bend on the Sacramento River north of the Delta, initiated by the Army Corps of Engineers (above). These programs are described in Whitlow *et al.*, 1979, and summarized below.

The object of the *Pilot Levee Maintenance Study* was to test alternative levee maintenance practices which would enhance the multiple uses of levees, including flood control, wildlife

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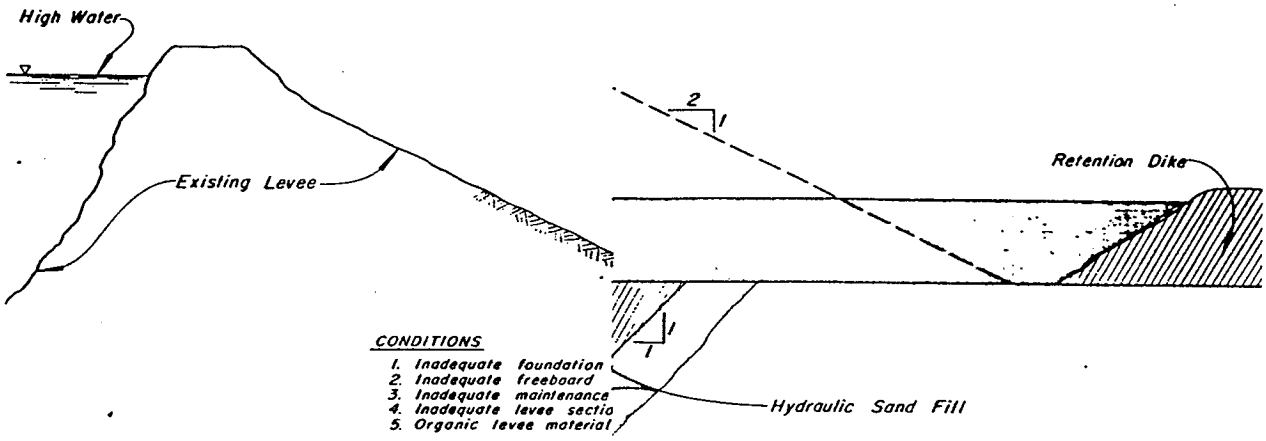


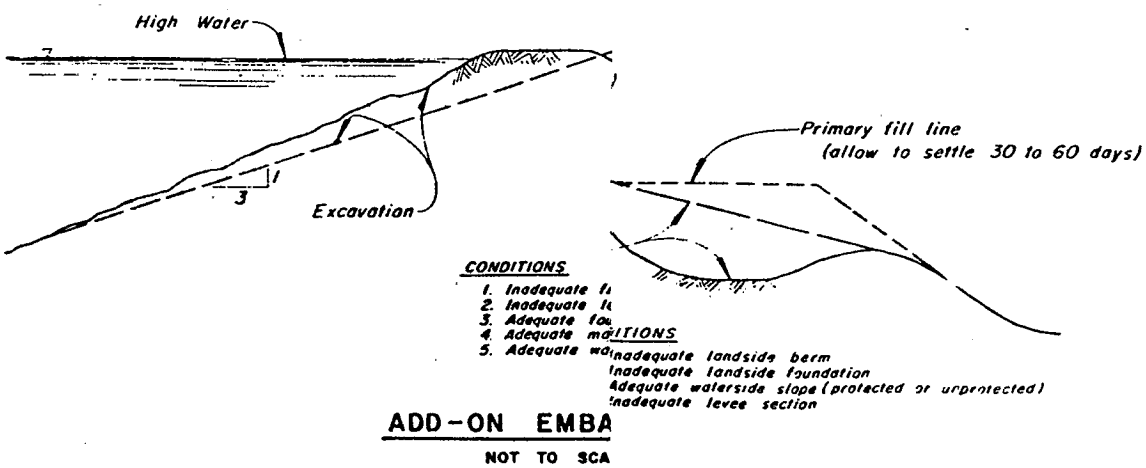
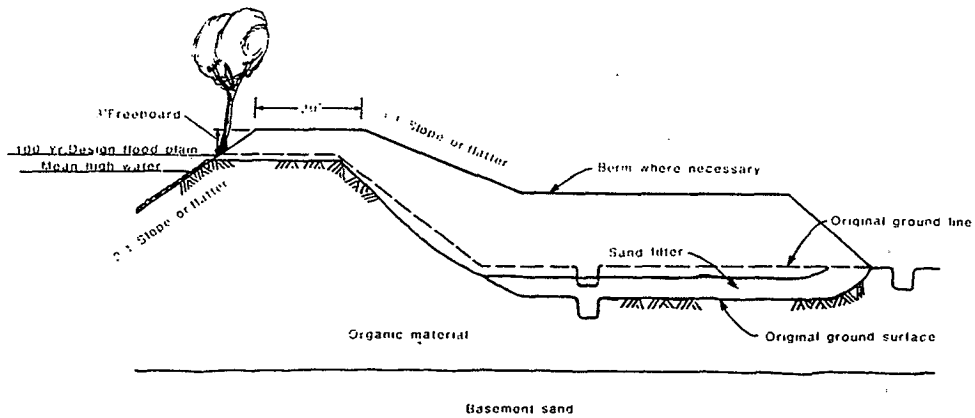
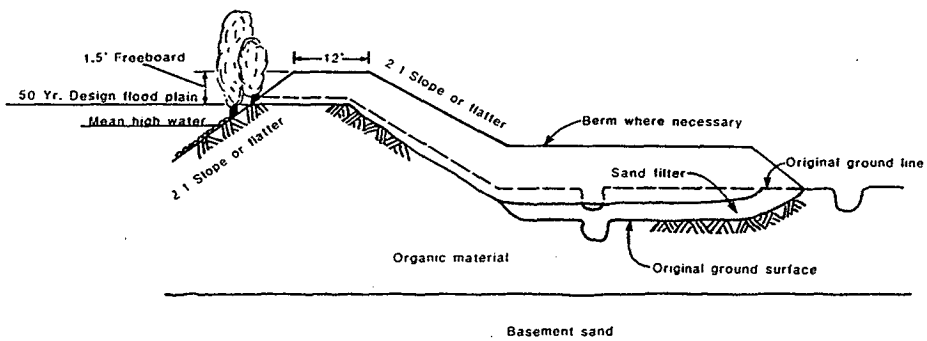


FIGURE 10
Levee Rehabilitation Methods

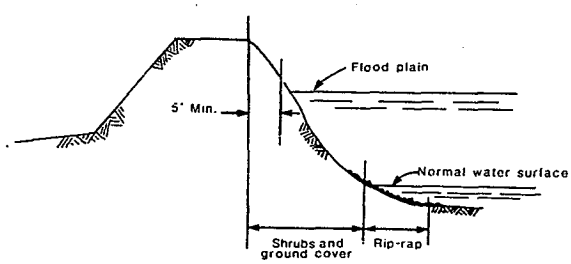
Source: Sacramento District Corps of Engineers, July 1979.



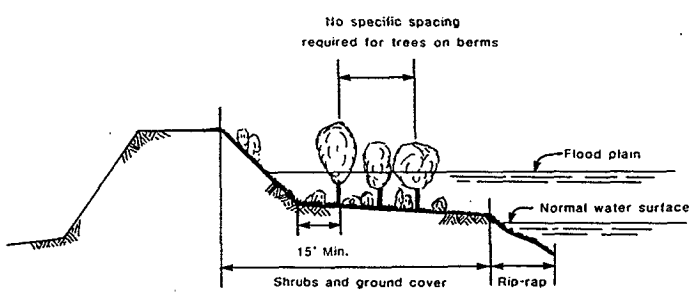
Cross section of improved levee for 100 year protection



Cross section of improved levee for 50 year protection.



Levee with berm



Levee without berm

FIGURE 11
Sections of Vegetated Levees
Source: DWR. Bulletin 192, 1975.

habitat, public recreation, and aesthetics. Several revegetation treatments were tested:

- *Ground cover adaptation* treatment tested various plant species (grasses primarily) for their success as ground cover. Of the species planted the survival of six was rated good or very good at the end of the study. Steps necessary to successfully establish ground cover were enumerated in the study.

- *Erosion control* treatment was carried out to determine which species function best to control erosion. Three grass species were found to effectively retard erosion: creeping wild rye (*Elymus triticoides*), Bermuda grass (*Cyonodon dactylon*), and kikuyu grass (*Pennisetum clandestinum*). Horsetail (*Equisetum* sp.) was also found to be effective. The study also concluded that erosion below the normal water level could only be controlled by use of some form of revetment.

- *Tree adaptation* treatment tested ten tree species for survival in two areas of the levee. It was found that red ironbark (*Eucalyptus sideroxylon* var. *rosea*) and purple plum (*Prunus cerasifera* 'Pissardi,' *P.c.* 'Thundercloud,' *P.c. blireiana*) survived best on levee berm rather than waterward slope.

- *Controlled growth* treatment compared the success of mechanical and chemical maintenance techniques. Chemical techniques were less effective than mechanical techniques, but the conclusions were based on the condition of the vegetation the year following herbicide application. Because many of the levee species are annuals (and thus would be expected to grow back the following year), the conclusions of the study may be invalid.

- *Planting of vegetation on riprap* was conducted to determine if spring or fall plantings are more resistant to flood damage. It was found that vegetation planted in the spring withstood flooding better.

- *Concrete block revetment* treatment tested the practicability of establishing a mechanical/vegetational erosion retardant (concrete blocks with holes through which plants could grow). Plants did not grow through the block holes, and the block mat fractured.

When two of the original test sites were inspected in 1979, some of the experimental grass stands were still present. The trees which were surrounded by riprap were healthy and the riprap in place. Erosion had taken place in areas which were not revetted. Fourteen of the forty trees originally planted were still alive; all of the surviving individuals were located above the levee berm.

A comparison of the costs of the *Pilot Levee Maintenance Study* alternatives showed that the maintenance cost of controlling natural or planted levee vegetation is less than that of maintaining man-made (structural) landscapes such as riprap. If vegetation were left in place above the level of mean high tide, riprap might be necessary only at the levee toe, thereby reducing initial materials costs. In an evaluation of DWR results, Whitlow *et al.* (1979) recommend that there be further experimentation on methods of herbicide application as a means of vegetation control (such as poison oak or blackberry) since it is cheaper than mechanical control.

In a recent study, DWR established plantings along the Sacramento Delta to determine the species and methods best suited for use in the levee intertidal zones (Whitlow *et al.*, 1979). Plants with known breakwater, flow reduction, and soil binding capabilities were chosen for the experimental plantings. Plantings were made on three levee sections: a recently dredged site; a site consisting of eroding levee stretches; and a site consisting of silty sand, which was spot-planted.

Overall, the plantings were deemed a "qualified failure", with high mortality at all three sites. Most of the plants at or near the waterline were physically removed by either wave erosion or slumping of the levee. Frequent, deep flooding was also a probable cause of mortality. Plants above the intertidal zone stayed in place and grew well. Willow (*Salix goodingii*) wattle stakes and wattling, as well as one species of spikerush (*Eleocharis macrostachys*) showed vigorous growth.

The DWR studies demonstrate that it is difficult to reestablish vegetation in the intertidal zone once the native vegetation has been removed (DWR, 1967; Whitlow *et al.*, 1979). Except in protected sloughs – free of boat wake, wind waves, and high velocity currents –it is doubtful that vegetation alone will stabilize levees. Nor is frequent re-facing of levees with dredged material over existing "pest" vegetation, like blackberry, effective, as it favors more erosion and does not prevent the return of blackberry and other plant species.

A third investigation by DWR which has important habitat implications is the *Integrated Pest Management Program for Ground Squirrels on DWR Levees* (JMI, 1978a). The study recommends a strategy for making a transition from conventional pest control and levee maintenance practices, which at present encourage ground squirrel populations, to an integrated approach based on an understanding of ground squirrel biology (*e.g.* reproduction, natural enemies, and predators) and management of selected vegetation. The practice of stripping levees of vegetation and burning, mowing, and use of herbicides would be eliminated, and landowners educated to the dynamics of ground squirrel colonies and improved modes of eradication. Other nonpest forms of wildlife would indirectly benefit from the retention of selected vegetation in place of barren levee slopes (see Figure 7).

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California State Reclamation Board

The Reclamation Board assumes responsibility for project levees and flood control projects by assigning maintenance to local districts, providing project assurances, and acquiring rights of way, including environmental easements or fee acquisition of riparian areas. The Board's jurisdiction extends over State lands (not clearly defined in the Delta) as well as over project levees through provision of assurances to the federal government (Sands, pers. comm.). Private levees are entirely outside the Board's present authority (See Chapter 3).

In conjuction with regulating works (structures, *etc.*) which will have an impact on project levees, the Reclamation Board adopted and has since revised a guide for use of vegetation on levees – *Levee Encroachment: Guide for Vegetation on Project Levees* (1967, rev. 1976). Its purpose is to establish standards and to guide the planting, retention, and maintenance of vegetation on flood control project levees in the Sacramento-San Joaquin Valleys. General standards comply with guidance contained in Bulletin No. 167 (DWR, 1967). Standards encourage planting of native (and other) species but place on the applicant/landower full liability for maintenance of vegetation and for damages which might result from the presence of vegetation (Figures 12 and 13).

A select number of species of trees and shrubs are considered acceptable to the waterside of project levees (Appendix D). Generally, only deciduous trees are permitted: 40 feet or smaller when full-grown, adequately spaced (25 feet on centers), located above the design floodplain, and deep-rooted with clean trunks. Shrubs should also be deciduous (or evergreen, if they do not impede inspection), and limited in number so as not to restrict inspection and flood control operations. Requirements for landside and waterside berms are less restrictive.

A draft "Guide for Permissible Vegetation on Levees Under Reclamation Board Jurisdiction" has been under review since October 1979 but has not been adopted (December 1980). It differs from the *Levee Encroachment Guide* in that it would permit tree growth on the waterward levee slope below floodplain, it would apply the same vegetation criteria to both revetted and non-revetted areas; and it would reduce the levee crown minimum width required for vegetation on landward and waterward slopes from 30 feet to 25 feet. These points are at variance with federal regulations, and the COE has questioned their acceptability for project levees.

The Board has been actively involved in Phase II of the Sacramento River Bank Protection Plan, conditioning State assurances for various portions of the project with specific requests from the Department of Fish and Game for features which will maintain existing woody riparian vegetation and for changes to the Corps' maintenance manual (for the Project) to promote vegetation "to benefit natural ecological systems" (DFG, 1979) (See also Chapter 3).

While much of the Sacramento River Bank Protection Project is outside the Delta, the pattern of interaction with the Army Corps of Engineers and other agencies is significant. For example, Unit 36 of the Sacramento River Project takes in an area of Steamboat Slough which has had minimal maintenance since 1955 under a moratorium on further levee improvement primarily to save abundant riparian vegetation.

Erosion is severe in several locations because of less-than-standard maintenance and heavy recreational use; however standard rock revetment would destroy the existing vegetation. Bulletin No. 167 reported good results on a test section along a 400-foot shoreline in the slough, in which underwater low level rock revetment allowed vegetation to remain but presented a hazard to boaters. This method was recommended by the Reclamation Board to the Corps as a means of limiting levee erosion and providing vegetation control measures in this portion of the Sacramento River Bank Protection Program, although at the expense of optimum recreational use.

The communication between the Reclamation Board and the Corps indicates that it is possible to achieve a better level of environmental protection in levee maintenance and reconstruction through cooperative technical and institutional means, even though it is difficult to satisfy all "multiple-users" equally. The Reclamation Board is in a position to influence the management of Delta levees through its direct interaction with the Corps concerning project levees.

Department of Fish and Game

DFG comments directly to the Corps of Engineers concerning fish and wildlife aspects of federal flood control and navigation projects which involve levee construction and maintenance and is responsible for environmental review of all levee projects and plans which require a State or Corps permit. DFG also maintains an active liaison role with the Reclamation Board, providing recommendations to be included as conditions on assurances for work on the Sacramento River Bank Protection Project and other project levees. Some of these recommendations for Phase II of the Sacramento River Project include:

- Woody vegetation, including tree forms, be allowed and encouraged to grow in the rock face of berms and oversized levees;
- Minimal vegetation be removed during construction;
- Assurances must be acquired...that maintenance practices (burning and herbicide spraying) will not harm vegetation on the waterward side of levee; and
- The (Corps) maintenance manual should be modified to promote vegetation on the berm(s) to benefit natural ecological systems...(DFG, 1979).

Fish and Wildlife Service

As with the Department of Fish and Game, FWS is empowered to review and make recommendations on federal and State levee projects, and private projects which require a federal permit, license, or funding. FWS has not formulated a policy with specific regard to levees.

At the request of COE, the Service did prepare a fish and wildlife management plan for the Sacramento River Bank Protection Project in conjuction with seeking modifications of Project authorization to offset or mitigate earlier losses in Phase I of the Project. The FWS found heavy habitat losses in Phase I and recommended specific measures to compensate for these losses. The study determined that levees and berm areas could be designed for both recreation and fish and wildlife habitat and still provide for flood (and erosion) control and water conveyance (USFWS, 1976).

The response of FWS to COE public notices which involve levee construction and maintenance activities varies with each project. Past recommendations with regard to vegetation and protection of fish and wildlife have included such measures as:

- Seasonal limitation on (all but emergency) waterside construction work to avoid major juvenile anadromous fish migrations and the avian nesting season, February 15-June 15 (this does not take into account salmon migration from October to December);
- Recommended minimum 3:1 slope (subject to specific design requirements);
- Use of quarry stone or clean concrete rubble for riprap, no higher than 5 feet above MHW elevation, with soil reinforcement matting between top of riprap and access road;
- Replanting with willow, cottonwood, alder, and/or oak tree clusters and other native riparian vegetation...between top of riprap and levee access road, tree clusters to be planted no more than 30 feet apart;
- No removal of vegetation upon project completion unless the levee is being jeopardized by vegetation's presence. FWS and the DFG should be notified and must concur that the levee is jeopardized by such vegetation before removal will be approved;
- Hardstem bulrush (*Scirpus acutus*) or other species of bulrush should be reestablished as growing conditions permit and be retained below the MHW line upon completion; and
- The FWS should be notified 30 days in advance of project activity so that annual or biannual inspection of the project area may be conducted by Service personnel.

National Marine Fisheries Service

NMFS, under authorities similar to those which guide FWS, reviews and makes recommendations on federal, State, and private levee or flood control projects which require federal permit or funding. NMFS is particularly concerned with maintenance of Delta anadromous fish resources. Although its role in Delta aquatic habitats has not been clearly established, riparian vegetation is regarded as an essential resource by NMFS. Among other attributes, this vegetation supports large and diverse insect populations which provide a food source to anadromous fish as well as wildlife species (Leh, pers. comm.).

Other Research Programs Concerning Vegetation Species for Delta Levees

Other research pertaining to levee revegetation has been conducted by State and federal agencies. From 1967 to the present, the Department of Environmental Horticulture at U.C. Davis has conducted flood tolerance research on almost 100 tree or shrub species under flooded conditions. The research quantifies flood tolerance in terms of flooding depth and duration. Many ornamental species were found to be flood-tolerant in addition to the few species already recognized as having this characteristic.

A study for the USDA Aquatic Weeds Laboratory, U.C. Davis, was published by Yeo and Fisher in 1970. The object was to determine the effectiveness of spikerush (*Eleocharis* spp.) as a biological control for aquatic weeds. Spikerush species are able to outcompete less desirable species and seem well-suited to survive and reproduce under levee conditions of flooding, draining, high water velocity, and need for binding soil.

Rollins (1976) prepared a list titled *Wildlife Plants Selected for Study on the Peripheral Canal Test Levee* . The list includes 25 species which could be used to create and enhance wildlife habitat along the proposed Peripheral Canal.

The Soil Conservation Service's Lockeford Plant Materials Center conducted studies in 1977 and 1978 on seven species, planted in flood control channels and a creek watershed, to determine their effectiveness in soil stabilization and erosion control. Several grass species performed well under conditions typical of levees, such as fluctuating water levels. This evidence conflicts with more recent evidence of high mortality of new plants at the waterline, which suggests that grasses might have to be restricted to areas above the mean high tide level (Whitlow *et al.* 1979).

The John Muir Institute report, titled *Integrated Pest Management,* provides a vegetation checklist of potentially useful plant species for introduction into DWR levee systems (JMI, 1978a;b). This list was prepared for the specific purposes of managing the Beechey ground squirrel through habitat manipulation and maintaining habitat for other nonpest wildlife species. Plant species are also noted for flood value and salt tolerance and their utility in controlling erosion.

A recent list, titled *Revegetation Criteria for Riparian Plants Along the Sacramento River, California,* was prepared by Arnold in 1979 for the USFWS. This list, compiled in conjunction with the Corps' Chico Landing to

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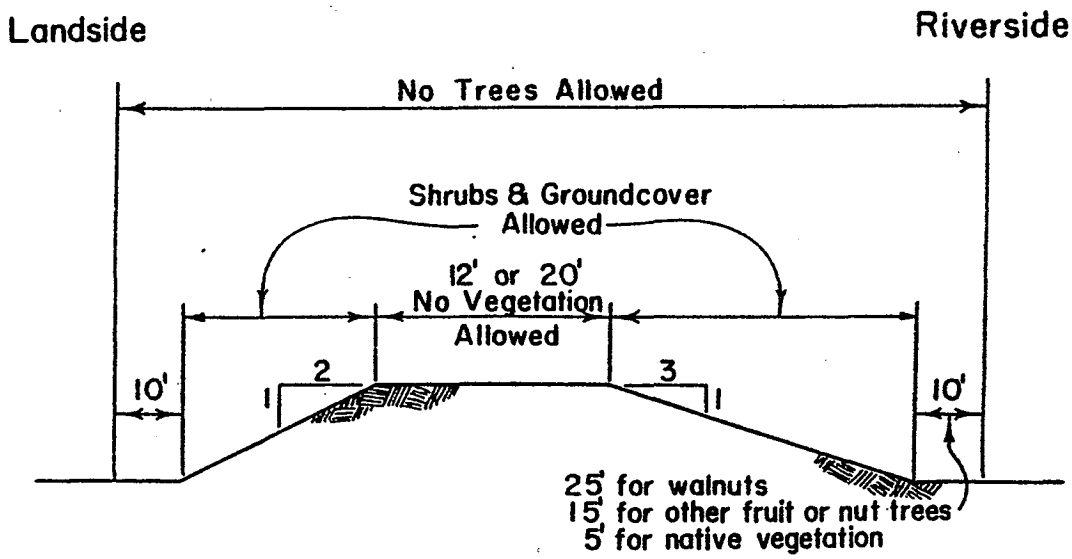
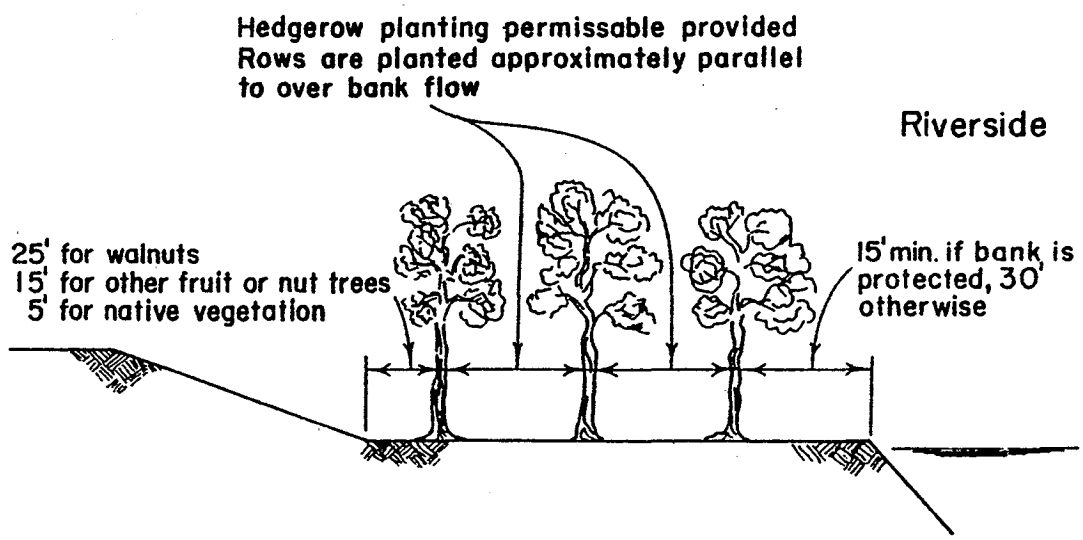


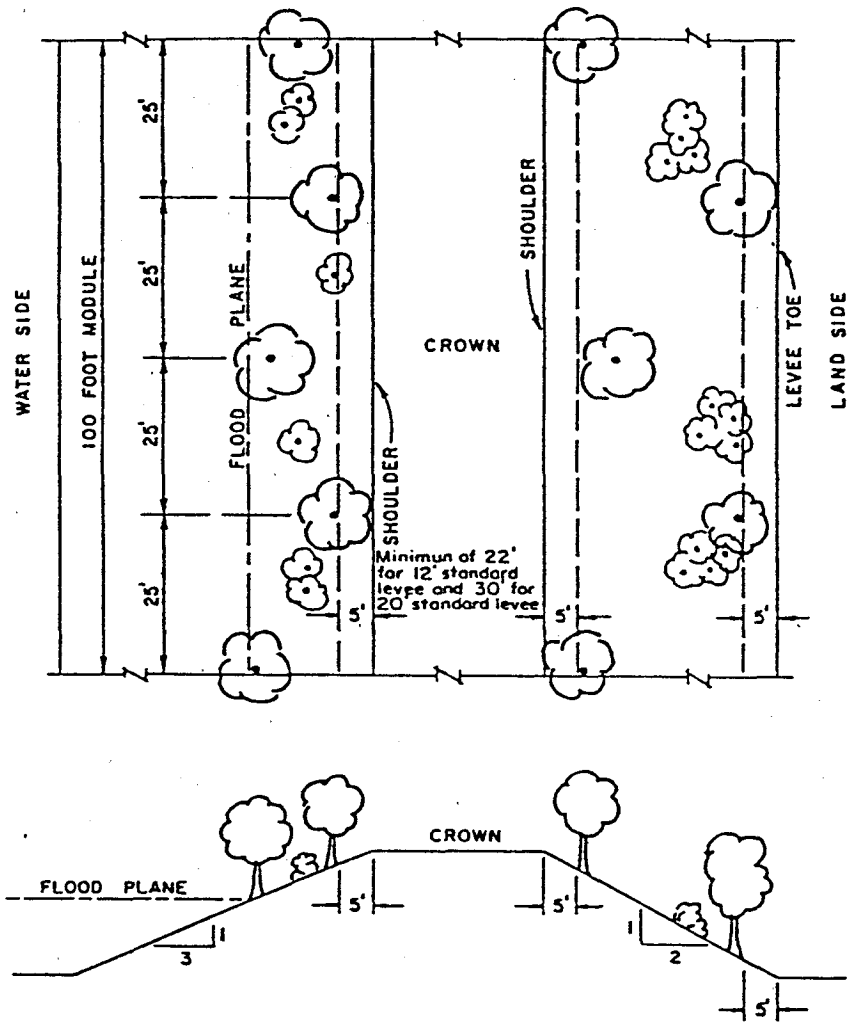
Standard Project Levee



Berm and Overflow Areas

FIGURE 12
Standard Project Levee, Berm and Overflow Areas

Source: State of California. The Resources Agency, Reclamation Board, 1976.



0 20 40 ft.

FIGURE 13
Oversize Levee

Source: State Reclamation Board, 1976.

Red Bluff Bank Protection Project, includes plants suitable for planting on the Sacramento River banks (Arnold, 1979 in Whitlow *et al.*,1979).

The various lists of species suitable for levee revegetation have been compiled by government agencies to meet specific management objectives. No single list meets all of these objectives. A composite list was compiled by Whitlow *et al.* (1979). The list is adapted in Appendix D.

Technical, Cost, and Implementation Considerations

Technical Considerations

It is apparent from research evidence that multiple-use levees can be maintained to provide benefits beyond flood control (DWR, 1967; COE, 1978). Problems which are created by vegetation on levees often can be solved by selective control of native growth and careful planning of revegetation projects (Figures 11, 12, 13). Growth can be open, not bushy, to allow inspection and flood fighting. Grass can be mowed, instead of disced or burned, for inspection purposes. Plants can be selectively encouraged or removed at the water's edge. Trees can be topped when mature and removed when dead. Trees with limited horizontal-spreading root systems can be chosen for revegetation (DWR, 1967).

Consideration must be given to the condition of the levee in determining the feasibility of vegetative enchancement and restoration. Some private levees are too small in cross section to support much growth, especially trees. These should be revegetated only after a modification of the levee section and a stability analysis. If the levees now sustain healthy vegetation, new well-designed set-back levees could be built landward of them in order to save the existing riparian habitat (Figure 10).

Project and direct agreement levees offer the best opportunity for enhancement or restoration, through cooperation between the Corps, the State, and the landowner or local district. Under a management program, existing perennial vegetation which can be supported along the Delta levees could be incorporated into the protection design rather than stripped. Levee inspection and maintenance might be eased rather than made more difficult under a managed vegetation program. Levee management plans similar to those of the forest industry and modeled after those of the California Division of Forestry could be developed, using nurseries to grow sufficient numbers of tules. Willows could be planted as cuttings without risking destruction of native vegetation (Whitlow *et al.*, 1979).

Cost and Implementation Considerations

Reconstructing levees to multiple-purpose environmental standards and modifying maintenance practices to enhance levee habitat are costly, although some techniques appear to be competitive with current practices. For example, preventive maintenance through repair and construction of berms was found to be almost the same cost as complete rehabilitation of a critically eroded levee (DWR, 1967).

The extra costs cannot be allocated solely to the farmers and landowners who own the levees and who depend on them principally for flood control. Because of the increased wildlife and recreational benefits, the general public should share in meeting the costs. Funds might be generated through use fees on newly constructed private recreation and fishing areas. Additional sources should be investigated.

In summary, the most significant problems currently confronting the achievement of multiple-purpose flood control levees are:

- sharing of costs;
- public access to levees; and
- absence of administrative procedures for multiple-purpose flood control projects.

At the present time, most levee maintenance costs are borne by direct flood control beneficiaries, *i.e.*, the landowners. Major repair costs are borne by the public. The introduction of uses other than flood control would require sharing of costs among all users in some manner proportional to the value received.

If sections of levees are developed and maintained for active recreational uses, strong provisions must be made for allowing and controlling public access to be compatible with adjacent land uses and with wildlife habitat, as well as with the primary purpose of flood control. Increasing the number of well-defined recreation sites would take some pressure off the natural areas and also help the farmer who is having problems with trespassing and vandalism. Proposed agency levee improvement plans recognize this need (COE, 1979b; DWR, 1975).

Finally, there is no single agency that now has the authority and responsibility to implement a program of multiple-purpose levee use. The achievement of multiple-purpose levees will depend on flood control, recreation, and wildlife interests working together toward mutually acceptable objectives.

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Guidelines for Management of Levees as Habitat

The following guidelines are suggested for improved levee management in the Delta by the various public and private entities which exercise responsibility:

For all Types of Levees

1. **Require the highest level of environmental protection (maximum vegetation retention) for vegetation and wildlife habitat on and along levees in areas designated as "Natural Areas" in the Delta Waterways Use Program, as well as other significant wildlife habitat areas, consistent with other needs such as agriculture and recreation.**

2. **Where vegetation clearing is unavoidable, use only selective thinning. Discourage the removal of trees and brush on the waterside of the levee, especially on berms, unless there are overriding conditions which jeopardize levee stability.**

3. **Maintain at least major trees and scattered foliage on the landside of the levee, with sufficient spacing to permit inspection but with adequate quantity and distribution to discourage ground squirrel nesting.**

4. **Discourage use of fire and chemicals for vegetation removal on all levees and limit discing, where unavoidable, to the landside of levees.**

5. **Limit riprap (revetment) for erosion control wherever possible to the height of mean high water level on levees which have sufficient cross section. It should be demonstrated that there is a need for additional protection from high velocity water flow or winds, which can generally only be accomplished by riprap.**

6. **In significant natural areas seek the incorporation of berms and set-back levees into design and repair specifications for levees to support tule stands and riparian vegetation. Priority should be given also to levees where the roots of mature trees are exposed.**

7. **Ensure that use of soil from channel islands for levee work repair, in violation of Section 404 and 1601-3 (See Chapter 3), be reported to the Corps or Reclamation Board, and that the damaged habitat be restored or compensated by the development of new habitat.**

8. **Ensure through Section 404 regulations that hardstem bulrush (*Scirpus acutus*) stands along the edges of waterways are protected, unless it can be demonstrated that they create erosion problems in high water. Otherwise the species should not be removed by levee work unless reestablished after losses.**

9. **Limit all but emergency waterside work during the major juvenile downstream anadromous fish migration periods or the major avian nesting season, February 15-June 15, and encourage all major work to be done at other times.**

10. **For subsidy programs for interim private levee maintenance, which have entailed stripping, modify legislation to ensure funding is conditioned on the retention of vegetation on the levees and berms, where possible. Unless emergency conditions can be demonstrated and mitigation measures are included, priority for allocation of funds should go first to areas identified as "Multiple Use" in the Delta Waterways Use Program, then to "Scenic Areas," with "Natural Areas" excluded from the program.**

11. **In replanting programs, encourage native riparian species and other species which have proved effective (See Appendix D). Guidance should be sought from the Department of Fish and Game.**

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For the Proposed Corps of Engineers — DWR Levee Improvement Program

In addition to the foregoing:

1. **Revise and update the Corps' project levee maintenance manuals (originally published in the 1950's) and ensure that environmentally acceptable uniform standards for multiple-purpose levee maintenance are adopted and implemented. These would include vegetation retention wherever levee stability permits.**

2. **Wherever possible, ensure that areas designated as "Natural Areas" with significant vegetation or areas with potential habitat value be preserved by incorporating set-back levee design. Develop berms with marsh and riparian vegetation as part of the new levee construction. Provide only that amount of riprap necessary to reduce erosion losses along the original levee. The resulting habitat should be managed as a preserve with limited access.**

3 **Locate public use sites where there is minimum competition with wildlife habitat and farming.**

4. **Establish a funding program consistent with levee restoration in which all beneficiaries share in the costs, including recipients of SWP and CVP water, boaters, and other waterway users. (Federal cost-sharing regulations require nonfederal interests to provide lands, easements, and rights-of-way for levee rehabilitation and to maintain levees to federal standards. States are also required to contribute a percentage share of the first cost of construction.)**

5. **Ensure that the degree of flood protection (i.e. for 50, 100, or 333-year floods) is appropriate for the type of land use protected.**

AGRICULTURAL LANDS AS HABITAT

Agricultural land occupies roughly 500,000 acres in the Delta and is the dominant land use. A number of agricultural crops and practices provide significant wildlife benefits, subject to the dictates of local soil type and the economics of marketplace demand and production costs.

Wildlife habitat values of agricultural lands are discussed in detail in Chapter 6. Some of these lands are heavily used in the winter, when fields flooded for leaching provide essential habitat for thousands of geese, swans, and ducks. Late summer flooding for weed and pest control attracts migrating shorebirds, ducks, and sandhill cranes.

Year-round cover and nest sites are provided by permanent pasture and orchards. Heavily cultivated row crops are more frequently disturbed and offer minimal wildlife habitat. Adjacent riparian growth, brushy field edges, vegetated irrigation ditches, and ruderal lands are all valuable habitat.

It is important to recognize the various aspects of farm management practices that specifically benefit wildlife. Maintenance of these beneficial practices to provide habitat values will insure continued agricultural use that maximizes wildlife habitat on cultivated lands in the Delta.

Problems of Maintaining Agriculture and Implications for Wildlife

The long-range problems that threaten the future of agriculture in the Delta also threaten the future of wildlife habitats associated with these agricultural lands. Technical and economic problems could have a considerable impact on farming in some parts of the Delta, at the least necessitating a change in current management policies or crop selection, and, at the worst, making farming marginal, and in some cases infeasible or impossible. The major problems are outlined below.

Irrigation and Leaching

Since most of the farmland in the Central Delta lies below sea level, the water table is quite close to the soil surface. This, along with an irregular land surface from uneven decomposition and settlement of the predominantly peat soils, makes subirrigation the most practical method of irrigation. Subirrigation involves raising the water table to the crop root zone several times during the growing season by siphoning water over the levee into a ditch system and subsequent draining by pumping into adjacent sloughs. The below-sea level elevation of most of the islands requires increasing energy costs for the almost constant operation of pumps to maintain a desirable water table elevation in the island interiors.

Both the peat soils and subirrigation contribute to the building of soil salinity in the Delta. Oxidation of peat removes organic matter and leaves mineral matter behind. With subirrigation, the salts left behind by evaporation and transpiration accumulate in the root zone instead of being washed downward as they are in surface irrigation. The increased salinity of the soils necessitates flooding and leaching of the fields every four to six years, generally in fall or winter. Where salt build-up is severe, the tailwater derived from this leaching process poses a disposal problem. Pollution of the waterways from agricultural return waters is more of a threat in the low-flow portions of the southern Delta

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than in the north and central Delta, where high spring flows adequately dilute and flush the salt-laden leaching waters.

The quality of the water in the surrounding sloughs and waterways is a critical problem. If water quality should be degraded, as by excessive agricultural return waters from the San Joaquin Valley or salinity intrusion from the Bay, salt accumulation in the soil would be increased and there would be a need to leach more frequently. Poor water quality in the waterways would limit effective leaching to only a few months of the year, when freshwater flows would be at a peak.

Sprinkler irrigation provides an optional means of controlling salinity in the root zone by flushing salts downward, but also requires a suitable water supply and large capital expenditures to set up the system, and high energy costs to operate it (Meyer *et al.*, 1979).

Fields now flooded for leaching following the corn harvest in late October or November are heavily used by waterfowl which arrive in peak numbers beginning in December. During the 1975-1977 drought, many farmers were reluctant to leach with the relatively saline waters and, in the absence of winter rains, were able to cultivate the peat soils that in a normal year would have been waterlogged. Waterfowl wintering habitat was adversely affected by the lack of flooded fields and the plowing and discing of the corn stubble, which eliminated cover and waste grain (Rollins, pers. comm.).

Increased salinities in Delta water and soils affect the types of crops grown there, which in turn affects wildlife use. Corn is one of the most valuable crops to wildlife, but also is one of the most salt-sensitive crops. A concentration of 300 mg/1 (approximately 0.3 ppt) may be the maximum permissible salt concentration of irrigation water to sustain corn production. For comparison, irrigation water in the north and central Delta currently averages 200 mg/1 of total dissolved salts (approximately 0.2 ppt) during the crop season. The specific salt tolerance of corn grown on Delta organic soils is under current study (Hoffman *et al.*, 1979). More salt-tolerant crops, such as barley, have less economic return and less value as waterfowl food.

Increased salinities in the Delta waters and increasing energy costs necessary for pumping could also be expected to halt or curtail the current practice of plowing, discing, and flooding certain annual crops in late summer for Johnson grass weed control. While the food value of these flooded areas is relatively low, they provide a ponded water habitat that is in short supply elsewhere in the region and is used preferentially by migrating shorebirds and a few early-arriving ducks.

Subsidence and Levee Stability

Closely related to problems of irrigation and leaching are those of subsidence and levee stability, which are discussed above. Levee maintenance problems are all relevant to continued agricultural production throughout the Delta. Subsidence of organic peat lands in the central Delta is especially important. As islands have subsided, the hydrostatic pressure on the outer face of levees has added to already difficult drainage problems by increasing water seepage through levees. Continuing subsidence makes irrigation and drainage more expensive by requiring the deepening of drainage and irrigation ditches. This, in turn, increases pumping and energy costs.

Economics

Increasing energy costs may eventually affect both management costs (pumping and cultivation) and market revenues (increased costs of producing and transporting crops). At present, the most immediate economic influences on wildlife habitat in the Delta are reflected in: crop selection, which responds to market demand; clean farming techniques, which maximize use of productive lands; and, use of most efficient harvesting method.

Crop Selection. The change in crop predominance in the Delta over the past 15 to 20 years has increased waterfowl use of the area (Rollins, pers. comm.). Winter food supply for these birds was provided as economic demand caused a shift from potatoes, asparagus, and tomatoes to corn and milo. These waterfowl populations now depend on the Delta cornfields for overwintering food, as much of their alternate marshland habitats have disappeared. A significant change in cultivation costs or market demand could dictate a shift to crops with less wildlife food value than corn and milo, seriously affecting some of the waterfowl populations, like the whistling swans that now use the Delta almost exclusively as winter habitat.

Clean Farming. Removal of irrigation ditch vegetation and brush along field margins to enlarge the cleared areas for cultivation maximizes crop production but removes valuable wildlife cover and food sources. Not only riparian vegetation but any brushy cover adjacent to agricultural lands benefits wildlife. Ruderal lands in particular provide valuable wildlife habitat. Rodent and insect control on adjacent agricultural lands is provided by the raptorial and insect-eating birds attracted to edge vegetation. At present there is no economic incentive for Delta farmers to maintain "edge" habitat or ruderal lands, with the possible exception of farms subsidized by pheasant hunting clubs or other private interests.

Harvesting Efficiency. Under prevailing harvest practices, corn and grain are harvested in late fall, and the uncut stubble is left in the fields until spring cultivation and planting.

Recently-developed harvest equipment cuts grain off close to the ground, leaving little stubble for cover and virtually no waste grain for wildlife (Rollins, pers. comm.). Widespread use of such equipment could have as serious an effect on wintering waterfowl habitat as a large scale shift in crop type.

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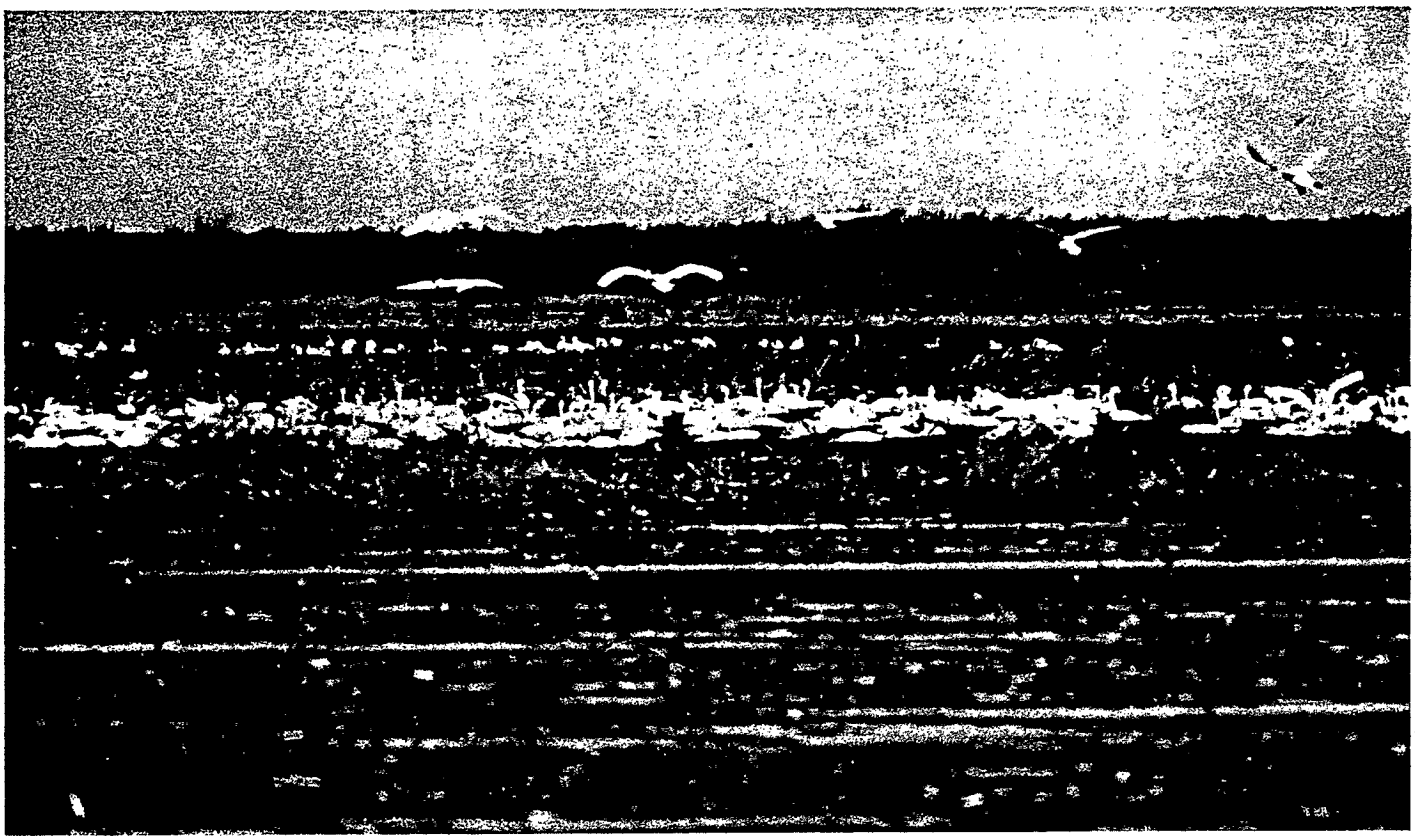

Guidelines for Enhancing Agricultural Habitats

As long as agriculture continues to dominate the Delta, the most important measures that can be taken to enhance wildlife habitat on agricultural lands are those which perpetuate agriculture and also encourage management practices that optimize wildlife habitat. Since crop selection and specific practices are dictated by costs and returns, it may be that governmental subsidies or tax benefits are the only feasible means of implementing habitat enhancement and restoration programs. Education of landowners and farm managers regarding the benefits derived from maintaining wildlife habitat and the value of various agricultural management practices to habitat could help perpetuate the more beneficial practices, as long as economics permit.

Specific guidelines include the following:

1. **Encourage planting of corn, milo, wheat, and other grain crops with high wildlife food value during years when market demand might otherwise favor another crop.**

2. **Encourage establishment and long-term maintenance of brushy hedgerows along field edges, and the maximum practical amount of vegetation along drainage ditches, in long-term ruderal ("waste") patches, and on the landward face of levees.**

3. **Encourage experimental planting and flooding to maximize waterfowl use at selected spots, as is practiced at wildlife refuges. Depredation of field crops by waterfowl is not as serious a problem in the Delta where seasonally dormant leach fields receive the most intensive use as it is in rice fields and winter grain fields.**

4. **Encourage management and harvest techniques that leave some waste grain and stubble or unharvested strips or patches in fields.**

5. **Maintain present water quality in the Delta. Increased salinity would necessitate a change to crop types that are less valuable to wildlife.**

FLOODING OF SUBSIDED LANDS

Technical Problems

The perennial problems of subsidence, levee stability, and soil/water management inevitably lead to questions about the practicality of farming some Delta lands. Further subsidence may make it either attractive to flood an island intentionally, or economically infeasible to drain an accidentally flooded island (Figure 14). Levee repair, extensive pumping, and reclamation and recultivation of flooded lands could prove to be a greater economic cost than the expected return from continued farming of the affected islands (COE, 1979b).

Intentional flooding of marginally productive agricultural lands is frequently proposed as a habitat enhancement measure that would return subsided reclaimed lands to a more productive habitat type for wildlife. Permanent flooding of one or more of the Delta islands, whether accidental or intentional, carries with it many technical problems other than economic costs which will require extensive further study. Some of these problems are reviewed below.

Water Quality

Because virtually all of the reclaimed lands are substantially below sea level, the immediate effect of flooding a central Delta island is inflow of salt water from the west. The long-term effect on water quality is not clear; predictions as to the nature and degree of salinity intrusion are at variance:

- Water and Power Resources Service (formally Bureau of Reclamation): With the increased water surface, the tidal prism would increase, allowing larger volumes of salt water to move further into the Delta with the flood tides. The greater water surface would allow greater evaporation, adding to the salinity problem (CACW, 1975).
- Corps of Engineers: The tidal prism would increase while the island is filling; the extent of salt intrusion would depend on the season (CACW, 1975).
- Department of Water Resources: The tidal prism would not be significantly affected, but if the flooded area is large, there would be some effect on the total salt water volume in the Delta (CACW, 1975).
- Delta Advisory Planning Council: Extensive intrusion of salt water would result from loss of land surface and dilution of fresh water (DAPC, 1976a).

No governmental agency can offer quantitative evaluations of the effects of island flooding on water quality. They agree that the effects depend on the size and location of the area flooded. Site-specific studies of proposed areas or recently flooded areas would be required before intentional flooding could occur. Mathematical models of the Delta and the Corps of Engineers' Bay-Delta model might provide assumptions upon which to judge the physical/ecological merits of flooding or allowing flooded islands to remain so.

Historically, water from upstream reservoirs has been released to repel salt intrusion after major island floods. This is one method of dealing with water quality problems associated with permanent flooding, but is very wasteful and also costly. The 1972 Brannan-Andrus Flood cost $18 million for water released (CACW, 1975). These releases were not completely successful in maintaining water quality in the central and southern Delta, where salt water had to be pumped out.

Other options for repelling salinity have been investigated, including a physical barrier in Carquinez Strait. The potential adverse effects on navigation, fish, wildlife, and public health have kept this proposal from being seriously considered.

Another aspect of water quality which would be affected by flooding is the dispersal of agricultural, industrial, and municipal wastes that are discharged into the Delta. Permanent flooding might lessen flow rates so that these wastes would not be flushed downstream to San Francisco Bay waters, but would accumulate and concentrate in Delta channels.

Levee Stability

The increased water surface created by permanent flooding produces a longer fetch, allowing the wind to create larger waves. These waves increase the erosion rate of the remaining exposed levees, increasing the probability of levee failure and further flooding. The Department of Water Resources has stated, "Inundation of some small islands probably would not significantly affect the stability of the Delta. Small islands, with their limited distance for the generation of wind waves, probably would not have a major effect on adjacent levees." (CACW, 1975). In contrast, waves generated on Franks Tract, a major island now permanently flooded, are considered a hazard to recreationists in small boats, and wind-generated wave erosion probably contributed to the 1980 levee failure on Holland Tract, which borders Franks Tract on the south.

Implications for Fish and Wildlife

The effects on fish and wildlife of accidental flooding, as through levee failure, and intentional flooding following the development of a restoration plan for wetland (marsh) habitat, are substantially different. The latter case is discussed below (see Marshland as Habitat).

Since many Delta islands are as much as twenty feet below sea level, a flooded island would support aquatic species, such as resident warmwater fish or striped bass populations, providing salinity intrusion could be controlled and hydraulic connection with waterways were maintained (See Chapter 4, below).

Generally, however, the effect of uncontrolled flooding of an island is to increase salinity, which is detrimental to Delta aquatic habitat. Low salinity is required for striped bass spawning and also for the survival of the mysid shrimp (*Neomysis*), an important food source of the striped bass. Increased salinity also has a detrimental effect on Suisun Marsh, where low salt levels are necessary to survival and seed production of preferred waterfowl food plants, such as alkali bulrush. In addition, if flooding decreases channel velocities in the Delta, there might be an adverse effect on anadromous fish. Salmon migration is dependent on flow rate, as is the survival of young striped bass and other sport fish.

Merely flooding an island would not create substantial habitat for birds and mammals, except around the fringe. Fields which are seasonally flooded for leaching are used by migratory and wintering waterfowl as feeding areas. These waterfowl require either the grain lost during harvest, or the emergent food plants which grow in shallow water. Unless flooded islands were filled to the level of a marsh (near sea level) and revegetated with valuable fresh and brackish water food plants, flooding would destroy habitat for terrestrial and water-associated wildlife more valuable than that which it would create.

Wildlife objectives will be better met and achieved in a more cost-effective manner if conversion of a subsided island to wetland habitat is intentional and predesigned, rather than merely reactive to an event of accidental flooding that renders an island permanently unuseable for agriculture (see Marshland as Habitat, below).

Preliminary Guidelines For Use Of Subsided Lands As Habitat

1. **Acquire with public funds or private land trust funds marginal farmlands that are no longer capable of producing a positive return on agricultural investment, because of subsidence, increased salinity, loss of peat soils, *etc.***

   These areas would have to be managed by a responsible public agency, such as FWS or DFG, for wildlife habitat. Since the general public will be the beneficiary, acquisition costs could be borne by the State as is now done for park lands. Appropriate levee access and recreation sites could also qualify such a project for consideration as part of a State park or recreation area (DAPC, 1975).

2. **Designate certain small subsided islands as "mitigation land banks."**

   This is proposed as an option in Appendix C. The concept requires interim purchase with either private land trust funds (*e.g.,* Nature Conservancy; Trust for Public Land) or public funds. Subsequent "investment" is made by individual applicants in an appropriate portion of the total land bank, as mitigation for adverse impacts which their specific development proposals elsewhere in the Delta might have on fish and wildlife habitat. It offers a practical means to restore a large, diversified wetland habitat to offset the numerous small losses of habitat in individual development projects.

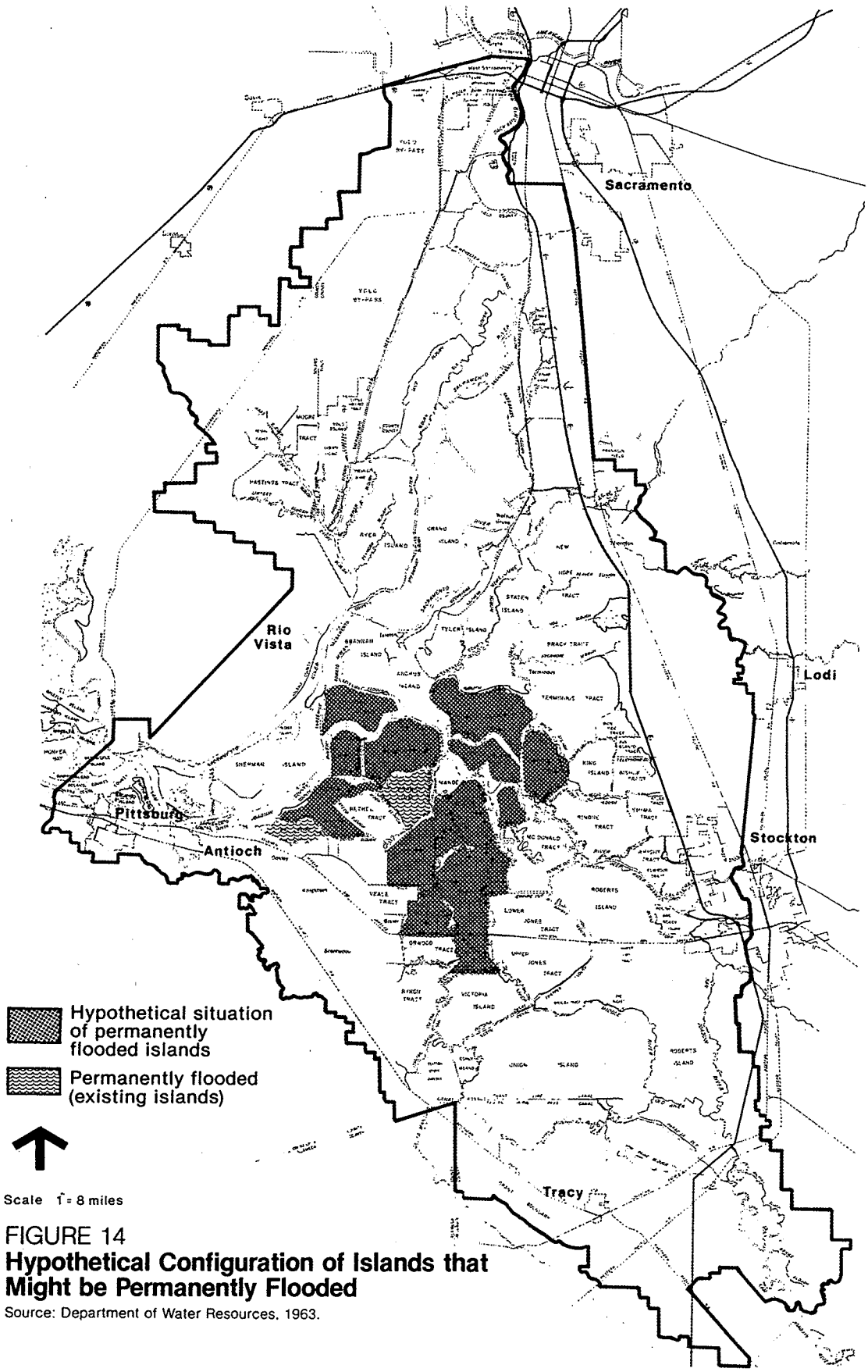

FIGURE 14
Hypothetical Configuration of Islands that Might be Permanently Flooded
Source: Department of Water Resources, 1963.

MARSHLAND AS HABITAT

Reclamation of marshlands and development of Delta waterways has reduced marsh areas to a fraction of their former extent. Because marshland is one of the more valuable of Delta habitats (see Chapters 2 and 6), it is essential that all remaining marshes be protected and new areas be created wherever possible.

Technical Considerations in Restoring and Managing Marshes in the Delta

Marshes are complex physical and biological systems. While they may appear to simply "happen," given appropriate water submergence, elevations, soils, and a plant source (seeds, fragments, rhizomes, *etc.*), in an ecosystem which is already as highly managed as the Delta, restoring as well as protecting marshes requires a comprehensive management program to produce optimum wildlife habitat. Some of the requirements of such a program are considered below.

Formation

The term "marsh" encompasses a variety of situations and conditions in the Delta: tidal and nontidal; fresh water and brackish. Tidal marshlands develop on sediments that are at or slightly above mean sea level, a narrow range of elevations which is critical to the establishment and maintenance of marsh plants. If the land surface is too high, upland vegetation develops; if it is too low, tidal flats or aquatic habitats predominate.

In the Delta, natural tidal and channel currents and wave wash, influenced by human activities, are in a constant process of depositing sediments along the inner beds of channels, in eddies and shoreline inlets, and eroding them in more exposed locations and on outer river bends. Where sediments remain in protected locations, tules and other emergent species become established.

Nontidal marshes in the Delta have developed on overflowed lands, behind natural or man-made berms and levees, and in oxbow sloughs, cut off from main channels. Both tidal and nontidal situations are discussed in detail in Chapter 6.

Creating new marshland requires a protected site with suitable soil surface and water elevations. Since virtually all such existing sites in the Delta are already established with emergent vegetation, creation of new marshland requires restoring former wetlands or developing suitable new sites. Combining two concepts: *viz.* committing subsided lands to permanent wildlife habitat, and using dredge materials as a means of gaining appropriate elevations prior to flooding, offers one opportunity for restoring to the Delta a small portion of the wetlands that once predominated (See Use of Dredged Materials for Habitat, below).

Deposition of dredged material is not the only means of creating suitable sites for marsh formation. Where erosion or future maintenance and deepening of Delta channels might compromise the stability of existing levees, construction of set-back levees behind the existing levee and the new levee can create a peripheral "back marsh" site, between the old levee remnant (the berm) and the new levee (Figure 10).

In the absence of erosive effects of currents or waves, vegetation occurs naturally on a suitable sediment elevation from seeds and plant fragments washed into the area or carried in by waterfowl and other birds. If more rapid revegetation is desired for wildlife habitat or to protect against erosion, planting should be done behind enclosed temporary or permanent levees. Establishing new vegetation in the intertidal zone without protection has been found to be unsuccessful (Chapter 4, above). Once vegetation is established, stabilizing new sediments, some breaches could be made or appropriate tidal structures placed in levees to either restrict or reestablish tidal flow and exchange with the waterways.

Wildlife Habitat Objectives

There are no models for restoration of tidal or nontidal freshwater marshes in the Delta. Suisun Marsh offers the best model for management of brackish nontidal marsh, and there are several experimental tidal salt marsh restortion projects in the San Francisco Bay which provide guidance for formerly diked lands.

The examples which do exist point up the need for a carefully conceived set of habitat objectives, taking into account both the overall ecosystem –that is, the relationship of new or expanded wetland to existing Delta habitats– and specific attributes of the new marsh desired for specific species or wildlife groups.

Observations of relative use of Delta tule marshes are in agreement that the value of tule marsh to various species depends on the type of management it receives (or doesn't receive):

- An unmanaged tidal or nontidal tule marsh is poor waterfowl habitat. *Scirpus acutus*, the principal species, grows in dense stands, limiting the amount of open water available to waterfowl. However, dense stands are useful as nesting habitat for passerines such as blackbirds and marsh wrens, and for rails.

- Dispersed stands of tule provide better habitat not only for waterfowl but for shorebirds as well, which require some mudflat areas.

- Tule areas which are unmanaged, whether tidal or nontidal, will rapidly grow into thick stands. Management is necessary to gain greater diversity of plant species, community form, height, and niches for a more diverse assemblage of birds and mammals.

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- A primary objective of managing tule marsh should be production of food plants, which would include. aquatic as well as emergent plants. Thus, some variation in soil elevation and water level is desirable.

- A comparison of use of seasonally flooded agricultural lands (corn principally) and tule marsh reveals that greater numbers of a few species use corn fields seasonally, whereas more diverse species with fewer numbers use tule marshes year-round. Their diversity depends on the condition of the tule marsh.

