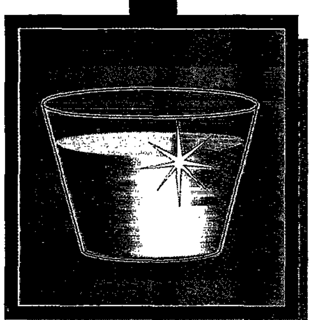

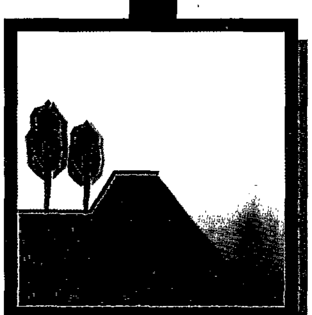

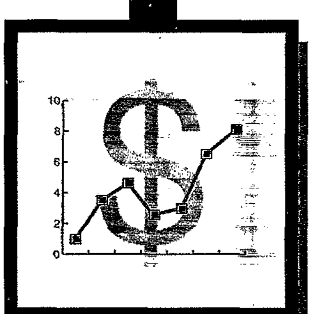

CALFED
BAY-DELTA
PROGRAM

Long-Term Levee Protection Plan

Programmatic EIS/EIR
Technical Appendix
March 1998

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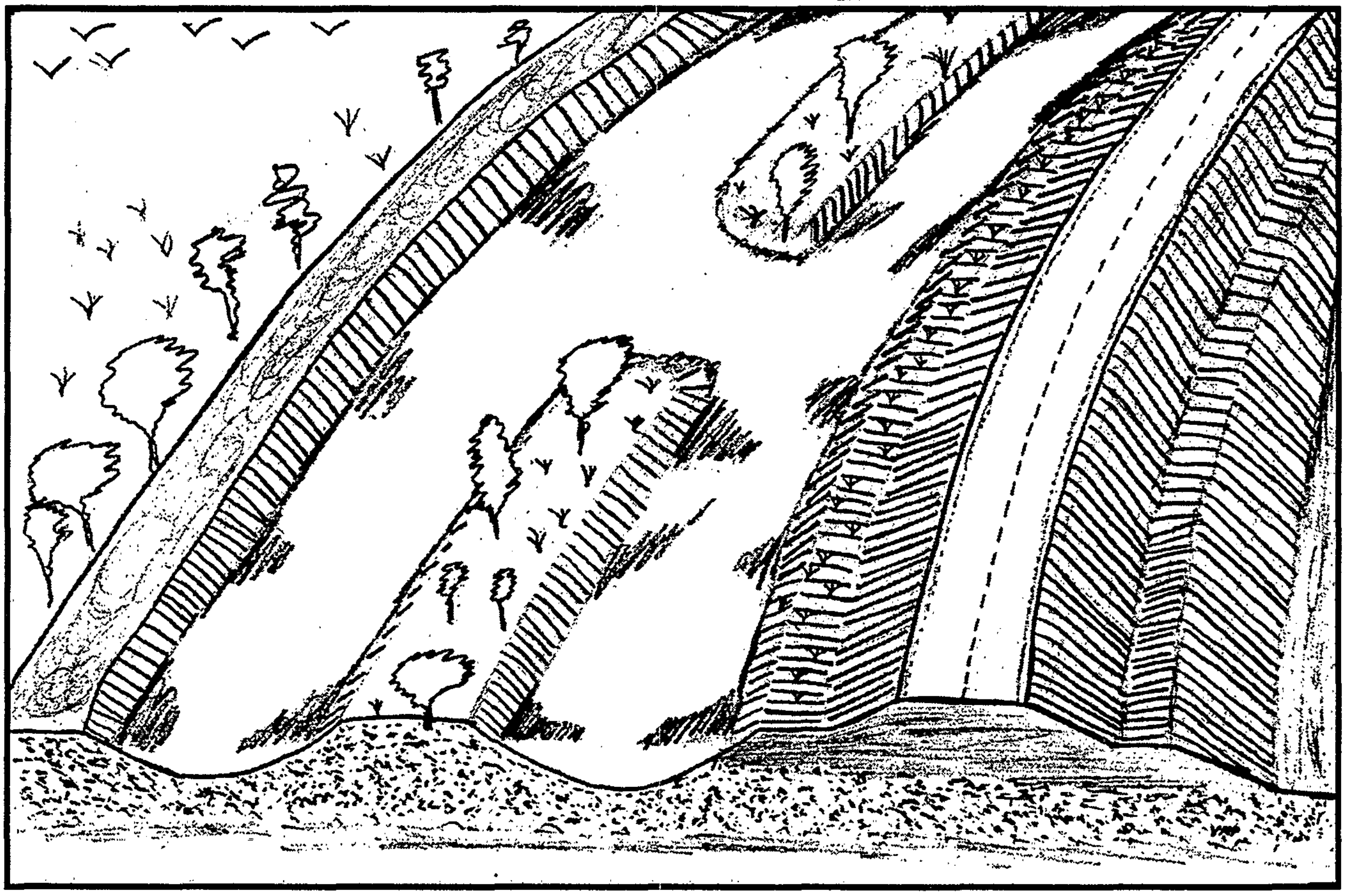
CALFED Delta Levee System Integrity Program



Long-Term Levee Protection Plan
Draft
December 1997

Reduce the risk to land use and associated economic activities, water supply, infrastructure, and ecosystem, from catastrophic breaching of Delta Levees

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DELTA LEVEE SYSTEM INTEGRITY PROGRAM

Foreword

This program, like all components of the Program's alternatives, is being developed and evaluated at a programmatic level. The complex and comprehensive nature of a Bay-Delta solution means that it will be composed of many different programs and activities that will be implemented over time. Solution alternatives will be evaluated as sets of programs and activities so that broad benefits and impacts can be identified. More focused analysis and environmental documentation of specific programs and actions will occur in subsequent refinement efforts.

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Glossary

The following terms are used in describing the Delta Levee System Integrity Program:

Action - A physical, operational, legal, or institutional change intended to maintain or achieve a desirable condition (target) of the Delta levee system.

Boil - Seepage exit point on the land side of the levee characterized by the rapid movement (boiling) of sand particles.

Channel islands - Small unleveed land masses within Delta channels which typically provide good wildlife habitat. Some are remnants of original Delta marsh lands and others are the result of channel widening, levee construction, and dredged material disposal.

Cut-off wall - An impermeable barrier constructed through the levee to interrupt (cut-off) seepage through the levee and or foundation. A slurry cutoff wall is a combination of soil, cement, and bentonite (a clay material) constructed inside a trench down the center of the levee. This trench must be sufficiently deep to cut off or reduce seepage through or under the levee.

Delta islands - Islands in the Sacramento-San Joaquin Delta protected by levees. The surface of the majority of islands are below sea level and provide many benefits including agriculture, recreation, water quality, and habitat for fish and wildlife.

Drainage blanket - A layer of crushed rock which may be encapsulated in filter fabric that is placed on the slope and land side toe of a levee prior to placement of a stability berm. It helps to control seepage and piping.

Erosion - Loss of levee material due to the effects of channel flows, tidal action, boat wakes, and wind-generated waves.

Ecosystem Restoration Program Plan - A comprehensive plan for restoration and management of the Bay-Delta ecosystem, including upstream tributaries and watersheds.

Hydrostatic pressure - The pressure of water at a given depth resulting from the weight of the water above it.

Implementation Objective - A description of what the program will strive to maintain or achieve for the Delta levee system which is not intended to change over the life of the program.

Levee crown - The top surface between the edges of a levee.

Liquefaction - The process in which a saturated sandy soil loses strength when subjected to ground shaking during an earthquake.

Non-project levee - A flood control levee in the Delta that is not a federal flood control project levee.

Oxidation - The conversion of organic soil (such as peat) by bacteria to carbon dioxide. The conversion is directly related to aerobic soil bacteria.

Piping - The process of seepage carrying away levee material resulting in larger seepage paths within the levee.

Primary zone - The Delta land and water area of primary state concern and statewide significance which is situated within the boundaries of the Delta, but which is not within either the urban limit line or sphere of influence line of any government's general plan or currently existing studies, as of January 1, 1992 (Delta Protection Act of 1992).

Project levee - A flood control levee which is part of a federal flood control project.

Reclamation district - A local agency responsible for the maintenance of levees within their boundaries.

Seepage - A slow movement of water through permeable soils caused by hydrostatic pressure.

Seismicity - The frequency, intensity, and distribution of earthquake activity in an area.

Setback levee - A constructed embankment to prevent flooding that is positioned some distance from the edge of the river or channel. Setback levees provide area for wildlife habitat to develop and for floodflow capacity.

Settlement - The sinking of surface elevations as a result of underlying soil consolidation caused by an increase in the weight of overlying deposits, the movement of foundation materials, or the extrusion of water.

Slope protection - Various types of materials used to protect the levee surface and streambank adjacent to the levee from erosion.

Stability berm - Earth fill usually placed against the levee land side slopes to act as a counterweight to prevent rotational slides.

Subsidence - The loss of soil within the first few feet of the surface due to organic soil oxidation and topsoil erosion is referred to as shallow subsidence. Deep subsidence is caused by groundwater withdrawal and a decline of natural gas pressure due to gas extraction wells.

Target - A qualitative or quantitative statement of an implementation objective. Targets may vary as new information becomes available and may vary based on Delta conveyance alternatives. Targets are to be set based on realistic expectations, must be balanced against other resource needs, and must be reasonable, affordable, cost effective, and practicably achievable.

Toe ditch - The open trench along the land side toe of the levee usually used for collection of seepage water and distribution for agricultural purposes.

Toe drain - A trench along the land side toe of the levee designed to reduce saturation of the levee, control seepage, and help prevent boils. A toe drain is constructed by placing crushed rock in a trench at the land side toe of the levee. The rock is encapsulated in filter fabric that prevents levee and foundation soils from migrating into the rock.

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CALFED Bay-Delta Program

DELTA LEVEE SYSTEM INTEGRITY PROGRAM

Objective

Reduce the risk to land use and associated economic activities, water supply, infrastructure, and the ecosystem from catastrophic breaching of Delta levees.

Vision

The Sacramento-San Joaquin Delta is an area of great regional and national importance, which provides a broad array of benefits including agriculture, water supply, transportation, navigation, recreation and fish and wildlife habitat. Delta levees are the most visible and critical feature of this system.

Historically, the levee system has been viewed as a means of protecting other Delta resources. However, levees are an integral part of the Delta landscape and are key to preserving the Delta's physical characteristics and processes. A goal for the program is to integrate their role in defining the waterways and islands with long-term ecosystem restoration of the Bay-Delta system.

Given the numerous public benefits protected by Delta levees, the focus of the Delta Levee System Integrity Program is to supplement and improve Delta levee maintenance and emergency management practices. Developing a mechanism to ensure long-term availability of funding to implement the Delta Levee System Integrity Program and equitable distribution of the costs is an important component of the Finance and Assurances Implementation Strategy for the overall CALFED Bay-Delta Program.

Introduction

The mission of the CALFED Bay-Delta Program is to develop a long-term comprehensive plan that will restore ecosystem health and improve water management for beneficial uses of the Bay-Delta system. CALFED addresses problems in four resource areas: ecosystem quality, water quality, system integrity, and water supply reliability. Programs are designed and integrated to address problems in the four resource areas to fulfill the CALFED mission.

The Delta levee system provides protection to:

- Delta communities
- Existing land use
- Water quality
- Ecosystem
- Infrastructure
- Economic activities
- Water supply operations

These resources are at risk from potential failure of the Delta levees and flooding of Delta islands. Water supply operations and water quality are at risk from increased salinity intrusion which could result from the sudden catastrophic inundation of Delta islands.

The focus of the Delta Levee System Integrity Program is to provide long-term protection for multiple Delta resources by maintaining and improving the integrity of the Delta levee system. In addition, this program aims to integrate ecosystem restoration and Delta conveyance actions with levee improvement activities. Improvements in the reliability of water quality will be a natural by product of this program.

Background

Delta islands, of which the majority have land surface elevations below sea level, provide many benefits including agriculture, transportation, water quality, recreation, and fish and wildlife habitat. Natural settling of the levees and shallow subsidence of Delta island soils (oxidation which lowers the level of the land over time) has resulted in a need to increase levee heights to maintain protection. This increased height relative to the islands interior surface elevation, coupled with poor levee construction and inadequate maintenance, makes Delta levees vulnerable to failure, especially during earthquakes or floods.

The following reclamation and water management activities greatly influenced the current Delta which includes over 700,000 acres, 700 miles of meandering waterways and over 1,100 miles of levees.

1849 Settlers began arriving in the Delta to farm its rich soils. The majority of the Delta was marsh land prior to subsequent reclamation and conversion to agricultural lands.

1850 Congress passed the Federal Swamp and Overflow Act, which provided for the title of wetlands to be transferred from the federal government to the states.

1861 California legislature authorized the State Reclamation District Act. As a result of state and federal legislation, swamp and overflow land was sold and reclaimed for agricultural use by construction of levees. The Delta was transformed from a large tidal marsh to a system of improved channels and levees by the early 1900s.

Congress authorized the Central Valley Water Project (CVP).

1933 The Stockton Deep Water Ship Channel, which extends from the confluence of the Sacramento and San Joaquin Rivers to the City of Stockton, was completed.

1940 The Contra Costa Canal, which exports water from the south Delta to the Bay Area, was completed. This was the first unit of the CVP which utilized existing channels to convey water through the Delta for export.

1944 Shasta Dam and Reservoir, a key feature of the CVP used to capture and store water, was completed. This project provided additional water to Delta channels during low-flow periods.

1951 The Delta-Mendota Canal, which exports water from the Delta via the Tracy Pumping Plant to the San-Joaquin valley, was completed. This is another unit of the CVP which increases exports from the Delta.

The Delta Cross Channel, which aids transfer of water from the Sacramento River across the Delta to the Tracy Pumping Plant, was completed.

1959 The Delta Protection Act was enacted by the California Legislature to protect, conserve, develop, control, and use the waters of the Delta for the public good.

1960 Voters approved the State Water Resources Development Bond Act (also known as the Burns-Porter Act) to help finance the initial facilities of the State Water Project (SWP). These facilities included master levees, control structures, channel improvements, and appurtenant facilities in the Sacramento-San Joaquin Delta used for water conservation, water supply in the Delta, transferring water across the Delta, and flood and salinity control.

The Sacramento River Flood Control Project, authorized by Congress, was completed by the U.S. Army Corps of Engineers. This project incorporated and improved certain Delta levees to provide improved flood control for a portion of the Delta. These levees are commonly referred to as "project" levees.

1963 The Sacramento Deep Water Ship Channel, which extends from the confluence of the Sacramento and San Joaquin Rivers, was completed.

1967 Oroville Dam and Reservoir, which provides increased channel flows during low-flow periods, was completed. This is a key feature of the State Water Project (SWP) and includes the Feather River Fish Hatchery to replace spawning areas lost as a result of the Dam.

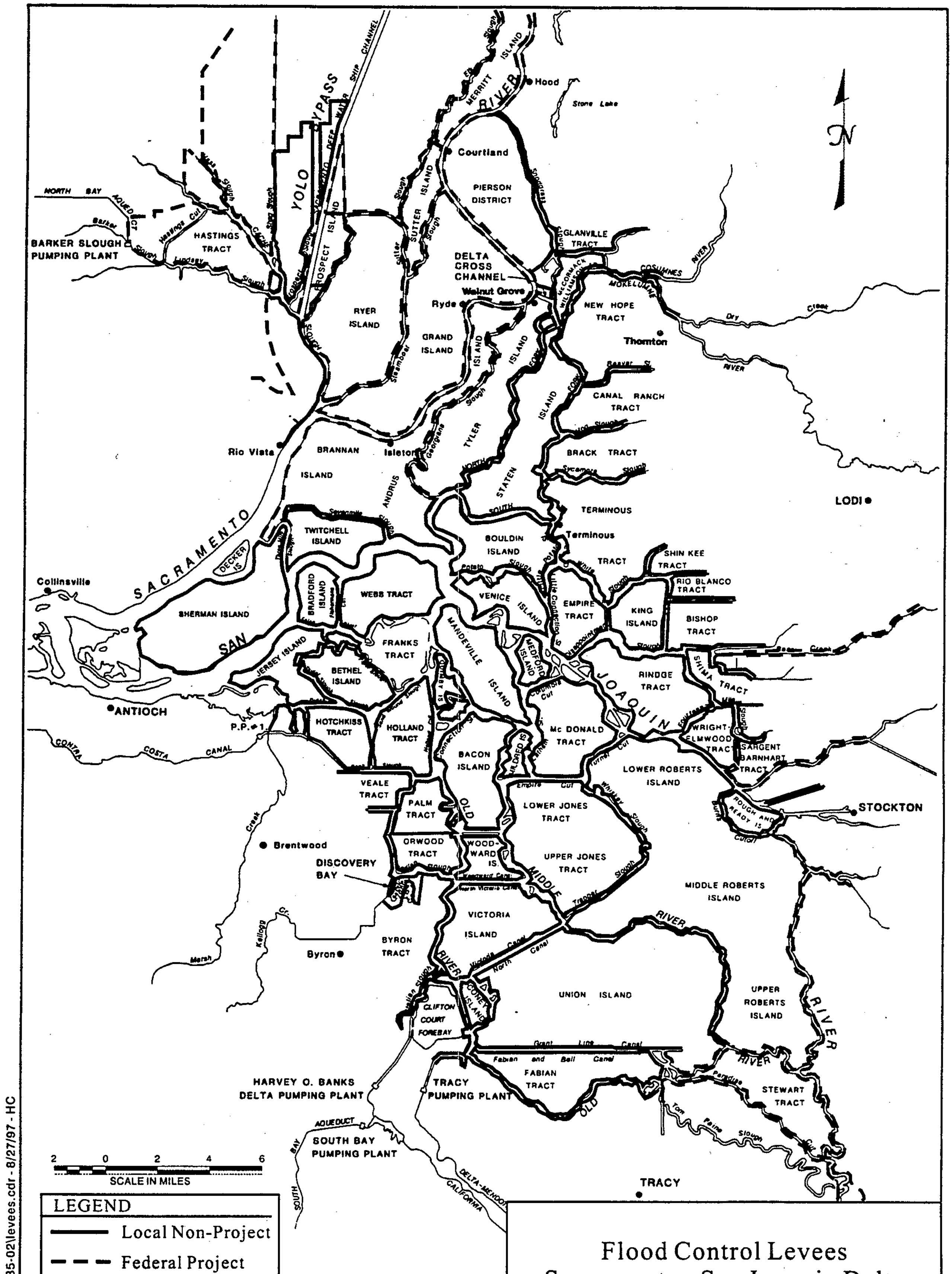
The first stage of the Harvey O. Banks Delta Pumping Plant, another unit of the SWP, was completed along with the John E. Skinner Fish Facility. Diversions from the Delta to the California and South Bay aqueducts of the SWP began.

Construction of Clifton Court Forebay located in the south Delta began. This is another unit of the SWP to facilitate export of water from the Delta.

1988 Barker Slough Pumping Plant, which provides water from the northwest Delta for the North Bay aqueduct, was completed.

Suisun Marsh salinity control gates, which aid in controlling water quality in the marsh for protection of waterfowl, was completed.

FIGURE 1



Flood Control Levees
Sacramento - San Joaquin Delta

Source: DWR 1993.

Inundation of one or more islands in the Delta can disrupt wildlife habitat, farming operations, and other land uses either permanently or for a significant period of time until repairs can be made. Inundation of roads, electric power lines, telephone lines, gas mains, and other infrastructure can cause lengthy delays in service. Several state highways and many Delta roads run along levees that are vulnerable to collapse due to erosion, seismic events, or overtopping. Major water distribution systems also pass through the Delta and are at risk of failure. Even if these numerous facilities survive the initial effects of inundation, long-term inundation would make continued maintenance and repair difficult, if not impossible. If a flooded island is not repaired and drained, the resulting large body of open water can expose adjacent islands to increased wave action and additional seepage.

Long-term flooding of key Delta islands can also affect water quality by changing the rate and extent of saltwater intrusion from San Francisco Bay. Inundation of one or more key islands in the western and central Delta would allow salinity to intrude further into the Delta. This would be of particular concern in a low water year when less freshwater would be available to repel the incoming salt water. This salinity intrusion would degrade water quality and could result in water supply interruption for in-Delta and export use by both urban and agricultural users, until the salt water could be flushed from the Delta. In order to lower salinity in the Delta to acceptable levels, flushing flows would need to be released from upstream reservoirs. Stored water supplies in these reservoirs could be seriously depleted.

The California Legislature recognized that the Delta levee system benefits many segments and interests of the public at large and approved a conceptual plan in 1973 to preserve the integrity of the Delta levee system. The Delta Levee Maintenance Subvention Program was enacted to provide state funding and technical assistance for maintenance and rehabilitation of non-project Delta levees. The Delta Flood Protection Act of 1988 (SB 34) created the Special Flood Control Project Program for eight islands in the western Delta and the towns of Thornton and Walnut Grove. This act also amended the Delta Levee Maintenance Subvention Program and established a special account in the California Water Fund for appropriation by the Legislature for mitigation activities. Later, SB 1065 and AB 360 amended SB 34.

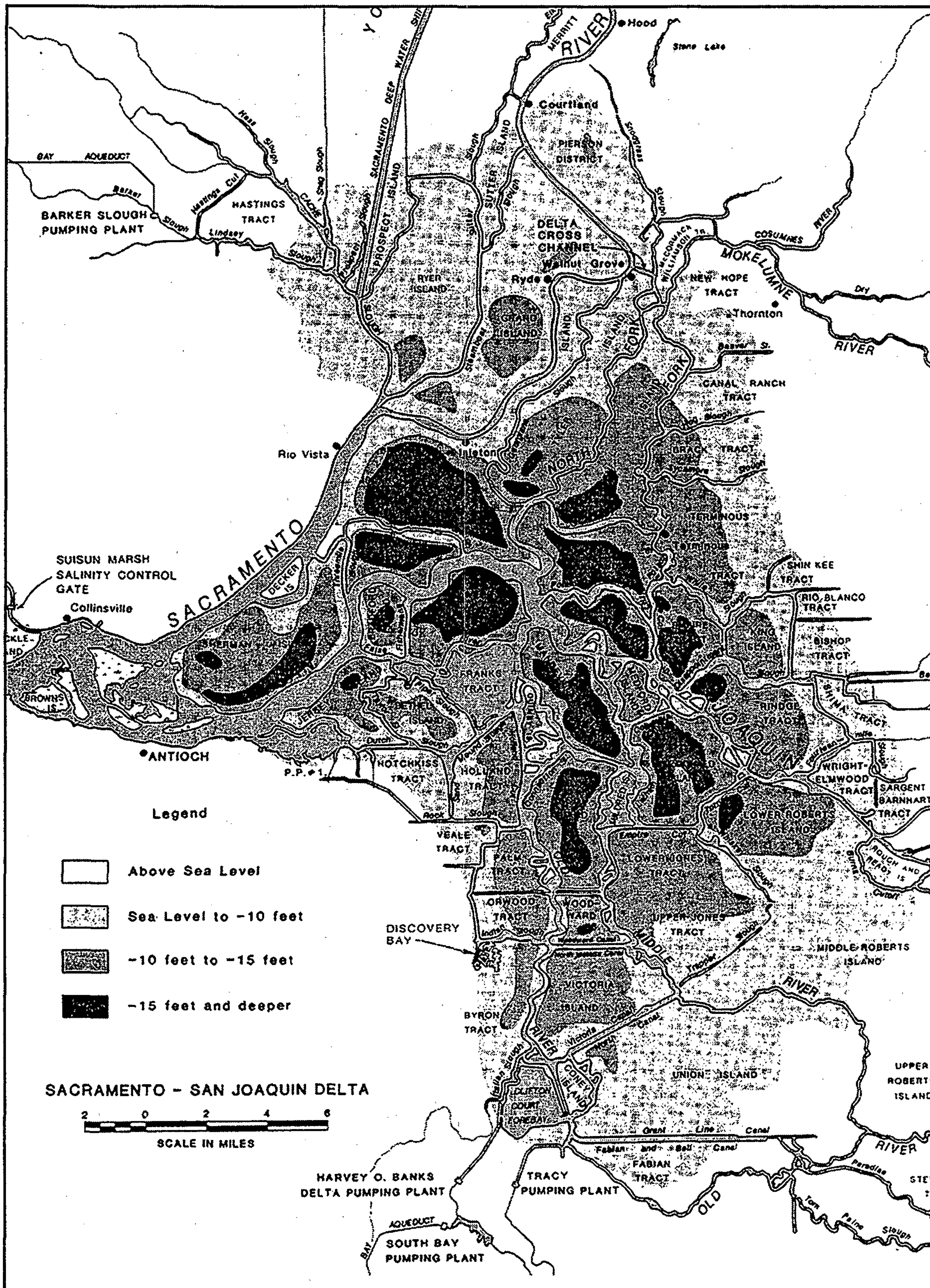


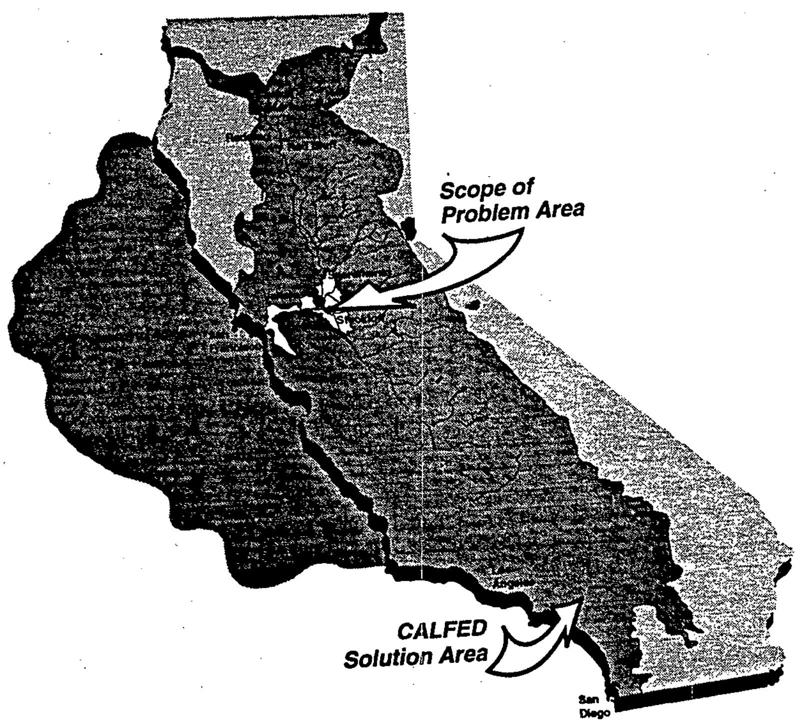
Figure 2
Land Surface Below Sea Level

The Delta Protection Commission (DPC) was established by the Delta Protection Act of 1992. The Act acknowledges that agricultural land within the Delta is of significant value, including its function of providing open space and habitat for waterfowl using the Pacific Flyway. The DPC has prepared a regional long-term resource management plan for the Delta to protect, maintain, and, where possible, enhance and restore the overall quality of the Delta environment, including, but not limited to agriculture, wildlife habitat, and recreational activities. All local general plans for areas within the Primary zone and within the boundaries of the Delta are required to be consistent with the DPC regional plan. In addition, the Safe, Clean, Reliable Water Supply Act (Proposition 204) was approved by voters in 1996 to fund a variety of Delta improvements and local programs designed to address California water needs, including Delta levee system improvements.

Geographic Scope

The geographic scope of the CALFED Bay-Delta Program consists of the legally defined Delta, Suisun Bay (extending to the Carquinez Strait), and Suisun Marsh. The Delta Levee System Integrity Program is focused on the legally defined Delta. The relationship between Delta channels, tributaries to the Delta, and upstream watersheds may require actions within the geographic solution area defined by the Program to resolve Delta levee system problems.

FIGURE 3



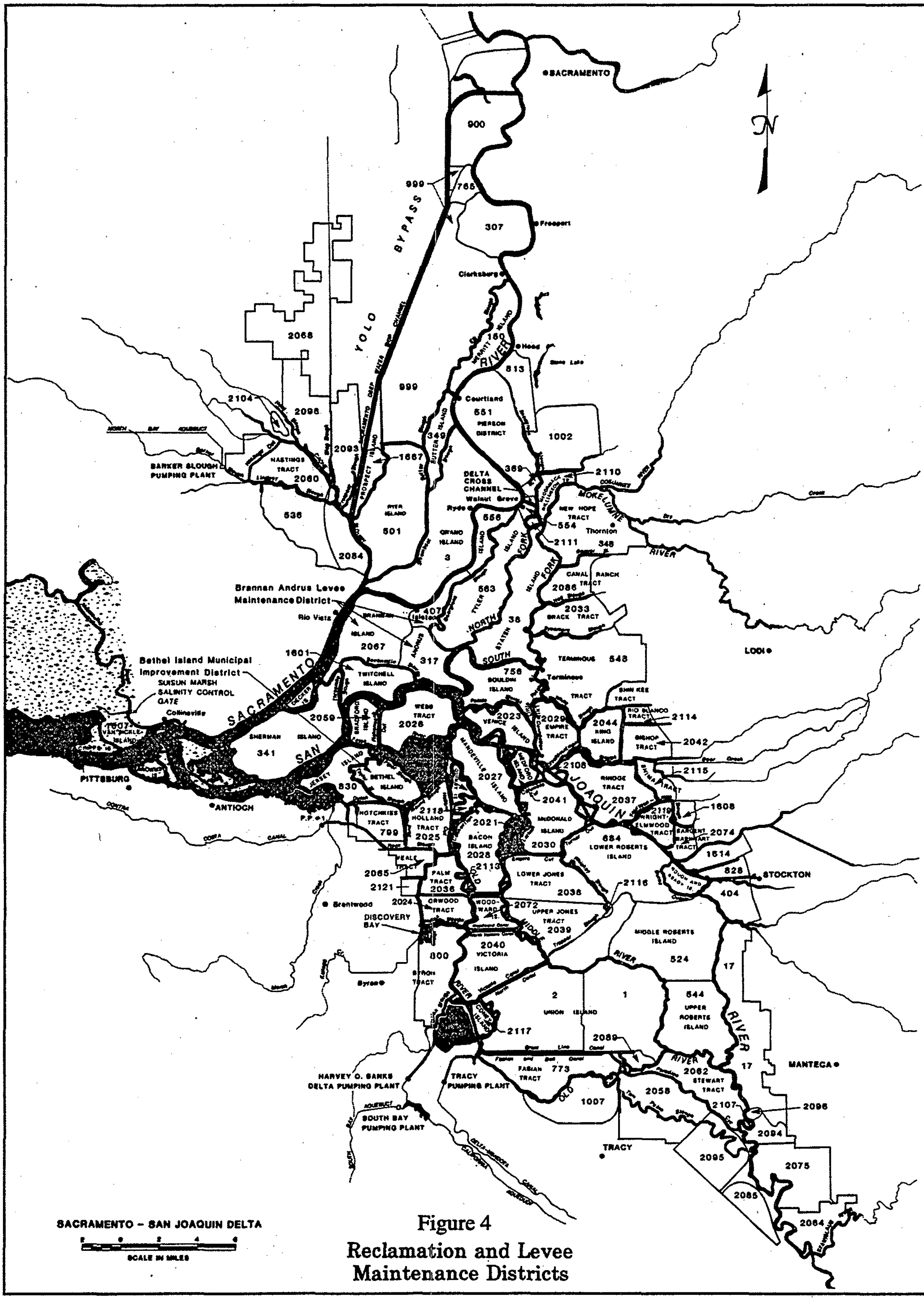


Figure 4
Reclamation and Levee Maintenance Districts

Implementation Strategy

The general approach for the Delta Levee System Integrity Program will be built upon a foundation of existing state, federal, and local agency programs. The focus of this program is to supplement and improve these existing programs where deficiencies are identified, and enhance opportunities to integrate ecosystem restoration with efforts to preserve and improve system integrity.

In most cases, system integrity problems are well understood and the actions needed to improve conditions are clear. In other cases, additional research is needed before potential solutions can be developed. Improvement of Delta levees and channels will require years of evaluation and coordination. For example, subsidence of Delta islands is well understood, but measures to slow or reverse the process are still being developed. Implementing this program will require reliable, long-term funding which distributes the costs of assuring long-term levee system integrity among all beneficiaries.