There is also general agreement that restoring, enhancing, or simply protecting wetland habitats in the Delta requires careful consideration of the relationships between waterfowl use in Suisun Marsh and in the Delta, such that the two areas meet complementary waterfowl needs. Management of Delta wetlands must also be considered in the context of Central Valley habitats, since waterfowl tend to move from one area to another in response to availability of food and other factors.

Managing the Delta for further waterfowl habitat is probably less important than managing it for specific waterfowl populations. The overall habitat is abundant as long as the present agricultural regime continues (Rollins, pers. comm.). Management should probably concentrate at this time on achieving nongame wildlife objectives.

Management Factors

To achieve optimum new marsh habitat, several general management areas must be considered: vegetation control, physical/hydraulic configuration and maintenance, biological balance, and vector and disease control. Balancing these to meet specific wildlife habitat objectives can be problematic and costly.

Vegetation Control. Successful restoration involves not only planting vegetation, or allowing it to naturally reestablish, but removal as well. Uncontrolled vegetation, such as tule, not only limits diversity but inhibits good water circulation as well. Where currents are slow and erosion is minimal in the Delta, vegetation will occur naturally. Diversity can be accomplished by encouraging both emergent and aquatic plants through establishment of dry and submerged islands; by periodic draining to maintain dispersed stands of tule; by permitting both dense and dispersed tule stands; and by including peripheral upland revegetation in overall planting schemes.

Physical and Hydraulic Control. Physical management involves a number of factors, only briefly listed here. The elevation, contours, soils, and texture of the substrate, along with water source and hydraulic control, are all determinants of vegetation and habitat. Water depth, quality, flow patterns, tidal flux or nontidal internal circulation, drawdown capability, and levee or bank stability are key factors in establishing and managing the physical regime of marshes.

Biological Balance. A well-managed marsh requires periodic monitoring of less conspicuous aquatic and benthic organisms, such as soil microbes, invertebrates, phyto- and zooplankton, including fish larvae, and fish themselves. Generally, diverse vegetation and substrate, with good water circulation, will automatically induce a diverse faunal community.

Vector and Disease Control. The most serious disease affecting waterfowl is botulism. The factors that create conditions which are conducive to botulism are not precisely known, although the bacterium *Clostridium botulinum* is ubiquitous in marsh soils and is important to nitrogen cycling. It is only the proliferation of the bacteria, with toxic side effects, which leads to outbreaks of botulism in waterfowl. Management techniques for avoiding outbreaks include manipulating water depth to minimum but fluctuating levels, maintaining water circulation, removal of dead debris and vegetation, and fairly steep configuration of banks.

The techniques which discourage the botulism bacterium also assist in mosquito control. Large expanses of open water with wave action, rather than small water bodies, will accomplish similar ends. In both cases, drawdown capability is essential.

Guidelines for Protection of Existing Marshes

1. **To maintain the existing marshes of the Delta, it will be necessary to protect them from the heavy wakes of boats, from uncontrolled access, from use of channel tule islands as an emergency source of levee repair materials, and from direct loss of marsh habitat to permitted developments such as marinas or similar projects.**

2. **A greater level of protection of existing marshes will involve a careful evaluation of their condition and use by waterfowl and other wildlife, and their inclusion in an overall DFG/FWS management program for both new (restored) and existing Delta habitats.**

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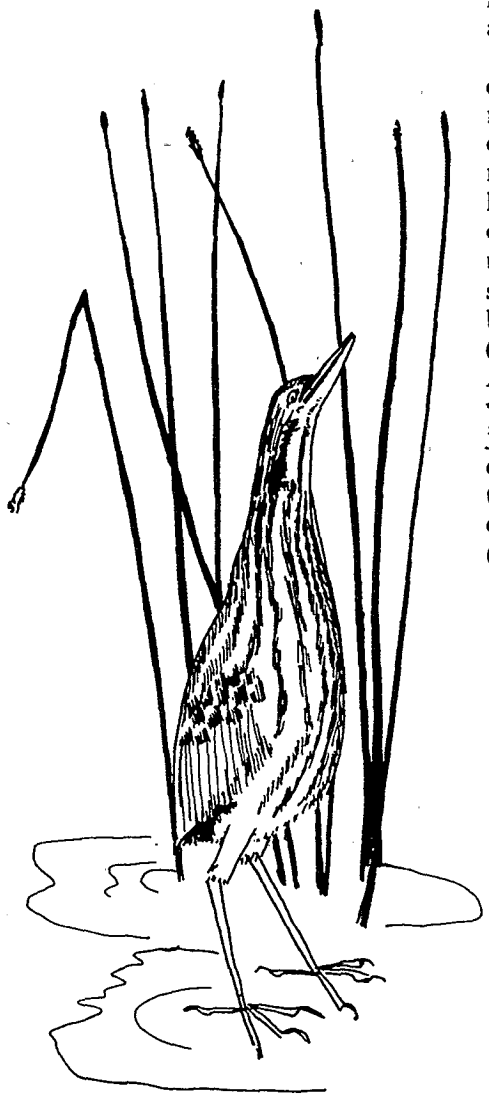

USE OF DREDGED MATERIALS FOR HABITAT

The indiscriminate placement of clamshell and hydraulic dredge spoils in the Delta has in the past eliminated or degraded valuable wildlife habitat by destroying vegetation, raising marshlands above the tidal zone, and burying fertile organic soils with relatively sterile sands. Poor management and containment of spoils has produced sediment discharge into the water, increasing turbidity to the detriment of aquatic organisms.

Since operation of the deep water channels in the Delta will continue to require periodic dredging, responsible disposal of the dredged material is necessary to prevent further loss of habitat. Creation of new habitat or enhancement of existing habitat through use of dredge spoils may be possible in some cases. The Corps of Engineers has been specifically authorized by Congress (Sec. 150, Water Resources Development Act of 1976. PL 94-587) to establish wetlands on dredged material in conjunction with proposed dredging and deepening of Sacramento and Stockton (Baldwin) Deep Water Channels, and disposal sites have been designated (see Figure 15, Chapter 5).

Guidelines for Habitat Development

Several types of situations present possibilities for constructive use of dredged materials for both wetland and terrestrial habitat development.

1. **Dredged materials should be used to bring interior portions of subsided islands to a level appropriate for wetland establishment.**

   The area to be filled, and the amount of filling, will depend on the availability and quantities of dredged materials. At present, it seems unlikely that a sufficient quantity will be produced by pending projects for anything more than a very small island or selected portions of a larger one.

   Since all dredge spoils require time to settle and consolidate before a suitable surface elevation is reached, containment of spoils would require levee repair or construction at the outset of the project. The island or area to be filled and flooded could be sectioned with internal levees and filled in phases, providing a long-term disposal site for channel spoils.

   Deposition of spoils in a presently unflooded island would not threaten water quality if perimeter levees were left intact and if, following flooding, the interior remained hydraulically isolated from Delta waterways and was maintained as a nontidal wetland. This option would preclude its use by anadromous fish (NMFS, 1980), but would at the same time not induce salinity intrusion.

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2. **Dredged materials should also be used to reinforce or replenish eroding channel tule islands or berms, or be placed in between berms and set-back levees, thus extending existing areas of tule marsh or creating slightly higher elevations for riparian growth.**

   If quantities of material are limited, this becomes a more desirable option. As in the first case, containment of spoils would be necessary during the period of settlement and consolidation. This would require construction of interim or "training" dikes.

3. **If carefully controlled, sandy dredge spoils should be used to duplicate and maintain "dune" habitat in selected sites.**

   Upland (dry land) disposal of hydraulic spoils throughout the Delta has created patches of sandy habitat. The western tip of Grand Island is covered with recent sandy spoils, as is another disposal site near Rio Vista. Presumably these sandy areas resemble the old alluvial sands of dune deposits of the primordial Delta, a specialized habitat type for a number of unique animals and plants (*e.g.*, Antioch Dunes).

   Introduction of endangered and candidate threatened species, such as the Sacramento anthicid beetle, could be done on an experimental basis under the auspices of the FWS and DFG. In addition to the beetle, endangered species that might benefit from such a program are the Contra Costa wallflower, the Antioch Dunes evening primrose, and Lange's metalmark butterfly (and its food plant, the Antioch buckwheat).

OTHER HABITAT NEEDS

Channel Islands

Channel islands encompass a variety of habitat types, including riparian woodland, shrub-brush, dredge spoils, and grassland. Major threats to these islands are boat wakes that erode the banks and destroy riparian vegetation, and boater-recreational use that disturbs wildlife, tramples vegetation, and weakens levees through boat tie-ups and foot traffic.

Guidelines for Protection and Enhancement

1. **Boat speed limits should be established and enforced in areas with significant concentrations of channel islands, (*e.g.*, Snodgrass Slough near Delta Meadows, portions of Old River, Middle River, White Slough, Potato Slough, and others).**

2. **The most valuable channel islands should be secured, through easements, purchase, or other arrangements, using public funds to protect these important wildlife areas.**

   Certain islands with exceptional attributes and sensitivities, such as Lost Lake Tule Island, and, where appropriate, newly created island marshes, could be designated as DFG ecological reserves, with "off-limits" or "limited use" areas. There should be minimal human disturbance, and encouragement of wildlife use of the area. This could be accomplished by limiting or discouraging recreational use through posting and, if possible, patroling the areas.

Riparian Woodlands, or Forests

Trees and bankside vegetation occur on unleveed banks, *e.g.* Howard Landing on Grand Island, and throughout the southern Delta on Old River; on wooded islands, *e.g.* Snodgrass Slough and Five Finger Island; and on channel islands with upland wooded areas, *e.g.* Lost Lake Tule Island. A few significant stands of riparian woodlands are found on the periphery of the Delta.

The most significant attribute of this habitat is its structural (vegetational) diversity. Most of the problems discussed in conjunction with levees apply to protection and enhancement of riparian vegetation on channel banks. It appears unlikely that levee construction and maintenance which has flood control as its principal objective will ever permit the rich diversity — trees, shrubs, vines, and ground herbs — which characterizes true riparian habitat.

Guidelines for Restoration

1. **Restoration of areas of riparian forest should be encouraged through dedication of land which can be subjected to occasional seasonal flooding, simulating the conditions of the early overflow lands of the Delta, but high enough to permit natural drainage.**

   Such areas still occur in mineral soils on the periphery of the Delta or on some of the higher, larger islands in the central Delta. Once established, riparian tree species would create the microclimate suitable for natural invasion of other plants. Restoration should be monitored to ensure naturalization of introduced native species and to discourage exotics (See Appendix D).

2. **Construction of set-back levees should be encouraged as a means of creating potential sites for riparian woodland.**

   Where new set-back levees are constructed, the abandoned "front levee" becomes a berm. This berm and the area between it and the new levee provide ideal conditions for development of riparian trees, which can be allowed to grow without risk to levee stability. Elevations can be manipulated to encourage riparian vegetation or marsh, or both in adjacent locations.

Habitat Complexes

Areas of unusual wildlife and habitat diversity in the Delta include the Delta Meadows/Snodgrass Slough/Lost Slough complex; the Stone Lakes; and the three major dead-end sloughs (Beaver, Hog, and Sycamore) in the eastern Delta. Of the three complexes, the dead-end sloughs (Beaver, Hog, and Sycamore) and the lands lying between offer the greatest potential for overall habitat improvement and enhancement of some unique values.

The sloughs are "backwater" areas, and their quiet waters are undisturbed by high velocity through-flow, or heavy boater use. As a consequence, bank erosion is less of a problem there than in other parts of the Delta. The protected nature of the sloughs makes them unique fish habitat, important to the survival of native fish species. In addition to the aquatic values of these sloughs, flooded and dry agricultural lands and marshy areas adjacent to the sloughs are important as sandhill crane wintering habitat.

Although existing bank vegetation is minimal on Hog and Sycamore Sloughs, and confined to a narrow band immediately adjacent to Beaver Slough, the eastern ends of the sloughs lie in alluvial (mineral) soils (DAPC, 1976a), that have the potential for supporting well-developed riparian woodland. Peat soils in the central Delta and at the western ends of the dead-end sloughs do not have the structural strength to support the root systems of large trees, as do mineral soils found on levees and the Delta margins.

Guidelines for Protection and Restoration

1. **Wildlife habitat values should be maximized and the important interactions between habitat types recognized by managing these complexes as ecological units.**

2. **Through easements, use agreements, or long-term contracts, lands between the sloughs should be secured or protected so that a management plan for sandhill cranes and waterfowl can be formulated and implemented. Control of cropping and flooding of the fields to maximize habitat value for the cranes are key management tools.**

3. **Lands at the eastern ends of the sloughs should be secured where possible, and seasonal marshland established or expanded.**

   Where there are suitable alluvial soils on the slough banks, a riparian planting program should be initiated to eventually develop into an oak woodland. Woodland along Blossom Slough (between Hog and Sycamore Slough) and at the eastern end of the management area would buffer the area from urban uses and I-5.

4. **The isolated nature of the sloughs is integral to their biological value and should be preserved.**

   This condition should be considered in future operation of the proposed Peripheral Canal, which, as currently planned, would interconnect the sloughs and discharge freshwater flows into them. Controlled inflow should be designed to increase summer dissolved oxygen levels, but maintain low current velocity.

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5 Scenarios for the Future of Delta Wildlife Habitat

To identify and assess the potential impact of the future land and water uses in the Delta upon fish and wildlife, two contrasting scenarios (that is, predictions of future actions and events) are presented in Chapter 5:

- The *Development Projection Scenario* depicts habitat conditions that could result if existing resource uses and conflicts, as indicated by some apparent trends, continue in the future, fulfilling local general plans and government programs (Figure 15).

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- The *Fish and Wildlife Habitat Enhancement Scenario* is based upon optimum maintenance of existing Delta fish and wildlife habitat,the restoration of other areas which at one time supported habitat,and the creation of new habitat. This scenario, too, depicts future habitat conditions, envisioning an "ideal" future with respect to fish and wildlife resources (Plates B1-8).

Scenarios of this nature can be misleading in their one-sided presentations and arbitrary assumptions. Both scenarios require that certain assumptions be made:

1. the continued operation of the CVP and SWP at projected levels of export;
2. the proposed Peripheral Canal (both scenarios can be developed with or without the Canal)
3. the continued need for levee maintenance that affords adequate flood protection;
4. dredging of deep water channels with designated areas for deposition of spoils;
5. continued urban expansion around the periphery of the Delta; and
6. possible new local water diversions from the Delta, such as near north Stockton, or via the North Bay Aqueduct in Solano County.

In reality, the ultimate future will be some mix of the many possibilities within each scenario grouping. The exercise does accomplish two important functions: predictable uses of land and other resources can be assessed now (even though many potential developments cannot be mapped); and the long-range goal of this Habitat Plan (*viz.*, to protect habitat and expand it where possible through restoration) can be portrayed as if all the necessary funds were available and all implementing decisions had been made. In other words, the *Development Projection Scenario* suggests how land and resources will continue to occur if no *new* management actions are taken. In contrast, the *Enhancement Scenario* suggests how this overall plan, if fully implemented, could substantially improve wildlife conditions in the Delta.

The exercise also encourages two kinds of assessment of the future: a quantitative one, in which actual acreages of wetland and related habitats which are lost or gained can be calculated; and a qualitative one, in which projected cumulative development can serve as a basis for evaluating on a case-by-case basis incremental actions and their impacts, and the probable effectiveness of habitat protection and restoration.

The two scenarios depict future wildlife habitat conditions in somewhat different mapped forms. The *Enhancement Scenario* maps the distribution of fish and wildlife habitats as extensions of existing habitat (Plate A1-8), indicating where levees might be restored with vegetation as a continuation of existing vegetation. Significant natural resource areas are also shown, on the assumption that they would be subject to permanent protection under this scenario (Plates B1 through 8). Chapter 7 lists these areas.

The *Development Projection Scenario* assumes that habitat would be reduced in extent from its present distribution (Figure 15). Certainly habitats would not be expanded. The map for this scenario shows at a generalized scale the variety of potential threats (*i.e.*, human uses and developments) which could displace or degrade fish and wildlife habitats in the Delta.

In addition to predicting actions which may displace habitat directly in the future, it is necessary to consider other activities, such as recreation, which indirectly affect the *quality* of habitat or the viability of wildlife populations. This form of habitat change is difficult to assess or depict as part of a future picture and almost impossible to attribute to any single activity. For this reason, certain uses and activities in the two scenarios are viewed as generally "good" or "bad" for habitat. These distinctions are somewhat arbitrary, dependent in part on one's point of view. For example, the Peripheral Canal is presented as a possible project in both scenarios. Emphasis is placed on either its "conservation" features or its "development" (and growth inducing) features, according to the objectives of each scenario.

DEVELOPMENT PROJECTION SCENARIO

A major function of the *Development Projection Scenario* is to predict the consequences of authorized or probable projects and authorized urban expansions shown on city and county general plan maps (as of late 1979). The second function is to review uses that are or could be permitted by present zoning, particularly as they may adversely affect fish and wildlife habitat in the Delta. Some pressures which might alter local plans and zoning are also noted.

The major use categories, below, correspond closely to those discussed in Chapter 2, in the present Delta. In addition to predicting these continuing uses, the scenario makes some projections regarding the conservation of resources, which will influence the Delta regardless of whether this Habitat Plan is implemented.

Urban and Population Growth Projections

The *Development Projection Scenario* assumes that as urban areas grow, there is inevitable displacement, or conversion, of areas of fish and wildlife habitat. This is the primary impact of growth even though not all of the habitat lost is of equal value.

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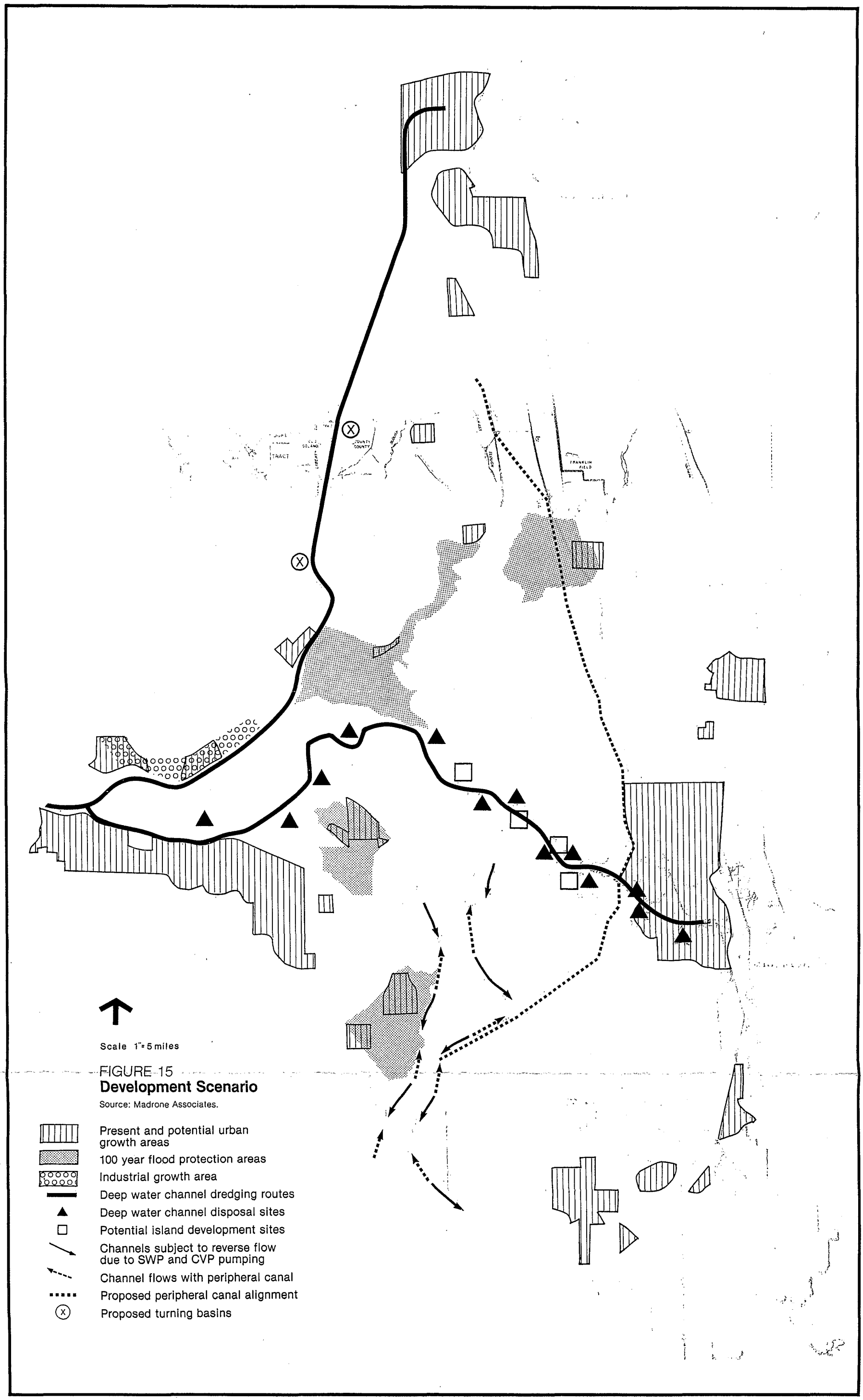

FIGURE 15
Development Scenario
Source: Madrone Associates.

TABLE 5 **Population Growth Projections**

County	1980	1985	2000	2010
Contra Costa	652,800	698,000	829,300	991,100
Sacramento	749,700	853,900	1,015,600	1,104,400
San Joaquin	330,200	349,700	426,800	478,800
Solano	215,900	269,300	385,400	472,000
Yolo	111,500	119,400	133,500	148,900

Source: California Department of Finance

Projections of population growth in the counties which comprise the Delta have been made using the Department of Finance E-150 "A" analysis (*i.e.*, birthrate of 2.1; immigration rate of 150,000/year). The E-150 rates were adjusted for most counties in early 1980 (Table 5).

The Delta urban growth pattern and potential is reviewed in clockwise fashion:

Sacramento County is the fastest-growing urban complex in the Delta area. Growth into the Delta has been reasonably well-controlled to date, attributable in part to public acquisition of the Beach/Stone Lakes Basin Recreation and Wildlife Preserve (see Chapter 7). The Preserve will serve as a buffer area for the regional sewage facility, leaving several hundred acres of Delta land in open space.

The opening of the final link of Interstate 5 between Stockton and Sacramento in October, 1979, has created an entirely new set of growth pressures on the towns of Franklin (on the edge of the Delta planning area), Walnut Grove, and Thornton (in San Joaquin County). None of these areas have community plans establishing development criteria, although present zoning does not permit much outward expansion.

In 1979, Sacramento (City) approved a large subdivision which reached down into the Delta to Freeport on the Sacramento River, completing urbanization to the city's southern limits. Sacramento County has maintained its agricultural zoning from that point, but, with the completion of I-5, growth pressure can be expected to push the suburbs toward the Stone Lake sewage plant buffer area and the Delta south county in general.

San Joaquin County. The completion of I-5, with an offramp adjacent to the unincorporated town of Thornton, will increase growth pressure in this once overlooked area of San Joaquin County. Under almost all options now being studied, the COE intends to provide 100-year (or more) flood protection to this area, a condition that may also stimulate development pressure. The proximity of this area to important wildlife habitat along the Mokelumne River and Beaver Slough creates concerns for these areas in the future.

Stockton has been growing at an accelerated rate, second only to Sacramento. Its suburbs reach into once excellent farmlands north of the city and generally east of I-5. There is already housing on former agricultural lands to the west of I-5. City and County plans have set Bear Creek as the northern urban limit line for the year 2000 (Figure 15). However, growth pressure is continuing in this area. It is possible that Stockton will grow northward to meet Lodi reaching southward.

Lodi has already begun expanding into its western farmlands and vineyards, a trend that could be hastened by expansion into the lands between the two cities. In October, 1979, the voters of Stockton voted to restrict this possibility by endorsing the urban limit and requiring any future changes to the growth area to be ratified by public vote. Opinion has been expressed, however, that this action may cause Stockton growth to be displaced to the Lodi area.

Contra Costa County. Discovery Bay is a water-oriented residential community near the San Joaquin County line. Development is made up primarily of single-family homes and some multiple-family residential development around artificial lagoons and water channels. The community will also have some commercial development in its center and at its southerly edge along

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Highway 4. The community could well grow beyond a population of approximately 12,000 persons, especially since its growth area was recently increased by the County.

The Oakley-Brentwood area is somewhat peripheral to the central Delta. Moderate growth is expected to continue in the general area between these communities. The growth, primarily residential, is being channeled into the area served at present, or capable of being served, by sewer and water facilities. At the western entrance to the Delta, near Bethel Island and Hotchkiss Tract, development will continue until the urban complex is filled in entirely. In the Pittsburg-Antioch area, substantial urban growth will continue. Much of this growth, including industrial, commercial, and residential, will consist of infilling of areas previously passed over, so it represents efficient growth which can readily be serviced.

There are important habitat resources within this area. The edges of Big Break (see Chapter 7) are industrially zoned. New development in this vicinity could alter habitat quantity and quality.

Solano County. Solano County is favoring future industrialization of a portion of the Montezuma Hills between Suisun Marsh and Rio Vista. The Final EIR for the Collinsville General Plan (1979) estimated that future industrial development could increase County population by 6,000 to 9,000 persons. Growth in Rio Vista from such industrial development has not been estimated.

Yolo County. With one of the best implemented Williamson Act programs in California, this County is likely to remain an agricultural area well into the future. The East Yolo County area (including West Sacramento) was addressed by a community plan adopted in 1976. Its modest contiguous growth area presents a reasonable expansion with minor effect on wildlife habitat. Even this area does not appear to be growing rapidly.

Industrial Development

The eastern portion of Contra Costa County has long been an industrial complex and is not expected to expand beyond its present boundaries. However, two important habitat sites within the complex –the Antioch Marsh and the Antioch Sand Dunes, in which live three endangered species (see Chapter7)– could be lost or damaged by industrial infilling of this area. Big Break, another significant resource area, could also be affected.

From the Suisun Bay, along the Sacramento River, past the Montezuma Hills, and up the deep water channel into Yolo County, is one of the last places in California where undeveloped land flanks deep water. The potential exists for industrialization of this relatively quiet side of the Delta, indicated by growth interests in Solano County, by the Sacramento-Yolo Port District, and by the possiblility of federal deepening of the Sacramento Deep Water Channel.

The *Collinsville-Montezuma Hills Plan* (1979), which includes 29,640 acres of industrial land, proposes land allocations in this area for water-dependent industrial (7,440 acres) and water-dependent industrial reserve (2,690 acres). These uses would replace present low-intensity agriculture. The proposed area is directly opposite the convergence of the Sacramento and San Joaquin Rivers, typical location of the Delta nutrient "entrapment" zone (see Chapter 2). Potential spills and waste discharge could cause substantial adverse impacts on the fisheries associated with this zone, and perhaps on Suisun Marsh and San Pablo-San Francisco Bay downstream.

Industrialization is likely to occur in this area both with and without the proposed deepening of the navigation channel (COE, 1979c). Potential growth pressures were noted in the Solano County Area Plan, specifically related to wetlands, but pertinent to other lands in that area as well:

> "Increasing pressures to develop these wetlands for industrial uses may be created by their proximity to the Sacramento River Deep Water Ship Channel, by their level topography, by adjacent waterfront industrial use designation of this plan, by the transportation infrastructure which has been specified to support these designated industrial areas, and by the fact that the Bay region inventory of undeveloped land next to the Deep Water Channel is dwindling." (Solano County, 1979).

In July, 1979, the State Energy Commission endorsed the location of a PG&E coal-fired power plant in the Montezuma Hills upstream from Suisun Marsh. No other proposals are now pending.

The Sacramento-Yolo Port District has long been interested in the industrialization of its corridor and has had long-standing plans to develop industry along the Sacramento Deep Water Channel in Yolo County (Shore, 1974). The Port Commission owns a strip of land approximately 500 feet wide and 20 miles long on the west side of the Channel. It was originally acquired for spoils disposal. The present Yolo County zoning is agricultural, except near the Port itself.

The Port District has noted the special attributes of industrial potential along the lower reaches of the ship channel in Yolo County and has urged the designation of an area immediately to the east of the ship channel in the lower end of Yolo County for future industrial use (Shore, 1976). County and regional plans do not support this designation.

The proposed deepening of the Sacramento Deep Water Channel is closely related to future industrial uses on shore. The project would increase the channel to 35 feet from its present 30-foot depth, with widening in some areas to improve navigability for large vessels. A turning basin has been proposed for a site on the west side of the channel in Yolo County to permit industrial development at this location but has been dropped as unjustified at this time. If the need develops, the Corps of Engineers believes the basin should be located in Cache Slough near the mouth of the man-made channel (COE, 1979c).

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The identification of these two general locations for industrial development suggests that a potential for "strip industrialization" exists along the Channel. Such development would not occur in the near future, but as industrial-zoned lands are used, the eventual effect would be pressure for conversion of agricultural and natural lands to industrial uses. The Corps of Engineers further recognizes industrial growth potentials along the Channel (COE, 1979c):

- "The 35-foot Channel would induce a small increase in industrial development in the Sacramento area and a moderate increase in the Collinsville-Montezuma Hills area."
- "Secondary adverse environmental impact on water quality, air quality, wildlife habitat, land use, and esthetics could occur due to industrialization induced by Channel deepening."

The potential for a future Delta with clusters and strips of industrial development along its western and northern reaches cannot be ignored, and with it will come inevitable impacts of varying degree on the Sacramento River fisheries, Suisun Marsh, and the San Pablo-San Francisco Bay.

Dredging and Spoils Disposal

Water-related industrial uses and navigation improvements presuppose the need for dredging and disposal of spoils. The proposed Sacramento Deep Water Channel improvement would produce about 30 million cubic yards of spoil, while the Stockton Channel project would result in 12.2 million cubic yards. The question of dredging and spoils disposal has both adverse and beneficial implications for the future of Delta habitats to be considered under both scenarios.

The principal negative effects are associated with channel depth and dredging itself. Increasing channel depth would lengthen the longitudinal mixing zone of saline and fresh water, causing slight increases in dry season and dry year salinities in Suisun Bay. Secondly, dredging itself typically causes damage to benthic (bottom dwelling) organisms, which require up to 2 years to recolonize. Short-term local turbidity would exceed already high background levels.

Deposition of spoils can be considered either adverse or, conversely, beneficial. Disposal and storage of hydraulic suction dredge spoils is difficult due to to the fluid nature of the material. The drying time for spoils is one to two years, during which the material is confined by levees (COE, 1979b). Disposing of the amount anticipated will require 3,500 acres of land, much of which has been used for disposal in the past but most of which now is being farmed. Losses of some natural areas may also occur, although mitigation measures call for the creation of new marshes from spoils (See *Enhancement Scenario* below, and Chapter 4). Dredging for both the Sacramento and Stockton Deep Water Channels was authorized by Congress in 1965. Major environmental problems have been analyzed and resolved for both projects in coordination with the State of California, and both projects are economically feasible (COE, 1980a).

Agriculture

Although urban and recreational uses will increase, the Delta, about 90% of which is zoned for farming and 75% cultivated, will continue to be an agricultural region (DAPC, 1976a; DWR, 1978). Farmlands do provide wildlife values (see Chapter 1,4, and 6) if natural vegetation is retained to provide habitat diversity wherever possible and fields are managed for winter habitat. These values are rarely considered.

Farmers nearing retirement are often eager to give up at least some of their land for a marina and/or trailer park. The tradition of family farms passed down through the generations has been diminished by the burden of inheritance taxes and by increasing absentee ownership. In the Central Delta there is growing concern about the future of farming, exacerbated by the constant threat of salinity intrusion and levee failure. Both absentee ownership and these fears may contribute to a reduced level of soil husbandry and investments for the future.

In the *Development Projection Scenario*, no specific prediction can be made of areas or their distribution where farming will become marginal to the point of conversion to other uses. However, if 100-year flood protection is provided to some islands, the direction may well be toward urban development rather than continued farming, with new "Discovery Bays" in the future.

Agriculture-Related Industry

No trend toward the development of canneries and other agriculture-related industry is now apparent, but it continues to be a possibility in the Delta fringes where roads and railroads provide access. A 1976 report by Sacramento County on cannery siting noted several problems and potentials. The siting of a plant near an area of important wildlife value "could reduce the adjoining area's use for nesting, resting, and/or feeding by wildlife sensitive to human activity." The County report notes: "the likelihood of adverse impact depends primarily on the size of the wildlife area in relation to the size of the industrial facility and the distance between the plant and that area." Each use would be buffered in some fashion, and the potential for enhancing habitats with ponds of treated wastewater would be considered. In spite of possible mitigation, this scenario takes a negative view of such development.

Recreational Uses and Facilities

The *Delta Master Recreation Plan* (1976) predicts that "visitor days" in the Delta will increase substantially by the year 2000. The recent completion of I-5 will greatly increase the Delta recrea-

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tional visitation (as might the Peripheral Canal). 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.

Although permits are not easily secured, marina developments will continue to be eagerly sought in coming years. The present trend toward expansion of existing facilities is apparently due to greater ease in securing governmental approval. Mobile home and trailer parks at these sites will grow, and many have the potential of becoming the size of small towns.

Piers and docks continue to proliferate. The condition of wall-to-wall boat storage which Bethel Island now presents, to the detriment of other uses and visual quality, provides an insight into the meaning of "cumulative impacts." In 1979, the Corps of Engineers issued a general permit for piers in waters surrounding Bethel Island. The *Delta Master Recreation Plan* (1976) noted:

> "Recreational use of the Delta's waterways is essentially unplanned and unregulated."

Conflicts will continue to increase, as will adverse impacts.

The Army Engineers' *Delta Levee Investigation* interim report (COE, 1979b) proposed a number of new recreation sites (See Figure 15). Designating specific use areas may help to control visitation, which may in turn reduce trespass on private land and the miscellaneous adverse effects of dispersed uncontrolled use.

The *Development Projection Scenario* takes a pessimistic view and assumes that in spite of the obvious amenities, increased recreational facilities will induce further damage to habitats rather than mitigate existing problems.

Continuation of Current Levee Maintenance Practices

The unqualified view of levee vegetation as being a nuisance and flood hazard risk will no doubt continue to prevail. Media reports on the January,

1980, flooding of two islands observed that heavy brush overgrowing levees prevented detection and control of rodent damage. This view, reinforced by regulation, leaves little room for the redeeming values of vegetation.

A recent State-sponsored report commented on this trend:

> "In spite of studies and new rules, the Delta levees are barer now than they were ten or even five years ago" (DEAC, 1977).

Even though there are apparent changes in regulatory and planning attitudes, the *Development Projection Scenario* takes the view that levees, under present maintenance practices, will continue to lose riparian and fringe marsh vegetation rather than make any net gain. This anticipated loss is difficult to quantify or to depict on a map, however, and must be left to the imagination.

Water Project Construction

The controversial Peripheral Canal is the major outstanding, unsettled issue (July, 1980) of the Delta's future. Its complexity and mixture of adverse and beneficial impacts requires that it be reviewed in a separate section (Chapter 5, below). A related project of concern is the proposed San Luis Drain, which would possibly discharge treated agricultural drainage water into the Carquinez Strait near Martinez. The addition of more saline water to this critical area has raised concerns. Other options have been considered.

Near the northern edge of the Delta, the proposed North Bay Aqueduct, a long-planned segment of the SWP, would divert water from Lindsey or Cache Slough. The project is expected to be in operation by the mid-1980's with a contracted delivery obligation of 67,600 acre-feet. The populations of Solano and Napa Counties which it would serve are outside the Delta.

With or without the Peripheral Canal, the SWP and CVP will continue to increase their exportation of Delta water. Since 1969, the amount of export has about doubled, and it will be doubled again in the next 20-25 years (DEAC, 1977). Already the damage to the fishery from the pumping for these two projects is immense and will increase in the future unless mitigation is provided (See Chapter 2). The *Development Projection Scenario* assumes that

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predictions of water exportation will be fulfilled, with adverse impacts.

Mineral Extraction, Commercial Harvesting, and Mining

By the year 2000, the Delta's gas fields are expected to be largely depleted, although import of gas for subterranean storage will continue. Oil production does not appear to be a future use of high impact. The other uses listed in Chapter 2 are not subject to any apparent trend, so do not enter into the *Development Projection Scenario.*

Aquaculture Potential

The state-of-the-art in aquaculture (raising of fish and shellfish under controlled aquatic conditions) has not reached the point of secure investment. However, progress is evident, and when farming ceases on some Delta islands this form of ranching by the private sector may become a viable alternative.

Aquaculture can be a beneficial use in terms of its compatibility with fish and wildlife habitat, especially when the creation of new wetlands is involved. But the facilities for this activity can displace resident species if existing habitat is used, and it is unlikely that conversion of existing seasonal or permanent wetlands to aquaculture use would be approved. No assumptions can be made at this time that would permit including this water use in a future scenario.

Resource Conservation Conditions

Even under the conditions of the *Development Projection Scenario*, some resource programs and areas which now exist will continue to be preserved. For example, the qualified effectiveness of the Corps of Engineers' Section 10/404 Permit Program, reinforced by the Resources Agency Wetland Policy (Chapter 3) and the *Delta Master Recreation Plan* (see Chapters 1 and 3), indicates that most existing wetlands will be protected from major physical developments in the future, although deliberate or accidental vegetation removal by private landowners or users will continue. The unleveed tidal channel islands fall into a somewhat protected category in this regard, while those islands with upland elevations above higher high water or lying behind levees receive little protection.

The Doctrine of the Public Trust (see Chapter 3) will also continue to be used to control developments of tidal islands and in waterways. Its enforcement is jeopardized, however by poor understanding of its importance and applications.

Under both scenarios, agriculture will continue to be conserved as the primary land use, although it is threatened by an array of problems (see Chapters 2 and 4).

FISH AND WILDLIFE HABITAT ENHANCEMENT SCENARIO

This *Habitat Enhancement Scenario* envisions a Delta in which there is preservation into the future of significant resources and the restoration/creation of habitat areas which have been severely depleted (Plates B1 through 8). Several documents provide a policy basis and reinforcement for the design and objectives of this scenario: the "natural area" designations in the Delta Waterways Use Program of the *Delta Master Recreation Plan* (DMRP, 1976); the "Significant Natural Resource Areas" designated in the *Delta Action Plan* (DAPC, 1976a) and in the *Delta Environmental Atlas* (COE, 1979a); the concept of "multiple purpose levees" established in Bulletin No. 192 by the Department of Water Resources (DWR, 1975) and in the *Delta Levee Investigation* (COE, 1979b); and the Senate Concurrent Resolution 28 (State of California, 1979) regarding wetland restoration.

The inventory of Delta resources (see Chapters 1 and 6) reveals that the three Delta habitat types which are most seriously reduced from their former extent are: riparian vegetation along and on the levees, riparian forests, and marshes. Channel islands, which are often complexes of riparian vegetation and emergent marsh vegetation, have also been recognized as one of the most important and threatened habitat resources remaining in the Delta. The *Habitat Enhancement Scenario* suggests that preservation of these habitats or habitat complexes should receive highest priority in the Delta of the future. Plates B1 through 8 depict these enhanced or restored habitat areas as they might appear in the future Delta

Significant Natural Resource Areas

A total of 66 sites were identified as "Significant Natural Resource Areas" in the *Delta Action Plan* (DAPC, 1976a). These were largely repeated in the *Delta Environmental Atlas*, although some of the specific resource sites were combined into habitat complexes (COE, 1979a). The present Plan adds several sites to the inventory. These are areas having "important open space, ecological, scientific, educational, or wildlife values" (DAPC, 1976a). The definitions include the undeveloped and unleveed channel islands, all of which would be preserved in their entirety in a scenario which calls for enhancing wildlife habitat. These resource areas are described in Chapter 7.

Riparian Vegetation On Levees

The *Habitat Enhancement Scenario* envisions a condition of sufficient funds to undertake extensive restoration of vegetation and habitat on Delta levees. Under this scenario, a substantial growth of riparian vegetation could be established within a relatively short period on the 15% (or about 165 miles)

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of the Delta levee system which are "project levees." These levees were built with federal funds and are maintained by local districts according to strict standards published by the Army Engineers (see Chapter 4). Most of these levees have a substantial cross section, in contrast to most private levees, enabling them to support ample vegetation and still meet engineering requirements. It is proposed that changes could be made to the Corps of Engineers' levee maintenance standards to discourage vegetation removal and incorporate revegetation and selective vegetation management (see Chapter 4).

When the COE/DWR *Delta Levee Investigation* is completed in 1981, the agencies are expected to initiate a joint program of levee rehabilitation. Although many decisions are yet to be made, it can now be estimated that 209 to 508 miles of the privately-owned and COE direct agreement levees (85% of the total system, or about 935 miles) would be rebuilt according to "multiple-purpose standards." This includes the requirement that they support native or other allowable riparian vegetation (DWR, 1975).

With these two arrangements, up to 650 miles out of 1,100-plus miles of Delta levees could have at least limited vegetation. Of the remaining 450 miles of private levees, perhaps half have some vegetation; those levees which are not highly threatened by floodwaters have generally suffered less stripping and would probably not be part of a federal-State investment program.

The *Enhancement Scenario* maps show virtually all Delta levees as being revegetated to at least a limited degree within the next 20 years. The future Delta could probably see up to 875 miles (about 80% of the levee system) having at least moderate amounts of vegetation. Even this improvement is far from ideal. It would generally provide a minimal strip of habitat, given the nearly universal farming practice of removing all growth to the toe of the levee and the typical clearing of important brush vegetation, used by wildlife for cover (see Chapter 4).

Riparian Woodland

Riparian wildlife habitat will not be adequate in the Delta until greater depth is added to what has become a thin and sparse habitat corridor. Remnants of the formerly extensive riparian forests do exist in the Delta. Throughout the Delta and Central Valley, much of this resource has been diminished by agricultural clearing. An "enhanced Delta" would require protection of remaining stands and the reestablishment of several forest sites on public lands, perhaps starting with those already in State ownership, such as at Clifton Court Forebay. New forest sites are not depicted on the Enhancement maps.

Marsh

Even though the Delta is often popularly referred to as a "swamp" or "marsh," there is surprisingly little pristine or modified marshland in the region. Numerous estimates have been made of the virtual decimation of tidal and nontidal marshes, depending on definitions of present and past wetlands.

The *Enhancement Scenario* shows some areas which are potentially restorable as marshes, through two processes: purchase and restoration to wetland condition of small subsided islands where continued agricultural use is no longer economically feasible and catastrophic flooding is an increasing hazard (Figure 6); and creation of "spoils" marshes, as mitigation for losses from dredging the Stockton and Sacramento Deep Water Channels, and additional enhancement wetland areas. This has been authorized by Congress (Sec. 150, Water Resources Development Act of 1976. PL 94-587). In this light, the channel dredging takes on attributes of "enhancement," as well as "development." (Enhancement, in strict federal terms, must go beyond mitigating losses).

California State Senate Concurrent Resolution 28, passed in 1979 (see Chapter 3) directed that State and federal agencies should strive to increase the wetlands in California by 50%. A goal of the Resources Agency, then, should be to add 6,000 acres of new marsh to the Delta by the year 2000. Some of these potential wetlands are depicted in the *Enhancement Scenario* maps.

Restoration of Dead-end Sloughs

One of the highest candidates for public investments in a habitat restoration program are the several dead-end sloughs in the Delta. Their importance as wildlife habitat, or potential habitat, is described in Chapters 2, 4, and 6.

Some of these sloughs (*e.g.* Beaver Slough) are already at least partially vegetated and would be preserved as "Significant Natural Resource Areas." Others, such as Hog and Sycamore Sloughs off the Mokelumne River South Fork, have been severely stripped. In that area, the proximity of the sloughs to each other suggests that the levees and at least some of the lands between could be acquired for a restoration program. Such an area could become a Department of Fish and Game administered ecological reserve (see also Chapter 4).

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Creation of Tidal Marsh (Channel) Islands

Many of the Delta's "tule islands" are threatened by erosion or conversion into boating and recreational facilities. Restoration and expansion of some of the more vulnerable tule islands, through the careful placement of dredging spoils, would create some highly productive and valuable habitats (see Chapter 4).

Variation on the Enhancement Theme

An "Environmental Quality Plan" (EQ Plan) has been presented for purposes of alternative analysis by the Corps of Engineers in the interim report on the *Delta Levees Investigation* (COE, 1979b). The EQ Plan has both negative and positive aspects. The possibility that much of the Delta would come under 100- and 333-year flood protection might stimulate development pressure. On the other hand, the balance of the EQ Plan alternative includes important environmental components:

> "The goal of Environmental Quality (EQ) Plan is the management, conservation, preservation, creation, restoration or improvement of natural and cultural resources and ecological systems in the area under study...*The plan formulated to maximize Environmental Quality was not constrained by monetary requirements and* (it) *endeavors to maximize net positive benefits.*" (editorial emphasis)

Specific objectives of the EQ Plan include:

- management, protection, enhancement, or creation of areas of natural beauty and human enjoyment;
- management, preservation, or enhancement of especially valuable or outstanding archeological, historical, biological, and geological resources and ecological systems;
- enhancement of quality aspects of water, land, and air by control of pollution or prevention of erosion and restoration of eroded areas; and
- avoiding irreversible commitment of resources to future use.

Included in the Plan proposal would be these specific actions:

1. permanent acquisition in public ownership of approximately 370 acres in five different locations within the Delta (Trapper Slough, Rhode Island, two islands near Widdows Island, White Slough Marsh, and the tip of Jersey Island).
2. acquisition of environmental easements on approximately 830 acres, and establishment of a plan for public use protection of these lands (unnamed islands in Connection Slough, Blossom Slough, unnamed lake on Webb Tract, and Oak Island);
3. modification of construction methods in areas identified as having high environmental values for fish, wildlife, and recreation, and containing significant riparian or wetland vegetation. For example, the levee set-back method of construction (Figure 10) would be used in areas of high environmental value along Snodgrass Slough and the Mokelumne River.
4. levee maintenance modifications for maximum retention of habitat (see Chapter 4).

The EQ Plan closely approximates the enhancement recommendations of this Habitat Plan and contains many of the elements of the *Enhancement Scenario* which are mapped in Plates B1 to 8.

RELATIONSHIP OF A PERIPHERAL CANAL TO THE FUTURE DELTA

Both of the scenarios must assume, yet neither can take for granted, the development of the Peripheral Canal. The Canal Plan and its many alternatives contain elements of both development and enhancement far too complex for more than a brief summary.

Project Description

Since 1959, with the passage of the *Burn Porter Act* authorizing the State Water Project, a "Delta Water Transfer Facility" has been advocated and debated. The facility was actually included in the original enactment of 1959, but because of its controversy and the multitude of associated problems, the State has sought separate legislation.

This 42-mile channel would receive Sacramento River water just below the town of Hood (20 miles south of the City of Sacramento) and skirt the eastern Delta to discharge into Clifton Court Forebay. The Canal is expected to include a right-of-way encompassing about 6,573 acres. It would have an average center depth of about 30 feet and an average water surface width of about 500 feet, requiring right-of-way widths varying from 800 to 1,000 feet. The earthen canal would be a combined system of 3:1 and 8:1 slopes (DWR, 1977). Twelve outlet gates along the length of the Canal would release fresh water into the eastern slough, interconnecting also the dead-end sloughs (Figure 16). Eight major recreation sites have been proposed, as have a number of wildlife conservation areas.

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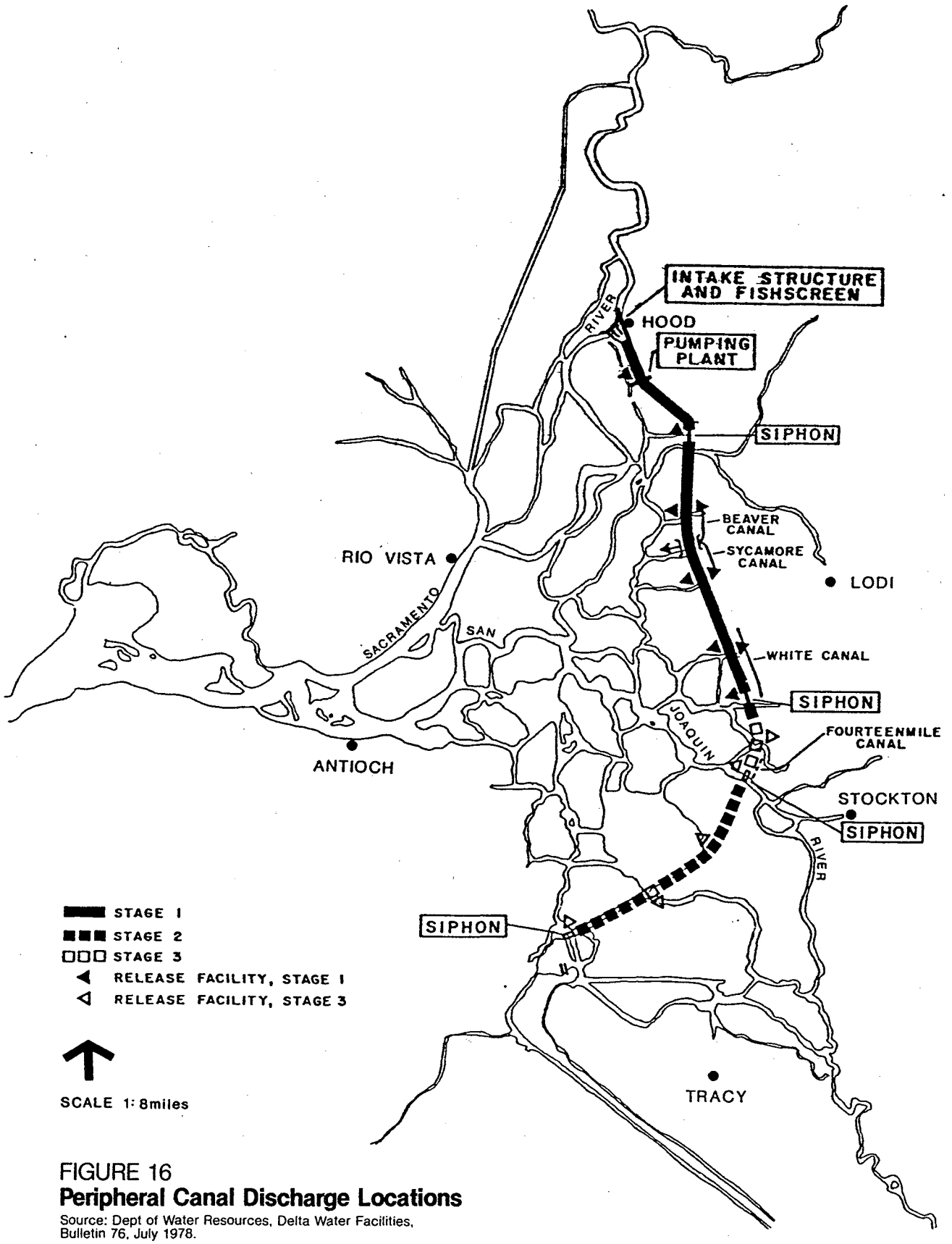

FIGURE 16
Peripheral Canal Discharge Locations
Source: Dept of Water Resources, Delta Water Facilities, Bulletin 76, July 1978.

Impacts: Beneficial And Adverse

The physical plan for the Peripheral Canal was originally conceived as the most practical means of counteracting the adverse effects of water conveyance and pumping on the environmental quality of the Delta. It was designed to:

— resist salinity intrusion into the central Delta more effectively;

— reduce fish mortality associated with pumps by moving the intake from the nursery area (millions of fish eggs and fry are sucked into the present system each year); and

— eliminate reverse channel flows and elevated flow velocities which are caused by the pumping.

Project planning has included provisions for other fish and wildlife benefits.

The project has also been planned to provide new recreation opportunities. By 1990, the Canal could attract 346,000 recreation days. By 2020, this usage could rise to 1,257,000 (DWR, 1978). At present, the project is expected to be designed as a recreational facility with flat, landscaped slopes and fishing and swimming areas. While this concept is attractive in many respects, it is likely that as recreation increased in this area so might efforts to change adjacent agricultural zoning to provide more services. The easy access from I-5 would assure high usage and development interest, and, indirectly, be growth-inducing.

The Environmental Impact Report on the Peripheral Canal observed:

> "Peripheral Canal-induced population growth, both in the small Delta towns and in the communities, large and small, near the Delta, can be attributed almost entirely to recreation-related growth stemming from the planned development of recreational sites along the Peripheral Canal right-of-way" (Socio-Economics Systems, 1974).

Controversy and differing policy positions center not so much in the physical components of the proposed canal, or even its local growth-inducing impacts, as in the basic questions of export of northern California water and the future effectiveness of legal and institutional guarantees to protect water quality and Delta outflow as well as candidate sources for new northern California supply. With specific regard to the future of the overall Bay-Delta ecosystem, it is most critical to predict adverse impacts of the Canal.

Neither scenario can map the future implications of the Peripheral Canal, except to indicate that with the Canal, reverse flow arrows should be changed to indicate net positive downstream flow in the San Joaquin River. There is no means of predicting or mapping the possible adverse effects on habitat resources of further reducing Delta outflow.

The Department of Fish and Game has played a major role in designing the Peripheral Canal to mitigate the adverse effects of the present export and pumping regime. The Department's position is that the Canal in itself is a mitigation measure and contains enhancement provisions which offset potential adverse impacts of its construction and use (Arnett, 1973). The position of U.S. Fish and Wildlife Service is in agreement with DFG with respect to the mitigative attributes of the Canal on Delta fisheries. However, FWS does not endorse the Peripheral Canal. The Service bases its argument on the insufficiency of present guarantees on water quality and outflow. Of specific concern are the possible exploitation of north coast rivers and degradation of both the upper Sacramento River system and the Bay-Delta ecosystem (Sweeny, 1979).

The National Marine Fisheries Service shares this position with FWS, addressing in particular the need for comprehensive review of Statewide water development, study of alternatives such as groundwater management and conservation, restrictions on existing pumping and export, and further study of instream standards and freshwater outflow requirements of the Bay and Delta (Howard, 1980).

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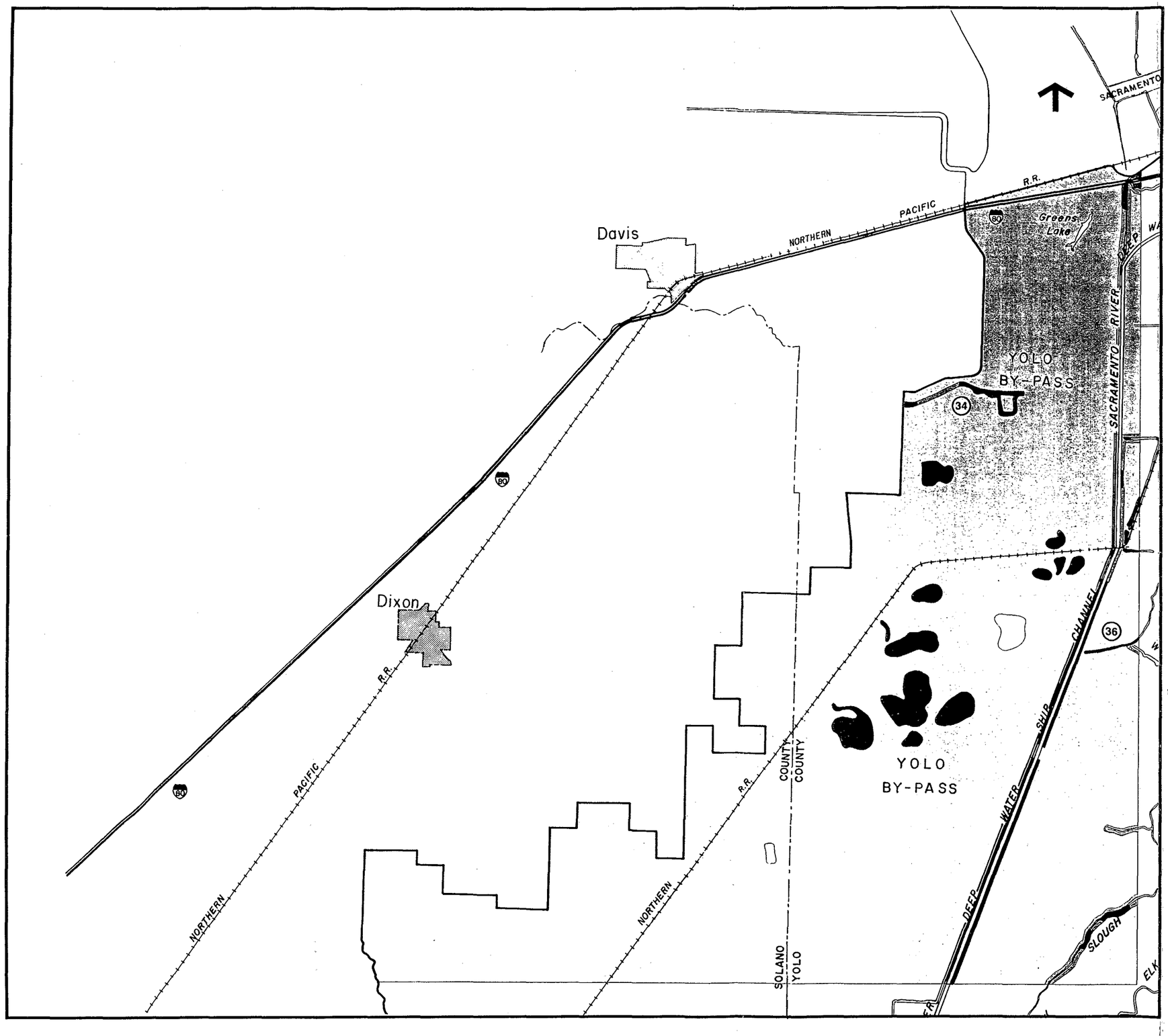


Enhancement Scenario

- Existing Habitat - Freshwater Marshland and Riparian Vegetation
- Future Habitat - Freshwater Marshland and Riparian Vegetation
- Channels and Open Water
- Agriculture and Upland
- Urban
- Important Areas for Migratory and Wintering Waterfowl
- Special Management Areas
- (8) Significant Natural Resource Areas*
- Proposed Peripheral Canal
- Study Area Boundary

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

*see text, Chapter 7

Enhancement Scenario

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

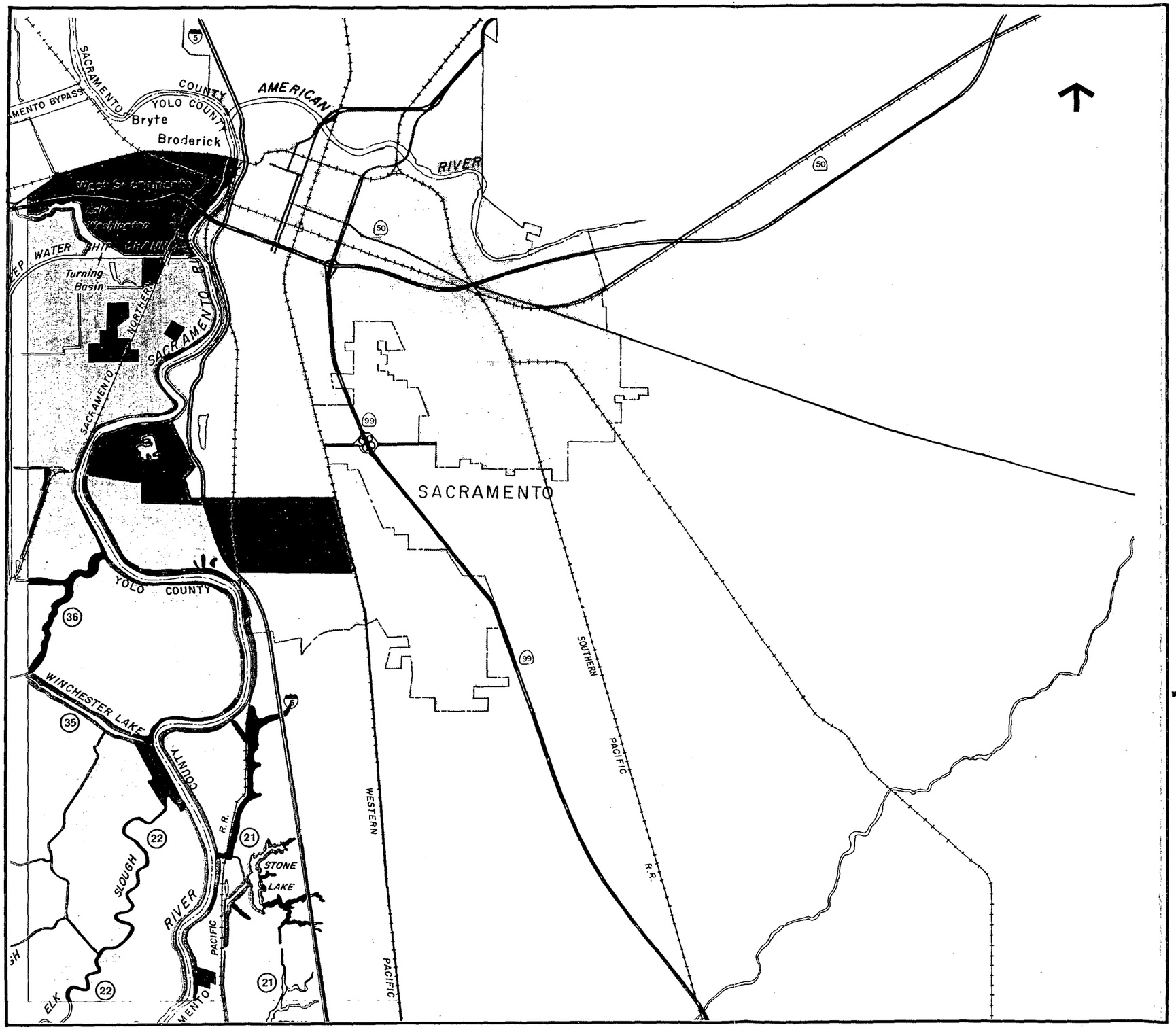
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **B-1**

C-056305

C-056305



Enhancement Scenario

- Existing Habitat - Freshwater Marshland and Riparian Vegetation
- Future Habitat - Freshwater Marshland and Riparian Vegetation
- Channels and Open Water
- Agriculture and Upland
- Urban
- Important Areas for Migratory and Wintering Waterfowl
- Special Management Areas
- (8) Significant Natural Resource Areas*
- Proposed Peripheral Canal
- Study Area Boundary

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

*see text, Chapter 7

Enhancement Scenario

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

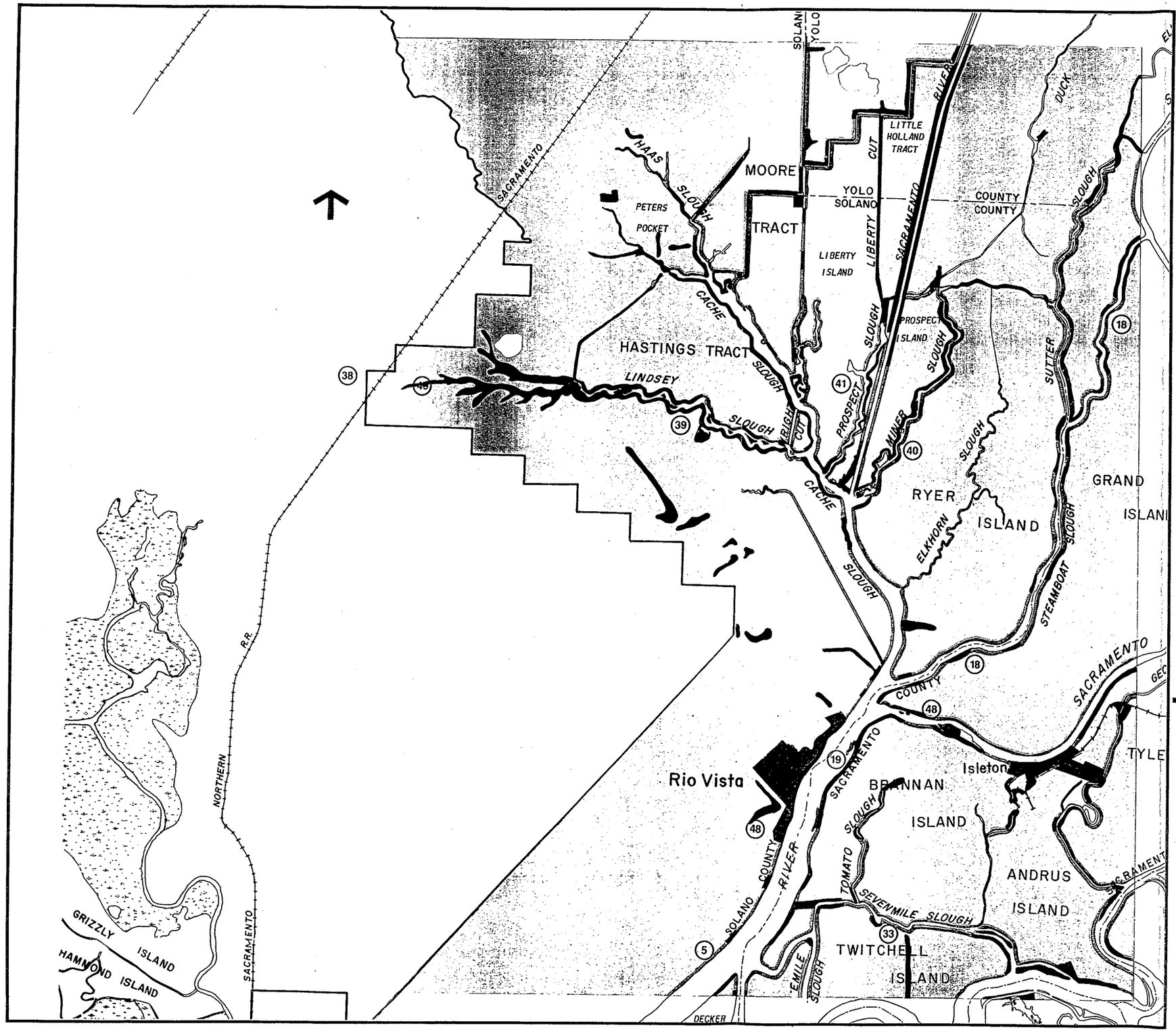
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **B-2**

C-056306

C—056306



Enhancement Scenario

- Existing Habitat - Freshwater Marshland and Riparian Vegetation
- Future Habitat - Freshwater Marshland and Riparian Vegetation
- Channels and Open Water
- Agriculture and Upland
- Urban
- Important Areas for Migratory and Wintering Waterfowl
- Special Management Areas
- (8) Significant Natural Resource Areas*
- Proposed Peripheral Canal
- Study Area Boundary

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

*see text, Chapter 7

Enhancement Scenario

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

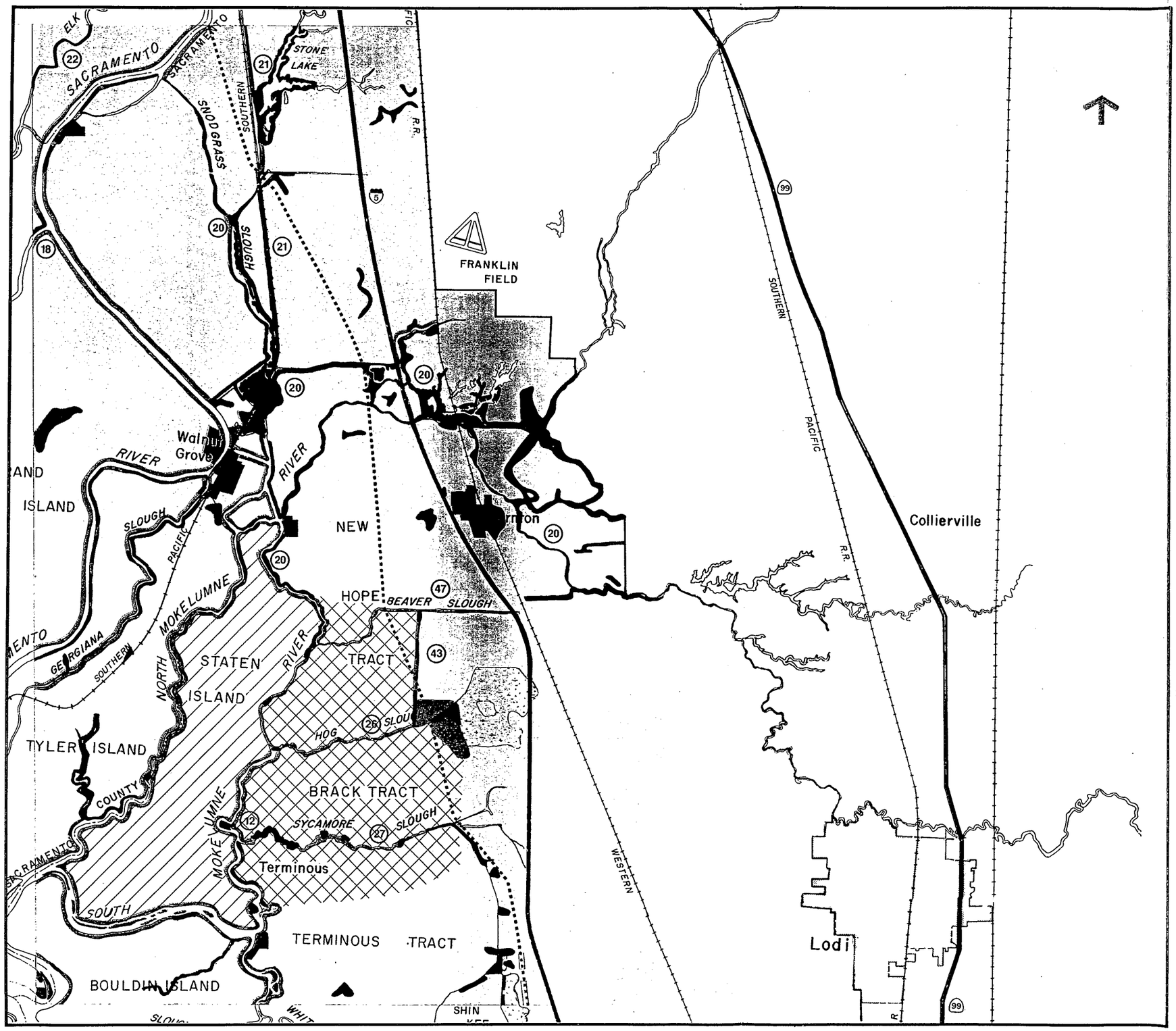
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **B-3**

C-056307

C—056307



Enhancement Scenario

- Existing Habitat - Freshwater Marshland and Riparian Vegetation
- Future Habitat - Freshwater Marshland and Riparian Vegetation
- Channels and Open Water
- Agriculture and Upland
- Urban
- Important Areas for Migratory and Wintering Waterfowl
- Special Management Areas
- (8) Significant Natural Resource Areas*
- Proposed Peripheral Canal
- Study Area Boundary

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

*see text, Chapter 7

Enhancement Scenario

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

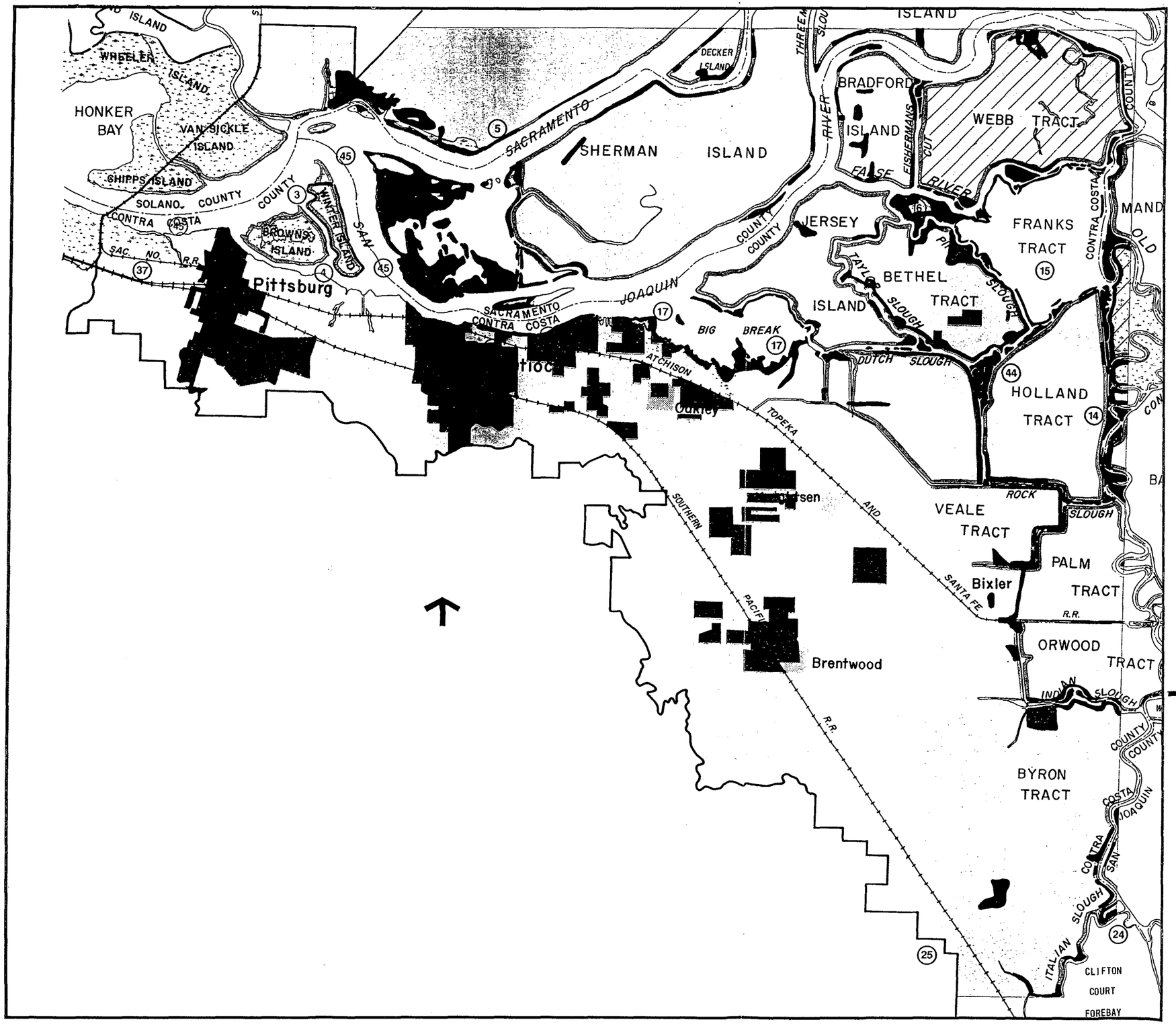
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **B-4**

C-056308

C—056308



Enhancement Scenario

- Existing Habitat - Freshwater Marshland and Riparian Vegetation
- Future Habitat - Freshwater Marshland and Riparian Vegetation
- Channels and Open Water
- Agriculture and Upland
- Urban
- Important Areas for Migratory and Wintering Waterfowl
- Special Management Areas
- (8) Significant Natural Resource Areas*
- Proposed Peripheral Canal
- Study Area Boundary

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

*see text, Chapter 7

Enhancement Scenario

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

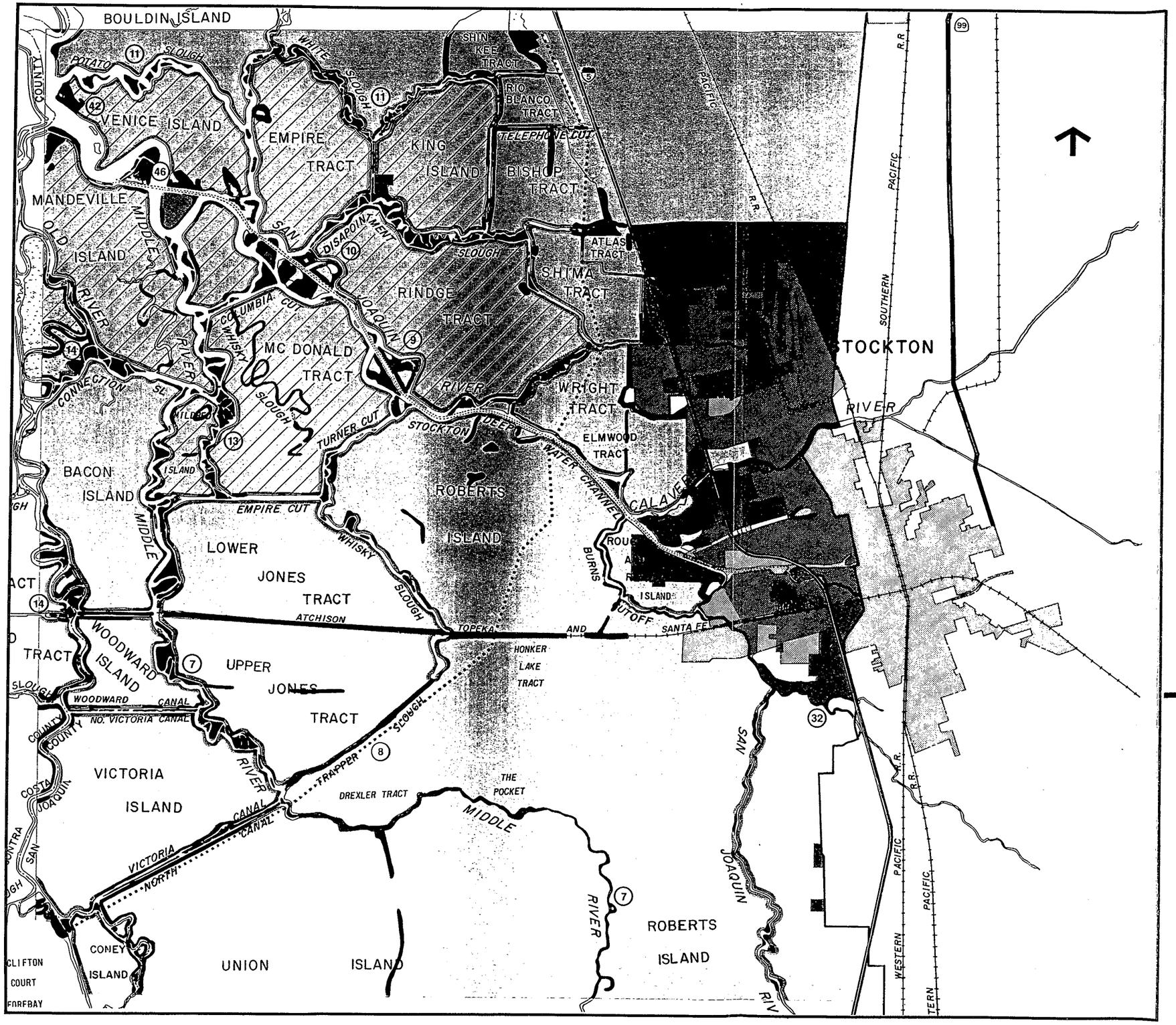
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **B-5**

C-056309

C-056309



Enhancement Scenario

- Existing Habitat - Freshwater Marshland and Riparian Vegetation
- Future Habitat - Freshwater Marshland and Riparian Vegetation
- Channels and Open Water
- Agriculture and Upland
- Urban
- Important Areas for Migratory and Wintering Waterfowl
- Special Management Areas
- (8) Significant Natural Resource Areas*
- Proposed Peripheral Canal
- Study Area Boundary

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

*see text, Chapter 7

Enhancement Scenario

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

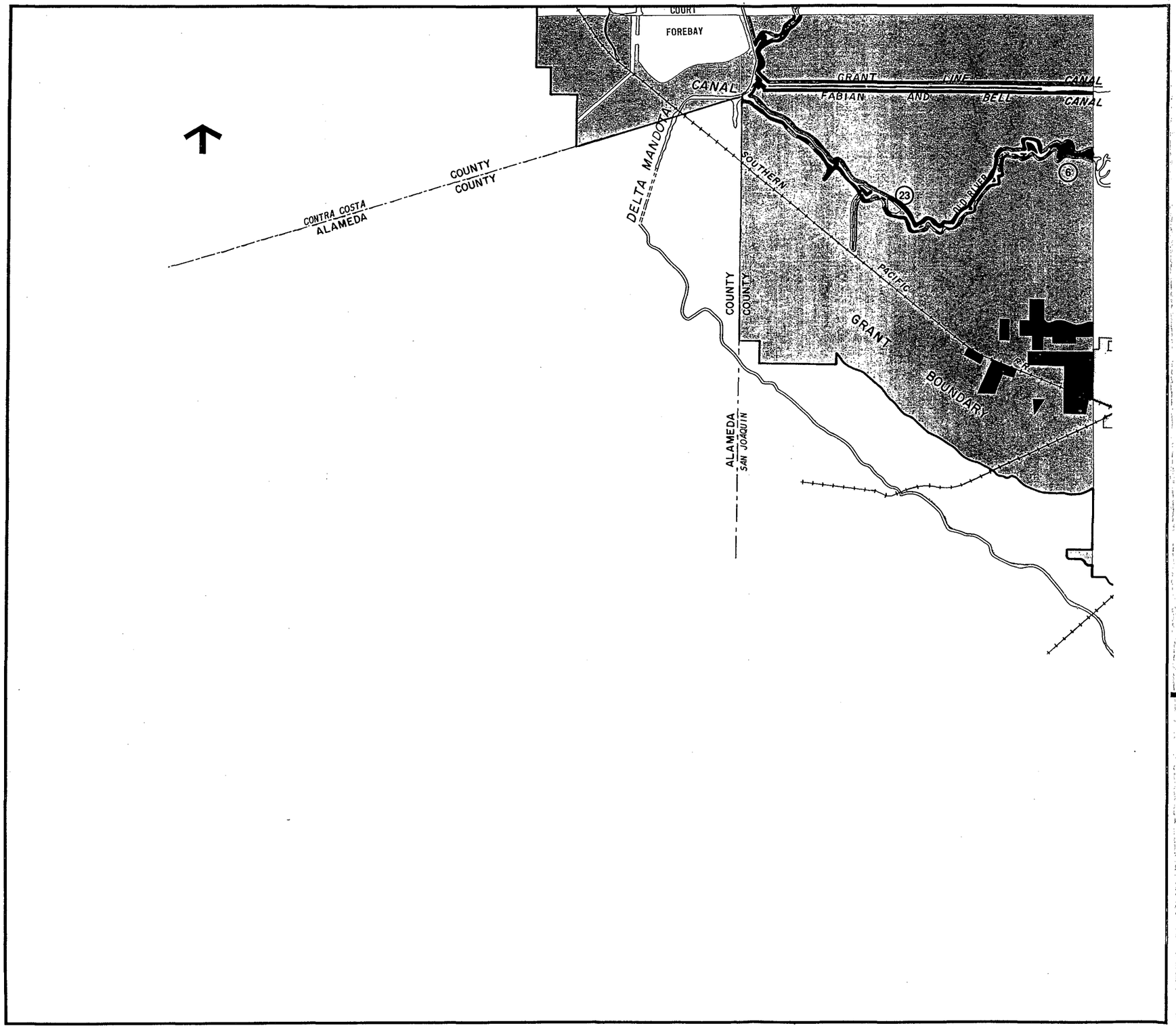
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **B-6**

C-056310

C-056310



Enhancement Scenario

- Existing Habitat - Freshwater Marshland and Riparian Vegetation
- Future Habitat - Freshwater Marshland and Riparian Vegetation
- Channels and Open Water
- Agriculture and Upland
- Urban
- Important Areas for Migratory and Wintering Waterfowl
- Special Management Areas
- (8) Significant Natural Resource Areas*
- Proposed Peripheral Canal
- Study Area Boundary

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

*see text, Chapter 7

Enhancement Scenario

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

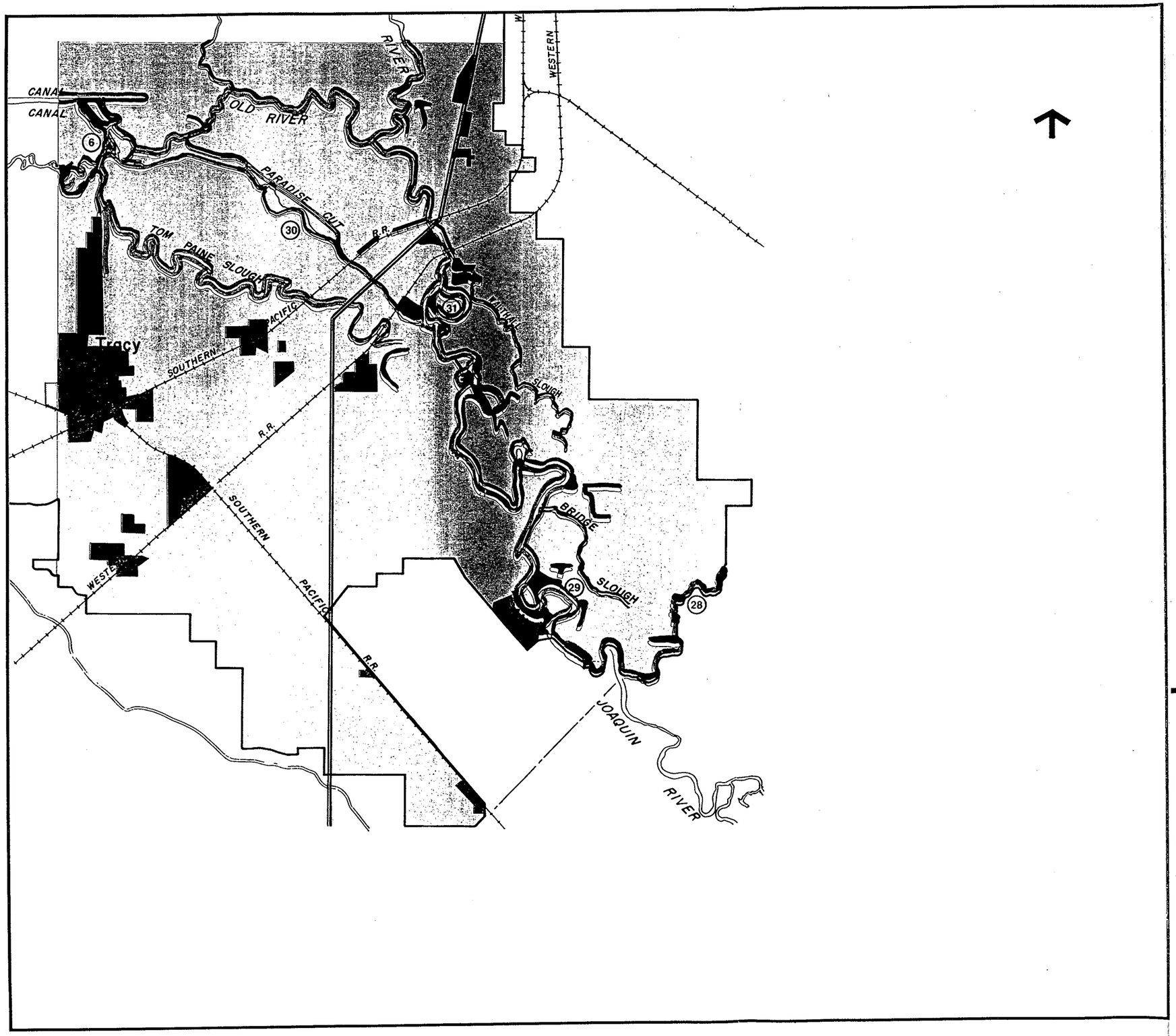
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **B-7**

C-056311

C—056311



Enhancement Scenario

- Existing Habitat - Freshwater Marshland and Riparian Vegetation
- Future Habitat - Freshwater Marshland and Riparian Vegetation
- Channels and Open Water
- Agriculture and Upland
- Urban
- Important Areas for Migratory and Wintering Waterfowl
- Special Management Areas
- (8) Significant Natural Resource Areas*
- Proposed Peripheral Canal
- Study Area Boundary

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

*see text, Chapter 7

Enhancement Scenario

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **B-8**

C-056312

C-056312

PART II: DELTA HABITATS AND WILDLIFE

Habitat Descriptions, Classification, and Fish and Wildlife Use

6

Although habitat characteristics and ecological relationships of the Delta have undergone profound changes in the past century or more, considerable wildlife habitat still exists in the region. Today this resource is supported by a mixture of relatively natural and intensively managed areas.

The fish and wildlife value of a habitat, whether it be natural or managed, is a function of the life support attributes – food, cover, nesting and spawning areas – which it provides. These are determined largely by the type, form, and distribution of vegetation and by the physiography and soil-water relations of a given location. The degree of animal use of an area of habitat is usually a good indicator of its wildlife

C—056314

C-056314

TABLE 6 **Bird and Mammal Census Sites**

Habitat Types	"North" Delta	"Central" Delta	"South" Delta
Woodland Riparian	(1) Delta Meadows	(2) Howard Landing	(3) Little Mandeville Island
Shrub-Brush Riparian	(4) Delta Meadows	(5) Grand Island	(6) Lost Lake Tule Island
Riprap - Grass	(7) North Fork, Mokelumne River	(8) Howard Landing	(9) Mandeville Island
Riprap - Shrub	(10) North Fork, Mokelumne River	(11) Bacon Tract	(12) Columbia Cut McDonald Tract
Flooded Corn (Nov-Feb)	(13) Tyler Island, North Fork Mokelumne R.	(14) Webb Tract	(15) Rindge Tract
Unflooded Corn (Nov-Feb)	(16) Tyler Island, North Fork Mokelumne R.	(17) Andrus Island Near Korth's	(18) Herman & Helen's, Empire Tract
Island - Marsh	(19) Delta Meadows	(20) Headreach Island	(21) S.J. River - between Webb and Mandeville
Island - Wooded	(22) Snodgrass Slough	(23) Lost Lake Tule Island	(24) Five Fingers Island
Dredge Spoils	(25) Grand Island	(26) Sherman Island	(27) Tule Island
Ruderal	(28) Andrus Island, Brannan Island Road	(29) Highway 12, Terminous "V"	(30) Near Brannan Island St. Park

value. Further, it is generally safe to assume that another site with similar characteristics will have comparable value to wildlife.

These assumptions, supported by a year of field observations of representative sites and other research, are the basis for the description and evaluation of Delta habitats and wildlife use which follows. With the exception of censuses of waterfowl and game species and sporadic trapping records, little research had been done previously on Delta wildlife.

One purpose of the Delta Habitat Plan was to close this information gap. To promote a better understanding of the Delta and provide necessary background information, a year-long (January 1979-February 1980) bird and mammal census was carried out as part of this planning study. Thirty census sites were established, representing ten different habitat types in the south, north, and central regions of the Delta (See Figure 17; and Table 6). Birds were censused at these sites every two weeks throughout the year. Mammals were trapped three times during the year (late winter, summer, and late fall) at selected census sites and other locations in the Delta (See also Chapter 8: References).

Fish and aquatic invertebrates are obviously also important components of the Delta ecosystem. They have been studied for more than 20 years in connection with a variety of water development projects. Information on fish and invertebrates is only summarized in this report. More detailed information is available from other sources (Skinner, 1972; Moyle, 1976; Siegfried *et al.*, 1978; Sitts and Knight, 1979; Kelley, 1966; and Turner & Kelley, 1966).

HABITAT USE BY FISH AND WILDLIFE

Information gathered through the censuses and other research is summarized in a comprehensive species list (Chapter 8), and is the primary information source for the habitat use charts which accompany the following habitat descriptions. Other sources are listed in Chapter 8. Only species whose presence in the Delta was actually documented in the field, by personal interviews, literature, or museum collections are included.

The habitat use charts are useful in determining the relative value of each habitat to various wildlife species.

- E, or "essential," denotes that a species is dependent for survival on some feature of the habitat (*e.g.*, special food, highly selective nesting or roosting sites, critical nursery area, traditional migration corridor), or that a species is a narrowly distributed endemic, found nowhere else.
- P, or "preferred," denotes that the general living requirements of a particular species (food, shelter, nesting habitat, *etc.*) are met by certain habitat features, and that the majority of the Delta population of that particular species is commonly found in that habitat.
- S, or "secondary," indicates that the general living requirements of broadly adapted wildlife species are met by more than one habitat, or that a species makes occasional use of the habitat but finds essential or preferred habitat elsewhere.

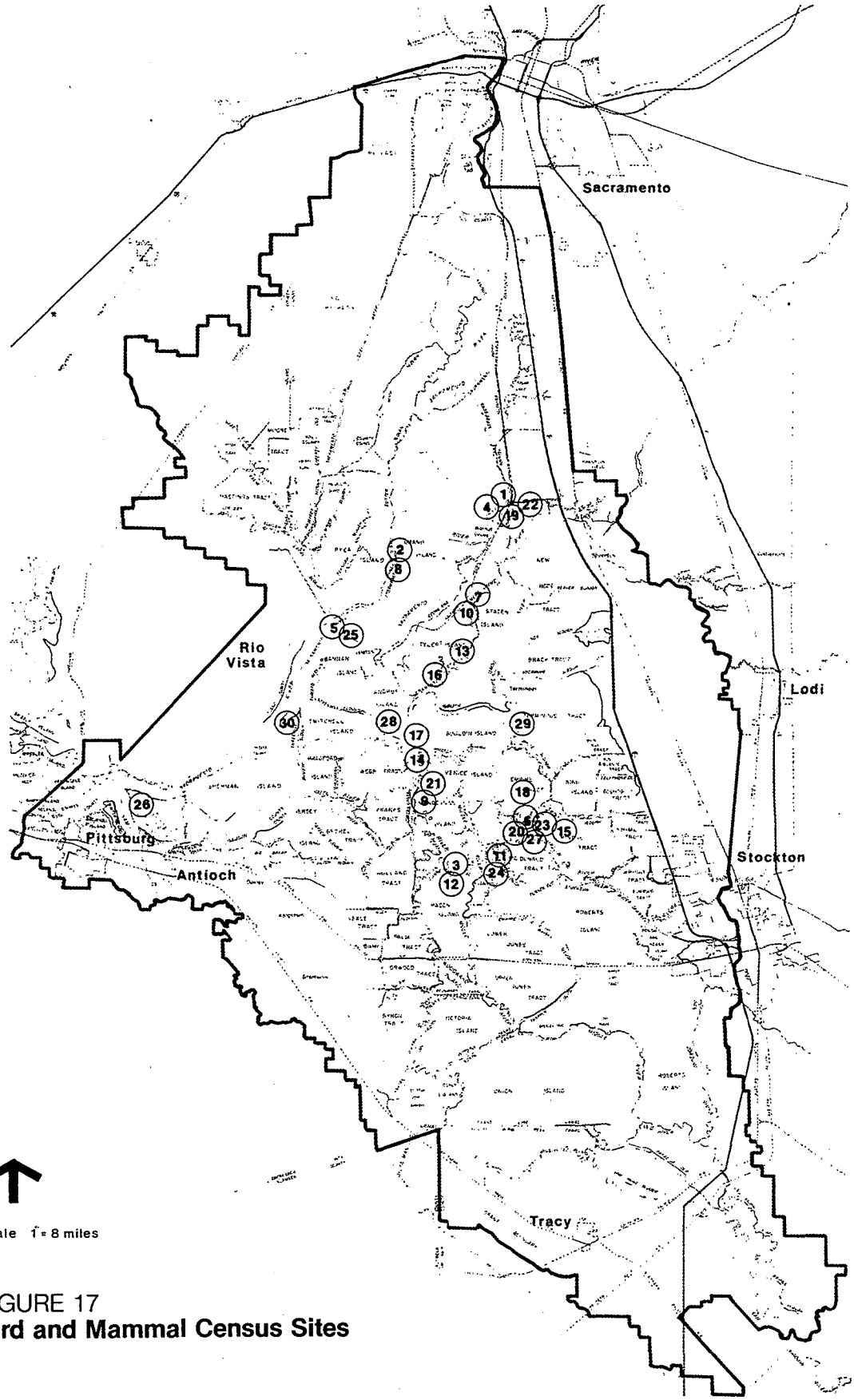


FIGURE 17
Bird and Mammal Census Sites

Habitat use charts provide both general information on the characteristic diversity of wildlife found there, and relative values and sensitivities among the various habitat types. For example, habitats with a high number of "E's" provide specialized resources to a corresponding number of wildlife species. Maintenance of these habitats is essential for the long-term maintenance of these wildlife populations either in the Delta, or, with endemics, throughout their range.

Habitats with a high number of "P's" are generally important habitats for a wide range of organisms. While loss or degradation of these habitats probably would not actually eliminate any wildlife species from the Delta, it would have long-term adverse effects on wildlife populations that would be forced to seek less suitable, or secondary, habitat.

Habitats dominated by "S" users are, in general, least valuable of the Delta habitats from an ecological perspective. However, reduction of the areal extent of these habitats would increase competition for resources of other habitats, resulting in probable long-term reduction of wildlife populations in all affected habitat types. Conversely, an increase in acreage of secondary habitats might reduce competition between "generalist" and "specialist" species for specialized resources, and thus benefit populations of both wildlife groups.

RELATIVE VALUES OF DELTA HABITATS

In the Delta, the most valuable wildlife habitat is *riparian woodland.* This habitat type surpasses other Delta habitats in the number of animals (at least 34 species of birds and 1 mammal) that find essential ("E") habitat there. Approximately 36 bird, 7 mammal, and 1 amphibian species use riparian woodland as preferred ("P") habitat. Altogether at least 107 species use the riparian woodlands regularly; some of these animals, such as hole-nesting and bark-gleaning birds, are absolutely dependent upon this habitat for their continued existence in the Delta.

Riparian habitat also enhances adjacent habitat types such as agricultural lands and ruderal lands. This beneficial range of influence extends roughly a quarter of a mile into the adjoining habitat for most wildlife species, and even further for wide-ranging raptorial birds (USFWS, 1976). The production of upland game birds (pheasants, doves, quail) is increased when riparian woodland is nearby. Aquatic habitats in the Delta benefit from shade of riparian trees, from the diversity of niches provided by structural irregularities along waterway banks, and from the rich insect production which characterizes the structurally diverse vegetation.

Riparian habitats are the most structurally diverse of all habitats in the Delta, with trees, shrubs, overhanging banks, and emergent vegetation providing a wide variety of microhabitats. The value of riparian woodlands depends in large part on the plant species, maturity, and diversity of the vegetation. Some of the larger species of riparian trees take 30 to 40 years to reach maturity (USFWS, 1976). Willows and shrubs mature more rapidly. When this habitat is removed or altered, full replacement of diverse vegetation takes a relatively long time, thus limiting the habitat value during the replacement period. Banks where riparian vegetation has been removed have significantly less wildlife value than do other Delta habitats.

Freshwater marshes are the next most valuable Delta habitat, in terms of the diversity of wildlife species for which the habitat is essential. Eleven bird, 3 mammal, 1 reptile, and 3 amphibian species find essential habitat in freshwater marshes. Two of these, the black rail and the giant garter snake, are rare species (DFG, 1978). Altogether at least 57 different wildlife species use freshwater marshes.

In addition to providing unique cover, nesting sites, and feeding habitat for wildlife, freshwater marshes have a high biological productivity (Atwater *et al.*, 1979). Photosynthesis by tules and other marsh plants captures the energy of sunlight; dead tissues of plants decompose and accumulate in place or are circulated as detritus and transported by currents and tidal flushing, providing one of the nutrient bases for the Delta and Bay ecosystems. The precise nutritional value of plant detritus in the Delta is unknown.

The slow accumulation of the fibrous remains of tules and reeds in the ancestral Delta marshes built up the thick organic deposits of peat which are so highly valued today as agricultural land. Peat formation continues to occur in freshwater marshes throughout the Delta. Marshes also accomodate seasonal overflows, providing some flood control, and contribute to water purification by metabolizing excess nutrients and acting as a sediment trap.

Including the dead-end sloughs, the *channels* and *open waters* of the Delta provide essential habitat to at least 12 fish and 10 bird species, and preferred habitat to 12 fish, 11 bird, and 9 invertebrate species. A total of at least 94 different animals use this habitat. This includes most of California's anadromous sport fish, and resident native fishes that are not abundant anywhere else. Phytoplankton in the water contributes to the nutrient base of the Bay-Delta aquatic system. Channel flows and tidal fluxes are transport and dispersal mechanisms for nutrients, fish and invertebrate eggs, and larvae.

C—056317

C-056317

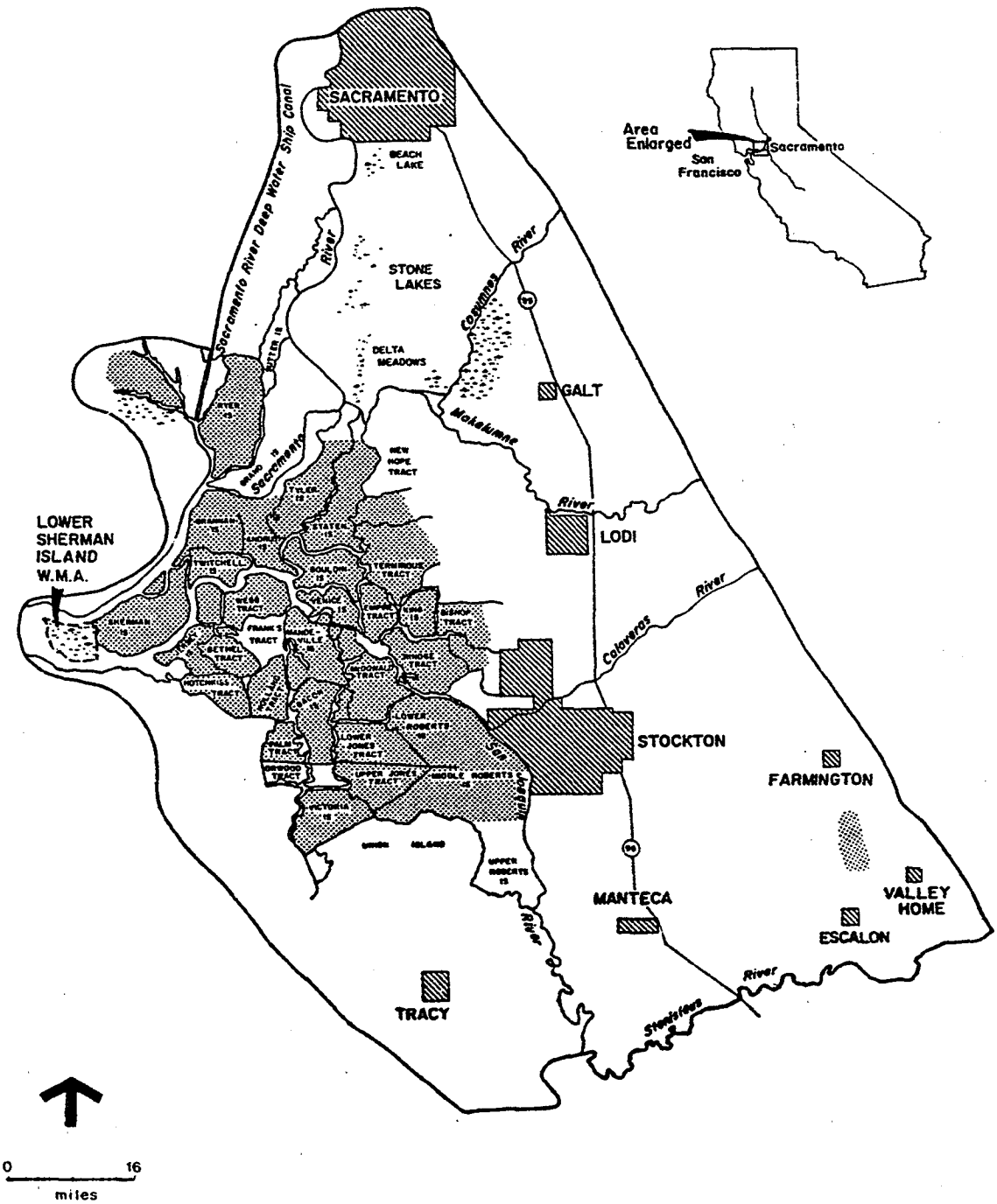
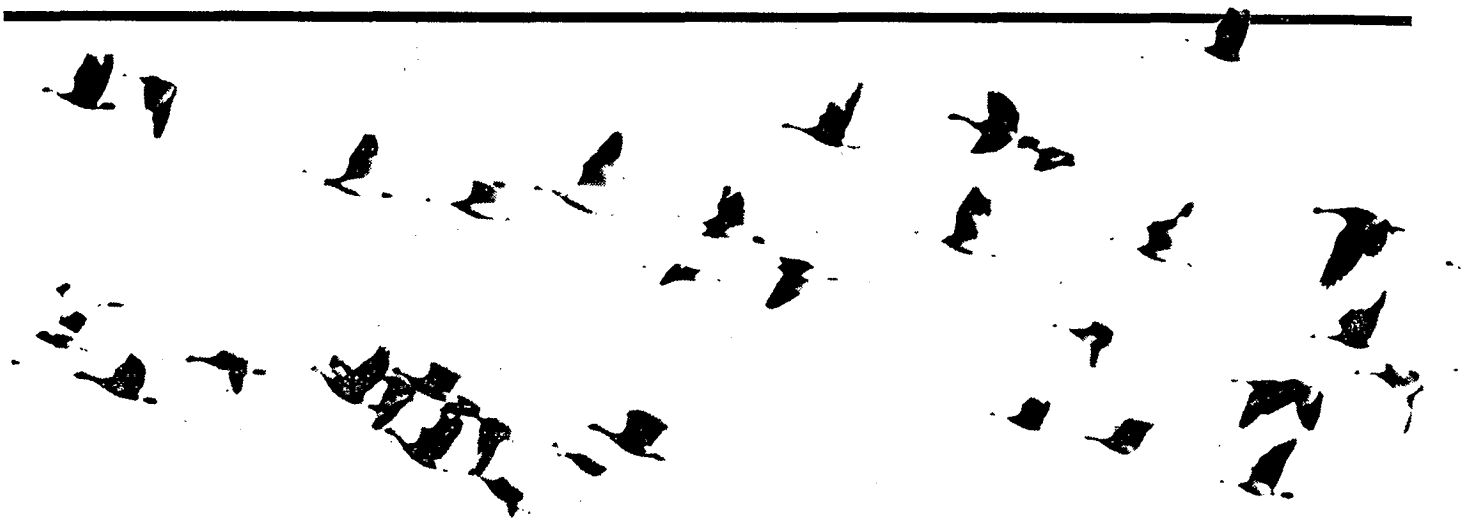


FIGURE 18
The Delta Private Wetlands
Source: USFWS, 1977.

Seasonally flooded agricultural lands
Natural marsh



Agricultural habitats occupy most of the land area in the Delta and provide a range of wildlife habitat values. The most significant are flooded and unflooded winter fields, especially those grown to corn and other grain crops, and currently uncultivated ruderal fields. In terms of numbers of wildlife individuals per acre, these habitats surpass in value all others in the Delta. Fields flooded in the winter for leaching or to attract waterfowl are specialized habitats of essential value to three species of birds, including 73% of all whistling swans wintering in the Central Valley (Figure 18).

Unflooded fields are essential habitat for at least three species of birds. Geese, sandhill cranes, and other waterfowl using unflooded fields also visit flooded fields for alternate resting and feeding habitat. The habitat value of unflooded fields, especially for pheasant and other upland game species, is greatly enhanced by the nearness of riparian vegetation or any other brushy cover. Agricultural lands of special value are shown in Plates B-1 to 8.

Orchards and vineyards are used by resident birds and have greater value than fields under active cultivation. Management practices (crop selection, schedule and amount of flooding, clean farming, efficiency of harvest, discing of stubble) can profoundly affect agricultural habitat values.

Ruderal lands and brushy edges along ditches and cultivated fields provide undisturbed cover for wildlife. These habitats are at a premium in the Delta, where most lands are cleared and farmed. While ruderal lands provide no essential wildlife habitat, they are used as preferred habitat by 12 bird and 7 mammal species, and as secondary habitat by 73 bird, 7 mammal, 5 reptile, and 2 amphibian species.

Upland habitats surrounding the Delta include a diversity of habitat types. Some of these areas, like the Antioch dunes and the vernal pools on the western Delta margin, have unique wildlife values and support several species of plants and one animal listed by the federal government as endangered (USFWS, 1979a).

Channel islands in the waterways of the Delta present a wide array of physiographic types and include a complex of habitats ranging from small tule islands, that are essentially freshwater marshlands, to large upland sites with riparian woodland, dredge spoils, brushland, lakes, and a variety of marshland types. All islands, however, share a relative isolation from mainland activities that contributes significantly to their wildlife habitat value.

HABITAT CLASSIFICATION AND DESCRIPTION

The habitat use charts supplement the following narrative descriptions of habitat types which are found within the Delta. Number and letter combinations in parentheses, given for each habitat type (*e.g.*, PEM1, L2EM2, L1AB, UP, AG), are the mapping symbols used in the COE *Delta Environmental Atlas* (1979a). For example, marsh habitats in the Delta are represented in the Atlas by several sub-habitats and map symbols. These symbols are indicated in the description of marshes below. The symbols are based on a recent U.S. Fish and Wildlife Service wetland habitat classification system (Cowardin *et al.*, 1979) which attempts to unify wetland classification for the entire nation (Table 7).

While the COE Atlas maps habitats using geomorphology, vegetation growth form, hydrology, and substrate as the basis for habitat classification, this report has simplified and generalized the distinctions, basing habitat descriptions in part on vegetation and functional characteristics and in part on wildlife use. Thus, each habitat described below may encompass several COE mapped types. Some habitats included in this report are outside the COE study area, and are not included in the Atlas (*e.g.*, vernal pools). The reader is encouraged to use the detailed, large-scale COE maps to locate specific areas of a given habitat type "on the ground".

The COE mapped habitat types provide a useful guide to the distribution and extent of the specific habitat types discussed here. However, the maps should be applied cautiously. Habitats inevitably change with time, sometimes rapidly: herbaceous banks sprout shrubs; shrub-brush riparian grows into young trees; agricultural fields revert to ruderal lands if left untended; dry land converts to open water if surrounding levees fail; channel islands erode from wave wash; and marshland is converted to marinas. Thus habitats which were mapped under one designation in 1978, when the Atlas was begun, may require another designation in 1980 or beyond.

C—056319

C-056319

TABLE 7 **Habitat Types and Mapping Symbols**

COE DELTA ATLAS (1979)[1/]

SYMBOL	TYPE	ACREAGE IN DELTA[2/]		DESCRIPTION
P	PALUSTRINE	Total:	17,342	All nontidal wetlands less than 2 meters deep, and all tidal wetlands where salinity is less than 0.5 parts per thousand.
PEM1	Emergent Wetland		10,203	- Persistent erect, rooted, herbaceous perennial plants (those which remain standing at least until next growing season).
PEM2	Emergent Wetland		40	- Non-persistent plants (those which fall to the ground or below the surface of the water at certain seasons).
PSS1	Scrub/Shrub		4,367	- Dominated by woody vegetation less than 6m (20 ft.) in height; broad-leaved deciduous plants.
PFO1	Forested		2,732	- Riparian forest of broad-leaved deciduous vegetation 6m or more in height.
R	RIVERINE	Total:	949	All wetlands and deep water habitats contained within a channel *except* wetlands dominated by trees, shrubs, or persistent emergents.
R2EM1	Emergent		594	- Persistent vegetation associated with a slow flowing stream with relatively low gradient.
R2BB	Beach/Bar		63	- Level landforms composed of unconsolidated sediments which may be colonized by herbaceous annuals or seedlings with less than 30% coverage.
R2SB	Streambed		147	- All other parts of the streambed usually not regulated and exposed.
R2AB	Aquatic Bed		145	- Dominated by submergent, floating-leaved, or floating plants.
L	LACUSTRINE	Total:	6,913	Wetlands and open water habitats situated in a topographic depression or a dammed river channel.
L1	Limnetic		5,705	- All open-water habitats in the lacustrine system (lakes, ponds, closed sloughs).
L1AB	Aquatic Bed		94	- Dominated by submergent, floating-leaved, or floating plants.
L2EM1	Emergent Wetland		286	- All wetland habitats in the lacustrine system with persistent vegetation.
L2EM2	Emergent		828	- All wetland habitats in the lacustrine system with non-persistent vegetation.
O	OPEN WATER	Total:	46,720	All flowing waters, including connecting sloughs and canals with undetermined bottom.
UP	UPLAND	Total:	44,446	Grassland, nonirrigated grazing lands, and undisturbed areas above influence of waterway. May be vegetated with grasses, scrub/shrub, or large trees.
AG	AGRICULTURE	Total:	531,156	Irrigated crops, orchards, vineyards, and other croplands, including farm buildings, unvegetated irrigation ditches, and roadways.
UR	URBAN	Total:	31,896	Cities, towns, and large concentrations of marinas and mobile homes.
		TOTAL ACREAGE:	679,422	

[1/] Classification system adapted from Cowardin et al., 1977.

[2/] Based on COE Atlas mapping.

AQUATIC HABITATS

Freshwater Marshes (PEM1, PEM2, R2M1, PSS1, L2EM1, L2EM2)

Freshwater marshes have been typical of the California Delta region since the end of the Pleistocene and were the dominant habitat there until the introduction of agriculture. Before reclamation, marshes occupied the sloping river banks outboard of the natural alluvial levees, as well as many square miles of shallow backswamp or overflowed lands behind these levees (Thompson, 1957). During winter rains and spring floods, these back areas were regularly inundated. The peat soils, slow to drain, supported marsh vegetation throughout the year. While winter rains and spring floods still do periodically flood these lands, enlarged levees, extensive drainage and pumping systems, and cultivation have eliminated almost all of the interior wetland habitat.

Vegetation of the marshes is adapted to the complex and dynamic pattern of overflow, bank erosion, and sediment deposition that occurred over time as the rivers and channels of the Delta flooded or changed course. Even though the Delta is now largely constrained by levees, the process continues to exert its influence.

As a consequence, freshwater marshes in the Delta include a successional progression of community types that range from tules and reed grass, newly established on recently deposited sediment, to more complex tule and shrub associations growing on older islands or on river bank sediment deposits. Just as succession of vegetation occurs over time so does it occur within a range of elevations relative to water levels and submergence. The earliest phases occupy the lowest elevations, and later phases occupy higher locations. Freshwater marsh habitat at any given place in the Delta is a complex mosaic of these successional phases, determined by local conditions.

Many marshes in the Delta include a significant amount of open water as an integral component of the habitat. The large marsh on Headreach Island in the Stockton Deepwater Channel is a good example of a marsh where emergent vegetation is interspersed with stretches of floating aquatic plants and shallow, open water.

Vegetation. In freshwater tidal marshes of the Delta (PEM1, PEM2, R2EM1, PSS1), marsh colonization typically begins in the slowest moving water of the river current or shoreline ebb and flow of tides. Sand or silt is deposited, and when the sediment reaches approximately one meter or less from the water surface, seedlings of California tule (*Scirpus californicus*) and commmon reed grass (*Phragmites communis*) develop as a thin stand of plants (Mason, 1972). California tule is typically less than four meters in height, and its stems or culms remain in place and decay while still attached to the base of the plant. The decay contributes organic material to the sand and silt at the base of the plants, forming a muck. Water between the emergent plants contains floating algae and diatoms.

Small patches, or narrow bands, of this type of marsh are common throughout the Delta: on sand bars, dredge spoil islands along the main ship channel, and natural meander deposits (tule islands); around the margins of larger islands; and along many miles of waterways at the base of levees where silt accumulates.

As time passes, muck accumulates and common tule (*Scirpus acutus*) becomes established among the pioneer species, forming a dense stand. The organic muck which collects at the base of the plants becomes "raw peat"; silt is deposited on top of the peat only when floods cover the organic substrate. This marsh type most commonly occurs with the pioneer marsh type, described above, occupying a slightly higher elevational position around the margins of channel islands and along the waterway banks. Common reed grass may also occupy this middle zone (Whitlow *et al.*, 1979).

Where soils with increased shear strength have developed at a higher elevation, Arroyo, sandbar, and Gooding's willows (*Salix lasiolepis, S. hindsiana,* and *S. goodingii*), buttonbush (*Cephalanthus occidentalis* var. *californicus*), and American dogwood (*Cornus stolonifera*) are characteristic plants. The growth is often dense, and an herbaceous understory may be absent. This shrubby marsh commonly occurs along with the other two successional or elevational phases, and typically occupies the higher central areas of tule islands or embayed marshes. It is not common along leveed banks because the elevational gradient there is too abrupt.

Good examples of tule island, many with shrubby marsh on the higher soils, just at or slightly above the high tide level, occur in Sycamore Slough, Disappointment Slough, White Slough, Lindsey Slough, Sand Mound Slough, around the perimeter of Franks Tract and Webb Tract, and in the downstream reaches of Middle River. These islands are among the few significant remnants of largely "pristine" marshland in the Delta today (Atwater *et al.,* 1979) (Figure 19).

Embayed marshes have developed on a number of the channel islands, including Tinsley Island, Mandeville Tip, and Lost Lake Tule Island. The marshland at the Delta Meadows is another example of an embayed marsh, with open water, tules, and cattails in the center, ringed by shrubs and small trees on slightly higher ground.

Freshwater marshland that develops on undisturbed, undiked, consolidated peat islands has been described by Mason (1972). On these willow-fern swamp islands, the shrubby vegetation (dogwood, buttonbush, willows) is well established, from two to three meters tall, with a three-to-four-storeyed undergrowth of lady fern (*Athyrium felix-femina*), California hibiscus (*Hibiscus californicus*), *Tillaea aquatica,* spike rush (*Eleocharis* spp.), *Lilaeopsis,* and marsh pennywort (*Hydrocotyle* spp.).

These willow-fern swamp islands were widespread in the late nineteenth century. Extensive reclamation and dredging since that time have left few suitable sites undisturbed long enough for this relatively complex marshland association to develop. A wooded, marshy island in the south fork of the Mokelumne River between Sycamore and Hog Sloughs, identified by DAPC (1976a)[1] as a valuable natural resource area, is one of the few remaining examples of Mason's willow-fern swamp (Plate B-3). On this island, tules, sedges (*Carex*), cattails (*Typha*), nettles (*Urtica*), lady fern, chain fern (*Woodwardia*), and other herbaceous plants grow in flooded areas beneath a wood canopy dominated by low-growing willows, dogwood, alder, and buttonbush.

[1] This island, #12 on the Delta Significant Resource Areas list presented in the Delta Atlas (COE, 1979a), is mapped incorrectly in that document as occurring south of Sycamore Slough; it actually lies just north of the Slough.

Freshwater nontidal marshes (L2EM1, L2EM2) are behind levees or in the interior of some of the larger islands. They are associated with lakes or extensive patches of open water, which have relatively calm patterns of flow and deposition. The plant community which develops there includes two species of cattails (*Typha latifolia, T. domingensis*), common reed, four species of tule or bulrush (*Scirpus californicus, S. acutus, S. olneyi,* and *S. microcarpus*), barnyard grass (*Echinochloa crusgalli*), and nutgrass (*Cyperus eragrostus*). Pretty water smartweed (*Polygonum coccineum*) and yellow water weed (*Jussiaea repens* var. *peploides*) crowd between the emergent plants and float partially submerged.

Four species of willow (black, arroyo, smooth, and sandbar) and other shrubs such as dogwood and buttonbush become established on the higher margins of the marsh. The interior marsh on Headreach Island and Beaver Lake on Grand Island are examples of nontidal, palustrine wetlands. Jepson (1893) describes this marsh type as typical behind the natural river bank levees which have formed a rim around the islands of the overflowed lands. Brannan, Andrus, Tyler, Grand, and Ryer Islands provide examples. A relatively undisturbed lake at Potato Point, at the western tip of Venice Island, supports nontidal marsh, open water, and a dense growth of willows and shrubby vegetation. This may be a remnant example of a native backswamp.

Wildlife. Both tidal and nontidal freshwater marshes are important to wildlife of the region as a food web base, and as essential habitat. The nature of the food web is only partly known and differs with the type of marsh. Waterfowl feed directly on species of bulrush, and tule detritus is consumed by zooplankton, but the nutritional value of some marsh plants is not documented.

Insects, worms, mollusks, and other invertebrates also feed on algae, diatoms, and detritus. Both native and introduced fishes use tule marshes for spawning and nursery grounds, as well as resting; they feed on plankton and small invertebrates rather than directly on detrital plant material. The reduction of tule marshes to remnants has probably contributed to the gradual reduction or extinction of many native fish species which now are found only in the least disturbed back sloughs, such as thicktail chub and other deep-bodied forms like Sacramento perch, hitch, and tule perch.

Fish, shellfish, crayfish, reptiles, and amphibians are prey for ducks, wading birds, raccoons, mink, weasels, and other larger vertebrates. Marsh vegetation provides cover and nesting habitat for coots, pied-billed grebes, and other birds rarely found elsewhere in the Delta, including the sora, black rail, Virginia rail, long-billed marsh wren, and common yellowthroat. The density of tule marshes determines the use of the habitat by birds and waterfowl. Denser stands are favored by rails and marsh wrens. More dispersed stands, with areas of open water and mudflat, are used by shorebirds such as herons and egrets. Song sparrows nest in the bushes, and swallows hunt insects in the air above. Ducks that winter on the open water of the enclosed lakes feed and find cover when the marshy vegetation is not too dense.

Freshwater marshes are essential habitat for two animals listed by the California Department of Fish and Game as rare. The California black rail finds suitable food and cover in the dense, protective tules and cattails of a few marshes in the Delta. The giant garter snake feeds on fish and inhabits open water areas in or along freshwater marshes, using the marsh vegetation as escape cover and adjacent grassy banks for sunning and resting (Brode, pers. comm.). Five species of plants that are considered rare or species of concern by the California Fish and Game Commission grow in tidal and nontidal marshlands of the Delta (Rae, pers. comm.).

Cattails and tules are an important food source for muskrat, and provide an alternative diet for beaver. While some beaver lodges are dug into berms or banks, most are constructed of sticks and hidden in cattails or tules. Muskrat also lodge in these marshes. Both species are abundant and commercially important Delta residents. On higher ground within the marshland complex, California voles and western harvest mice are reasonably abundant. Introduced populations of house mouse and Norway rat are common here and in all other Delta habitats and may be displacing some of the native mammals.