Ecosystem restoration and conveyance improvements will be integrated with levee improvements to protect existing Delta physical characteristics and processes. This integration will provide opportunities to address multiple problems in the Delta and to coordinate with other program actions.

Full implementation of this program will meet Public Law 84-99 (PL-99) performance criteria for project and non-project levees in the Delta. Over several decades, a phased process will coordinate potential improvement actions with ecosystem restoration and conveyance improvements. For example, actions to control subsidence can be implemented in conjunction with ecosystem restoration activities and provide an opportunity to continue investigation for reversing subsidence. Habitat improvements, such as creating corridors or Delta channel conveyance improvements, can provide opportunities for improvements for flood control. A comprehensive emergency management plan will be implemented to address protection and recovery of Delta resources in coordination with maintenance and improvement measures.

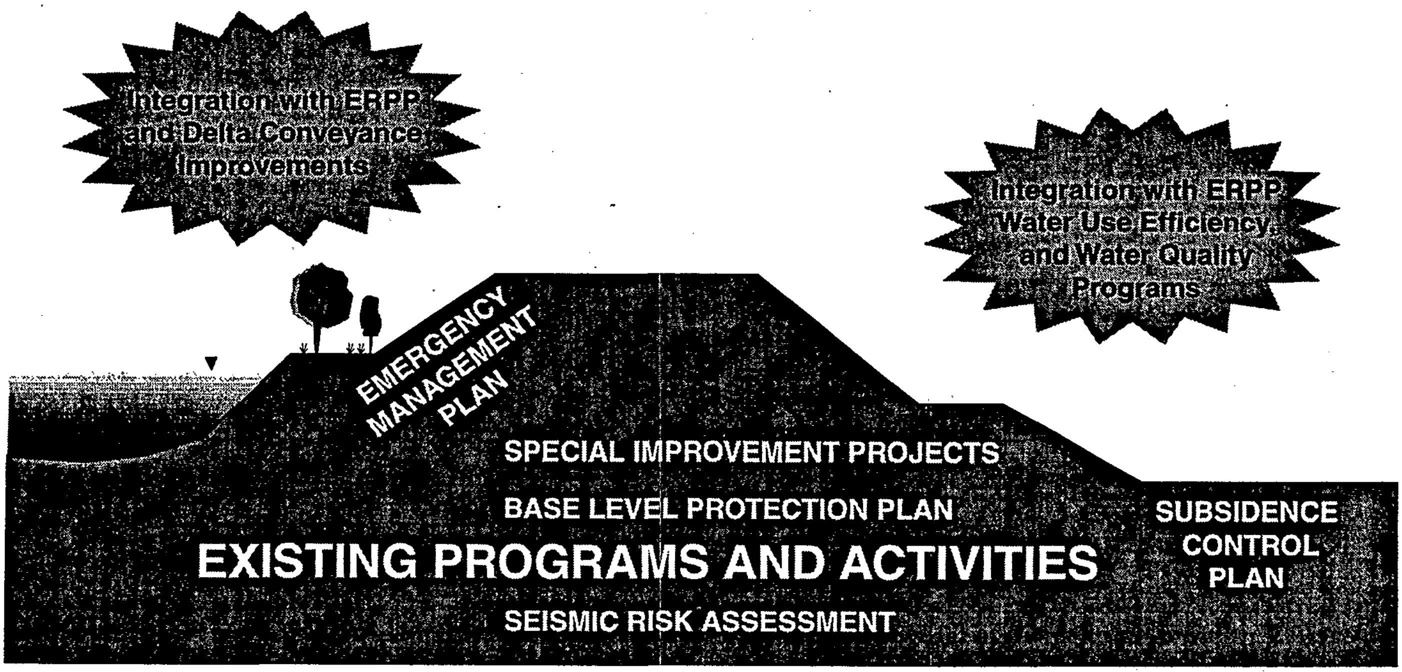
Program Elements

The specific elements of the Delta Levee System Integrity Program include:

- Delta Levee Base Level Protection Plan
- Delta Levee Special Improvement Projects
- Delta Island Subsidence Control Plan
- Delta Levee Emergency Management Plan
- Delta Levee Seismic Risk Assessment

FIGURE 5

Delta Levee System Integrity Program Elements



Program staff will work with stakeholders, the public, and state and federal agencies, to identify existing programs, potential deficiencies within existing programs, and specific actions for each element of the program to address any identified deficiencies. These actions will be closely integrated with the Ecosystem Restoration Program Plan and Delta conveyance actions to simultaneously increase system integrity, increase ecosystem quality, and protect water quality and water supply reliability.

Delta Levee Base Level Protection Plan

Implementation Objective	Target	Action
Uniformly improve Delta levees	Improve Delta levee system stability to meet PL 84-99 criteria	Modify levee cross sections by raising levee height, widening levee crown, flattening levee slopes, and/or constructing stability berms
	Maintain Delta levees to the PL 84-99 standard	Develop a long term maintenance plan
Establish a stable funding source	Provide necessary funding to improve and then maintain Delta levees to the PL 84-99 standard for the CALFED planning horizon	Prepare cost estimates
		Identify beneficiaries to provide equitable distribution of costs
		Develop funding sources
Streamline and consolidate the permitting process	Reduce the time required to acquire all necessary permits	Develop a uniform process to coordinate and approve all permits
		Provide regional mitigation banking
		Coordinate with the EERP to provide an environmental enhancement component

This plan will build upon existing programs to improve levees to meet the U. S. Army Corps of Engineers PL 84-99 standard. Please see Appendix B for more detailed information on this element of the program.

Delta Levee Special Improvement Projects

Implementation Objective	Target	Action
Enhance flood protection for key islands that provide statewide benefits to the ecosystem, water supply, water quality, economics, infrastructure, etc.	Improve levee stability in key Delta locations to a level commensurate with the benefits which the levees protect	Modify levee cross sections by raising levee height, widening levee crown, flattening levee slopes, and/ or constructing stability berms in key Delta locations
	Maintain improved levees	Develop a long term maintenance plan
Establish a stable funding source	Provide necessary funding to improve and then maintain key levees for the CALFED planning horizon	Prepare cost estimates
		Identify beneficiaries to provide equitable distribution of costs
		Develop funding sources
Streamline and consolidate the permitting process	Reduce the time required to acquire all necessary permits	Develop a uniform process to coordinate and approve all permits
		Provide regional mitigation banking
		Coordinate with the EERP to provide an environmental enhancement component

These projects will provide increased flood protection separate from the Delta Levee Base Level Protection Plan for Delta islands that protect many public benefits such as water quality, agricultural production, cultural resources, recreation, the ecosystem, life and personal property, and local and statewide infrastructure. Please see Appendix C for more detailed information on this element of the program.

Delta Island Subsidence Control Plan

Implementation Objective	Target	Action
Reduce the risk to levee stability from subsidence	Reduce, eliminate, or reverse subsidence adjacent to affected levees	Fund grant projects to develop BMP's that restore interior island elevations
		Fund subsidence grant projects after BMP's are established
Streamline and consolidate the permitting process	Reduce the time required to acquire all necessary permits	Develop a uniform process to coordinate and approve all permits
		Provide regional mitigation banking
		Coordinate with the EERP to provide an environmental enhancement component

Please see Appendix D for more detailed information on this element of the program.

C-007117

Delta Levee Emergency Management Plan

Implementation Objective	Target	Action
Enhance emergency response capabilities and resource allocation	Develop the capability to efficiently respond to multiple concurrent levee breaks within the Delta	Develop a Delta-focused multi-agency emergency response team
		Implement the recommendations made in the FEAT Report dated May 10, 1997
		Develop SEMS/ICS organization and implementation criteria
		Purchase materials in advance and place in strategic locations
		Develop standardized contracts with contractors for forces and equipment to respond with short notice
		Improve site access and develop mobilization strategy
Develop a stable funding source for emergency response	Provide funding for a well defined Disaster Assistance Program	Prepare cost estimates
		Identify beneficiaries to provide equitable distribution of costs
		Develop funding sources

This plan will enhance existing emergency management response capabilities to protect critical Delta resources in the event of a disaster. Please see Appendix E for more detailed information for this element of the program.

C-007117

Delta Levee Seismic Risk Assessment

Implementation Objective	Target	Action
Quantify Delta levee seismic risk and compare it to other failure modes	Document findings in a report to CALFED	Continue to gather baseline seismic information Perform dynamic testing of levee material properties, and levee stability analysis Assemble a board of seismic and geotechnical experts (Delta Levee Consulting Board) to make recommendations to CALFED decision makers on the potential impact of seismic loading on Delta levees and how it compares with other failure modes
Determine how Delta levees can best be improved to reduce their susceptibility to damage/failure from seismic loading	Document findings in the report to CALFED	Delta Levee Consulting Board will make recommendations to CALFED on the potential for seismic retrofitting of Delta levees

This assessment will identify the risk to Delta resources during catastrophic seismic events and develop recommendations to improve the stability of Delta levees. The Department of Water Resources' Seismic Investigation is being continued. This investigation consists of installing strong-motion accelerometers at three to four levee sites in the Delta; creating a geologic model for deeper soil deposits; ongoing field and laboratory testing to better determine the static and dynamic properties of organic soils; field and laboratory testing to better determine liquefaction potential; and investigation of the potential activity of the Coast Range-Sierra/Nevada Boundary Zone. A board of seismic and geotechnical experts, The Delta Levee Consulting Board, will make recommendations on the potential impact of seismic loading on Delta levees and how it compares with other failure modes. The Board will also make recommendations on the potential for seismic retrofitting of Delta levees.

Please see Appendix F for more detailed information for this element of the program.

Related Program Activities

The CALFED Ecosystem Restoration Program Plan will address special habitat improvements, levee associated habitat, Delta in-channel islands, and beneficial reuse of dredge material which were formerly included as elements of the Delta Levee System Integrity Program. In addition, the conveyance/storage elements of the proposed CALFED Bay-Delta Program alternatives will address Delta recreation which was formerly included as an element of the Delta Levee System Integrity Program. However, these areas will continue to be considered in development of each area of the CALFED Bay-Delta Program. The Delta Levee System Integrity Program actions will be closely integrated with the Ecosystem Restoration Program Plan and Delta conveyance improvements that simultaneously improve Delta levee system performance, increase ecosystem quality, and protect water quality and water supply reliability.

APPENDIX A

PROBLEM/OBJECTIVE DEFINITION

DELTA LEVEE SYSTEM INTEGRITY PROGRAM

CALFED
Bay-Delta Program

DRAFT
December, 1997

PROBLEM AND OBJECTIVE STATEMENTS FOR DELTA LEVEE SYSTEM INTEGRITY

The CALFED Bay-Delta Program will develop a long-term comprehensive plan to solve problems in the Bay-Delta system related to four resource areas: ecosystem quality, water supply reliability, water quality, and Delta levee system integrity. Problems and program objectives related to Delta levee system integrity are listed below.

Problem

Levees were first constructed in the Sacramento-San Joaquin Delta during the mid-to-late 1800s, when settlers began to turn tidal marshes into agricultural land. Over time, both natural settling of the levees and shallow subsidence of Delta island soils (oxidation which lowers the level of the land over time) resulted in a need to increase levee heights to maintain protection. There is a growing concern that this increased height relative to the island's interior surface elevation, coupled with poor levee construction and inadequate maintenance, makes Delta levees vulnerable to failure, especially during earthquakes or floods.

Failure of Delta levees can result in flooding of Delta island farmland and wildlife habitat. If a flooded island is not repaired and drained, the resulting large body of open water can expose adjacent islands to increased wave action and possible levee erosion. Inundation of one or more islands in the Delta would disrupt farming operations and other land uses either permanently or for a significant period of time until repairs can be made. Inundation of roads, electric power lines, telephone lines, gas mains, and other infrastructure would cause lengthy breaks in service. Several state highways and many Delta roads run along levees that are vulnerable to collapse due to erosion, seismic events or structural failure.

Levee failure on specific islands can have impacts on water supply distribution systems such as the Mokelumne Aqueduct. Even if they survive the initial effects of inundation, long-term inundation would make continued maintenance and repair much more difficult. Similarly, levee failure on key Delta islands can draw salty water up into the Delta, as water from downstream rushes to fill the breached island. This would be of particular concern in a low water year when less freshwater would be available to repel the incoming salt water. This salinity intrusion would degrade water quality and result in a need to halt in-Delta use as well as export pumping, perhaps for extended periods. In order to lower salinity in the Delta to acceptable levels again, flushing flows would need to be released from upstream reservoirs. Stored water supplies in these reservoirs could be seriously depleted. Long-term flooding of key Delta islands can also have an effect on water quality by changing the location and volume of the mixing zone.

Failure of Delta levees can result from earthquakes and floods, or from gradual deterioration. The subsidence of the Delta island peat soils and settling of levee foundations places additional pressure on levees and increases the risk of failure.

Local reclamation districts are concerned with the cost of maintaining and improving the levee and channel system. The complex array of agencies with planning, regulatory, and/or permitting authorities over levees makes rehabilitation and maintenance efforts difficult. Regulatory measures which protect endangered species or critical habitat sometimes conflict with and prolong levee rehabilitation and maintenance work, which can further increase the vulnerability of the system.

Delta Levee System Integrity -- Problem Statements

Many of the "problems" commonly listed for the vulnerability of Bay-Delta system functions are actually causes of problems. For example, poor levee construction, inadequate maintenance, the lowering of the islands due to subsidence, levee instability, and lack of resistance to earthquake and floods are causes of the problems tied to levee failure. There are four major problems for the vulnerability of Bay-Delta system functions due to potential failure of Delta levees and inundation of islands: loss of land use, infrastructure and associated economies; damage to wildlife habitat, interruption of water supply, and reduction in Delta water quality. The problems can be categorized as follows:

A. **Existing agricultural land use, economic activities, and infrastructure** in the Delta are at risk from gradual deterioration of Delta conveyance and flood control facilities as well as sudden catastrophic inundation of Delta islands.

    1. **Reduction of agricultural productivity and damage to infrastructure** can result from seepage and overtopping of the levees.

    2. **Long-term loss of agricultural productivity and infrastructure** can result from catastrophic island inundation.

B. **Water supply facilities and operations** in the Delta are at risk from increased salinity intrusion, which can result from sudden catastrophic inundation of Delta islands.

    1. **In-Delta water supply** can be interrupted as a result of catastrophic island inundation and resultant salinity intrusion. (See Water Supply Problem Statement.)

2. **Export water supply** can be interrupted as a result of catastrophic island inundation and resultant salinity intrusion. (See Water Supply Problem Statement.)

C. **Water quality** in the Delta is at risk from increased salinity intrusion which can result from sudden catastrophic inundation of Delta islands.

1. Water quality for some **in-Delta beneficial uses** can be degraded as a result of catastrophic island inundation and resultant salinity intrusion. (See Water Quality Problem Statement).

2. Water quality for **export water supply** can be degraded as a result of catastrophic island inundation and resultant salinity intrusion. (See Water Quality Problem Statement.)

D. The existing **Delta ecosystem** is at risk from gradual deterioration of Delta conveyance and flood control facilities as well as catastrophic inundation of Delta islands.

1. **Reduction of ecosystem productivity** and damage to valuable habitat can result from seepage, erosion, and overtopping of levees.

2. **Long-term loss of valuable aquatic and terrestrial habitat** can result from catastrophic island inundation and resultant salinity intrusion.

Objective

The primary program objective for addressing Bay-Delta levee system integrity is to reduce the risk to land use and associated economic activities, water supply, infrastructure, and the ecosystem from catastrophic breaching of Delta levees. The vulnerability of the levee system to both general failure and sudden catastrophic failure can be reduced by implementing an integrated and comprehensive program for Delta levees and channels. This plan would need to streamline and consolidate the planning, regulatory, and permitting processes which affect the system, and provide a reliable funding source for system maintenance and rehabilitation.

Delta Levee System Integrity – Objective Statements

A. **Manage the risk to existing land use, associated economic activities, and infrastructure** from gradual deterioration of Delta conveyance and flood control facilities and catastrophic inundation of Delta islands.

1. **Manage the risk of reduction of agricultural productivity and damage to infrastructure** from seepage and overtopping of the levees. **Manage subsidence** of the Delta island peat soils and foundations which places additional pressure on surrounding levees and increases the risk of failure.

2. **Manage the risk of long-term loss of agricultural productivity and infrastructure** which can result from sudden catastrophic inundation.

B. **Manage the risk to water supply facilities and operations** in the Delta from catastrophic inundation of Delta islands.

1. **Manage the risk of interruption of in-Delta water supply** which can result from sudden catastrophic island inundation and the resultant salinity intrusion. (See Water Supply Objective Statement.)

2. **Manage the risk of interruption of export water supply** which can result from sudden catastrophic island inundation and the resultant salinity intrusion. (See Water Supply Objective Statement.)

C. **Manage the risk to water quality** in the Delta from catastrophic inundation of Delta islands.

1. **Manage the risk of degradation of in-Delta water quality** which can result from sudden catastrophic island inundation and the resultant salinity intrusion. (See Water Quality Objective Statement.)

2. **Manage the risk of degradation of export water supply** which can result from sudden catastrophic island inundation and the resultant salinity intrusion. (See Water Quality Objective Statement).

D. **Manage the risk to existing Delta ecosystem** from gradual deterioration of Delta conveyance and flood control facilities and catastrophic inundation of Delta islands.

1. **Manage the risk of reduction of ecosystem productivity and damage to valuable habitat** which can result from seepage, erosion, and overtopping of levees. **Manage subsidence** of the Delta island peat soils and foundations providing this ecosystem productivity which places additional pressure on surrounding levees and increases the risk of failure.

2. **Manage the risk of long-term loss of valuable aquatic and terrestrial habitat** which can result from sudden catastrophic inundation and the resultant salinity intrusion.

Linkages

An important aspect of reducing risk and making the system less vulnerable to failure will be to reduce the conflict between protection of wildlife habitat that occurs on levees, and maintenance of these levees to prevent failure. Riparian woodland, shaded riverine, aquatic, and shallow water habitats are very important for fish and wildlife in the Delta, including threatened and endangered species. In many cases, objectives of reducing risk of catastrophic failure and protection of ecosystem quality can be achieved by incorporating habitat restoration and protection elements in levee system stabilization actions. Conversely, projects to restore or enhance habitat can achieve multiple objectives if they are planned with levee vulnerability in mind. A second critical linkage can occur between efforts to reduce or reverse subsidence and efforts to restore habitat. Both the Delta ecosystem (including the aquatic habitat and the terrestrial habitat found on the levees and inside the islands) and system stability can benefit from reducing land surface subsidence adjacent to the levees. This achievement of multiple objectives can occur where levee stabilization is proposed and where habitat enhancement (riverine and riparian) is proposed. For example, one method to reduce subsidence, the creation of shallow wetlands adjacent to the land side toe of the levee, also serves to enhance habitat.

APPENDIX B

DELTA LEVEE BASE LEVEL PROTECTION PLAN

DELTA LEVEE SYSTEM INTEGRITY PROGRAM

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Bay-Delta Program

DRAFT
December, 1997

C-007126

Delta Levee Base Level Protection Plan - Levee Reconstruction to a Delta Wide Standard

One of the primary goals of the CALFED Delta Levee System Integrity Program is to reconstruct Delta levees up to a particular levee standard. This goal is being developed through the Delta Levee Base Level Protection Plan. Figure B-1 shows several established levee standards. The Program has tentatively selected the U.S. Army Corps of Engineers PL 84-99 standard. This standard is a prerequisite for requesting post-flood disaster assistance. If the selected levee standard is too low then many of the benefits that the levees provide will be lost. If the levee standard is too high then reconstruction becomes too expensive and implementation is not uniform. However, the selection of any levee standard must be congruent with available funding.

Historically, local reclamation districts have been responsible for maintaining and improving Delta levees and have been the primary source of resources through assessments imposed on local property owners. The federal government has provided some resources for maintenance of federal flood control project levees. The state increased its participation when it established the Delta Levee Maintenance Subvention Program and the Special Flood Control Project Program to address maintenance and improvement projects for certain areas of the Delta. Cost sharing partners for this reconstruction would most likely include Federal, State and local agencies. It is important that each of these cost-sharing partners be able to pay its share of costs for reconstruction to the selected levee standard. Preliminary costs to reconstruct levees to PL 84-99 are shown in Appendix G. CALFED staff is continuing to refine these costs.

Integration of Levee Reconstruction and Ecosystem Restoration

Another goal of the Delta Levee System Integrity Program is to integrate levee reconstruction with ecosystem restoration. Figures B-2 through B-4 illustrate various methods to integrate levee reconstruction with direct ecosystem restoration features. These three methods were selected from a larger list of methods shown in Appendix G. About 160 miles of levee reconstruction and ecosystem restoration integration is being planned, representing about 10 percent of historic habitat levels. CALFED and the Corps of Engineers are planning to implement the balance of the 160 miles in various locations on the Sacramento River from Sacramento to Collinsville. Site specific details and costs are not yet available.

Figure B -1

Levee Standards

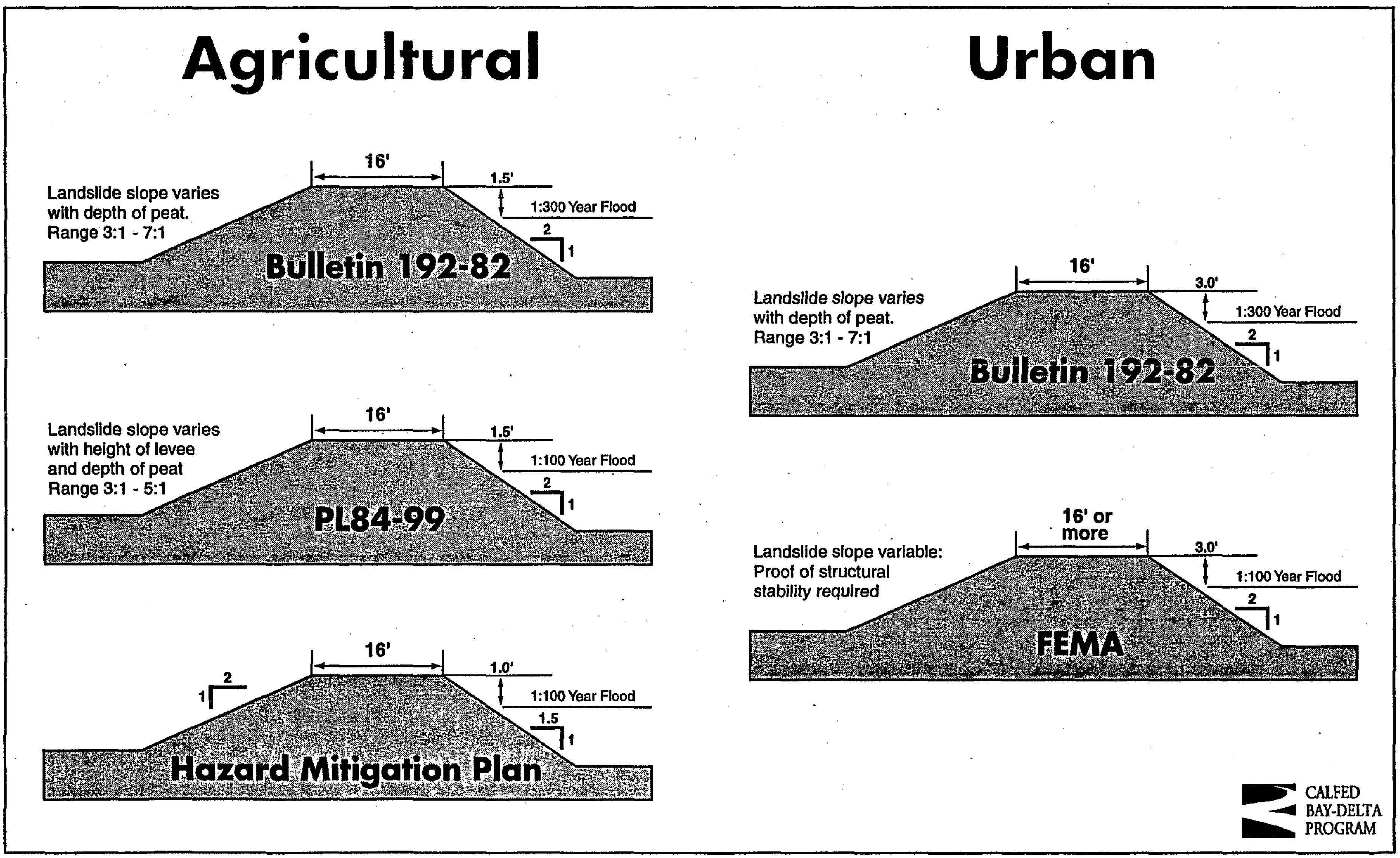
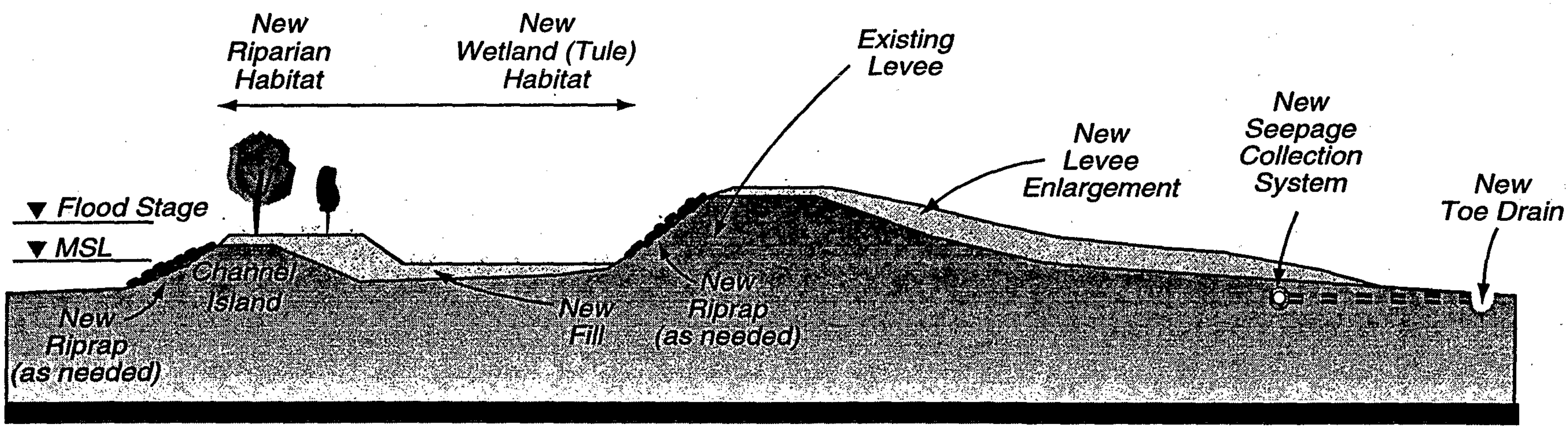


Figure B - 2

Examples of Levee and Habitat Improvements

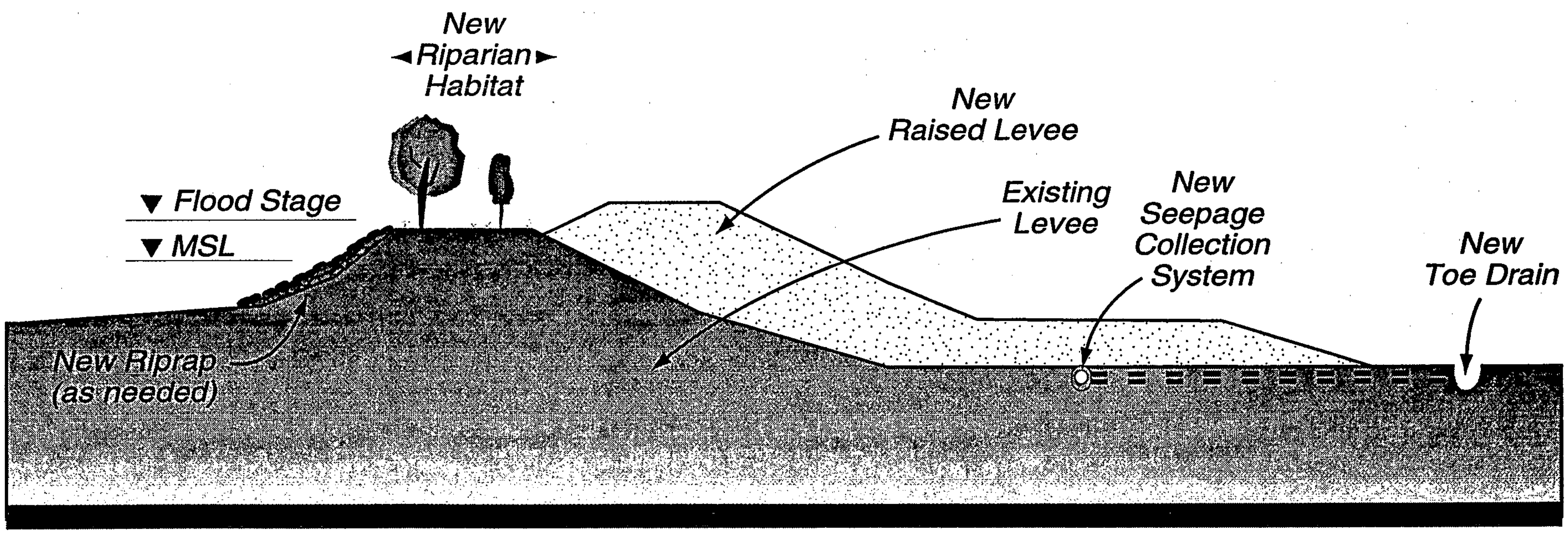


Levee Enlargement, Waterside Berm with New Riparian Habitat

CALFED BAY-DELTA PROGRAM

Figure B - 3

Examples of Levee and Habitat Improvements



Raised Levee with New Riparian Habitat

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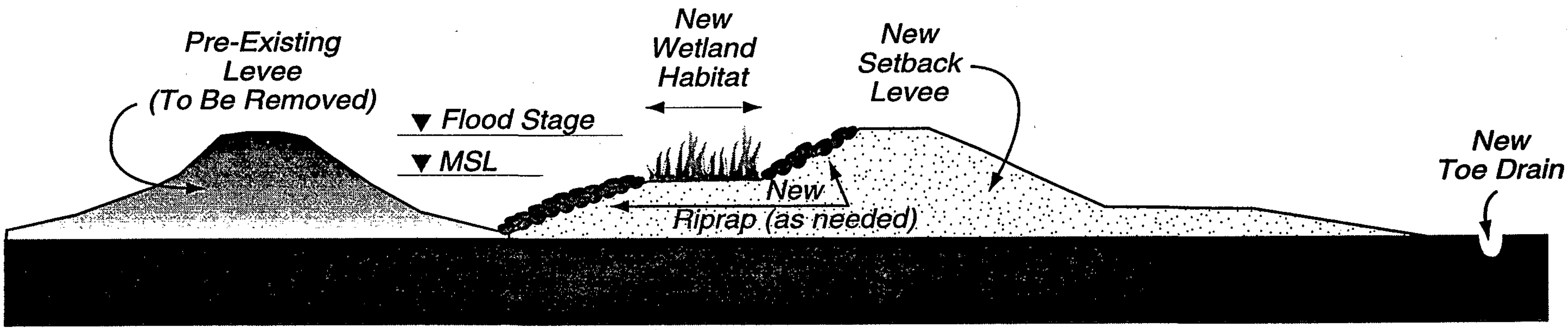
Figure B - 4

Examples of Levee and Habitat Improvements



Setback Levee with Habitat Improvements

CALFED BAY-DELTA PROGRAM

APPENDIX C

DELTA LEVEE SPECIAL IMPROVEMENT PROJECTS

DELTA LEVEE SYSTEM INTEGRITY PROGRAM

CALFED
Bay-Delta Program

DRAFT
December, 1997

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LEVEE-IMPROVEMENT FUNDING DISCUSSION PAPER

INTRODUCTION

This discussion paper focuses on the special-projects funding program as discussed during Levee and Channel Technical Team meetings and the December 17, 1996 public workshop and gives a brief overview of the base-level funding and special levee-improvement-project funding programs.

The purpose of this discussion paper is to provide CALFED with a relational analysis of the benefits of flood control projects and associated maintenance activities for each Delta island included in the evaluation. Several benefit categories have been quantified, including, but not limited to, agricultural production, infrastructure, resident popluations, and habitat conditions on each island. Information provided in this discussion paper will serve as input to decision-making processes and resource allocation measures for the Delta.

BASE-LEVEL FUNDING

Base-level funding (i.e., subventions funding) provides equitably distributed funding to participating local agencies in the Delta. Under this program, all local agencies (i.e., reclamation districts) will be eligible for the same base level of funding. The objectives of this program are to improve the reliability of Delta levee funding, improve cost sharing, provide funding for levee maintenance activities, use funds to implement a long-term levee standard for all levees, and fund emergency response activities. The recommended long-term levee standard is the Federal Public Law 84-99 (PL-99) standard, which provides 100-year-flood protection with 1.5 feet of freeboard and provides eligibility for postdisaster rehabilitation assistance.

The base-level funding program will be integrated into existing funding mechanisms. The passage of Proposition 204 in November 1996 activated Assembly Bill 360 (AB360), which amends the Delta Flood Protection Act of 1988 (Senate Bills 34 and 1065 [SB34 and SB1065]). Under the base-level funding program, the State would fully fund the SB34/AB360 program to realize a 75%/25% cost sharing between the State and local levee-maintenance agencies. All levees eligible for subventions funding under AB360 are nonproject levees in the Delta and project levees within the Delta primary zone. Under the proposed funding program, the State would guarantee a certain base level of maintenance funding per levee-mile per year and would provide additional funding (currently undefined) to enable local districts to upgrade levees to PL-99 standards over time.

SPECIAL-PROJECTS FUNDING

The special-projects funding program sets priorities and establishes a funding mechanism for special habitat improvement and levee stabilization projects in the Delta. Special-projects funding is intended to augment the base-level funding program. Under the special-projects funding program, levee improvement projects would be funded based on public benefits. The objectives of the special-projects funding program are to improve cost sharing and funding for projects not funded under the base-level program; implement levee improvement projects based on public benefits; and implement projects recommended for subsidence control, levee-associated and inchannel habitat improvement, beneficial reuse of dredged material, seismic susceptibility improvements, and levee-associated recreation. Levee improvement projects would be identified and prioritized based on the public benefit accruing from island protection. Benefits include factors such as protection of water quality, conservation or enhancement of fish and wildlife habitat, and protection of public and private infrastructure.

Special-projects funding under AB360 is applicable to nonproject levees in the Delta, project levees in the primary zone, and 12 miles of Suisun Marsh levees. Similar to the base-level funding program, SB34/AB360 special-project funding will use a 75%/25% cost sharing between the State and local levee maintenance agencies.

Special-projects funding is based on the benefit to the public of a specific levee improvement project, not on the need for improvement. Determining the need for improvement may play a part in the timing of levee improvement funding, but is not the goal of special-projects funding. The idea is that base-level funding will adequately meet the 'needs' of the levee system and that special-projects funding will increase public benefits of the levee improvement program.

To determine which projects would most likely have priority for special-projects funding, the CALFED Levee and Channel Technical Team established a process for determining priorities based on public benefits. Although projects throughout the Bay-Delta would be eligible for special-projects funding, the Levee and Channel Technical Team looked at how special projects on different islands (or reclamation districts) would best meet the objectives for special-projects funding. This information-gathering process, referred to as the "island prioritization" process, is described below.

ISLAND PRIORITIZATION FOR SPECIAL PROJECTS

The first step in prioritizing islands based on benefits is to establish discrete objectives (e.g., protection of agricultural production) that can be used to rank the islands. The second step is to define the attributes of an island that are applicable to each objective (e.g., acres of agricultural lands, value of harvested crop), and the third step is to gather information on each island's attributes and rank the islands by objective.

The CALFED Levee and Channel Technical Team identified the following objectives for island prioritization:

- life and personal property,
- water quality,
- agricultural production,
- recreation,
- cultural resources,
- ecosystems,
- infrastructure of local concern,
- infrastructure of statewide concern, and
- adjacent island resources.

These objectives were based on discussions held at technical meetings between October and December 1996.

After determining objectives, the team identified attributes that could be used to evaluate an island's relative benefit under each objective. For example, acres of native vegetation, wetlands, and riparian habitats are some of the attributes used for ranking the relative ecosystem benefit of levee protection. The availability of data also directed the list of attributes; where data were not readily available, an alternative attribute was selected. Table 1 presents the attributes selected for each objective.

The California Department of Water Resources and Jones & Stokes Associates staff produced a matrix of information that presents attribute data for all reclamation districts within the lowlands of the legal Delta. The Levee and Channel Technical Team reviewed the data presented and recommended changes to data sources and attributes. The information matrix and detailed list of data sources are presented in Attachment 1. Staff used the best available data to develop the matrix, but it should be noted that the data is used to present <u>relative</u> values, not absolute values, for the reclamation districts. For example, the volume of each island is a function of the size and depth of the island. To give a relative value for volume, an estimate of acres approximately 0-20 feet below sea level was used. The Bay-Delta is a dynamic environment. Data presented in the information matrix will need to be updated to take into consideration changes in elevations over time caused by subsidence, changes in land uses and agricultural practices, and ongoing studies that may produce more accurate or thorough information.

Decision Process for Special Projects

The objectives of the special-projects funding program may be prioritized to guide the allocation of funds for special projects. This process could involve weighting the objectives discussed above or establishing priorities for the timing of long-term fund allocation. The Levee and Channel Technical Team's role has been to gather information and present options for a decision-making body. The Bay Delta Advisory Council or a CALFED policy group will establish the priorities for special-projects funding.

Table 1. Special-Projects Funding Objectives and Attributes

Objective	Island Attribute
Life and Personal Property	Permanent population Towns Housing units Residential lands
Water Quality	Long-term salinity intrusion induced Critical to water quality as determined by SB34 Island volume
Agricultural Production	Total agricultural lands Value of damageable crops
Recreation	State or regional parks Recreation lands Recreation resorts
Cultural Resources	Known prehistoric sites Potential historic sites
Ecosystems	Native vegetation Wetlands Riparian habitats Agricultural waterfowl habtiats Known special-status plant occurrences Known special-status wildlife occurrences
Infrastructure of Local Concern	County roads Commercial lands Industrial lands Acreage protected per levee mile
Infrastructure of Statewide Concern	Federal and State highways Water supply conveyance Railroad mainlines Natural gas pipelines Natural gas fields and storage Power transmission lines
Adjacent Island Resources	Adjacent levees at risk Seepage risk

ATTACHMENT 1. INFORMATION MATRIX

C-007139

Introduction

The information matrix presents attribute data for the reclamation districts within the lowlands of the legal Delta (as defined by Section 12220 of the Water Code). The information matrix, an Excel spreadsheet, is organized by subject or objective. For each subject area, an introductory table lists the sources of information for the attribute data and includes comments on the data set or additional information pertinent to the subject area.

Notes on the Islands and Reclamation Districts

The information matrix displays island names and reclamation districts with the lowlands of the legal Delta. Because Brannan/Andrus Island, Jones Tract, Roberts Island, and Tyler Island/Walnut Grove include more than one reclamation district, information is presented for each reclamation district wherever possible. Where information is available for the entire island only, the cumulative information for the island is presented under the complete island name (e.g., Jones Tract), and a "-" is included in the column for the individual reclamation districts (e.g., Lower Jones RD 2038).

Three islands do not have a reclamation district number. The Bethel Island reclamation district is the Bethel Island Municipal Improvement District. Shim Kee Tract and Rough & Ready Island levees are managed and maintained privately by the independent landowner.

Information for Winters Island is not complete for many attributes. A member of the Levee and Channel Technical Team recommended that Winter Island - RD2122, located south of Collinsville and immediately east of Browns Island, be included in the study area. The island has been included in the information spreadsheet but little attribute data has been compiled to complete the matrix information on this small west Delta island.

Instances where no data was available for an island or reclamation district are indicated by "N/D".

ISLAND ACREAGE AND LEVEE MILEAGE

ISLAND ATTRIBUTE	DATA SOURCE and NOTES
Island size	California Department of Water Resources. 1994. Land use mapping program. Sacramento, CA. (DWR Land use mapping data)
Length of project levees	California Department of Water Resources. 1993. Sacramento-San Joaquin Delta atlas. Sacramento, CA. (DWR Delta atlas)
Length of nonproject levees	DWR Delta atlas The data for levee lengths is taken from both the Delta Atlas and GIS coverage produced by Jones & Stokes Associates.

		Island Acres & Levee Miles		
ISLAND	Reclamation District	Island Size (Acres)	Flood-Control Levees, federal (Miles)	Flood-Control Levees, local (Miles)
Bacon Island	2028	5589	0	14.3
Bethel Island	-	3532	0	11.5
Bishop Tract	2042	2975	0	5.8
Boggs (Moss Tract)	404	3211	4	1.2
Bouldin Island	756	6020	0	18.0
Brack Tract	2033	4621	0	10.8
Bradford Island	2059	2183	0	7.4
Brannan/Andrus Island	-	15383	30.5	10.6
Andrus	317	3606		
Andrus, Isleton	407	1648		
Andrus, Upper	556	2351		
Brannan	2067	7778		
Byron Tract	800	6249	0	9.7
Canal Ranch	2086	3213	0	7.5
Coney Island	2117	998	0	5.4
Dead Horse Island	2111	225	0	2.6
Empire Tract	2029	3688	0	10.5
Fabian Tract	773	6725	0	18.8
Fay	2113	99	0	1.6
Glanville Tract	1002	6994	0	13.0
Grand Island	3	16892	29.0	0.0
Hastings Tract	2060	4519	16.0	0.0
Holland Tract	2025	4254	0	10.9
Holt Station	2116	197	0	0.4
Hotchkiss Tract	799	3621	0	6.3
Jersey Island	830	3571	0	15.6
Jones Tract	-			
Jones, Lower	2038	5743	0	8.8
Jones, Upper	2039	6501	0	9.3
King Island	2044	3256	0	9.0
Little Mandeville	2118	360	0	4.5
Mandeville Island	2027	5266	0	14.3
McCormack Williamson Tract	2110	2139	0	8.8
McDonald Island	2030	6058	0	13.7
Medford Island	2041	1205	0	5.9
Merritt Island	150	4901	18.1	0.0
Mildred Island	2021	1001	0	7.3
Naglee Burke	1007	5917	0	8.3
New Hope Tract	348	9798	0	18.6
Orwood Island	2024	2431	0	10.9
Palm Tract	2036	2505	0	7.5
Pescadero	2058	9004	6.7	2.2
Pierson District	551	9427	8.4	7.0
Prospect Island	1667	2275	2.9	7.1
Quimby Island	2090	809	0	7.0
Rindge Tract	2037	6840	0	15.7
Rio Blanco Tract	2114	959	0	4.0
Roberts Island	-	36189		
Roberts, Lower	684	10819	0.0	16.0
Roberts, Middle	524	12839	6.1	3.7
Roberts, Upper	544	8248	10.6	4.4
Rough and Ready Island	-	1461	0	6.7
Ryer Island	501	11955	20.6	0.0
Sargent Barnhart Tract	2074	1051	1.5	2.8
Sherman Island	341	11321	9.7	9.8
Shima Tract	2115	1848	0	6.6
Shin Kee Tract	-	960	0	3.9
Smith	1614	2163	6	2.8
Stark	2089	742	2.8	0.7
Staten Island	38	9229	0	25.4
Stewart Tract	2062	5364	12.3	0.0
Sutter Island	349	2619	12.5	0.0
Terminous	548	12187	0	16.1
Twitchell	1601	3648	2.5	9.3
Tyler Island	563	9453	12.2	10.7
Walnut Grove	554	459	1	1.2
Union Island	-	25016	1.0	29.2
Van Sickle Island	1607	2193	0	3.8
Veale Tract	2065	1499	0	5.7
Venice Island	2023	3159	0	12.3
Victoria Island	2040	7266	0	15.1
Webb Tract	2026	5507	0	12.8
Weber	828	1149	0	1.2
Winter Island	2122	482	0	4.8
Woodward Island	2072	1859	0	8.8
Wright-Elmwood Tract	2119	2134	0	6.8
-	307	6016.9	7.8	5.2
-	369	532.3	1	0.7
-	536	6389.7	14	0
-	765	1348.8	1.7	4
-	813	2537.5	2	6
-	900	10832.3	12	1.3
-	999	25775.7	27	5.8
-	1608	906.1	0	4
-	2084	3170.4	0	7
-	2093	5031.3	0	20.5
-	2095	5552.1	4	0
-	2098	6033.7	18.5	0
-	2121	527.9	0	2.3

LIFE AND PERSONAL PROPERTY

ISLAND ATTRIBUTE	DATA SOURCE and NOTES
Permanent population (1990)	DWR Delta atlas
Towns	DWR Delta atlas
Housing units	DWR Delta atlas
Residential lands	DWR Land use mapping data Residential lands include farmsteads (see Agricultural data). In some cases, residential lands = 0 yet housing units are shown (see for example, Victoria Island). This is probably because some housing units are located on lands that are not considered 'residential". Specifically, agricultural farmworker housing is often located on lands categorized as "incidental agricultural lands" or a specific crop rather than farmsteads or residential lands.

		Life and Property			
ISLAND	Reclamation District	Permanent Population (1990)	Towns	Housing Units	Residential Lands (Acres)
Bacon Island	2028	260		39	35.7
Bethel Island	-	2115		1257	133.8
Bishop Tract	2042	52		23	16.6
Boggs (Moss Tract)	404	N/D		N/D	3.7
Bouldin Island	756	74		19	17.5
Brack Tract	2033	80		22	18.5
Bradford Island	2059	0		0	43.4
Brannan/Andrus Island	-	2093	-	1014	-
Andrus	317	-		-	167.6
Andrus, Isleton	407	-	Isleton	-	57.4
Andrus, Upper	556	-		-	36.0
Brannan	2067	-		-	38.9
Byron Tract	800	6336	Byron, Disco Bay	2964	12.2
Canal Ranch	2086	103		30	10.7
Coney Island	2117	0		0	2.8
Dead Horse Island	2111	39		23	0.0
Empire Tract	2029	5		3	10.8
Fabian Tract	773	130		28	45.9
Fay	2113	N/D		N/D	0.0
Glanville Tract	1002	N/D		N/D	24.6
Grand Island	3	1021	Ryde	411	193.8
Hastings Tract	2060	94	Hastings	22	17.6
Holland Tract	2025	35		28	14.1
Holt Station	2116	N/D		N/D	8.0
Hotchkiss Tract	799	847		373	122.8
Jersey Island	830	13		3	8.7
Jones Tract	-	-	-	-	-
Jones, Lower	2038	112		14	30.2
Jones, Upper	2039	46		8	57.0
King Island	2044	195		94	4.2
Little Mandeville	2118	N/D		N/D	0.0
Mandeville Island	2027	118		5	29.9
McCormack Williamson Tr	2110	0		0	2.5
McDonald Island	2030	95		0	73.2
Medford Island	2041	14		9	0.0
Merritt Island	150	238		97	68.7
Mildred Island	2021	0		0	0.0
Naglee Burke	1007	24		5	0.0
New Hope Tract	348	1376	Thornton	501	124.3
Orwood Island	2024	98		22	31.3
Palm Tract	2036	16		5	3.2
Pescadero	2058	54		19	164.2
Pierson District	551	355	Courtland	140	146.1
Prospect Island	1667	N/D		N/D	3.1
Quimby Island	2090	N/D		N/D	0.0
Rindge Tract	2037	33		29	31.6
Rio Blanco Tract	2114	10		5	7.4
Roberts Island	-	-	-	-	-
Roberts, Lower	684	221		88	113.6
Roberts, Middle	524	435		95	114.4
Roberts, Upper	544	231		75	91.2
Rough and Ready Island	-	174		43	0.0
Ryer Island	501	246		98	83.6
Sargent Barnhart Tract	2074	1902		806	0.0
Sherman Island	341	233		105	46.7
Shima Tract	2115	101		N/D	6.2
Shin Kee Tract	-	8		3	0.0
Smith	1614	N/D		N/D	0.0
Stark	2089	N/D		N/D	3.2
Staten Island	38	35		13	16.6
Stewart Tract	2062	213		104	29.5
Sutter Island	349	173		48	31.9
Terminous	548	602	Terminous	279	52.5
Twitchell	1601	87		41	15.4
Tyler Island	563	644		286	40.0
Walnut Grove	554	-	Walnut Grove	-	-
Union Island	1,2	779		144	151.6
Van Sickle Island	1607	0		0	0.0
Veale Tract	2065	4		2	0.0
Venice Island	2023	0		0	4.1
Victoria Island	2040	155		6	10.8
Webb Tract	2026	0		0	24.1
Weber	828	N/D		N/D	0.0
Winter Island	2122	0		N/D	0.0
Woodward Island	2072	6		1	4.6
Wright-Elmwood Tract	2119	31		0	20.3
-	307	N/D		N/D	33.9
-	369	N/D	Locke	N/D	4.1
-	536	N/D		N/D	53.9
-	765	N/D		N/D	5.5
-	813	N/D		N/D	15.4
-	900	N/D		N/D	130.7
-	999	303	Clarksburg	11652	375.6
-	1608	N/D		N/D	0.0
-	2084	N/D		N/D	0.0
-	2093	N/D		N/D	220.6
-	2095	N/D		N/D	43.5
-	2098	N/D		N/D	38.8
-	2121	N/D		N/D	2.9

AGRICULTURAL PRODUCTION

ISLAND ATTRIBUTE	DATA SOURCE and NOTES
Total agricultural lands	DWR Land use mapping data Includes grain and hay crops, field crops, truck and berry crops, pasture, rice, idle agricultural area, deciduous fruits and nuts, vineyards, and semiagricultural and incidental to agricultural area. Farmstead lands, shown here, are included in the "residential" land category.
Value of damageable crops	DWR Land use mapping data and California Department of Food and Agriculture. 1996. County Agriculture Commissioner's Reports for 1995. Sacramento, CA. Value is determined by crop acreages multiplied by the average values for each major agricultural classification. Crop values are based on 1995 production value information for Sacramento, San Joaquin, Contra Costa, Yolo, and Solano counties. In some instances, value of crops is $0 although agricultural acres are shown. This is the result of those lands being categorized as idle, semiagricultural and incidental to agricultural, or farmsteads which are not included in the value of damageable crops analysis.

Agricultural Production

Crop Acreages and Values

ISLAND	Reclamation District	Grain & Hay Crops (Acres)	Field Crops (Acres)	Truck & Berry Crops (Acres)	Pasture (Acres)	Rice (Acres)	Subtropical Fruits (Acres)	Deciduous Fruits & Nuts (Acres)	Vineyards (Acres)	Idle (Acres)	Semiagricultural & Incidental to Agriculture w/farms(Acres)	Farmsteads (Acres)	Semiagricultural & Incidental to Agriculture (Acres)	Total Agricultural (Acres)	Total Value ($1,000)
Bacon Island	2028	0.0	2148.9	2905.8	0.0	0.0	0.0	0.0	56.7	29.0	35.7	35.7	0.0	5140.4	$10,968
Bethel Island	-	0.0	0.0	0.0	7.7	0.0	0.0	0.0	0.0	2484.8	136.5	14.8	121.7	2614.2	$4
Bishop Tract	2042	523.6	293.9	191.8	1730.8	0.0	0.0	0.0	0.0	0.0	50.1	16.6	33.5	2773.6	$1,815
Boggs (Moss Tract)	404	0.0	0.0	0.0	78.1	0.0	0.0	0.0	0.0	0.0	152.3	3.7	148.6	226.7	$37
Bouldin Island	756	1982.9	3393.1	0.0	0.0	0.0	0.0	0.0	0.0	4.1	17.5	17.5	0.0	5380.1	$2,826
Brack Tract	2033	607.2	2182.4	404.8	567.3	0.0	0.0	2.7	472.3	145.5	18.5	18.5	0.0	4382.2	$4,429
Bradford Island	2059	0.0	0.0	0.0	636.7	0.0	0.0	0.0	0.0	1286.2	8.6	8.5	0.1	1923.0	$306
Brannan/Andrus Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Andrus	317	440.3	2741.1	0.0	0.0	0.0	0.0	0.0	0.0	34.1	1.6	1.6	0.0	3215.5	$1,900
Andrus, Isleton	407	406.9	713.7	0.0	0.0	0.0	0.0	122.7	20.6	3.4	8.8	8.8	0.0	1267.3	$964
Andrus, Upper	556	534.7	704.3	233.7	217.5	0.0	0.0	426.6	0.0	0.0	28.4	28.4	0.0	2116.8	$2,600
Brannan	2067	1528.4	5104.4	25.3	62.9	0.0	0.0	164.5	102.5	43.4	36.3	0.0	36.3	7067.7	$4,580
Byron Tract	800	802.9	731.0	1204.2	1103.9	0.0	0.0	0.0	0.0	119.9	12.2	12.2	0.0	3961.9	$5,176
Canal Ranch	2086	476.6	1891.8	419.8	167.1	0.0	0.0	0.0	34.7	0.0	10.7	10.7	0.0	2990.0	$2,904
Coney Island	2117	347.9	526.1	30.9	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.8	0.0	904.9	$552
Dead Horse Island	2111	0.0	0.0	190.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	190.1	$618
Empire Tract	2029	1343.9	1979.7	122.6	0.0	0.0	0.0	0.0	0.0	0.0	10.8	10.8	0.0	3446.2	$2,109
Fabian Tract	773	260.8	743.0	2972.9	2240.0	0.0	0.0	52.7	0.0	36.8	34.5	34.5	0.0	6306.2	$11,436
Fay	2113	0.0	63.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.9	$41
Glanville Tract	1002	931.1	2346.5	534.9	2108.9	0.0	0.0	131.4	309.8	0.0	63.8	24.6	39.2	6401.8	$5,713
Grand Island	3	4576.2	6465.5	1820.4	1047.9	0.0	0.0	1903.1	0.0	0.0	177.7	174.1	3.6	15816.7	$17,015
Hastings Tract	2060	291.8	1584.3	517.1	1970.8	0.0	0.0	0.0	28.5	1388.6	21.4	17.6	3.8	5784.9	$3,811
Holland Tract	2025	2923.7	62.7	0.0	303.9	0.0	0.0	0.0	0.0	481.2	14.1	14.1	0.0	3771.5	$1,151
Holt Station	2116	96.5	17.1	0.0	18.7	0.0	0.0	0.0	0.0	37.3	8.0	8.0	0.0	169.6	$52
Hotchkiss Tract	799	179.9	8.6	1.0	1709.4	0.0	0.0	54.7	0.0	476.4	60.5	32.9	27.6	2457.6	$1,031
Jersey Island	830	0.0	0.0	0.0	2803.0	0.0	0.0	0.0	0.0	16.2	8.7	8.7	0.0	2819.2	$1,345
Jones Tract	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jones, Lower	2038	1752.9	929.2	2568.7	0.0	0.0	0.0	0.0	0.0	266.2	30.2	30.2	0.0	5517.0	$9,521
Jones, Upper	2039	1103.5	3140.5	3688.4	1810.1	0.0	0.0	0.0	0.0	18.0	57.0	57.0	0.0	9760.6	$15,230
King Island	2044	1888.7	689.7	511.4	0.0	0.0	0.0	0.0	0.0	0.0	4.2	4.2	0.0	3089.8	$2,727
Little Mandeville	2118	0.0	269.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	269.2	$172
Mandeville Island	2027	400.3	2634.9	1015.2	5.8	0.0	31.8	1.1	464.0	46.8	28.6	28.5	0.1	4600.0	$6,422
McCormack Williamson Tr	2110	180.7	1271.5	275.9	0.0	0.0	0.0	0.0	0.0	65.9	2.5	2.5	0.0	1794.0	$1,770
McDonald Island	2030	911.8	1000.9	2389.8	559.4	0.0	0.0	0.0	0.0	533.8	73.2	73.2	0.0	5395.7	$8,977
Medford Island	2041	134.2	942.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1077.0	$648
Merritt Island	150	839.2	845.1	776.9	547.3	0.0	0.0	380.1	1092.2	24.7	68.7	68.6	0.1	4505.6	$7,455
Mildred Island	2021	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$0
Naglee Burke	1007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$0
New Hope Tract	348	1646.1	3333.5	2050.2	390.2	0.0	0.0	279.9	1174.2	0.8	124.1	108.8	15.3	8890.2	$13,331
Orwood Island	2024	172.2	438.1	1146.8	381.2	0.0	0.0	0.0	0.0	31.6	31.3	31.3	0.0	2169.9	$4,247
Palm Tract	2036	1308.6	573.8	15.1	292.2	0.0	0.0	0.0	0.0	81.3	3.2	3.2	0.0	2271.0	$988
Pescadero	2058	118.4	1868.1	1778.7	3511.6	0.0	0.0	247.8	0.0	99.9	216.1	117.3	98.8	7723.3	$9,345
Pierson District	551	871.2	2535.6	0.0	332.1	0.0	0.0	1840.4	1002.2	312.1	146.1	146.1	0.0	6893.6	$9,480
Prospect Island	1667	388.9	489.2	226.9	0.0	0.0	0.0	0.0	0.0	7.4	3.1	3.1	0.0	1112.4	$1,179
Quimby Island	2090	303.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	295.4	0.0	0.0	0.0	598.6	$100
Rindge Tract	2037	710.9	4532.4	1024.6	19.3	0.0	0.0	0.0	0.0	132.4	31.6	31.6	0.0	6419.6	$6,475
Rio Blanco Tract	2114	351.1	126.1	0.0	326.4	0.0	0.0	0.0	0.0	0.0	7.4	7.4	0.0	803.6	$353
Roberts Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roberts, Lower	684	2829.2	2791.8	3134.8	1268.3	0.0	0.0	14.1	0.0	202.8	113.6	113.6	0.0	10241.0	$13,554
Roberts, Middle	524	1083.7	3675.9	2958.5	3902.6	0.0	0.0	31.9	0.0	33.2	142.5	114.4	28.1	11713.9	$14,282
Roberts, Upper	544	1712.9	2012.2	957.8	2882.8	0.0	0.0	228.0	121.8	20.2	91.2	91.2	0.0	7935.7	$7,262
Rough and Ready Island	-	357.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	357.9	$118
Ryer Island	501	3252.4	3868.4	2122.4	1163.6	0.0	19.8	418.7	536.6	22.4	79.3	79.3	0.0	11404.3	$13,551
Sargent Barnhart Tract	2074	129.5	25.6	0.0	147.2	0.0	0.0	0.0	0.0	79.8	0.0	0.0	0.0	382.1	$130
Sherman Island	341	1731.2	6581.4	462.5	379.6	0.0	0.0	0.0	0.0	645.6	46.7	46.7	0.0	9800.3	$6,469
Shima Tract	2115	263.9	178.0	266.2	783.9	0.0	0.0	208.8	0.0	8.1	6.2	6.2	0.0	1708.9	$1,985
Shin Kee Tract	-	283.6	321.6	147.9	180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	933.1	$866
Smith	1614	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	130.4	0.0	130.4	130.4	$0
Stark	2089	129.8	209.7	0.9	308.1	0.0	0.0	0.0	0.0	0.0	3.2	3.2	0.0	648.5	$328
Staten Island	38	3201.3	5196.6	336.8	0.0	18.2	0.0	0.0	0.0	0.0	16.6	16.6	0.0	8752.9	$5,494
Stewart Tract	2062	760.5	355.4	1288.3	2223.4	0.0	0.0	153.3	0.0	0.0	22.9	22.9	0.0	4780.9	$6,131
Sutter Island	349	180.4	453.8	284.3	166.9	0.0	12.6	1078.8	152.9	0.9	31.9	31.9	0.0	2330.6	$4,592
Terminous	548	3532.2	5618.9	331.4	1345.1	0.0	0.0	0.0	190.6	205.7	90.7	52.5	38.2	11262.1	$6,984
Twitchell	1601	188.9	2567.1	242.2	319.9	0.0	0.0	0.0	0.0	24.7	15.4	15.4	0.0	3342.8	$2,646
Tyler Island	563	2671.7	4918.8	198.8	350.9	0.0	0.0	274.5	0.0	4.9	39.9	39.9	0.0	8419.6	$5,558
Walnut Grove	554	137.8	0.1	0.0	179.2	0.0	0.0	0.0	0.0	3.8	4.4	0.1	4.3	325.2	$132
Union Island	-	1099.2	9100.7	5025.9	8372.9	0.0	0.0	512.9	0.0	45.8	151.6	151.6	0.0	24157.4	$27,874
Van Sickle Island	1607	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$0
Veale Tract	2065	926.2	0.0	0.0	73.7	0.0	0.0	0.0	0.0	311.5	0.0	0.0	0.0	1311.4	$341
Venice Island	2023	1145.4	1568.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	4.1	0.0	2713.7	$1,382
Victoria Island	2040	1316.9	933.9	3235.9	1400.9	0.0	0.0	0.0	0.0	0.0	10.8	10.8	0.0	6887.6	$12,221
Webb Tract	2026	1332.8	3461.6	0.0	0.0	0.0	0.0	0.0	0.0	45.9	24.1	24.1	0.0	4840.3	$2,655
Weber	828	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$0
Winter Island	2122	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$0
Woodward Island	2072	898.1	0.0	748.6	0.0	0.0	0.0	0.0	0.0	40.1	4.6	4.6	0.0	1686.8	$2,729
Wright-Elmwood Tract	2119	1238.1	601.3	143.7	0.0	0.0	0.0	0.0	0.0	0.0	20.3	20.3	0.0	1983.1	$1,260
-	307	882.7	2315.3	1091.9	1049.0	0.0	18.8	21.0	201.9	23.1	33.9	33.9	0.0	5603.7	$6,458
-	369	0.0	0.0	0.0	59.3	0.0	0.0	89.2	0.0	0.6	4.2	4.1	0.1	149.2	$260
-	536	476.6	1640.4	0.0	1159.7	0.0	0.0	0.0	0.0	1489.6	42.0	42.0	0.0	4766.3	$1,764
-	765	227.7	201.0	365.6	390.1	0.0	0.0	0.0	0.0	0.0	5.5	5.5	0.0	1184.4	$1,579
-	813	113.8	714.8	336.3	204.9	0.0	0.0	166.7	787.6	25.1	15.4	15.4	0.0	2349.2	$4,183
-	900	1183.8	2802.9	256.7	603.1	0.0	0.0	93.7	50.3	426.0	193.7	130.7	63.0	5479.5	$3,684
-	999	5976.1	8191.2	4199.2	4442.3	0.0	0.0	74.4	711.9	387.6	375.6	375.6	0.0	23982.7	$25,053
-	1608	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.1	0.0	30.1	30.1	$0
-	2084	3.5	1766.6	283.3	559.7	0.0	0.0	0.0	0.0	289.2	0.0	0.0	0.0	2902.3	$2,321
-	2093	2533.1	1230.1	264.5	0.0	0.0	0.0	0.0	0.0	24.9	220.6	220.6	0.0	4052.6	$2,483
-	2095	280.6	1413.5	1236.6	1832.5	0.0	0.0	36.7	0.0	39.3	62.5	31.4	31.1	4870.3	$5,991
-	2098	985.2	498.8	581.7	1801.8	0.0	0.0	0.0	0.0	666.9	53.0	38.8	14.2	4548.6	$3,400
-	2121	261.9	0.0	1.7	0.0	0.0	0.0	0.0	0.0	233.9	2.9	2.9	0.0	497.5	$92
CROP VALUES	($/ACRE)	$330	$640	$3,250	$480	$930	$2,600	$2,600	$2,620	$0		--	$0		

WATER QUALITY

ISLAND ATTRIBUTE	DATA SOURCE and NOTES
Long-term salinity intrusion induced	Enright, Chris. n.d. Western Delta Island Flood Assumptions - DWRDSM Modeling Analysis. California Department of Water Resources, Delta Modeling Section. Sacramento, CA. Represents the long-term average change in salinity at Clifton Court Forebay based on DWR's Delta Simulation Model (DWRDSM) analysis.
Critical to water quality (SB-34)	California Water Code Section 12311(a) The Delta Flood Protection Act (SB-34) identified eight islands as critical to water quality.
Island volume	DWR Delta atlas and DWR Land use mapping data The island volume is used as an indicator of short-term water quality effects during specific hydrologic conditions in the Delta. An island breach would have a short-term, immediate effect on salinity intrusion only if the rate of filling of an island is greater than the outflow of water through the Delta. These elements are a function of the inflow of water into the Delta, the rate of water being exported out of the Delta, and the location and size of the breached island. Because most levee breaches occur during high inflows when outflow would exceed the rate of island filling, short-term effects on water quality (i.e., salinity) would seldom occur. However, the team felt it important to capture the possible of water quality effects of a levee breach during low inflow periods. Island volume estimates are derived from information on the "Land Surface Below Sea Level" and "Lowest surface Elevation" maps in the DWR Delta atlas. Weighted average surface elevations are multiplied by the island acreage (from DWR land use mapping data) to produce the estimated island volume.