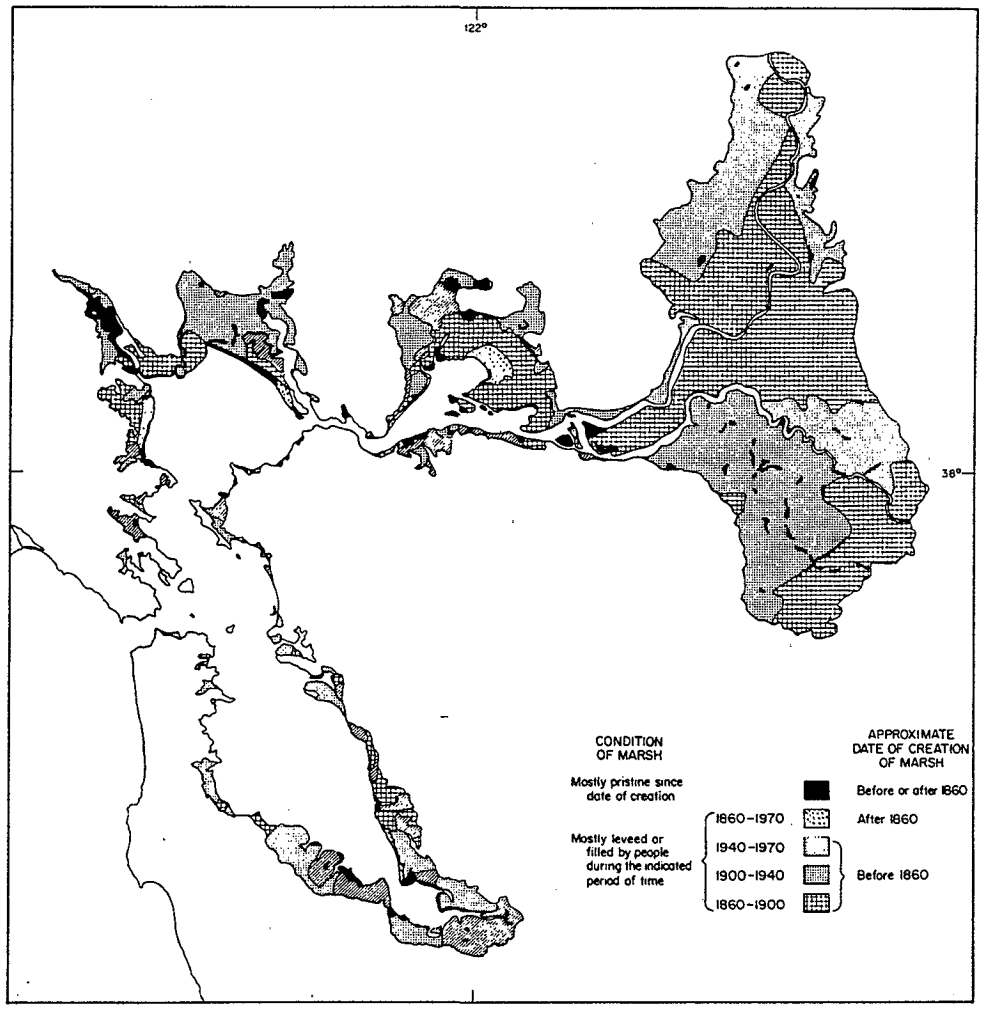
Most small, unleveed marshy islands offer few places to land a boat and little dry land on which to come ashore. Consequently, recreational use of these islands by boaters, fishermen, picnickers, and other visitors is extremely low, particularly in comparison to the larger leveed islands and the banks of most Delta channels. Freedom from human instrusion turns these marshy islands into wildlife refuges during the spring and summer months when recreational use of the Delta is at a peak.

Channels and Open Water
(0)

The network of tidal channels which connect the San Joaquin and Sacramento Rivers and other channels of the Delta vary from a few hundred feet to a mile wide; many have been dredged for ship traffic but are seldom more than 30 to 40 feet deep. Below the high tide limit, most of the banks are steep levees of either mud or riprap.

Channels throughout the Delta are tidal, with a twice-daily rise and fall. Currents in Delta channels and in open water are fairly strong, with velocities of 2.5 feet per second on the ebb and flow of the tide commonly occurring. Pumping of water for export from the southern Delta, and conveyance of water through channels and waterways has increased velocities in the channels of the northern Delta, particularly the forks of the Mokelumne River, and reversed flows in the waterways of the southern Delta (Old River, Middle River, and elsewhere).

Delta water is mostly fresh water, and salinities are in general very low, ranging from 400 parts per million, total dissolved solids (ppm TDS) in the San



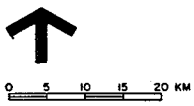


FIGURE 19
Pristine and Modified Marshlands of the San Francisco Bay-Delta

Source: Atwater *et al.*, 1977. In Conomos, 1979.

Joaquin River waters to 50 ppm TDS in the freshwater streams on the eastern side (see also Chapter 2).

Vegetation. Where channel velocities are abnormally high, as along the Sacramento River, North and South Forks of the Mokelumne, and other northern Delta channels, emergent vegetation is now confined to the channel banks, and floating plants rarely persist in open water. During the summer, water milfoil (*Myriophyllum spicatum* var. *exalbescens*) and yellow water weed are common species that become established in eddies and coves along the banks of the larger channels, and may grow more densely in slower moving low-flow channels. Other common aquatic plants that grow in Delta waters are discussed in more detail under *Lakes and Dead-end Channels.*

Water hyacinth (*Eichhorinia crassipes*), an introduced floating plant, grows profusely during the summer and fall in places in the southern Delta, clogging waterways and at times blocking navigation. Every spring, water hyacinth are carried into the Delta by the San Joaquin River. They originate upstream, growing in great profusion on the Merced River and other tributaries to the San Joaquin. Individual plants and floating mats break loose, float downstream and become established in quiet, nutrient-rich waters. Southern reaches of Old River and Middle River backwaters of the San Joaquin may become heavily vegetated. Water hyacinth is found as far north as Disappointment Slough. It is not commonly found in northern portions of the Delta which are fed by the Sacramento River (Taylor, pers. comm.). Factors that control its distribution are probably the flow patterns that carry the floating plants about and current velocities that permit or discourage establishment of floating mats. Water hyacinth are killed seasonally by frosts. Coot and other waterfowl consume the dead plant material, and by winter the waterways are clear. New plant material is then supplied on spring inflows.

Plankton. The phytoplankton populations of the open water form the base of the Delta food web. Phytoplankton "blooms," or peaks in abundance, can occur anytime between February and September, but normally occur in late winter and spring. The availability of nutrients (especially inorganic nitrogen), water temperatures, and light levels appear to be the primary factors regulating phytoplankton abundance. Diatoms are the most abundant component of the phytoplankton community. The dominant forms include species of *Cyclotella, Melosira, Coscinodiscus,* and *Skeletonema* (Siegfried *et al.*, 1978; Sitts and Knight, 1979).

Green algae comprise a lesser fraction of the community, and blue-green algae dominate the phytoplankton in the eastern Delta during the fall. Spring and summer phytoplankton population peaks result in such a large production of oxygen that dissolved oxygen concentrations of the waters can reach 200% of saturation. Conversely, in the fall declining and decaying phytoplankton populations contribute to the dissolved oxygen deficits of 10 to 30% below saturation levels (Stevens and Chadwick, 1979).

Zooplankton populations in the open water channels of the Delta are another important component of the food web, serving as the major food source for the young fishes. Copepods dominate the zooplankton community throughout the year. The dominant species include cyclopoid, calanoid, and harpacticoid copepods, and occasionally cladocerans and rotifers. Less abundant members of the zooplankton community include molluscan larvae, decapod crustacean larvae, and larval fish. Zooplankton abundance usually peaks in late winter or early spring, generally remains high throughout the summer, and finally declines in the fall (Siegfried *et al.*, 1978; Sitts and Knight, 1979).

The opossum shrimp (*Neomysis mercedis*) is an extremely important component of this community. These small mysid shrimp are important as fish food, especially for young-of-the-year striped bass. Opossum shrimp populations generally increase in abundance in the spring, peak between late spring and late summer, then rapidly decline in the fall and winter. The center of maximum abundance coincides with the location of the entrapment zone (see Chapter 2). The abundance varies annually with Delta outflow. During years with high outflows, mysids are abundant throughout a large area of the estuary, with the population centered in Suisun Bay. During low flow years, the population is less abundant and restricted to narrow channels of the Delta (Siegfried *et al.*, 1978; 1979; Orsi and Knutson, 1979).

Invertebrates. Two decapod shrimp are abundant in the downstream, more saline waters of the Delta: the bay shrimp (*Crangon franciscorum*) and the grass shrimp (*Palaemon macrodactylus*). Both of these shrimp are eaten by several species of fish. The bay shrimp, a native species, supports a commercial bait fishery centered in Suisun and San Francisco Bays. The bay shrimp is generally most abundant in the Delta during the spring and summer.

The grass shrimp was accidentally introduced into the San Francisco Bay Estuary during the 1950's by ships returning from the Orient (Smith and Carlton, 1975). The grass shrimp exhibits habits similar to those of the bay shrimp, rising in the water column at night and feeding primarily on the opossum shrimp. The similarities between the bay shrimp and grass shrimp suggest that competitive interactions may be significant. The introduced grass shrimp appears to be more successful in brackish and fresh water than the native bay shrimp, which dominates in more saline areas (Carlton, 1979). The fact that the grass shrimp can reproduce in fresh water, unlike the bay shrimp which requires saline waters, may give it a competitive advantage in the Delta region (Siegfried *et al.*, 1978).

The benthic community of the Delta channels, ditches, tidal flats, and submerged islands and marshes is not particularly diverse. The dominant species include amphipods (*Corophium spinicorne, C. stimpsoni*), polychaete worms (*Neanthes limnicola, Boccardia berkelyorum*), unidentified oligochaete worms, mud crabs (*Rhithropanopeus harrisii*), clams (*Corbicula fluminea, Gemma gemma, Tapes japonica*), and

crayfish (*Pacifasticus leniusculus, Procambarus clarkii*) (Hazel and Kelley, 1966; Siegried *et al.*, 1978).

The two amphipods dominate benthic samples. Amphipods are eaten by a number of fish, including the striped bass (Ganssle, 1966). The species *Corophium stimpsoni* is usually most abundant in broad tidal channels of the Delta, particularly in the San Joaquin River. Within the channels, *C. spinicorne* usually occurs along the banks between the low tide mark and depths of 10 feet, while *C. stimpsoni* exhibits a preference for deeper waters. The two species do coexist, but where one species is abundant, the other is usually rare (Hazel and Kelley, 1966).

The mud crab was introduced into San Francisco Bay Estuary from the Atlantic coast, and has become established in the brackish and fresh waters of the Delta. It is occasionally important in the diet of white sturgeon and other bottom-feeding fish in the Delta (Carlton, 1979).

Introduced species dominate the molluscan fauna, including the gem clam (*Gemma gemma*), Japanese cockle (*Tapes japonica*), and the Asiatic clam (*Corbicula fluminea*). The Asiatic clam is abundant in many parts of the Delta, particularly on tule berms and nearshore areas. Population density of the Asiatic clam is usually greatest in the winter between January and March (Hazel and Kelley, 1966; Siegfried *et al.*, 1978). The Asiatic clam is sold as bait for catfish. This clam has become so abundant in the Delta that tons of them are dredged when the Delta-Mendota Canal is drained for repairs. The Japanese cockle and gem clam are eaten by bottom-feeding fish, such as white sturgeon, by raccoons, and by some shorebirds (Carlton, 1979).

Two introduced species of crayfish are common in the Delta. They are sold commercially as bait and for human consumption, and are the basis of a small but popular sport fishery. *Pacifasticus leniusculus* occurs in a variety of habitats in the Delta, ranging from swift channels to muddy sloughs. *Procambarus clarkii* prefers warm vegetated sloughs (Riegel, 1959). During daylight crayfish stay concealed beneath riprap rocks and other debris, moving out to feed at night. Crayfish are important forage food for bass and other fish, birds, turtles, and raccoons.

Fish. Channels and open water are habitat for at least 44 species of fish, including sunfish, bass, and catfish, which spend their entire lives in the Delta, as well as anadramous species which spawn in the cold waters of the Delta tributaries and migrate through San Francisco Bay to the Pacific Ocean (Kelley, 1966). The Sacramento-San Joaquin Estuary is essential habitat for 10 species of native and introduced anadramous fish, including striped bass, king and silver salmon, white and green sturgeon, and other important game fish (see Habitat Use Chart).

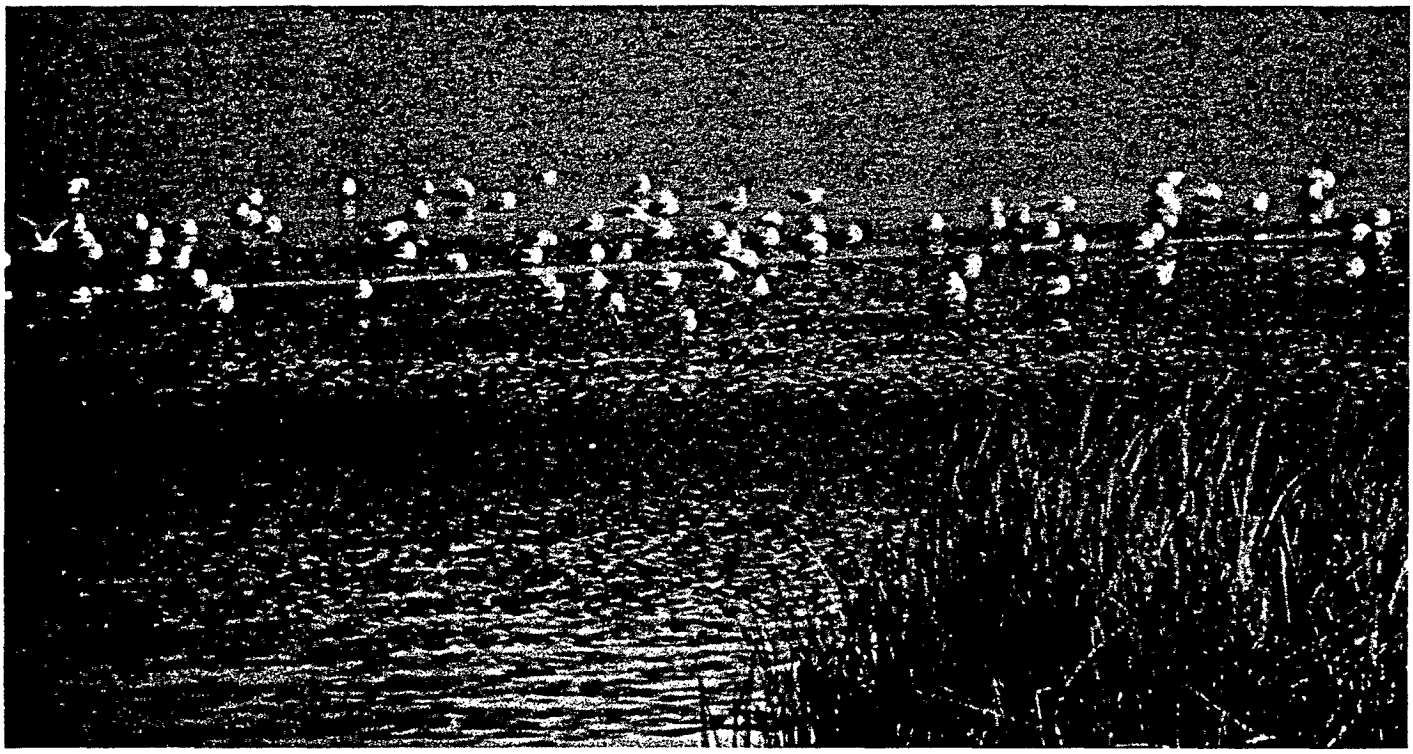
Introduced species in the Delta include striped bass, American shad, carp, threadfin shad, largemouth bass, white catfish, and Mississippi silverside. These species have been very successful, and in many cases have increased in great numbers, out-competing the native species. Native fish, which are now rare or have been reduced to a minority status, include the Sacramento perch, the tule perch, and the minnows: hitch, hardhead, squawfish, Sacramento blackfish, and splittail. The thicktail chub, once fairly common, now is considered extinct. Despite recent searches, the last known specimen was collected from Cache Slough near Rio Vista, in 1958 (Moyle, 1976; Bartell, pers. comm.). The reduction of quiet slough waters and marshes is one probable cause of the loss of native fishes.

Reverse flows in the southern Delta caused by pumping interfere with the movements of all life stages of anadromous fish. Freshwater outflows must be of a proper velocity to keep striped bass eggs and larvae suspended, but velocities increased by pumping can wash eggs and larvae away before development is complete. More complete information concerning the life histories of the anadromous fish species which inhabit the Delta and the impacts of water diversions and pumping is available in various publications of the California Department of Fish and Game Interagency Ecological Study Program Annual Reports. In the past few years, these annual reports have included valuable information documenting decreases in the striped bass population that spawns in the Delta.

Wildlife. Wintering birds, particularly American coots, western and eared grebes, diving and ruddy ducks; and western, herring, ring-billed, California, and Bonaparte's gulls rest and feed on the open waters, favoring areas that are protected from the frequent strong winds and from commercial and recreational boat traffic. These birds feed primarily on fish and aquatic invertebrates, with the exception of coots, which feed on seeds as well as spiders, insects, and small crustaceans.

Belted kingfishers are seen and heard along banks in a variety of habitats but always are associated with open water of a channel, lake, or even a drainage ditch, where they feed. Kingfishers construct nests in burrows on steep, unvegetated, and unriprapped banks. Swallows also use other habitats but nest near and feed extensively on insects over water.

While not common in the Delta, harbor seals and sea lions occasionally make an appearance in the area. Beaver, muskrat, and river otters also swim in the main channels, in transit to their more typical bankside habitats.



Submerged Islands
(0)

Submerged islands include Franks Tract, Big Break, Lower Sherman Island, and Clifton Court Forebay, where open water now overlies former agricultural lands. Because of land subsidence on the former islands, water may be as deep as 15 to 20 feet in areas which were formed when levees were breached, either intentionally (Clifton Court) or during floods, and reclamation of the flooded lands was judged to be uneconomical. For plants, mammals, and birds, the habitat is essentially the same as other open water areas, although exposure to wind and wave action on these relatively broad expanses of open water makes it quite unprotected. The aquatic habitat on submerged islands appears to be much the same as other open water and channel areas. Fish populations are similar, although white catfish have been found to predominate on Franks Tract (Turner, 1972).

In January, 1980, flood waters broke surrounding levees and submerged Webb and Holland Tracts to depths of 10 to 20 feet. Marshy and partially ponded fields on Webb Tract that provided significant wintering habitat for large numbers of white-fronted geese, snow geese, and other waterbirds were temporarily converted to open water habitat.

Tideflats
(R2BB, R2SB)

Exposed shoals, sandy mud bars, and portions of the streambed exposed at low tide are grouped as tideflats. These flats have occasional tules or other emergent vegetation that constitutes less than 30% cover. Algae and diatoms on the mud surface are the principal source of tideflat productivity.

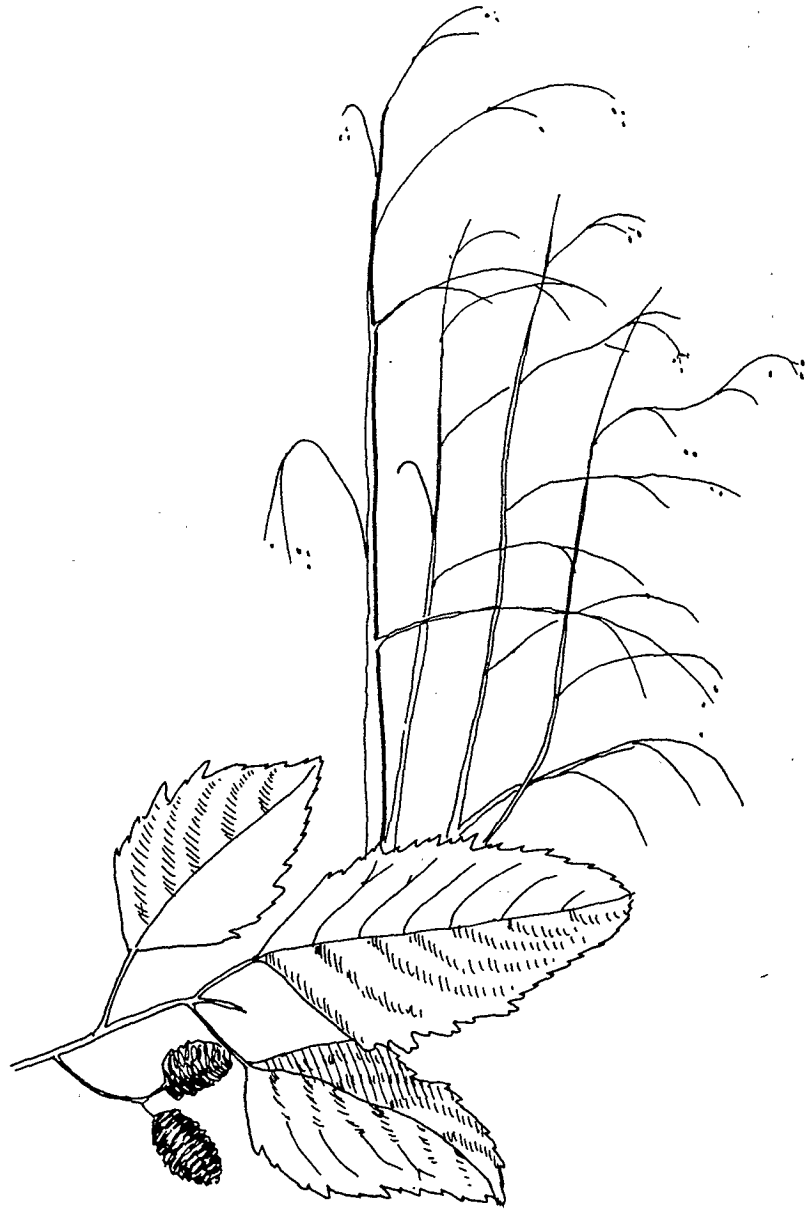
Tideflats are not common and are located primarily in the western Delta. The best example occurs near Rio Vista across from the Cliff House, on the eastern bank of the Sacramento River near its confluence with Steamboat Slough. At low tide, ring-billed and California gulls, Forster's and Caspian terns, and migrating shorebirds commonly use this flat. Throughout the Delta, narrow mudflats exposed at low tide at the edges of the channels also provide a limited amount of tideflat habitat. Blackbirds have been observed congregating and bathing on these muddy banks. Raccoons, skunk, and a variety of other mammals also traverse these exposed channel flats.

Oxidation Ponds

Oxidation ponds associated with the Lodi and Stockton sewage treatment facilities provide a unique and attractive habitat for water-associated birds. The ponds contain water throughout the year, and are heavily used during migration and the winter months by shorebirds and winterfowl. Because most of the backswamp areas in the Delta that were originally flooded during fall, winter, and spring are now reclaimed and pumped dry, these oxidation ponds may be providing substitute habitat for visiting birds. Shrubby growth and grassland in the area surrounding the ponds supports sparrows and other songbirds.

Riparian Habitats

Riparian Woodland
(PF01)



Extensive riparian woodland, which once covered the floodplains of rivers and tributaries of the Central Valley, occurred around the outer margins of the Delta area. Major stands were on the San Joaquin River, east and south of Stockton, on the Sacramento River in the Delta Meadows area and to the north, and near the confluence of the Cosumnes and Mokelumne Rivers (Roberts *et al.*, 1977). Old drawings and historic writings indicate there was some riparian woodland in the Delta proper along the natural levees of the major waterways (Thompson, 1957). While much of this original woodland was cleared for levee construction or maintenance, remnants exist in a few places.

Vegetation. Riparian woodland trees are over three meters tall, with a dense, shrubby understory. Cottonwood (*Populus fremontii*), western sycamore (*Platanus racemose*), white alder (*Alnus rhombifolia*), valley oak (*Quercus lobata*), and willow (*Salix* spp.) are common trees, and blackberries (*Rubus procerus*), buttonbush (*Cephalanthus occidentalis*), wild rose (*Rosa* spp.), wild grape (*Vitis californica*), and mugwort (*Artimesia douglasii*) are typical of the understory. Riparian woodlands of the Central Valley have been described in detail by Jepson (1893), Thompson (1957), Conard *et al.*, (1977), and Robichaux (1977). There is much floristic variation from site to site, with well-developed, mature woodlands in some places (*e.g.*, Cosumnes-Mokelumne area, southern reaches of Middle River and Old River), mature but modified woodlands in others (*e.g.*, Delta Meadows), and young mixed stands of alder, cottonwood, and oak (*e.g.*, Little Mandeville, Quimby, Tinsley, Lost Lake Tule Islands).

In the southern reaches of the Delta and along the Consumnes-Mokelumne area, alluvial soils predominate, and in places the woodland extends well back from the river. Along Middle and Old River, oaks dominate and the forest may have a park-like aspect. Where alluvial soils are found only as a narrow levee or margin bordering peat lands in the center of the Delta, riparian woodlands are less extensive and less well-developed.

Within each patch of woodland there is further variation in response to the changing elevational gradient, illustrated by a mature woodland remnant near Howard's Landing on Steamboat Slough. At its very lowest elevation, on a terrace plateau, an open stand of white alders grows with *Carex* spp. as a groundcover. Alders probably are the pioneer species of this tree community. Alder trees have root nodules tht contain a symbiotic nitrogen-fixing bacterium (*Frankia alni*) which undoubtedly permits the alder to live on this permanently saturated, nitrogen-poor substrate. Along most of the river bank there is a dense tangle of naturalized blackberry, buttonbush, wild rose, mugwort, and other plants. Further upslope in the dark shady forest there are few understory plants. Trees occurring in these mixed stands at slightly higher elevations are ash (*Fraxinus latifolia*), box elder (*Acer negundo* var. *californicum*), western sycamore, cottonwood, and valley oak. Understory is also absent where grazing has occurred.

Wildlife. Of all types of habitat in California, riparian woodland supports the highest diversity of bird life (Small, 1974), reflecting the great structural

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diversity provided by towering trees, dead snags, shrubby understory, and varied ground cover adjacent to open waters and marshland (MacArthur and MacArthur, 1961; Balda, 1975). The stratified foilage profile of ground cover, understory, where it exists, and multilayered canopy provides many different places or niches for nesting, feeding, and cover. The absence of an understory reduces this habitat diversity somewhat. The deciduous trees and shrubs of the riparian woodland contribute to a moist litter layer underneath, which is habitat for mulitudes of insects, other invertebrates, reptiles and amphibians, and small mammals, all important components of a rich food web that supports many larger animals. Acorns, grapes, rose hips, berries, and other fruits produced by the riparian vegetation also provide an important seasonal food source.

Many features of riparian woodland are valuable to fish habitat: the shaded canopy with branches hanging over and in the water; exposed roots; irregular banks; leaves, twigs, and other organic material shed into the river; and submerged snags. Riparian vegetation increases the diversity of niches available to fish for spawning, larval development, and adult maintenance. Temperature control, cover, and suitable habitat for an abundance of fish food organisms vary with the condition and extent of riparian woodland (USFWS, 1976).

Woodland riparian is essential habitat for at least 34 species of birds (see Habitat Use Chart). These birds include hole nesters, such as the woodpeckers, tree swallows, and wood ducks; insect feeders such as the flycatchers and vireos; bark gleaners such as the nuthatch and titmouse; high canopy nesters such as great blue herons, Swainson's hawks, and other raptors; and other birds that require one of the special habitat features found only in woodland riparian habitat.

Certain birds introduced to the west with the advent of active settlement, such as brown-headed cowbirds and starlings, have had a severe impact on native songbirds of the Central Valley through nest parasitism (cowbird) and aggressive competition for nest sites (starlings). In the Delta, this impact has been most severe in the riparian woodlands, where warblers, vireos, and hole nesters have been particularly affected.

Mammal activity in riparian woodland is diverse. Bats glean the insect population; skunks, raccoons, mink, occasional grey squirrels, and other native mammals forage and find cover in the woodlands. Black rats and house mice, both introduced species, are abundant in this type of habitat throughout the Delta. Beavers may excavate their lodges in the banks, but more often do so in the berms which may lie between the banks and the open channels.

Riparian Shrub-Brush
(PSS1)

Vegetation. Riparian shrub-brush is characterized by broad-leaved woody growth predominantly less than 6 meters tall. The most common plants are shrubs like blackberry, wild rose, young alder, and willow, and herbaceous species like stinging nettle and mugwort. An occasional tree, usually willow, cottonwood, or sycamore, may be present. These shrub-brush communities occur on broad, unriprapped levees, and on natural berms on the margins of some of the channel islands. If left undisturbed, most riparian shrub-brush would eventually develop into woodland, but periodic disturbance from levee maintenance practices discourages this long-term successional process.

Shrub-brush vegetation varies in composition from one locality to another, reflecting differences in topography, disturbance history, and surrounding vegetation. Where clearing to facilitate levee inspection has been incomplete or infrequent, riparian shrub-brush vegetation becomes most well-developed. As an example, the banks along the western tip of Grand Island, at the confluence of the Sacramento River and Steamboat Slough, support impenetrable thickets of wild rose, elderberry, and stinging nettle, with a few sand bar willows, young coast live oaks, sycamores, ash, alders, and box elders.

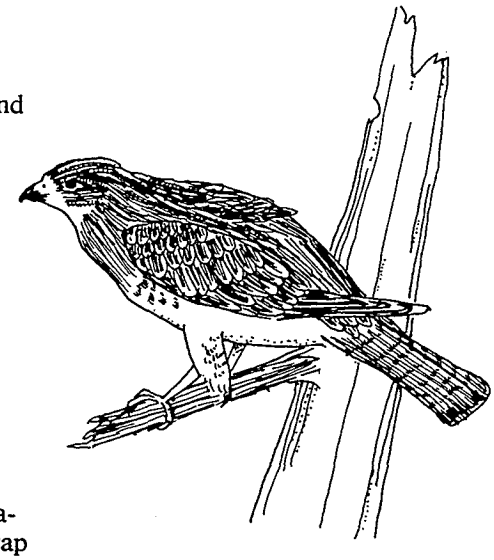
Wildlife. Birds use shrub-brush riparian thickets for foraging and as cover. The linear arrangement of the shrubby growth adjacent to the waterways provides a protected travel corridor for small birds during daily or migratory movements. Common species include the white-crowned sparrow, rufous-sided towhee, house finch, scrub jay, song sparrow, bushtit, ruby-crowned kinglet, and fox sparrow. At

least six birds depend on riparian shrub-brush to meet essential habitat needs during some phase of their lives (see Habitat Use Chart). Many of the mammals, reptiles, and amphibians that frequent riparian woodland also use riparian shrub-brush areas, particularly if the two types are adjacent. The diversity of cover types and denning or nesting opportunities are much reduced in the shrub-brush community, however. Fish habitat benefits from shrub-brush riparian in proportion to the extent and maturity of the riverside vegetation.

Brushy Riprap
(PSS1)

Vegetation. Shrubs and brush become established when riprapped banks are undisturbed by inspection or maintenance clearing for several years, or where riprapping has been limited to the lower portions of the levee (low-level rocking), allowing natural vegetation to remain on the upper part. Topographic diversity of these riprapped banks is generally lower than unriprapped or natural levees, and consequently the developing vegetation is somewhat less varied. Cultivated blackberries gone wild dominate shrubby riprap in the Delta. Other common species include alder, stinging nettles, wild radish, milkweed, willows, and smartweed.

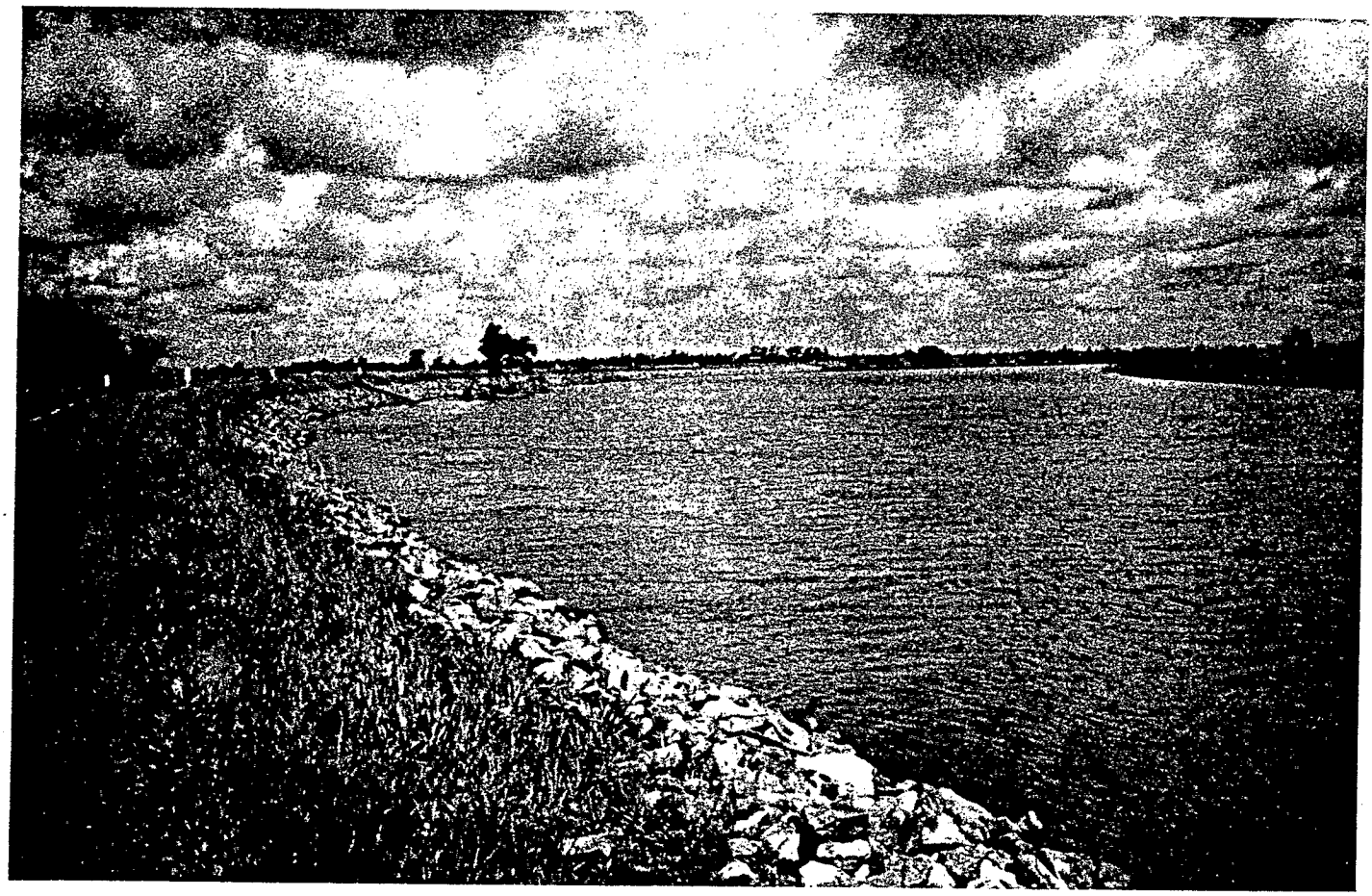
Wildlife. Habitat values of the shrubby, riprapped banks are generally less than those of the unriprapped shrub-brush riparian areas. During the wildlife census, fewer birds were observed using shrubby riprap sites than unriprapped, herbaceous, or shrub-brush banks in the immediate vicinity. Only where the vegetative cover on riprapped banks has grown almost out of the brush stage does the habitat appear to support a comparable degree of wildlife activity. Where riprap is present, and no mudflats at the base are exposed at low tides, bank burrowing by beavers, muskrats, kingfishers, and other animals is not possible. In some respects riprap diminishes fish habitat diversity, particularly by removing subhabitats (bank-side pools, eddies) used for spawning and incubation (USFWS, 1976).Some species are favored, however, by the concentrations in riprap of crayfish, which provide forage for black bass and striped bass. Shoreline with old riprap and shrub vegetation is ideal for bass fishing.



Herbaceous Banks
(UP)

Vegetation. Where the banks are frequently and seriously disturbed, woody vegetation (bushes and trees) does not have the opportunity to become established, and grasses and herbaceous plants predominate. Herbaceous banks are most common on riprap where recent rehabilitation or frequent maintenance eliminates shrubby growth. During the winter these banks are functionally bare, but summer growth can reach 5 to 7 feet (1.5 to 2 meters) or more. The most prominent plants on these banks are reed grass, which may reach 10 to 12 feet (3 to 4 meters), and giant reed, which towers over the waterways at 20 to 25 feet (6 to 7 meters).

There is considerable variation in the types of plants growing on herbaceous banks. For example, a levee on Grand Island at Howard's Landing is covered during the summer with grasses, including wild oats, ripgut brome, and Bermuda grass. Growing among the grasses are scouring rush (*Equisitum hymale*), mustard, blackberry, wild asparagus, filaree, mugwort, and fennel. Grassy riprap on Tyler Island along the north fork of the Mokelumne has a slightly different mix of introduced grasses and herbs, such as Italian ryegrass, rabbit's foot grass, (*Hordeum* spp.), nut grass, milk thistle, wild oats, and Bermuda grass. A bank on Mandeville Island, facing Franks Tract, supports a cover of poison hemlock, young sand bar willow, wild radish, Bermuda grass, and thistles on the top, and sedges and tules on the wave-washed river side. Detailed descriptions of herbaceous levee vegetation at a number of sites along the Sacramento River, including one in the Delta study area, are given by the John Muir Institute (1978a; 1978b).



Wildlife. During the fall and winter, when the cover on these banks is at a minimum, wildlife use is limited, and small flocks of sparrows are the most common birds. When summer growth is present, bushtits, house finches, and other small seed-eating birds visit the banks. Kingfishers may perch on pipes, old docks, or other structures associated with the grassy banks.

California voles, house mice, Norway rats, and California ground squirrels are the most common resident mammals. Norway rats and ground squirrels inhabit burrows that they dig in banks where vegetation is low or sparse. Ground squirrels are most active and conspicuous during the spring and summer months. Extensive burrowing can lead to levee failure, and control of ground squirrels is an important levee management consideration. Clearing of levees by cutting and burning facilitates visual inspection, but also attracts the ground squirrels by creating the open, disturbed habitat that they prefer (JMI, 1978a; 1978b).

Unvegetated Riprap
(mapped according to adjacent habitat type)

Recently rehabilitated or cleared riprap is devoid of plants. This condition is temporary, however, as grass and other plants become prominent on these banks during the spring and summer, as they do on herbaceous banks.

Wildlife. Lack of vegetation for cover makes the habitat value of these riprapped banks minimal for most species of animals. The rocks do provide perches and resting areas for birds using the open water and nearby brushy areas, however, and water that collects between the rocks may be used as bathing pools by some birds. Norway rats are one of the few residents in these areas, finding adequate cover under the rocks and in accumulated debris. Crayfish make use of riprap below the waterline for habitat.

Channel Islands
(PPF01,PSS1, PEM1, PEM2, UP)

Islands in the Delta waterways are of many kinds, from small patches of tules to more well-established mixed habitats, with riparian woodland, dense shrubs, open lakes, grassland, and freshwater marshes. Many of the islands were products of channel dredging and levee building, which cut off peninsulas and looping protuberances and left them isolated from the main tracts of land.

Most of the channel islands are in the central and southern Delta, on Disappointment Slough, White Slough, Potato Slough, the San Joaquin ship channel, Old River, and Middle River. Size, configuration, and vegetation of the islands are variable, but they are all surrounded by water and more or less isolated from the more intensively used agricultural portions of the Delta. Some islands receive high seasonal use from houseboaters and water skiers, but most are privately owned and infrequently used.

Vegetation. Islands used as disposal sites for major channel dredging (*e.g.*, western tips of Grand and Sherman Islands, and near the Delta Yacht Club on Tule Island in the Stockton deep water channel) are characterized by sandy soils. Vegetation on these areas varies with the age of the spoils. Recent disposal areas are open with grasses, Russian thistle, and herbaceous plants; older areas support young willows and other shrubs.

Because deposition of streambed sediments is a natural deltaic process, many native plants are adapted to periodic disturbance and apparently are able to recolonize the dredge spoils sites as well. Deposition of dredge spoils may cause a major change in the ecological nature and habitat value of a site, however. The spoils area at the western end of Sherman Island was a marshy area before deposition of dredge materials occurred there. Now the site is more than four feet higher than the original elevation, and while willows and other terrestrial vegetation are gradually colonizing the area, the biological productivity of the site is less than it was before the dredge spoils were disposed there (Beauchamp, pers. comm.).

Wildlife. Wildlife habitat on the islands is enhanced by the relative isolation from human activities and disturbance. General wildlife uses of the islands are discussed under the component habitat types.

Lost Lake Tule Island, in the Stockton deep water channel near Disappointment Slough, exemplifies the mixed habitat nature of some of the channel islands. Alluvial soils form uplands on the north and west of the island; riparian woodland, shrub-brush, and grassy open fields occur there. On the southeast are tidal and nontidal marshlands, where at least one black rail, a bird listed by the California Department of Fish and Game (DFG, 1978) as rare, was recorded during this study. Wildlife use of this particular island with its wide variety of habitats is correspondingly varied and extensive.

Wooded islands occur throughout the Delta, but are nowhere common. Five Fingers Islands, in Middle River between Connection Slough and Columbia Cut, is covered with young riparian woodland. While there are a few high spots on the island, probably formed from dredge spoils that were placed there when the "fingers" were created, most of the island is inundated by high tides and floods. House mice, Norway rats, and voles are common resident mammals; a wide variety of birds feed and nest in the woodland tangle.

Shrubby willows are occasionally present on dredge spoils disposal sites, and provide cover for many small birds (see Habitat Use Chart). Wildlife use of the sandy, open dredge spoils area may be high, particularly when the spoils site is adjacent to a more fully vegetated habitat type. American kestrels, white-tailed kites, turkey vultures, and other raptorial birds take advantage of the open areas for hunting. Mammal use also depends on the amount of cover in the spoils area and in the quality of adjacent habitats.

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AGRICULTURAL HABITATS

Cultivated Lands
(UP,AG)

The predominant habitat in the Delta today is an agricultural one. A variety of crops are grown, and permanent pasture lands occur on the eastern and western periphery of the Delta. The vegetational characteristics and the types and intensity of cultivation, irrigation, and other management practices influence the wildlife habitat uses and values of the agricultural lands.

Vegetation. Forage crops – hay and alfalfa – are periodically cut or plowed under. Vegetative cover in these fields is low and uniform. Corn and sorghum are planted for harvest for the commercial market and also by game clubs and private farmers for wildlife food and cover. Most of the crop is harvested in late summer; a small percentage is left standing to attract wildlife, but most fields are left as stubble over the winter or plowed under. Asparagus, tomatoes, sugar beets, and other row crops are intensively cultivated; orchards and vineyards are more permanent, less intensively worked, and provide a significant amount of cover.

Wildlife. During the fall and winter, agricultural fields are important habitat for shorebirds and large flocks of geese, swans, and ducks. Shorebirds and ducks migrating south are attracted to agricultural fields that are flooded in the late summer and fall. These fields are typically flooded for a day or two with shallow water to control weeds and centipedes (Orr, pers. comm.; Zobel, pers. comm.), and provide resting and feeding habitat for the migrant birds.

While most open fields in the Delta receive some waterfowl use, cornfield stubble, fallow lands, and bare plowed fields on a number of islands and tracts near the center of the Delta are most consistently valuable to wintering birds. These areas of heavy use include Rindge, Empire, Webb, and MacDonald Tracts, and Staten, King, Venice, Mandeville, Medford, Mildred, and Quimby Islands. Whistling swans, Canada geese, and large numbers of ducks are attracted to fields that are flooded for several months during the winter for leaching or to create waterfowl habitat, and to areas flooded by ponded rainwater and unpumped seepage (see Habitat Use Chart). Swans, geese, and sandhill cranes in particular are dependent upon these flooded fields for winter feeding and resting habitat. A few Aleutian Canada geese, a subspecies listed by the U.S. Fish and Wildlife Service as endangered (USFWS, 1979b), use these flooded fields each year as a resting or feeding stopover on the way to their traditional wintering grounds in similar habitat in the San Joaquin Valley. The flooded fields of the Delta areas to some degree substitute for the ancestral wintering habitat that was lost when the many acres of backswamp were converted during reclamation. Winter food is supplied by unharvested grain, weed seeds, young sprouts, insects, worms, and grubs in the field.

Suitable wintering habitat is a critical limiting factor for many Pacific Flyway waterfowl populations. The Central

Valley is habitat for roughly 60% of all Pacific Flyway waterfowl, and for 91% of all waterfowl wintering in California. Approximately 10% of all Central Valley waterfowl populations winter in the Delta, including an estimated 38,000 whistling swans, 73% of the Central Valley population (USFWS, 1977). When the amount of suitable available wintering habitat is reduced, waterfowl crowd into the remaining flooded areas. Conditions of overcrowding and poor nutrition from inadequate food supplies lower resistance and are conducive to outbreaks of avian cholera and avian botulism.

The number and location of flooded fields in the Delta varies from year to year, depending on the weather and current leaching practices. Increased salinity of Delta water would limit the winter leaching of fields, reduce the amount of waterfowl habitat, and cause a shift to more salt-tolerant crops with less wildlife food value than corn. Improved harvest efficiency leaves less corn and grain in the fields; discing of stubble in the fall instead of leaving it until spring also reduces the available food for waterfowl (USFWS, 1977). Poor levee maintenance that leads to the permanent, deep flooding of agricultural lands converts fields used heavily by waterfowl into open water habitat, with minimal wintering value.

Associated with the flooded fields are many acres of unflooded fields, particularly cornfields and pasture, that are also valuable winter wildlife habitat. White-fronted geese, snow geese, and Ross' geese winter in the Delta area in large numbers, and depend on cornfields in particular for wintering habitat. Fields of stubble or uncut stalks provide a favored daytime resting area and food supply. During the hunting season geese often leave the relative protection of the cornfields to feed on the grain and seeds in the more exposed flooded fields during the night.

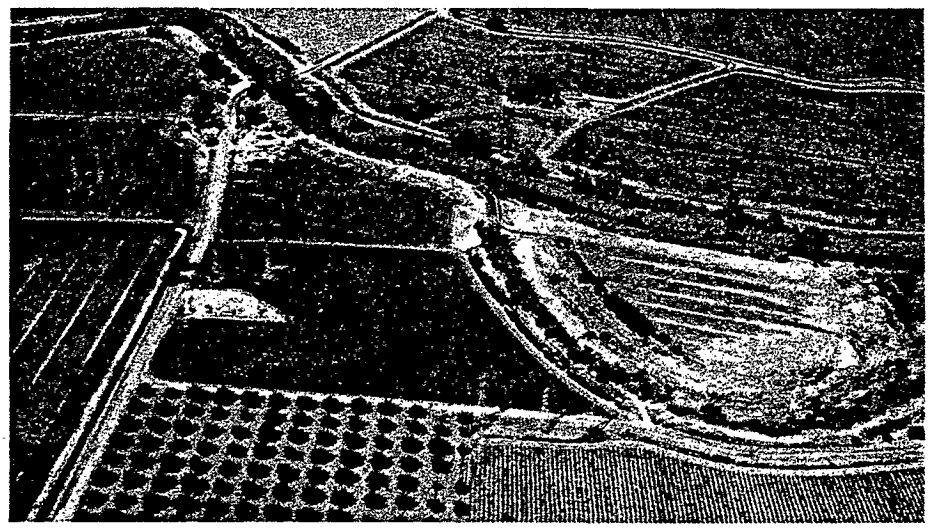
Pastureland includes permanent pasture and mowed pasture (*e.g.*, alfalfa fields). Permanent pasture is not cultivated or mowed but is left largely undisturbed. This relative habitat stability is important for wildlife, as it permits year-round use, abundant cover, insect and plant food, and the development of a diverse and complex wildlife community. In contrast, mowed pasture is periodically disturbed by planting, cultivation, and mowing, and the habitat value is correspondingly less.

Pastureland and open fields on the eastern side of the Delta are a wintering habitat of Statewide significance for thousands of greater and lesser sandhill cranes. Brack Tract and the southern part of New Hope Tract form the core of the crane habitat, although the birds disperse from there to feed on Staten and Tyler Island and elsewhere. Sandhill cranes use unflooded fields, but seem to prefer these fields interspersed with wet and marshy areas for roosting. Duck clubs in this area fill their ponds in late September and early October, creating essentially the only ponded areas in the Delta at that season (Rollins, 1977).

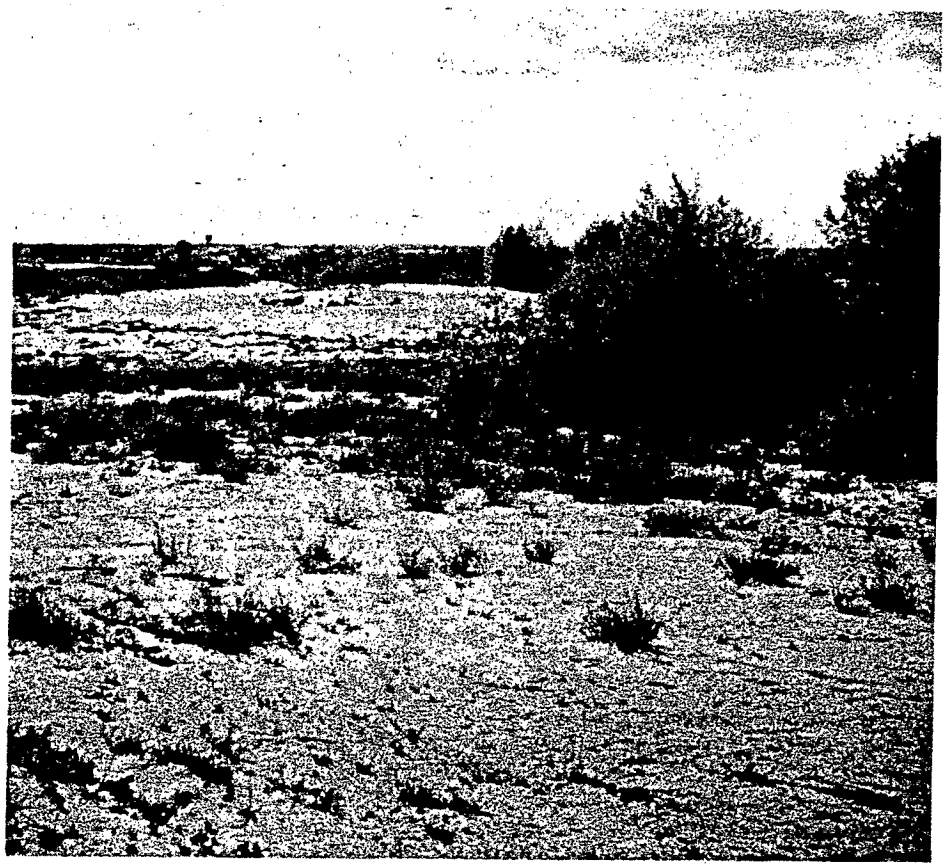
Unflooded wheat fields, corn fields, sugar beet fields, and pasture provide habitat for the three most important upland game birds in the Delta: the introduced ring-necked pheasant and the native California quail and mourning dove. In 1977, 80 to 90,000 pheasant, 35,000 quail, and 110,000 doves were taken in the Delta by hunters (Slosson, pers. comm.). Riparian woodland is extremely important habitat for all three game species. Abundance of these birds on agricultural lands is increased by the proximity to riparian vegetation (Rollins, 1977). Brushy growth along field borders and adjacent ruderal lands provide cover and nesting habitat that enhances the agricultural habitat in much the same way riparian vegetation does. Patches of farmland throughout the Delta are managed for pheasant production, often in cooperation with a local gun club.

Blackbirds (Brewer's and red-winged) are often abundant in both flooded and unflooded agricultural fields. During much of the year, blackbirds feed on weed seeds and field grain, but during the spring and early summer, when they are feeding nestlings a high-protein diet, blackbirds consume mostly insects and grubs from farm fields.

Orchards and vineyards are used by songbirds as feeding and nesting habitat, particularly during the spring and summer. Application of insecticides and herbicides during times of heavy bird use may reduce the available food source and limit the habitat value. Row or truck crops are regularly disturbed by farm machinery and consequently receive only sporadic and limited use by wildlife, mostly as a feeding area. Forage crops are less frequently disrupted, and provide cover and nesting as well as feeding opportunities.



Ruderal Lands
(UP [AF])



Long-fallow agricultural fields, abandoned homesites and fields, untended lands in urban or residential areas, and other lands where the native vegetational cover has been interrupted or disturbed by humans are grouped as ruderal lands. Unlike most fallow fields, which are left untended for only a season or two, ruderal lands have been allowed to revert to some degree to a natural state and are characteristically early successional communities. Ruderal lands are not widespread throughout the Delta, as most available land is intensively cultivated, particularly in the peat-soil region of the central Delta. Towards the south, where mineral soils predominate, ruderal lands occur more frequently, but even there they are small and not common.

Vegetation. Ruderal lands differ floristically from each other, depending on past land use and surrounding habitat types. For example, an abandoned homesite overlooking the Sacramento River at Brannan Island State Park contains a small group of native trees, including sand bar, Gooding's, and arroyo willows. Other vegetation on the site includes ornamental trees and shrubs which were planted there; the ground cover is a mix of native and exotic grasses and herbaceous plants. A second ruderal site, in Terminous, also includes native and ornamental trees but is dominated by a thick tangle of blackberry. Past land use history of this site is not apparent from the vegetation.

A third ruderal site, on Andrus Island, is adjacent to cultivated fields. Ground cover at this third site is primarily wild radish and various grasses. Willows have become established in some of the lower-lying, soggy places, and along Brannan Island Road, which fronts the site. This site lies immediately behind the spot where the levee failed June, 1972, causing the Brannan Island flood of that year. Sandy sediments deposited on the site during the break and subsequent levee repair have made it unsuitable for recultivation (Simpson, pers. comm.).

Wildlife. Available cover, food, and lack of disturbance contribute to the high wildlife value of these lands. Little natural or naturalized upland habitat is available in the Delta, because of the intensive agriculture there. Where such habitat exists, wildlife use can be extensive, even though the habitat may be relatively small in acreage. Even narrow brushy margins between fields and along the insides of levees provide a significant amount of wildlife habitat, but clean-cropping practices eliminate most of this edge habitat. Specific wildlife use of an area depends to some degree on the different kinds of cover and habitat found there and on adjacent lands.

On the Andrus Island ruderal site, a large group (± 20) of short-eared owls was found to use heavy radish cover there as a winter roosting area, and over 75 white-tailed kites used a willow clump there as a winter roost. Clearing of the willows in early February eliminated this roost site, and the kites were not seen there the following season. These and other raptorial birds that frequent ruderal sites (see Habitat Use Chart) find abundant prey (house mice and California voles) there and in adjacent agricultural lands.

Roughly 330 kite pellets containing regurgitated, indigestible prey remains were collected from underneath the kite roost in February, 1979 and analyzed for content. The remains of 59 California voles and one house mouse were found in a sample of 50 pellets, with an average of 1.2 individuals per pellet (Madrone Associates, unpublished data).

Not all pellets underneath the roost were collected. It is not known how long this particular roost had been occupied by the kites, so it is not possible to estimate the total impact this kite population had on the local rodent population on the basis of this pellet analysis. However, if it is assumed that each pellet represents roughly one day's meal for each bird, then every day while they occupied the roost, this flock of 75 kites was removing approximately 90 voles from the surrounding agricultural fields.

The actual number of prey taken may be even greater. Not all small

mammals eaten by raptorial birds are represented in pellets (Brooks, 1929). Other investigators, looking at a larger sample, found a slightly higher pellet content count of 1.43 individuals per pellet (777 small mammals in 544 kite pellets) (Waian and Stendall, 1970). Based on observations made by Warner and Rudd (1974) in the Sacramento Valley near Davis, during the winter a typical adult kite makes about 12 hunting forays each day, with a successful capture rate of 31%, for an average capture rate of 3.7 prey animals daily.

Since voles and other small rodents have home ranges that are generally less than 2 acres (Harestad and Bunnell, 1979), significant reductions in local rodent populations can be made by a concentration of raptorial birds such as these white-tailed kites, which hunt over areas up to 1.8 miles away from their perching sites (Warner and Rudd, 1974).

Although they are small in extent, ruderal lands are often heavily populated with house mice, California voles, pocket gophers, and California ground squirrels. Black-tailed jackrabbits feed in the area, as do various mammalian predators and scavengers, including grey fox, weasel, raccoon, skunk, and Norway rats. Among the reptiles likely to be found there are western fence lizards, gopher snakes, and racers. Where there is fresh water in ditches or seepage areas, toads, treefrogs, bullfrogs, and crayfish may breed.

Drainage and Irrigation Ditches
(AG,PEM2)

Drainage and irrigation ditches are found throughout the Delta, bordering and criss-crossing agricultural fields and levees. In cultivated areas, ditches are usually cleared periodically of vegetation. On the periphery of fields and in other less intensively used areas, ditch marshes may develop, containing tules, cattails, reed grass, and herbaceous annuals; floating aquatic plants like duckweed, *Azolla*, and pretty water smartweed; and submerged plants such as waterweed, pondweed, *Myriophyllum*, and water milfoil.

Wildlife. In a vegetated ditch, wildlife habitat values are similar to those of freshwater marshland, although the total area included in the ditch habitat is usually linear and relatively small. Because they are so numerous and widespread, however, drainage and irrigation ditches contribute a significant amount of wildlife habitat to the Delta region at large.

Crayfish and bullfrogs are characteristic inhabitants of irrigation ditches and may spread from there to flooded fields. Burrows dug into the ditches, banks, and agricultural lands by crayfish are reported to cause damage to levees and crops (Riegel, 1959).

UPLAND
(UP)

On the edge of the Delta is a mixture of upland habitats, including pasturelands, grazed grasslands, other agricultural areas, and a few remnants of oak savannah. These uplands on the periphery are qualitatively different from similar habitats in the Delta, which are all more or less associated with sloughs and waterways.

Undeveloped upland occurs on the southwest of the Delta area, between Tracy and Byron; in the west, on the hills surrounding Rio Vista; and to the east, on the lands between Sacramento and Stockton. According to early accounts (Fremont, 1845), in presettlement days much of the Delta periphery was a "grassy sward", with innumerable wildflowers and oak trees growing in open savannahs. Perennial grasses occupied the hillsides to the west. Today grassland still covers these hills, but the composition is not the same. Native perennial grasses have been replaced and the grasslands are dominated by introduced annual species. To the east, native valley vegetation has been converted to pasture. Remnants of oak savannah

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are few; one example occurs in a county park adjacent to Highway 5 at Eight Mile Road.

A unique upland habitat occurs at the western end of the study area, in the sand dunes near Antioch. These dunes are a remnant example of a more extensive system that once occurred along the now developed southern bank of the San Joaquin River. Two plants and a butterfly, listed by the U.S. Fish and Wildlife Service as endangered, occur on these dunes (USFWS,1979b). Under the provisions of the *Endangered Species Act* of 1973, critical habitat has been established in the dunes for the two plants, the Contra Costa wallflower and the Antioch Dunes evening primrose. These are the only two plants on the federal endangered species list for which official critical habitat had been designated as of November 30, 1979 (USFWS, 1979a). Official designation of critical habitat confers additional protection to endangered species from activities carried out or funded by federal agencies.

Wildlife. Wildlife use of these peripheral upland habitats is much the same as it is over the many square miles of California where similar habitat occurs. But when compared with the inner Delta, where the continual presence of water enhances the attractiveness of most habitats, wildlife use of the uplands is less varied and less extensive. That there is a functional difference between the Delta proper and the flanking upland habitats is suggested by the fact that during this study, no deer mice (*Peromyscus maniculatus*) were trapped anywhere within the water-dominated portion of the Delta, even though all habitat types there were investigated. The only records of the mouse for the area come from the oak savannah at the county park adjacent to Highway 5, in an upland habitat removed from the influence of tidal waterways.

The only known population of Lange's metalmark, an endangered butterfly, occurs in the Antioch Dunes, along with its necessary food plant, the Antioch buckwheat. In addition, the northernmost point of distribution of the California legless lizard occurs in these dunes (Stebbins, 1966). The San Joaquin kit fox, another federally-listed endangered species (USFWS, 1979b), has been reported from orchards and brushland in the agricultural areas south of Brentwood (Morrell, 1975). This area is the northernmost portion of the kit fox range. The foxes are not as abundant here as they are at the southern end of the San Joaquin Valley.

Vernal Pools
(not mapped)

Vernal pools are a unique habitat feature, with unusual edaphic characteristics and a high proportion of endemic, specialized native plants. They are formed when winter rains collect in shallow pools underlain by an impervious hardpan layer. Once more common throughout the Central Valley, vernal pool habitat has been lost on a large scale to agricultural conversion. Pools are now far less numerous, and found mostly on the terrace soils on

the eastern margin of the Valley, although remnant examples have survived elsewhere as well (Holland and Griggs, 1976).