		Water Quality		
ISLAND	Reclamation District	Salinity Intrusion Induced (% salinity increase @ Clifton Court)	Critical to Water Quality SB 34	Island Volume (short-term water quality effects) (Acre Feet; estimate)
Bacon Island	2028		No	77700
Bethel Island	-		Yes	29600
Bishop Tract	2042		No	10400
Boggs (Moss Tract)	404		No	0
Bouldin Island	756	2%	No	83700
Brack Tract	2033		No	32900
Bradford Island	2059		Yes	25100
Brannan/Andrus Island	-	-5%	-	-
Andrus	317		No	52400
Andrus, Isleton	407		No	10700
Andrus, Upper	556		No	11800
Brannan	2067		No	117200
Byron Tract	800		No	37500
Canal Ranch	2086		No	19700
Coney Island	2117		No	5000
Dead Horse Island	2111		No	1100
Empire Tract	2029		No	50500
Fabian Tract	773		No	16800
Fay	2113		No	500
Glanville Tract	1002		No	0
Grand Island	3		No	110000
Hastings Tract	2060		No	5600
Holland Tract	2025	12%	Yes	38800
Holt Station	2116		No	1000
Hotchkiss Tract	799		Yes	10000
Jersey Island	830	40%	Yes	33500
Jones Tract	-		-	-
Jones, Lower	2038		No	45900
Jones, Upper	2039		No	71500
King Island	2044		No	30900
Little Mandeville	2118		No	1800
Mandeville Island	2027		No	76400
McCormack Williamson Tr	2110		No	2100
McDonald Island	2030	2%	No	83000
Medford Island	2041		No	15100
Merritt Island	150		No	0
Mildred Island	2021		No	0
Naglee Burke	1007		No	0
New Hope Tract	348		No	17100
Orwood Island	2024		No	21300
Palm Tract	2036		No	23800
Pescadero	2058		No	0
Pierson District	551		No	35400
Prospect Island	1667		No	8500
Quimby Island	2090		No	7100
Rindge Tract	2037		No	71800
Rio Blanco Tract	2114		No	2900
Roberts Island	-		-	-
Roberts, Lower	684		No	97400
Roberts, Middle	524		No	32100
Roberts, Upper	544		No	0
Rough and Ready Island	-		No	3700
Ryer Island	501		No	68700
Sargent Barnhart Tract	2074		No	3200
Sherman Island	341	41%	Yes	133600
Shima Tract	2115		No	9200
Shin Kee Tract	-		No	3800
Smith	1614		No	0
Stark	2089		No	3000
Staten Island	38	-4%	No	108400
Stewart Tract	2062		No	0
Sutter Island	349		No	10500
Terminous	548		No	102100
Twitchell	1601	19%	Yes	47900
Tyler Island	563		No	85600
Walnut Grove	554		No	2300
Union Island	1,2		No	103200
Van Sickle Island	1607		No	0
Veale Tract	2065		No	7500
Venice Island	2023		No	44700
Victoria Island	2040		No	74500
Webb Tract	2026	24%	Yes	80400
Weber	828		No	0
Winter Island	2122		No	0
Woodward Island	2072		No	21600
Wright-Elmwood Tract	2119		No	10700
-	307		No	0
-	369		No	2100
-	536		No	9600
-	765		No	0
-	813		No	0
-	900		No	0
-	999		No	6400
-	1608		No	3600
-	2084		No	15100
-	2093		No	8800
-	2095		No	0
-	2098		No	1500
-	2121		No	800
		0.41		133600

RECREATION

ISLAND ATTRIBUTE	DATA SOURCE and NOTES
State or regional parks, wildlife areas, and easements	Parisi, Monica. Geographic information System specialist. California Department of Fish and Game, Sacramento, CA. January 2 and 3, 1997 - telephone conversations. These figures do not include parks and boating facilities external to the levee system.
Recreation lands	DWR Land use mapping data. 1993. Recreational lands include commercial lands related to recreational activities. There are many areas of the Delta that are used for private recreation (e.g., waterfowl hunting) but are not categorized as 'recreational' lands. We were unable to get island-specific data on private recreation lands and hunting clubs. Therefore, these figures most likely underestimate all the recreational resources in the area.
Recreation resorts	DWR Delta atlas and Schnell, Hal. n.d. San Joaquin River - Sacramento River California Delta boating map. Stockton, CA. Most of these 'resorts' are marinas and boating facilities external to the levee system.

		Recreation		
ISLAND	Reclamation District	State or Regional Parks (Acres)	Recreation Lands (Acres)	Recreation Resorts
Bacon Island	2028	0	0.0	0
Bethel Island	-	0	6.4	19
Bishop Tract	2042	0	17.7	1
Boggs (Moss Tract)	404	0	0.0	2
Bouldin Island	756	0	0.0	0
Brack Tract	2033	359	0.0	0
Bradford Island	2059	0	0.0	0
Brannan/Andrus Island	-		0.0	24
Andrus	317	0	7.2	-
Andrus, Isleton	407	0	0.0	-
Andrus, Upper	556	0	5.2	-
Brannan	2067	0	93.4	-
Byron Tract	800	0	0.0	1
Canal Ranch	2086	0	0.0	0
Coney Island	2117	0	0.0	0
Dead Horse Island	2111	0	0.0	0
Empire Tract	2029	0	7.0	1
Fabian Tract	773	0	0.0	2
Fay	2113	0	0.0	0
Glanville Tract	1002	0	0.0	1
Grand Island	3	0	4.9	9
Hastings Tract	2060	0	0.0	0
Holland Tract	2025	0	0.0	2
Holt Station	2116	0	0.0	0
Hotchkiss Tract	799	0	0.0	18
Jersey Island	830	0	0.0	0
Jones Tract	-		0.0	-
Jones, Lower	2038	0	0.0	1
Jones, Upper	2039	0	0.0	1
King Island	2044	0	0.0	3
Little Mandeville	2118	0	0.0	0
Mandeville Island	2027	0	0.0	0
McCormack Williamson Tr	2110	0	0.0	0
McDonald Island	2030	0	0.0	0
Medford Island	2041	0	0.0	0
Merritt Island	150	0	0.0	1
Mildred Island	2021	0	0.0	0
Naglee Burke	1007	0	0.0	0
New Hope Tract	348	915	0.0	3
Orwood Island	2024	0	0.0	1
Palm Tract	2036	0	0.0	0
Pescadero	2058	0	9.3	0
Pierson District	551	0	0.0	3
Prospect Island	1667	0	0.0	1
Quimby Island	2090	0	0.0	0
Rindge Tract	2037	0	0.0	0
Rio Blanco Tract	2114	0	0.0	1
Roberts Island	-		-	-
Roberts, Lower	684	0	47.6	4
Roberts, Middle	524	0	0.0	0
Roberts, Upper	544	0	0.0	0
Rough and Ready Island	-	0	0.0	0
Ryer Island	501	0	17.0	2
Sargent Barnhart Tract	2074	0	32.5	3
Sherman Island	341	3100	66.7	7
Shima Tract	2115	0	0.0	0
Shin Kee Tract	-	0	0.0	2
Smith	1614	0	0.0	1
Stark	2089	0	0.0	0
Staten Island	38	0	0.0	0
Stewart Tract	2062	0	0.0	2
Sutter Island	349	0	0.0	1
Terminous	548	0	0.0	5
Twitchell	1601	0	0.0	1
Tyler Island	563	0	0.0	2
Walnut Grove	554	0	4.5	3
Union Island	1,2	0	0.0	0
Van Sickle Island	1607	0	0.0	0
Veale Tract	2065	0	0.0	0
Venice Island	2023	0	0.0	0
Victoria Island	2040	0	0.0	0
Webb Tract	2026	285	0.0	0
Weber	828	0	0.0	3
Winter Island	2122	0	0.0	0
Woodward Island	2072	0	0.0	0
Wright-Elmwood Tract	2119	0	0.0	1
-	307	0	0.0	1
-	369	0	0.0	0
-	536	0	0.0	0
-	765	0	0.0	N/D
-	813	0	0.0	0
-	900	0	0.0	2
-	999	0	0.0	1
-	1608	0	15.4	2
-	2084	0	0.0	1
-	2093	0	0.0	0
-	2095	0	0.0	0
-	2098	0	0.0	0
-	2121	0	0.0	0
			93.4	24
			0.0	

CULTURAL RESOURCES

ISLAND ATTRIBUTE	DATA SOURCE and NOTES
Known prehistoric sites	U.S Bureau of Reclamation. 1996. Cultural resources of the Sacramento-San Joaquin Delta, CALFED Bay-Delta Program. Draft. Sacramento, CA. The information on prehistoric and historic resources in the Delta depends on whether an area has been surveyed and results have been reported. Therefore, the lack of an occurrence on an island does not preclude the presence of prehistoric and historic resources.
Potential historic sites	U.S Bureau of Reclamation. 1996. Cultural resources of the Sacramento-San Joaquin Delta, CALFED Bay-Delta Program. Draft. Sacramento, CA. See above note.

ISLAND	Reclamation District	Cultural Resources	
		Known Prehistoric Sites	Potential Historic Sites
Bacon Island	2028		13
Bethel Island	-	4	
Bishop Tract	2042	1	
Boggs (Moss Tract)	404	1	
Bouldin Island	756		6
Brack Tract	2033		
Bradford Island	2059		
Brannan/Andrus Island	-		
Andrus	317		
Andrus, Isleton	407		
Andrus, Upper	556	1	
Brannan	2067		
Byron Tract	800	5	1
Canal Ranch	2086		
Coney Island	2117		
Dead Horse Island	2111		
Empire Tract	2029		
Fabian Tract	773	3	2
Fay	2113		
Glanville Tract	1002	2	
Grand Island	3		
Hastings Tract	2060		
Holland Tract	2025	4	2
Holt Station	2116		
Hotchkiss Tract	799	8	
Jersey Island	830	1	
Jones Tract	-		
Jones, Lower	2038		
Jones, Upper	2039		
King Island	2044		
Little Mandeville	2118		
Mandeville Island	2027		
McCormack Williamson Tr	2110		
McDonald Island	2030	1	
Medford Island	2041		
Merritt Island	150	2	
Mildred Island	2021		
Naglee Burke	1007		
New Hope Tract	348	24	2
Orwood Island	2024		
Palm Tract	2036	1	
Pescadero	2058	2	1
Pierson District	551	3	
Prospect Island	1667		
Quimby Island	2090		
Rindge Tract	2037		
Rio Blanco Tract	2114		
Roberts Island	-	-	
Roberts, Lower	684		
Roberts, Middle	524	1	
Roberts, Upper	544		
Rough and Ready Island	-		
Ryer Island	501		
Sargent Barnhart Tract	2074	1	1
Sherman Island	341		
Shima Tract	2115		
Shin Kee Tract	-		
Smith	1614		
Stark	2089		
Staten Island	38		1
Stewart Tract	2062		
Sutter Island	349		
Terminous	548	1	
Twitchell	1601		
Tyler Island	563	4	
Walnut Grove	554	-	
Union Island	1,2	1	
Van Sickle Island	1607		
Veale Tract	2065	2	
Venice Island	2023		
Victoria Island	2040		
Webb Tract	2026		2
Weber	828	1	
Winter Island	2122		
Woodward Island	2072		1
Wright-Elmwood Tract	2119		
-	307	5	1
-	369	4	
-	536		
-	765		
-	813	4	
-	900		
-	999	5	
-	1608		
-	2084		
-	2093		
-	2095	1	
-	2098		
-	2121		

INFRASTRUCTURE OF LOCAL CONCERN

ISLAND ATTRIBUTE	DATA SOURCE and NOTES
County roads	DWR Delta atlas. The team selected "present/absent" as the appropriate unit to report over "miles of roadway" because if any portion of a road is damaged or inundated during a levee breach or flood event, circulation patterns would need to be re-routed.
Commercial lands	DWR Land use mapping data.
Industrial lands	DWR Land use mapping data.
Acreage protected per levee mile	DWR Delta atlas and DWR Land use mapping data. Acreage protected per levee mile was computed by dividing each island's acreage by the corresponding number of levee miles.

		Infrastructure of Local Concern			
ISLAND	Reclamation District	County Roads	Commercial Lands (Acres)	Industrial Lands (Acres)	Acreage Protected per Levee Mile (Acres/Mile)
Bacon Island	2028	present	0.0	13.8	393
Bethel Island	-	present	0.0	0.0	304
Bishop Tract	2042	present	0.0	0.0	374
Boggs (Moss Tract)	404	absent	31.5	42.0	617
Bouldin Island	756	absent	0.0	45.3	334
Brack Tract	2033	present	0.0	0.0	451
Bradford Island	2059	absent	0.0	0.0	277
Brannan/Andrus Islan	-	-	-	-	376
Andrus	317	present	0.0	5.3	-
Andrus, Isleton	407	present	3.8	46.7	-
Andrus, Upper	556	present	0.0	1.8	-
Brannan	2067	present	2.4	9.8	-
Byron Tract	800	present	0.0	0.0	715
Canal Ranch	2086	absent	0.0	0.0	399
Coney Island	2117	absent	0.0	0.0	173
Dead Horse Island	2111	absent	0.0	0.0	81
Empire Tract	2029	present	0.0	0.0	327
Fabian Tract	773	present	0.0	0.0	347
Fay	2113	absent	0.0	0.0	63
Glanville Tract	1002	present	0.0	0.0	538
Grand Island	3	present	5.8	5.3	587
Hastings Tract	2060	absent	0.0	0.0	447
Holland Tract	2025	present	0.0	0.0	372
Holt Station	2116	present	0.0	0.0	490
Hotchkiss Tract	799	present	17.3	9.9	492
Jersey Island	830	present	0.0	0.0	223
Jones Tract	-	-	-	-	-
Jones, Lower	2038	present	0.0	0.0	670
Jones, Upper	2039	present	0.0	0.0	673
King Island	2044	present	0.0	0.0	362
Little Mandeville	2118	absent	0.0	0.0	80
Mandeville Island	2027	absent	0.0	0.0	371
McCormack Williamso	2110	absent	0.0	3.0	188
McDonald Island	2030	absent	0.0	84.0	449
Medford Island	2041	absent	0.0	0.0	207
Merritt Island	150	present	0.0	3.3	262
Mildred Island	2021	absent	0.0	0.0	137
Naglee Burke	1007	present	0.0	0.0	734
New Hope Tract	348	present	18.8	26.0	500
Orwood Island	2024	present	0.0	0.0	380
Palm Tract	2036	absent	0.0	0.0	325
Pescadero	2058	present	3.1	138.4	955
Pierson District	551	present	0.0	16.4	612
Prospect Island	1667	absent	0.0	0.0	123
Quimby Island	2090	absent	0.0	0.0	110
Rindge Tract	2037	absent	0.0	0.0	435
Rio Blanco Tract	2114	absent	0.0	0.0	176
Roberts Island	-	-	-	-	-
Roberts, Lower	684	present	5.5	53.5	676
Roberts, Middle	524	present	0.0	672.2	1310
Roberts, Upper	544	present	0.0	0.0	550
Rough and Ready Isla	-	absent	0.0	835.7	218
Ryer Island	501	present	0.0	0.0	577
Sargent Barnhart Trac	2074	present	0.0	0.0	282
Sherman Island	341	present	7.1	0.0	510
Shima Tract	2115	absent	0.0	0.0	363
Shin Kee Tract	-	absent	0.0	0.0	246
Smith	1614	present	0.0	0.0	246
Stark	2089	absent	0.0	0.0	210
Staten Island	38	present	0.0	9.4	361
Stewart Tract	2062	present	0.0	0.0	318
Sutter Island	349	present	0.0	0.0	210
Terminous	548	present	0.0	0.0	650
Twitchell	1601	present	0.0	10.1	298
Tyler Island	563	present	0.0	3.0	375
Walnut Grove	554	present	0.0	25.3	208
Union Island	1,2	present	10.1	0.0	735
Van Sickle Island	1607	absent	0.0	0.0	278
Veale Tract	2065	present	0.0	4.0	228
Venice Island	2023	absent	0.0	0.0	262
Victoria Island	2040	absent	0.0	0.0	480
Webb Tract	2026	absent	0.0	0.0	429
Weber	828	absent	0.0	0.0	958
Winter Island	2122	absent	0.0	0.0	100
Woodward Island	2072	absent	0.0	0.0	207
Wright-Elmwood Tract	2119	present	0.0	0.0	312
-	307	present	0.0	1.7	463
-	369	present	0.0	0.0	313
-	536	present	0.0	0.0	456
-	765	present	0.0	0.0	237
-	813	present	0.0	0.0	317
-	900	present	0.0	0.0	814
-	999	present	0.0	105.2	786
-	1608	absent	0.0	39.8	302
-	2084	present	0.0	51.1	453
-	2093	absent	0.0	0.0	245
-	2095	present	147.8	55.6	1388
-	2098	absent	0.0	0.0	326
-	2121	present	0.0	0.0	229
			147.844	835.6962	1388

INFRASTRUCTURE OF STATEWIDE CONCERN

ISLAND ATTRIBUTE	DATA SOURCE and NOTES
Federal and state highways	DWR Delta atlas. See note for "County Roads" above.
Water supply conveyance	DWR Delta atlas.
Railroad mainlines	DWR Delta atlas.
Natural gas pipelines	Warner, Chris. Supervisor of mapping. Pacific Gas and Electric, Central Area, Walnut Creek, CA. November 25 and December 7, 1996; January 2,3 and 17, 1997 - telephone conversations and facsimile. (PG&E natural gas facilities data) Gas distribution line mileages are approximate.
Natural gas fields and storage	DWR Delta atlas and PG&E natural gas facilities data.
Power transmission lines	DWR Delta atlas.

		Statewide Infrastructure					
ISLAND	Reclamation District	Federal and State Highways	Water Supply Conveyance (Miles)	Railroad Mainlines (Miles)	Natural Gas Fields and Storage	Natural Gas Pipelines (Miles)	Power Transmission Lines (Miles)
Bacon Island	2028	absent	0	0	Absent	4.32	0
Bethel Island	-	absent	0	0	Production	1.29	0
Bishop Tract	2042	present	0	0	Absent	0	2
Boggs (Moss Tract)	404	present	0	3	Production	na	1
Bouldin Island	756	present	0	0	Absent	0	0
Brack Tract	2033	absent	0	0	Absent	10.03	0
Bradford Island	2059	absent	0	0	Production	5.43	0
Brannan/Andrus Island	-		-	-	-	-	-
Andrus	317	present	0	0	Production	15.34	0
Andrus, Isleton	407	present	0	0	Production	na	0
Andrus, Upper	556	absent	0	0	Production	na	0
Brannan	2067	present	0	0	Production	49.26	6
Byron Tract	800	present	0	1	Absent	1.85	2
Canal Ranch	2086	absent	0	0	Absent	0.89	0
Coney Island	2117	absent	0	0	Absent	0	0
Dead Horse Island	2111	absent	0	0	Absent	0	0
Empire Tract	2029	absent	0	0	Absent	0	0
Fabian Tract	773	absent	0	0	Absent	0	0
Fay	2113	absent	0	0	Absent	0	0
Glanville Tract	1002	present	0	0	Absent	0	0
Grand Island	3	present	0	0	Production	6.06	9
Hastings Tract	2060	absent	3.4	0	Production	3.91	2
Holland Tract	2025	absent	0	0	Absent	0	0
Holt Station	2116	present	0.2	0	Absent	na	0
Hotchkiss Tract	799	absent	1.7	0	Production	9.2	3
Jersey Island	830	absent	0	0	Production	4.89	3
Jones Tract	-	-	-	-	-	-	-
Jones, Lower	2038	absent	5.5	5	Absent	0	0
Jones, Upper	2039	present	5.5	0	Absent	0	4
King Island	2044	absent	0	0	Production	0.61	0
Little Mandeville	2118	absent	0	0	Absent	na	0
Mandeville Island	2027	absent	0	0	Absent	0	0
McCormack Williamson Tr	2110	absent	0	0	Present	na	0
McDonald Island	2030	absent	0	0	STORAGE	9.27	0
Medford Island	2041	absent	0	0	Absent	0	0
Merritt Island	150	absent	0	0	Production	0	0
Mildred Island	2021	absent	0	0	Absent	2.53	0
Naglee Burke	1007	absent	0	0	Absent	na	3
New Hope Tract	348	present	0	2	Production	16.46	0
Orwood Island	2024	absent	2.6	0	Absent	1.15	0
Palm Tract	2036	absent	0	2	Absent	5.24	0
Pescadero	2058	present	0	4	Absent	0	0
Pierson District	551	present	0.8	0	Production	0.05	4
Prospect Island	1667	absent	0	0	Absent	0	0
Quimby Island	2090	absent	0	0	Absent	0	0
Rindge Tract	2037	absent	0	0	Absent	0	0
Rio Blanco Tract	2114	absent	0	0	Production	0	1
Roberts Island	-	-	-	-	-	15.34	-
Roberts, Lower	684	absent	3	5	Production	-	3
Roberts, Middle	524	present	0	0	Production	-	1
Roberts, Upper	544	absent	0	0	Production	-	4
Rough and Ready Island	-	absent	0	0	Absent	0	0
Ryer Island	501	present	0	0	Absent	0	0
Sargent Barnhart Tract	2074	absent	1.5	0	Absent	0	0
Sherman Island	341	present	0	0	Production	40.72	13
Shima Tract	2115	absent	0	0	Absent	0	1
Shin Kee Tract	-	present	0	0	Absent	0.97	1
Smith	1614	present	0	0	Absent	na	0
Stark	2089	absent	0	0	Absent	0	1
Staten Island	38	absent	0	0	Production	4.15	0
Stewart Tract	2062	present	0	3	Absent	0	1
Sutter Island	349	absent	0	0	Absent	0	0
Terminous	548	present	0	0	Production	7.56	3
Twitchell	1601	absent	0	0	Production	8.89	0
Tyler Island	563	absent	0.8	0	Production	19.09	0
Walnut Grove	554	absent	0.7	0	Production	-	-
Union Island	1,2	absent	0	0	Production	12.53	6
Van Sickle Island	1607	absent	0	0	Absent	0	0
Veale Tract	2065	absent	0	0	Absent	1.02	1
Venice Island	2023	absent	0	0	Absent	0	0
Victoria Island	2040	present	0	0	Absent	0	0
Webb Tract	2026	absent	0	0	Production	0.02	0
Weber	828	present	0	0	Production	N/D	0
Winter Island	2122	absent	0	0	Absent	N/D	0
Woodward Island	2072	absent	1.5	0	Absent	0	0
Wright-Elmwood Tract	2119	absent	0	0	Absent	0	2
-	307	absent	0	0	N/D	N/D	3
-	369	absent	0	0	Production	N/D	0
-	536	absent	0	0	Production	N/D	2
-	765	present	0	0	N/D	N/D	0
-	813	present	0	0	Absent	N/D	2
-	900	present	0	0	N/D	N/D	0
-	999	present	0	0	Absent	N/D	1
-	1608	present	0	0	Absent	N/D	0
-	2084	absent	0	0	Production	N/D	0
-	2093	absent	0	0	Production	N/D	0
-	2095	present	0	2.7	Absent	N/D	3
-	2098	absent	0	0	Production	N/D	3
-	2121	absent	0	1	Absent	N/D	0
			5.5	5.3		49.26	12.9

ADJACENT ISLAND RESOURCES

ISLAND ATTRIBUTE	DATA SOURCE and NOTES
Adjacent levees at risk	**
Adjacent acreage at risk	**
Seepage risk	**

Adjacent island resources are an important element to the Delta levee system integrity program. This objective has been included in the Special Projects prioritization process to recognize the relationships between a breached island and adjacent islands. The main factors that the team wants to capture in the information matrix include wind and wave erosion and seepage. Waterside levee slopes are subject to varying erosional effects of channel flows, tidal action, wind-generated waves, and boat wakes. A levee breach can result in increased wave action over time because the wind fetch across open water results in bigger waves which can affect erosion of an adjacent island's exterior levee slopes. Seepage of water from waterways or adjacent islands is a major concern of Delta land users. Seepage from these sources can affect levee erosion problems or instability and create drainage problems for landowners. The amount of seepage that occurs is controlled by the permeability of soils, length of the seepage path, and height of the hydraulic head (i.e., the pressure created by water within a given volume). A flooded island would result in potential increases in seepage to adjacent islands.

In discussing how to capture these issues, the team recommended using the attributes listed above. However, detailed assumptions needed to characterize these attributes have not yet been worked out. For example, what is an appropriate distance between levees to define "adjacent"? How can the seepage risk attribute capture differences in soil and current seepage conditions throughout the Delta? and How should the seepage risk attribute be characterized (e.g., a qualitative or quantitative scale). Additional investigation and discussion is needed to fully develop the "Adjacent Island Resources" attributes. Therefore, data will be presented in a future version of the information matrix.

		Adjacent Islands		
ISLAND	Reclamation District	Adjacent Levees At Risk (Miles)	Adjacent Acreage At Risk (Acres)	Seepage Risk
Bacon Island	2028		19512	
Bethel Island	-		10631	
Bishop Tract	2042		13193	
Boggs (Moss Tract)	404			
Bouldin Island	756		50326	
Brack Tract	2033		22639	
Bradford Island	2059		22414	
Brannan/Andrus Island	-		50542	
Andrus	317		-	
Andrus, Isleton	407		-	
Andrus, Upper	556		-	
Brannan	2067		-	
Byron Tract	800		13210	
Canal Ranch	2086		23346	
Coney Island	2117		29452	
Dead Horse Island	2111		28710	
Empire Tract	2029		29790	
Fabian Tract	773		36972	
Fay	2113		8061	
Glanville Tract	1002		10634	
Grand Island	3		38930	
Hastings Tract	2060		0	
Holland Tract	2025		16728	
Holt Station	2116			
Hotchkiss Tract	799		12329	
Jersey Island	830		18588	
Jones Tract	-		-	
Jones, Lower	2038		52398	
Jones, Upper	2039		41619	
King Island	2044		24624	
Little Mandeville	2118			
Mandeville Island	2027		22468	
McCormack Williamson Tr	2110		34664	
McDonald Island	2030		51794	
Medford Island	2041		18095	
Merritt Island	150		11600	
Mildred Island	2021			
Naglee Burke	1007		15210	
New Hope Tract	348		13823	
Orwood Island	2024		11191	
Palm Tract	2036		15121	
Pescadero	2058		12590	
Pierson District	551		31370	
Prospect Island	1667		11880	
Quimby Island	2090		9360	
Rindge Tract	2037		52066	
Rio Blanco Tract	2114		6445	
Roberts Island	-		56009	
Roberts, Lower	684		-	
Roberts, Middle	524		-	
Roberts, Upper	544		-	
Rough and Ready Island	-		33761	
Ryer Island	501		20858	
Sargent Barnhart Tract	2074		36098	
Sherman Island	341		25118	
Shima Tract	2115		11124	
Shin Kee Tract	-		14435	
Smith	1614			
Stark	2089		34792	
Staten Island	38		42439	
Stewart Tract	2062		64163	
Sutter Island	349		42610	
Terminous	548		27758	
Twitchell	1601		32928	
Tyler Island	563		58484	
Walnut Grove	554		-	
Union Island	1,2		51906	
Van Sickle Island	1607			
Veale Tract	2065		9596	
Venice Island	2023		21445	
Victoria Island	2040		38151	
Webb Tract	2026		35543	
Weber	828			
Winter Island	2122			
Woodward Island	2072		36099	
Wright-Elmwood Tract	2119		42989	
-	307			
-	369			
-	536			
-	765			
-	813			
-	900			
-	999			
-	1608			
-	2084			
-	2093			
-	2095			
-	2098			
-	2121			
			64163	

ECOSYSTEM

ISLAND ATTRIBUTE	DATA SOURCE and NOTES
Native vegetation	DWR Land use mapping data. 1993.
Wetlands	U.S. Fish and Wildlife Service. 1995. National Wetland Inventory based on 1985 aerial photographs mapped at 1:124,000 scale. (NWI mapping data)
Riparian habitats	NWI mapping data
Agricultural waterfowl habitats	DWR Land use mapping data. 1993. Agricultural land classifications considered potential waterfowl habitat are grain and hay crops (barley, wheat, oats, miscellaneous and mixed hay and grain); field crops (safflower, flax, hops, sugar beets, corn [field or sweet], grain sorghum); and rice.
Known special-status plant occurrences	Natural Diversity Database. 1996. Records search for the Bay-Delta study area. California Department of Fish and Game. Sacramento, CA. (NDDB) California Department of Fish and Game. 1995. SB 34 Delta Levees Master Environmental Assessment. Sacramento, CA. (SB 34 MEA) Data for the "Habitat and Special-Status Species Interior to Levee Systems" category was compiled from the Natural Diversity Database and California Department of Fish and Game's SB 34 Delta Levees Master Environmental Assessment. Species locations were reconciled (cross-referenced) in order to eliminate duplicative data. The information on special-status plant and wildlife occurrences in the Delta depends on whether an area has been surveyed and results have been reported. Therefore, the lack of an occurrence on an island does not preclude the presence of special-status plants and wildlife.
Known special-status wildlife occurrences	NDDB and SB 34 MEA See above notes.

Ecosystem attribute data (acreages and species occurrences) have been presented in three ways: totals for each island, resources interior to the levee system, and resources on the exterior (water side) of the island levees. The attribute data are divided this way to distinguish those resources that are protected by the existing levee system (interior to the levee system) and those resources exterior to the system. This distinction was used in ranking the islands for the Special Projects prioritization exercise.

		Island Total							
						Known Special-Status Plant Occurrences (by 1995)		Known Special-Status Wildlife Occurrences (by 1995)	
ISLAND	Reclamation District	Native Vegetation (Acres)	Wetlands (Acres)	Riparian Habitats (Acres)	Agricultural Waterfowl Habitats (Acres)	# species	# occurences	# species	# occurences
Bacon Island	2028	360.3	0.0	7.2	1112.7	4	48	3	9
Bethel Island	-	344.7	2.4	90.9	0	4	19	1	1
Bishop Tract	2042	103.1	7.6	1.7	817.5	1	1	1	1
Boggs (Moss Tract)	404	193.5	3.4	62.5	0.0				
Bouldin Island	756	217.4	0.3	5.3	5348.9	5	46	4	5
Brack Tract	2033	196.0	8.3	0.0	1263.7	2	7	3	15
Bradford Island	2059	171.1	0.0	14.8	0.0	2	5		
Brannan/Andrus Island	-	-	-	-	-	6	46	3	7
Andrus	317	136.0	7.7	5.6	2723.4	-	-	-	-
Andrus, Isleton	407	138.6	24.1	0.0	947.7	-	-	-	-
Andrus, Upper	556	157.1	0.0	1.7	873.3	-	-	-	-
Brannan	2067	475.5	26.5	15.6	4691.5	-	-	-	-
Byron Tract	800	874.3	54.9	0.6	1280.8	7	17	2	5
Canal Ranch	2086	179.4	18.5	0.0	2255.8	4	9	2	8
Coney Island	2117	84.4	2.5	1.6	658.1	2	8	1	3
Dead Horse Island	2111	28.8	0.0	0.0	0.0	1	5	1	1
Empire Tract	2029	176.6	18.2	14.7	2159.9	4	15	2	2
Fabian Tract	773	339.6	13.0	38.6	1003.8	2	9	3	10
Fay	2113	31.4	0.0	2.7	63.9	2	5	1	1
Glanville Tract	1002	298.5	100.9	39.6	1212.1	4	9	3	3
Grand Island	3	666.6	37.3	28.8	7901.0			1	2
Hastings Tract	2060	385.0	82.2	0.0	503.3	2	3		
Holland Tract	2025	384.0	15.8	31.0	2923.7	4	39	2	2
Holt Station	2116	2.9	0.9	0.0	113.6				
Hotchkiss Tract	799	746.5	4.7	44.5	185.4	2	11	2	2
Jersey Island	830	697.5	16.8	58.3	0.0				
Jones Tract	-	-	-	-	-	-	-	-	-
Jones, Lower	2038	167.6	0.0	1.1	2458.4	4	14	2	3
Jones, Upper	2039	406.1	5.5	0.0	2447.7	4	15	3	4
King Island	2044	115.0	0.0	0.0	2819.3				
Little Mandeville	2118	50.3	0.0	7.6	269.2				
Mandeville Island	2027	336.1	85.7	41.9	501.6	3	20	1	1
McCormack Williamson Tr	2110	66.7	0.0	8.5	180.7	4	18	1	5
McDonald Island	2030	395.2	76.8	14.2	1537.6	4	16	2	2
Medford Island	2041	84.7	3.2	17.4	328.8	2	4	3	3
Merritt Island	150	238.5	0.0	1.0	1007.5			1	2
Mildred Island	2021	151.9	0.0	0.0	-	1	1		
Naglee Burke	1007	0.0	0.0	0.0	-			1	1
New Hope Tract	348	303.0	54.5	4.7	3905.7	1	12	4	17
Orwood Island	2024	212.3	0.0	4.7	596.2	2	4		
Palm Tract	2036	205.6	0.6	0.0	1882.4	3	17	2	5
Pescadero	2058	304.9	10.5	24.2	873.4			2	6
Pierson District	551	277.7	64.4	24.7	2012.2	2	6	3	5
Prospect Island	1667	418.4	3.3	3.4	389.0	2	3		
Quimby Island	2090	139.4	0.0	14.2	303.2	4	7		
Rindge Tract	2037	347.3	0.0	0.6	3075.4	3	26	1	1
Rio Blanco Tract	2114	94.5	17.1	14.4	422.4			1	1
Roberts Island	-	-	-	-	-	3	9	4	23
Roberts, Lower	684	303.8	26.7	10.0	4947.3	-	-	-	-
Roberts, Middle	524	177.3	8.8	24.8	4569.8	-	-	-	-
Roberts, Upper	544	207.1	9.9	7.4	3141.5	-	-	-	-
Rough and Ready Island	-	233.9	84.6	118.7	358.0	1	2		
Ryer Island	501	317.8	6.0	12.3	6178.8				
Sargent Barnhart Tract	2074	41.6	4.3	9.3	155.1	1	1		
Sherman Island	341	381.9	40.6	2.4	1772.4	5	65	5	6
Shima Tract	2115	103.1	0.0	0.0	442.0	2	3	1	2
Shin Kee Tract	-	26.7	0.2	0.0	605.2	1	1	2	2
Smith	1614	24.3	0.0	38.3	0.0				
Stark	2089	85.9	9.4	6.8	339.5	1	2	2	4
Staten Island	38	250.1	0.0	2.4	8397.9	7	26	3	11
Stewart Tract	2062	233.9	42.9	17.2	1115.9				
Sutter Island	349	223.5	0.0	0.0	494.1				
Terminous	548	648.0	181.5	4.4	7859.6	5	19	4	8
Twitchell	1601	236.7	0.0	4.6	632.1	4	5		
Tyler Island	563	403.8	10.2	1.4	5599.8	3	4	3	5
Walnut Grove	554	23.8	0.0	0.0	137.8	-	-	-	-
Union Island	1,2	645.0	8.9	46.7	8391.0	4	29	4	11
Van Sickle Island	1607	0.0	0.0	0.0	0.0	4	14	1	1
Veale Tract	2065	161.1	5.2	0.0	926.2				
Venice Island	2023	265.0	3.2	66.9	1211.9	3	7	1	1
Victoria Island	2040	265.6	1.7	0.0	2097.6	4	34	1	3
Webb Tract	2026	400.6	78.7	92.9	1332.8	5	33		
Weber	828	0.0	0.0	3.9	898.1				
Winter Island	2122	N/D	N/D	N/D	0.0				
Woodward Island	2072	143.0	0.1	0.0	0.0	2	22	3	4
Wright-Elmwood Tract	2119	122.9	0.1	7.7	0.0	1	1		
-	307	199.7	10.9	6.0	1264.7				
-	369	73.9	156.8	139.5	0.0				
-	536	1179.4	78.9	0.3	807.6				
-	765	96.2	4.8	11.2	428.8				
-	813	90.9	9.3	1.7	405.9				
-	900	687.7	70.7	21.8	1740.2				
-	999	852.5	33.6	23.3	8779.4				
-	1608	0.0	0.1	0.0	0.0				
-	2084	205.4	1.1	5.7	1005.6				
-	2093	240.8	39.6	12.5	3087.3				
-	2095	228.9	69.7	74.9	1111.8				
-	2098	1265.8	857.0	5.8	1350.4				
-	2121	10.3	45.6	0.4	261.9				

		Interior to Levee						
					Known Special-Status Plant Occurrences (by 1995)		Known Special-Status Wildlife Occurrences (by 1995)	
ISLAND	Reclamation District	Native Vegetation (Acres)	Wetlands (Acres)	Riparian Habitats (Acres)	# species	# occurences	# species	# occurences
Bacon Island	2028	260.5	0.0	6.8	1	1	1	1
Bethel Island	-	326.7	2.4	90.7			1	1
Bishop Tract	2042	70.2	6.7	1.1			1	1
Boggs (Moss Tract)	404	158.2	3.4	61.9				
Bouldin Island	756	144.2	0.0	5.3				
Brack Tract	2033	106.3	8.3	0.0	1	2	2	8
Bradford Island	2059	121.9	0.0	14.8				
Brannan/Andrus Island	-	-	-	-	3	6	2	2
Andrus	317	67.5	6.2	2.2	-	-	-	-
Andrus, Isleton	407	44.2	23.9	0.0	-	-	-	-
Andrus, Upper	556	8.6	0.0	0.0	-	-	-	-
Brannan	2067	124.9	21.6	5.7	-	-	-	-
Byron Tract	800	836.5	54.7	0.3	6	7	1	3
Canal Ranch	2086	132.1	18.5	0.0			2	6
Coney Island	2117	35.4	1.8	1.4				
Dead Horse Island	2111	10.1	0.0	0.0				
Empire Tract	2029	106.2	18.2	14.6				
Fabian Tract	773	124.4	10.9	10.0				
Fay	2113	18.4	0.0	2.7				
Glanville Tract	1002	239.0	55.7	11.3				
Grand Island	3	256.7	37.3	13.2	2	3	1	1
Hastings Tract	2060	266.8	80.3	0.0				
Holland Tract	2025	310.9	15.7	31.0			1	1
Holt Station	2116	2.2	0.8	0.0				
Hotchkiss Tract	799	723.5	4.3	44.5				
Jersey Island	830	574.6	16.3	51.6				
Jones Tract	-	-	-	-	-	-	-	-
Jones, Lower	2038	95.6	0.0	1.1			1	1
Jones, Upper	2039	312.7	2.4	0.0				
King Island	2044	51.2	0.0	0.0				
Little Mandeville	2118	33.4	0.0	5.8				
Mandeville Island	2027	291.3	85.6	13.7				
McCormack Williamson Tr	2110	34.1	0.0	6.6				
McDonald Island	2030	223.1	76.8	10.9				
Medford Island	2041	67.9	2.3	16.2			1	1
Merritt Island	150	117.1	0.0	0.0				
Mildred Island	2021	100.2	0.0	0.0				
Naglee Burke	1007	0.0	0.0	0.0				
New Hope Tract	348	236.1	52.9	4.2			1	1
Orwood Island	2024	158.7	0.0	3.3				
Palm Tract	2036	148.9	0.0	0.0				
Pescadero	2058	164.6	8.7	6.4			2	4
Pierson District	551	124.6	25.8	3.6				
Prospect Island	1667	368.4	2.6	0.2	1	1		
Quimby Island	2090	120.6	0.0	13.6				
Rindge Tract	2037	232.8	0.0	0.5				
Rio Blanco Tract	2114	76.7	16.6	4.7				
Roberts Island	-	-	-	-			2	6
Roberts, Lower	684	173.5	21.4	4.7	-	-	-	-
Roberts, Middle	524	99.6	8.8	1.3	-	-	-	-
Roberts, Upper	544	47.8	0.7	4.2	-	-	-	-
Rough and Ready Island	-	201.2	80.7	113.0				
Ryer Island	501	66.7	4.5	0.4				
Sargent Barnhart Tract	2074	19.4	1.2	8.3				
Sherman Island	341	167.4	0.0	2.0			2	2
Shima Tract	2115	64.7	0.0	0.0				
Shin Kee Tract	-	3.7	0.1	0.0	1	1		
Smith	1614	12.1	0.0	1.9				
Stark	2089	47.7	8.3	0.4				
Staten Island	38	138.5	0.0	0.9	2	2	1	6
Stewart Tract	2062	105.9	2.6	3.6	2	2	2	2
Sutter Island	349	104.7	0.0	0.0				
Terminous	548	517.3	174.9	4.4			1	1
Twitchell	1601	141.6	0.0	4.5				
Tyler Island	563	50.7	9.9	0.5			1	1
Walnut Grove	554	11.9	0.0	0.0	-	-	-	-
Union Island	1,2	398.2	7.0	42.8	2	2	3	5
Van Sickle Island	1607	0.0	0.0	0.0				
Veale Tract	2065	125.6	4.4	0.0				
Venice Island	2023	216.0	3.2	66.5				
Victoria Island	2040	140.6	0.0	0.0				
Webb Tract	2026	337.9	78.7	84.3				
Weber	828	0.0	0.0	3.9				
Winter Island	2122	n/d	n/d	n/d				
Woodward Island	2072	79.8	0.0	0.0				
Wright-Elmwood Tract	2119	67.4	0.0	7.5				
-	307	153.5	10.9	1.2				
-	369	63.6	15.6	18.3				
-	536	1154.5	78.9	0.0				
-	765	85.4	4.8	0.0				
-	813	57.3	9.1	0.0				
-	900	531.2	66.5	17.6				
-	999	420.2	28.4	18.6				
-	1608	0.0	0.0	0.0				
-	2084	161.6	1.1	5.7				
-	2093	140.3	21.9	2.8				
-	2095	191.5	60.3	63.2				
-	2098	1229.0	844.8	0.0				
-	2121	10.2	43.7	0.0				

		Exterior to Levee						
					Known Special-Status Plant Occurrences (by 1995)		Known Special-Status Wildlife Occurrences (by 1995)	
ISLAND	Reclamation District	Native Vegetation (Acres)	Wetlands (Acres)	Riparian Habitats (Acres)	# species	# occurences	# species	# occurences
Bacon Island	2028	99.7	0.0	0.4	4	47	2	8
Bethel Island	-	18.0	0.0	0.2	4	19		
Bishop Tract	2042	32.9	0.9	0.5	1	1		
Boggs (Moss Tract)	404	35.3	0.0	0.7				
Bouldin Island	756	73.2	0.3	0.0	5	46	4	5
Brack Tract	2033	89.6	0.0	0.0	2	5	2	7
Bradford Island	2059	49.2	0.0	0.0	2	5		
Brannan/Andrus Island	-	-	-	-	6	40	3	5
Andrus	317	68.5	1.5	3.3	-	-	-	-
Andrus, Isleton	407	94.5	0.2	0.0	-	-	-	-
Andrus, Upper	556	148.5	0.0	1.7	-	-	-	-
Brannan	2067	350.6	10.0	2067	-	-	-	-
Byron Tract	800	37.8	0.2	0.3	3	10	1	2
Canal Ranch	2086	47.3	0.0	0.0	4	9	1	2
Coney Island	2117	49.0	0.7	0.2	2	8	1	3
Dead Horse Island	2111	18.7	0.0	0.0	1	5	1	1
Empire Tract	2029	70.4	0.0	0.1	4	15	2	2
Fabian Tract	773	215.1	2.1	28.6	2	9	3	10
Fay	2113	13.1	0.0	0.0	2	5	1	1
Glanville Tract	1002	59.5	45.3	28.3	4	9	3	3
Grand Island	3	410.0	0.0	15.6			1	1
Hastings Tract	2060	118.2	1.9	0.0	2	3		
Holland Tract	2025	73.1	0.1	0.0	4	39	1	1
Holt Station	2116	0.7	0.2	0.0				
Hotchkiss Tract	799	23.1	0.4	0.0	2	11	2	2
Jersey Island	830	122.9	0.5	6.6				
Jones Tract	-	-	-	-	-	-	-	-
Jones, Lower	2038	72.0	0.0	0.0	4	14	1	2
Jones, Upper	2039	93.3	31.4	0.0	4	15	3	4
King Island	2044	63.8	0.0	0.0				
Little Mandeville	2118	17.0	0.0	1.8				
Mandeville Island	2027	44.8	0.1	28.2	3	20	1	1
McCormack Williamson Tr	2110	32.6	0.0	1.9	4	18	1	5
McDonald Island	2030	172.1	0.0	3.3	4	16	2	2
Medford Island	2041	16.8	0.9	1.1	2	4	2	2
Merritt Island	150	121.4	0.0	1.0			1	2
Mildred Island	2021	51.7	0.0	0.0	1	1		
Naglee Burke	1007	0.0	0.0	0.0			1	1
New Hope Tract	348	66.9	1.6	0.5	1	12	4	16
Orwood Island	2024	53.6	0.0	1.3	2	4		
Palm Tract	2036	56.7	0.6	0.0	3	17	2	5
Pescadero	2058	140.3	1.8	17.8			1	2
Pierson District	551	153.0	38.6	21.1	2	6	3	5
Prospect Island	1667	50.0	0.7	3.2	2	2		
Quimby Island	2090	18.8	0.0	0.6	4	7		
Rindge Tract	2037	114.6	0.0	0.1	3	26	1	1
Rio Blanco Tract	2114	17.8	0.5	9.7			1	1
Roberts Island	-	-	-	-	3	9	4	17
Roberts, Lower	684	130.2	5.3	5.2	-	-	-	-
Roberts, Middle	524	77.7	0.1	23.5	-	-	-	-
Roberts, Upper	544	159.3	9.2	3.2	-	-	-	-
Rough and Ready Island	-	32.7	3.9	5.7	1	2		
Ryer Island	501	251.1	1.5	11.9				
Sargent Barnhart Tract	2074	22.2	3.1	0.9	1	1		
Sherman Island	341	214.5	40.6	0.4	5	65	3	4
Shima Tract	2115	38.4	0.0	0.0	2	3	1	2
Shin Kee Tract	-	23.0	0.1	0.0			2	2
Smith	1614	12.2	0.0	36.3				
Stark	2089	38.2	1.1	6.4	1	2	2	4
Staten Island	38	111.7	0.0	1.5	7	24	3	5
Stewart Tract	2062	127.9	40.4	13.6				
Sutter Island	349	118.8	0.0	0.0				
Terminous	548	130.7	6.6	0.0	5	19	4	7
Twitchell	1601	95.1	0.0	0.0	4	5		
Tyler Island	563	353.0	0.3	0.9	3	4	2	4
Walnut Grove	554	11.9	0.0	0.0	-	-	-	-
Union Island	1,2	246.8	1.9	3.9	4	27	2	6
Van Sickle Island	1607	0.0	0.0	0.0	4	14	1	1
Veale Tract	2065	35.5	0.8	0.0				
Venice Island	2023	49.0	0.0	0.3	3	7	1	1
Victoria Island	2040	125.0	1.7	0.0	4	34	1	3
Webb Tract	2026	62.7	0.0	8.6	5	33		
Weber	828	0.0	0.0	0.0				
Winter Island	2122	n/d	n/d	n/d				
Woodward Island	2072	63.2	0.1	0.0	2	22	3	4
Wright-Elmwood Tract	2119	55.6	0.1	0.1	1	1		
-	307	46.2	0.0	4.8				
-	369	10.3	141.2	121.2				
-	536	24.9	0.0	0.3				
-	765	10.8	0.0	11.2				
-	813	33.6	0.2	1.7				
-	900	156.5	4.2	4.2				
-	999	432.3	5.1	4.7				
-	1608	0.0	0.1	0.0				
-	2084	43.8	0.0	0.1				
-	2093	100.5	17.7	9.7				
-	2095	37.4	9.4	11.7				
-	2098	36.8	12.2	5.8				
-	2121	0.1	1.8	0.4				
		432.2915	141.1941	121.199				

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ISLAND	Mason's Lilaeopsis	Delta Tule Pea	California Hibiscus	Elderberry Bush	Suisun Marsh Aster	Delta Button Celery	Caper Fruited Tropidocarpum	Recurved Larkspur	Delta Mudwort	Sanford's Arrowhead	Antioch Dunes Evening Primrose	Carquinez Goldenbush	Brittlescale	San Joaquin Saltbush	Soft Bird's Beak	Slough Thistle	Marsh Skullcap
	Known Special-Status Plant Occurrences Interior to Levee Systems (by 1995)																
Bacon Island			1														
Bethel Island																	
Bishop Tract																	
Bouldin Island																	
Brack Tract			2														
Bradford Island																	
Brannan Island	2				2						2						
Byron Tract			1				2	1				1	1	1			
Canal Ranch																	
Coney Island																	
Dead Horse Island																	
Decker Island																	
Empire Tract																	
Fabian Tract																	
Fay																	
Glanville Tract																	
Grand Island	2	1															
Hastings Tract																	
Holland Tract																	
Hotchkiss Tract																	
Jersey Island																	
Jones, Lower																	
Jones, Upper																	
King Island																	
Mandeville Island																	
McCormack Williamson Tract																	
McDonald Island																	
Medford Island																	
Merritt Island																	
Mildred Island																	
Naglee Burke																	
New Hope Tract																	
Orwood Island																	
Palm Tract																	
Pescadero																	
Pierson District																	
Prospect Island		1															
Quimby Island																	
Rindge Tract																	
Rio Blanco Tract																	
Roberts Island																	
Rough and Ready Island																	
Ryer Island																	
Sargent Barnhart Tract																	
Sherman Island																	
Shima Tract																	
Shin Kee Tract			1														
Stark																	
Staten Island		1	1														
Stewart Tract						1										1	
Sutter Island																	
Terminous																	
Twitchell																	
Tyler Island																	
Union Island			1	1													
Van Sickle Island																	
Veale Tract																	
Venice Island																	
Victoria Island																	
Webb Tract																	
Woodward Island																	
Wright-Elmwood Tract																	

C-007163

Known Special-Status Wildlife Occurrences Interior to Levee Systems (by 1995)

ISLAND		Swainson's Hawk	Giant Garter Snake	Western Pond Turtle	Burrowing Owl	San Joaquin Pocket Mouse	California Black Rail	Greater Sandhill Crane	Valley Elderberry Longhorn Beetle	San Joaquin Kit Fox	Lange's Metalmark Butterfly	Tri-colored Blackbird	Great Blue Heron	Salt Marsh Harvest Mouse	Sacramento Anthicid Beetle	California Least Tern	Antioch Dunes Anthicid Beetle	White-tailed Kite	Double Crested Cormorant
Bacon Island					1														
Bethel Island					1														
Bishop Tract		1																	
Bouldin Island																			
Brack Tract					1			7											
Bradford Island																			
Brannan Island		1													1				
Byron Tract					3														
Canal Ranch		1						5											
Coney Island																			
Dead Horse Island																			
Decker Island																			
Empire Tract																			
Fabian Tract																			
Fay																			
Glanville Tract																			
Grand Island		1																	
Hastings Tract																			
Holland Tract												1							
Hotchkiss Tract																			
Jersey Island																			
Jones, Lower					1														
Jones, Upper																			
King Island																			
Mandeville Island																			
McCormack Williamson Tract																			
McDonald Island																			
Medford Island		1																	
Merritt Island																			
Mildred Island																			
Naglee Burke																			
New Hope Tract		1																	
Orwood Island																			
Palm Tract																			
Pescadero		3										1							
Pierson District																			
Prospect Island																			
Quimby Island																			
Rindge Tract																			
Rio Blanco Tract																			
Roberts Island	f	5			1														
Rough and Ready Island																			
Ryer Island																			
Sargent Barnhart Tract																			
Sherman Island								1											1
Shima Tract																			
Shin Kee Tract																			
Stark																			
Staten Island								6											
Stewart Tract		1										1							
Sutter Island																			
Terminous			1																
Twitchell																			
Tyler Island								1											
Union Island	g	3				1			1										
Van Sickle Island																			
Veale Tract																			
Venice Island																			
Victoria Island																			
Webb Tract																			
Woodward Island																			
Wright-Elmwood Tract																			

C-007165

C—007165

Known Special-Status Plant Occurrences Exterior to Levee Systems (by 1995)

ISLAND		Mason's Lilaeopsis	Delta Tule Pea	California Hibiscus	Elderberry Bush	Suisun Marsh Aster	Delta Button Celery	Caper Fruited Tropidocarpum	Recurved Larkspur	Delta Mudwort	Sanford's Arrowhead	Antioch Dunes Evening Primrose	Carquinez Goldenbush	Brittlescale	San Joaquin Saltbush	Soft Bird's Beak	Slough Thistle	Marsh Skullcap
Bacon Island		22		15		8				2								
Bethel Island		7		2		4				6								
Bishop Tract				1														
Bouldin Island		10	9	6		18				3								
Brack Tract		4		1														
Bradford Island		3				2												
Brannan Island		8	11		6	10				2		3						
Byron Tract		4		4				2										
Canal Ranch		3	2	3						1								
Coney Island		5		3														
Dead Horse Island					5													
Decker Island																		
Empire Tract		3		5		6				1								
Fabian Tract		8			1													
Fay		4		1														
Glanville Tract		1	3	4	1													
Grand Island																		
Hastings Tract		2				1												
Holland Tract		16		12		10												1
Hotchkiss Tract		8								3								
Jersey Island																		
Jones, Lower		6	1	6						1								
Jones, Upper		6	4	4														1
King Island																		
Mandeville Island		11		2		7												
McCormack Williamson Tract		1	5	1	11													
McDonald Island		2		6	2	6												
Medford Island		3				1												
Merritt Island																		
Mildred Island							1											
Naglee Burke																		
New Hope Tract					12													
Orwood Island		2		2														
Palm Tract		10		4		3												
Pescadero																		
Pierson District			2	4														
Prospect Island		1	1															
Quimby Island		3		2		1												1
Rindge Tract		7		8		11												
Rio Blanco Tract																		
Roberts Island	f		1	7		1												
Rough and Ready Island			2															
Ryer Island										1								
Sargent Barnhart Tract				1														
Sherman Island		35	2			25				2						1		
Shima Tract		2		1														
Shin Kee Tract																		
Stark					2													
Staten Island		9	3	2	3	1				5								1
Stewart Tract																		
Sutter Island																		
Terminous		3	2	3		9				2								
Twitchell		1	1			1						2						
Tyler Island		2	1								1							
Union Island	g	4		11	9		3											
Van Sickle Island		2	6			5				1								
Veale Tract																		
Venice Island		2		1		4												
Victoria Island		8	5	20														1
Webb Tract		9	2	5		13				4								
Woodward Island		10		12														
Wright-Elmwood Tract				1														

		Known Special-Status Wildlife Occurrences Exterior to the Levee Systems (by 1995)																	
ISLAND		Swainson's Hawk	Giant Garter Snake	Western Pond Turtle	Burrowing Owl	San Joaquin Pocket Mouse	California Black Rail	Greater Sandhill Crane	Valley Elderberry Longhorn Beetle	San Joaquin Kit Fox	Lange's Metalmark Butterfly	Tri-colored Blackbird	Great Blue Heron	Salt Marsh Harvest Mouse	Sacramento Anthicid Beetle	California Least Tern	Antioch Dunes Anthicid Beetle	White-tailed Kite	Double Crested Cormorant
Bacon Island				2			6												
Bethel Island																			
Bishop Tract																			
Bouldin Island				1	1		2	1											
Brack Tract		1						6											
Bradford Island																			
Brannan Island		2													2		1		
Byron Tract				2															
Canal Ranch								2											
Coney Island		3																	
Dead Horse Island									1										
Decker Island																			
Empire Tract					1		1												
Fabian Tract		8	1	1															
Fay							1												
Glanville Tract		1			1				1										
Grand Island		1																	
Hastings Tract																			
Holland Tract							1												
Hotchkiss Tract					1					1									
Jersey Island																			
Jones, Lower							2												
Jones, Upper				1			2								1				
King Island																			
Mandeville Island							1												
McCormack Williamson Tract									5										
McDonald Island							1		1										
Medford Island							1		1										
Merritt Island		2																	
Mildred Island																			
Naglee Burke					1														
New Hope Tract		9	1				1		5										
Orwood Island																			
Palm Tract				1			4												
Pescadero		2																	
Pierson District		3	1															1	
Prospect Island																			
Quimby Island																			
Rindge Tract									1										
Rio Blanco Tract					1														
Roberts Island	f	8			1				5			3							
Rough and Ready Island																			
Ryer Island																			
Sargent Barnhart Tract																			
Sherman Island			1								2				1				
Shima Tract		2																	
Shin Kee Tract			1				1												
Stark		2		2															
Staten Island				2				2	1										
Stewart Tract																			
Sutter Island																			
Terminous			2		1		3	1											
Twitchell																			
Tyler Island		2							2										
Union Island	g	4	2																
Van Sickle Island				1															
Veale Tract																			
Venice Island													1						
Victoria Island				3															
Webb Tract																			
Woodward Island				1			2								1				
Wright-Elmwood Tract																			

C-007166

ISLAND		Mason's Lilaeopsis	Delta Tule Pea	California Hibiscus	Elderberry Bush	Suisun Marsh Aster	Delta Button Celery	Caper Fruited Tropidocarpum	Recurved Larkspur	Delta Mudwort	Sanford's Arrowhead	Antioch Dunes Evening Primrose	Carquinez Goldenbush	Brittlescale	San Joaquin Saltbush	Soft Bird's Beak	Marsh Skullcap
		Known Special-Status Plant Occurrences (by 1995)															
Bacon Island		22		16		8				2							
Bethel Island		7		2		4				6							
Bishop Tract				1													
Bouldin Island		10	9	6		18				3							
Brack Tract		4		3													
Bradford Island		3				2											
Brannan Island		10	11		6	12				2		5					
Byron Tract		4		5				4	1				1	1	1		
Canal Ranch		3	2	3						1							
Coney Island		5		3													
Dead Horse Island					5												
Decker Island																	
Empire Tract		3		5		6				1							
Fabian Tract		8			1												
Fay		4		1													
Glanville Tract		1	3	4	1												
Grand Island		2	1														
Hastings Tract		2				1											
Holland Tract		16		12		10											1
Hotchkiss Tract		8								3							
Jersey Island																	
Jones, Lower		6	1	6						1							
Jones, Upper		6	4	4													1
King Island																	
Mandeville Island		11		2		7											
McCormack Williamson Tract		1	5	1	11												
McDonald Island		2		6	2	6											
Medford Island		3				1											
Merritt Island																	
Mildred Island							1										
Naglee Burke																	
New Hope Tract					12												
Orwood Island		2		2													
Palm Tract		10		4		3											
Pescadero																	
Pierson District			2	4													
Prospect Island		1	2														
Quimby Island		3		2		1											1
Rindge Tract		7		8		11											
Rio Blanco Tract																	
Roberts Island	f		1	7		1											
Rough and Ready Island			2														
Ryer Island										1							
Sargent Barnhart Tract				1													
Sherman Island		35	2			25				2						1	
Shima Tract		2		1													
Shin Kee Tract				1													
Stark					2												
Staten Island		9	4	3	3	1				5							1
Stewart Tract							1										
Sutter Island																	
Terminous		3	2	3		9				2							
Twitchell		1	1			1						2					
Tyler Island		2	1								1						
Union Island	g	4		12	10		3										
Van Sickle Island		2	6			5				1							
Veale Tract																	
Venice Island		2		1		4											
Victoria Island		8	5	20													1
Webb Tract		9	2	5		13				4							
Woodward Island		10		12													
Wright-Elmwood Tract				1													

ISLAND		Swainson's Hawk	Giant Garter Snake	Western Pond Turtle	Burrowing Owl	San Joaquin Pocket Mouse	California Black Rail	Greater Sandhill Crane	Valley Elderberry Longhorn Beetle	San Joaquin Kit Fox	Lance's Metalwork Butterfly	Tri-colored Blackbird	Great Blue Heron	Sacramento Anthicid Beetle	California Least Tern	Antioch Dunes Anthicid Beetle	White-tailed Kite	Double Crested Cormorant
		Known Special-Status Wildlife Occurrences (by 1995)																
Bacon Island				2	1		6											
Bethel Island					1													
Bishop Tract		1																
Bouldin Island				1	1		2	1										
Brack Tract		1			1			13										
Bradford Island																		
Brannan Island		3												3		1		
Byron Tract				2	3													
Canal Ranch		1						7										
Coney Island		3																
Dead Horse Island									1									
Decker Island																		
Empire Tract					1		1											
Fabian Tract		8	1	1														
Fay							1											
Glanville Tract		1			1				1									
Grand Island		2																
Hastings Tract																		
Holland Tract							1					1						
Hotchkiss Tract					1					1								
Jersey Island																		
Jones, Lower					1		2											
Jones, Upper				1			2							1				
King Island																		
Mandeville Island							1											
McCormack Williamson Tract									5									
McDonald Island							1		1									
Medford Island		1					1		1									
Merritt Island		2																
Mildred Island																		
Naglee Burke					1													
New Hope Tract		10	1				1		5									
Orwood Island																		
Palm Tract				1			4											
Pescadero		5										1						
Pierson District		3	1														1	
Prospect Island																		
Quimby Island																		
Rindge Tract									1									
Rio Blanco Tract					1													
Roberts Island	f	13			2				5			3						
Rough and Ready Island																		
Ryer Island																		
Sargent Barnhart Tract																		
Sherman Island			1					1			2			1				1
Shima Tract		2																
Shin Kee Tract			1				1											
Stark		2		2														
Staten Island				2				8	1									
Stewart Tract		1										1						
Sutter Island																		
Terminous			3		1		3	1										
Twitchell																		
Tyler Island		2						1	2									
Union Island	g	7	2			1			1									
Van Sickle Island				1														
Veale Tract																		
Venice Island													1					
Victoria Island				3														
Webb Tract																		
Woodward Island				1			2							1				
Wright-Elmwood Tract																		

USGS 1

ISLAND	Reclamation District	USGS Quad
Bacon Island	2028	Bouldin Island, Woodward Island
Bethel Island	-	Bouldin Island, Jersey Island
Bishop Tract	2042	Terminous
Boggs (Moss Tract)	404	Stockton West
Bouldin Island	756	Bouldin Island, Isleton, Terminous
Brack Tract	2033	Thornton
Bradford Island	2059	Jersey Island
Brannan/Andrus Island	-	
Andrus	317	Bouldin Island, Isleton
Andrus, Isleton	407	Isleton
Andrus, Upper	556	Isleton
Brannan	2067	Rio Vista, Jersey Island
Byron Tract	800	Clifton Court Forebay, Woodward Island
Canal Ranch	2086	Thornton
Coney Island	2117	Clifton Court Forebay
Dead Horse Island	2111	Thornton
Empire Tract	2029	Terminous
Fabian Tract	773	Clifton Court Forebay, Union Island
Fay	2113	Woodward Island
Glanville Tract	1002	Bruceville
Grand Island	3	Rio Vista, Courtland, Isleton
Hastings Tract	2060	Dozier, Liberty Island
Holland Tract	2025	Bouldin Island, Woodward Island
Holt Station	2116	Holt
Hotchkiss Tract	799	Jersey Island
Jersey Island	830	Jersey Island
Jones Tract	-	
Jones, Lower	2038	Woodward Island, Holt
Jones, Upper	2039	Woodward Island, Holt
King Island	2044	Terminous
Little Mandeville	2118	Bouldin Island
Mandeville Island	2027	Bouldin Island
McCormack Williamson Tr	2110	Bruceville
McDonald Island	2030	Bouldin Island, Woodward Island, Holt, Terminous
Medford Island	2041	Bouldin Island
Merritt Island	150	Clarksburg, Courtland
Mildred Island	2021	Woodward Island
Naglee Burke	1007	Union Island
New Hope Tract	348	Bruceville, Thornton
Orwood Island	2024	Woodward Island
Palm Tract	2036	Woodward Island
Pescadero	2058	Lathrop, Union Island
Pierson District	551	Courtland
Prospect Island	1667	Rio Vista, Liberty Island
Quimby Island	2090	Bouldin Island
Rindge Tract	2037	Holt, Terminous

USGS 2

ISLAND	Reclamation District	USGS Quad
Rio Blanco Tract	2114	Terminous
Roberts Island	-	
Roberts, Lower	684	Holt
Roberts, Middle	524	Stockton West, Holt
Roberts, Upper	544	Lathrop, Union Island, Holt
Rough and Ready Island	-	Stockton West
Ryer Island	501	Rio Vista, Liberty Island, Courtland, Isleton
Sargent Barnhart Tract	2074	Stockton West
Sherman Island	341	Antioch North, Jersey Island
Shima Tract	2115	Lodi South, Terminous
Shin Kee Tract	-	Terminous
Smith	1614	Stockton West
Stark	2089	Union Island
Staten Island	38	Bouldin Island, Isleton, Thornton
Stewart Tract	2062	Stewart, Union Island
Sutter Island	349	Courtland
Terminous	548	Thornton, Terminous
Twitchell	1601	Jersey Island
Tyler Island	563	Isleton
Union Island	1, 2	Clifton Court Forebay, Woodward Island, Union Island, Holt
Van Sickle Island	1607	Honker Bay
Veale Tract	2065	Woodward Island
Venice Island	2023	Bouldin Island
Victoria Island	2040	Clifton Court Forebay, Woodward Island, Holt
Walnut Grove	554	Thornton, Isleton
Webb Tract	2026	Bouldin Island, Jersey Island
Weber	828	Stockton West
Winter Island	2122	Antioch North
Woodward Island	2072	Woodward Island
Wright-Elmwood Tract	2119	Stockton West, Lodi South, Holt, Terminous
-	307	Clarksburg
-	369	Thornton, Courtland
-	536	Rio Vista
-	765	Clarksburg
-	813	Courtland
-	900	Sacramento West
-	999	Clarksburg, Liberty Island, Courtland
-	1608	Lodi South, Stockton West
-	2084	Rio Vista
-	2093	Liberty Island
-	2095	Vernalis, Lathrop
-	2098	Liberty Island
-	2121	Woodward Island

PRIORITY AREAS FOR SUBSIDENCE MITIGATION IN THE SACRAMENTO-SAN JOAQUIN DELTA

by
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Consulting Hydrologist
Draft, October 23, 1997

1.0 Introduction and Background

Prior to 1850, the Sacramento-San Joaquin Delta was a tidal marsh. The Delta was drained for agriculture in the late 1800's and early 1900's. The organic or peat deposits of the Delta formed during the past 7,000 years from decaying plants at the confluence of the Sacramento and San Joaquin Rivers. The drained peat soils on over 100 islands and tracts are highly valued for their agricultural productivity and have undergone continuous subsidence since drainage. A network of levees protects the island surfaces that are now 6 to 21 feet below sea level, from inundation. As subsidence continues, the potential for flooding due to levee failure increases significantly.