Two groups of vernal pools occur on the westernmost edge of the Delta study area. The Jepson Prairie, also known as the Dozier vernal pools or the Dixon vernal pools, lies at the western end of Lindsey Slough, roughly between Barker and Calhoun Cuts. These pools are surrounded by remnant perennial grasslands and are of great botanical significance (Medeiros, 1976). On the southwest, along the railroad tracks south of Byron, is a second group of vernal pools. These differ somewhat from the other pools in the Central Valley in that they are slightly alkaline, and the plant community composition is correspondingly different (Hood, 1978). Four of the plant species found in vernal pools peripheral to the Delta are listed by the U.S. Fish and Wildlife Service or the California Department of Fish and Game as endangered or of concern (USFWS, 1979b; Rae, pers. comm.).

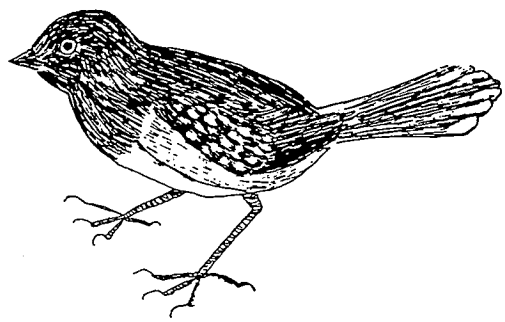
Wildlife. In the spring, the fresh water that collects in the pools is a valued habitat resource to many wildlife species, particularly amphibians which use it for egg-laying. During the remainder of the year, vernal pool areas are barely distinguishable from the surrounding grasslands, and the overall habitat value is also very much the same.

DEVELOPED AREAS
(UR)

Town centers (*e.g.*, Isleton, Rio Vista, Walnut Grove), residential homesites, trailer parks, marinas, and other places where buildings, pavement, and other artificial structures dominate the habitat, are lumped as developed areas. Vegetation in these places can be as varied as the landscaper's imagination, with exotic plantings of oleanders, palm trees, fruitless mulberry, eucalyptus, fruit trees, and lawns. Around marinas, original marshland may have been dredged and natural banks reconfigured with bulkheads and riprap; open water is covered with docks and boat slips.

Wildlife. Most of the Delta is rural or small town in character, and a considerable amount of wildlife habitat remains even within the developed areas. Some species are able to successfully adapt to this habitat, including robins, attracted to lawns; house finches; house sparrows; yellow-rumped warblers; mockingbirds; starlings; orioles; and other songbirds. Seagulls frequent fishing centers and marinas, scavenging bait and offal. Other, more sensitive species primarily inhabit adjacent undeveloped areas but visit the developed habitats regularly. Common mammals include the house mouse, Norway rat, raccoon, opossum, and feral cats and dogs.

Increased automobile and truck traffic and human presence associated with developed areas have a direct, adverse effect on the native wildlife, which suffer from roadkills and are driven out of former habitat. Domestic and feral cats and dogs can become efficient wildlife predators, and may cause depredations of some concern.



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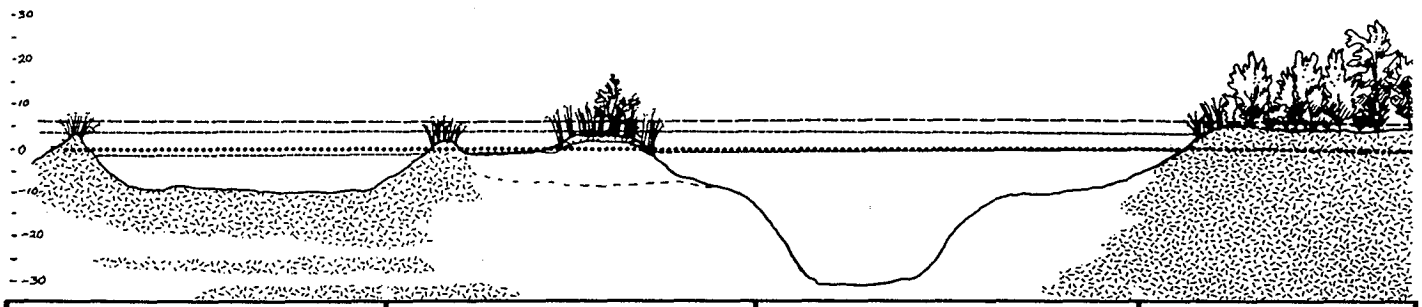
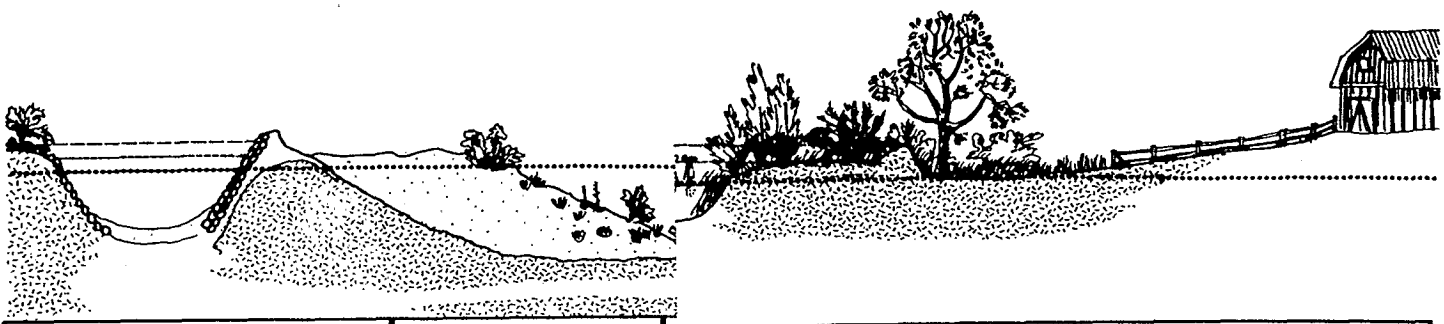
Cross Section of Delta Habitats



SUBMERGED ISLAND	TULE ISLAND AND MUDFLAT	RIVER AND DEEP WATER CHANNEL	WOODED ISLAND
Location Franks Tract, Big Break, Lower Sherman Island, Clifton Court Forebay.	**Location** Tule Islands in central and southern Delta: Disappointment Slough, White Slough, Potato Slough, the San Joaquin Ship Channel, Old River, Middle River. Mudflats primarily in western Delta.	**Location** Channel network connects the San Joaquin and Sacramento Rivers; some broader expanses of open water.	**Location** A few scattered throughout Delta: Five Fingers Islands.
Vegetation Vegetation varies with protection from currents, winds, and recreation. Floating, submergent, and emergent plants; diatoms, phytoplankton, and other algae; woody plants on margins; water milfoil, yellow water weed, water hyacinth, duck weeds, water fern, pondweeds, naiad, parrot feather, tules, and cattails.	**Vegetation** Islands may contain tules, bulrushes, common reed, rushes, and other marsh vegetation as well as riparian woodland, shrub-brush, and upland vegetation; mudflats covered by bulrushes, cattails or other emergent species on 30% or less of total area.	**Vegetation** Vegetation varies with protection from currents, winds, and recreation. Floating, submergent, and emergent plants; diatoms, phytoplankton, and other algae; woody plants on margins; water milfoil, yellow water weed, water hyacinth, duck weeds, water fern, pondweeds, naiad, parrot feather, tules, and cattails.	**Vegetation** Young riparian woodland: cottonwood, western sycamore, white alder, valley oak, willow, ash, box elder, buttonbrush, blackberry, wild rose, wild grape.
Wildlife Invertebrates: copepods, *Neomysis*, and other zooplankton; decapod shrimp, worms, mud crab, clams, and crayfish. Fish: sunfish, bass, catfish, striped bass, king salmon, silver salmon, white sturgeon, green sturgeon. Birds: grebes, double-crested cormorant, diving ducks, ruddy duck, American coot, gulls, terns, belted kingfisher, swallows. Mammals: beaver, muskrat, river otter, occasional harbor seal.	**Wildlife** Invertebrates: amphipods, polychaetes, oligochaetes, mud crab, clams, crayfish. Birds: Pied-billed grebe, American bittern, Virginia rail, sora, black rail (rare), American coot, long-billed marsh wren, common yellowthroat, red-winged blackbird, and song sparrow on tule islands; herons, egrets, least sandpiper, dunlin, killdeer, terns, and gulls on mudflats. Mammals: beaver, muskrat, raccoon, skunk. Reptiles and Amphibians: common garter snake, western pond turtle, bullfrog, Pacific treefrog.	**Wildlife** Invertebrates: codepods, *Neomysis*, and other zooplankton; decapod shrimp, worms, mud crab, clams, and crayfish. Fish: sunfish, bass, catfish, striped bass, king salmon, silver salmon, white sturgeon, green sturgeon. Birds: grebes, double-crested cormorant, diving ducks, ruddy duck, American coot, gulls, terns, belted kingfisher, swallows. Mammals: beaver, muskrat, river otter, occasional harbor seal.	**Wildlife** Birds: diverse assemblage - herons, wood duck, red-tailed hawk, California quail, American coot, woodpeckers, swallows, bushtit, wrens, thrushes, ruby-crowned kinglet, warblers, finches, sparrows. Mammals: house mouse, Norway rat, California vole. Amphibians: Pacific treefrog.
Values and Sensitivities — Wind and wave action greater than on other open water areas, because submerged islands are relatively unprotected. — Habitat value of islands used by waterfowl may decrease following inundation (*e.g.*, Webb Tract). — Deliberate inundation of subsided island requires careful study and management objectives.	**Values and Sensitivities** — Wildlife use of islands high because of relative isolation (and high habitat diversity on some islands). — Migratory shorebirds feed on mudflats. — Threatened by recreational overuse.	**Values and Sensitivities** — Essential habitat for plankton, the base of the Delta food web; various invertebrate species harvested for commercial bait; and a variety of game fish, including 10 anadromous species. — Reverse flows and high channel velocities threaten reproductive success of anadromous fish. — Profuse growth of water hyacinth in the spring reduces navigability of some channels.	**Values and Sensitivities** — Relative isolation increases already high habitat value (high vegetative diversity, rich food source, nesting sites, cover, insect production). — Uncommon in Delta. — Unprotected from vegetation removal and recreational use.

C—056339

C-056339



RIPRAPPED LEVEES	SANDY DREDGE SPOILS AND RUDERAL	LOUGH D-OFF H	RIPARIAN WOODLAND	UPLAND - DEVELOPMENT
Location: Throughout the Delta	**Location** Grand Island, Sherman Island Headreach Island	ımore Sloughs ern Delta: Sloughs	**Locations:** Outer margins of Delta: southeast San Joaquin River, Delta Meadows, Cosumnes and Mokelumne Rivers confluence.	**Location** Upland - on the edge of the Delta between Tracy and Byron, on hills surrounding Rio Vista, and between Sacramento and Stockton, dunes near Antioch. Development - towns, homesites, marinas, etc.
Vegetation: Relatively undisturbed riprapped banks are brushy (blackberry, alder, stinging nettles, wild radish, milkweed, smartweed); riprapped banks more frequently maintained are herbaceous (introduced grasses and herbs, wild oats, ripgut brome, Bermuda grass, mustard, wild asparagus, Italian ryegrass, rabbit's foot grass, poison hemlock, thistles; tall native grasses: reed grass, giant reed); and recently rehabilitated banks are unvegetated.	**Vegetation** Willows, native and introduced grasses, and herbaceous shrubs.	and emergent n margins. weeds, water rweed, water hyacinth	**Vegetation:** Variable tall riparian woodland trees, dense shrubs. Cottonwood, western sycamore, white alder, valley oak, willow, ash, box elder, buttonbrush, blackberry, wild rose, wild grape.	**Vegetation** Introduced annual grasses and forbs: wild oats, ripgut brome, foxtail, Italian wildrye, canary grass, horseweed, sowthistle, mustard, sweet clover, common knotweed; various exotics including oleanders, palm trees, fruitless mulberry, eucalyptus and fruit trees in residential areas
Wildlife: Fish: black bass and striped bass attracted by crayfish concentrations near submerged riprap Birds: On brushy, riprapped banks - hawks, California quail, wrentit, warblers, northern oriole, finches, sparrows; On herbaceous banks - California quail, killdeer, owls, horned lark, swallows, water pipit, western meadowlark, blackbirds, finches, sparrows; On unvegetated riprap - belted kingfisher, killdeer, mourning dove, western meadowlark, house finch. Mammals: brushy riprap - desert cottontail, western harvest mouse, Norway rat, house mouse; Herbaceous - California ground squirrel, California vole, Norway rat, house mouse, striped skunk; Unvegetated - Norway rat. Reptiles and Amphibians: western fence lizard, California alligator lizard, Pacific gopher snake (in cover areas), western toad, Pacific treefrog (in moist cover areas), yellow-bellied racer, common kingsnake.	**Wildlife** Birds: many hawk species, white-tailed kites, California quail, ring-necked pheasant, killdeer, mourning dove, owls, flycatchers, swallows, warblers, blackbirds, sparrows. Mammals: California vole, black rat, Norway rat, house mouse, pocket gopher, California ground squirrel. Reptiles and Amphibians: western fence lizard, yellow-bellied racer, Pacific gopher snake, western toad, Pacific treefrog.	is. ish - white d, black crap- th bass, ng grounds for Delta smelt. pied-billed k; dependent - egret and d kingfisher. skrat, river homesites.	**Wildlife:** Birds: diverse assemblage - herons and egrets, wood duck, Swainson's hawk, owls, woodpeckers, flycatchers, plain titmouse, nuthatches, western bluebird, warblers. Mammals: bats, skunk, raccoon, occasional grey squirrel, black rat, occasional beaver. Reptiles and Amphibians: western fence lizard, valley garter snake, Pacific gopher snake, common kingsnake, Pacific treefrog, slender salamander.	**Wildlife** Birds: horned lark, western meadowlark, blackbirds, mockingbird, robin, starling, yellow-rumped warbler, house sparrow, orioles, house finch Mammals: house mouse, Norway rat, raccoon, opossum, feral cats and dogs Reptiles and Amphibians: western fence lizard, yellow-bellied racer, common kingsnake, Pacific gopher snake, western toad, Pacific treefrog
Values and Sensitivities: — Riprapping generally reduces wildlife value of levee banks. — Vegetation removal minimizes wildlife habitat value of banks to most wildlife but attract ground squirrels which burrow into levees.	**Values and Sensitivities** — Cover attracts many small birds; open areas used by wide variety of raptors. — Many native plants able to recolonize spoils sites. — Deposition of dredge spoils may reduce habitat value in some areas (e.g., marshes) — Spoil sites can be used to recreate "sand June" habitat for several rare or endangered species.	es e, valuable rs to native m intensive cor in habitat es for arian habitat bird resour	**Values and Sensitivites:** — Most diverse habitat in Delta, rich food source, nesting sites, cover, insect production valuable for aquatic organisms. — Habitat most threatened by levee maintenance and urban and recreational development on former flood plains	**Values and Sensitivities** — Antioch dunes provide critical habitat for several endangered species. — A few remnants of oak savannah present Wildlife use of these areas less extensive than undeveloped inner Delta habitats

Freshwater Marshes

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
BIRDS								
Pied-billed Grebe	E				E,5	P	P	
Double-crested Cormorant	S						S	Mainly immatures; summer birds do not breed in Delta.
Great Blue Heron	P					P	P	
Great and Snowy Egret	S					S	S	
Black-crowned Night Heron						P	S	
Least Bittern	?	E			E?,5	E	E	
American Bittern	E				E?,5	P	P	More common in winter than as a breeding bird.
Mallard	S	P	S		S	P	P	Small numbers breed at edge of marshes. Larger numbers in winter, but minority of population in this habitat.
Pintail	S	P	S			P	P	
Green-winged Teal			S			S	S	
Cinnamon Teal	S				S,5	S	S	Small numbers breed in summer. Langer numbers in winter, but minority of population in this habitat.
American Wigeon			S			S	S	
Northern Shoveler			S			S	S	
Wood Duck						S	S	
Ruddy Duck	S?		S			S	S	
White-tailed Kite; Sharp-shinned and Cooper's Hawk						S		
Marsh Hawk	P				P	P	P	
Virginia Rail; Sora	E?		E		?	E	E	Both Virginia Rail and Sora known to be in Delta all year and probably nest due to ideal habitat, but no records to confirm this.
Black Rail	?	E			?	E	E	Heard calling in breeding season in ideal habitat for nesting.

LEGEND: (Numbers refer to references that follow the species list.)

E = Essential - This species depends upon some feature of this habitat for the indicated habitat use.

P = Preferred - Most general living requirements of this species are met in this habitat. In the Delta, the majority of the population is found here.

S = Secondary - Some general living requirements of this species are met in this habitat, but other habitats are used as well.

X = Species was observed but data are inadequate to determine specific habitat use.

C-056341

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C-056342

Freshwater Marshes

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Common Gallinule	E				E,5	P	P	
American Coot	P		S		P,5	P	P	Preferred for breeding, but not other seasons.
Common Snipe			S			S	S	
Short-eared Owl			P			S	P	Roost also in overgrown fields where undisturbed.
Belted Kingfisher						S	S	
Black Phoebe	S					S	S	
Tree, Rough-winged, Barn, and Cliff Swallow	P					P	S	Many aerial insects taken for food.
Long-billed Marsh Wren	E				E,5	E	E	
Common Yellowthroat	E				E,5	P	P	
Yellow-headed Blackbird	E				E,5	P	P	Loss of habitat has reduced numbers.
Red-winged Blackbird	P				P	P	P	
Tricolored Blackbird	E				E	P	P	
Brewer's Blackbird	S					S	S	
Brown-headed Cowbird	S				?		S	Parasite — places its eggs in other birds' nests.
Song Sparrow	P				P	P	P	
MAMMALS								
Beaver	E				E	S	S	Many houses are built in marshes or marshy islands. Feed on tule roots but prefer bark.
Western Harvest Mouse	S				S	S	S	Prefers grassy areas; sometimes found at margins of marsh.
California Vole	S				S	S	S	Similar to above.

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C—056342

Freshwater Marshes

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Muskrat	E				E,P	P	P	
Norway Rat	S				S	S	S	Usually prefer an area with more solid ground, yet are abundant here.
House Mouse	S				S	S	S	As above, yet are found here.
Raccoon	?				?	S	S	Undoubtedly are here, but may be only passing through while feeding.
Weasel	?				?	S	?	
Mink	E,P				?	P	P	May breed if enough solid ground for den exists.
River Otter	?					S?	?	Very scarce.
Bats						S		Feed over the marsh; no species identified
REPTILES								
Western Pond Turtle	E				P	E	P	Common; nests on shore, not in water.
Valley Garter Snake	P					P	P	Feeds on and around marsh.
Giant Garter Snake	E					E	E	Prefers open water and grassy banks in and adjacent to marshes. Now scarce in Delta, listed as rare by California Department of Fish and Game.
AMPHIBIANS								
Western Toad					E			Terrestrial, except for breeding (1,2,3,4)
Pacific Treefrog	S				E	S		Widespread in Delta.
Bullfrog	E				E	P		Introduced but now widespread.

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C-056343

C-056343

C-056344

Channels And Open Water

SPECIES	HABITAT USE									COMMENTS
	NATIVE	INTRODUCED	RESIDENT	SEASONAL	EGG/LARVAE	JUVENILE/ADULT	RECREATIONAL FISH (R);	COMMERCIAL FISH (C);	NON-GAME FISH (N)	ANADROMOUS	
FISH											
Pacific lamprey	X			X	E	E			N	X	Parasitic on fish in ocean.
River lamprey	X			X	E	E			N	X	Parasitic on fish in salt and fresh water.
White sturgeon	X			X	E	E	R			X	Commercial fishery closed in 1917.
Green sturgeon	X			X	E	E	R			X	Less desirable than white sturgeon.
Threadfin shad		X	X		P	P			N		Important forage species.
American shad		X		X	E	E	R			X	Commercial fishery closed in 1957.
King salmon	X			X	E	E	R	C		X	Most are fall spawners.
Silver salmon	X			X	E	E	R	C		X	Rare in Delta.
Steelhead	X			X	E	E	R			X	Anadromous form of rainbow trout; most popular freshwater gamefish.
Delta smelt	X		X			P			N		Prefers low salinity; restricted to Sacramento-San Joaquin Estuary.
Longfin smelt	X			X	E	E	R			X	Important forage species.
Hitch	X		X		S	S			N		Abundance declining in Delta.
California roach	X		X		S	S			N		Most abundant in intermittent foothill streams.
Sacramento blackfish	X		X		P	P		C			Prefer turbid waters.
Sacramento splittail	X		X			E	R				Confined to Delta region; tolerates brackish water; most abundant native cyprinid.
Hardhead	X		X		S	S			N		Prefers undisturbed sections of foothill streams.
Sacramento squawfish	X		X		P	P			N		Siltation and competition of introduced predatory fish reducing populations.
Golden shiner		X	X		S	S		C			Sold as bait fish.
Fathead minnow		X	X		S	S		C			Sold as bait fish; common in intermittent streams.
Goldfish		X	X		S	S			N		Disturb gamefish habitats.
Carp		X	X		S	S	R	C			Detrimental to native species and gamefish.
Sacramento sucker	X		X		S	S			N		Uncommon when competing with introduced species (e.g., carp and goldfish).
Black bullhead		X	X		S	S			N		Overcrowded populations often contain stunted individuals.
Brown bullhead		X	X		P	P	R				Largely unexploited by sport fishermen.

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S = Secondary - Some general living requirements of this species are met in this habitat, but other habitats are used as well.

C-056344

Channels And Open Water

SPECIES	HABITAT USE									COMMENTS
	NATIVE	INTRODUCED	RESIDENT	SEASONAL	EGG/LARVAE	JUVENILE/ADULT	RECREATIONAL FISH (R);	COMMERCIAL FISH (C);	NON-GAME FISH (N)	ANADROMOUS	
INVERTEBRATES											
Opossum shrimp *(Neomysis mercedis)*	X		X		P	P					Primary food of young striped bass.
Amphipod *(Corophium spinicorne)*	X		X		P	P					
Amphipod *(Corophium stimpsoni)*	X		X		P	P					
Bay shrimp *(Crangon franciscorum)*	X			X		S		C			Important food for fish.
Grass shrimp *(Palaemon macrodactylus)*		X	X		P	P		C			Introduced; competes with bay shrimp.
Mud crab *(Rhithropanopeus harrisi)*		X	X		P	P					Introduced; now common.
Crayfish *(Pacifastacus leniusculus)*		X	X		P	P	R	C			Most edible crayfish.
Crayfish *(Procambarus clarkii)*		X	X		S	S	R	C			Burrows in banks and levees.
Asiatic clam *(Corbicula fluminea)*		X	X		P	P		C			Extremely abundant in places.
Japanese cockle *Tapes japonica)*		X	X		P	P					
Gem clam *(Gemma gemma)*		X	X		P	P					

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C-056345

C-056345

C-056346

Channels And Open Water

SPECIES	HABITAT USE									COMMENTS
	NATIVE	INTRODUCED	RESIDENT	SEASONAL	EGG/LARVAE	JUVENILE/ADULT	RECREATIONAL FISH (R);	COMMERCIAL FISH (C);	NON-GAME FISH (N)	ANADROMOUS	
FISH (Continued)											
White catfish		X	X		S	S	R				Favor low-current areas.
Channel catfish		X	X		P	P	R				Prefer deep, swift channels; more desirable than white catfish as a sport fish and for aquaculture.
Rainwater killifish		X	X		P	P			N		Prefer brackish water.
Mosquitofish		X	X		S	S			N		Effective for mosquito control; may eliminate other small fish.
Mississippi silverside		X	X		S	S			N		Spreading throughout Delta.
Threespine stickleback	X		X		S	S			N	X	Both anadromous and freshwater populations exist.
Striped bass		X		X	E	E	R			X	Commercial fishery closed in 1935; abundance correlated to Delta outflows. Delta essential habitat for anadromous populations.
Sacramento perch	X		X		P	P	R				Only native centrarchid; rare in Delta; population decline due to interactions with introduced centrarchids.
Bluegill		X	X		S	S	R				Abundant; often large populations of stunted individuals.
Green sunfish		X	X		S	S			N		Pioneer species; prefer intermittent streams, often replacing California roach; aggressive and abundant; often large populations of stunted individuals.
Warmouth		X	X		P	P			N		Prefer warm, turbid, muddy-bottomed, vegetated sloughs.
Black crappie		X	X		S	S	R				Prefer warm, clear, vegetated lakes; thriving in some sloughs and irrigation ditches.
Largemouth bass		X	X		S	S	R				Prefer disturbed or artificial habitats; popular gamefish.
Smallmouth bass		X	X		S	S	R				Most abundant in large tributaries of Sacramento & San Joaquin Rivers.
Bigscale logperch		X	X		P	P			N		Prefer muddy-bottomed, turbid sloughs.
Tule perch	X		X		P	P	R				Only freshwater surfperch.
Yellowfin goby		X	X			S			N		May compete with native gobies and sculpins; abundant in fresh and sea water; may spawn in fresh water.
Prickly sculpin	X		X		S	S			N		Fresh and salt water; streams and lakes.
Pacific staghorn sculpin	X			X		S	R	C			Mostly juveniles and newly mature adults in fresh water; sold as bait.
Starry flounder	X			X		S	R	C			Mostly immature fish in fresh water; possibly spawn in fresh water.

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S = Secondary - Some general living requirements of this species are met in this habitat, but other habitats are used as well.

C-056346

C-056347

Open Water

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
BIRDS								
Common and Red-throated Loon			E			E	E	Only one record each, in 11/79.
Eared and Western Grebe			E	E		E	E	
Pied-billed Grebe						E	E	
Double-crested Cormorant	E					E		Summer residents are mainly immatures.
Mallard; Gadwall; Pintail	S		S			S	S	Greater numbers in winter.
Green-winged Teal; American Wigeon; Northern Shoveler			S			S	S	
Wood Duck	S					S	S	
Redhead			S			S	S	
Ring-necked Duck; Canvasback; Lesser Scaup; Ruddy Duck			P			P	P	
Common Merganser			P			P	P	
Common Gallinule	S					S	S	
American Coot	S					S	S	
Western Gull			P			P	P	
Herring Gull						P	P	Found in winter.
California and Ring-billed Gull						S	S	Found in water all year.
Bonaparte's Gull; Forster's Tern						E	S	Seen most of year.
Caspian Tern						E	S	Seen over water, mainly in summer.
Belted Kingfisher	E					E		
Tree Swallow	P					P		Feed over water; roost elsewhere.
Rough-winged, Barn, and Cliff Swallow		P				P		Feed over water; roost elsewhere.

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X = Species was observed but data are inadequate to determine specific habitat use.

C-056347

C-056348

Open Water

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
MAMMALS								
Beaver								Passing through.
Muskrat								Passing through.
River Otter						S		
Harbor Seal						S		Several instances in Delta including the American River, Lower Delta, and up the Mokelumne as far as Thornton.
California Sea Lion						S	?	

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C-056348

Lakes And Dead-End Channels

SPECIES	HABITAT USE									COMMENTS
	NATIVE	INTRODUCED	RESIDENT	SEASONAL	EGG/LARVAE	JUVENILE/ADULT	RECREATIONAL FISH (R);	COMMERCIAL FISH (C);	NON-GAME FISH (N)	ANADROMOUS	
FISH											
Threadfin shad		X	X		P	P			N		Often concentrate in dead-end sloughs.
Delta smelt	X		X		E	E			N		Most spawning in dead-end sloughs; restricted to Sacramento-San Joaquin Estuary.
Hitch	X		X		P	P					Common in lakes and reservoirs.
Sacramento blackfish	X		X		P	P					Abundant in oxbows.
Sacramento splittail	X		X		E	E	R				Require dead-end sloughs with submerged vegetation for spawning.
Golden shiner		X	X		P	P		C			Sold as bait fish.
Carp		X	X		S	S	R	C			Detrimental to native species and gamefish.
Sacramento sucker	X		X		S	S			N		Uncommon where there are introduced species (e.g., carp and goldfish).
Black bullhead		X	X		P	P			N		Often populations are overcrowded, with stunted individuals.
Brown bullhead		X	X		S	S	R				Largely unexploited by sport fishermen.
White catfish		X	X		P	P	R				Favor low-current areas.
Mosquitofish		X	X		S	S			N		Prefer shallow, high temperature zones.
Mississippi silverside		X	X		P	P			N		Introduced to control midges and gnats; replace other small fish as forage species.
Bluegill		X	X		S	S	R				Abundant, often large populations of stunted individuals.
White crappie		X	X		P	P	R				Prefer warm, turbid lakes and reservoirs; displacing black crappie in some areas.
Black crappie		X	X		P	P	R				Prefer warm, clear, vegetated lakes.
Largemouth bass		X	X		P	P	R				Prefer disturbed or artificial habitats; popular gamefish.
Smallmouth bass		X	X		S	S	R				Most abundant in large tributaries of Sacramento & San Joaquin Rivers.
Prickly sculpin	X		X		S	S			N		Fresh and salt water; streams and lakes.
INVERTEBRATES											
Opossum shrimp *(Neomysis mercedis)*	X		X		S	S					Primary food of young striped bass.
Amphipod *(Corophium spinicorne)*	X		X		S	S					

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C-056349

C-056349

C-056350

Lakes And Dead-End Channels

SPECIES LAKES AND DEAD-END CHANNELS	HABITAT USE NATIVE	INTRODUCED	RESIDENT	SEASONAL	EGG/LARVAE	JUVENILE/ADULT	RECREATIONAL FISH (R); COMMERCIAL FISH (C); NON-GAME FISH (N)	ANADROMOUS	COMMENTS
INVERTEBRATES (Continued)									
Amphipod *(Corophium stimpsoni)*	X		X		S	S			
Crayfish *(Procambarus clarki)*		X	X		P	P	R C		Burrowing may damage levees.
Asiatic clam *(Corbicula fluminea)*		X	X		S	S	C		May become extremely abundant.

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C-056350

Tideflats

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
BIRDS								
Double-crested Cormorant							S	
Great Blue Heron; Great and Snowy Egret							S	
Mallard; Pintail							S	
Common Gallinule; American Coot						S	S	
Killdeer; Common Snipe; Greater Yellowlegs						S	S	
Black-bellied Plover				S		S	S	During migration and in winter.
Lesser Yellowlegs				S		S	S	Seen in migration.
Least Sandpiper			P			P	P	
Dunlin; Long-billed Dowitcher			S			S	S	
Western Sandpiper				P		P	P	
American Avocet						S	S	
Western Gull						S	P	
Herring Gull			S			S	P	
California, Ring-billed, and Bonaparte's Gull	S					S	P	Nonbreeding gulls "hang out" here.
Mew Gull							P	
Foster's Tern	S					S	P	
Caspian Tern		S				S	P	
Common Crow						S	S	
Water Pipit			S			S	S	
Red-winged and Brewer's Blackbird						S	S	

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X = Species was observed but data are inadequate to determine specific habitat use.

C-056351

C-056351

C-056352

Oxidation Ponds

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
BIRDS								
Eared Grebe			P			P	P	
Pied-billed Grebe	S					S	S	
Double-crested Cormorant							S	
Great Blue and Green Heron	S					S	S	
Great and Snowy Egret			S			S	S	
Mallard	S				?	S	S	Breeds nearby, probably.
Pintail	S					S	S	
Green-winged and Cinnamon Teal; American Wigeon			S			S	S	
Northern Shoveler			P			P	P	
Redhead; Ring-necked Duck; Canvasback; Lesser Scaup; Ruddy Duck	S					S	S	
Common Gallinule; American Coot	S					S	S	
Killdeer	S				S	S	S	
American Golden and Black-bellied Plover				P		P	P	Many black-bellieds in fall and winter.
Common Snipe			S			S	S	
Long-billed Curlew			S			S	S	
Spotted Sandpiper			P			P	P	
Greater Yellowlegs			S			S	S	
Lesser Yellowlegs				S		S	S	Many in migration.
Pectoral Sandpiper				P		P	P	Only records from here 9/76 and 10/24/79.
Least Sandpiper			S	P		S	S	
Dunlin			S			S	S	
Short-billed Dowitcher				P		P	P	
Long-billed Dowitcher			S			S	S	

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C—056352

Oxidation Ponds

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Western Sandpiper				P		P	P	
Marbled Godwit				P		P	P	
American Avocet		S				S	S	
Black-necked Stilt		P			P?	P	P	Seen with young in August; may be nesting area.
Wilson's and Northern Phalarope				P		P	P	
Herring Gull			S			S	S	
California and Ring-billed Gull	S					S	S	
Mew Gull			S			S	S	
Bonaparte's Gull			S	S		S	S	
Forster's Tern	S?					S	S	
Rock Dove	S				?	S	S	Nests on buildings and other structures.
Mourning Dove	S					S	S	
Black Phoebe	S				?	S	S	
Tree Swallow	S					S	S	Swallows are aerial feeders.
Rough-winged Swallow		S				S	S	
Barn and Cliff Swallow	S				S	S	S	Nests on buildings and other structures.
Common Crow	S					S	S	
Water Pipit			S			S	S	
Starling	S					S	S	
House Sparrow	S				S	S	S	Nests on buildings and other structures.
Western Meadowlark	S					S	S	
Red-winged, Tricolored, and Brewer's Blackbird	S					S	S	
Brown-headed Cowbird	S					S	S	
House Finch	S				S	S	S	Nests on buildings and other structures.
Savannah Sparrow	S					S	S	

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C-056353

C-056353

Oxidation Ponds

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
White-crowned Sparrow								
Song Sparrow	S		S			S	S	

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C-056354

Riparian Woodland

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
BIRDS								
Great Blue Heron	E				E		P	Essential for breeding in spring
Green Heron	E				E,5		P	Essential for breeding in spring
Great Egret	E				E?,5		S	No rookery noted this year, but formerly known to nest.
Black-crowned Night Heron	E				E,5		P	
Wook Duck	E				E,5		P	
Turkey Vulture	S						P	
White-tailed Kite	S				P,5		S	
Sharp-shinned Hawk			P			P	P	
Cooper's Hawk	E				E,5	P	P	
Red-tailed Hawk	P				P,5		S	
Red-shouldered Hawk	E				E,5		P	
Swainson's Hawk		E			E		P	
American Kestrel	P				P		S	
California Quail	S				S,5	S	S	
Mourning Dove	P				P		P	
Barn Owl	S				S,5		S	
Screech Owl	P				P,5		P	
Great Horned Owl	E				E,5	S	E	
Anna's Hummingbird	S					S	P	
Belted Kingfisher							S	
Common Flicker	E				E,5	S	E	
Acorn Woodpecker	E				E,5	P	P	
Yellow-bellied Sapsucker			S			S	S	

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C-056355

C-056355

C-056356

Riparian Woodland

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Downy Woodpecker; Nuttall's Woodpecker	E				E,5	P	P	
Western Kingbird		S			S	S	S	
Ash-throated Flycatcher		E			E	P	P	
Black Phoebe	S					S	S	
Willow Flycatcher				E	E,5	E	E	Probably former nester, may be only fall migrant now.
Western Flycatcher; Western Wood Pewee				P		P	P	
Tree Swallow	E				E	S	P	Threatened by Starlings taking over nest sites.
Scrub Jay	P				P		P	
Yellow-billed Magpie	P				P,5		P	
Common Crow	E				E,5		P	
Plain Titmouse	E				E,5	E	E	Threatened by Starlings taking over nest sites.
Bushtit	P				E,5	P	P	
White-breasted Nuthatch	E				E,5	E	E	Threatened by Starlings taking over nest sites.
Red-breasted Nuthatch				E		E	E	
Wrentit	P				?	P	P	Preference here is for the bushy areas.
House Wren		E		P	?	P	E	Occasional winter resident
Winter Wren			E			E	E	
Bewick's Wren	P				P	P	P	
American Robin	P				P,5	S	P	Wintering population much higher
Varied Thrush			P			P	P	
Hermit Thrush			E			E	E	
Swainson's Thrush				E		E	E	
Western Bluebird	E				E,5	S	S	Hole nester

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C—056356

Riparian Woodland

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Blue-gray Gnatcatcher				E		E	E	Occasional winter resident.
Ruby-crowned Kinglet			E			E	E	
Cedar Waxwing			P			P	P	
Loggerhead Shrike	E				E,5		S	
Starling	P				P		P	Favor holes for nesting.
Hutton's Vireo				E		E	E	Status of residency not well known but may not migrate.
Solitary Vireo				E		E	E	
Warbling Vireo		?		E	?	E	E	
Orange-crowned Warbler			P			P	P	
Yellow Warbler		E			E,5	E	E	
Yellow-rumped Warbler			P			P	P	
Townsend's, Black-Throated Gray, and MacGillivray's Warbler				P		P	P	
Common Yellowthroat	S					S	S	
Yellow-breasted Chat		E			E,5	E	E	
Wilson's Warbler				P		P	P	
Northern Oriole		P			P	P	P	
Brewer's Blackbird	S				S,5		S	
Brown-headed Cowbird	S				?		S	Lays its eggs in nests of other birds.
Western Tanager				P			P	
Black-headed Grosbeak		P			E,5		P	
Blue Grosbeak		P			S,5		P	Most likely to breed in shrubby willows.
Lazuli Bunting				P			P	
Purple Finch			P				P	
House Finch	S				S	S	S	

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C-056357

C-056357

C-056358

Riparian Woodland

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
American Goldfinch	P				P,5		P	
Rufous-sided Towhee	P				P	P	P	
Dark-eyed Tunco			P			S	P	
White-crowned, Golden-crowned, White-throated, and Fox Sparrow			P			S	P	Most likely to be found in brush.
Lincoln's Sparrow			S				S	
Song Sparrow	P				P	P	P	
MAMMALS								
Virginia Opossum	P				P	S	S	Will occupy many habitats and raids agricultural lands, too.
Ornate Shrew	S				S	P	P	Very scarce or at least seldom trapped.
Broad-footed Mole	P				P	P	P	Occupy many other areas as well.
Yuma Myotis	?				?	S	S	One collected here; most of the Myotis migrate south.
California Myotis						?	?	Expected, not recorded.
Big Brown Bat	?					S		Expected during the summer.
Red Bat	?				?	S	S	Recorded in Delta during breeding season.
Hoary Bat	P				P	P	P	Hibernates and roosts in trees.
Townsend's Big-eared Bat	?				?	?	?	Expected but no Delta records.
Pallid Bat								Not as likely in this habitat
Brazilian Free-tailed Bat	?				?	?	?	Might feed here
Desert Cottontail	S				S	S	S	
Black-tailed Jack Rabbit	S				S	S	S	
Gray Squirrel	E				E	P	P	Only where there are oaks.
Botta's Pocket Gopher	S				S	S	S	Varies in parts of Delta.

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C—056358

C-056359

Riparian Woodland

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Western Harvest Mouse	S				S	S	S	In grassy areas of the woods; less abundant than House Mouse.
California Vole	S				S	S	S	In grassy areas of the woods; less abundant than House Mouse.
Black or Roof Rat	P				P	P	P	Seems most abundant in this habitat.
Norway Rat	S				S	S	S	Seems to be less abundant here than the Roof Rat.
House Mouse	S				S	S	S	Always abundant but possibly fewer here than in Ruderal or other areas.
Coyote	S				?S	S		Some evidence that they feed here.
Gray Fox	S				S	S	S	Prefers brushy areas.
Raccoon	P				P	P	P	Often den in hollow trees.
Long-tailed Weasel	S				S	S	S	Where there are mice there are weasels.
Striped Skunk	P				P	P	P	Skunks use many habitats.
Bobcat	S				S	S	S	Usually prefers drier areas.
REPTILES								
Western Fence Lizard	S				S	S	S	These reptiles breed in or adjacent to this habitat.
California Alligator Lizard	2				2			
Yellow-bellied Racer	2				2	2		
San Joaquin Whipsnake	2				2	2		
Pacific Gopher Snake	2				2	2		
Common Kingsnake	2				2	2		
Valley Garter Snake	S,2				S,2	S,2		
Western Rattlesnake						?		Probably no resident population; individuals arrive on flood debris.

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C—056359

C-056360

Riparian Woodland

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
AMPHIBIANS								
Western Toad						S	S	May be here most of year, leaving to breed in nearby water.
Pacific Treefrog						P	P	May be here most of year, leaving to breed in nearby water.

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C-056360

Riparian Shrub-Brush

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
BIRDS								
Green Heron	E				E,5		P	
Black-crowned Night Heron	E				?		P	
American Bittern			S				S	
Turkey Vulture	S						S	
White-tailed Kite	P						P	Large winter roosts found in shrubby willows.
Sharp-shinned Hawk			P			P	P	
Cooper's Hawk	P				S,5	P	P	
Red-tailed and Red-shouldered Hawk	S						S	
Swainson's Hawk		S					S	
Marsh Hawk; American Kestrel	S						S	
California Quail	P				P,5	S	P	
Ring-necked Pheasant	S						S	
Rock Dove	S						S	
Mourning Dove	P				P		P	
Barn, Screech, and Great Horned Owl	S				?	S	S	Heard calling during breeding season.
Long-eared Owl	E				?		E	Status uncertain
Anna's Hummingbird	S				?	S	S	Seen during breeding season.
Selasphorus sp. Hummingbird				S		S	S	
Belted Kingfisher	S						S	Nest in burrows in steep dirt banks.
Common Flicker; Downy and Nuttall's Woodpecker	S					S	S	Prefer the occasional trees in this habitat.
Western Kingbird		S			S	S	S	
Ash-throated Flycatcher		S		S		S	S	
Black Phoebe	S					S	S	

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C-056361

C-056361

C-056362

Riparian Shrub-Brush

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Say's Phoebe			S			S	S	
Willow Flycatcher				P	P,5	P	P	Formerly nested, but now only migrant.
Western Flycatcher; Western Wood Pewee				P		P	P	
Tree Swallow	S					S		
Rough-winged, Barn, and Cliff Swallow		S				S		
Scrub Jay	P					P	P	
Yellow-billed Magpie	S					S	S	
Common Crow	S				S		S	
Bushtit	P				P	P	P	Probably breeds here. Usually does in such habitats.
Wrentit	P				P?	P	P	Probably breeds in brush area.
House Wren		P				P	P	Occasionally found in winter.
Winter Wren			S			S	S	
Bewick's Wren	P				P	P	P	
American Robin	S					S	S	
Hermit Thrush			P			P	P	
Swainson's Thrush				P?		P?	P?	Status uncertain.
Blue-gray Gnatcatcher			?	P		P	P	
Ruby-crowned Kinglet			P			P	P	
Loggerhead Shrike	S						S	
Hutton's Vireo				P		P	P	Status of residency uncertain; may not migrate.
Solitary Vireo				P		P	P	
Warbling Vireo		P		P	?	P	P	
Orange-crowned Warbler			P	P		P	P	
Yellow Warbler		P		P	P,5	P	P	
Yellow-rumped Warbler			S			S	S	

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C-056362

Riparian Shrub-Brush

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Black-throated Gray and Townsend's Warbler				S	S	S	S	
McGillivray's and Wilson's Warbler				P		P	P	
Common Yellowthroat	S				S	S	S	Nests in tules, cattails, brush, etc., usually over moist soil or water.
Yellow-breasted Chat		E			E,5	E	E	
Red-winged Blackbird	S				?		S	
Northern Oriole		P			P	P	P	
Brewer's Blackbird	S				S,5		S	
Brown-headed Cowbird	P				?		P	
Western Tanager				S		S	S	
Black-headed Grosbeak		P			P,5	P	P	
Blue Grosbeak		E		P	?	S	P	Known to nest in shrubby willows.
Purple Finch			S			S	S	
House Finch	S				S,5	S	S	
American Goldfinch	E				E,5	S	P	
Rufous-sided Towhee	P				P	P	P	
Brown Towhee	S				?	S	S	
Dark-eyed Junco; White-crowned, Golden-crowned, and Lincoln's Sparrow		P				S	P	
Fox Sparrow			P			P	P	
Song Sparrow	P				P,5	P	P	
MAMMALS								
Virginia Opossum	P				P	P	P	
Ornate Shrew	?				?	?	?	Presence depends on ground cover; scarce.
Broad-footed Mole	S				S	S	S	

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C-056363

C-056363

C-056364

Riparian Shrub-Brush

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Bats						?		Most bats will feed in this area.
Desert Cottontail	P				P	P	P	
Black-tailed Jack Rabbit	S				S	S	S	
California Ground Squirrel	P				P	P	P	If some open areas exist.
Botta's Pocket Gopher	S				S	S	S	
Western Harvest Mouse	S				S	S	S	In open, grassy areas in brush.
California Vole	S				S	S	S	In open, grassy areas in brush.
Norway Rat	P				P	P	P	
House Mouse	P				P	P	P	
Coyote	S				?	S	S	Not observed, but reported by trappers.
Gray Fox	P				P	P	P	
Raccoon	P				P	P	P	
Long-tailed Weasel	S				S	S	S	
Spotted Skunk	P				P?	P	P	
Striped Skunk	P				P	P	P	
Bobcat	S				S	S	S	
REPTILES								
Western Fence Lizard	P				P	P		Common
California Alligator Lizard	P				P	P		Not common during this study period.
Yellow-bellied Racer	S				S	S		Not common during this study period.
Pacific Gopher Snake	P				P	P		
Common Kingsnake	2				2	2		
Valley Garter Snake	S,2				S,2	S,2		If water is nearby.

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C-056364

Riparian Shrub-Brush

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
AMPHIBIANS								
Western Toad						S	S	Leaves to breed, spends part of time in ground.
Pacific Treefrog						S	S	Present most of year.

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C-056365

C-056365

C-056366

Riprap With Brush Cover

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
BIRDS								
Green Heron	S					S	S	
Sharp-shinned and Cooper's Hawk						S	S	
White-tailed Kite, Red-tailed Hawk, Marsh Hawk, and American Kestrel						S	S	Often the only available perch in cultivated areas; will feed on available prey.
California Quail	S				?	S	S	May nest on ground in brush; expected.
Mourning Dove	S					S	S	
Barn Owl							S	
Great Horned Owl						S	S	
Belted Kingfisher							S	Found everywhere next to water.
Common Flicker							S	
Western Kingbird		S			S	S	S	
Ash-throated Flycatcher						S	S	
Black Phoebe						S	S	
Scrub Jay	S					S	S	
Yellow-billed Magpie and Common Crow							S	
Bushtit	S				S,5	S	S	
Wrentit	S				?	S	S	May nest in brush.
Bewick's Wren	S				S	S	S	
American Robin	S		?			S	S	More abundant in winter.
Hermit Thrush			?			S	S	
Blue-gray Gnatcatcher				S		S	S	
Ruby-crowned Kinglet			S			S	S	
Loggerhead Shrike							S	
Starling						S	S	
Warbling Vireo				S		S	S	
Orange-crowned Warbler			S	S		S	S	

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X = Species was observed but data are inadequate to determine specific habitat use.

C—056366

Riprap With Brush Cover

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Yellow Warbler		S		S		S	S	
McGillivray's Warbler				S		S	S	
Common Yellowthroat	S				S	S	S	Usually nests in tules, cattails, etc. May nest in bushes hanging over water.
Wilson's Warbler				S		S	S	
Red-winged Blackbird							S	
Northern Oriole		S			S	S	S	
Brewer's Blackbird; Brown-headed Cowbird	S				?		S	
Black-headed and Blue Grosbeak		S			?	S	S	
House Finch	S				S	S	S	
American Goldfinch	S				S,5	S	S	
Rufous-sided Towhee	S				S	S	S	
Dark-eyed Junco; White-crowned, Golden-crowned, Fox, and Lincoln's Sparrow			S			S	S	
Song Sparrow			S		?	S	S	May nest in brush but nests not seen.
MAMMALS								
Virginia Opossum	?				?	S	S	
Desert Cottontail	P				?	S	S	
Black-tailed Jack Rabbit	S					S	S	
California Ground Squirrel	S				S	S	S	Favors open areas.
Western Harvest Mouse	S				S	S	S	Usually in some grass under brush.
California Vole	S				S	S	S	
Black Rat	S				S	S	S	
Norway Rat	P				P	P	P	
House Mouse	P				P	P	P	
Coyote						?	?	

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X = Species was observed but data are inadequate to determine specific habitat use.

C-056367

C-056367

C-056368

Riprap With Brush Cover

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Gray Fox						?	?	Probably, as it moves from place to place.
Raccoon	?				?	S	S	
Striped Skunk	S				?	S	S	
REPTILES								
Western Fence Lizard	S				?	S	S	All of these reptiles breed in the Delta and may use this or nearby habitats.
California Alligator Lizard	S,2				?	S	S	
Yellow-bellied Racer	S,2				?	S	S	
San Joaquin Whipsnake	S,2				?	S	S	
Pacific Gopher Snake	S				S	S	S	
AMPHIBIANS								
Western Toad						S	S	
Pacific Treefrog						S	S	

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C-056368

C-056369

Riprap With Herbaceous Cover

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
BIRDS								
Green Heron; American Bittern						S	S	
California Quail	S				S,5	S	S	
Common Gallinule; American Coot						S	S	
Killdeer	S				S	S	S	Nests in open area.
Spotted Sandpiper; Greater Yellowlegs						S	S	
Rock and Mourning Dove						S	S	
Barn and Great Horned Owl						S		Feed on *Microtus*, other rodents.
Burrowing Owl			S			S?	S?	
Short-eared Owl						S	S	
Belted Kingfisher							S	Found almost everywhere near water.
Common Flicker						S	S	
Black Phoebe						S	S	
Horned Lark						S	S	
Barn and Cliff Swallow						S	S?	Use riprap for bathing, drinking, and feeding young.
Bewick's Wren						S		
Mockingbird						S		
Water Pipit			S			S	S	
Loggerhead Shrike						S		
Starling						S	S	
House Sparrow						S		
Western Meadowlark	S					S		
Red-winged Blackbird	S				S?	S	S	May nest in taller plants such as mustard.
Brewer's Blackbird						S	S	
Brown-headed Cowbird						S	S	

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C—056369

C-056370

Riprap With Herbaceous Cover

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Black-headed and Blue Grosbeak						S		
House Finch	S					S		
American Goldfinch	S					S		
Rufous-sided Towhee						S		
Dark-eyed Junco; White-crowned, Golden-crowned, and Lincoln's Sparrow			S			S	S	
Song Sparrow	S					S	S	
MAMMALS								
Virginia Opossum						S	S	
Broad-footed Mole	S				?	S	S	If enough cover and not too dry.
Black-tailed Jack Rabbit						S	S	
California Ground Squirrel	P				P	P	P	Prefer low vegetation or open areas.
Botta's Pocket Gopher	S				S	S	S	
Western Harvest Mouse	?				?	S	S	
California Vole	P				P	P	P	
Norway Rat	S				S	S	S	
House Mouse	S				S	S	S	
Weasel						S	S	
Striped Skunk						S	S	
REPTILES								
Western Fence Lizard	S				S	S		
California Alligator Lizard	S					X		
Yellow-bellied Racer						2		

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C—056370

Riprap With Herbaceous Cover

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Pacific Gopher Snake	2				2	2		Depends on amount of cover during year. Might only enter to feed.
Common Kingsnake						2		Depends on amount of cover during year. Might only enter to feed.
AMPHIBIANS								
Western Toad						S	S	Abundance depends on amount of growth and moisture for both these species. Will leave for part of year.
Pacific Treefrog						S	S	

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C-056371

C-056371

C-056372

Dredge/Spoils

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
BIRDS								
Turkey Vulture	S					S	S	Mainly hunts open areas.
White-tailed Kite	S				S,5	S	S	Prefers willows for roosting.
Sharp-shinned Hawk			S			S	S	Hunts in willows.
Cooper's Hawk	S					S	S	Hunts in willows.
Red-tailed Hawk, Red-shouldered Hawk, American Kestrel	S					S	S	Hunts open areas.
Marsh Hawk	S				S?	S	S	May breed in grassy area.
California Quail, Ring-necked Pheasant	S				S?	S	S	Heavy grass and brush areas.
Killdeer	S				S?	S	S	
Rock Dove	S					S	S	
Mourning Dove	S				S,5	S	S	
Barn Owl, Great Horned Owl	S					S	S	
Burrowing Owl, Short-eared Owl			S			S	S	
Anna's Hummingbird	S					S	S	Near flowering plants.
Common Flicker	S					S	S	Feeds on ants on ground.
Downy Woodpecker, Nuttall's Woodpecker	S					S	S	In larger willows.
Western Kingbird		S		S	S	S	S	Mostly in migration.
Black Phoebe	S					S	S	
Say's Phoebe			S	S		S	S	
Willow Flycatcher, Western Flycatcher, Western Wood Pewee				S				Willows.
Horned Lark	S					S	S	In open.
Tree Swallow	S					S	S	More common in summer.
Rough-winged Swallow, Barn Swallow, Cliff Swallow		S				S		Aerial feeders.

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C—056372

Dredge/Spoils

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Scrub Jay	S				S	S	S	In willows, other brush
Yellow-billed Magpie	S					S	S	
Common Crow	S					S	S	
Bushtit	S				S,5	S	S	In vegetation.
Wrentit	S				S?	S	S	In brush areas.
Bewick's Wren	S				S	S	S	In brush.
American Robin	S				?	S	S	Larger numbers in winter; may breed here.
Hermit Thrush			S			S	S	Winter in willows.
Blue-gray Gnatcatcher			S?	S		S	S	Prefers willow.
Ruby-crowned Kinglet			S			S	S	Prefers willows and riparian.
Water Pipit			S			S	S	Open areas.
Loggerhead Shrike	S				S	S	S	
Starling	S					S	S	
Hutton's Vireo, Solitary Vireo, Warbling Vireo				S		S	S	Found in willows.
Orange-crowned Warbler			S	S		S	S	Found in brush and riparian.
Yellow Warbler		S		S	S,5	S	S	Prefers willows.
Yellow-rumped Warbler			S			S	S	Willows
Black-throated Gray Warbler, Townsend's Warbler, McGillivray's Warbler, Wilson's Warbler				S		S	S	Willows.
Common Yellowthroat	S				S?	S	S	Nest usually in tules or brush, over water or damp soil.
Western Meadowlark	S					S		In open, grass.
Red-winged Blackbird, Tricolored Blackbird, Brewer's Blackbird	S					S	S	
Brown-headed Cowbird	S				?	S	S	
Black-headed Grosbeak		S		S	S?,5	S	S	Willows.

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C-056373

C-056373

C-056374

Dredge/Spoils

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Blue Grosbeak		S			S?,5	S	S	Willows.
House Finch	S				S	S	S	
American Goldfinch	S				S,5	S	S	Willows for nesting.
Rufous-sided Towhee	S				S	S	S	Brush.
Brown Towhee	S				?	S	S	Brush and grass.
Savannah Sparrow			S?			S	S	Grass.
Dark-eyed Junco; White-crowned, Fox, Golden-crowned, and Lincoln's Sparrow			S			S	S	Mainly brush.
Song Sparrow	S				S	S	S	Herbaceous plants and brush.
MAMMALS								
Virginia Opossum								Expected here as opossums wander over most areas.
Broad-footed Mole	S				S	S	S	
Desert Cottontail	S				?	S	S	Will depend on cover that has developed on spoil.
Black-tailed Jack Rabbit	S				S	S	S	
California Ground Squirrel	S				S	S	S	
Botta's Pocket Gopher	S				S	S	S	
Western Harvest Mouse	S				S	S	S	
California Vole	S				S	P	S	
Black Rat	S				S	S	S	Not common unless trees or large shrubs are present.
Norway Rat	P				P	P	P	Very abundant.
House Mouse	P				P	P	P	Very abundant.
Coyote						S		

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C-056374

Dredge/Spoils

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Gray Fox						S		
Raccoon						S		
Long-tailed Weasel						S	?	
Striped Skunk						S	?	
REPTILES								
Western Fence Lizard	P				P	P	P	Common here.
California Alligator Lizard	S				?	S	S	Breed here or not far away.
Yellow-bellied Racer	S				?	S	S	
San Joaquin Whipsnake	S				?	S	S	
Pacific Gopher Snake	S				?	S	S	
Common Kingsnake	S				?	S	S	
AMPHIBIANS								
Western Toad						S	S	
Pacific Treefrog						S	S	Where there is vegetation.

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C-056375

C-056375

C-056376

Flooded Agricultural Fields (Winter Use)

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
BIRDS								
Great Blue Heron; Cattle, Great, and Snowy Egret						S		
Whistling Swan			E			E	E	Large numbers; a major wintering area.
Canada Geese			P			P	P	Occasionally includes 1 or 2 Aleutian geese.
White-fronted, Snow, and Ross' Goose			E			E	S	Feed at night, rest in dry fields.
Mallard, Green-winged Teal, Cinnamon Teal, American Wigeon, Northern Shoveler						P	P	Present in large numbers; also found in marshes, oxidation ponds.
Pintail						P	P	Abundant in winter.
Redhead, Canvasback, Ruddy Duck						S	S	Also found at oxidation ponds.
Sandhill Crane			S			S	E	Major wintering population present in Delta; feeds in dry fields and pastures, roosts in ponded or wet fields.
American Coot			S			S	S	
Killdeer			S			S	S	
Common Snipe			S			S	S	Feeds on edges.
Long-billed Curlew			S			S	S	
Greater Yellowlegs, Least Sandpiper, Dunlin, Long-billed Dowitcher			P			P	P	Feeds on edges of water; also on tideflats.
Herring Gull			S			S	S	
California Gull, Ring-billed Gull						S	S	
Tree Swallow						S		Feeds in air over water.
Common Crow						S	S	
Water Pipit			S			S	S	Feeds on edges of water.
Starling, Red-winged Blackbird, Brewer's Blackbird						S	S	

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C-056376

Unflooded Agricultural Fields (Winter Use)

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
BIRDS								
Great Blue Heron, Great Egret, Snowy Egret, American Bittern						S	S	
Cattle Egret						P	S	
Canada Goose			P			P	P	
White-fronted Goose			E			E	E	
Snow Goose, Ross' Goose			E			E	E	Strong preference for corn fields.
Mallard, Pintail, American Wigeon, Northern Shoveler			S			S	S	
Turkey Vulture						S		
White-tailed Kite						S		
Sharp-shinned Hawk, Cooper's Hawk						S		Hunts birds in field.
Red-tailed Hawk						S	S	Will often sit in field.
Red-shouldered Hawk						S		
Marsh Hawk						S	S	
American Kestrel						S		
Ring-necked Pheasant						S	S	
Sandhill Crane			E			E	P	A major wintering area in California; includes pasture, plowed fields. Roosts in wet areas.
American Coot						S	S	
Killdeer, Common Snipe						S	S	
Herring Gull, California Gull, Ring-billed Gull						S	S	
Rock Dove, Mourning Dove						S	S	
Horned Lark						S	S	
Common Crow						S	S	

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C-056377

C-056377

Unflooded Agricultural Fields (Winter Use)

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Water Pipit						P?	S	
Loggerhead Shrike						S	S	
Starling						S	S	
Western Meadowlark						P	S	
Red-winged Blackbird, Brewer's Blackbird, Brown-headed Cowbird						S	S	
House Finch						S		
Savannah Sparrow, White-crowned Sparrow, Golden-crowned Sparrow, Song Sparrow						S	S	

LEGEND: (Numbers refer to references that follow the species list.)

E = Essential - This species depends upon some feature of this habitat for the indicated habitat use.

P = Preferred - Most general living requirements of this species are met in this habitat. In the Delta, the majority of the population is found here.

S = Secondary - Some general living requirements of this species are met in this habitat, but other habitats are used as well.

X = Species was observed but data are inadequate to determine specific habitat use.

Ruderal

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
BIRDS								
Great Blue, Green, and Black-crowned Night Heron	S					S	S	Most common along drainage ditches.
American Bittern	P				?	P	P	May nest here. Greater numbers in winter
Turkey Vulture	S					S		Hunts area
White-tailed Kite	P				5	P	P	Willows, trees may support winter roosting congregations.
Sharp-shinned Hawk			S			S	S	
Cooper's, Red-tailed, and Red-shouldered Hawk	S					S	S	
Marsh Hawk	P				?	P	P	Ground nester.
American Kestrel	S				S,5	S	S	Nests in cavity of some sort.
California Quail	P				P,5	P	P	
Ring-necked Pheasant	P				P,5	P	P	Introduced species frequently managed and released for hunting.
Killdeer	S				S	S	S	
Rock Dove	S				S	S	S	
Mourning Dove	S					S	S	
Barn Owl	S				S	S	S	Nests in old barns, hollow trees, etc.
Great Horned Owl	S					S	S	
Burrowing Owl	P					P	P	Some are there year-round.
Short-eared Owl			P			P	P	Very important habitat for ground roosting; also use marshes.
Anna's Hummingbird	S					S	S	
Selasphorus sp. Hummingbird				S		S	S	
Common Flicker; Downy and Nuttall's Woodpecker	S					S	S	
Western Kingbird		S		S	S	S	S	

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X = Species was observed but data are inadequate to determine specific habitat use.