Subsidence is caused primarily by the oxidation of soil organic carbon. The peat soil is a complex mass of carbon. Microorganisms such as bacteria and fungi use it as an energy source resulting in peat decomposition and the release of carbon dioxide (CO_2) under drained, oxygen-rich conditions. Studies by the Department of Water Resources and the US Geological Survey (Deverel and Rojstaczer, 1996) demonstrate that the amount of oxidation is proportional to the soil temperature and moisture content. Oxidation and therefore subsidence is lowest when temperatures are cooler and the soil is wet.

Drainage of the Delta islands was essentially complete by the 1930's when the Delta assumed its present configuration of about 100 islands and tracts surrounded by 1,100 miles of man-made levees and 675 miles of channels and sloughs. When most of the existing levees were constructed, the difference between the water level in the channels and island surfaces was less that 5 feet. Because of the decreasing island-surface elevations due to subsidence, the levees are now required to hold substantially more water than when they were originally constructed. This increase in hydraulic pressures on levees that were constructed on foundations of sand, peat and organic sediments contributed to about 35 levee failures since the 1930's. The primary reasons for levee failure are instability, seepage and overtopping.

The cumulative historic cost of levee failures and flood damage is estimated to be in the hundreds of millions of dollars. Levee repair and maintenance can cost over 1 million dollars per mile. Another important detrimental consequence of Delta island flooding is the movement of saline water into the Delta from Suisun Bay. This degradation of the water for two thirds of California residents due to increasing salinity can result from the failure of one of more of the western Delta levees. If the flooded island is not reclaimed, the rate and area of fresh and salt water mixing and evaporation losses increase, causing a long term salinity increase. Even if the island is reclaimed, there can be substantial short term increases in the salinity of the water supply.

Because of the high cost of levee maintenance and repair and the potential for damage to property and wildlife habitat, impaired recreational use and water quality degradation, there is ongoing interest in preventing the flooding of Delta islands. As the islands continue to subside, levee repair and maintenance will become more critical and expensive. A critical factor in preventing future losses due to levee failure is stopping and reversing the effects of subsidence of the peat soils. A key factor in implementing water- and land-management strategies for subsidence control is the delineation of priority areas based on subsidence rates and peat thickness. Higher subsidence rates and thicker peats require more immediate implementation than lower subsidence rates and thin peats.

The California Department of Water Resources previously estimated subsidence rates for the Delta (Department of Water Resources, 1980). The subsidence rates were apparently estimated for entire islands by comparing elevations for topographic maps published in 1952 and 1976 and 1978, and by comparing elevations for topographic maps published in the early 1900's and 1952. The authors also used other miscellaneous measurements such as elevation changes adjacent to the permanent structures. The Department of Water Resources published maps of peat thicknesses and elevations of Delta islands in the Delta Atlas. The elevations of the Delta islands are based on 1978 topographic mappings of the Delta. The peat thickness maps in the Atlas are the result of lithologic data gathered from borehole logs cited in Department of Water Resources (1980). Most of these logs were collected during the 1950's and 1960's.

The objective of the work reported here was to delineate and prioritize areas for subsidence control in the Delta. The general approach was to enter recent available data for the Delta for subsidence rates, depth of peat soils and soil characteristics into a geographic information system (GIS). The estimates presented here for rates of subsidence and peat thickness are an improvement relative to the previous efforts by the Department of Water Resources because 1) the error in the estimated subsidence rate is lower, quantifiable and the result of uniform elevation change measurements, and 2) the estimates for peat thickness are based on more recent and comprehensive data.. Also, the data was entered into a GIS which facilitated the evaluation of the data for delineation of priority areas in greater areal detail than entire islands such as is presented in Department of Water Resources (1980).

2.0 Methods

2.1 Determination of Areal Variability of Subsidence Rates

Two sets of US Geological Survey topographic maps were used to estimate the time-averaged rates of subsidence throughout the Delta from the early 1900's to 1976 through 1978. Specifically, topographic maps for the 1906-1911 mapping of the Delta at 1:31,680 scale were used to estimate land surface elevation on a 500-meter grid. The 1976 to 1978, 1:24,000 scale topographic maps were used to estimate land surface elevation for the same 500-meter grid. The difference in elevation between the two time periods was estimated to be the total depth of subsidence. The time-averaged rate of subsidence was calculated as the total amount of subsidence divided by the time interval that ranged from 60 to 72 years.

The error in the subsidence rate estimate results from the error in the elevation estimate for the contours and the change in mean sea level datum from the early 1900's to 1976 to 1978. Early leveling in California used the average of tide level gauges in California for the mean sea level datum (Birdseye, 1925). The sea level datum for the 1976 to 1978 maps is the National Geodetic Vertical Datum of 1929 that was an average of mean sea level data for 21 tide stations in the United States (Ziloski and others, 1992). The apparent error resulting from the comparison of the two datums for mean sea level is on the order of plus 0.5 to 1.0 foot based on a comparison of bench marks for the sets of maps.

The error due to estimating the elevations from the contours is about one-half of the contour interval (5 feet) for the topographic maps or 2.5 feet (Joe Vukovitch, USGS, Denver, personal communication, 1996). The percent error for each subsidence rate was calculated as follows. The subsidence rate was calculated at each grid point as the difference between the elevations on the two maps plus or minus the error, divided by the time interval between the two mappings:

subsidence rate = (Elev1978 - Elev1906 +/- e)/T

where Elev1978 is the elevation from the 1976 to 1978 USGS topographic maps,

Elev1906 is the elevation from the 1906 to 1911 USGS topographic maps,

e is the error associated with the elevation contours (½ the contour interval) and,

T is the time interval between the two elevation measurements.

The error was calculated as

$e = E1978 + E1906 = +/- 5$ feet

where E1978 and E1906 are the errors associated with the two sets of topographic maps ($E1978 = E1906 = +/- 2.5$ feet).

The percent error was calculated as the absolute value of 5 feet divided by the total subsidence multiplied times 100. The total subsidence is the difference in elevation between the two topographic maps. The percentage error in the subsidence rate is dependent on the amount of subsidence that occurred during the approximately 70 years that elapsed between the surveying for the topographic maps.

2.2 Determination of the Areal Variability of Peat Thickness

Peat thickness was estimated from the basal elevations of the peat deposits mapped by Atwater (1982) and the 1978 elevations on the 500-meter grid. The basal elevation of the peat deposit was subtracted from the elevation from the 1976 to 1978 topographic maps to estimate the peat thickness for each point on the grid. The areal distribution of the basal elevations of the peat deposits was delineated from about 1,200 borehole logs collected through 1980. The majority of the locations of the borehole logs were on or near the levees. The peat thickness data was compared with the delineation of organic soils or highly organic mineral soils in the soil surveys for Contra Costa (Soil Conservation Service, 1978), San Joaquin (Soil Conservation Service, 1992) and Sacramento counties (Soil Conservation Service, 1993). Where there were discrepancies between the two sources of information for the extent of peat soils, the soil survey data was assumed to be correct and a basal peat elevation was assigned based on the nearest borehole information mapped in Atwater (1982).

2.3 Areal Variability of Soil Characteristics

The delineation of soil series as mapped in the soil surveys for Contra Costa (Soil Conservation Service, 1978), San Joaquin (Soil Conservation Service, 1992) and Sacramento counties (Soil Conservation Service, 1993) were entered into the GIS in digital form. The soil organic matter content was the primary soil characteristic of interest. The soil organic matter content was estimated for the 11 soil series which were either organic soils or highly organic mineral soils based on the data provided in the soil surveys. Specifically, the soil surveys for San Joaquin and Sacramento counties provided a range of values for percent soil organic matter. The midpoint of this range was assigned to that series in the GIS data base. The percent organic matter for the soil series mapped in Contra Costa was estimated from the data provided in the soil surveys for San Joaquin and Sacramento Counties.

2.4 Geographic and hydrographic data

Geographic and hydrographic data was obtained as USGS Digital Line Graphs at 1:100,000 scale from the Teale Data Center.

2.5 Analysis of Spatial Data and Delineation of Priority Areas for Subsidence

The areal distribution of subsidence rates and peat thickness were used to delineate priority areas for subsidence control. For protection of Delta islands, the areas of highest priority are those within 2,000 feet of the island levees. Within the 2,000-foot boundary, the first priority areas are those where the subsidence rates are high and there is substantial peat remaining. The first priority was delineated as those areas where the time-averaged subsidence rates were greater than 1.5 inches per year (subsidence rates ranged from about 0.4 inches per year to 5 inches per year) and the peat thickness is greater than 10 feet within the 2,000 foot boundary. The second priority areas are those where the time-averaged subsidence rate is greater than 1.5 inches per year and the peat thickness is less than or equal to 10 feet. The third priority includes those areas outside the 2,000 foot boundary (towards the center of the islands) where the subsidence rate is greater than 1.5 inches per year and the peat is greater than 10 feet thick. The fourth priority includes those areas outside the 2,000 foot boundary where the peat is less than or equal to 10 feet thick and the subsidence rate is greater than 1.5 inches per year.

3.0 Results of Spatial Analysis

Figure 1 shows the distribution of the four priority areas in the Delta. Table 1 shows the approximate acreage for each island for priority 1; areas where the peat thicknesses are greater than 10 feet and the time-averaged subsidence rate is greater than 1.5 inches per year. Peat thickness is generally greatest in the western and northern parts of the Delta; the largest areas of peat thickness greater than 10 feet are on Sherman, Twitchell, Brannan-Andrus, Grand, Staten and Tyler islands and Webb Tract. The amount of area in priority 1 varies among these islands according to the subsidence rate.

The largest acreage for priority 1 is on Webb Tract in the west-central Delta (about 2,500 acres). Venice, Bouldin and Mandeville islands in the central Delta also have large acreage assigned to priority 1, between about 950 and 1,360 acres.. In the western Delta, Brannan-Andrus, Twitchell, Bradford, Jersey and Sherman islands have between about 470 and 810 acres in priority 1. Although Grand Island has a large acreage of peat thicker than 10 feet, the subsidence rates are almost all less than 1.5 inches per year. Tyler and Staten islands in the northern Delta have about 730 to 835 acres in priority 1. The total area for priority 1 is about 14,300 acres (Table 1).

Table 1 shows the acreage for priority 2; areas with peat thicknesses less than or equal to 10 feet and having subsidence rates greater than 1.5 inches per year within 2,000 feet of the levee. The islands with the largest areas in priority 2 are in the central Delta where subsidence rates have been historically high and there are large areas of peats that are less than 10 feet thick. MacDonald, Bacon and Mandeville islands and Empire Tract in the Central Delta and Rindge Tract in east-central Delta and Webb Tract in the west-central

Delta have areas in priority 1 that range from about 1,020 to 2,160 acres. Other central Delta islands (Lower Jones Tract, Bouldin Island and Venice Island) have areas in priority 2 that range from about 450 to 620 acres. The islands and tracts of the western and northern Delta generally have low acreage in priority 2 because of the low subsidence rates.

EXPLANATION

Subsidence rate greater than 1.5 inches per year

Peat thickness greater than 10 feet.

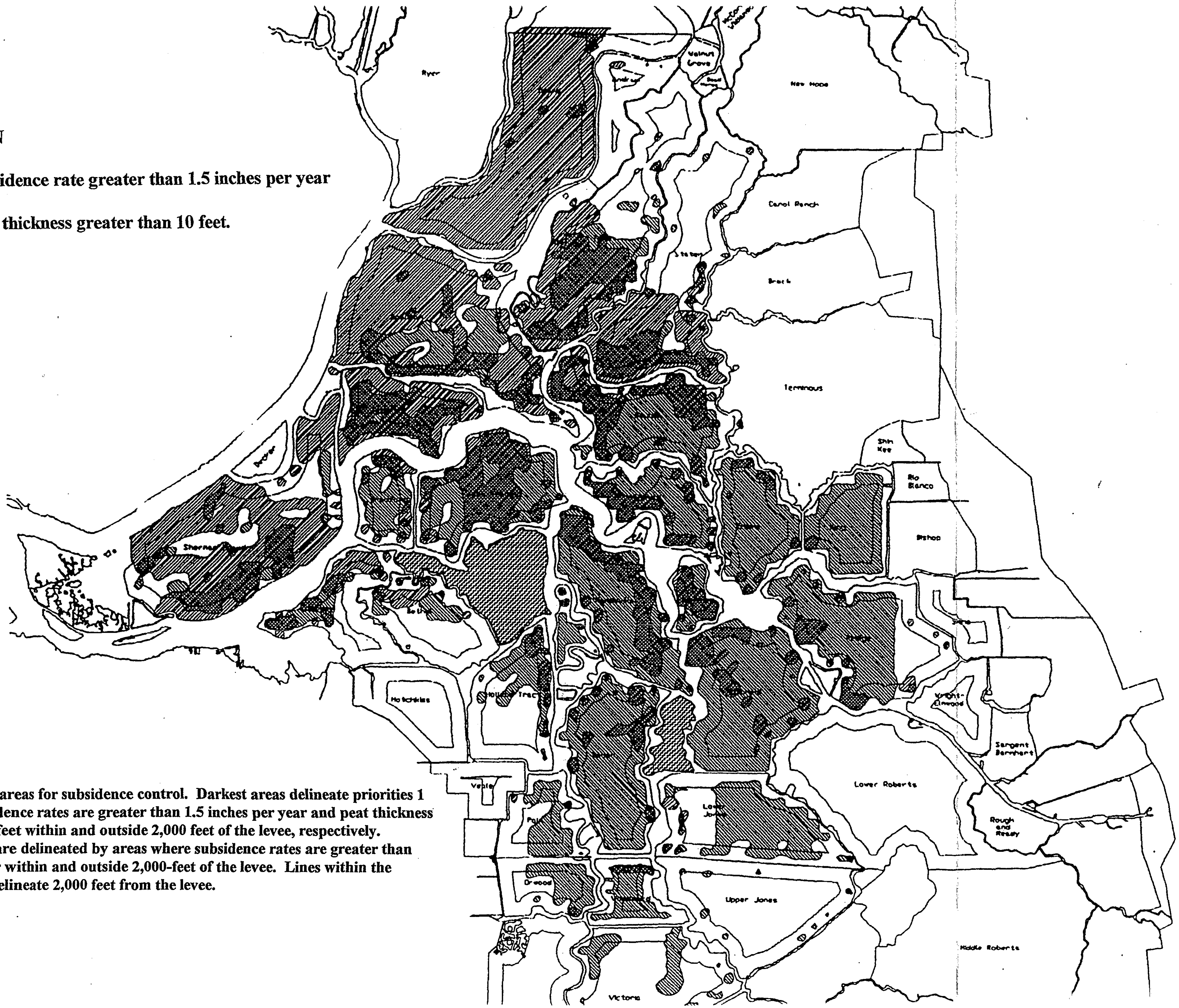

Figure 1. Priority areas for subsidence control. Darkest areas delineate priorities 1 and 3 where subsidence rates are greater than 1.5 inches per year and peat thickness is greater than 10 feet within and outside 2,000 feet of the levee, respectively. Priorities 2 and 4 are delineated by areas where subsidence rates are greater than 1.5 inches per year within and outside 2,000-feet of the levee. Lines within the island boundary delineate 2,000 feet from the levee.

Table 1. Acreage by island for the 4 priorities for subsidence control. Priority 1 includes areas within 2,000 feet of the levee where the subsidence rate is greater than 1.5 inches per year and the peat thickness is greater than 10 feet. Priority 2 includes areas within 2,000 feet of the levee where the subsidence rate is greater than 1.5 inches per year and the peat thickness is less than or equal to 10 feet. Priority 3 includes areas beyond 2,000 feet of the levee where the subsidence rate is greater than 1.5 inches per year and the peat thickness is greater than 10 feet. Priority 4 includes areas beyond 2,000 feet of the levee where the subsidence rate is greater than 1.5 inches per year and the peat thickness is less than or equal to 10 feet.

Priority 1		Priority 2		Priority 3		Priority 4	
Island	Acres	Island	Acres	Island	Acres	Island	Acres
Quimby	35	Quimby	35	Rindge	130	Staten	83
Grand	51	Staten	61	Medford	130	Sherman	152
King	68	King	68	Bacon	163	Bethel	265
Bethel	68	Brannan	74	Grand	194	Woodward	308
Woodward	131	Bethel	82	McDonald	299	Orwood	392
Holland Tract	413	Tyler	178	Staten	565	Palm	405
Medford	438	Sherman	233	Mandeville	581	Tyler	428
Rindge	468	Bradford	234	Bouldin	794	Victoria	482
Sherman	473	Holland Tract	413	Brannan	883	Holland Tract	521
Empire	546	Lower Jones	433	Twitchell	1,003	Bradford	622
McDonald	613	Bouldin	1,293	Sherman	1,007	Venice	667
Bacon	626	Orwood	450	Webb Tract	1,403	Webb Tract	1,087
Jersey	668	Victoria	522	Tyler	1,453	Mandeville	1,307
Bradford	707	Venice	607	**Total**	**8,607**	Brannan	1,363
Twitchell	715	Palm	619			King	1,410
Tyler	728	Empire	1,019			Empire	1,547
Brannan	814	Mandeville	1,040			Bouldin	1,647
Staten	836	Rindge	1,105			Lower Jones	1,911
Venice	952	Webb Tract	1,315			Bacon	2,402
Bouldin	1,066	Bacon	1,423			Rindge	2,577
Mandeville	1,362	McDonald	2,157			McDonald	2,778
Webb Tract	2,518	**Total**	**13,360**			**Total**	**22,354**
Total	**14,295**						

Other data provides concurrence that subsidence rates for the central Delta are high relative to the western Delta. The soils of the central Delta are generally higher in organic matter content and have subsided faster than the western Delta islands (Rojstaczer and Deverel, 1995; Deverel and others, 1997). Rojstaczer and Deverel (1995) reported subsidence rates of 2 to 3 inches per year on Lower Jones Tract and Mildred and Bacon islands compared with 1.25 inches or less for Sherman and Jersey islands. The total area for priority 2 is about 13,360 acres (Table 1). The combined acreage for priorities 1 and 2 is about 27,700 acres.

Priority 3 includes those areas beyond 2,000 feet of the levee where the peat thicknesses are greater than 10 feet and the time-averaged subsidence rate is greater than 1.5 inches per year. The islands with the largest areas in this priority are primarily the areas of deep peats in the western, west-central and northern Delta. Twitchell, Brannan-Andrus and Sherman islands and Webb Tract in the western and west-central Delta and Tyler Island in the northern Delta have the largest acreage in this priority ranging from about 880 to 1,450 acres (Table 1). Bouldin Island in the central Delta also has large areas of peat thickness greater than 10 feet and high subsidence rates and almost 800 acres in priority 3. Mandeville Island in the west-central Delta, Staten Island in the northern Delta, Medford, Bacon and McDonald islands in the central Delta and Rindge Tract in the east-central Delta have between about 130 to 580 acres in priority 3. The total acreage for priority 3 is about 8,600 acres. The combined acreage for priorities 1, 2 and 3 is about 36,300 acres.

Priority 4 includes those areas beyond 2,000 feet of the levee with high subsidence rates and less than 10 feet of peat soil. Table 1 shows the acreage for the different islands for priority 4. The majority of the islands with large areas in priority 4 are in the central Delta. The central Delta islands of McDonald, Bacon, Bouldin and Lower Jones, and

Empire tracts have acreage in priority 4 that range from about 1,550 to 2,780 acres. Venice Island also in the central Delta has about 670 acres in priority 4. Rindge Tract in the east-central Delta has about 2,580 acres in priority 4. Webb Tract in the central-western Delta has about 1,090 acres. The total area for priority 4 is about 22,350 acres. The total area for priorities 3 and 4 is about 31,000 acres. The total area for all 4 priorities is about 58,600 acres.

The percent soil organic matter is a key factor in determining the subsidence rates and therefore the acreage in the different priorities. On Sherman Island, the subsidence rates are generally low due to the relatively low percent organic matter of the near surface soils (Rojstaczer and Deverel, 1996). Therefore, the amount of area for priority 1 on Sherman Island is relatively small even though there are large areas of peats that are thicker than 10 feet. In contrast, Twitchell Island has large areas of peats that are thicker than 10 feet and some areas where surface soils have high organic matter contents (Roger Fujii, US Geological Survey, personal communication, 1996) which correspond to large subsidence rates. A similar situation apparently exists on Webb Tract.

Figure 2 shows the distribution of percent soil organic matter in the Delta (Figure 2 is too large to fit in this report and therefore not included. It is available through the CALFED office. The lines shown in figure 2 generally represent the outlines of soil series for which organic matter contents were determined as part of the data collection efforts for the soil survey. The distribution of soil organic matter content generally reflects the distribution of subsidence rates (figure 1). For example, the highest organic matter contents (greater than 15 and 30 percent) were mapped in the central, east-central and the west-central Delta (Twitchell Island, Bradford Island, Webb Tract, Bouldin Island, Venice Island, Empire Tract, Rindge Tract, King Island, Bacon Island, Lower Jones Tract). The subsidence rate for the majority of these islands is greater than 1.5 inches per year (figure 1). Islands where organic matter contents are generally lower than 15 percent such as Sherman Island, Brannan-Andrus Island, Staten Island, Terminous Tract, Upper Jones Tract and Victoria Island are generally at the periphery of the Delta. The subsidence rates on these islands are generally less than 1.5 inches per year.

On individual islands, the subsidence rate generally corresponds to the soil percent organic matter shown in figure 2. For example, on Brannan-Andrus Island, much of the southern island has organic matter contents greater than 15 and 30 percent corresponding to areas where subsidence rates are greater than 1.5 inches per year. Similarly on Tyler Island, the southwest part of the island has soils with organic matter contents greater than 15 and 30 percent corresponding to areas where subsidence rates are larger than 1.5 inches per year.

The use of subsidence rates in determining priorities for subsidence control reflects the primary cause of subsidence, oxidation of soil organic matter. The total amount of subsidence as reflected in the land surface below sea level map in the Delta Atlas reflects not only the subsidence rate but also the amount of time since the island was first reclaimed. For example, an assignment of priorities based on the land surface elevation shown in the Delta Atlas would include large areas of Sherman and Brannan-Andrus islands in priority 1 and 3 where land-surface elevations are some of the lowest in the Delta. These were also some of the first islands leveed and drained in the Delta (Thompson, 1958). However, the time-averaged subsidence rates are less than 1.5 inches per year based on the data for this report and in previous studies (Rojstaczer and Deverel, 1995, Rojstaczer and others, 1991).

4.0 Uncertainty in the Spatial Analysis

The primary uncertainties in the spatial analysis are the result of uncertainties in the estimated basal elevation of the peat soil and the error in the estimation of the subsidence rate. The subsidence rate error is the result of errors associated with the use of topographic elevations as described above and the use of different datums for the 2 surveys for the topographic maps published in 1906 to 1911 and 1976 to 1978. Figure 3 shows the distribution of the error in the subsidence rate as the result of error in topographic maps (Figure 2 is too large to fit in this report and therefore not included. It is available through the CALFED office. In general, large errors in the subsidence rates correspond to areas of the lowest subsidence rates.

Figure 3 shows that the error in the subsidence rate estimate due to the mapping error is 50 percent or less for much of the Delta. Specifically, the error in the subsidence rate on the central Delta islands, Bouldin, Island, Venice Island, Empire Tract, Mandeville Island, Bacon Island, Lower Jones Tract, McDonald Island and Empire Tract is generally less than 50 percent. Also, the error in the subsidence rates for the west-central and east-central islands, Webb Tract, Twitchell Island, Bradford Island, Rindge Tract and King Island is also generally lower than 50 percent. The error in the subsidence rate generally increases as one approaches the periphery of the Delta. The error in the western, eastern, southern and northern edges of the Delta generally approaches or exceeds 100 percent.

Figure 4 shows the exponential decrease in the percent error in the subsidence rate as the result of mapping errors with increases in the subsidence rate (Figure 4 is too large to fit in this report and therefore not included. It is available through the CALFED office. The error was calculated for the average time between elevation measurements of 69 years for the topographic maps used in determining the total elevation change. The key questions related to the error for the purpose of assigning the priority based on subsidence rates are: 1) Is the distribution of subsidence rates consistent with the what is known about the distribution of present-day subsidence rates? and 2) What is the error associated with assignment of areas to one of the two categories (less than and greater than 1.5 inches per year) for subsidence rates?

The first question can be answered qualitatively based on recently collected data for subsidence for selected areas of the Delta. Specifically, data from Rojstaczer and Deverel (1995), Rojstaczer and others (1991) and Deverel and Rojstaczer (1996) are consistent with the spatial distribution of subsidence rates presented here. Subsidence rates in the central Delta (Lower Jones Track, Bacon and Mildred islands) are greater than in the western Delta (Sherman and Jersey islands). However, subsidence has not been measured extensively throughout the Delta so that it is impossible to compare rates for all the islands. The subsidence rates in figure 1 are generally consistent with what is known about subsidence and organic soils in the Delta. The highest soil organic matter contents and subsidence rates are in the central Delta. The soils are lower in organic matter content and subsidence rates are lower approaching the margins of the Delta

The second question can be answered based on the distribution of error for subsidence rates. Further error analysis using the data shown in figures 3 and 4 was used to determine the effect of the distribution of error on the assignment of priorities. Considering the data used in figures 3 and 4, the lowest rate that could be erroneously classed as a rate of over 1.5 inches per year is 0.7 inches per year (the error associated with this rate is 122 percent). The highest subsidence rate that could be classed under 1.5 inches per year is 2.3 inches per year (the error associated with this rate is 36 percent). To evaluate the effect on the amount of acreage in each priority, data for Sherman Island and Webb Tract was used to determine the range in acreage for the priority classes based on the estimated error for the subsidence rate.

The data for these islands represent the apparent variability in the data set. About 80 percent of the area of Sherman Island in the western Delta has peat greater than 10 feet thick but the subsidence rates were below 1.5 inches per year. In contrast, Webb Tract has experienced subsidence at rates generally greater than 2.5 inches per year and about 50 percent of the island has peat soils greater than 10 feet thick. Webb Tract has the largest acreage in priority 1 and the third and second largest areas in priority 2 and 3, respectively. The acreage on Sherman Island is about the median in priorities 1 and 2. Sherman Island has one of the largest acreage in priority 3 and one of the smallest acreage in priority 4.

The results of the error analysis are shown in Table 2. The range of acreage on Webb Tract for priority 1 represents a 24 % decrease and 4% increase in the estimated acreage shown in Table 1. Similarly, for priorities 2 and 3, the changes in the acreage range from 2 to 18 percent (Table 2). For priority 4, the low estimate is 35 percent below, and the high estimate is 8 percent above, the acreage in Table 1.

In contrast, the range of acreage in each priority for Sherman Island is large, ranging up to 1,000 percent. The subsidence rates for Sherman are lower than Webb and therefore the error associated with the subsidence-rate estimate is higher and the range of acreage classified in each priority is large. The subsidence rates over much of the island are about 1 to 1.5 inches per year. Also, the peat thicknesses over most of Sherman Island are greater than 10 feet so the area in priorities 1 and 3 increase substantially when the limit of the subsidence rate decreases. The area for priority 1 ranges from a low of 0 to a high of 1,083 acres. For priority 2, the area ranges from a low of 41 and high of 513 acres. For priority 3, the area ranges from a low of 0 to a high of 4,331 acres. For priority 4, the area ranges from a low of 0 to a high of 1,694 acres. The results of this analysis point to a need for additional data collection in the western Delta where implementation of subsidence control measures is more critical than other parts of the Delta.

Table 2. Range in acreage for each priority for Sherman Island and Webb Tract.

	Priority 1		Priority 2		Priority 3		Priority 4	
	low	high	low	high	low	high	low	high
Sherman	0	1,083	41	513	0	4,331	0	1,694
Webb	612	2,518	1,149	1,475	1,156	1,425	710	1,176

The error in the subsidence rate associated with the change in datums for the two maps is systematic and small, on the order of 0.5 to 1.0 foot that would be subtracted from the total subsidence for all the data points. This would change the subsidence rates by about 0.1 to 0.2 inch per year and would not alter the relative distribution of the subsidence-rate values because the same amount would be added to all the values.

The error association with the mapping of peat thickness is related to the number of data points that was used to determine the distribution of peat thickness. Table 3 shows the number and average density of data points from borehole logs used to estimate the peat thickness. The data in Table 3 does not present the entire picture relative to the density of data points for peat thickness. Some data points were used for islands besides those for which they are assigned in Table 3 since the data for peat thickness can be extrapolated across channels. Also, most of the data points are on the levees so that the range of area without borehole data for each island varies substantially. In general, data densities greater than 200 acres per point result in moderate to high uncertainty in the estimation of peat thickness for large areas of the islands.

Of those islands where the density of peat thickness data is greater than 200 acres per point, only 6 have acreage in the 4 priorities (Orwood Tract, Victoria Island, Brannan-Andrus Island, King Tract, Tyler Island and Grand Island). Brannan-Andrus Island, King Tract and Tyler Island have significant acreage in the 4 priorities. Grand Island is mapped as having a large area of deep peat but has little area in the 4 priorities because of the low subsidence rates. Tyler, Grand and Brannan-Andrus islands are in the western Delta.

Table 3. Number of data points, acreage and data density for each island used to delineate the distribution of peat thickness.