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Ruderal

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Ash-throated Flycatcher		S		S		S	S	
Black Phoebe	S					S	S	Nests under bridges or eaves, near water.
Say's Phoebe			S		S	S	S	
Willow and Western Flycatcher; Western Wood Pewee				S		S	S	
Tree Swallow	S	S				S		Many more in summer.
Rough-winged Swallow		S				S		
Barn and Cliff Swallow		S			S	S	S	Nests on buildings and bridges.
Scrub Jay	S				S?,5	S	S	
Yellow-billed Magpie	S				?	S	S	
Common Crow	S					S	S	
Bushtit	S				S,5	S	S	
Wrentit	S				?	S	S	In brushy areas.
Bewick's Wren	S				S	S	S	In brush.
Long-billed Marsh Wren	S					S	S	Where marshy cover exists.
Mockingbird	S				S	S	S	Breeds in this habitat.
American Robin	S				?	S	S	
Varied and Hermit Thrush			S			S	S	
Blue-Gray Gnatcatcher			?	S		S	S	
Ruby-crowned Kinglet			S			S	S	
Cedar Waxwing			S			S	S	
Loggerhead Shrike	S				S	S	S	
Starling	S				S	S	S	
Hutton's, Solitary, and Warbling Vireo				S		S	S	Residency status unknown.
Orange-crowned Warbler			S			S	S	
Yellow Warbler		S		S	S	S	S	

LEGEND: (Numbers refer to references that follow the species list.)

E = Essential - This species depends upon some feature of this habitat for the indicated habitat use.

P = Preferred - Most general living requirements of this species are met in this habitat. In the Delta, the majority of the population is found here.

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X = Species was observed but data are inadequate to determine specific habitat use.

C-056380

Ruderal

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Yellow-rumped Warbler			S			S	S	Abundant in eucalyptus and other cover.
Black-throated Gray, Townsend's, Mac-Gillivray's, and Wilson's Warbler				S		S	S	Prefers urban, suburban, or farm yards.
Common Yellowthroat	S				?	S	S	Near ditches, wet areas.
House Sparrow	S				?	S	S	
Western Meadowlark	S				?	S	S	
Red-winged Blackbird	S				S	S	S	Nests in large numbers but not as extensively as in marshes.
Tricolored Blackbird	S					S	S	
Northern Oriole		S			S	S	S	
Brewer's Blackbird; Brown-headed Cowbird	S				?	S	S	May nest here.
Western Tanager				S		S	S	
Black-headed and Blue Grosbeak		S			?	S	S	May nest in willows.
House Finch	P				P	P	P	
American Gold Finch	S				S	S	S	Nests in willows.
Rufous-sided Towhee	S				S	S	S	
Brown Towhee	S				?	S	S	May nest in the brush areas.
Savannah Sparrow	S					S	S	
Dark-eyed Junco; White-crowned, Golden-crowned, and Lincoln's Sparrow			P			P	P	
Fox Sparrow			S			S	S	
Song Sparrow	S				S	S	S	
MAMMALS								
Virginia Opossum						S	S	No live specimens observed, but expected. Dead animals noted.
Broad-footed Mole	P				P	P	P	

LEGEND: (Numbers refer to references that follow the species list.)

E = Essential - This species depends upon some feature of this habitat for the indicated habitat use.

P = Preferred - Most general living requirements of this species are met in this habitat. In the Delta, the majority of the population is found here.

S = Secondary - Some general living requirements of this species are met in this habitat, but other habitats are used as well.

X = Species was observed but data are inadequate to determine specific habitat use.

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Ruderal

SPECIES	HABITAT USE							COMMENTS
	YEAR-ROUND RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	MIGRANT	BREEDING: KNOWN RECORDS IN THE DELTA AREA FOR THIS HABITAT TYPE	FEEDING	RESTING, ROOSTING	
Desert Cottontail	S				S	S	S	
Black-tailed Jack Rabbit	P				P	P	P	
California Ground Squirrel	P				P	P	P	Varies from site to site; prefers grassy or open areas.
Botta's Pocket Gopher	P				P	P	P	
Western Harvest Mouse	S				S	S	S	Where grassy areas are available.
California Vole	P				P	P	P	As above, but can use shorter grass.
Norway Rat	P				P	P	P	Favors trash, debris.
House Mouse	P				P	P	P	Abundant
Coyote						?		Wandering through
Gray Fox					?	S		
Raccoon						S		Raccoons cover all bases.
Long-tailed Weasel						S		Where there are mice there soon will be weasels.
Striped Skunk	S				S	S	S	Quite varied in distribution.
REPTILES								
Western Fence Lizard	S				?	S	S	
Yellow-bellied Racer	S				?	S	S	
San Joaquin Whipsnake	S				?	S	S	
Pacific Gopher Snake	S				?	S	S	
Common Kingsnake	S				?	S	S	
AMPHIBIANS								
Western Toad						S	S	If water is available, will breed.
Pacific Treefrog						S	S	

LEGEND: (Numbers refer to references that follow the species list.)

E = Essential - This species depends upon some feature of this habitat for the indicated habitat use.

P = Preferred - Most general living requirements of this species are met in this habitat. In the Delta, the majority of the population is found here.

S = Secondary - Some general living requirements of this species are met in this habitat, but other habitats are used as well.

X = Species was observed but data are inadequate to determine specific habitat use.

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Significant Resources

7

RARE, THREATENED, AND ENDANGERED SPECIES

In recent years, the vulnerability and significance of natural resources has become increasingly evident in the face of spreading human developments. Society has come to recognize the comparative rarity of certain plants and animals and their habitats and to place value on them. Species are considered rare, threatened, or endangered: because they have very specialized habitat requirements; because modification or destruction of their specialized habitats has jeopardized their continued existence; or because their habitats themselves are comparatively rare. These species are valued for their distinctiveness as organisms that have adapted to specific conditions in a highly

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TABLE 8

Rare, Threatened, and Endangered Fish and Wildlife Whose Distribution May Include the Sacramento-San Joaquin Delta Area

SYMBOL	COMMON AND SCIENTIFIC NAMES	STATUS	PLATE C NUMBERS	DISTRIBUTION[4/]	COMMENTS[4/]
--	Bald eagle *(Haliaeetus leucocephalus)*	E[1/]		Ranges over most of California, nests in northern coastal and interior mountains. Winter roosts in riparian woodlands of Sacramento and San Joaquin Valleys. Casual visitor to Delta.	Decline appears to be from shooting, removal of nesting trees, human encroachment, and environmental pollution (*e.g.*, pesticides) resulting in reduced reproductive success.
--	American peregrine falcon *(Falco peregrinus anatum)*	E[1/, 2/]		Extinct as a breeding bird east of the Rocky Mountains. Breeds in the mountains and along the coast in California. Casual visitor to Delta.	Human disturbances and pesticides in food chain have endangered this bird.
A1	California black rail *(Laterallus jamaicensis coturniculus)*	R[2/]	4, 5, 6	Found in tidal marshes, there usually associated with pickleweed, from Tomales Bay south to northern Baja California; in the Sacramento-San Joaquin Delta; and in fresh and brackish marshes inland in southern California to the Colorado River.	The filling of marshes has eliminated much of its habitat.
--	Aleutian Canada goose *(Branta canadensis leucopareia)*	E[1/]		Winters in the upper San Joaquin Valley. Occasionally visits Delta.	Decline due to predation on breeding grounds by introduced foxes.
--	California yellow-billed cuckoo *(Coccyzus americanus occidentalis)*	R[2/]		Sparse breeding populations are now known to occur along the Sacramento River from Red Bluff to Colusa during June, July, and August. Not reported from Delta (see comment).	Has also been identified south of Stockton on the Stanislaus River. Suitable habitat (dense riparian vegetation) does exist in a few places within the Delta.
A2	Salt marsh harvest mouse *(Reithrodontomys raviventris)*	E[2/]	3, 5	Formerly found throughout the extensive pickleweed marshes once bordering San Francisco Bay. Now restricted to scattered areas within its original range. Reported from Collinsville at the western boundary of the Delta.	Population decline reflects loss of habitat due to destruction of salt marshes.

E = Endangered, T = Threatened, R = Rare.

1/ Designated by U.S. Fish and Wildlife Service as endangered (USFWS, 1979).

2/ Designated by the California Fish and Game Commission as rare or endangered (California Admin. Code Title 14, Section 67.5).

3/ Proposed for listing as a threatened species (USFWS, 1978).

4/ Information on distribution and comments taken from COE Atlas (1979) with modifications by California Department of Fish and Game (CDFG).

KEY TO MAP SYMBOLS:

Confirmed Sighting -

Presumed range from series of sightings -

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SYMBOL	COMMON AND SCIENTIFIC NAMES	STATUS	PLATE C NUMBERS	DISTRIBUTION[4/]	COMMENTS[4/]
A3	San Joaquin kit fox *(Vulpes macrotis mutica)*	R[2/], E[1/]	5, 7, 8	Occurs in south San Joaquin Valley, Carrizo Plain, Salinas Valley, and surrounding foothills north to San Joaquin, Contra Costa, and Alameda counties. Occurs only on southwest border of Delta.	Restricted to saltbush and shadscale vegetation, below 2,000 feet elevation. Also occurs in agricultural areas but only where suitable denning sites are available. Conversion of valley lands to cultivated agriculture is reducing its range.
A4	Giant garter snake *(Thamnophis couchi gigas)*	R[2/]	2, 4, 6	Known distribution extends from near Gridley, Butte Co., to Burrell, Fresno, Co. One of the most aquatic of garter snakes, it is confined to areas around permanent fresh water.	Populations have been decimated or eliminated by the filling of sloughs, drainage of marshy areas, and other land use changes. Known distribution extends from near Gridley, Butte Co., to Burrell, Fresno, Co.
--	Thicktail chub *(Gila crassicauda)*	E[2/]		The last known specimen was collected in 1957 from Steamboat Slough. Range once included the Sacramento and San Joaquin River systems.	May now be extinct.
A5	Lange's metalmark butterfly *(Apodemia mormo langei)*	E[1/]		Populations restricted to a few acres north of Wilbur Road near Antioch, in dunes.	Loss of habitat due largely to industrial and agricultural development and sand mining. Critical habitat designation has been proposed.
A6	Sacramento anthicid beetle *(Anthicus sacramento)*	T[3/] (candidate)	3	Occurs only in two sandy sites; one at the western tip of Grand Island, the other roughly 2 miles south of Rio Vista.	Off-road vehicle activity and use of site as garbage dump threaten habitat integrity. Entire known range proposed as critical habitat. Candidate for official listing (August, 1980).
A7	Delta green ground beetle *(Elaphrus viridis)*	T[3/]	3	Habitat limited to margins of 2 vernal pools in Solano County. Probably had more extensive range before large-scale conversion to agriculture.	Agricultural conversion, drainage changes, and pipeline construction could seriously affect habitat. Entire known range proposed as critical habitat. Official listing expected by August, 1980.

E = Endangered, T = Threatened, R = Rare.

1/ Designated by U.S. Fish and Wildlife Service as endangered (USFWS, 1979).

2/ Designated by the California Fish and Game Commission as rare or endangered (California Admin. Code Title 14, Section 67.5).

3/ Proposed for listing as a threatened species (USFWS, 1978).

4/ Information on distribution and comments taken from COE Atlas (1979) with modifications by California Department of Fish and Game (CDFG).

KEY TO MAP SYMBOLS:

Confirmed Sighting -

Presumed range from series of sightings -

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TABLE 9

Rare and Endangered Plants Which May Occur Within the Sacramento-San Joaquin Delta

SYMBOL	SPECIES	TAXON CODE	STATUS STATE/FEDERAL	PLATE C NUMBERS	HABITAT AND DISTRIBUTION: COE MAPPING SYMBOL	HABITAT AND DISTRIBUTION: CHARACTERISTIC HABITAT TYPE	HABITAT AND DISTRIBUTION: GENERAL DESCRIPTION	COMMENTS
P1	*Cirsium crassicaule* (Slough thistle)	CICR	Concern[3/]	6, 8	PEM1, PEM2, R2EM1, L2EM1, L2EM2	Freshwater marshes	Shallow water, wet places in fields near San Joaquin River.	Annual (?), whitish pinkish flowers.
P2	*Eryngium racemosum* (Delta coyote thistle)	ERRA-2	Concern[3/]	8	PEM1, PEM2, R2EM1, L2EM1, L2EM2	Freshwater marshes	Low wet places below 100 feet.	Perennial, blue or purple flowers.
P3	*Erysium capitatum* var. *angustatum* (Contra Costa wallflower)	ERCAA	Concern[3/], E[4/]	5	UP	Only in Antioch Dunes	Critical habitat has been established in sand dunes near Antioch (USFWS, 1978).	Biennial, flowers yellow to purple.
P4	*Hibiscus californicus* (California hibiscus)	HICA	Concern[3/]	4, 5, 6	PEM1, PEM2, R2EM1	Freshwater marshes	Moist banks, freshwater marsh, lower Sacramento and San Joaquin Rivers.	Shrub, white or pinkish flowers with crimson centers.
P5	*Lilaeopsis masonii* (Lilaeopsis)	LIMA-5	R[2/]	5	PEM1, PEM2, R2EM1	Freshwater marshes	Zone of tidal fluctuation of the Lower Delta.	White flowered perennial. Recent sightings.
P6	*Oenothera deltoides* var. *howellii* (Antioch dunes evening primrose)	OEDEH	E[2/, 4/]	3, 5	UP	Only in Antioch Dunes	Critical habitat has been established in sand dunes near Antioch (USFWS, 1978).	Annual, white to aging pink flowers.
P7	*Tropidocarpum capparideum* (Caper-fruited tropidocarpum)	TRCA-2	Concern[3/]	5, 7, 8	UP	Upland	Alkaline soils, low hills, below 500 feet, in grasslands near Mt. Diablo.	Annual, yellow flowers.
P8	*Neostapfia colusana* (Colusa grass)	NECO	E[2/]	3	UP	Vernal pools	In dry bed of vernal rain pools.	Low annual grass.
P9	*Orcuttia mucronata* (Crampton's orcuttia)	ORMU	E[2/, 4/]	3	UP	Vernal pools	In dry bed of vernal rain pools.	Low annual grass.
P10	*Cicuta bolanderi* (Bolander water hemlock)	CIBO	Concern[3/]	5	--	Tidal salt marshes	Intertidal areas in western Delta.	Perennial, white flowers.
P11	*Lasthenia conjugens* (Contra Costa baeria)	LACO-3	Concern[3/]		UP	Vernal pools	Drying borders of vernal rain pools.	Annual, yellow flowers.
P12	*Legenere limosa* (Legenere)	LELI	Concern[3/]		UP	Vernal pools	Drying borders of vernal rain pools.	Annual, yellow flowers.

R = Rare, E = Endangered

1/ List from COE (1979), modified by Steve Rae, California Department of Fish and Game (DFG).

2/ Designated by California Fish and Game Commission as rare or endangered.

3/ Under review by DFG for possible recommendation for designation by CF&GC.

4/ Designated by U.S. Fish and Wildlife Service as endangered (USFWS, 1979).

KEY TO MAP SYMBOLS:

Collected After 1945 or Recent Observation		Collection Before 1945	
●	Precisely Known	▲	Precisely Known
○	Not Precisely Known	△	Not Precisely Known

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specialized manner. The value of preserving these species is based on the premise that once lost, a particular genetic combination is gone forever, along with its role in ecosystem function, its scientific interest, and its potential for human use or enjoyment.

The population decline of some species (*e.g.* brown pelican, peregrine falcon), which has endangered their continued existence, can be attributed to perturbations in environmental conditions (excessive DDT-DDE in the food web). In such a case, the response of these species served as an early warning of environmental pollution that, if continued, could adversely affect the human population as well.

The genetic and social values of rare, threatened, and endangered species have been formally recognized by both federal legislation (Endangered Species Act of 1973, as amended), and State legislation (California Endangered Species Act of 1970). The distribution and maintenance of plant and animal species depends upon preservation of the particular habitat each requires. Destruction or modification of habitat is particularly hard on species which have special habitat requirements. As the habitat is removed, the ability of a population to maintain itself and reproduce decreases.

In the Delta, certain habitats have changed or been destroyed over the past decades through reclamation of former wetlands to agricultural land, conversion from one crop type to another, draining or filling of marshes, channelization of waterways, removal of riparian woodland, conversion of open lands to urban uses, and so on. This has caused drastic population declines especially in species that have specialized adaptations to particular habitat attributes and thus have not been able to survive habitat modification or loss.

The most seriously affected plant and animal populations have been placed on State and federal lists. Protection and enhancement of what specialized habitat does remain is the key to the continued existence and recovery of these rare, threatened, and endangered populations.

Both State and federal listings of rare, threatened, and endangered species are maintained and periodically updated. The federal list is supplemented with notices that are published periodically in the Federal Register as evidence of rarity or endangerment of a species becomes available. The notices remove species, propose the addition of new species, and propose or designate critical habitat for proposed or listed species. Animals (vertebrates and invertebrates), plants, and critical habitat areas are all included on the federal list. Currently, the FWS is considering an extensive list of plants for future listings and critical habitat designations.

California's listing of rare and endangered wildlife (DFG, 1978) has recently been supplemented with a list of plants now designated by the California Wildlife Commission as rare or endangered. The DFG is considering a new list of plant species for recommendation to the Commission for inclusion on the State rare and endangered list.

Information presented in Tables 9 and 10 reflects the current status of both State and federal listings as of January, 1980. Both tables are adapted from the COE Delta Atlas (1979a). They incorporate modifications provided by the DFG. Mapped information (Plates C1 -8) is also adapted from the COE Atlas (1979a), supplemented and modified with DFG suggestions, 1979-80 Delta bird census data, and Federal Register notices (USFWS, 1978a; 1978b).

Animals that occur only casually or infrequently in the Delta are not mapped. Only confirmed sightings or other official data are used to map individual occurrences or assumed ranges. Because field work and observations in the Delta have been limited, the number of confirmed sightings (particularly of plants) is also limited. Thus, the mapped distributions may not include *all* possible locations of rare, threatened, or endangered plants and animals that exist in the Delta, but all suitable habitats should be considered potential habitat for these species.

SIGNIFICANT NATURAL RESOURCE AREAS

Locations in the Delta which have significant natural resources have been identified and mapped in previous planning studies, most recently in the Delta Action Plan (DAPC, 1976a). This report inventoried significant Delta resource areas and classified them on the basis of resource type:

- natural resources
- historic resources
- recreational resources
- resource production areas
- natural hazard areas

Examples of the first three categories were mapped by DAPC and briefly described. The COE *Delta Environmental Atlas* (1979a) adapted the DAPC list, emphasizing natural resources but including also some recreational and historic resources. The Atlas mapped these areas in more detail and at a more useful scale than DAPC had done.

The following list of natural resource areas (Table 10) and the accompanying maps (Plates C1 - 8) are a refinement of the COE versions. Additional descriptive information, obtained during census or field work, has been added to amplify or clarify some of the descriptions. Several resources not previously identified have been added to the list, and in a few places resource areas have been expanded to include valuable adjacent areas. The COE Atlas can be used to locate approximate boundaries of most of the identified significant areas.

Many of the significant natural resource areas include historic and recreational resources as well, but these are regarded as secondary to the objectives of the Delta Habitat Plan. The areas all have important open space, ecologic, scientific, educational, and wildlife values. They should be primary candidates for preservation status, or for some other form of protection.

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TABLE 10
Delta Significant Natural Resource Areas

Map Symbol	Name	Plates B & C Numbers	Description of Area
1	Antioch Sand Dunes, San Joaquin River	5	40-acre site that is the home of two plants and a butterfly on the Federal Endangered Species list; also, the home of the California legless lizard. A unique community, remnant of the once extensive Antioch Dunes.
2	Antioch Sand Dunes and Quarry Canyon	5	Habitat of unique plants and animals, and a scenic revegetated quarry with high park value.
3	Browns Island and Winter Island	5	Upland habitat; blue heron rookery; two rare and endangered animals and one rare plant.
4	Antioch-Pittsburg Marsh	5	Large marsh; open space between industrial developments.
5	Sacramento River Bluffs	3,5	Scenic; native vegetation; unusual Delta geology; only such formation along Sacramento River.
6	Old River Islands Area	7,8	Along s. reaches of Old River, upper Tom Paine Slough. Upland islands; well-developed oak riparian along steep, unriprapped banks; oak savannah remnants in places. Deep mineral soils; very different from riparian elsewhere in Delta. Very scenic. Authorized State park since 1964, but may be dropped. Archaeological site. Designated natural area by Delta Master Recreation Plan (DMRP).
7	Upper Middle River	6	Well-developed riparian habitat, extending beyond levees in a few places. Surrounding agricultural habitat includes ruderal lands and orchards which provide good cover. Archaeological site. Designated natural area by DMRP.
8	Trapper Slough	6	Closed-off channel, now a freshwater marsh with a lush growth of water hyacinth and yellow water weed. Supports muskrats, a highly productive fishery, and a wide variety of birds. Designated natural area by DMRP.
9	Stockton Deepwater Channel Islands	6	Hog and Spud Islands. Upland habitat; oaks; freshwater marsh. Scenic, public recreation area. Designated natural area by DMRP.
10	Disappointment Slough and Stockton Deepwater Channel Islands	6	Includes tidal tule islands in Disappointment Slough, diverse mix of upland and marsh habitats on Lost Lake Tule, Headreach, Tinsley Islands. Young riparian trees. Freshwater marsh with open water, valuable to wintering ducks, is also habitat for rare bird (black rail).
11	White Slough and Marsh and Potato and Little Potato Sloughs	6	Channel tule islands; freshwater marsh; some riparian habitat; very scenic. Two rare animals have been sighted here (giant garter snake and black rail). Also Grindstone Joe's, an island reclaimed and beautified by one man in 1930's, now a private club. Marsh areas and islands designated natural areas by DMRP. Sloughs designated scenic areas by DMRP.
12	Island, South Fork of Mokelumne River at mouth of Sycamore Slough	4	Some higher ground in center. Diverse vegetation. May be remnant example of an original Delta vegetational community. Designated natural area by DMRP. This island is incorrectly identified on the COE Atlas maps.
13	Latham Slough	6	Channel tule islands, as well as some with riparian shrub-brush and woodland. Shrub-brush riparian habitat along levees. Designated natural area by DMRP.

Map Symbol	Name	Plates B & C Numbers	Description of Area
14	Connection Slough, Quimby Island, Rhode Island, Old River Complex	5,6	A diverse mix of upland habitat, agricultural lands, riparian trees and shrub-brush, marsh, and tule islands. Excellent wildlife habitat, particularly for raptorial birds, songbirds, and game species. All islands, except Quimby Island, designated natural areas by DMRP. Sloughs designated scenic areas by DMRP.
15	Franks Tract	5	Flooded island of 3,507 acres, of which all but 300 acres are under water. Popular recreation area for boating, fishing, and water skiing. Designated scenic area by DMRP.
16	Little Franks Tract	5	A freshwater marsh in a drowned island, protected by a levee. Nature study area. Black-crowned night heron rookery in riparian shrub-brush along levees.
17	Big Break	5	Emergent marsh. Tract flooded in 1930's. Good fishing. Designated natural area by DMRP.
18	Steamboat Slough	3,4	Some riparian shrub-brush and woodland at s. end, near Howard Landing, and along n. portion. Archaeological site. Very scenic; designated scenic area by DMRP.
19	Cliff House Beach	3	Largest Delta beach. Scenic recreation area with shaded banks. Adjacent to most extensive tidal flats in Delta.
20	Delta Meadows, Snodgrass Slough, Badger Slough, Mokelumne-Cosumnes River Complex	4	Marsh, riparian, and upland habitat; many oaks, wooded islands. Ecologically tied to Stone Lake Basin. Invaluable ecological area. Heavy early winter use by sandhill cranes. Habitat for rare animal (giant garter snake). Heavy use in places during summer by houseboats, recreationists. Area of great archaeological interest. Contains National Natural Landmark Area (Cosumnes River Riparian Woodland), and a National Historical Landmark (Delta Meadows). Designated natural areas by DMRP. Planned Wildlife Management Area.
21	Stone Lake Complex	2,4	Old overflow basins, with diversity of habitat types: lakes, freshwater marshes, riparian trees and bushes, grassland, quiet sloughs. Specialized habitat for rare animal (giant garter snake), unique plant (slough thistle). Great blue heron and egret rookeries. Removed from summertime recreational activities. Many archaeological sites. One of the most important ecological complexes in Delta.
22	Elk Slough	2,4	Mature riparian woodland along levees. Scenic area; slough full of snags, fallen trees; good aquatic habitat for bass, other species. Archaeological sites. Designated natural area by DMRP.
23	Island in Old River	7	Upland habitat. Designated natural area by DMRP.
24	Eucalyptus Island	5	Upland habitat. Flooded island. Designated natural area by DMRP.
25	Byron Alkali Vernal Pools	5	250-acre site supporting unique flora adapted to vernal rain pools that collect in alkaline soils.

Map Symbol	Name	Plates B & C Numbers	Description of Area
26	Hog Slough	4	One of 3 major dead-end sloughs, with unique aquatic characteristics. A plant species of concern (California hibiscus) reported from here. Seasonal marsh at head of slough and agricultural fields on either side are important winter roosting areas for sandhill cranes. Archaeological site. Designated scenic area by DMRP.
27	Sycamore Slough	4	One of 3 major dead-end sloughs. Tule islands in channel; some sparse riparian vegetation on levees. Lands on both sides important winter areas for sandhill cranes.
28	Caswell Memorial Park	8	Riparian forest. Blue heron rookery.
29	South County Park	8	Riparian habitat.
30	Paradise Cut	8	Western end with mature oak riparian woodland. Cottonwood riparian in middle stretch, to Paradise Road. To the east, levees lined with riparian shrub-brush, flanked by walnut orchard.
31	Circle Lake	8	Fish spawning area. Oxbow lake. High recreation potential in developed residential area.
32	French Camp Slough	6	Mature riparian habitat. Archaeological site. Designated natural area by DMRP.
33	Seven Mile Slough	3	Riparian trees and shrub-brush along a little-used slough. Designated natural area by DMRP.
34	Putah Creek	1	Riparian habitat. Designated natural area by DMRP.
35	Winchester Lake	2	Expanse of open water; scattered trees on bank at western end of lake. Excellent recreational potential for water skiing, picnicking. Eastern end with more bank vegetation, more aquatic vegetation in lake, and more wildlife value than western section.
36	Babel Slough	1,2	Narrow strip of riparian trees, shrub-brush, occasionally on both sides of slough. Some dead snags offer hole-nesting opportunities. Not extensive, but valuable wildlife habitat.
37	Salt marsh west of Pittsburg	5	Habitat for endangered saltmarsh harvest mouse, rare California black rail.
38	Vernal pools west of Hastings Tract (Jepson Prairie)	3	Unique complex of vernal pools, remnant native bunchgrass communities. Ecological values of Statewide significance. Vernal pools support many unique plants, including Crampton's orcuttia (on Federal Endangered Species list) and Colusa grass (on State Endangered Species list).
39	Lindsey Slough	3	Black-crowned night heron rookery and heavy use by raptors. Geologically interesting; formed as an historical drainage of the Yolo Basin. Archaeological site. Marsh area designated natural area by DMRP. Slough designated scenic area by DMRP.
40	Miner Slough	3	Emerging marsh; scenic. Designated natural area by DMRP.

Map Symbol	Name	Plates B & C Numbers	Description of Area
41	Prospect Slough	3	Scenic; upland and riparian habitat. Impressive open waterway vista. Designated natural area by DMRP.
42	Potato Point	6	100 acres of original Delta backswamp vegetation. Willows, giant reed, beaver ponds, freshwater marsh; extensive raptor, songbird and waterfowl use. Surrounding levees grazed by goats.
43	Blossom Slough	4	Large willows and cottonwoods; tule-lined. Both ends closed; private and protected from recreational use. Valuable bird habitat. Part of dead-end slough-sandhill crane complex.
44	Sand Mound Slough	5	Good examples of tule islands. Islands designated natural areas by DMRP. Slough designated scenic area by DMRP.
45	Entrapment Zone	5	The entrapment zone occurs generally between Honker Bay and Antioch. Here supended organics and nutrients tend to accumulate, creating a highly biologically-productive area.
46	Mandeville Tip	6	Freshwater marsh complex, used in part as County Park. Valuable wildlife habitat; also recreational value.
47	Beaver Slough	4	The northernmost of the 3 major dead-end sloughs, with the most extensive riparian vegetation. East of Blossom Road, trees are well-developed; many snags in water. E. end inaccessible to all but small, slow boats, preserving wildlife habitat. Surrounded by sandhill crane winter habitat.
48	Sacramento anthicid beetle habitat	3	Sandy areas on Grand Island and near Rio Vista have been proposed as critical habitat for this beetle, candidate for Federal listing as a threatened species.
49	Delta green ground beetle habitat	3	Two vernal pools in Solano County are the only places in which this species is found, and the immediate area surrounding these pools has been proposed as critical habitat for this beetle, which is proposed for Federal listing as a threatened species.

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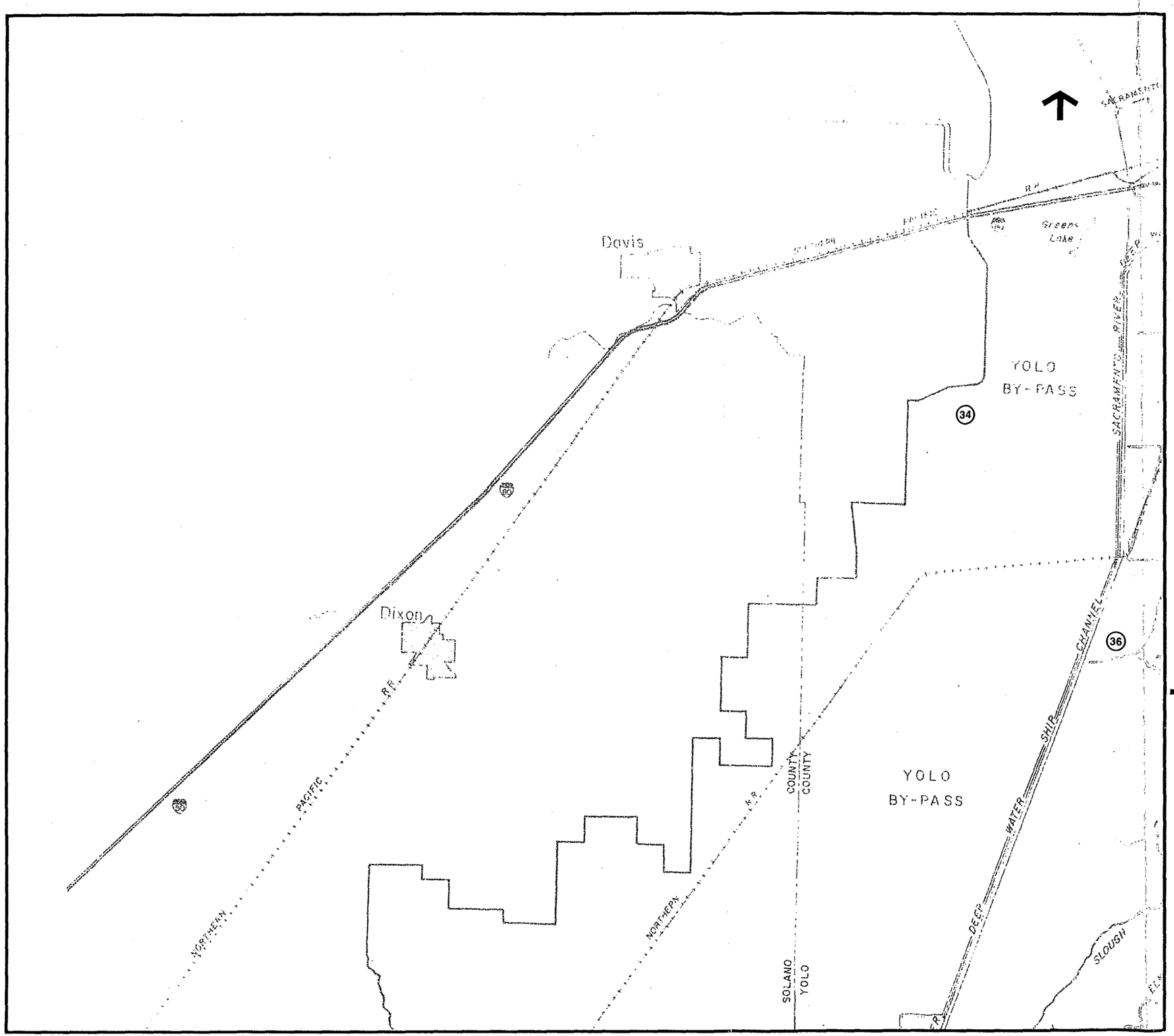
C-056391



Significant Resources

Rare, Threatened, & Endangered Plants

Collection After 1945 or Recent Observation

- Precisely Known
- Not Precisely Known

Collection Before 1945

- Precisely Known
- Not Precisely Known

Rare, Threatened, & Endangered Fish & Wildlife

- Confirmed Sighting
- Presumed Range from Series of Sightings

Significant Natural Resource Areas

- (8) Significant Natural Resource Areas*

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

*see text. Chapter 7

Significant Resources of the Delta

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

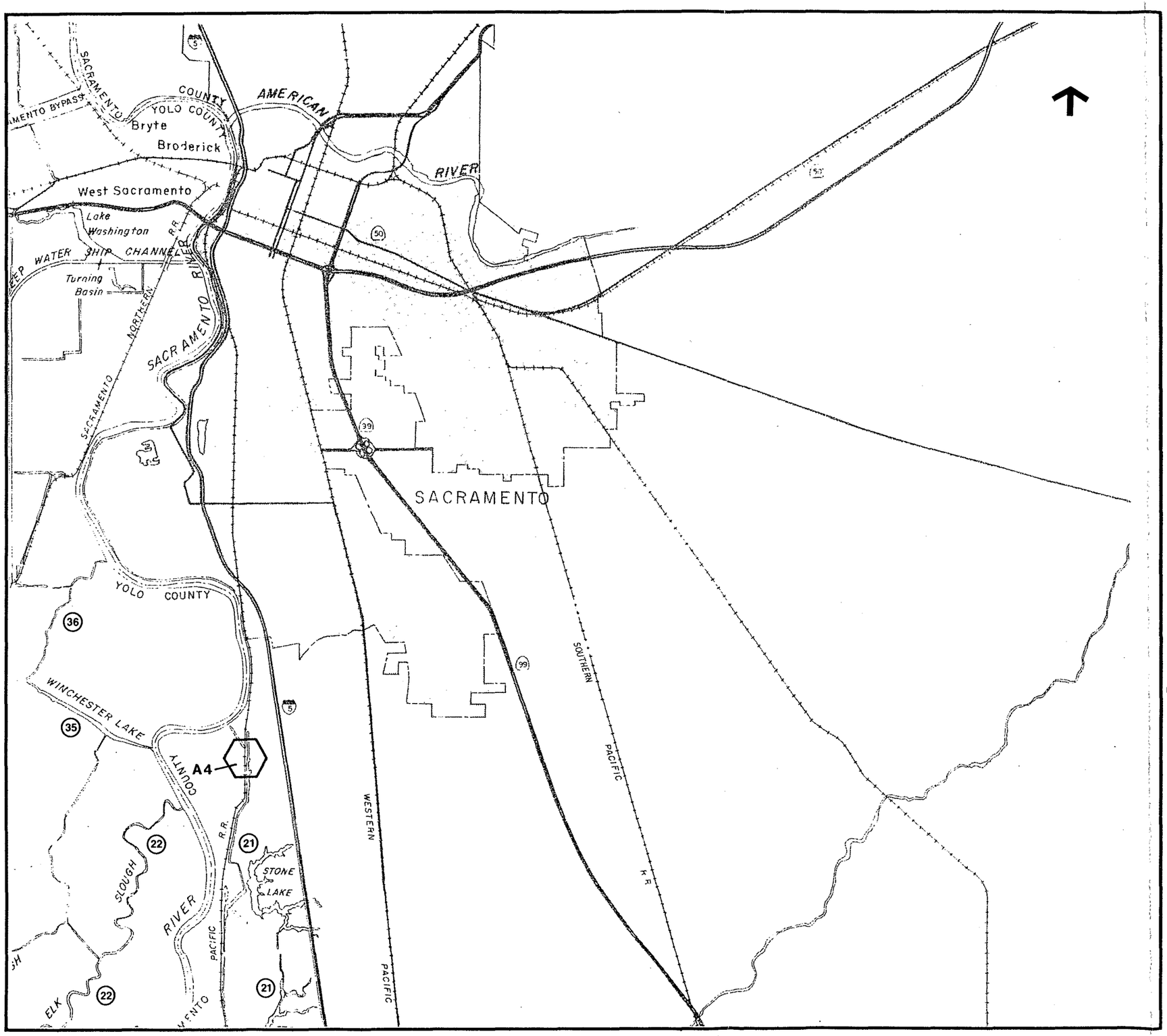
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **C-1**

C-056392

C—056392



Significant Resources

Rare, Threatened, & Endangered Plants

Collection After 1945 or Recent Observation

- Precisely Known
- Not Precisely Known

Collection Before 1945

- Precisely Known
- Not Precisely Known

Rare, Threatened, & Endangered Fish & Wildlife

- Confirmed Sighting
- Presumed Range from Series of Sightings

Significant Natural Resource Areas

- (8) Significant Natural Resource Areas*

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

*see text, Chapter 7

Significant Resources of the Delta

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

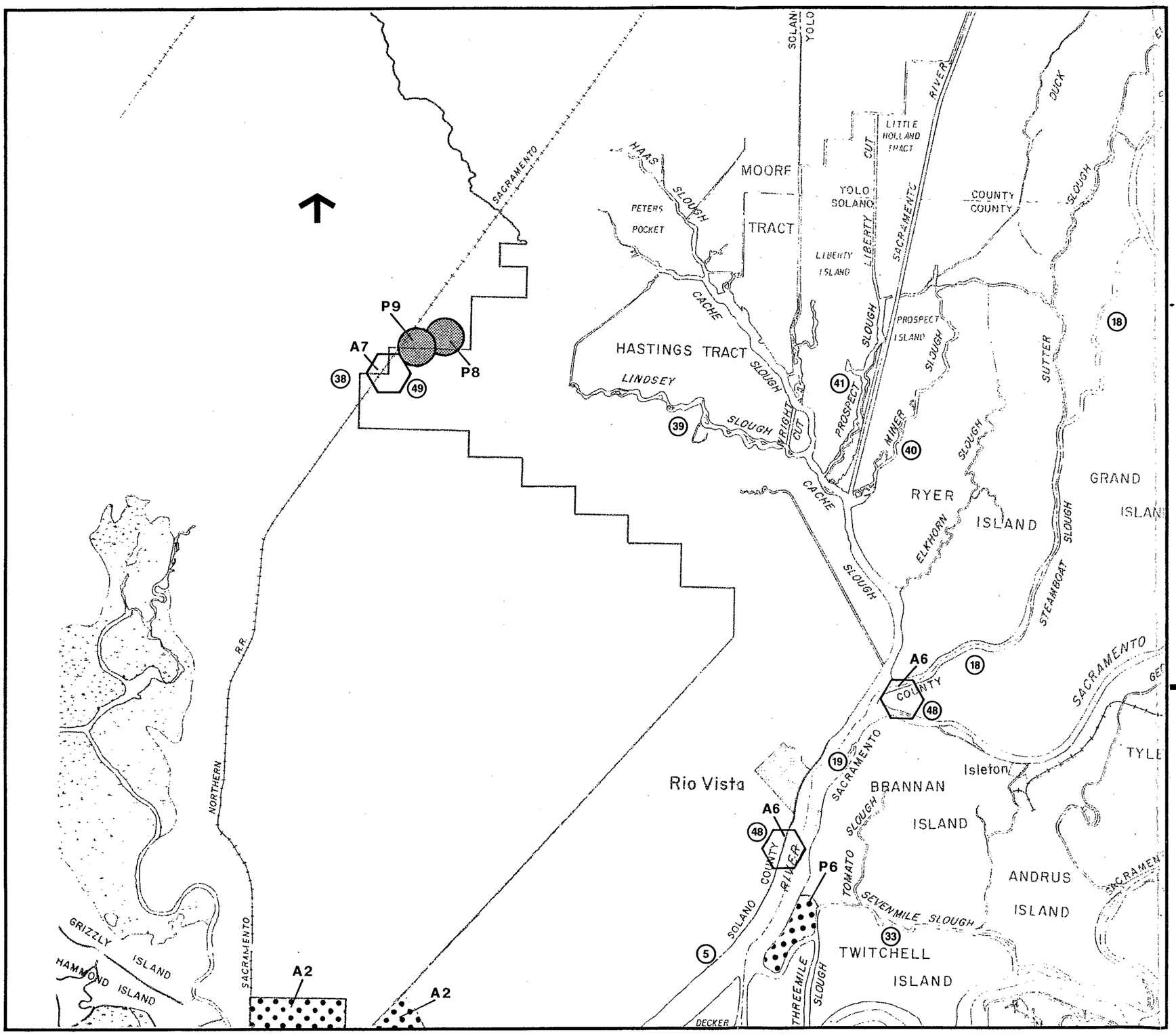
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **C-2**

C-056393

C—056393



Significant Resources

Rare, Threatened, & Endangered Plants

Collection After 1945 or Recent Observation

- Precisely Known
- Not Precisely Known

Collection Before 1945

- Precisely Known
- Not Precisely Known

Rare, Threatened, & Endangered Fish & Wildlife

- Confirmed Sighting
- Presumed Range from Series of Sightings

Significant Natural Resource Areas

- (8) Significant Natural Resource Areas*

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

*see text, Chapter 7

Significant Resources of the Delta

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

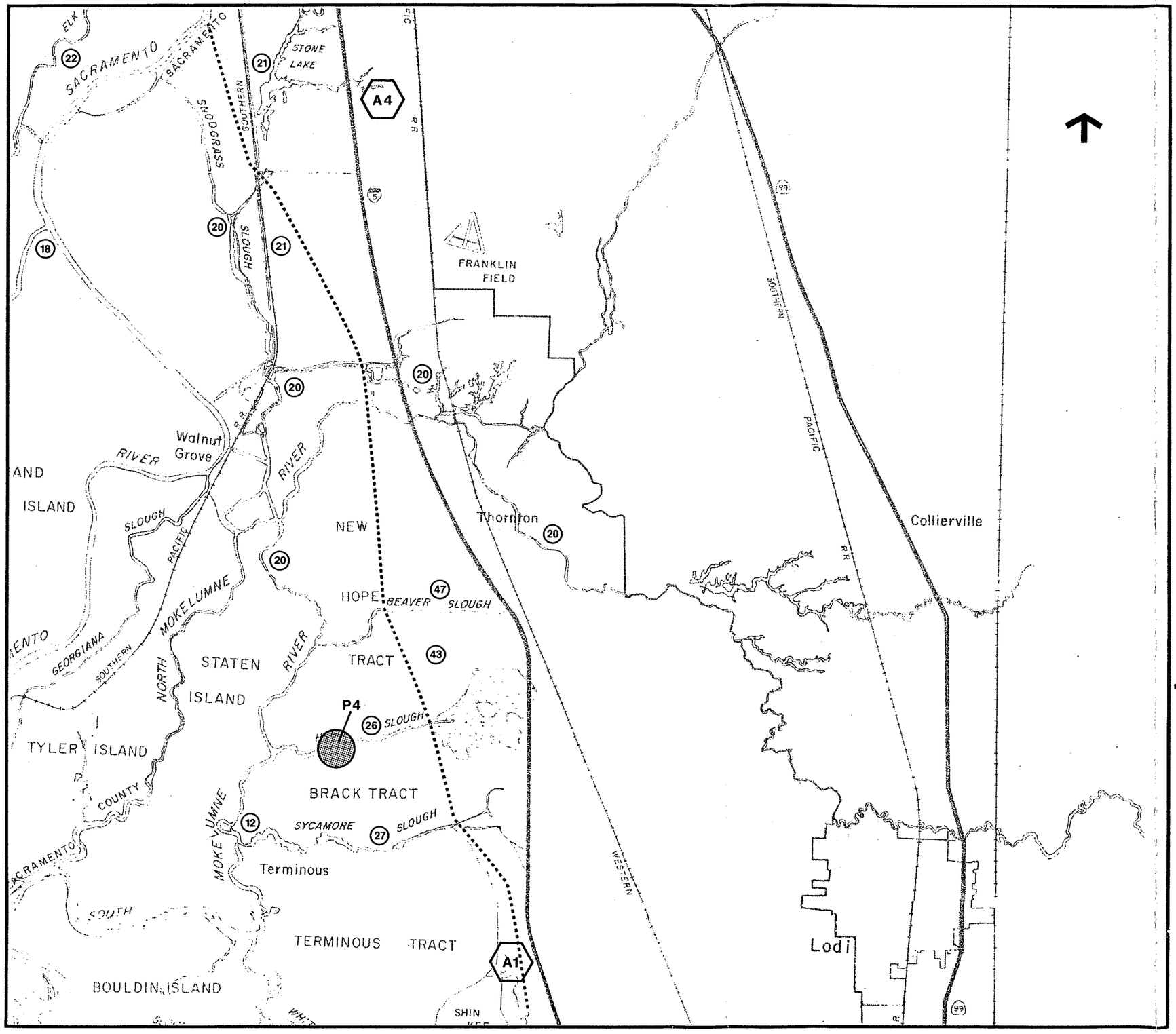
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **C-3**

C-056394

C-056394



Significant Resources

Rare, Threatened, & Endangered Plants

Collection After 1945 or Recent Observation

- Precisely Known
- Not Precisely Known

Collection Before 1945

- Precisely Known
- Not Precisely Known

Rare, Threatened, & Endangered Fish & Wildlife

- Confirmed Sighting
- Presumed Range from Series of Sightings

Significant Natural Resource Areas

- (8) Significant Natural Resource Areas*

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

*see text, Chapter 7

Significant Resources of the Delta

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

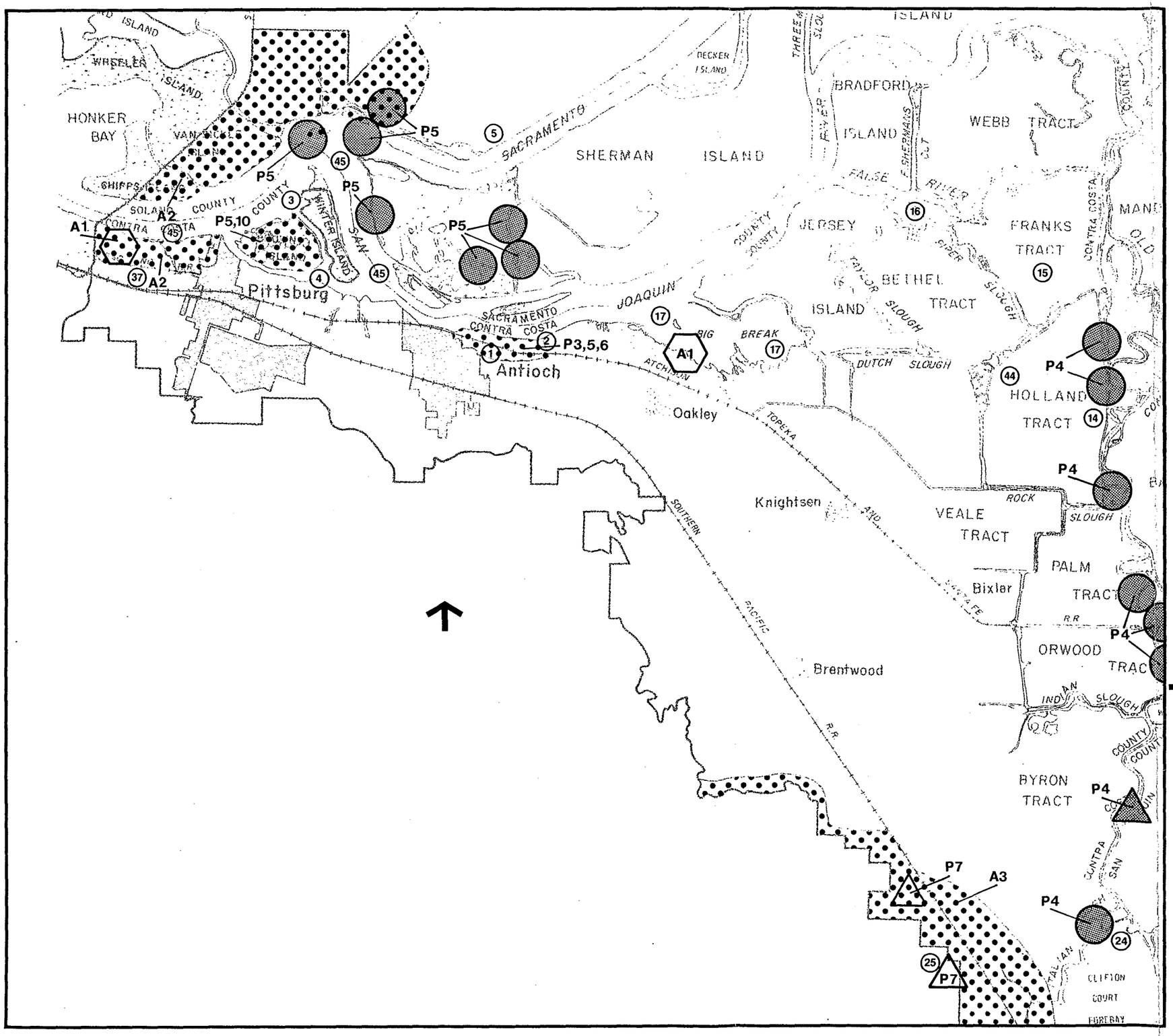
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **C-4**

C-056395

C—056395



Significant Resources

Rare, Threatened, & Endangered Plants

Collection After 1945 or Recent Observation

- Precisely Known
- Not Precisely Known

Collection Before 1945

- Precisely Known
- Not Precisely Known

Rare, Threatened, & Endangered Fish & Wildlife

- Confirmed Sighting
- Presumed Range from Series of Sightings

Significant Natural Resource Areas

- (8) Significant Natural Resource Areas*

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

*see text, Chapter 7

Significant Resources of the Delta

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

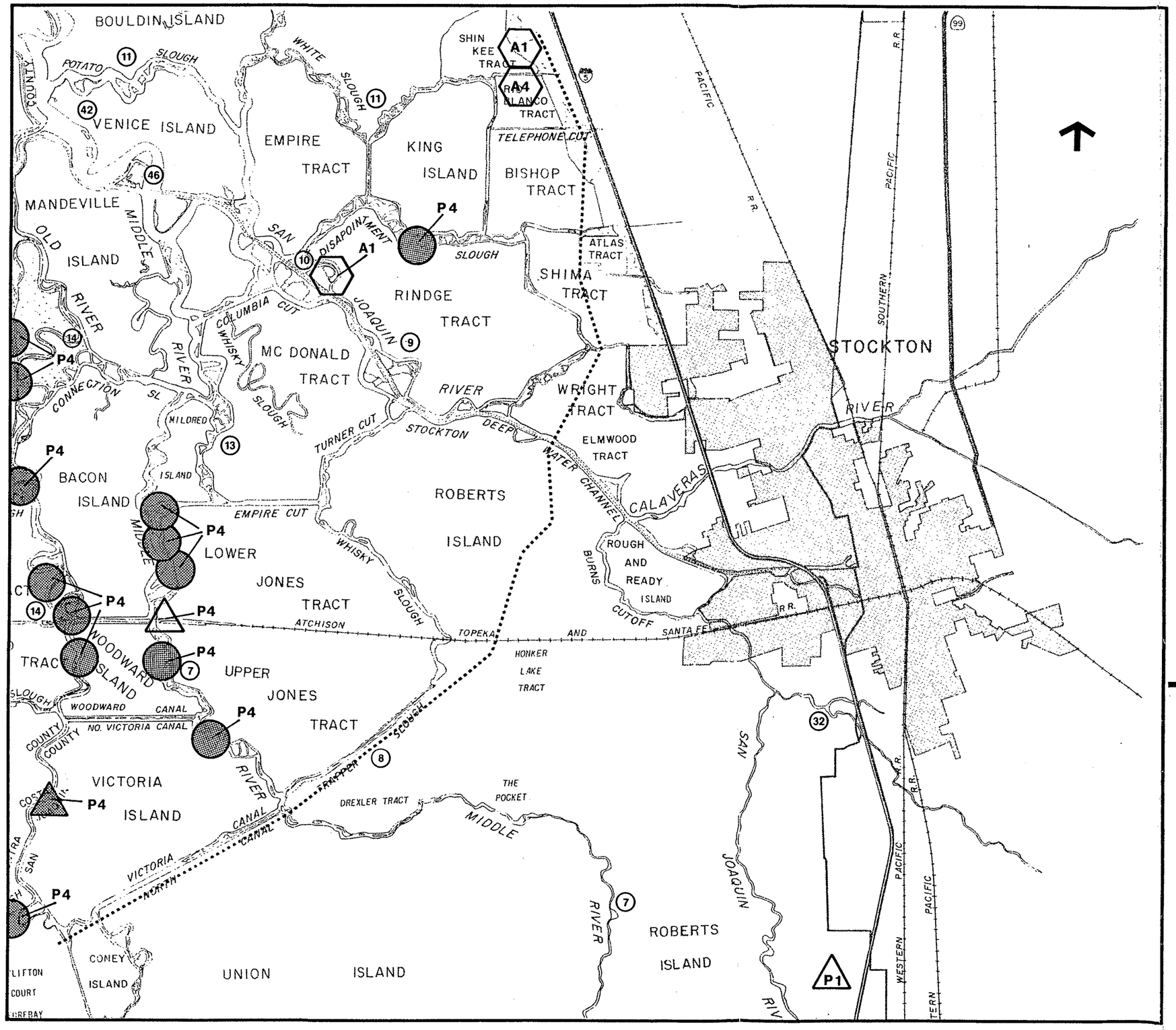
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **C-5**

C-056396

C-056396



Significant Resources

Rare, Threatened, & Endangered Plants

Collection After 1945 or Recent Observation

- Precisely Known
- Not Precisely Known

Collection Before 1945

- Precisely Known
- Not Precisely Known

Rare, Threatened, & Endangered Fish & Wildlife

- Confirmed Sighting
- Presumed Range from Series of Sightings

Significant Natural Resource Areas

- (8) Significant Natural Resource Areas*

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

*see text, Chapter 7

Significant Resources of the Delta

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

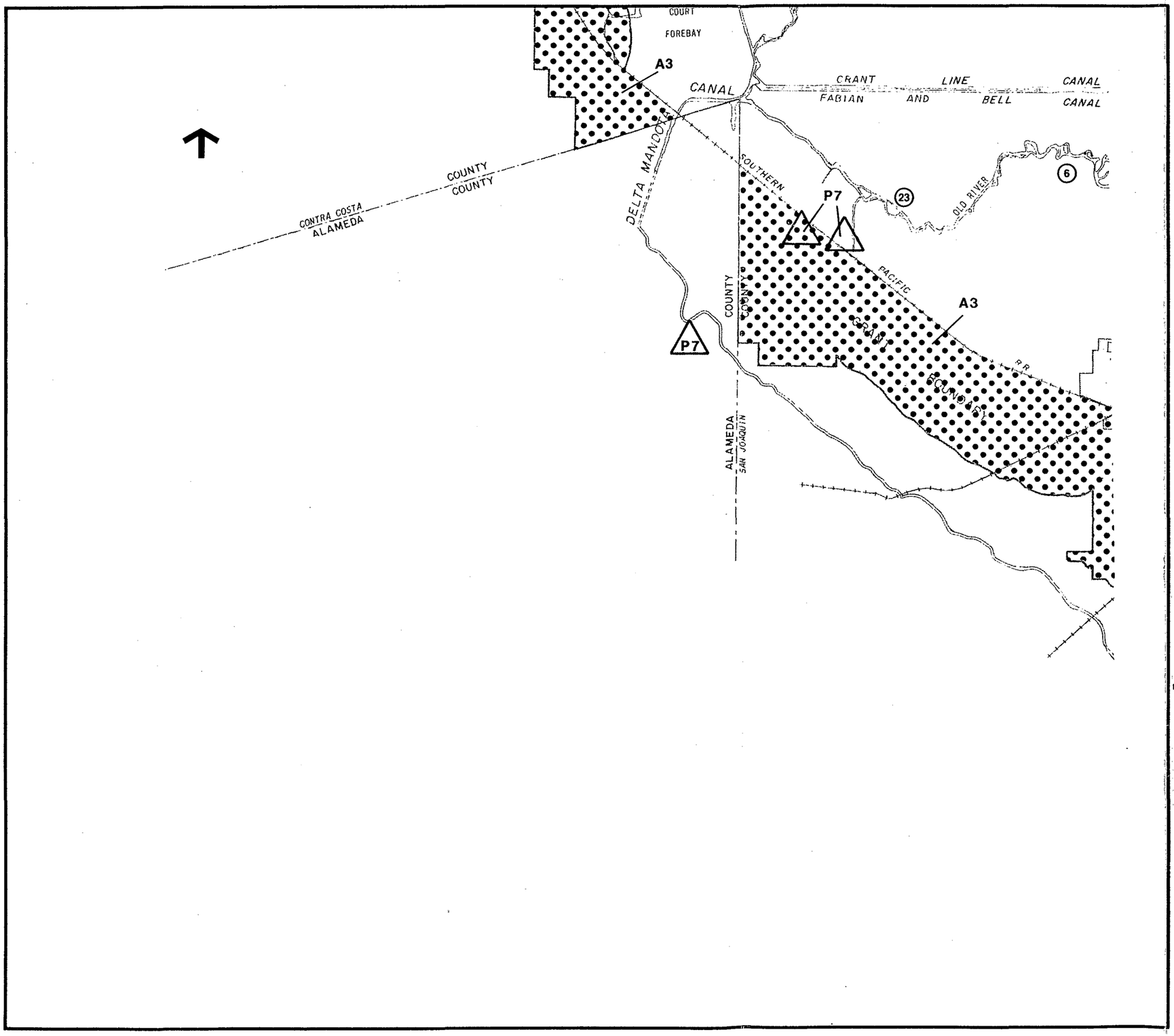
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **C-6**

C-056397

C—056397



Significant Resources

Rare, Threatened, & Endangered Plants

Collection After 1945 or Recent Observation

- Precisely Known
- Not Precisely Known

Collection Before 1945

- Precisely Known
- Not Precisely Known

Rare, Threatened, & Endangered Fish & Wildlife

- Confirmed Sighting
- Presumed Range from Series of Sightings

Significant Natural Resource Areas

- (8) Significant Natural Resource Areas*

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

*see text, Chapter 7

Significant Resources of the Delta

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

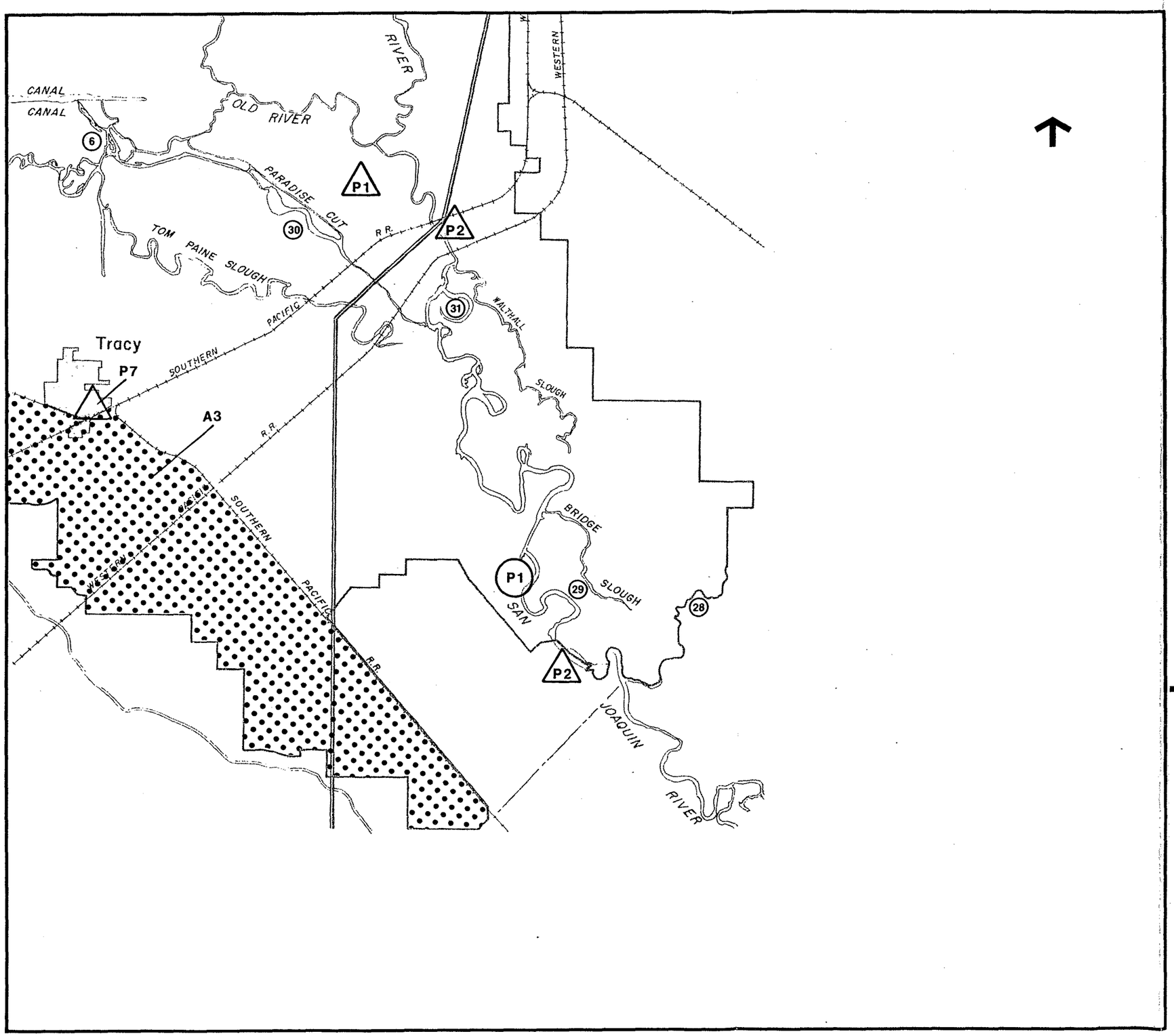
Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **C-7**

C-056398

C—056398



Significant Resources

Rare, Threatened, & Endangered Plants

Collection After 1945 or Recent Observation

Precisely Known

Not Precisely Known

Collection Before 1945

Precisely Known

Not Precisely Known

Rare, Threatened, & Endangered Fish & Wildlife

Confirmed Sighting

Presumed Range from Series of Sightings

Significant Natural Resource Areas

(8) Significant Natural Resource Areas*

Source: U.S. Army Corps of Engineers - Delta Environmental Atlas, 1979 (Adapted by Madrone Associates).