Island	Number of points	Acreage	Data density (acres/point)
Medford	31	1,219	39
Jersey	60	3,471	58
Bradford	28	2,051	73
Palm	32	2,436	76
Mandeville	68	5,300	78
Woodward	23	1,822	79
Bethel	43	3,500	81
Bacon	66	5,625	85
Sherman	105	9,937	95
Webb Tract	58	5,490	95
Twitchell	36	3,516	98
Venice	31	3,220	104
Empire	28	3,430	123
Canal Ranch	23	2,996	130
Holand	31	4,060	131
Coney	7	935	134
Bouldin	44	6,006	137
Staten	61	9,173	150
McDonald	39	6,145	158
Lower Jones	33	5,894	179
Hotchkiss	17	3,100	182
Byron	36	6,933	193
Rindge Tract	35	6,834	195

Terminous	50	10,470	209
Lower Roberts	48	10,600	221
Upper Jones	27	6,259	232
Orwood	13	4,138	318
Brack	14	4,873	348
Victoria	19	7,250	382
Brannan-Andrus	31	13,000	419
Bishop	3	2,169	723
King	4	3,260	815
New Hope	8	9,300	1,163
Tyler	7	8,583	1,226
Grand	3	17,010	5,670
Veale	0	1,298	____
Shin Kee	0	1,016	____
Rio Blanco	0	705	____
Union	0	22,202	____
Shima	0	2,394	____
Ryer	0	11,880	____

5.0 Status of Subsidence Mitigation Alternatives

The primary factor contributing to subsidence in the Delta is oxidation of soil organic matter. The oxidation of soil organic matter is directly proportional to soil temperature and generally decreases with increasing soil moisture. The results of studies conducted by the US Geological Survey and Department of Water Resources (Deverel and others, 1997) demonstrated that permanent shallow flooding reversed the effects of subsidence on Twitchell Island. Permanent shallow (about 1 foot) flooding results in a net carbon accumulation and accretion of the land surface. Other water-management strategies that were evaluated; seasonal flooding during the late fall and winter with and without irrigation during the spring and summer, resulted in a net carbon loss and are not viable strategies for stopping subsidence.

Other water- and land-management strategies are being evaluated that may stop or reverse the effects of subsidence include capping the organic soil with mineral material and reverse wetland flooding. Preliminary results by the USGS (Lauren Hastings, personal communication, 1996) indicate that capping the unsaturated peat soil with 2 feet of dredge sand reduces the oxidation rate by about 50 percent. Capping saturated peat soil with dredge material would provide upland habitat in shallow flooded wetlands. Capping of the peat reduces the transport of oxygen and carbon dioxide in and out of the soil, causing the oxidation rate to decrease. Reverse wetland flooding involves shallow flooding during the spring and summer and drainage during the fall and winter. This may reduce oxidation when it is usually the greatest and result in organic matter accumulation The USGS is currently evaluating this as a subsidence mitigation strategy.

6.0 Limitations of the Analysis

The primary limitation of this analysis is the error in the spatial distribution and age of the data for the key variables, peat thickness and subsidence rates. The plotted subsidence rates are based on data for topographic maps spaced about 70 years apart. The error associated with the calculation of subsidence rates due to mapping error is discussed above and ranges from less than 30 to over 150 percent. The error associated with the use of different datums is systematic and about 0.5 to 1.0 feet.

The error in assignment of areas to priorities for subsidence control varies by island depending on the subsidence rate and the depth of peat. Where the time-averaged subsidence rate is high, the error associated with assignment of priorities is low as is illustrated in the example on Webb Tract. The opposite is true for assignment of priorities to areas where the time-averaged subsidence rate is relatively low as is illustrated in the example on Sherman Island. The error associated with assignment of priorities based on the depth of peat is related to the level of confidence in the peat thickness as determined by the density of borehole data.

The assignment of priorities based on distribution of subsidence rates in figure 1 is consistent with what is known about the spatial variability of subsidence rates in the Delta based on previous studies cited above. Also, subsidence rates are correlated with soil organic matter content and the distribution of subsidence is consistent with the distribution of soil organic matter content (figure 2). High subsidence rates correspond with soil organic matter contents greater than 30 percent in the central Delta. Towards the margins of the Delta, subsidence rates are lower and the soil organic matter content generally decreases to less than 15 percent. Based on available information, subsidence rates shown in figure 1 are distributed similarly to present day subsidence rates. Similarly, the distribution of peat thickness estimates, although 20 years old, reflect the current distribution of peat thicknesses because the primary process causing change in peat thickness, the relative distribution of subsidence rates, has not changed in the last 20 years because land use has not changed significantly.

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7.0 Conclusions and Recommendations

7.1 Conclusions

Time-averaged subsidence rates and peat-thickness estimates were used to determine priorities for subsidence control in the Sacramento-San Joaquin Delta. Subsidence rates were determined from two sets of topographic maps from the early 1900's and 1978-76. The peat-thickness distribution in the Delta was determined from borehole logs and the 1976-1978 elevation data. Four priorities for subsidence control were determined as follows.

- Priority 1 is the area within 2,000 feet of the levee where time-averaged subsidence rates are greater than 1.5 inches per year and peat thicknesses are greater than 10 feet.
- Priority 2 includes those areas that are within 2,000 feet of the levee and the subsidence rates are greater than 1.5 inches per year and the peat is less than or equal to 10 feet thick.
- Priority 3 includes those areas beyond 2,000 feet from the levee where subsidence rates are greater than 1.5 inches per year and the peat thickness is greater than 10 feet.
- Priority 4 includes those areas beyond 2,000 feet from the levee where subsidence rates are greater that 1.5 inches per year and the peat is less than or equal to 10 feet thick.

The largest acreage for priority 1 are in the west central and central Delta (Webb Tract, Venice, Bouldin and Mandeville islands). In the western Delta, Brannan-Andrus, Twitchell, Bradford, Jersey and Sherman islands have between about 470 and 810 acres in priority 1. Tyler and Staten islands in the northern Delta have about 730 to 835 acres in priority 1. The total area for priority 1 is about 14,300 acres.

The islands with the largest areas in priority 2 are in the central Delta where subsidence rates have been historically high. MacDonald, Bacon and Mandeville islands and Empire Tract in the Central Delta and Rindge in east-central Delta and Webb Tract in the west-central Delta have areas in priority 1 that range from about 1,020 to 2,160 acres. Other central Delta islands (Holland Tract, Lower Jones Tract, Bouldin Island and Venice Island) have areas in priority 2 that range from about 450 to 620 acres. The islands and tracts of the western and northern Delta generally have low acreage in priority 2 because of the low subsidence rates. The total area for priority 2 is about 13,360 acres. The combined acreage for priorities 1 and 2 is about 27,700 acres.

The islands with the largest areas in priority 3 are primarily the areas of deep peats in the western, west-central and northern Delta. Twitchell, Brannan-Andrus and Sherman islands and Webb Tract in the western and west-central Delta and Tyler Island in the northern Delta have the largest acreage in this priority ranging from about 880 to 1,450 acres. Bouldin Island in the central Delta also has a large area of peat thickness greater than 10 feet and high subsidence rates and almost 800 acres in priority 3. The total acreage for priority 3 is about 8,600 acres. The combined acreage for priorities 1, 2 and 3 is about 36,300 acres.

The majority of the islands with large areas in priority 4 are in the central Delta. The central Delta islands of McDonald, Bacon, Bouldin islands and Lower Jones, and Empire tracts have acreage in priority 4 that range from about 1,550 to 2,780 acres. Venice Island also in the central Delta has about 670 to 1,300 acres in priority 4. Rindge Tract in the central eastern Delta has about 2,580 acres in priority 4. Webb Tract in the central-western Delta has about 1,090 acres. The total area for priority 4 is about 22,350 acres. The total area for priorities 3 and 4 is about 31,000 acres. The total area for all 4 priorities is about 58,600 acres.

The uncertainty in the estimation of priorities depends on the magnitude of the subsidence rate and the uncertainty in the estimation of the peat thickness. The error in the subsidence rate estimate is generally less than 50 percent where subsidence rates are greater than 1.5 inches per year. This corresponds to areas in the central Delta. The error in the subsidence rate increases to over 50 and approaches and exceeds 100 percent approaching the margins of the Delta. The error in the subsidence rate has little effect in the assignment of priorities on islands where the subsidence rates are high such as Webb Tract. However, it has a large effect on the assignment of priorities for islands such as Sherman where subsidence rates are lower.

7.2 Recommendations for Additional Data Collection

Eight western Delta islands (Sherman, Jersey, Twitchell, Bradford, Holland, Hotchkiss, Bethel and Webb) encompass a key area for subsidence control because of the potential for water quality deterioration as the result of a levee break on these islands. Figure 1 shows that large areas of Twitchell, Webb and Bradford are included in the four priorities. Relatively small areas of Sherman, Jersey, Bethel, Hotchkiss and Holland are included in the four priorities. However, the error analysis discussed above indicates that the uncertainty in the assignment of priority areas on Sherman Island is as large as 1000 percent. The uncertainty on Webb Tract is small. Examination of the subsidence rates and the error in the subsidence rates for the other western Delta islands is generally similar to those for Sherman Island (Figures 1 and 3).

The uncertainty in the assignment of priorities in these and other areas where subsidence rates are low, points to the need for additional data for subsidence rates in these areas prior to implementation of subsidence control measures. Since subsidence control is critical in the western Delta yet the uncertainty in the subsidence rates is relatively high, additional data about the distribution of subsidence rates on seven of the eight western Delta islands is recommended for a higher level of certainty for the implementation of subsidence control measures. Additionally, analysis by Rojstaczer and others (1991) and Deverel and Rojstaczer (1996) demonstrate that subsidence rates throughout the Delta are decreasing with time. Therefore, the present-day subsidence rates are lower than those reported here and additional information is required to reevaluate priority areas based on present-day subsidence rates.

Uncertainty in the basal peat elevations and current elevations in the Delta also point to the need for additional data. Because the most recent topographic leveling in the Delta was completed in the 1970's, the peat thicknesses presented here are about 20 years old. These peat thicknesses could be in error by as much as 8 feet because of subsidence that has occurred over the past 20 years. However, the relative distribution of peat depths presented here is reasonable because the processes affecting the areal distribution of subsidence have remained stable during the last 20 years. The peat thicknesses are also uncertain for several islands as discussed above.

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APPENDIX E

DELTA LEVEE EMERGENCY MANAGEMENT PLAN

DELTA LEVEE SYSTEM INTEGRITY PROGRAM

CALFED
Bay-Delta Program

DRAFT
December, 1997

DELTA LEVEE EMERGENCY MANAGEMENT PLAN

Foreword:

This paper provides a description of the CALFED Bay-Delta Program's approach to emergency management for the Delta. The plan will build upon existing emergency management systems, identify pre-emergency measures and post-disaster recovery measures, and enhance integration of local and regional emergency management agency actions to protect Delta resources in the event of a disaster.

This element of the Program, like all components of the Program's alternatives, is being developed and evaluated at a programmatic level. More focused analysis and environmental documentation of specific targets and actions will occur in subsequent refinement efforts.

C-007198

Introduction

The Emergency Management Plan will build upon existing state, federal, and local agency emergency management responsibilities to improve protection of Delta resources in the event of a disaster. It will identify deficiencies and propose specific actions which will improve flexibility to respond to changing Delta conditions, assure that appropriate resources are available and properly deployed, and provide for effective disaster recovery measures.

Background

The most recognizable threat to Delta islands and resources in the Delta is inundation due to winter flood events. In addition, other potential disasters threaten these same resources. They include seismic events, fire, burrowing animals, toxic spills, and failure of Delta levees during low flow periods. Approximately 20 islands have flooded since the 1960s, including multiple flooding of some islands.

There are no reports of Delta levee failure and island inundation as a result of a seismic event. However, there are several active faults located sufficiently close to the Delta to pose a potential threat. There are numerous natural gas storage and pipeline facilities in the Delta where fires could originate in the event of a failure of such a facility. Although plans are in place to address fires at these facilities, fires on Delta islands with peat soils are extremely difficult to extinguish. Commercial shipping traffic regularly passes through the Delta and the cargo of some of these ships can be toxic to certain resources in the Delta. The inadvertent release of cargo such as fertilizer could potentially affect water quality in the Delta, particularly during low flow periods. Another potential threat to Delta water quality is the failure of Delta levees during low flow periods. This type of disaster can result in intrusion of salinity from the Bay, as occurred during the 1972 inundation of Brannan/Andrus Island.

The existing emergency management structure is designed to coordinate activities of multiple State, Federal, and local agencies with varying responsibilities to provide emergency assistance in the event of a disaster. The Standardized Emergency Management System (SEMS) provides a framework for coordinating state and local government emergency response in California using the incident command system and mutual aid agreements. SEMS facilitates priority setting, inter-agency cooperation, and the efficient flow of resources and information.

When the Governor declares a State of Emergency, the Governor's Office of Emergency Services serves as the coordinator for state agency response. When an incident appears to potentially exceed the resources of the local responsible agency, emergency personnel conduct on-site evaluations to determine what, if any, additional emergency support is warranted. Cities and counties can proclaim local disaster events and, in general, local or maintaining agencies are first in line for responsibility to address disaster events. Although certain agencies may have resources to provide initial emergency action, they typically cannot provide a sustained effort during a large disaster event. The majority of local agencies do not have the resources to address major disaster events, and existing agreements may provide a means for sharing additional resources from surrounding areas. The federal government provides financial assistance through the Federal Emergency Management Agency under declaration of a Presidential Disaster; however, other federal agencies such as the U.S. Army Corps of Engineers may provide assistance and/or resources under existing authorities.

There is a tendency to focus emergency response measures on those sites facing imminent failure at the expense of actions which could prevent threatening sites from escalating into emergencies. Current emergency response procedures could also be streamlined to reduce delays in mobilizing resources. A quick response can often prevent costly levee failures.

Emergency Management Approach

The emergency management plan will address the following issues through refinement and implementation of the objectives, targets, and actions identified in Table 1.

- Eligibility criteria needs to be clearly defined with "shelf time" - fixed definitions per agreement for disaster event assistance and post event recovery efforts

- Coordination of available resources and support between agencies, counties, etc.. needs to be addressed. MOU or some agreement between all parties for funding, support, criteria, etc.

- Centralized location for dissemination of information (resources, support adequately addressed)

TABLE E - 1

Implementation Objective	Target	Action
Enhance emergency response capabilities and resource allocation	Develop the capability to efficiently respond to multiple concurrent levee breaks within the Delta	Develop a Delta-focused multi-agency emergency response team Implement recommendations made in the FEAT Report dated May 10, 1997 Develop SEMS/ICS organization and implementation criteria Purchase materials in advance and place in strategic locations Develop standardized contracts with contractors for forces and equipment to respond with short notice Improve site access and develop mobilization strategy
Develop a stable funding source for emergency response	Provide funding for a well defined Disaster Assistance Program	Prepare cost estimates Identify beneficiaries to provide equitable distribution of costs Develop funding sources

This plan will enhance existing emergency management response capabilities to protect critical Delta resources in the event of a disaster. Program staff will work with stakeholders, the public, and state and federal agencies, to identify pre-emergency and post-disaster recovery measures.

C-007201

- Program staff will work with stakeholders, the public, and state and federal agencies, in identifying pre-emergency and post-disaster recovery measures such as:

- Establish a Delta emergency management team consisting of existing state, federal, and local agency personnel among existing agencies with disaster related authorities and responsibilities. This team will enhance coordination and implementation of emergency actions for protecting Delta resources consistent with Program objectives. The focus will be on local agency preparation, coordination, and responsibility to provide enhanced initial response efforts to prevent damages and recovery measures. However, the plan will provide flexibility within each agency for specific implementation of the emergency actions based on resource availability, type of disaster, and extent of disaster.

- Identify criteria and emergency actions consistent with Program objectives to ensure protection of Delta resources. Separate criteria will be needed for various types of disasters such as single island failure during a low Delta inflow period, multiple island failure during a high Delta inflow period, or toxic spill within Delta channels during a low Delta inflow period. In addition, criteria will be needed for emergency actions prior to, during, and after a disaster event. Criteria such as stages or flows in certain Delta channels or seepage flows will determine specific emergency actions. Criteria for threatening situations such as imminent failure of Delta levees would identify equipment and manpower to prevent such failure. For example, stages in the Yolo Bypass or Delta Cross Channel could identify actions such as mobilization of equipment or materials and coordinated planning efforts to evaluate subsequent eventual actions. Criteria for post disaster situations such as after toxic spills would identify actions such as clean-up or other recovery actions. For example, criteria such as depth of flooding or salinity intrusion may identify post-emergency measures such as water management operations, and levee rehabilitation.

- Identify preventive measures to improve the efficiency of implementing emergency actions. Initial emergency actions and resources should be identified and available in advance of a disaster. Examples of preventive measures include identification of potential staging areas, advance collection and strategic placement of materials such as sandbags, visquine, stakes, pumps, etc., and identification of specific emergency actions. It is important to remember that criteria and emergency actions must be simple to understand and easy to implement. Complicated criteria or actions will only hinder emergency response effectiveness.

C-007202

- Identify recovery measures to prevent damages to adjacent areas and reduce long-term damages of affected areas. Examples of recovery measures include toxic spill clean-up, levee rehabilitation, and habitat restoration. Implementation of these measures to protect Delta resources will be consistent with Program objectives. For example, rehabilitation of Delta levees would incorporate habitat improvements consistent with Ecosystem Restoration Program Plan actions. It is important to remember that criteria and emergency actions must be simple to understand and easy to implement. Complicated criteria or actions will only hinder emergency response effectiveness.

C-007203

APPENDIX F

DELTA LEVEE SEISMIC RISK ASSESSMENT

DELTA LEVEE SYSTEM INTEGRITY PROGRAM

CALFED
Bay-Delta Program

DRAFT
December, 1997

Foreword

This paper provides a description of the CALFED Bay-Delta Program's approach to seismic risk assessment for the Delta. The plan will build upon existing seismic risk analysis, identify the risk to Delta resources during catastrophic seismic events and develop recommendations to improve stability of Delta levees to protect Delta resources in the event of a disaster.

This element of the Program, like all components of the Program's alternatives, is being developed and evaluated at a programmatic level. More focused analysis and environmental documentation of specific targets and actions will occur in subsequent refinement efforts.

Introduction

The goal of this assessment is to improve the understanding of the risk to Delta levees from earthquakes and to develop a work plan to improve the stability of Delta levees. This assessment will build upon current Delta seismic risk studies and develop recommendations for additional specific actions. These recommendations will be closely integrated with Ecosystem Restoration Program Plan and Delta conveyance actions to simultaneously reduce system vulnerability, increase ecosystem quality, and protect water quality and water supply reliability.

Background

Earthquakes can cause levees to fail by slumping or liquefaction of underlying soils. To date, there have been no known Delta levee failures or island inundations as a result of seismic events. However, there are several active faults located sufficiently close to the Delta to present a threat to Delta levees.

In 1992, the Department of Water Resources, Division of Engineering completed the "Phase I Report, Seismic Stability Evaluation of the Sacramento-San Joaquin Delta Levees." Subsequently, the Department took several actions to reduce some of the unknowns which influence the evaluation of levee stability during earthquake shaking. The Department:

- Selected four different sites in the Delta to place new surface and subsurface accelerometers;
- Performed Geologic Investigation and Shear Wave Velocity Testing at selected sites;
- Installed surface and subsurface strong motion instruments at the selected sites;
- Installed a strong motion instrument on rock near the western side of the Delta;
- Performed geotechnical laboratory studies to define the static site characteristics of the accelerometer locations; and
- Performed geotechnical laboratory studies to define the dynamic response characteristics of organic soils.

Seismic Risk Assessment Approach

The seismic risk assessment will address the following issues through refinement, and implementation of the objectives, targets, and actions identified in Table 1.

Issues to be addressed

- Performance of existing levee system during seismic event
- Recovery actions and accessibility following a seismic event

TABLE F-1

Implementation Objective	Target	Action
Quantify Delta levee seismic risk and compare it to other failure modes	Document findings in a report to CALFED	Continue to gather baseline seismic information Perform dynamic testing of levee material properties, and levee stability analysis Assemble a board of seismic and geotechnical experts (Delta Levee Consulting Board) to make recommendations to CALFED decision makers on the potential impact of seismic loading on Delta levees and how it compares with other failure modes
Determine how Delta levees can best be improved to reduce their susceptibility to damage/failure from seismic loading	Document findings in the report to CALFED	Delta Levee Consulting Board will make recommendations to CALFED on the potential for seismic retrofitting of Delta levees

This assessment will identify the risk to Delta resources during catastrophic seismic events and develop recommendations to improve the stability of Delta levees. The Department of Water Resources' Seismic Investigation is being continued. This investigation consists of installing strong-motion accelerometers at three to four levee sites in the Delta; creating a geologic model for deeper soil deposits; ongoing field and laboratory testing to better determine the static and dynamic properties of organic soils; field and laboratory testing to better determine liquefaction potential; and investigation of the potential activity of the Coast Range-Sierra/Nevada Boundary Zone. A board of seismic and geotechnical experts, The Delta Levee Consulting Board, will make recommendations on the potential impact of seismic loading on Delta levees and how it compares with other failure modes. The Board will also make recommendations on the potential for seismic retrofitting of Delta levees.

The following draft questions are related to the performance of the Delta levee system during seismic events. There are several policy level and technical questions to focus CALFED discussion and assist with future decisions on proposed alternatives. The technical questions will be addressed in a report being produced by the Department of Water Resources Division of Engineering. This report will be presented to the Consulting Board to the Department of Water Resources Sacramento-San Joaquin Levees currently under contract to DWR's Division of Engineering. The seismic susceptibility sub-team will prepare a work plan and summary report using this technical report and suggestions from the consulting board. The work plan and recommendations of the sub-team will be used to develop specific actions for Delta levee seismic performance. These recommendations will be closely integrated with Ecosystem Restoration Program Plan and Delta conveyance actions to simultaneously reduce system vulnerability, increase ecosystem quality, and protect water quality and water supply reliability.

Preliminary Questions for Agencies/Stakeholders

1. What is an acceptable risk for reliance on the Delta levee system for water supply?

2. What is an acceptable risk for continued investment of public funds for infrastructure, environmental resources, and other public resources?

3. What method would you recommend to calculate an overall risk of failure from all occurrences including flood, seismic, other forces? What approach would you recommend for presentation of the results?

4. What method would you use in assessing recommended actions and making decisions for implementation?

Preliminary Technical Questions[1]

1. What is the potential for the occurrence of a seismic event which could produce a level and duration of movement likely to produce levee failure in the Delta?

2. What is the magnitude of an event likely to produce levee failure in the Delta?

3. What is the likely regional distribution of an event likely to produce levee failure in the Delta?

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[1] DWR, Division of Engineering will prepare initial report addressing these questions for review by Consulting Board to the Department of Water Resources Sacramento-San Joaquin Levees. The Seismic Susceptibility Sub-Team will use this report in developing a work plan and report for CALFED.

4. What are reasonable, cost effective actions which could be undertaken to improve the stability of the Delta Levee system under seismic events?

5. What regions of the Delta, in order of priority, require improvements?

6. What are recommended actions, in order of priority, for these regions?

7. What are the elements of a program which can identify outstanding Delta levee seismic issues which need to be addressed? Can these elements fit within our adaptive management approach?

8. In what order of priority should these actions be undertaken?

Phasing Sequence

Program staff will work with stakeholders, the public, and state and federal agencies to build upon existing seismic information and activities to prepare an implementation plan. This plan will identify outstanding issues requiring subsequent action, then coordinate and implement recommendations with other program actions.

The following activities have been identified for completion by the Department of Water Resources Division of Engineering:

- Refine the seismic stability evaluations of Delta Levees based on new information
- Prepare report to address technical seismic questions
- Convene Delta Levee Consulting Board to make recommendation to CALFED

The following activities have been identified as potentially needing additional work to provide information in the seismic assessment process:

- Updating seismicity risk evaluation of the Delta by region. The USGS has been tentatively identified as the agency to complete this task.
- Updating seismic probabilistic analysis for the Delta by region. The USGS has been tentatively identified as the agency to complete this task.

APPENDIX G

DELTA LEVEES AND CHANNELS COST ESTIMATE

DELTA LEVEE SYSTEM INTEGRITY PROGRAM

DELTA LEVEE AND CHANNELS COST ESTIMATE

CALFED
Bay-Delta Program

DRAFT
December, 1997

Foreword

The following cost estimate only includes costs for the Delta Levee Base Level Protection Plan. Costs associated with other elements of the Delta Levee System Integrity Program are not yet available.

This estimate is preliminary and is being developed and evaluated at a programmatic level. More focused analysis and detailed estimates will occur in subsequent refinement efforts.

Introduction

The following preliminary cost estimate is for the Delta Levee Base Level Protection Plan without Ecosystem Restoration Program Plan actions.

This estimate is for the total cost to reconstruct all Project and non-Project levees in the legal Delta up to the PL 84-99 standard. This estimate assumes work will be performed on approximately 600 of the 1100 miles of levee in the Delta. The estimate includes costs for design, construction, and lands, easements, rights of way, and relocations.

Cost Estimate

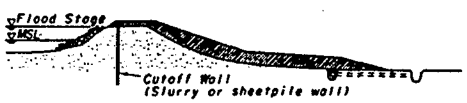
The preliminary cost estimate to achieve the Base Level Protection Plan is $1 billion.

Assumptions:

- Quantities are based on a "typical" levee section for non-project levees and proposed levee improvement cross sections.
- Federal Flood Control Project Levees, such as Sacramento River Levees, are assumed to require no improvements unless identified in the U.S. Army Corps of Engineers' 1993 report, "Sacramento River Flood Control Project Systems Evaluation Report - Lower Sacramento (USACE, 1993)."
- The estimate assumes that a majority of the design, construction, and right-of-way acquisition will be accomplished with local resources. It is also assumes that local borrow is readily available on the islands, and that beneficial reuse of dredged materials will be maximized.

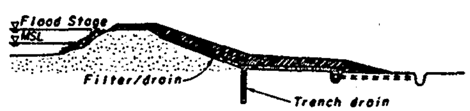
C-007214

TABLE 4-1: EXAMPLES OF LEVEE AND HABITAT IMPROVEMENTS

LEVEE IMPROVEMENT EXAMPLES	PURPOSE	APPLICABLE AREAS	POSITIVES	NEGATIVES
 A. Placement of Fill on Levee Crown and Landside Slope in Firm Mineral Soil Foundation Areas	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path.	Firm foundation areas, generally located in outer fringes of Delta and on old stream channels filled with mineral soils.	a. Levee structural stability is improved. b. Levee improvements stay within general footprint of existing levee and drain ditch. c. Relatively easily maintained as a flood control levee. d. Provides small increase in seismic stability.	a. Requires import of mineral soil. b. Represents a significant cost. c. Provides no environmental enhancement. d. Provides no significant increase in seismic stability. e. Addition of fill may result in short-term instability and/or cracking if levee/foundation system is weak.
 B. Placement of Fill on Levee Crown and Landside Slope, Together with Landside Berm in Soft Foundation Areas	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path. o Placement of berm accounts for soft foundation.	Most areas of Delta, but especially applicable in areas where soft foundation material exists.	a. Levee structural stability is improved. b. Relatively easily maintained as a flood control levee. c. Provides limited increase in seismic stability.	a. Requires significant import of mineral soil. b. Represents a significant cost. c. Provides no environmental enhancement. d. Provides only slight increase in seismic stability. e. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. f. Seepage system may need to be modified. g. Infringes on inboard farm land or habitat areas.
 C. Placement of Fill on Levee Crown, on Landside Slope, and in Landside Berm in Soft Foundation Areas - Together with Seepage Cutoff Wall (Slurry or Sheetpile Wall)	o Increases freeboard and flood protection. o Increases landside slope stability. o Significantly lengthens seepage path, stops concentrated seepage areas. o Placement of berm accounts for soft foundation.	Areas of the Delta where both soft foundation materials and significant, concentrated seepage problems exist.	a. Levee structural stability is improved. b. Provides significant improvement in control of seepage problems in levee. c. Relatively easily maintained as a flood control levee. d. May provide moderate improvement in seismic stability of levee if water levels inboard of cutoff wall are greatly reduced within levee (reduces amount of possible liquefaction).	a. Requires significant import of mineral soil. b. Placement of fill represents a significant cost. c. Construction of cutoff wall represents a major cost. d. Provides no environmental enhancement. e. Levee and foundation may still be unstable during earthquake loading. f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. g. Construction of cutoff wall may result in hydraulic fracturing and/or levee cracking if not carried out carefully. h. Lowered ground water inboard of wall may result in differential settlement and cracking. i. Seepage system may need to be modified.

C-007214

TABLE 4-1: EXAMPLES OF LEVEE AND HABITAT IMPROVEMENTS

LEVEE IMPROVEMENT EXAMPLES	PURPOSE	APPLICABLE AREAS	POSITIVES	NEGATIVES
 D. Placement of Fill on Levee Crown, on Landside Slope, and in Landside Berm in Soft Foundation Areas - Together with Filter/Drain System on Landside Slope	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path, stabilizes concentrated leaks and prevents piping erosion. o Placement of berm accounts for soft foundation.	Areas of the Delta where both soft foundation materials and significant, concentrated seepage or settlement and cracking problems exist.	a. Levee structural stability is improved. b. Provides significant improvement in control of seepage problems in levee. c. May prevent piping erosion associated with both flood events and moderate earthquake-induced settlement and cracking.	a. Requires significant import of mineral soil. b. Placement of fill represents a significant cost. c. Construction of filter/drain represents additional cost. d. Provides no environmental enhancement. e. Levee and foundation may still be unstable during earthquake loading. f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. g. Seepage system may need to be modified. h. Seepage and filter/drain system may need to be maintained. i. Infringes on inboard farm land or habitat areas.
 E. Placement of Fill on Levee Crown, on Landside Slope, and in Landside Berm in Soft Foundation Areas - Together with Filter/Drain System on Landside Slope and Toe Drain	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path, stabilizes concentrated leaks and prevents piping erosion through both levee and foundation. o Placement of berm accounts for soft foundation.	Areas of the Delta where both soft foundation materials and significant, concentrated seepage or settlement and cracking problems exist. Particularly suited where piping erosion problems exist within levee foundation.	a. Levee structural stability is improved. b. Provides significant improvement in control of seepage problems in levee and foundation. c. May prevent piping erosion associated with both flood events and moderate earth quake-induced settlement and cracking.	a. Requires significant import of mineral soil. b. Placement of fill represents a significant cost. c. Construction of filter/drain on both slope and in trench represents additional cost. d. Provides no environmental enhancement. e. Levee and foundation may still be unstable during earthquake loading. f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. g. Construction of drain trench may cause levee distress or seepage problems if not carried out carefully. h. Seepage system may need to be modified. i. Seepage and filter/drain system may need to be maintained. j. Infringes on inboard farm land or habitat areas.

C —0 0 7 2 1 5

C-007215

TABLE 4-1: EXAMPLES OF LEVEE AND HABITAT IMPROVEMENTS

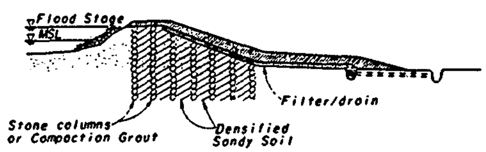
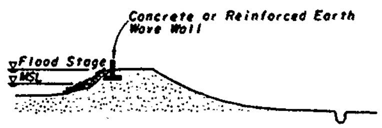
LEVEE IMPROVEMENT EXAMPLES	PURPOSE	APPLICABLE AREAS	POSITIVES	NEGATIVES
 F. Placement of Fill on Levee Crown, on Landside Slope, and in Landside Berm in Soft Foundation Areas - Together with Filter/Drain System on Landside Slope. Densification of Levee and Foundation Soils Using Vibroreplacment (Stone Columns) or Compaction Grouting.	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path, stabilizes concentrated leaks and prevents piping erosion through levee. o Placement of berm accounts for soft foundation. o Densification of levee and foundation soils prevents/limits earthquake-induced liquefaction.	Areas of the Delta where both soft foundation materials and liquefiable materials exist within levee and/or levee foundation.	a. Levee structural stability is improved. b. Provides significant improvement in control of seepage problems in levee. c. Densification reduces amount of slumping and cracking which may occur during an earthquake. Filter/drain may prevent piping erosion following an earthquake (and flood events).	a. Requires significant import of mineral soil. b. Placement of fill represents a significant cost. c. Construction of filter/drain represents additional cost. d. Densification represents a major cost. e. Provides no environmental enhancement. f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. g. Densification construction may cause levee distress or seepage problems if not carried out carefully. h. Seepage system may need to be modified. i. Seepage and filter/drain system may need to be maintained. j. Infringes on inboard farm land or habitat areas.
 G. Construction of Concrete Wave Wall on Levee Crown	o Provides wave protection during high tides and flood events (Probably only an interim measure).	Areas of the Delta where levee freeboard is of immediate concern.	a. Provides wave protection. b. Relatively inexpensive. c. Can be constructed relatively quickly.	a. Provides no significant improvement in: - overall freeboard. - structural stability. - seepage control. - piping erosion. - seismic stability. b. Provides no environmental enhancement.
 H. Construction of Sheetpile Wave Wall on Levee Crown	o Provides wave protection during high tides and flood events (Probably only an interim measure).	Areas of the Delta where levee freeboard is of immediate concern.	a. Provides wave protection. b. Relatively inexpensive. c. Can be constructed relatively quickly.	a. Provides no significant improvement in: - overall freeboard. - structural stability. - seepage control. - piping erosion. - seismic stability. b. Requires limited import of fill. c. Provides no environmental enhancement. d. Installation of sheetpile wall may result in cracking of levee if not carried out with care.