*see text, Chapter 7

Significant Resources of the Delta

CALIFORNIA DEPARTMENT OF FISH & GAME
U.S. FISH & WILDLIFE SERVICE

Prepared by: MADRONE ASSOCIATES

0 ½ 1 2 3 4 miles
0 2 4 6 kilometers

PLATE **C-8**

C-056399

C—056399

Flora and Fauna of the Delta

8

Information gathered during this planning study is summarized in the following species lists. Primary sources of information for the animal data are:

— the bird and mammal censuses – (January, 1979 - February, 1980. [See Chapter 6]);

— other field work in the study area;

— personal interviews with knowledgeable individuals;

— literature review; and

— museum research.

Specimen collections which pertain to the Delta study area are found in the

C —0 5 6 4 0 0

C-056400

Museum of Vertebrate Zoology, Berkeley; California Academy of Sciences, San Francisco; Sonoma State University, California; National Museum of Natural History and Smithsonian Institution, District of Columbia; specimens from private collections; and zoological material in the Western Foundation of Vertebrate Zoology, Los Angeles. Journal articles and reports of other censuses in the Delta were also reviewed.

Field observations are indicated on the tables by an "x". Where records are based on the literature or other secondary sources, the tables cite references by numbers, listed immediately following the animal species table.

Birds are listed by common name, in accordance with the American Ornithologists' Union (1976). Only those species whose presence in the Delta is documented by field observation are included.

The mammal list includes species verified through trapping, sighting, or other evidence (tracks, droppings, other signs), as well as those documented for the Delta area in museum collections, literature, or informal personal observations. A few species not verified but expected are included, as noted in the "Comments" column.

Reptile and amphibian listings are based on field observations and the COE Atlas (1979a) species list. Species on the COE list which are not supported by field research evidence from this study are indicated in the "Comments" column. Fish and aquatic invertebrate species lists are based solely on literature.

The list of plants in the Delta area is adapted from the COE Environmental Atlas (1979a). On the basis of literature and field observations, each species is assigned to the typical Delta habitats where it is expected to occur. Both COE *Delta Environmental Atlas* mapping symbols and descriptive names from the Delta Habitat Plan for these habitats are given. Plants are also classified as "native" or "introduced," and rated as to their relative abundance in the Delta.

C—056400—001

C-056401

TABLE 11

Fauna of the Delta Area

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
BIRDS								
Common Loon	X							One known record (11-9-79)
Arctic Loon	X							One known record (1-29-80)
Red-throated Loon	X							One known record (11-5-79)
Eared Grebe	X,1,5							
Western Grebe	X,1,5							
Pied-billed Grebe	X,1,5	X						
White Pelican	X,5	X,5						
Double-crested Cormorant	X,5	X,5						
Great Blue Heron		X,5	X,5	X,5	X,5		X,5	
Green Heron		X,5	X,5	X,5			X,5	
Cattle Egret					?	?	X	One known record (12-6-79 to 12-20-79)
Great Egret		X,5	5	?	X,1		X,5	
Snowy Egret		X,5	?	X	?		X	
Black-crowned Night Heron		X,5	X,5	X,5			X,5	
Least Bittern		5					5	
American Bittern		X,5	X,5	X,5		1?	X,5	
White-faced Ibis		5					5	
Bewick's Swan							4,8	Will probably be lumped soon with Whistling Swan.
Whistling Swan	X,5	X,5					X,5	
Trumpeter Swan							5	
Canada Goose	X,5						X,5	
White-fronted Goose	X,5						X,5	
Snow Goose	5?						X,5	
Ross' Goose	5?						X,5	
Fulvous Whistling-duck		?						Only a few records, around 1879 (5)
Mallard	X,5	X,5					X,5	
Gadwall	X,5	5					5	
Pintail	X,5	X,5					X,5	
Green-winged Teal	X,5	? X					X	

LEGEND: (Numbers refer to references that follow the species list)

X = animal or evidence observed during this study

Bird names are in accordance with the American Ornithologists' Union (1976)

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
Baikal Teal								One record near Brentwood on 12/13/31 (4)
Blue-winged Teal	X	?					?	5; two seen at Stockton oxidation ponds 1-8-80
Cinnamon Teal	X,1,5	5					X,5	
American Wigeon	X,5	X,?					X,5	
Northern Shoveler	X,1,5	?					X,5	
Wood Duck	X,5	X,5	X,5	X,5			5	1
Redhead	X,5						X,5	
Ring-necked Duck	X,5	X					?	
Canvasback	X,5						X,5	
Greater Scaup	?						?	5
Lesser Scaup	X,5						X,5	
Common Goldeneye	?						5	
Bufflehead	X,5							one seen at Stockton oxidation ponds 1-8-80
Ruddy Duck	X,5	5					X,5	
Common Merganser	5							
Red-breasted Merganser	5							Records for Delta margin
Turkey Vulture			X,5	X,5	X,5		X,5	
White-tailed Kite			X,5	X,5	X,5		X,5	
Sharp-shinned Hawk		X	X,5	X,5	X,5	X	X	
Cooper's Hawk		X	X,5	X,5	X,5	X	X	
Red-tailed Hawk		X,5	X,5	X,5	X,5	?	X,5	
Red-shouldered Hawk		X,5	X,5	X,5	X,5		X,5	
Swainson's Hawk			X,5	?	X,5		X,5	1?
Rough-legged Hawk					?		?	X
Ferruginous Hawk			?	5	5?		5?	Inexact records; habitat type not indicated
Golden Eagle					?		?	5, rare since 1900
Bald Eagle								19th century records (5)
Marsh Hawk		X,5	X	X	X,5		X,5	Rarely roosts in woodland

LEGEND: (Numbers refer to references that follow the species list)
X = animal or evidence observed during this study

C-056402

C-056403

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
Prairie Falcon					8			Only known record in Delta February 18, 1978; probably more
Peregrine Falcon							5	
Merlin		X			5		5	Records are for general area
American Kestrel		X	X,5	X,5	X,5	X,5	X,5	
California Quail			X,5	X,5	X,5	X,5	X,5	
Ring-necked Pheasant		X,5	X,5	X,5	?	X	X,5	
Sandhill Crane					X,1		X,1,5	
Virginia Rail		X,5						
Sora		X,1,5						
Black Rail		X,1,3,5						Rare species that may nest
Common Gallinule	X,5	X,5	X,5	X,5		X	X,5	1
American Coot	X,5	X,5	X,5	X,5		X,5	X,5	
Semipalmated Plover							X	One record (8-13-79)
Killdeer		X,5			X,5	X,5	X,5	
Mountain Plover					5		5	
American Golden Plover						X	?	Seen at oxidation ponds
Black-bellied Plover		?				X	X,5	
Common Snipe		X,5			X,5	X	X,5	
Long-billed Curlew		?			X,5	X	X,1,5	
Whimbrel		5					?	
Spotted Sandpiper		X,1				X		Pond and open water edges and sand bars
Willet		?						Pond and water edges in migration. X (Seen in flight over river)
Greater Yellowlegs		X,5			X,5	X	X,5	
Lesser Yellowlegs		5?			X	X	X	5, Migration
Pectoral Sandpiper						X		Migration
Least Sandpiper		X,5 ?			?	X,5	X,5	
Dunlin						X	X,5	
Short-billed Dowitcher						X	X	
Long-billed Dowitcher		X?			?	X	X,5	1?

LEGEND: (Numbers refer to references that follow the species list)

X = animal or evidence observed during this study

C-056403

C-056404

C-056405

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
Western Sandpiper					?	X	X,5	Migration
Marbled Godwit						X		
American Avocet					X,5	X	X,5	
Black-necked Stilt					X	X	X,5	
Wilson's Phalarope	X					X	X	Migration
Northern Phalarope	X					X	5	Migration
Glaucous-winged Gull	5?							
Western Gull	X,5							
Herring Gull	X,5					X	X,5	
Thayer's Gull							X	
California Gull	X,5					X,5	X,5	
Ring-billed Gull	X,5					X,5	X,5	
Mew Gull	X					X	X.	
Black-headed Gull	X,2					X,2		One record, oxidation ponds (3-20- to 3-27-79)
Bonaparte's Gull	X,5					X	?	
Little Gull	X,2					X,2		One record, oxidation ponds (3-20 to 3-27-79)
Forster's Tern	X,5					X		
Caspian Tern	X,5							
Black Tern		5					1,5	
Band-tailed Pigeon			5	5			?	
Rock Dove			X,5			X,5	X,5	
Mourning Dove			X,5	X,5	X,5	X,5	X,5	
Yellow-billed Cuckoo			5					No recent record, but still in other parts of Central Valley. Good habitat in S. Delta.
Roadrunner					5		?	
Barn Owl		X	X,5	X,5	X,5	X,5	X,5	1?
Screech Owl			X,5			5		1?
Great Horned Owl			X,5	X,5	X,5	X,5	X,5	
Burrowing Owl					5	?	X,5	
Long-eared Owl			5					

LEGEND: (Numbers refer to references that follow the species list)
X = animal or evidence observed during this study

C-056404

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
Short-eared Owl		X,5			5		X,5	1; exact location not given
Poorwill								1, 5; exact location not given
Lesser Nighthawk							5	
Vaux's Swift								X,5 aerial
Black-chinned Hummingbird			5	5	?	5		
Anna's Hummingbird			X,5	X,5	?	X,5		
Rufous Hummingbird			X			5		
Allen's Hummingbird			?			5		
Belted Kingfisher	X,5	X,1	X,5	X,5	X,1	X,5	X,1	
Common Flicker			X,5	X,5	X,5	X,5	X,5	
Acorn Woodpecker			X,5		X,5	X,5		
Lewis Woodpecker			X,5		?	5		
Yellow-bellied Sapsucker			X		5	5		
Downy Woodpecker		?	X,5	X,5		?		
Nuttall's Woodpecker			X,5		X,5	X,5		
Western Kingbird			X,5	X,5	X,5	X,5	X,5	
Eastern Kingbird					9			(one record June, 1977)
Ash-throated Flycatcher			X,5	X	?	X	?	
Black Phoebe		X,5	X,5	X,5		X,5	X,5	
Say's Phoebe			5	5	X,5	5	X,5	
Willow Flycatcher		X,5	X,5					
Hammond's Flycatcher			5	5				
Dusky Flycatcher			X	X				
Western Flycatcher			X	X				
Western Wood Pewee			X,5	X,5		X,5		
Vermilion Flycatcher								One record near Thornton (5) (date unavailable)
Horned Lark					X,5	5	X,5	
Violet-green Swallow								X aerial two known records (3-26-79, 8-13-79)
Tree Swallow		X,5	X,5	X,5	?	X,5	X,5	
Bank Swallow						X		One record at oxidation pond (8-29-79)

LEGEND: (Numbers refer to references that follow the species list.)
X = animal or evidence observed during this study

C-056405
C-056406

C-056407

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
Rough-winged Swallow		X,5	X,5	X,5	?	?	X,5	Aerial
Barn Swallow		X,5	X,5	X,5	X	X,5	X,5	1, aerial
Cliff Swallow		X,5	X,5	X,5	X	X,5	X,5	Aerial
Purple Martin						5		Aerial, former nester
Steller's Jay			5					Rare in Delta
Scrub Jay			X,5	X,5	X,5	X,1,5	X,5	
Yellow-billed Magpie			X,5	X,5	X,5	X,5	X,5	
Common Raven							X	
Common Crow			X,5	X,5	X,5	X,5	X,5	
Plain Titmouse			X,5		X,5	X,5		
Bushtit			X,5	X,5		X,5		
White-breasted Nuthatch			X,5			X,5		
Red-breasted Nuthatch			X,5			X,5		
Brown Creeper			5			5		
Wrentit			X,5	X,5				
House Wren			X,5	X,5		5		
Winter Wren		X	X		5			
Bewick's Wren			X,5	X,5		X,5		
Marsh Wren		X,5						1; habitat not specified
Rock Wren								1,5; one specimen
Mockingbird			X,5	X,5	X	X,5	X	
Sage Thrasher					9		9	2 records (Oct. 1977 and Dec. 1977)
Bendire's Thrasher						6		
American Robin			X,5	X,5	X,5	X,5	X,5	
Varied Thrush			X		5	X,5		
Hermit Thrush			X,5	X,5		1,5		
Swainson's Thrush			5	5				1; habitat not specified
Western Bluebird			X,5		5			
Mountain Bluebird						5	5	
Blue-gray Gnat catcher			X,5	X				
Golden-crowned Kinglet			X,5					1; habitat not specified
Ruby-crowned Kinglet			X,5	X,5		X,5		
Water Pipit		X,5			X,5	5	X,5	

LEGEND: (Numbers refer to references that follow the species list.)
X = animal or evidence observed during this study

C—056406

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
Bohemian Waxwing						5		
Cedar Waxwing			X,5	X		X,5		
Phainopepla			X					One known record 1-31-80
Loggerhead Shrike			X,5	X,5	X,5	X,5	X,5	
Starling		X,5	X,5	X,5	X,5	X,5	X,5	
Hutton's Vireo			X,5					
Bell's Vireo			5	5				No modern records; probably extinct in Central Valley.
Solitary Vireo			X,5	X,5				
Warbling Vireo			X,5	X,5				
Orange-crowned Warbler			X,5	X,5				
Nashville Warbler			5	5	5	5		
Yellow Warbler			X,5	X,5	5	5		
Yellow-rumped Warbler		X	X,5	X,5	X,5	X,5	X	
Black-throated Gray Warbler			X,5	X,5	5	1,5		
Townsend's Warbler			X,5			1,5		
Hermit Warbler			5	5				
MacGillivray's Warbler			X	X		5		
Common Yellowthroat		X,5	X,5	X,5		5		
Yellow-breasted Chat		X	X,5	X,5				
Wilson's Warbler			X,5	X,5		?		
American Redstart				10				One record (Phil Gordon, pers. comm., 12-29-79)
House Sparrow				X		X,5	X	
Western Meadowlark				X,5	X,5	X,5	X,5	
Yellow-headed Blackbird		5					5	
Red-winged Blackbird		X,5	X	X	X	X	X	
Tricolored Blackbird		X,5		X			X,5	
Hooded Oriole						5		
Northern Oriole			X,5	X,5		X,1,5		
Brewer's Blackbird		X	X,5	X,5	X,5	X,5	X,5	
Brown-headed Cowbird		X	X,5	X,5	5	X,5	X,5	

LEGEND: (Numbers refer to references that follow the species list.)
X = animal or evidence observed during this study

C-056407
C-056408

C-056409

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
Western Tanager			X,5	X,5		1,5		
Black-headed Grosbeak			X,5	X,5		X,5		
Blue Grosbeak			X,5	X,5				
Lazuli Bunting			X,5	X,5		5		
Evening Grosbeak						1,5		
Purple Finch			X	X		5		
House Finch			X,5	X,5	X,5	X,5	X,5	
Pine Siskin			X			5		
American Goldfinch			X,5	X,5		X,1,5	X,5	
Lesser Goldfinch			X	5	5	5		
Lawrence's Goldfinch					5	5		
Red Crossbill						5		One record (4-11-64) (5)
Green-tailed Towhee						5		One record (5-7-64) (5)
Rufous-sided Towhee			X,5	X,5	X,5	X,5		
Brown Towhee			X,5	X,5	X,5	X,5		
Savannah Sparrow				X	X,5		X,5	
Grasshopper Sparrow					7			One known record (3-78)
Vesper Sparrow					5?	5		
Lark Sparrow			5	5	5	5	5	
Dark-eyed Junco			X	X		X,5	X	
Chipping Sparrow			5	5	5	5		
White-crowned Sparrow			X,5	X,5	X,5	X,5	X,5	
Golden-crowned Sparrow			X,5	X,5	X,5	X,5	X,5	
White-throated Sparrow			X	X		5		
Fox Sparrow			X,5	X,5		1,5	X	
Lincoln's Sparrow			X,5	X,5			X	
Song Sparrow		X,5	X,5	X,5	?	X,5	X,5	

LEGEND: (Numbers refer to references that follow the species list)
X = animal or evidence observed during this study

C—056408

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
MAMMALS								
Virginia Opossum *(Didelphis virginiana)*			X,4,8	8		4,8	4,8	Observed and trapped. Some taken commercially. Often roadkilled.
Ornate Shrew *(Sorex ornatus)*			X,1,4	1,4				One collected in Cosumnes-Mokelumne wooded area.
Broad-footed Mole *(Scapanus latimanus)*			X	X	X			Observed on levees, dredge spoils.
Yuma Myotis *(Myotis yumanensis)*			X					One collected Delta Meadows woods. Most bats seen were unidentifiable in air.
California Myotis *(Myotis californicus)*		4	4	4	4	4,10	4	Roosts in artificial structures. Expected but not collected.
Western Pipistrelle *(Pipistrellus hesperus)*					4		4	Roosts in artificial structures. Expected but not collected.
Big Brown Bat *(Eptesicus fuscus)*			4	4	4	4	4	Probably common during summer.
Red Bat *(Lasiurus borealis)*			1,4	4				Specimen, Stockton, Feb. 16, 1951.
Hoary Bat *(Lasiurus cinereus)*			1,4	4				Specimen, Stockton, March 6, 1951; April 8, 1958
Townsend's Big-eared Bat *(Plecotus townsendii)*			1	1	1	1		Might occur in any part of Delta: hibernates in caves or hollow trees.
Pallid Bat *(Antrozous pallidus)*			1,4	1,4	1,4			Flies low, may feed at ground on Jerusalem crickets.
Brazilian Free-tailed Bat *(Tadarida brasiliensis)*			1	1	1,10	1	1	Some migrate south for winter. Roosts in houses, etc. during day.
Desert Cottontail *(Sylvilagus audubonii)*			X	X	X	1,4	1,4	Observed and trapped
Black-tailed Jack Rabbit *(Lepus californicus)*			X	X	X	1,4	1,4	Likely to appear anyplace in Delta; widespread
California Ground Squirrel *(Spermophilus beecheyi)*				X	X		X	Numerous in several areas, particularly waste edges.
Western Gray Squirrel *(Sciurus griseus)*			X					Found in oak groves in eastern and southern parts of Delta.
Botta's Pocket Gopher *(Thomomys bottae)*			X	X	X	1,4	1,4	Plentiful

LEGEND: (Numbers refer to references that follow the species list)

X = animal or evidence observed during this study

Mammal names in accordance with Jones et al. (1973)

C-056409

C-056410

C-056411

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
San Joaquin Pocket Mouse *(Perognathus inornatus)*					?3			Shown on range maps, but unable to trap or locate record in Delta.
Heermann's Kangaroo Rat *(Dipodomys heermanii)*					?3			Same as above.
Beaver *(Castor canadensis)*	X	X					Drainage Canals	Commercially trapped at about 100 a year (depends on price offered to trapper).
Western Harvest Mouse *(Reithrodontomys megalotis)*		X	X	X	X			In small numbers in grassy areas. Trapped.
Deer Mouse *(Peromyscus maniculatus)*								Found just outside of Delta in drier upland habitat but apparently not in Delta.
Dusky-footed Woodrat *(Neotoma fuscipes riparia)*			X					Reported from the Mokelumne River-Lost Slough area and a location just south of the Delta. No evidence found in this study.
California Vole *(Microtus californicus)*		X	X	X	X		4	Common in all our trapping areas.
Muskrat *(Ondatra zibethicus)*	X	X					X	In 1948-49, 8 were reported by trappers; now about 6,000 a year from the Delta.
Black Rat (Roof Rat) *(Rattus rattus)*			X	4		4		Trapped. More abundant in wooded areas.
Norway Rat *(Rattus norvegicus)*		X	X	X	X	X	X	Very abundant; destructive. Trapped.
House Mouse *(Mus musculus)*		X	X	X	X	X	X	Very abundant; common; in all habitats. Easily trapped.
Coyote *(Canis latrans)*			4	4	4		4	Trappers take 5 - 10 a year. One shot on Palm Tract in November, 1979.
Kit Fox *(Vulpes macrotis)*								If occurring in Delta, they would be on the southwestern margin. Scarce.
Gray Fox *(Urocyon cinereoargenteus)*			4	4			4	Talked to some trappers and they are now trapping about 100 foxes a year.
Ringtail *(Bassariscus astutus)*			?	?				No recent records in the Delta but occur further north in Sacramento Valley.
Raccoon *(Procyon lotor)*		X,4	X,4	X,4	4		4	Commercially trapped - about 500 a year from the Delta.

LEGEND: (Numbers refer to references that follow the species list)

X = animal or evidence observed during this study

C—056410

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
Long-tailed Weasel *(Mustela frenata)*		4	4	4	4		4	With many rodents, many weasels.
Mink *(Mustela vison)*		4	X,4	4				Found close to water. Well over 100 are trapped each year in the Delta.
Western Spotted Skunk *(Spilogale gracilis)*				2,4	2,4?			Prefers brushy areas. None observed but expected.
Striped Skunk *(Mephitis mephitis)*			X	X	X	2,4	2,4	One live-trapped and released. Several dead on highway. Evidence of presence in several locations.
River Otter *(Lutra canadensis)*	?	?						Now protected. One trapper reported some recovery but not enough for trapping. We did not see any.
Badger *(Taxidea taxus)*					?			Scarce, probably a few in northern Delta.
Bobcat *(Lynx rufus)*			2,8?	2,8?	?			Probably not numerous, but might be expected in the Cosumnes-Mokelumne area.
Mountain Lion *(Felis concolor)*				?				A number of years ago seen in above area. Rare in Delta.
Harbor Seal *(Phoca vitulina)*	9							Seen as far as American River.(9)
Mule Deer *(Odocoileus hemionus)*			X					Sign in Cosumnes-Mokelumne area.
Feral Cats and Dogs *(Felis domesticus, Canis domesticus)*								Might be a problem in some areas.
California Sea Lion *(Zalophus californicus)*	9							40 lb. Juvenile in Mokelumne River near Thornton. (9)
REPTILES								
Western Pond Turtle *(Clemmys marmorata)*	X	X						Lay their eggs on land, in shallow nest-burrow.
Western Fence Lizard *(Sceloporus occidentalis)*			X	X	X	X	X	Abundant and common.
Coast Horned Lizard *(Phrynosoma coronatum)*					?			Might occur in sandy areas on western margin of Delta. (2)

LEGEND: (Numbers refer to references that follow the species list.)

X = animal or evidence observed during this study

Reptile names are in accordance with Stebbins, 1966.

C-056411

C-056412

C-056413

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
Skink (*Eumeces* spp.)			?	?				None recorded from Delta but *E. gilberti* recorded in Contra Costa County and from just east of the Delta.
California Whiptail (*Cnmidophorus tigris*)					?			No records, but might occur.
California Alligator Lizard (*Gerrhonotus m. multicarinatus*)			2	X	X	2	2	
California Legless Lizard (*Anniella pulchra*)			?	?	?			One record on San Joaquin River near Antioch. (2)
Ringneck Snake (*Diadophis punctatus*)			?	?	?			No records, possible on margins. (2,3)
Western Yellow-bellied Racer (*Coluber constrictor*)			2	X	2.			
San Joaquin Whipsnake (*Masticophis flagellum*)			3	3	3		3	
Pacific Gopher Snake (*Pituophis melanoleucus*)			2	X	2	2	2	Good rodent control; widespread.
Common Kingsnake (*Lampropeltis getulus*)			2	2	2	2	2	Highly beneficial.
Common (Valley) Garter Snake (*Thamnophis sirtalis*)		2,3	2,3	2,3	2,3	2,3	2,3	Usually adjacent to water into which it retreats.
Giant Garter Snake (*Thamnophis couchi gigas*)	3,1	3,1						Prefers slough and areas with muddy bottoms, scarce.
Western Rattlesnake (*Crotalus viridis*)			?	?				Never common, but occasionally reported, usually after floods.
AMPHIBIANS								
Tiger Salamander (*Ambystoma tigrinum*)								There are records along the eastern margin of the Delta. (4)
California Newt (*Taricha torosa*)								Doubtful for the Delta. No museum specimens. (2,3)
California Slender Salamander (*Batrachoseps attenuatus*)								Possibly might occur under logs in the Cosumnes-Mokelumne River area.
Arboreal Salamander (*Aneides lugubris*)								Not likely to occur in the Delta.

LEGEND: (Numbers refer to references that follow the species list.)
X = animal or evidence observed during this study
Amphibian names in accordance with Stebbins, 1966.

C—056412

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
Western Toad *(Bufo boreas halophilus)*		4	X	4	4	X	4	Common.
Pacific Treefrog *(Hyla regilla)*		2,4	X	X	X	2,4	2,4	Common.
Foothill Yellow-legged Frog *(Rana boylei)*	?		?					An early record north of Lodi and records west of Delta. (3,4)
Bullfrog *(Rana catesbeiana)*	X	X						In backwaters, ditches, canals, and marshes.
FISH								
Pacific lamprey *(Lampetra tridentata)*	1,4							Parasitic.
River lamprey *(Lampetra ayresi)*	1							Parasitic.
White sturgeon *(Acipenser transmontanus)*	1-5							May have potential for aquaculture.
Green sturgeon *(Acipenser medirostris)*	1-4							Less desirable species.
Threadfin shad *(Dorosoma petenense)*	1-5							Forage fish; introduced species.
American shad *(Alosa sapidissima)*	1-5							Recreational species; introduced.
King salmon *(Oncorhynchus tshawytscha)*	1-5							Important sport and commercial fish in ocean.
Silver salmon *(Oncorhynchus kisutch)*	1							Rare in Delta.
Steelhead *(Salmo gairdneri)*	1-4							Important sport and commercial fish.
Delta smelt *(Hypomesus transpacificus)*	1-4							Forage fish.
Longfin smelt *(Spirinchus thaleichthys)*	1-4							Forage fish.
Hitch *(Lavinia exilicauda)*	1-3							Populations declining in Delta.

LEGEND: (Numbers refer to references that follow the species list.)
X = animal or evidence observed during this study
Fish names in accordance with Bailey *et al.*, 1970, and Miller and Lee, 1972.

C-056413
C-056414

C-056414

C-056415

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
California roach *(Hesperoleucus symmetricus)*	1							Uncommon.
Sacramento blackfish *(Orthodon microlepidotus)*	1-4							
Sacramento splittail *(Pogonichthys macrolepidotus)*	1-4							Most abundant native minnow.
Hardhead *(Mylopharodon conocephalus)*	1							Uncommon.
Sacramento squawfish *(Ptychocheilus grandis)*	1-4							Declining because of competition from introduced species.
Golden shiner *(Notemigonus crysoleucas)*	1,2							Bait fish; introduced species.
Fathead minnow *(Pimephales promelas)*	1							Introduced species.
Goldfish *(Carassius auratus)*	1,2,4							Disturb gamefish habitat; introduced species.
Carp *(Cyprinus carpio)*	1-4							Disturb gamefish habitat; introduced species.
Sacramento sucker *(Catostomus occidentalis)*	1,4							Uncommon where there are introduced species.
Black bullhead *(Ictalurus melas)*	1-4							Introduced species.
Brown bullhead *(Ictalurus nebulosus)*	1-5							Introduced species.
White catfish *(Ictalurus catus)*	1-5							Important sport fish; introduced species.
Channel Catfish *(Ictalurus punctatus)*	1-3							Important sport fish; introduced species.
Rainwater killifish *(Lucania parva)*	1							Uncommon; introduced species.
Mosquito fish *(Gambusia affinis)*	1							Valuable for mosquito control; may eliminate other small fish; introduced.
Mississippi silverside *(Menidia audens)*	1,3							Populations increasing; introduced species.
Threespine stickleback *(Gasterosteus aculeatus)*	1,4							

LEGEND: (Numbers refer to references that follow the species list.)

X = animal or evidence observed during this study

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
Striped bass *(Morone saxatilis)*	1-5							Key sport fish; apparently only reproduce in Sacramento-San Joaquin system; introduced.
Sacramento Perch *(Archoplites interruptus)*	1							Only native sunfish; rare in Delta; introduced species have caused decline.
Bluegill *(Lepomis macrochirus)*	1-5							Abundant; introduced species.
Green sunfish *(Lepomis cyanellus)*	1,3							Abundant; replaced California roach in many locations.
Warmouth *(Lepomis gulosus)*	1,2							Introduced species.
White crappie *(Pomoxis annularis)*	1							Uncommon; introduced species.
Black crappie *(Pomoxis nigromaculatus)*	1-5							Important sport fish; introduced species.
Largemouth bass *(Micropterus salmoides)*	1,2,3,5							Prefer clear waters; introduced species.
Smallmouth bass *(Micropterus dolomieui)*	1							Thrive in disturbed or artificial habitats; introduced species.
Bigscale logperch *(Percina macrolepida)*	1							Introduced species; now abundant.
Tule perch *(Hysterocarpus traski)*	1-4							Only fresh water surfperch.
Yellowfin goby *(Acanthogobius flavimanus)*	1							Introduced species; spreading throughout Delta; may compete with native gobies and sculpins.
Prickly sculpin *(Cottus asper)*	1-4							
Pacific staghorn sculpin *(Leptocottus armatus)*	1,2,4							Adults uncommon in fresh water.
Starry flounder *(Platichthys stellatus)*	1,2,4							Adults uncommon in fresh water.
INVERTEBRATES								
Cladoceran *(Bosmina longirostris)*	X							
Cladoceran *(Daphnia sp.)*	X							

LEGEND: (Numbers refer to references that follow the species list.)

X = animal or evidence observed during this study

C-056415

C-056416

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
Cladoceran *(Diaphanosoma brachyurum)*	X							
Copepod *(Eurytemora hirundoides)*	X							
Copepod *(Cyclops* sp.*)*	X							
Copepod *(Diaptomus* sp.*)*	X							
Opossum shrimp *(Neomysis mercedis)*	X							Primary food of young striped bass.
Amphipod *(Corophium spinicorne)*	X							
Amphipod *(Corophium stimpsoni)*	X							
Amphipod *(Gammarus* spp.*)*	X							
Isopod *(Asellus tomalensis)*	X							
Isopod *(Exosphaeroma oregonensis)*	X							
Bay shrimp *(Crangon franciscorum)*	X							Important food for fish.
Grass shrimp *(Palaemon macrodactylus)*								Introduced species; competes with bay shrimp.
Crayfish *(Pacifastacus leniusculus)*	X							Possible value for aquaculture; introduced.
Crayfish *(Procambarus clarkii)*	X						X	Burrowing may damage levees; introduced.
Mud crab *(Rhithropanopeus harrisi)*	X							Introduced species, now common.
Barnacle *(Balanus* sp.*)*	X							
Polychaete *(Boccardia berkeleyorum)*	X							
Polychaete *(Neanthes limnicola)*	X							

LEGEND: (Numbers refer to references that follow the species list.)

X = animal or evidence observed during this study

C-056417

C—056416

SPECIES	HABITAT							COMMENTS
	AQUATIC	MARSH	WOODLAND	BRUSH	UPLAND	DEVELOPED AREAS	CULTIVATED LANDS	
Asiatic clam *(Corbicula fluminea)*	X							Often extremely abundant; introduced.
Japanese cockle *(Tapes japonica)*	X							Introduced species.
Gem clam *(Gemma gemma)*	X							Introduced species.

LEGEND: (Numbers refer to references that follow the species list.)
X = animal or evidence observed during this study

C-056417
C-056418

FAUNAL SPECIES REFERENCES

Census Methods

A year-long (January, 1979 to February, 1980) bird and mammal census was carried out under the supervision of Diane Renshaw and John R. Arnold, Ph.D. Thirty separate census sites were established, representing ten different habitat types in three general regions of the Delta (south, north, and central). Birds were censused every two weeks throughout one year by Douglas Ellis, field ornithologist. Observations and identifications were made with binoculars, spotting scope, or by eye and ear, from a boat or from an established path or survey point. Numbers of individuals, habitat use (feeding, nesting, resting, *etc.*), weather conditions, and time of observation were recorded for each site. Occasional high winds, fog, or other inclement weather made it impossible to reach all boat sites on some of the census rounds.

Mammals were trapped three times during the year (late winter, summer, and late fall) at selected census sites and other locations in the Delta by O.V. Slayden, field zoologist, and John R. Arnold. During the summer round, nets were set to sample the bat population at the wooded location in the Delta Meadows. Observations and records were made of animal sign (tracks, droppings, burrows, *etc.*), and area trappers were interviewed for their personal information. Kite and owl pellets were collected and analyzed for content. Specimen collections in museums (Museum of Vertebrate Zoology, Berkeley; California Academy of Sciences, San Francisco; Sonoma State University; Western Foundation of Vertebrate Zoology, Los Angeles; National Museum of Natural History, Smithsonian Institution, District of Colum-Columbia) and personal collections were examined or curators were consulted.

Birds

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TABLE 12 **Flora of the Delta Area**

COMMON AND SCIENTIFIC NAMES[1/]	OCCURRENCE: COE ATLAS SYMBOL	OCCURRENCE: CHARACTERISTIC HABITAT TYPE	ABUNDANCE IN DELTA[2/]	STATUS: NATIVE	STATUS: INTRODUCED
NONFLOWERING PLANTS					
Aspidaceae					
Lady fern (*Athyrium filix-femina*)	PEM1, R2EM1	Freshwater marshes	Common	X	
Equisetaceae					
Common scouring rush (*Equisetum hymale*)	UP	Grassy riprap	Common	X	
FLOWERING PLANTS: MONOCOTYLEDONS					
Cyperaceae					
Sedge (*Cyperus eragrostis*)	PEM1, PEM2, R2EM1, L2EM1, L2EM2	Freshwater marshes	Common	X	
Sedge (*Cyperus niger* var. *rivularis*)	"	"	Uncommon	X	
Spike rush (*Eleocharis* spp.)	"	"	Common	X	
Common tule (*Scirpus acutus*)	"	"	Common	X	
Southern tule (*Scirpus californicus*)	"	"	Common	X	
Olney's bulrush (*Scirpus olneyi*)	"	"	Occasional	X	
Scirpus, bulrush (*Scirpus robustus*)	"	"	Occasional	X	
Gramineae					
Barnyard grass (*Echinochloa crusgalli*)	UP	Ruderal	Common		X
Iridaceae					
Iris (*Iris* sp.)	UP	Uplands	Occasional	X	
Juncaceae					
Baltic rush (*Juncus balticus*)	PEM1, PEM2, R2EM1, L2EM1, L2EM2	Freshwater marshes	Occasional	X	
Soft rush (*Juncus effusus*)	"	"	Occasional	X	
Iris-leaved rush (*Juncus xiphiodes*)	"	"	Occasional	X	
Liliaceae					
Asparagus (*Asparagus officinalis*)	UP, AG	Upland, ruderal, agricultural lands, herbaceous banks	Common		X
Water hyacinth (*Eichhornia crassipes*)	R2AB, L1AB	Aquatic bed	Common		X
Poaceae					
Giant reed (*Arundo donax*)	UP	Herbaceous banks	Occasional	X	
Oats (*Avena* spp.)	UP, AG	Upland, ruderal, agricultural lands, herbaceous banks	Common	X	X
Ripgut grass (*Bromus diandrus*)	UP, AG	"	Common		X
Pampas grass (*Cortaderia selloana, C. jubata*)	UP, AG	"	Common		X

[1/] Scientific nomenclature follows Munz and Keck, 1968; basic listing adapted from COE Atlas vegetation list, 1979a and supplemented by field observation.

[2/] Values are taken from COE Atlas vegetation list, 1979a, or based on field observation.

COMMON AND SCIENTIFIC NAMES[1/]	OCCURRENCE: COE ATLAS SYMBOL	OCCURRENCE: CHARACTERISTIC HABITAT TYPE	ABUNDANCE IN DELTA[2/]	STATUS: NATIVE	STATUS: INTRODUCED
Poaceae (continued)					
Bermuda grass (*Cynodon dactylon*)	UP, AG	Upland, ruderal, agricultural lands, herbaceous banks	Common		X
Salt grass (*Distichlis spicata* var. *stolonifera*)	UP, AG	"	Common	X	
Beardless wild-rye (*Elymus triticoides*)	UP, AG	"	Occasional	X	
Fescue (*Festuca* spp.)	UP, AG	"	Common	X	X
Little barley (*Hordeum pusillum*)	UP, AG	"	Occasional	X	
Foxtail (*Hordeum stebbinsi*)	UP, AG	"	Common		X
Barley (*Hordeum vulgare*)	UP, AG	"	Occasional		X
Italian wildrye (*Lolium multiflorum*)	UP, AG	"	Common		X
Colusa grass (*Neostapfia colusana*)	UP (Vernal Pools)	Vernal pools	Rare	X	
Crampton's orcuttia (*Orcuttia mucronata*)	UP (Vernal Pools)	Vernal pools	Rare	X	
Knot grass (*Paspalum dilatatum*)	UP, AG	Upland, ruderal, agricultural lands, herbaceous banks	Occasional		X
Canary grass (*Phalaris canariensis*)	UP, AG	"	Common		X
Common reed (*Phragmites communis*)	UP, PEM1, PEM2, R2EM1, L2EM1, L2EM2	Freshwater marshes	Common	X	
Rabbitfoot grass (*Polypogon monspeliensis*)	UP, AG	Upland, ruderal, agricultural lands, herbaceous banks	Common		X
Johnson grass (*Sorghum halpense*)	UP, AG	"	Common		X
Milo (*Sorghum vulgare*)	AG	Agricultural lands	Occasional		X
Corn (*Zea mays*)	AG	Agricultural lands	Occasional		X
Potamogetonacea					
Pondweed (*Potamogeton* sp.)	R2AB, L1AB	Aquatic bed	Common	X	X
Ruppiaceae					
Ditch-grass (*Ruppia maritima*)	R2AB, L1AB	Aquatic bed	Common	X	
Typhaceae					
Broad-leaved cat-tail (*Typha latifolia*)	PEM1, PEM2, R2EM1, L2EM1, L2EM2	Freshwater marshes	Common	X	

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COMMON AND SCIENTIFIC NAMES[1/]	OCCURRENCE: COE ATLAS SYMBOL	OCCURRENCE: CHARACTERISTIC HABITAT TYPE	ABUNDANCE IN DELTA[2/]	STATUS: NATIVE	STATUS: INTRODUCED
DICOTYLEDONS					
Aceraceae					
Box elder (*Acer negundo* var. *californicum*)	PSS1, PFO1, UP	Riparian, woodland, and shrub-brush, ruderal	Common	X	
Silver maple (*Acer saccharinum*)	UR, UP	Urban, upland	Uncommon		X
Alismataceae					
Broadleaf arrowhead (*Sagittaria latifolia*)	PEM1, PEM2, R2EM1, L2EM1, L2EM2	Freshwater marshes	Occasional	X	
Amaranthaceae					
Tumbling pigweed (*Amaranthus graecizans*)	UP	Upland, ruderal, agricultural lands, herbaceous banks	Common	X	
Anacardiaceae					
Poison oak (*Rhus diversiloba*)	UP, PSS1, PFO1	Upland, riparian, shrub-brush and woodland	Occasional	X	
California pepper (*Schinus molle*)	UP, UR	Upland, urban	Uncommon		X
Apiaceae					
Water hemlock (*Cicuta douglasii*)	PEM1, PEM2, R2EM1, L2EM1, L2EM2	Freshwater marshes	Occasional	X	
Poison hemlock (*Conium maculatum*)	UP, AG	Upland, ruderal, agricultural lands, herbaceous banks	Occasional		X
Fennel (*Foeniculum vulgare*)	UP, AG	Upland, ruderal, agricultural lands, herbaceous banks	Common		X
Cow parsnip (*Heracleum lanatum*)	UP, PFO1, PSS1	Upland, riparian, shrub-brush and woodland	Common	X	
Apocynaceae					
Oleander (*Nerium oleander*)	UR	Urban	Uncommon		X
Perwinkle (*Vinca major*)	UR	Urban	Common		X
Asteraceae					
Yarrow (*Achillea millefolium*)	UP, AG	Upland, ruderal, agricultural lands, herbaceous banks	Occasional	X	
Western ragweed (*Ambrosia psilostachya*)	UP, AG	"	Common	X	
Douglas mugwort (*Artemisia douglasiana*)	UP, AG	"	Common	X	
Slender aster (*Aster exilis*)	PEM1, PEM2, PFO1, R2EM1, L2EM1, L2EM2	Freshwater marshes	Common	X	

[1/] Scientific nomenclature follows Munz and Keck, 1968; basic listing adapted from COE Atlas vegetation list, 1979a and supplemented by field observation.

[2/] Values are taken from COE Atlas vegetation list, 1979a, or based on field observation.

COMMON AND SCIENTIFIC NAMES[1/]	OCCURRENCE: COE ATLAS SYMBOL	OCCURRENCE: CHARACTERISTIC HABITAT TYPE	ABUNDANCE IN DELTA[2/]	STATUS: NATIVE	STATUS: INTRODUCED
Asteraceae (continued)					
Baccharis (*Baccharis douglasii*)	PSS1, UP	Riparian shrub-brush, ruderal	Common	X	
Water-wally (*Baccharis glutinosa*)	UP	Ruderal	Occasional	X	
Coyote brush (*Baccharis pilularis*)	UP	Most dry habitats	Common	X	
Sunflower (*Balsamorhiza macrolepis*)	UP	Upland, ruderal, agricultural lands, herbaceous banks	Rare	X	
Bur marigold (*Bidens laevis*)	PEM1, PEM2, PF01, R2EM1, L2EM1, L2EM2	Freshwater marshes	Common	X	
Yellow star thistle (*Centaurea solstitialis*)	UP, AG, UR	Most dry habitats	Common		
Slough thistle (*Cirsium crassicaule*)	L2EM1, L2EM2, R2EM1, PEM1, PEM2	Freshwater marshes	Rare	X	
Bull thistle (*Cirsium vulgare*)	UP, AG	Upland, ruderal, agricultural lands, herbaceous banks	Common	X	
Horseweed (*Conyza canadensis*)	UP, AG	"	Common		X
Common brass buttons (*Cotula coronopifolia*)	All habitats where water ponds	Most wet habitats	Uncommon		X
Cardoon (*Cynara cardunculus*)	UP, AG	Upland, ruderal, agricultural lands, herbaceous banks	Occasional		X
Horseweed (*Erigeron canadensis*)	UP, AG	"	Common		X
Cud weed (*Gnaphalium chilense*)	UP, AG	"	Common	X	
Gum plant (*Grindelia camporum*)	UP	"	Uncommon	X	
Rosilla (*Helenium puberulum*)	UP, AG	"	Uncommon	X	
Common sunflower (*Helianthus annuus*)	UP, AG	"	Occasional	X	
Common spikeweed (*Hemizonia pungens*)	UP, AG	"	Uncommon	X	
Telegraph weed (*Heterotheca grandiflora*)	UP, AG, UR	Most dry habitats	Common	X	
Prickly lettuce (*Lactuca serriola*)	UP, AG	Upland, ruderal, agricultural lands, herbaceous banks	Common		X
Bristly oxtongue (*Picris echioides*)	UP, AG	"	Common		X
Shrubby butterweed (*Senecio douglasii*)	UP, AG	"	Uncommon	X	
Milk thistle (*Silybum marianum*)	UP, AG	"	Common		X
Western goldenrod (*Solidago occidentalis*)	UP, AG	"	Occasional	X	
Sow thistle (*Sonchus* spp.)	UP, AG	"	Occasional		X

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COMMON AND SCIENTIFIC NAMES[1/]	OCCURRENCE: COE ATLAS SYMBOL	OCCURRENCE: CHARACTERISTIC HABITAT TYPE	ABUNDANCE IN DELTA[2/]	STATUS: NATIVE	STATUS: INTRODUCED
Asteraceae (continued)					
Cocklebur (*Xanthium strumarium* var. *canadense*)	UP, AG	Upland, ruderal, agricultural lands, herbaceous banks	Occasional		X
Betulaceae					
White alder (*Alnut rhombifolia*)	PFO1	Riparian woodland	Occasional	X	
Boraginaceae					
Chinese parsley (*Heliotropium curassavicum* var. *oculatum*)	UP	Upland, ruderal, agricultural lands, herbaceous banks	Occasional	X	
Brassicaceae					
Mustard (*Brassica geniculata*)	UP, AG	"	Common		X
Common yellow mustard (*Brassica campestris*)	UP, AG	"	Common		X
Perennial peppergrass (*Lepidium latifolium*)	UP, AG	"	Uncommon		X
Wild radish (*Raphanus sativus*)	UP, AG	"	Common		X
Caprifoliaceae					
Blue elderberry (*Sambucus caerulea*)	PSS1, PFO1	Riparian shrub-brush and woodland	Occasional	X	
Chenopodiaceae					
Fat-hen (*Atriplex patula* var. *hastata*)	Tidal salt marsh PEM2	Wet saline or alkaline habitats	Occasional	X	
Australian saltbush (*Atriplex semibaccata*)	UP, AG	Upland, ruderal, or herbaceous banks, where saline	Occasional		X
Mexican tea (*Chenopodium ambrosioides*)	UP, AG	Upland, ruderal, agricultural lands, herbaceous banks	Common		X
Russian thistle (*Salsola kali*)	UP, AG	"	Common		X
Convolvulaceae					
Field bindweed (*Convolvulus arvensis*)	UP, AG	"	Common		X
Hedge bindweed (*Convolvulus sepium*)	UP, AG	"	Occasional		X
Alkali weed (*Cressa truxillensis*)	UP	"	Occasional	X	
Cornaceae					
Creek dogwood (*Cornus stolonifera* var. *california*	PEM1, PSS1, PFO1, L2EM1	Freshwater marshes	Uncommon	X	
Cruciferae					
Contra Costa wallflower (*Erysimum capitatum angustatum*)	UP	Only on Antioch dunes	Rare	X	

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COMMON AND SCIENTIFIC NAMES[1]	OCCURRENCE: COE ATLAS SYMBOL	OCCURRENCE: CHARACTERISTIC HABITAT TYPE	ABUNDANCE IN DELTA[2]	STATUS: NATIVE	STATUS: INTRODUCED
Cruciferae (continued)					
Wild radish (*Raphanus sativus*)	UP	Grassy riprap, ruderal	Common		X
Caper-fruited tropidocarpum (*Tropidocarpum capparideum*)	UP	Uplands, near Mt. Diablo	Rare	X	
Euphorbiaceae					
California croton (*Croton californicus*)	UP	Dry sandy places	Occasional	X	
Turkey mullein (*Eremocarpus setigerus*)	UP, UR	Most dry habitats	Occasional	X	
Fabaceae					
Acacia (*Acacia* sp.)	UP, AG, UR	Upland, ruderal, urban	Uncommon		X
Delta tule pea (*Lathyrus jepsonii jepsonii*)	PEMI, PEM2, R2EMI	Freshwater marsh	Rare	X	
Spanish clover (*Lotus purshianus*)	UP	Upland, ruderal	Common	X	
Deer weed (*Lotus scoparius*)	UP	Upland, ruderal	Uncommon	X	
Lotus (*Lotus uliginosus*)	UP	Upland, ruderal	Uncommon		X
Silver lupine (*Lupinus albifrons*)	UP	Sandy uplands	Uncommon	X	
Lindley's annual lupine (*Lupinus bicolor*)	UP	Sandy uplands	Uncommon	X	
White sweet clover (*Melilotus albus*)	UP, UR	Upland, ruderal	Common		X
Yellow sweet clover (*Melilotus indicus*)	UP, UR	Upland, ruderal	Common		X
Black locust (*Robinia pseudoacacia*)	UP, UR	Upland, ruderal, urban	Uncommon		X
Spanish broom (*Spartium junceum*)	UP	Upland, ruderal	Uncommon		X
Fagaceae					
Coast live oak (*Quercus agrifolia*)	PFOI, UP	Riparian woodland, upland	Common	X	
Valley oak (*Quercus lobata*)	PFOI, UP	Riparian woodland, upland	Uncommon	X	
Frankeniaceae					
Alkali heath (*Frankenia grandifolia*)	UP, E2EM4/5N3[3]	Saltmarsh, alkali flats	Uncommon	X	
Gentianaceae					
June century (*Centaurium floribundum*)	UP	Upland	Uncommon	X	
Geraniaceae					
Broad-leaf filaree (*Erodium botrys*)	UP, AG	Upland, ruderal	Common		X
Haloragaceae					
Parrot's-feather (*Myriophyllum brasiliense*)	R2AB, L1AB	Aquatic Bed	Common		X

[1] Scientific nomenclature follows Munz and Keck, 1968; basic listing adapted from COE Atlas vegetation list, 1979a and supplemented by field observation.

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[3] Classification from Jones & Stokes Associates, 1979.

COMMON AND SCIENTIFIC NAMES[1/]	OCCURRENCE: COE ATLAS SYMBOL	OCCURRENCE: CHARACTERISTIC HABITAT TYPE	ABUNDANCE IN DELTA[2/]	STATUS: NATIVE	STATUS: INTRODUCED
Juglandaceae					
Black walnut (*Juglans hindsii*)	PFO1, AG, UR	Riparian woodland, introduced elsewhere	uncommon	X	
English walnut (*Juglans regia*)	AG, UR, UP	Upland, ruderal, urban	Occasional		X
Lamiaceae					
Henbit (*Lamium* spp.)	UP	Upland, ruderal	Occasional		X
Water horehound (*Lycopus americanus*)	PEM1, PEM2, R2EM1, PSS1, L2EM1, L2EM2	Low wet places	Uncommon	X	
Horehound (*Marrubium vulgare*)	UP	Upland, ruderal	Common		X
Liliaceae					
Fragrant fritillary (*Fritillaria litiacea*)	UP	Upland	Rare	X	
Lythraceae					
California loosestrife (*Lythrum californicum*)	UP	Moist places	Uncommon	X	
Malvaceae					
Velvet leaf (*Arbutilon theophrasti*)	UP	Ruderal	Occasional		X
California hibiscus (*Hibiscus californicus*)	R2EM1	Freshwater marsh, along banks	Rare	X	
Cheeseweed (*Malva parviflora*)	UP, AG	Upland, ruderal	Common	X	
Moraceae					
Hemp (*Cannabis sativa*)	UP	Channel islands	Uncommon		X
Myrtaceae					
Bottlebrush (*Callistemon* spp.)	UP, UR	Ruderal, urban	Uncommon		X
Eucalyptus (*Eucalyptus* spp.)	UP, UR, AG	Ruderal, urban, agricultural	Occasional		X
Oleaceae					
Ash (*Fraxinus latifolia*)	PFO1, PSS1	Riparian woodland, brushy riprap	Common	X	
Onagraceae					
Panicled willow-herb (*Epilobium paniculatum*)	UP	Upland, ruderal	Common	X	
Antioch primrose (*Oenothera deltoides* var *howelli*)	UP	Only Antioch dunes	Rare	X	
Hooker's evening primrose (*Oenothera hookeri*)	UP	Upland, ruderal	Occasional	X	
Papaveraceae					
California poppy (*Eschscholtzia californica*)	UP	Upland	Uncommon	X	
Plantaginaceae					
Buckhorn plantain (*Plantago lanceolata*)	UP, UR	Upland, ruderal, urban	Uncommon		X

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2/ Values are taken from COE Atlas vegetation list, 1979a, or based on field observation.

COMMON AND SCIENTIFIC NAMES[1/]	OCCURRENCE: COE ATLAS SYMBOL	OCCURRENCE: CHARACTERISTIC HABITAT TYPE	ABUNDANCE IN DELTA[2/]	STATUS: NATIVE	STATUS: INTRODUCED
Platanaceae					
Western sycamore (*Platanus racemosa*)	PFO1, UR	Riparian woodland, introduced elsewhere	Occasional	X	
Polygonaceae					
Naked-stemmed eriogonum (*Eriogonum latifolium*)	UP	Upland	Uncommon	X	
Common knotweed (*Polygonum aviculare*)	UP	Upland, ruderal	Common		X
Water smartweed (*Polygonum amphibium*)	L1AB	Aquatic bed	Common		X
Curly dock (*Rumex crispus*)	All moist or ponded habitats	Most moist or seasonally ponded habitats	Common		X
Rosaceae					
Almond (*Prunus amygdalus*)	UP, AG, UR	Upland, urban	Uncommon		X
California rose (*Rosa californica*)	PFO1, PSS1, UP	Riparian woodland, shrub-brush, upland	Common	X	
Himalaya-berry (*Rubus procerus*)	PFO1, PSS1	Riparian woodland, grassy riprap, brush riprap, wooded island	Common		X
Blackberry (*Rubus vitifolius*)	PFO1, PSS1, UP	Riparian woodland, shrub-brush brushy riprap, ruderal, upland	Common	X	
Rubiaceae					
Buttonbush (*Cephalanthus occidentalis*)	PEM1, PSS1, PFO1, L2EM1	Freshwater marshes, riparian woodland and shrub-brush	Occasional	X	
Salicaceae					
Fremont's cottonwood (*Populus fremontii*)	PFO1, PSS1, PEM1, L2EM1	Riparian woodland, fresh-water marsh	Occasional	X	
Weeping willow (*Salix babylonica*)	UP, UR	Upland, urban	Uncommon		X
Gooding's willow (*Salix gooddingii*)	PFO1, PSS1, PEM1, L2EM1	Riparian woodland, shrub-brush, freshwater marsh	Common	X	
Sand bar willow (*Salix hindsiana*)	PFO1, PSS1, PEM1, L2EM1	Riparian woodland, shrub-brush, freshwater marsh	Common	X	
Red willow (*Salix laevigata*)	PFO1, PSS1, PEM1, L2EM1	Riparian woodland, shrub-brush, freshwater marsh	Occasional	X	
Arroyo willow (*Salix lasiolepis*)	PFO1, PSS1, PEM1, L2EM1	Riparian woodland, shrub-brush, freshwater marsh	Common	X	
Scrophulariaceae					
Common monkey-flower (*Mimulus guttatus*)	PEM1, PEM2, R2EM1, PSS1, L2EM1, L2EM2	Most wet places	Occasional	X	
Common mullein (*Verbascum thapsus*)	UP	Upland, ruderal	Occasional		X
Solanaceae					
Jimson weed (*Datura stramonium*)	UP, AG	Upland, ruderal, agri-cultural	Occasional		X
Tree tobacco (*Nicotiana glauca*)	UP	Upland, ruderal	Uncommon	X	

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2/ Values are taken from COE Atlas vegetation list, 1979a, or based on field observation.

COMMON AND SCIENTIFIC NAMES[1/]	OCCURRENCE		ABUNDANCE IN DELTA[2/]	STATUS	
	COE ATLAS SYMBOL	CHARACTERISTIC HABITAT TYPE		NATIVE	INTRODUCED
Ulmaceae					
Chinese elm (*Ulmus parviflora*)	UP, UR	Upland, urban	Uncommon		X
Umbelliferae					
Bolander water hemlock (*Cicuta bolanderi*)	Salt marsh	Tidal salt marsh	Rare	X	
Bee thistle (*Eryngium articulatum*)	PEM1, PEM2, R2EM1	Freshwater marshes	Uncommon	X	
Delta coyote thistle (*Eryngium racemosum*)	PEM1, PEM2, R2EM1, L2EM2	Freshwater marsh	Uncommon	X	
Lilaeopsis (*Lilaeopsis masonii*)	PEM1, PEM2, R2EM1, L2FM2	Marshes in western Delta	Rare	X	
Urticaceae					
Hoary nettle (*Urtica holosericea*)	PFO1, PSS1, UP	Moist, low habitats	Common	X	
Verbenaceae					
Mat-grass (*Lippia nodiflora*)	UP, UR	Upland, urban	Uncommon		X
Vitaceae					
California wild grape (*Vitis californica*)	PFO1, PSS1	Riparian woodland, mature riparian shrub-brush	Common	X	
Zygophyllaceae					
Puncture vine (*Tribulus terrestris*)	UP	Upland, ruderal	Uncommon		X

1/ Scientific nomenclature follows Munz and Keck, 1968; basic listing adapted from COE Atlas vegetation list, 1979a and supplemented by field observation.

2/ Values are taken from COE Atlas vegetation list, 1979a, or based on field observation.

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Glossary

10

A

A-95 NOTIFICATIONS — Circular from federal Office of Management and Budgets (OMB) coordinating federal and State activities in federally assisted projects and programs with each other and with local plans and projects.

ALLUVIAL FAN — An assemblage of sediments (clay, silt, sand, gravel, or similar detrital material) deposited where water flow moves from a steep to a flatter gradient and suddenly loses much of its transporting power. See: ALLUVIAL SOIL, DELTA.

ALLUVIAL SOIL — Soil that has developed from transported and relatively recently deposited material, characterized by little or no modification of the original material by soil-forming processes.

ANADROMOUS — Pertaining to fishes which spend most of their lives in salt water but migrate into fresh water to spawn; *e.g.* salmon, shad, striped bass, *etc.*

ANNUAL PLANTS — Plants living but one growing season.

B

BACKSWAMP — Lands behind natural levees which are regularly inundated during winter rains and spring floods. See: FLOODPLAIN.

BENTHIC — Relating to or occurring on the bottom of any body of water.

BERM — An earthen shelf or ledge, usually built at the waterside base of levees.

BRACKISH WATER — From 0.5 to 30 parts per thousand salinity. Compare: FRESH WATER and SALINE WATER.

C

CEQA — California Environmental Quality Act, enacted in 1970. Requires an Environmental Impact Report (EIR) for projects which will have significant impact on the environment.

COE — U.S. Army Corps of Engineers.

CSRWQCB — California State Regional Water Quality Control Board.

CVP — Central Valley Project, a federal water project begun in the 1930's by the U.S. Bureau of Reclamation to supply water to the farmers of the Central Valley.

CARNIVORE — An organism that eats animal tissue; a secondary or higher level trophic consumer. Compare: HERBIVORE and OMNIVORE.

CULM — A stem, especially the stem of grasses, with nodes and internodes.

D

DAPC	Delta Advisory Planning Council, Sacramento Regional Area Planning Commission.
DFG	California Department of Fish and Game, Resources Agency.
DO	Dissolved oxygen, measured in parts per million (ppm) dissolved in water. The minimum necessary for the survival of most marine life is 4.5 ppm.
DELTA	A plain underlain by an assemblage of sediments that have accumulated where a stream, flowing into a body of standing water, has had its velocity and transporting power suddenly reduced. The classical delta broadens seaward and meets the ocean directly, while the Sacramento-San Joaquin Delta narrows toward the sea, discharging its waters into estuarine bays and straits (Atwater, 1980). See: ALLUVIAL FAN.
DETRITUS	All types of biogenic material, in various stages of microbial decomposition, which represent a potential energy source to consumer organisms.
DIATOM	A one-celled, microscopic alga in the class Bacillariaceae, with siliceous walls.
DOCTRINE OF PUBLIC TRUST	Holds that tidelands (lands subject to tidal action and lying below the elevation of mean high water), as well as nontidal lands underlying navigable waters, are held by the State subject to a public trust for purposes (among others) of navigation and fisheries (Briscoe, 1979).
DREDGE SPOILS	Material removed from the bottom of a channel, usually by clamshell or suction dredge.

E

EIR	Environmental Impact Report, required by the California Environmental Quality Act (CEQA), 1970.
EIS	Environmental Impact Statement, required by the National Environmental Protection Act (NEPA), 1969.
ECOLOGICAL RESERVE	Defined in Sections 1580-1584, California Fish and Game Code, as "areas preserved in a natural condition for the benefit of the general public to observe native flora and fauna and for scientific study."
EDAPHIC	Of or relating to the soil.
EMERGENT VEGETATION	Aquatic plants which are not totally submerged; typically rooted in aquatic environment but having most of the photosynthesis occurring above water; *e.g.*, cattail, bulrush, sedge, *etc.*
ENDEMIC	Restricted to a particular geographical area.
ENTRAPMENT ZONE	An area near the mouth of the Delta where fresh water and salt water mix and where nutrients accumulate. Surface salinities are generally between one and six parts per thousand.
ESTUARY	A semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land or drainage.
EUTROPHIC	Refers to bodies of water, accumulations of peat, *etc.* which are rich in mineral nutrients and organic materials, and therefore productive.

F

FWS	U.S. Fish and Wildlife Service.
FETCH	The reach or stretch of a water surface.
FIVE FINGERS ISLAND	Located in the Central Delta on Middle River, just north of its confluence with Connection Slough.
FLOODPLAIN	The relatively flat area or lowlands adjoining a river, stream, ocean, watercourse, or lake, which has been or may be covered by water. See: BACKSWAMP.
FOOD CHAIN	A linear sequence of predators and prey showing a direct relationship series of the eaters and eaten in a food web and exhibiting the energy flow from producers through several trophic levels of consumers.
FOOD WEB	A model showing nutritional interrelationships of the organisms in a community, depicting the web-like interconnections of the numerous food chains of the eaters and eaten; a typical food web includes plants, herbivores, carnivores, omnivores, and detritus feeders.
FRESH WATER	Less than 0.5 parts per thousand salinity. Compare: BRACKISH WATER and SALINE WATER.

H

HEP	Habitat Evaluation Procedures of the U.S. Fish and Wildlife Service. List of procedures establishing habitat evaluation methodology and guidelines, originally developed for water project planning.
HEADREACH ISLAND	Located in the Central Delta on the west side of the Stockton Deepwater Channel, near its intersection with Disappointment Slough and Columbia Cut.
HERBACEOUS	Plants with one or more stems that die back to the ground each year; *i.e.*, grasses and forbs,as distinct from shrubs and trees.
HERBIVORE	An organism that eats plants; a primary consumer. Compare: CARNIVORE and OMNIVORE.
HOWARD LANDING	Located on Grand Island just south of the Steamboat Slough ferry crossing to Ryer Island.

L

LAFCO	Local Agency Formation Commission; country agencies which determine annexation policies.
LITTLE FRANKS TRACT	A small, State-owned island on the west side of Franks Tract, with marshland in the center, and designated as a nature study area.
LOST LAKE TULE ISLAND	Located on the eastern side of Stockton Deepwater Channel, at its confluence with Disappointment Slough.

M

MHHW	Mean higher high water.
MHW	Mean high water.
MSL	Mean sea level.
MANDEVILLE TIP	A channel island, now a county park, on the northeast side of the Stockton Deepwater Channel, between Mandeville and Venice Islands.
MYSID	A member of the order Mysidacea, a crustacean order that includes the opossum shrimps.

N

NEPA	National Environmental Policy Act, enacted in 1969. Requires an Environmental Impact Statement for federal projects which will have significant impact on the environment.

O

OPR	California Office of Planning and Research.
OLIGOCHAETE	A member of the class oligochaeta; includes earthworms and certain aquatic species.
OMNIVORE	An organism that eats both plants and animals. Compare: CARNIVORE and HERBIVORE.

P

PD; PUD	Planned Unit Development.
PACIFIC FLYWAY	The major migratory route used annually by west coast waterfowl and other birds.
PALUSTRINE	Pertaining to or living in or by a swamp, marsh, or other wetland.
PEAT	An organic soil resulting from underwater decomposition of marshland plants. Subject to oxidation, wind erosion, swell-shrink behavior, compression, liquefaction during an earthquake, and inflammability.
PERENNIAL	Plants having a life cycle lasting more than two years.
PHYTOPLANKTON	Suspended aquatic algae which do not require a solid substrate or attachment and which are able to photosynthesize. Compare: ZOOPLANKTON.
PRODUCTIVITY	A measure of biological activity, based on the amount of carbon fixed by the process of photosynthesis and available as calories to be used as energy within or exported from the producing system.

R

REVETMENT	The rock facing protecting levee banks; See: RIPRAP.
RIPARIAN	Relating to or living or located on land bordering a stream, lake, or tidewater.
RIPRAP	Stones placed on the face of a dam, stream banks, or other land surfaces in order to protect them from erosion. See: REVETMENT.
RUDERAL	Weedy; most common on spoil or refuse banks, but may occur anywhere where natural cover has been disturbed.

S

SLC	California State Lands Commission.
SWP	California State Water Project, authorized in 1951 by the Legislature, financed in 1959 by the Burns-Porter Act; includes the Feather River, Sacramento-San Joaquin Delta Diversion Project, Peripheral Canal.
SALINE WATER	Greater than 30 parts per thousand salinity. Compare: BRACKISH WATER and FRESH WATER.
STONE LAKES	Two complexes of lakes, marshland, and surrounding upland, lying in an historical overflow area on the east side of the Sacramento River, roughly midway between Walnut Grove and Sacramento near the town of Hood.
SUBIRRIGATION	Raising the water table to the crop root zone by allowing water to seep laterally from ditches into porous peat soils.
SUCCESSION	The replacement of one kind of community by another kind; the progressive changes in vegetation and in animal life which occur in one place over time, culminating eventually in an equilibrium situation for that location.
SYMBIOSIS	The kind of interspecies relationship that is obligatory and beneficial to the two or more participating organisms.

T

TDS	Total dissolved solids, a unit used to measure salinity.
TENDIPED	A member of the family Tendipedidae, or midges.
TIDAL PRISM	The volume of water involved in a tidal exchange.
TROPIC LEVEL	In the nutritive cycle of an ecosystem, a group of organisms at a certain stage in the food chain which secure food in the same general manner. The first or lowest trophic level consists of producers, the second level of herbivores, and the third and higher levels of carnivores.

U

USFWS United States Fish and Wildlife Service, Department of the Interior.

Z

ZOOPLANKTON Aquatic animals which cannot actively swim against the current or photosynthesize; includes many larval forms of otherwise nonplanktonic organisms. Compare: PHYTOPLANKTON.

Appendix A

KEY LAWS, REGULATIONS, AND POLICIES GUIDING THE DEPARTMENT OF FISH AND GAME AND THE U.S. FISH AND WILDLIFE SERVICE REGARDING DELTA FISH AND WILDLIFE HABITAT

The framework of laws, regulations, and policies which guide public decision making concerning Sacramento-San Joaquin Delta resources consist of State and federal laws, executive orders, agency regulations and a number of internal policies and guidelines. These may be considered "directives" which support the actions and recommendations of U.S. Fish and Wildlife Service and California Department of Fish and Game. The essence of each of these directives is presented below.

LEGISLATED POLICIES AND DIRECTIVES

State of California

- *Davis-Dolwig Act 1961; Water Code, Sections 11900-11925:*

"The Legislature finds and declares it to be necessary for the general public health and welfare that preservation of fish and wildlife be provided for in connection with the construction of State water projects...and that the project construction costs attributable to such enhancement of fish and wildlife and recreation features should be borne by them." (Section 11900)

- *California Environmental Quality Act 1970; Public Resources Code, Sections 21001-21176:*

"The Legislature...finds and declares that it is the policy of the State to: ... Prevent the elimination of fish and wildlife species due to man's activities, insure that fish and wildlife populations do not drop below self-perpetuating levels, and preserve for future generations representatives of all plant and animal communities and examples of the major periods of California history." (Section 21001)

- *Delta Levee Maintenance Fund 1973; Water Code, Sections 12980-129 :*

"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 reserve 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, and that the key to preserving the Delta's physical characteristics is the system of levees defining the waterways and protecting the adjacent lands." (Sections 12981 and 12984)

- *Z'berg Project Levee Vegetation Maintenance Fund; Water Code, Section 8450 (1973):*

"Flood control project levees are increasingly recognized as valuable wildlife, recreational, scenic, and aesthetic resources, and construction and maintenance

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standards have been developed by the Army Corps of Engineers and the State of California which minimize vegetation removal and which encourage or require, as a condition of the project work, replanting and controlled vegetation maintenance... Costs of maintaining vegetation on levees for such non-flood control purposes as wildlife enhancement, recreation, and scenic beauty are approximately double those of normal flood-control related maintenance and non local users are the prime beneficiaries. It is therefore appropriate that the general public participate in meeting such additional maintenance costs."

- *Fish and Game Code, Section 1600:*

"The protection and conservation of the fish and wildlife resources of this State are hereby declared to be of utmost public interest... Their conservation is a proper responsibility of the State."

- *California Endangered Species Act 1973; Public Resources Code, Section 2050-2055:*

"The Legislature finds that many species of birds, mammals, fish, amphibia, and reptiles are endangered because their habitat is threatened with destruction, drastic modifications, or servere curtailment..." The Act gives authority to DFG to deem what animals in California are rare and endangered.

- *Senate Concurrent Resolution No. 28, 1978:*

"It is the intent of the legislature to preserve, protect, restore, and enhance California's wetlands and the multiple resources which depend upon them for the benefit of the people of the State."

- *Nejedly-Mobley Delta Levees Act of 1976; Water Code, Section 12225:*

"The plan for improvement of the Sacramento-San Joaquin Delta levees as set forth in Bulletin No. 192 of the Department of Water Resources, dated May 1975, is approved as a conceptual plan to guide the formulation of projects to preserve the integrity of the Delta levee system."

- *Keene-Nejedly Wetlands Preservation Act of 1976:*

"...the remaining wetlands of this State are of increasingly critical economic, aesthetic, and scientific value to the people of California, and...there is need for an affirmative and sustained public policy and program directed at their preservation in order that such wetlands shall continue in perpetuity to meet the needs of the people."

Federal Government

- *River and Harbors Act of 1899; 33 USC Section 401 et seq:*

Prohibits obstruction of navigable waters without a permit from Corps of Engineers.

- *Fish and Wildlife Coordination Act; 16 USC Section 611 et seq (1958, amended 1965):*

Wildlife conservation shall be given "equal consideration" with other features of water resource development. Empowers Secretary of Interior to provide assistance

to and cooperate with public and private organizations in development of all species of fish and wildlife and their habitats.

- *National Environmental Policy Act of 1969; 42 USC Section 4321 et seq:*

"The purposes of this Act are: to declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere..."

- *Federal Water Pollution Control Act Amendments of 1972; 33 USC Section 1251 et seq, PL 92-500:* (Clean Water Act)

"It is the national goal that wherever attainable, an interim goal of water quality be provided for the protection and propagation of fish, shellfish, and wildlife..." (Section 101)

- *Endangered Species Act of 1973; 16 USC Section 1531, et seq:*

Endangered species of wildlife and plants "are of aesthetic, ecological, educational, historical, recreational, and scientific value to the nation and its people". The act seeks to provide "a means whereby the ecosystems upon which (they) depend may be conserved." (Section 1531)

EXECUTIVE ORDERS AND AGENCY REGULATIONS

State of California

- *Decision 1485, August 1978; State Water Resources Control Board:*

"Beneficial uses in the Delta and Suisun Marsh have been classified historically under three broad categories: 1) wildlife, 2) agricultural, and 3) municipal and industrial. Water quality standards have been established for each of these broad categories of use to insure that each is protected in its own right. The underlying principal of these standards is that water quality in the Delta should be at least as good as those levels which would have been available had the State and federal projects not been constructed, as limited by the constitutional mandate of reasonable use."

- *Governor's Executive Order B-39-77:*

"...all state agencies shall provide leadership in efforts to minimize the risk of flood losses in connection with state lands and installations and state financed, insured, or assisted improvements."

Federal Government

- *Principles and Standards for Planning Water and Related Land Resources, U.S. Water Resources Council (Federal Register, Vol. 38, September 10, 1973):*

"The overall purpose of water and land resource planning is to promote the quality of life by reflecting society's preferences for attainment of the objectives defined

below (including)... To enhance the quality of the environment by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological system."

- *Presidential Executive Order No. 11988, May 24, 1977:*

"Each agency shall...take action to...restore and preserve the natural and beneficial values served by floodplains..."

- *Presidential Executive Order No. 11990, May 24, 1977:*

"Avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practical alternative."

- *Guidelines of U.S. Fish and Wildlife Service; Fed. Register Vol. 40, No. 231, December 1, 1975:*

"Objectives of the Department (of Interior) and Service in relation to dredge and fill and other water-related activities are to protect and preserve fish and wildlife habitat, conserve fish and wildlife resources, and protect public trust rights of use and enjoyment in and associated with navigable and other waters of the United States."

- *Regulatory Programs of the U.S. Army Corps of Engineers, 33 CFR 320-340; Fed. Register Vol. 44, No. 98, May 18, 1979:*

- River and Harbor Act of 1899
- Federal Water Pollution Control Act Amended in 1972
- Refuse Act Permit Program
- Marine Protection, Research and Sanctuaries Act, 1972; Section 103.

State-Federal

- *Four-Agency (DFG, USFWS, DWR, WRPS [Water Resources and Power Service]) Memorandum of Agreement (For CVP-SWP Operation Affecting the Delta, Draft of September 7, 1977; adoption pending):*

"The projects shall be operated to achieve the following goals:

- Restore and maintain adult populations of fish and wildlife on its average at the historic level; and
- Realize the Projects' potential for increasing these resources above historical levels consistent with other purposes of the Projects."

"The following objectives are designed to achieve the (above) goals...:

- Provide suitable environmental conditions for young fish and their food supply;

- Provide suitable water conditions for the upstream and downstream migration and survival of anadromous fish;

- Limit the diversions of young fish and fish food from the Delta by facilities of the Projects;

- Manage any new lands of the Projects in the Delta to develop fish and wildlife resources and to provide for recreational use of these resources by the general public, both compatible with other objectives of the Projects, provided that fish and wildlife resources are maintained at least at Nonproject levels;

- Promote selected riparian vegetation consistent with flood safety by preserving and planting trees and shrubs having high value for wildlife on or adjacent to any existing Delta levees that are modified in the future by Projects."

INTERNAL POLICIES AND GUIDELINES

State of California

- *California Fish and Wildlife Plan, 1966:*

Statewide resource management goals are:

- To maintain all species of fish and wildlife for their intrinsic and ecological values as well as for their direct benefits to man.
- To provide for diversified recreational use of fish and wildlife.
- To provide for an economic contribution of fish and wildlife in the best interest of the people of the State.
- To provide for scientific and educational use of fish and wildlife.

- *California Fish and Game Commission Resolution, February 9, 1973:*

"Place a high priority on (wetland) value for waterfowl habitat purposes..."

- *DFG Position on Delta Fishery Protection By A Delta Water Facilities, Nov. 29, 1975:*

- Utilize only truly surplus flows when meeting export needs. As high a portion of needs as possible should be met by exporting flood flows.
- Eliminate cross-Delta flows to restore the Delta's capacity as a nursery area and migration route for fish.
- Maintain net downstream flows in all channels. Such flows should be large enough to prevent water quality problems and to facilitate fish migrations, but not so large as to deplete the food supply for fish. Locating the diversion point as far downstream on the Sacramento River as is compatible with other needs might help satisfy this characteristic with minimum impact on water supply.
- Maintain as much of the Delta as possible as part of the tidal estuary.
- Locate diversion points so that fish are not drawn out of their normal migratory path and to avoid having to transport salvaged fish.

- *DFG Position on Delta and Suisun Marsh Wildlife Conservation By A Delta Water Facility, November, 1975:*

- Preserve existing wildlife habitat, or compensate fully for any unavoidable degradation and utilize opportunities to enhance such habitat.
- Avoid adverse impacts on rare or endangered plants and animals. If such damage is unavoidable, acre-for-acre, in-kind, full compensation for lost habitat is essential.

- *Delta Waterways Use Program, Delta Master Recreation Plan, 1976:*

"The program is specifically intended to: protect, preserve, and restore the Delta's natural and ecological values; halt development of, and cause removal of, unauthorized projects in, on, over and abutting Delta waterways...protect the public trust in the Delta waterways... These standards shall be mandatory upon and observed by all departments, boards, and commissions of the Resources Agency unless they conflict with statutory authority and shall be used by the Resources Agency in responding to U.S. Army Corps of Engineer Public Notices for permit requests in the Delta."

- *Resources Agency Policy for Preservation of Wetland in Perpetuity, 1977:*

"It is the basic policy of the Resources Agency that this Agency and its Department Boards, and Commissions will not authorize or approve projects that fill or otherwise harm or destroy coastal, estuarine, or inland wetlands."

Federal Government

- *Concept Plan for Waterfowl Wintering Habitat Preservation, Central Valley, California, USFWS, May, 1978:*

Key wintering habitat, at present unprotected, should be preserved and emphasis should be placed on development of new wetlands within the former boundaries of ancestral marsh.

Appendix B

EXERPTS CONCERNING WILDLIFE HABITAT:

DELTA MASTER RECREATION PLAN,

The Resources Agency, 1976

The following recommendations relating to habitat provide an important basis for components and recommendations contained in the Delta Habitat Plan.

- The Legislature should provide adequate funds to enable the State Lands Division to do the necessary title work to document and substantiate all of the State's titles in the Delta. The State Lands Commission should then firmly establish its claim to many nonleveed channel islands, berms and waterways to make private owners aware of potential conflicts over ownership and eliminate controversies over claims to public lands by adverse possession.

- The Resources Agency, with cooperation from federal, regional and local government, should be the central State agency responsible for coordinating the waterways and abutting land use planning, regulation and development of the Delta.

- The State Lands Commission should give priority to the identification of the ownership of lands of the Delta currently funded for State Park acquisition (the Delta Meadows, Cosumnes River and Channel Islands projects). The Department of Parks and Recreation should then give priority to the acquisition of these lands and, in coordination with appropriate agencies as well as public and private organizations, should proceed to develop recreational facilities deemed acceptable after public hearings.

- The Department of Water Resources in coordination with other governmental agencies and private organizations, should upon the selection of a Delta Water Facility, reinitiate the formulation of the recreation and wildlife features of the selected project.

- The Department of Fish and Game in cooperation with affected public agencies should continue efforts to improve wildlife habitat at Clifton Court Forebay (Department of Water Resources), the City of Isleton's waste water treatment facility (City of Isleton), Rough and Ready Island (U.S. Navy), and within highway rights-of-way (Caltrans). The Department should also continue to motivate landowners to provide areas for the maintenance or development of wildlife habitat.

- The Department of Water Resources should carry out its recently authorized responsibilities under the Nejedly-Mobley Delta Levees Acts. The Department should prepare plans and specifications for levee improvements utilizing Department of Water Resources Bulletin No. 192 as a concepts plan, implement a pilot levee project in an area of critical need of improvement after consummating a cost sharing agreement with a local agency, and report to the Legislature by specific dates on the levee improvement program. Local agency plans for maintenance and improvement of Delta levees should be compatible with the plans shown in Department of Water Resources Bulletin No. 192 and this Delta Master Recreation Plan.

- Levee improvement programs should be planned so as not to encourage urban development on existing agricultural lands.

- Expansion of the road system should be allowed only to serve new urban developments within existing communities and new public recreational developments.

- The further extension of public-service facilities, particularly roads and sewers, should be timed and directed to prevent scattered urban development from unnecessarily encroaching on agricultural lands.

- The Departments of Fish and Game and Navigation and Ocean Development (now Boating and Water Safety) in consultation with the Department of Parks and Recreation, State Lands Division and the Delta counties should give priority to the acquisition and management of selected nonleveed channel islands and other islands for the preservation and enhancement of wildlife habitat and scenic quality of the Delta and to provide for public boater-destination anchorages.

- The Department of Fish and Game should establish a priority program for the evaluation, acquisition and management of those islands that have been tentatively identified as follows:

  (a) The Channel islands in Latham Slough between Empire and Columbia Cut.

  (b) The unnamed island in the South Fork of the Mokelumne River just north of Sycamore Slough.

  (c) Browns Island (near Pittsburg).

  (d) The unnamed island in Old River near Bethany.

  (e) Old River islands, particularly Rhode Island, between Rock Slough and Quimby Island, including those in Connection Slough.

  (f) Eucalyptus Island between Widdow and Kings Island of Clifton Court Forebay.

- Local governments, in coordination with the Department of Navigation and Ocean Development and the Resources Agency, should establish limited speed and recreational use zones in areas where desirable. Local governments in coordination with the Department of Navigation and Ocean Development should also evaluate methods of establishing a coordinated boat patrol for better enforcement of boating safety and waterways use regulations.

- The Department of Water Resources and the U.S. Army Corps of Engineers, through their new multiple-purpose levee improvement studies, should ensure that both the State and federal levee standards for the Delta permit a maximum of vegetation to be retained on the levees. Stripped levees should be replanted and multiple-purpose levee maintenance standards established to allow original or replanted vegetation to remain on newly rehabilitiated levees where its retention would not adversely affect levee stability, navigation and the necessary flood carrying capacity of the channels.

- State fiscal assistance programs which encourage the retention and planting of vegetation on levees should give priority to "Natural Areas" (as identified in the Waterway Use Program). The U.S. Army Corps of Engineers, special districts, and

districts and local governments should ensure that their regulations, actions, policies and fiscal programs are consistent with that objective.

The Departments of Water Resources and Fish and Game, the U.S. Bureau of Reclamation and the U.S. Fish and Wildlife Service should continue their cooperative studies and actions relative to the Delta environment, fish and wildlife resource water management, export and fish protective facilities so that:

(a) An adequate understanding of the fish and wildlife resources of the San Francisco Bay-Delta System is developed;

(b) Proper design and operating criteria are developed for the State Water Project and the Central Valley Project, and;

(c) Project operations are monitored, evaluated and modified as necessary to ensure the protection and enhancement of fish and wildlife in the Delta.

Federal and State agencies should carefully study any navigation project which involves the deepening of Delta ship channels to ensure that the operation does not damage the Delta environment. Adequate mitigation should be required of any channel-deepening project that would adversely affect environmental quality.

- The Departments of Fish and Game, Parks and Recreation and Conservation, the State Reclamation Board and the U.S. Army Corps of Engineers should investigate the feasibility of revegetating Delta spoil deposition areas on a rotation basis and they should renegotiate agreements on present spoil sites on Lower Sherman Island and on the west side of the Sacramento River below Rio Vista.

Dredged material could be placed on Lower Sherman Island to provide better public access and spoil from the Rio Vista area could be placed on the east side of the river to provide a beach area and give protection to State Highway 160.

- Local governments should develop plans and regulations to implement the Delta Master Recreation Plan and its Waterways Use Program. These plans and regulations should:

(a) Include adoption of zoning ordinances that assure that uses of land abutting Delta waterways are compatible with the Waterways Use Program.

(b) Protect existing wildlife habitat, particularly that abutting waterways classified as "Natural" or "Scenic".

(c) Emphasize the reduction of conflicts among the uses of the waterways.

Local governments should recognize that the agricultural, open space and recreational resources of the Delta are of critical concern to the State. Maximum use should be made of zoning and enforceable restrictions, such as Williamson Act contracts, to protect Delta agricultural lands and open space from urban encroachment. Delta lands included in open space, agricultural and flood-hazard designations should be given the maximum regulatory protection. Urban development should be allowed only where the proposed project areas are provided with at least 100-year flood protection.

- Local governments should require proof of ownership prior to accepting property taxes on nonleveed channel islands to prevent the seizing of these islands by private individuals to the exclusion of the public. The prolifieration of structures on nonleveed channel islands can best be controlled by implementation and enforcement of the Waterways Use Program and strong local zoning ordinances.

- Landowners and Resource Conservation Districts, with assistance from the State Resource Conservation Commission should make maximum use of the U.S. Department of Agriculture programs and funding to conserve Delta soil and improve wildlife habitat.

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Appendix C

OPTIONS AVAILABLE FOR HABITAT PROTECTION

A number of options for the protection, implementation and restoration of Delta wildlife habitats were identified in the course of developing this plan; several ideas were borrowed from Protection and Restoration of San Francisco Bay Fish and Wildlife Habitats (DFG, 1979). Those options which were judged to be of highest priority for implementation appear as "recommendations" in the Summary and Recommendations section of this Plan.

The options presented below demonstrate the wide range of actions which could be taken to protect and improve Delta wildlife habitats. Some are obviously more feasible than others. A number of them, while not as important or timely as the recommendations in protecting Delta habitats, may nevertheless be pursued in the future by the Department and/or the Service.

OPTION 1: DFG in cooperation with Office of Planning and Research (OPR) develop better guidelines for fish and wildlife habitat protection, maintenance and restoration policies and criteria to be included in local general plan; and develop methods for review of general plans.

At present the OPR Guidelines for preparing general plans are inadequate regarding habitat protection. This option would encourage habitat issues to be adequately addressed by the general plan.

OPTION 2: DFG, with OPR, formulate and circulate a model zoning code for a resource conservation overlay district pertaining to development regulations in or adjacent to important habitat areas, and advocate their use by local governments.

Such a model code would establish a zoning district and specify the uses permitted, including requirements for buffer zones, drainage plans, mitigation measures, environmental review procedures, site-specific development location restraints, and dedications or restriction measures.

Area covered: Development of a model code would emphasize the Bay-Delta area, but its application would be statewide as well.

OPTION 3: DFG, with OPR and the Legislature, create an enforcement program for Section 65910 of the Governmental Code which requires that open space zoning be consistent with the open space plan, and open space plans be formulated and implemented.

Zoning and general plans, since 1974, must be consistent, but in some cases still are not. General plans and open space elements would be evaluated in relation to local zoning ordinances and maps and the requirements of state planning law. The OPR would be the agency responsible for implementing this option in cooperation with other agencies including DFG and State Lands Commission.

OPTION 4: DFG, with OPR, formulate and recommend a density transfer ordinance to protect the threatened environmental resources, and advocate their use by local governments.

Such an ordinance can establish a system allowing the transfer of development density from parcels in areas of environmental significance to areas where high density development is more appropriate.

OPTION 5: Local subdivision ordinances be revised to require: (a) habitat assessments, (b) open space dedication of habitat areas, (c) habitat impact mitigation measures, (d) performance bonds for development within wetland areas, and (e) denial of tentative and final maps for projects shown to have potential significant adverse impact on the environment and for which mitigation measures are not adequate.

These requirements would strengthen review procedures for subdivisions proposed in or adjacent to habitat areas by incorporating the intent and general provisions of CEQA. The suggestion does not imply redundant processes. Implementation of this option would result in cities and counties regulating subdivisions so that wildlife habitats are not significantly damaged.

OPTION 6: Legislation be enacted to require local governments to adopt and map a significant resource areas inventory (at least including areas identified in this plan) as part of their open space/conservation elements, to protect them with an appropriate overlay zone and to require a DFG/FWS review of all development proposals and impact assessment documents affecting these sites.

Implementation of this option would provide a vehicle for local governments to obtain advice from the DFG on the potential effects of specific development proposals, and the need for mitigation measures. Inclusion of the identified significant resource areas in the General Plan with new overlay zoning would provide a level of protection absent in the Delta today.

OPTION 7: Legislation be enacted requiring LAFCOs to evaluate the adequacy of wildlife protection policies in annexation proposals.

LAFCO should review the development and conservation policies of the jurisdictions involved in the annexation in relation to the protection of fish and wildlife habitats in the proposed annexation area. Guidelines could be formulated and circulated by OPR proposing that annexations not be approved if the level of habitat protection would be reduced, unless adequate mitigation measures were implemented. LAFCO also could request that the DFG review and comment upon annexation proposals for designated habitat areas.

OPTION 8: Sacramento and Stockton Port Districts, develop master plans reflecting a maximum feasible fish and wildlife habitat protection policy.

Regional port agencies, in practice, are not subject to local planning and development review. The proposed deep water channel projects make the need for such plans even more important.

OPTION 9: Legislation be enacted establishing a "land bank" in the DFG (or the State Coastal or Delta Conservancy), wherein a developer could purchase an appropriate parcel of land, such as subsided land which has become marginally economic for agriculture, for compensation and restoration of habitat lost to approved developments.

It has been difficult for project sponsors to compensate for small losses of important wildlife habitats, since it is often almost impossible to locate or manage small parcels with potential for developing habitats of the type lost. The establishment of a land bank, from which the developer could acquire an appropriate parcel of land, would provide a feasible means of compensating unavoidable losses. For example, subsided lands could be restored to wetland to replace habitat values lost. (See Chapter 4)

OPTION 10: Legislation be enacted to authorize placement of a "Bay-Delta Habitat Restoration Bond Act" on the ballot, with the funds to be administered by DFG.

A funding source for Delta restoration is not presently available. The traditional funding sources of the Wildlife Conservation Board are heavily pressured and few Delta projects can be supported from that source.

OPTION 11: Legislation be enacted to codify the "Delta Waterways Use Program."

The Legislature should implement the Delta Waterways Use Program, determine the feasibility of establishing enforceable standards for restricted wake zones to protect sensitive ecological resources, and establish limited recreational use zones. Implementation of the present program has been uneven.

OPTION 12: Improve implementation of the Delta Waterways Use Program by adapting the Army Corps of Engineers Delta Environmental Atlas Maps (1979a), overlaying the three waterway use zones.

The present scale of the waterways use program map is 1:126,720, which is not adequate for day-to-day implementation. The Corps' Atlas maps are at a scale of 1:12000. Overlays would show the exact location of the "Multiple Use," "Scenic," and "Natural Areas" to facilitate execution of Section 10 and 404 permits by the Corps of Engineers. Distribution should be to all concerned Federal, State and Local agencies.

OPTION 13: The assessment of a user fee on boaters using Delta waters be investigated.

Boating is a significant cause of levee damage, which requires costly maintenance. Such costs should be fairly allocated to include these users rather than be borne largely by landwowners.

OPTION 14: DFG and the State Lands Commission develop a priority program for the evaluation, acquisition, management, and enhancement of channel islands to be administered as ecological reserves.

Recommended in the 1976 Delta Master Recreation Plan.

OPTION 15: State EIR guidelines be revised to require that:

a. An EIR shall always be required for development and clearing projects in or adjacent to all sensitive wildlife habitat areas, including wetlands, riparian forests, waterways, tidal islands, and habitat of rare and endangered species.

b. EIRs and negative declarations affecting above areas shall always be sent to the State Clearinghouse (and hence to DFG).

Under existing State law, construction of a limited number of structures is categorically exempt under usual circumstances from the requirements of CEQA. The revision would designate specific sensitive habitat areas and deny the exemption from CEQA requirements of any new construction except for very minor accessory structures.

At present, EIRs prepared for projects in the Delta are required by CEQA Guidelines to be sent to the State clearinghouse.

OPTION 16: Establish temporary task force of all concerned agencies and selected authorities from the private sector to review and revise the Corps of Engineers project levee maintenance guidelines for the Sacramento and San Joaquin Rivers; for formal submittal to the Corps by FWS, DFG, and the Resources Agency. A consensus statement of multiple-purpose levee restoration and maintenance guidelines, guide this effort.

The basic authority for levee maintenance by the Corps is found in Title 33 of the Federal Code and is further detailed in two Sacramento District documents entitled Standard Operation and Maintenance Manual for the Sacramento River Flood Control Project (1955), and The Manual for the Lower San Joaquin River Levees, Lower San Joaquin River and Tributaries Project, California (1959). These guidelines must reflect engineering requirements balanced with multiple purpose needs, to include sensitive environmental standards.

OPTION 17: FWS should urge the Corps of Engineers, Sacramento District, to extend its Section 10/404 permit jurisdiction to diked lands below MHW which meet the wetland definition; to refine the overall regulatory process to include conditions on permits issued; and to provide post-reports on actions taken or permitted.

Few Corps Districts extend jurisdiction behind dikes. Since some diked portions of the Delta represent historic "navigable waters," it would seem appropriate to apply permit actions to a broader area.

OPTION 18: DFG/FWS, seek State and federal approval of a "Delta Restoration Fund" for financing the State's share for construction of multiple-purpose levees and the costs of maintaining vegetation cover on the levees. Funding would be from an annual surcharge on the cost of each acre-foot of water extracted from the Delta by the State Water project and, if federal conformance can be secured, the Central Valley Project.

The need for such a fund is based on these conclusions:

1. The quality of Delta exported water is dependent upon the continued existence of leveed islands to prevent the increase of the tidal prism and the resulting increase of salt water intrusion. All beneficiaries should share in levee costs.

2. Not only could increased salinity intrusion jeopardize the quality of the water at the south Delta pumping plants, but it would require increased discharges of freshwater from storage and/or transfer facilities to meet Delta water quality standards. Such releases will become increasingly difficult to execute as water needs increase. Improved levees will minimize such releases.

3. The existing pumping practices are creating a scouring action which has weakened levees in the southern Delta. Responsibility for improvement of these levees should be shared by the beneficiaries of this pumping system.

4. An improved levee system with appropriate amounts of riprap and vegetation to limit bank erosion will help to reduce the sediment load in the Delta waterways, a condition which is the region's most severe water quality problem. Water users will therefore profit from such levee work.

OPTION 19: DFG/FWS, develop detailed written and published policies and guidelines regarding mitigation and compensation and a consistent procedure to help in the evaluation of cumulative impacts.

Written policies and procedures are needed for more consistent treatment of applicants and projects. In addition, applicants would be able to design their projects with potential mitigation requirements in mind. Projection and evaluation of cumulative impacts is difficult; the DFG and FWS should actively work on developing methods of plotting and recording the accumulating changes in land use and associated habitats. Documentation of cumulative impacts would support the Corps and other agencies in their permit reviews.

OPTION 20: DFG/FWS, urge appropriate public agencies to revegetate with native species those lands now barren (such as at Clifton Court Forebay) or poorly vegetated (such as the Cross Delta Channel.

OPTION 21: DFG/FWS, assist in developing an experimental program to create riparian forest (woodland) in the Delta, conducted on publicly owned land.

OPTION 22: DFG/FWS, seek the creation of a State-federal task force to develop a State policy and program under the Clean Water Act "208" non-point water pollution control authority to protect, enhance, and restore riparian vegetation and wetlands for their value as erosion retardants and sediment filters.

One of California's major water pollution problems is sedimentation, a reflection of the high soil erosion rate in the

State. Because of its scope and funding, the 208 water program is probably the only vehicle in the present legal structure that can address the issue.

OPTION 23: DFG, in cooperation with FWS, initiate a "Delta Wildlife Habitat Restoration Program," based on this plan, using funding from multiple sources, to identify appropriate "special restoration areas" for public investments and establishment of Ecological Reserves or Wildlife Management Areas.

A management recommendation from the *California Fish and Wildlife Plan* (1966) declared that programs would be established "to carry out public acquisition of wetland and riparian habitat, with particular attention to rapidly disappearing bay and estuarine habitats." This has not occurred in the Bay-Delta area. An ongoing habitat acquisition (in some cases via a less than fee purchase) and enhancement program is needed.

Appendix D

PLANT SPECIES FOR USE ON DELTA LEVEES

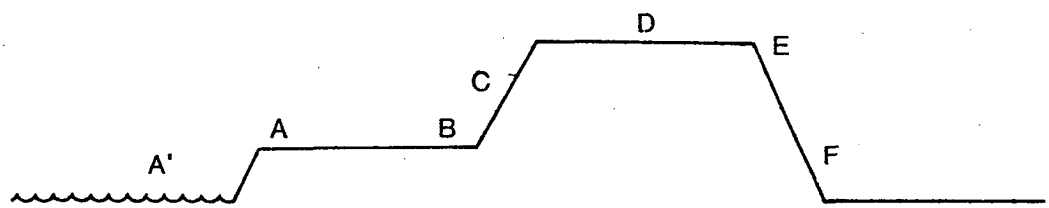
(Adapted from Whitlow et al.)

Introduction

The following appendix lists plant species which have been studied or suggested for use on levees. Part 1 includes those plants which are most promising for use on levees. Part 2 includes species for which there are limited observations or which may be useful under a limited set of conditions. Part 3 lists several species which are specifically unacceptable to the Reclamation Board and unsuitable for a variety of other reasons.

The listings are referenced to the studies or authors which have considered them (below), but their categories are based primarily on the opinion of the Whitlow study. Plants referenced specifically to the Whitlow study are considered most suitable. The lists do not include all plants found on levees or which could be suitable. Nor does it include all plants which are unsuitable for reasons of flood or salt intolerance. The reader should refer to Whitlow et al. for more detailed information.

Each list is broken down into the growth habit and functional use of the plants, i.e., trees, shrubs, vines, groundcovers, and aquatic plants. They are also keyed to "location on levee", shown in the following diagram.



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'ECIES MOST PROMISING FOR USE ON LEVEES

ıEES . RECOMMENDED SPECIES	LOCATION ON LEVEE	NATIVE OR EXOTIC	EVERGREEN, DECIDUOUS/ PERENNIAL, ANNUAL	REFERENCES	COMMENTS
cacia longifolia Golden wattle acacia	C, D, E	E	E	12	
cer negundo Box alder	A, B	N/E	D	1, 3, 6, 8, 12	Unacceptable to Rec. Bd.; some individuals survived Brannon Island flood.
lnus rhombifolia Sierra alder	A', A, B	N	D	1, 8, 12	
etula pendula White birch	A, B	E	D	6	Marginal flood tolerance
arya illinoensis Pecan	B, C, D, E, F	E	D	5, 6, 7	Survived '70 4' flood on Sherman Island, 120 day 16' flood at Folsom Lake. A "nut tree," therefore unacceptable according to Rec. Bd. standards.
atalpa speciosa Western catalpa	A, B		D	3, 11, 13	Not flood tolerant.
eltis australis European hackberry	A, B, C	E	D	3, 11, 13	Deciduous; both males and females required to produce fruit. Not flood tolerant.
Diospyros virginiana Persimmon	A, B, C	E	D	7	
Eleagnus angustifolia Russian olive	C, D, E, F	E	D	12	Sometimes spiny; not flood tolerant.
Eucalyptus camaldulenis (and varieties) River gum	A, C, D, E, F	E	E	4, 5, 6, 8	36" diameter individuals su vived 150 day, 12' flood on Sherman Island; performe well during Brannon Island flood.
Eucalyptus microtheca Flooded box	B, C, D, E, F	E	E	7	
Eucalyptus robusta Swamp mahogany	B, C, D, E, F	E	E	4,	Frost hardy to only 22° F.
Eucalyptus rudis Desert gum	A, B, C, D, E, F	E	E	3, 4, 6	Survived 112 day 13' flood on Brannon Island.
Eucalyptus sideroxylon Mulga ironbark	C, D, E, F	E	E	6, 7, 11	
Fraxinus latifolia Oregon ash	A, B	N	D	1	
Fraxinus pennsylvanica var. lanceolata Green ash	A, B	E	D	6	
Fraxinus velutina Arizona ash	A, B, C, D, E, F	E	D	3, 6, 8, 11, 13	

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C-056468

TREES (continued) RECOMMENDED SPECIES	LOCATION ON LEVEE	NATIVE OR EXOTIC	EVERGREEN, DECIDUOUS/ PERENNIAL, ANNUAL	REFERENCES	COMMENTS
Fraxinus velutina 'Modesto' Modesto ash	A, B, C, D, E, F	E	D	6	
Gleditsia triacanthos var. inermis thornless Honey locust	B, C, D, E, F	E	D	3, 6, 8, 11, 13	Some other varieties have stout thorns.
Liquidambar styraciflua Sweet gum	B, C, D, E, F	E	D	3, 6, 7	Survived Brannon Island flood.
Nyssa sylvatica Swamp tupelo	A, B	E	D	7	
Platanus racemosa California sycamore	A, B, C, D, E, F	N	D	1, 6, 8	
Populus fremontii Fremont's cottonwood	A, C, D, E, F	N	D	1, 3, 5, 6, 8	Judged unacceptable for levees by Rec. Bd.
Quercus agrifolia Coast live oak	C, D, E, F ?	N	E	1, 12	No flood tolerance.
Quercus lobata Valley oak	B, C, D, E, F	N	D	1, 3, 6, 8, 12	Slow growing; good mast producer
Robinia pseudoacacia Black locust	C, D, E, F	E	D	3, 5, 6, 8	Judged unacceptable for levees by Rec. Bd. Poor flood tolerance.
Salix goodingii var. goodingii and var. variabilis	A', A, B, C	N	D	1, 3, 5, 13	Judged unacceptable for levees by Rec. Bd.
Sapium sebiferum Tallow tree	A, B, C	E	D	7	
Taxodium distichum Baldcypress	A', A, B	E	D	6, 7, 8	Will grow under permanent flooding.
Zelkova serrata Zelkova	A, B, C	E	D	3, 8, 11, 13	Poor flood tolerance.
SHRUBS					
Artemisia douglasiana Mugwort	A, B, C	N		1, 8, 13	
Atriplex lentiformis Quail bush	A	N	E	1, 2, 12, 13	Forage for waterfowl and small mammals; do not plant near sugar beets. Salt tolerant.
Baccharis douglasii Quail bush	A', A, B	N	D	1, 8	

C—056468

C-056469

RUBS (continued) RECOMMENDED SPECIES	LOCATION ON LEVEE	NATIVE OR EXOTIC	EVERGREEN, DECIDUOUS/ PERENNIAL, ANNUAL	REFERENCES	COMMENTS
ccharis glutinosa False willow	A', A, B	N		1, 8	
ccharis pilularis Coyote bush	B, C, D, E, F	N	E	3, 8, 12	
accharis viminea Mule fat	A, B	N		1, 2, 8, 13	
allistemon citrinus Bottlebrush	C, D, E, F	E	E	6	
allistemon viminalis Weeping Bottlebrush	A', A, B, C	E	E	7	
eanothus foliosus Wavyleaf ceanothus	C, D, E, F	N	E	3, 13	Not flood tolerant.
Ceanothus thrysiflorus Blue brush	C, D, E, F	N	E	3, 11	Not flood tolerant
Cephalanthus occidentalis Buttonwillow	A', A, B	N	D	1, 7, 8, 12, 13	One of the most flood tolerant woody species.
Cornus glabrata Brown dogwood	A', A	N	D	1	
Cornus stolonifera Redosier dogwood	A', A	N	D	1, 7, 8, 13	
Heteromeles arbutifolia Toyon	C, D, E, F	N	E	1, 2, 3, 8, 11, 12, 13	Both accepted and rejected by Rec. Bd. Not flood tolerant
Hibiscus californicus California hibiscus	A	N	Biennial	1, 8	Considered rare but fairly widespread.
Isomeris arborea Bladder Pod	C, D, E, F	N	D	12	Fast growing; not flood tolerant
Salix hindsiana Sandbar willow	A', A, B, C	N	D	1, 8, 13	Common on Delta levees.
Salix lasiolepis Willow	A, B, C	N	D	1, 8	
Sambucus spp. Elderberry	A, B, C	N	D	3	Unacceptable to Rec. Bd; g forage and cover for birds and small mammals. Low flood tolerance. (Sambucus caerulea is acceptable for the Rec. Bd.)
Sambucus caerulea (S. glauca) Blue elderberry	A, B, C	N	D	2, 12	Produces small fruits whic are eaten by birds.

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SHRUBS (continued) RECOMMENDED SPECIES	LOCATION ON LEVEE	NATIVE OR EXOTIC	EVERGREEN, DECIDUOUS/ PERENNIAL, ANNUAL	REFERENCES	COMMENTS
Sambucus mexicana Elderberry	A, B, C, E, F	N	D	1	Produces small fruits which are eaten by birds. Low flood tolerance.
Sambucus racemosa Red elderberry	A, B, C	N	D	2	
VINES					
Campsis radicans Trumpet vine	E, F	E	D	6	A stout, woody climber, relatively easy to control. Low flood tolerance.
Clematis lasiantha Clematis	B, C, D, E, F	N	D	1	A stout, woody climber, relatively easy to control. No flood tolerance.
Clematis ligusticifolia Clematis	B, C, D, E, F	N	D	1	Somewhat woody but easily broken. No flood tolerance.
GROUND COVER					
Agropyron elongatum Largo tall wheatgrass	A, B, C, D, E	E	P	9, 13	
Agropyron intermedium 'Oahe' Intermediate wheatgrass	D, E, F	E	P	6	
Agropyron trichophorum 'Luna' Luna pubescent wheatgrass	A, B, C, D, E	E	P	9, 13	Drought tolerant
Cynodon dactylon 'Coastal' Coastal bermuda	All zones	E	P	3, 13	Very versatile, but will not form closed sward below MHT. Salt tolerant.
Cynodon dactylon 'Tufcote' Tufcote bermudagrass	All zones	E	P	9	
Distichlis spicata Salt grass	A, B, C	N	P	8, 13	Salt tolerant.
Festuca ovina var. duriuscula Durar hard fescue	B, C, D, E, F	E	A	9	Annual, first year cover crop
Iris pseudacorus Yellow iris	A'	E	P	13	Widely naturalized in the Delta.
Phyla nodiflora (=Lippia nodiflora) Garden lippia	A, B, C	E	P	9	Good bee plant.

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C-056471

GROUND COVER (continued) RECOMMENDED SPECIES	LOCATION ON LEVEE	NATIVE OR EXOTIC	EVERGREEN, DECIDUOUS/ PERENNIAL, ANNUAL	REFERENCES	COMMENTS
Mesembryanthemum spp. "Ice plant"	C, E	E	P	3	Very shallow roots.
Phalaris arundinacea Reed canary grass	A, B, F	N	P	6, 8	
Phalaris tuberosa var. hirtiglumis Perla koleagrass	A, B, C, D	E	P	9	
Vicia exigua California vetch	B, C, D, E, F	E	A	12	Good wildlife food and cover.
AQUATIC PLANTS					
Eleocharis acicularis Spikerush	A'	N	P	8, 14	Forms dense, closed swards, but may be hard to establish
Eleocharis coloradoensis Spikerush	A'	N	P	14	Forms dense, closed swards, but may be hard to establish
Eleocharis macrostachys Spikerush	A', A	N	P	3	Common and durable, but may be hard to establish.
Juncus effusus Rush	A', A	N	P		Forms clumps instead of clos swards.
Phragmites australis Common Reed	A', A	N	P	1, 13	
Salicornia depressa no common name	A', A		A	10	Colonizes readily on stable material; tolerates 70-80 ppm salinity.
Salicornia pacifica Pickleweed	A', A	N	P	10, 13	Salt tolerant.
Salicornia rubra Red pickleweed	A', A	N	A	10	Salt tolerant.
Scirpus acutus Common tule	A'	N	P	13	
Scirpus californicus California tule	A'	N	P	13	
Scirpus fluviatilis River bulrush	A'	N	P	13	
Scirpus robustus Saltmarsh bulrush	A'	N	P	13	
Spartina alterniflora Smooth cordgrass	A'	E	P	10, 13	Tolerates 50-60 ppm salinit
Spartina foliosa California cordgrass	A'	N	P	10, 13	

C—056471

C-056472

SPECIES WHICH MAY BE SUITABLE FOR USE ON LEVEES

TREES POSSIBLY SUITABLE SPECIES	LOCATION ON LEVEE	NATIVE OR EXOTIC	EVERGREEN, DECIDUOUS/ PERENNIAL, ANNUAL	REFERENCES	COMMENTS
Acacia baileyana Bailey's acacia	A, D, E, F	E	E	3	Unacceptable to Rec. Bd. No flood tolerance.
Acacia decurrens Green wattle	A, B, C, D, E, F	E	D	5	
Acacia melanoxylon Blackwood acacia	A, B, C, D, E, F	E	E	3, 5, 11	Unacceptable to Rec. Bd.
Acacia retinoides Water wattle	A, B	E	E	3, 11, 12	
Acacia verticillata Star acacia	C, D, E, F	E	E	3	Small tree if pruned. Low flood tolerance.
Acer rubrum var. Drumondii Drummond Red maple	A, B	E	D	7	
Acer saccharinum Silver maple	A, B, C	E	D	3, 6	Unacceptable to Rec. Bd., survived Brannon Island flood.
Aesculus californica California buckeye	D	N	D	1	A riparian species of the foothills woodland; drought deciduous. No flood tolerance.
Albizia julibrissin Silk tree	A, B	E	D	3, 11	
Arbutus unedo Strawberry tree	B, C		E	3	Slow growing, prefers acid soils. No flood tolerance.
Citrus paradisi Grapefruit	D, E, F	E	E	6	Low flood tolerance
Citrus sinensis Orange	D, E, F	E	E	6	Low flood tolerance
Eucalyptus aggregata Black gum	A, B, C, D, E, F	E	E	4, 6	A useful tree for marshy flats. Low flood tolerance.
Eucalyptus bicolor River black box	A, B, C, D, E, F	E	E	4	
Eucalyptus cosmophylla Cup gum	C, D, E	E	E	6	No flood tolerance.
Eucalyptus globulus var. compacta Swarf Tasmanian blue gum	C, D, E, F	E	E	4, 5, 6	Large individuals survived a 60 day, 4' flood on Sherman Island.
Eucalyptus gunnii Cider gum	C, D, E, F	E	E	4, 5	Low flood tolerance.
Eucalyptus kitsoniana Bog gum	A, B, C, D, E, F	E	E	4	

C—056472

C-056473

TREES (continued) POSSIBLY SUITABLE SPECIES	LOCATION ON LEVEE	NATIVE OR EXOTIC	EVERGREEN, DECIDUOUS/ PERENNIAL, ANNUAL	REFERENCES	COMMENTS
Eucalyptus polyanthemos Australian beech		E	E	11	
Eucalyptus populnea Bimble box	D, E, F	E	E	7	No flood tolerance.
Eucalyptus sargentii Sargents mallet	E, F	E	E	7	No flood tolerance.
Eucalyptus spathulata Swamp mallet	A, B, C, D, E, F	E	E	4	
Eucalyptus viminalis Manna gum		E	E	4	
Grevillea robusta Silk oak	B, C, D, E	E	E	11	Low flood tolerance.
Ligustrum lucidium Glossy privet	C, F	E	E	6	Somewhat drought tolerant. Low flood tolerance.
Melia azedarach China-berry	C, D, E, F	E	D	6	Drought tolerant.
Morus alba Fruitless mulberry cvs.	C, D, E, F	E	D	5, 6	No flood tolerance.
Olea europaea Olive	C, D, E, F	E	E	6, 12	No flood tolerance.
Platanus X acerifolia London Planetree	A, B, C, D, E, F	E	D	3, 5, 6	Judged unacceptable for levees by Rec. Bd.; numerous individuals survived the Brannon Island flood.
Populus alba White poplar	A, B, C, D, E, F	E	D	6	
Populus X canadensis Canadian poplar	A, B, C, D, E, F	E	D	6	
Populus balsimifera (P. candicans) Balsam poplar	A, B, C, D, E, F	E	D	6	13 plants survived a 97 day 10' flood on Brannon Island
Populus nigra 'Italica" Black poplar	A, B, C, D, E, F	E	D	5, 6	
Populus tomentosa Chinese White poplar	A, B, C, D, E, F	E	D	5	
Populus trichorcarpa Black cottonwood	A, B, C, D, E, F	N	D	5	
Prunus lyonii Catalina cherry	C, D, E, F	N	E	3	

C—056473

C-056474

TREES (continued) POSSIBLY SUITABLE SPECIES	LOCATION ON LEVEE	NATIVE OR EXOTIC	EVERGREEN, DECIDUOUS/ PERENNIAL, ANNUAL	REFERENCES	COMMENTS
Pyrus communis Pear	C, D, E, F	E	E	5, 6	
Quercus palustris Pin oak	B, C	E	D	6	
Quercus wislizenii Interior live oak	B, C, D, E, F	N	E	1	Low flood tolerance.
Salix alba 'Tristis' White willow	A, B	E	D	6	
Salix babylonica Babylon Weeping Willow	A, C, D, E	E	D	3, 5, 6	Survived a 133 day, 20' flood at Folsom Lake. Judged unacceptable for levees by Rec. Bd.
Salix blanda Wisconsin Weeping Willow	A, B, C	E	D	3, 5, 6	Judged unacceptable for levees by Rec. Bd.
Salix discolor Pussy willow	D	E	D	6	Low flood tolerance.
Salix laevigata Red willow	A', A, B	N	D	1	
Salix lasiandra Pacific willow	A', A, B	N	D	1	
Salix matsudana Pekin willow	A, B, C, D	E	D	6	
Schinus molle California pepper tree	C, D, E, F	E		3, 8	Unacceptable to Rec. Bd. No flood tolerance.
Sophora japonica Pagoda tree	B, C	E	D	1, 3	No flood tolerance.
Platycladus orientalis (Thuja orientalis) Oriental arborvitae	B	E	E	6	
Umbellularia californica California laurel	B, C, F	N	E	3, 8	
SHRUBS					
Abelia grandiflora Glossy abelia	C, D	E	1/2 E	6	
Aronia melanocarpa Red chokeberry	B, C, D	E	D	7	
Berberis darwinii Darwin barberry	C, D, E		E	2, 4	"Excellent for wildlife." No flood tolerance.

C—056474

C-056475

SHRUBS (continued)

RECOMMENDED SPECIES	LOCATION ON LEVEE	NATIVE OR EXOTIC	EVERGREEN, DECIDUOUS/ PERENNIAL, ANNUAL	REFERENCES	COMMENTS
Baccharis glutinosa False willow	A', A, B	N		1, 8	
Baccharis pilularis Coyote bush	B, C, D, E, F	N	E	3, 8, 12	
Baccharis viminea Mule fat	A, B	N		1, 2, 8, 13	
Callistemon citrinus Bottlebrush	C, D, E, F	E	E	6	
Callistemon viminalis Weeping Bottlebrush	A', A, B, C	E	E	7	
Ceanothus foliosus Wavyleaf ceanothus	C, D, E, F	N	E	3, 13	Not flood tolerant.
Ceanothus thrysiflorus Blue brush	C, D, E, F	N	E	3, 11	Not flood tolerant
Cephalanthus occidentalis Buttonwillow	A', A, B	N	D	1, 7, 8, 12, 13	One of the most flood tolerant woody species.
Cornus glabrata Brown dogwood	A', A	N	D	1	
Cornus stolonifera Redosier dogwood	A', A	N	D	1, 7, 8, 13	
Heteromeles arbutifolia Toyon	C, D, E, F	N	E	1, 2, 3, 8, 11, 12, 13	Both accepted and rejected by Rec. Bd. Not flood tolerant
Hibiscus californicus California hibiscus	A	N	Biennial	1, 8	Considered rare but fairly widespread.
Isomeris arborea Bladder Pod	C, D, E, F	N	D	12	Fast growing; not flood tolerant
Salix hindsiana Sandbar willow	A', A, B, C	N	D	1, 8, 13	Common on Delta levees.
Salix lasiolepis Willow	A, B, C	N	D	1, 8	
Sambucus spp. Elderberry	A, B, C	N	D	3	Unacceptable to Rec. Bd; gc forage and cover for birds and small mammals. Low flood tolerance. (Sambucus caerulea is acceptable for the Rec. Bd.)
Sambucus caerulea (S. glauca) Blue elderberry	A, B, C	N	D	2, 12	Produces small fruits which are eaten by birds.

C—056475

C-056476

SHRUBS (continued) RECOMMENDED SPECIES	LOCATION ON LEVEE	NATIVE OR EXOTIC	EVERGREEN, DECIDUOUS/ PERENNIAL, ANNUAL	REFERENCES	COMMENTS
Sambucus mexicana Elderberry	A, B, C, E, F	N	D	1	Produces small fruits which are eaten by birds. Low flood tolerance.
Sambucus racemosa Red elderberry	A, B, C	N	D	2	
VINES					
Campsis radicans Trumpet vine	E, F	E	D	6	A stout, woody climber, relatively easy to control. Low flood tolerance.
Clematis lasiantha Clematis	B, C, D, E, F	N	D	1	A stout, woody climber, relatively easy to control. No flood tolerance.
Clematis ligusticifolia Clematis	B, C, D, E, F	N	D	1	Somewhat woody but easily broken. No flood tolerance.
GROUND COVER					
Agropyron elongatum Largo tall wheatgrass	A, B, C, D, E	E	P	9, 13	
Agropyron intermedium 'Oahe' Intermediate wheatgrass	D, E, F	E	P	6	
Agropyron trichophorum 'Luna' Luna pubescent wheatgrass	A, B, C, D, E	E	P	9, 13	Drought tolerant
Cynodon dactylon 'Coastal' Coastal bermuda	All zones	E	P	3, 13	Very versatile, but will not form closed sward below MHT. Salt tolerant.
Cynodon dactylon 'Tufcote' Tufcote bermudagrass	All zones	E	P	9	
Distichlis spicata Salt grass	A, B, C	N	P	8, 13	Salt tolerant.
Festuca ovina var. duriuscula Durar hard fescue	B, C, D, E, F	E	A	9	Annual, first year cover crop
Iris pseudacorus Yellow iris	A'	E	P	13	Widely naturalized in the Delta.
Phyla nodiflora (=Lippia nodiflora) Garden lippia	A, B, C	E	P	9	Good bee plant.

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C-056477

GROUND COVER (continued) RECOMMENDED SPECIES	LOCATION ON LEVEE	NATIVE OR EXOTIC	EVERGREEN, DECIDUOUS/ PERENNIAL, ANNUAL	REFERENCES	COMMENTS
Mesembryanthemum spp. "Ice plant"	C, E	E	P	3	Very shallow roots.
Phalaris arundinacea Reed canary grass	A, B, F	N	P	6, 8	
Phalaris tuberosa var. hirtiglumis Perla koleagrass	A, B, C, D	E	P	9	
Vicia exigua California vetch	B, C, D, E, F	E	A	12	Good wildlife food and cover.
AQUATIC PLANTS					
Eleocharis acicularis Spikerush	A'	N	P	8, 14	Forms dense, closed swards, but may be hard to establish.
Eleocharis coloradoensis Spikerush	A'	N	P	14	Forms dense, closed swards, but may be hard to establish.
Eleocharis macrostachys Spikerush	A', A	N	P	3	Common and durable, but may be hard to establish.
Juncus effusus Rush	A', A	N	P		Forms clumps instead of closed swards.
Phragmites australis Common Reed	A', A	N	P	1, 13	
Salicornia depressa common name	A', A		A	10	Colonizes readily on stable material; tolerates 70-80 ppm salinity.
Salicornia pacifica Pickleweed	A', A	N	P	10, 13	Salt tolerant.
Salicornia rubra Red pickleweed	A', A	N	A	10	Salt tolerant.
Scirpus acutus Common tule	A'	N	P	13	
Scirpus californicus California tule	A'	N	P	13	
Scirpus fluviatilis River bulrush	A'	N	P	13	
Scirpus robustus Saltmarsh bulrush	A'	N	P	13	
Spartina alterniflora Smooth cordgrass	A'	E	P	10, 13	Tolerates 50-60 ppm salinity.
Spartina foliosa California cordgrass	A'	N	P	10, 13	

C-056477

C-056478

:S (continued)

)SSIBLY SUITABLE SPECIES	LOCATION ON LEVEE	NATIVE OR EXOTIC	EVERGREEN, DECIDUOUS/ PERENNIAL, ANNUAL	REFERENCES	COMMENTS
ıs communis ar	C, D, E, F	E	E	5, 6	
cus palustris n oak	B, C	E	D	6	
cus wislizenii terior live oak	B, C, D, E, F	N	E	1	Low flood tolerance.
x alba 'Tristis' ite willow	A, B	E	D	6	
x babylonica bylon Weeping Willow	A, C, D, E	E	D	3, 5, 6	Survived a 133 day, 20' flood at Folsom Lake. Judged unacceptable for levees by Rec. Bd.
x blanda sconsin Weeping Willow	A, B, C	E	D	3, 5, 6	Judged unacceptable for levees by Rec. Bd.
x discolor ssy willow	D	E	D	6	Low flood tolerance.
x laevigata d willow	A', A, B	N	D	1	
x lasiandra cific willow	A', A, B	N	D	1	
x matsudana cin willow	A, B, C, D	E	D	6	
ıus molle lifornia pepper tree	C, D, E, F	E		3, 8	Unacceptable to Rec. Bd. No flood tolerance.
ɔra japonica ɜoda tree	B, C	E	D	1, 3	No flood tolerance.
ɣcladus orientalis ıuja orientalis) iental arborvitae	B	E	E	6	
llularia californica lifornia laurel	B, C, F	N	E	3, 8	
3S					
ia grandiflora ɔssy abelia	C, D	E	1/2 E	6	
ia melanocarpa d chokeberry	B, C, D	E	D	7	
ɜris darwinii ɜwin barberry	C, D, E		E	2, 4	"Excellent for wildlife." No flood tolerance.

C—056478

C-056479

(continued)

SUITABLE SPECIES	LOCATION ON LEVEE	NATIVE OR EXOTIC	EVERGREEN, DECIDUOUS/ PERENNIAL, ANNUAL	REFERENCES	COMMENTS
rophylla onica ese boxwood	D, E	E	E	6	Low flood tolerance.
s spp. ring quince	D, E	E	D	6	
r lacteus otoneaster	C, D, E	E	E	2	No flood tolerance.
ria agatiflora ird bush		E	E	2	
s japonica euonymus	C, D, E, F	E	E	6	Low flood tolerance.
p.	C, D, E, F	E	E	6	Some species may become weeds. Low flood tolerance.
ssurgentiflora ia tree mallow	D, E	N	D	6	
ermum laevigatum an tea tree	B, C, D, E	E	E	6	Somewhat salt tolerant.
um spp.	D, E, F	E	E/D	5	No flood tolerance.
nvolucrata erry	A	N	D	1	
munis e	B, C	E	E	6	
domestica bamboo	A, B, C	E	D	6	Berries may be eaten by wildlife. Low flood tolerance.
leander id	B, C, D, E, F	E	E	3, 6, 8	Unacceptable to Rec. Bd.; poisonous to ungulates. Salt tolerant; low flood tolerance.
a glauca tree	C, D, E, F	N	D	3	Unacceptable to Rec. Bd. No flood tolerance.
serrulata e photinia	C, D, E, F	E	E	2	No flood tolerance.
tobira range	C, D, E, F	E	E	6	Low flood tolerance.
liniana cherry laurel	C, F (?)	E	E	6	Low flood tolerance
folia cherry laurel	C, D, E, F	N	E	3, 12	No flood tolerance.

C-056479

C-056480