TABLE 4-1: EXAMPLES OF LEVEE AND HABITAT IMPROVEMENTS

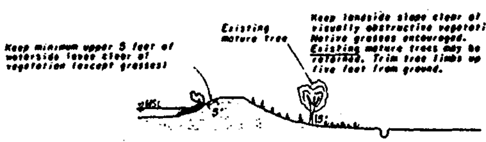
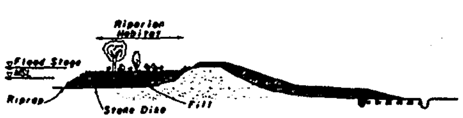
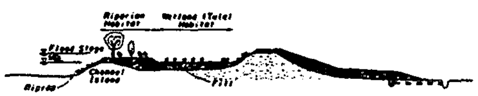
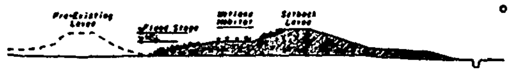
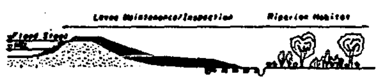
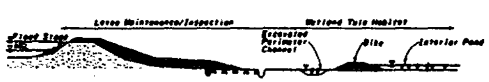
LEVEE IMPROVEMENT EXAMPLES	PURPOSE	APPLICABLE AREAS	POSITIVES	NEGATIVES
 I. Maintenance of Vegetation on Existing Levee Slopes	o Provides reasonable on-site growth and regrowth of vegetation while maintaining safety, access, and inspectability of levees.	Most areas in the Delta, but impact on levee stability must be first evaluated on a site by site basis. Waterside vegetation must be integrated with wave protection systems such as riprap to prevent major levee erosion.	a. Limited waterside vegetation provides some riparian and shaded aquatic habitat. b. Limited waterside vegetation provides some wave protection for levee. c. Grass vegetation provides erosion control for surface runoff. d. Preservation of existing trees provides valuable riparian habitat.	a. If Engineer's guidance not followed and vegetation becomes overgrown, then: - Vegetation limits access for inspection, maintenance, and flood fighting. - Vegetation encourages burrowing rodents. - Downing of trees during storms causes damage to levees due to fallen root balls pulling out chunks of the levee. - Tree roots can also eventually provide a seepage path through levee when they decay. b. Cannot be implemented on Federal levees. c. Because levees require continual maintenance and remediation, some developed habitats need to be covered over with stabilizing berms.
 J. Placement of Fill on Levee Crown and Landside Slope, Together with Landside Berm in <u>Soft</u> Foundation Areas. Creation of <u>Waterside Berm at Mean Sea Level</u> to Create Waterside Wetland Habitat.	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path. o Placement of berm accounts for soft foundation. o Provides <u>Waterside Wetland Habitat.</u>	Areas of Delta where soft foundation material exists and where waterside slope is not steep (deep). Cannot be used where channel capacity is severely limited.	a. Levee structural stability is improved. b. Relatively easily maintained as a flood control levee. c. Provides limited increase in seismic stability. d. Provides valuable <u>Waterside Wetland Habitat</u> (Waterside fill may limit seepage and improve waterside slope stability).	a. Requires major import of mineral soil. b. Placement of landside fill represents a significant cost. c. Placement of waterside fill represents a significant cost. d. Provides only limited increase in seismic stability. e. Limits channel capacity. f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. g. Dredging may be needed on waterside. h. Seepage system may need to be modified.
 K. Placement of Fill on Levee Crown and Landside Slope, Together with Landside Berm in <u>Soft</u> Foundation Areas. Creation of <u>Waterside Berm above Mean Sea Level</u> to Create Waterside Riparian Habitat.	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path. o Placement of berm accounts for soft foundation. o Provides <u>Waterside Riparian Habitat.</u>	Areas of Delta where soft foundation material exists, and where waterside slope is not steep (deep). Cannot be used where channel capacity us severely limited.	a. Levee structural stability is improved. b. Relatively easily maintained as a flood control levee. c. Provides limited increase in seismic stability. d. Provides valuable <u>Waterside Riparian Habitat</u> (Waterside fill may limit seepage and improve waterside slope stability).	a. Requires major import of mineral soil. b. Placement of landside fill represents a significant cost. c. Placement of waterside fill represents a significant cost. d. Provides only limited increase in seismic stability. e. Limits channel capacity. f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. g. Dredging may be needed on waterside. h. Seepage system may need to be modified.

TABLE 4-1: EXAMPLES OF LEVEE AND HABITAT IMPROVEMENTS

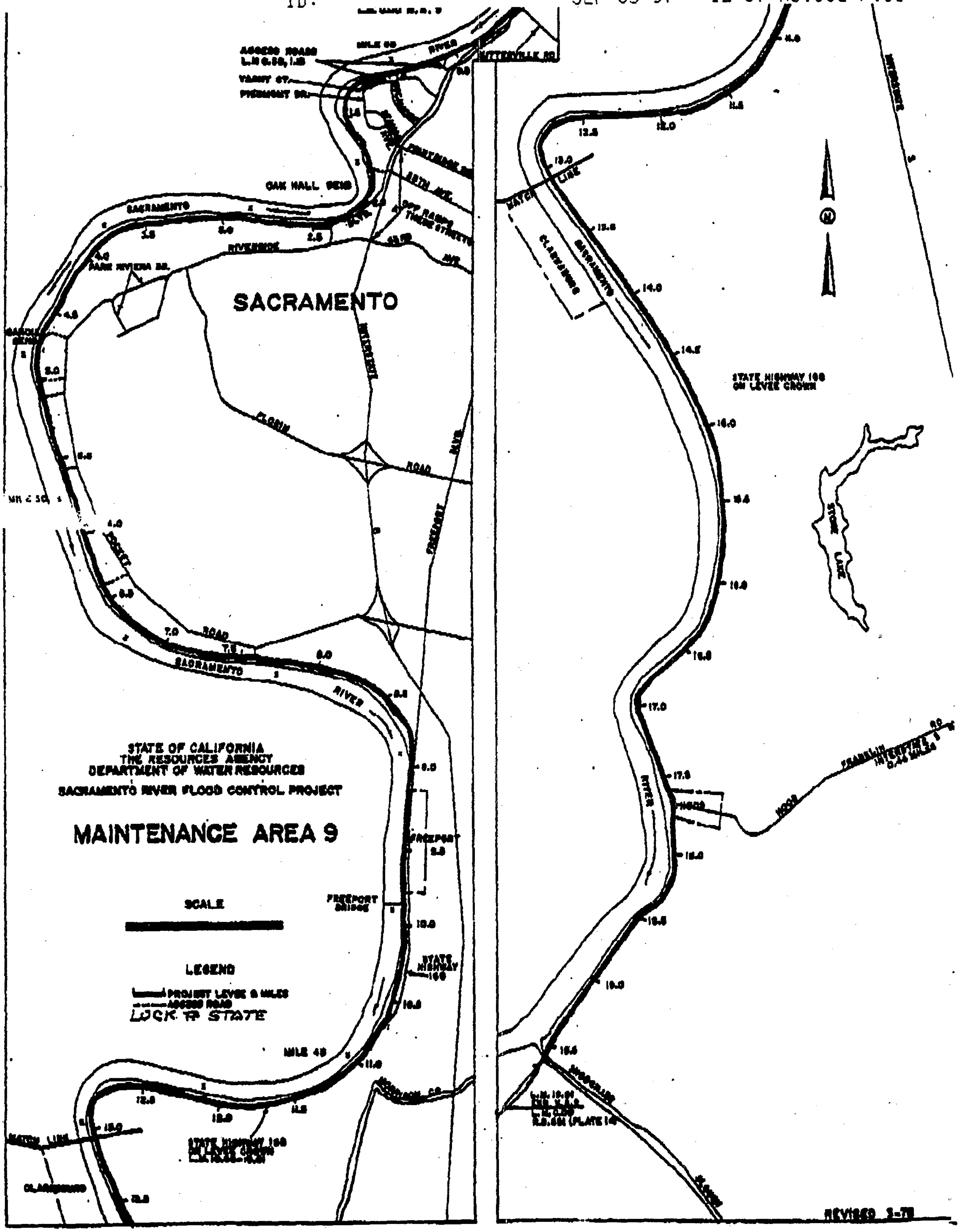
LEVEE IMPROVEMENT EXAMPLES	PURPOSE	APPLICABLE AREAS	POSITIVES	NEGATIVES
 L. Placement of Fill on Levee Crown and Landside Slope. Together with Landside Berm in Soft Foundation Areas. Placement of Fill between Channel Island and Levee to Create Waterside Wetland and Riparian Habitat.	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path. o Placement of berm accounts for soft foundation. o Provides Waterside Riparian and Wetland Habitat.	Areas of Delta where soft foundation material exists, and where channel islands and channel between island levee is not too deep. Cannot be used where channel capacity is severely limited.	a. Levee structural stability is improved. b. Relatively easily maintained as a flood control levee. c. Provides limited increase in seismic stability. d. Provides valuable Waterside Riparian and Wetland Habitat (Waterside fill may limit seepage and improve waterside slope stability).	a. Requires major import of mineral soil. b. Placement of landside fill represents a significant cost. c. Placement of waterside fill represents a significant cost. d. Provides only limited increase in seismic stability. e. Limits channel capacity. f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. g. Dredging may be needed on waterside. h. Seepage system may need to be modified. i. Channel island requires protection.
 M. Placement of Fill on Levee Crown and Landside Slope. Together with Landside Berm in Soft Foundation Areas. Placement of Sand Beach on Waterside Slope to Create Recreation Area.	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path. o Placement of berm accounts for soft foundation. o Provides Recreation Area.	Areas of Delta where soft foundation material exists, and where waterside slope is not too steep (deep). Cannot be used where channel capacity is severely limited.	a. Levee structural stability is improved. b. Relatively easily maintained as a flood control levee. c. Provides limited increase in seismic stability. d. Provides valuable Waterside Recreation Area. (Waterside fill may limit seepage and improve waterside slope stability.)	a. Requires major import of mineral soil. b. Placement of landside fill represents a significant cost. c. Placement of waterside sandy fill represents a significant cost. d. Provides only limited increase in seismic stability. e. Limits channel capacity. f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. g. Dredging may be needed on waterside. h. Seepage system may need to be modified. i. Beach area requires maintenance.
 N. Partial Setback of Levee to Create Waterside Riparian Habitat. Placement of Fill on Levee Crown and Landside Slope. Slope. Together with Landside Berm in Soft Foundation Areas.	o Increases freeboard and flood protection. o Increases overall slope stability. o Lengthens seepage path. o Placement of berm accounts for soft foundation. o Provides Waterside Riparian Habitat.	All areas of Delta, but especially applicable in areas where soft foundation material exists.	a. Levee structural stability is improved. b. Relatively easily maintained as a flood control levee. c. Provides limited increase in seismic stability. d. Lengthens seepage path.	a. Requires significant import of mineral soil. b. Fill placement and cost associated with levee setback greater than simply raising levee crown and adding berm. c. Provides only limited increase in seismic stability. d. Addition of fill likely to result in short-term instability and/or cracking if staged-construction is not used. e. Seepage system may need to be modified. f. Infringes on inboard farm land or habitat areas.

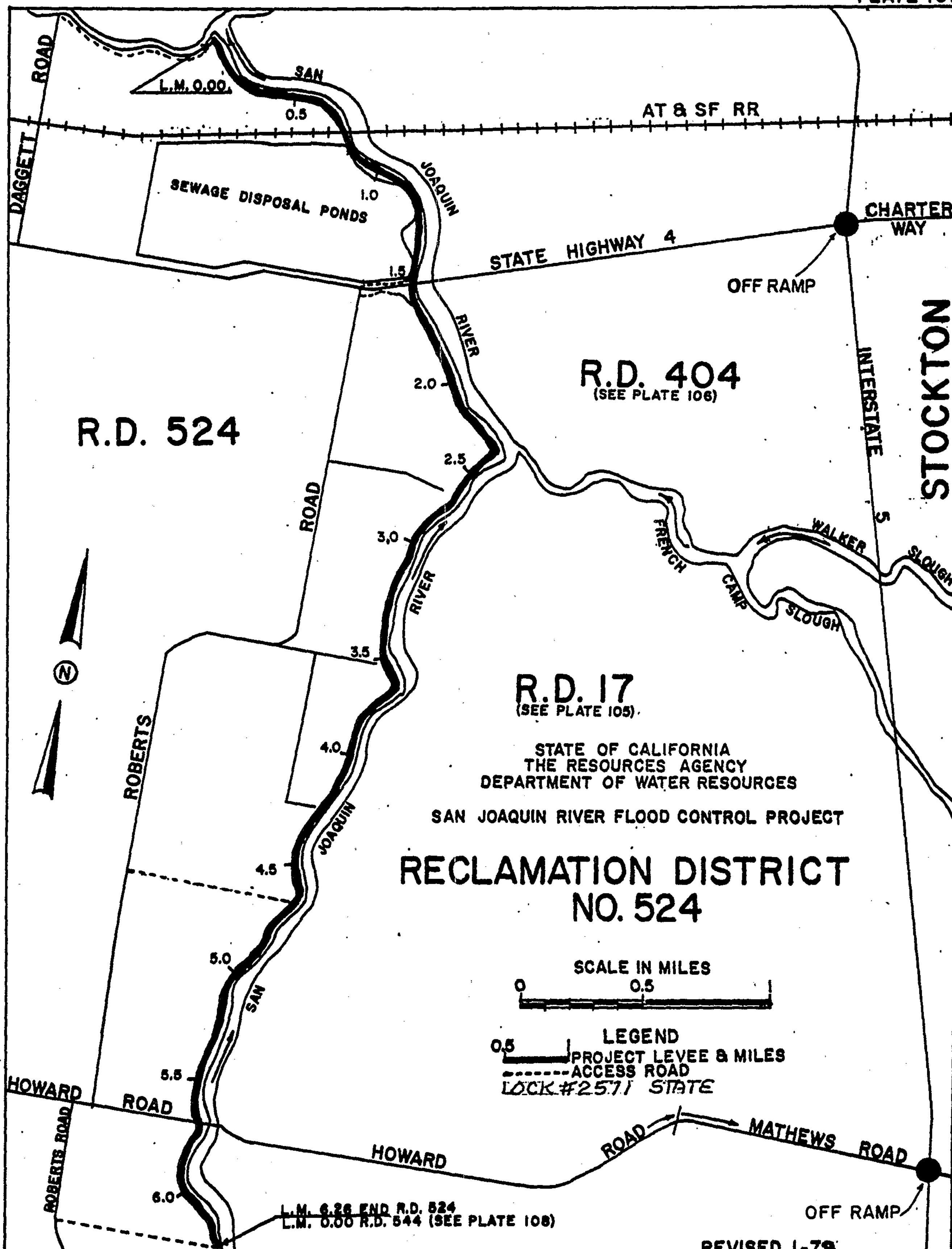
C-007219

TABLE 4-1: EXAMPLES OF LEVEE AND HABITAT IMPROVEMENTS

LEVEE IMPROVEMENT EXAMPLES	PURPOSE	APPLICABLE AREAS	POSITIVES	NEGATIVES
 O. Complete Setback of Levee to Improve Channel Capacity, Improve Levee Structural Stability and Provide Waterside Wetland Habitat.	o Increases channel capacity. o Improves levee stability. o Provides Waterside Wetland Habitat.	Many areas of Delta, but possibly not in areas where very thick layers of soft foundation material may make creation of new setback levees infeasible.	a. Increases channel capacity and improves flood control. b. New levee would be an engineered fill and would not liquefy during seismic events. c. Provides Waterside Wetland Habitat.	a. Requires major import of mineral soil. b. Fill placement and cost associated with levee setback greater than simply raising levee crown and adding berm. c. Foundation liquefaction could still cause failure during future earthquake. d. New levee fill likely to result in short-term instability and/or cracking if staged-construction is not used. This could temporarily make new levee less reliable than existing levee. e. Significantly infringes on inboard farm land or habitat areas.
 P. Placement of Fill on Levee Crown and Landslide Slope, Together with Landside Berm in Soft Foundation Areas. Creation of Landside Riparian Habitat.	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path. o Placement of berm accounts for soft foundation. o Provides Landside Riparian Habitat.	All areas of Delta, but especially applicable in areas where soft foundation material exists.	a. Levee structural stability is improved. b. Relatively easily maintained as a flood control levee. c. Provides limited increase in seismic stability. d. Provides Landside Riparian Habitat. e. Reduces subsidence near levee by not tilling land in habitat area.	a. Requires significant import of mineral soil. b. Represents a significant cost. c. Provides only slight increase in seismic stability. d. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. e. Seepage system may need to be modified. f. Significantly infringes on inboard farm land and requires some land to be taken out of agricultural production.
 Q. Placement of Fill on Levee Crown and Landslide Slope, Together with Landside Berm in Soft Foundation Areas. Creation of Inboard Ponds and Waterfilled Perimeter Ditches for Landside Wetland Habitat.	o Increases freeboard and flood protection. o Increases landside slope stability. o Lengthens seepage path. o Placement of berm accounts for soft foundation. o Provides Landside Wetland Habitat.	All areas of Delta, but especially applicable in areas where soft foundation material exists and significant inland subsidence is occurring.	a. Levee structural stability is improved. b. Relatively easily maintained as a flood control levee. c. Provides limited increase in seismic stability. d. Provides Landside Wetland Habitat. e. Reduces subsidence near levee by keeping organic soils saturated.	a. Requires significant import of mineral soil. b. Represents a significant cost. c. Provides only slight increase in seismic stability. d. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used. e. Seepage system may need to be modified. f. Significantly infringes on inboard farm land and requires some land to be taken out of agricultural production. g. Inland pond and dike systems require maintenance.

C-007219


STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SACRAMENTO RIVER FLOOD CONTROL PROJECT
MAINTENANCE AREA 9
SCALE
LEGEND
PROJECT LEVEE & MILES
ACCESS ROAD
LOCK TO STATE
SACRAMENTO
OAK HALL BEND
SACRAMENTO RIVER
RIVERSIDE
FLORIN ROAD
POCKET ROAD
FREEPORT
FREEPORT BRIDGE
STATE HIGHWAY 160
MILE 43
MATCH LINE
CLARKSBURG
STATE HIGHWAY 160 ON LEVEE CROWN
STONE LAKE
HOOD
REVISED 3-78



STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

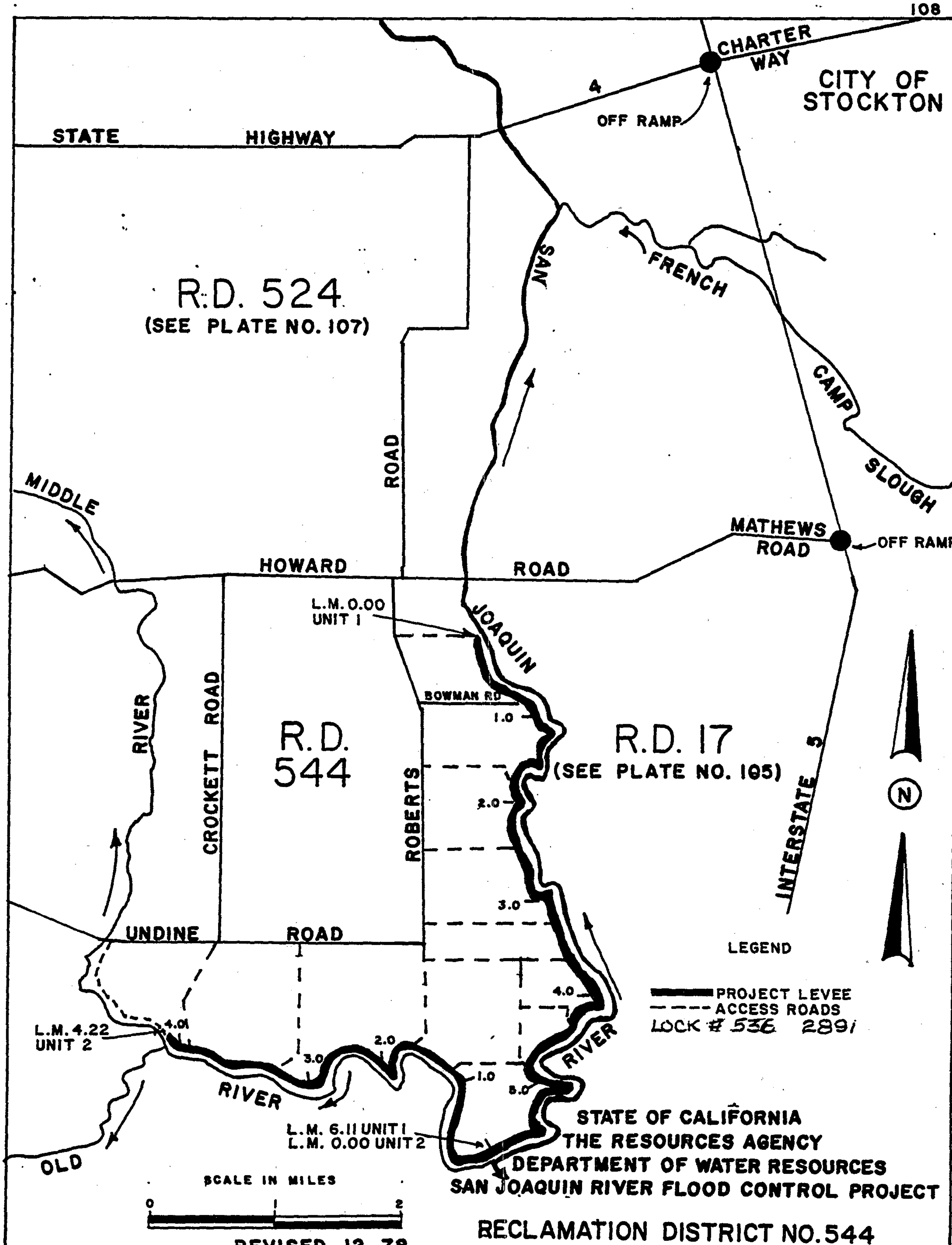
SAN JOAQUIN RIVER FLOOD CONTROL PROJECT

RECLAMATION DISTRICT NO. 524

SCALE IN MILES
0 0.5 1

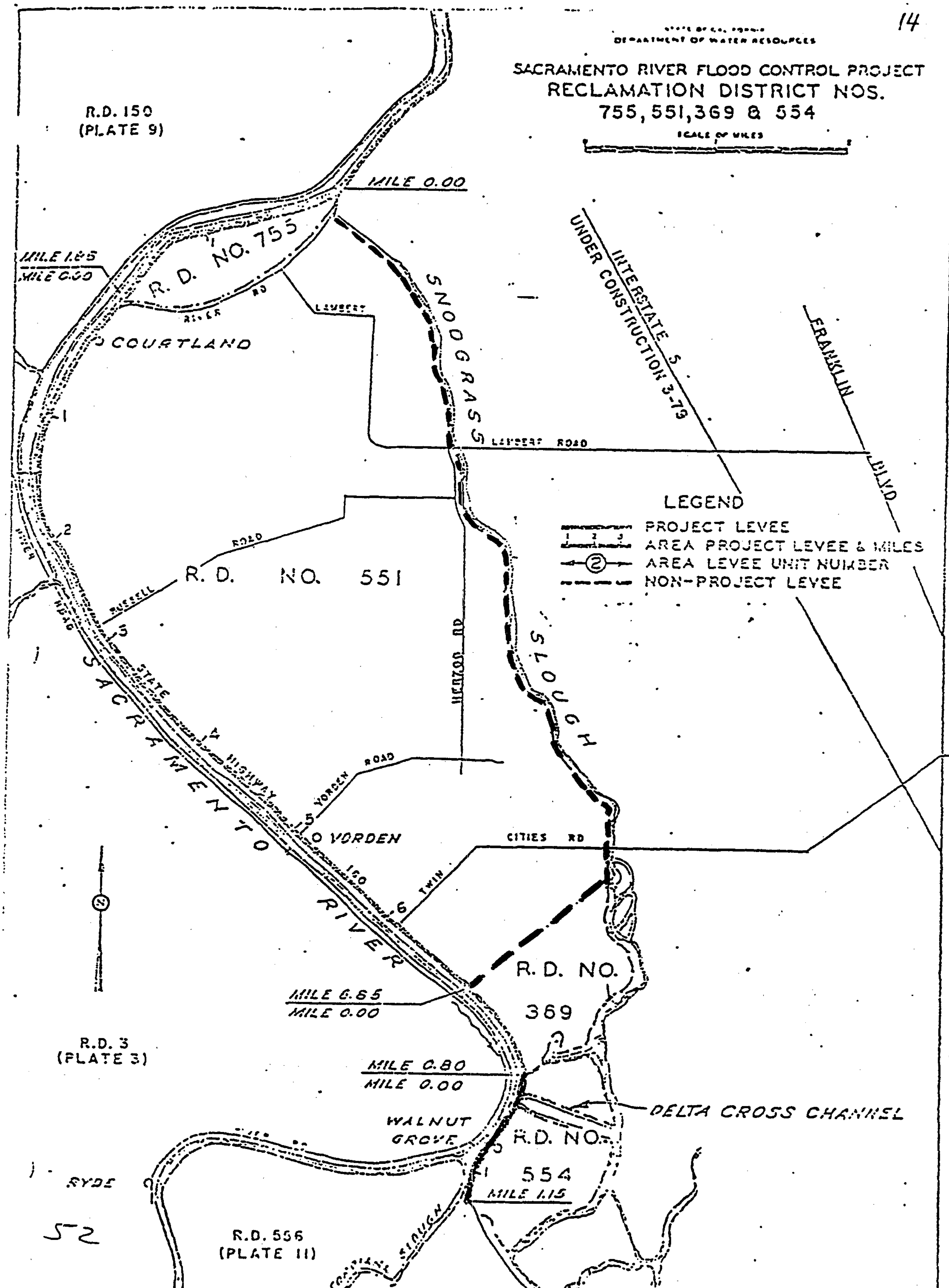
LEGEND
0.5 PROJECT LEVEE & MILES
------- ACCESS ROAD
LOCK #2571 STATE

C—007221



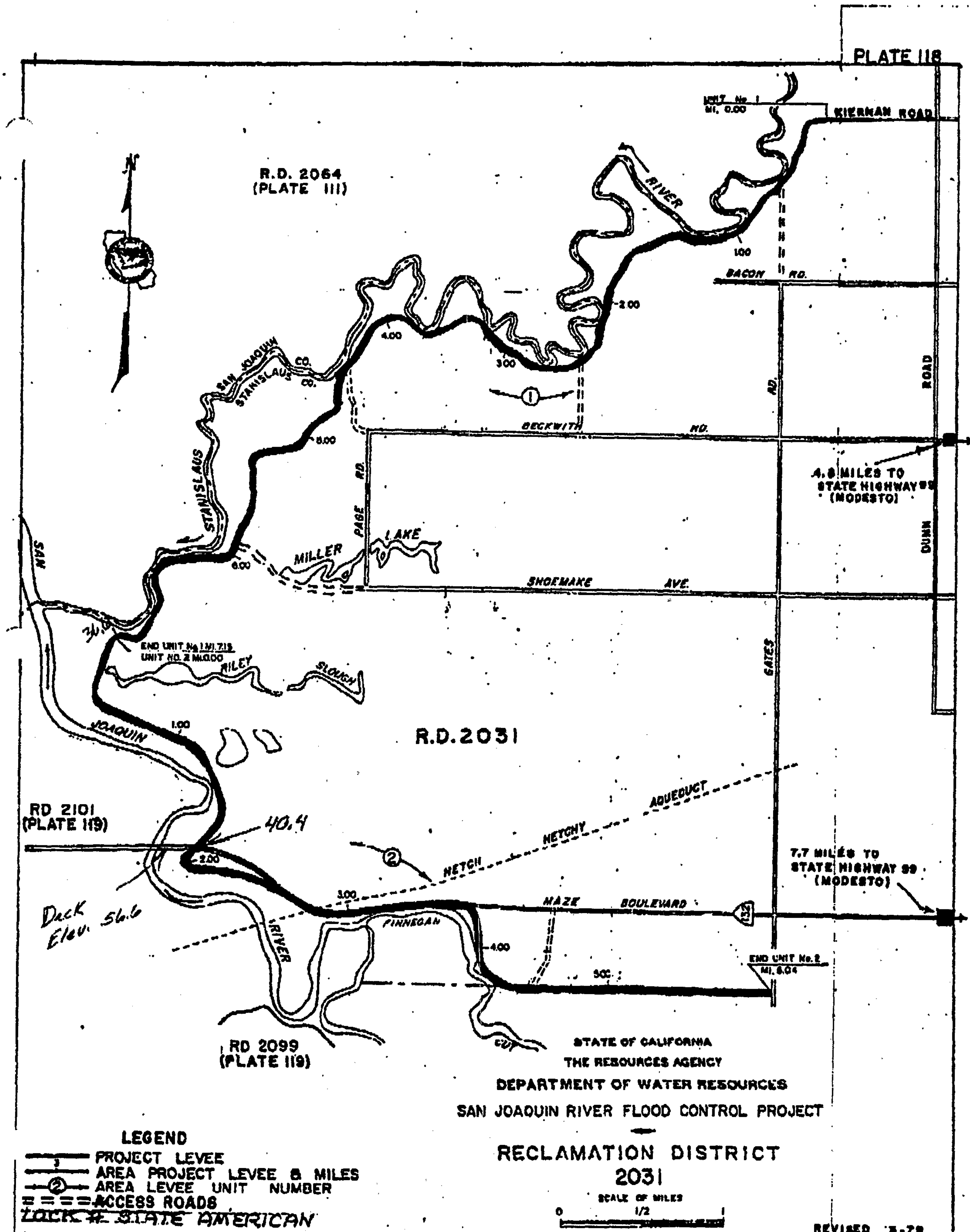
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN RIVER FLOOD CONTROL PROJECT

RECLAMATION DISTRICT NO. 544


STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SACRAMENTO RIVER FLOOD CONTROL PROJECT
RECLAMATION DISTRICT NOS.
755, 551, 369 & 554
SCALE OF MILES
R.D. 150
(PLATE 9)
MILE 0.00
R. D. NO. 755
MILE 1.85
MILE 0.00
RIVER RD
LAMBERT
COURTLAND
SNODGRASS SLOUGH
INTERSTATE 5
UNDER CONSTRUCTION 3-79
FRANKLIN BLVD.
LAMBERT ROAD
LEGEND
PROJECT LEVEE
AREA PROJECT LEVEE & MILES
AREA LEVEE UNIT NUMBER
NON-PROJECT LEVEE
RUSSELL ROAD
R. D. NO. 551
RIVER ROAD
STATE HIGHWAY 160
SACRAMENTO RIVER
VORDEN ROAD
VORDEN
CITIES RD
TWIN
MILE 6.65
MILE 0.00
R. D. NO. 369
R.D. 3
(PLATE 3)
MILE 0.80
MILE 0.00
DELTA CROSS CHANNEL
WALNUT GROVE
R.D. NO. 554
MILE 1.15
RYDE
R.D. 556
(PLATE 11)
GEORGIANA SLOUGH

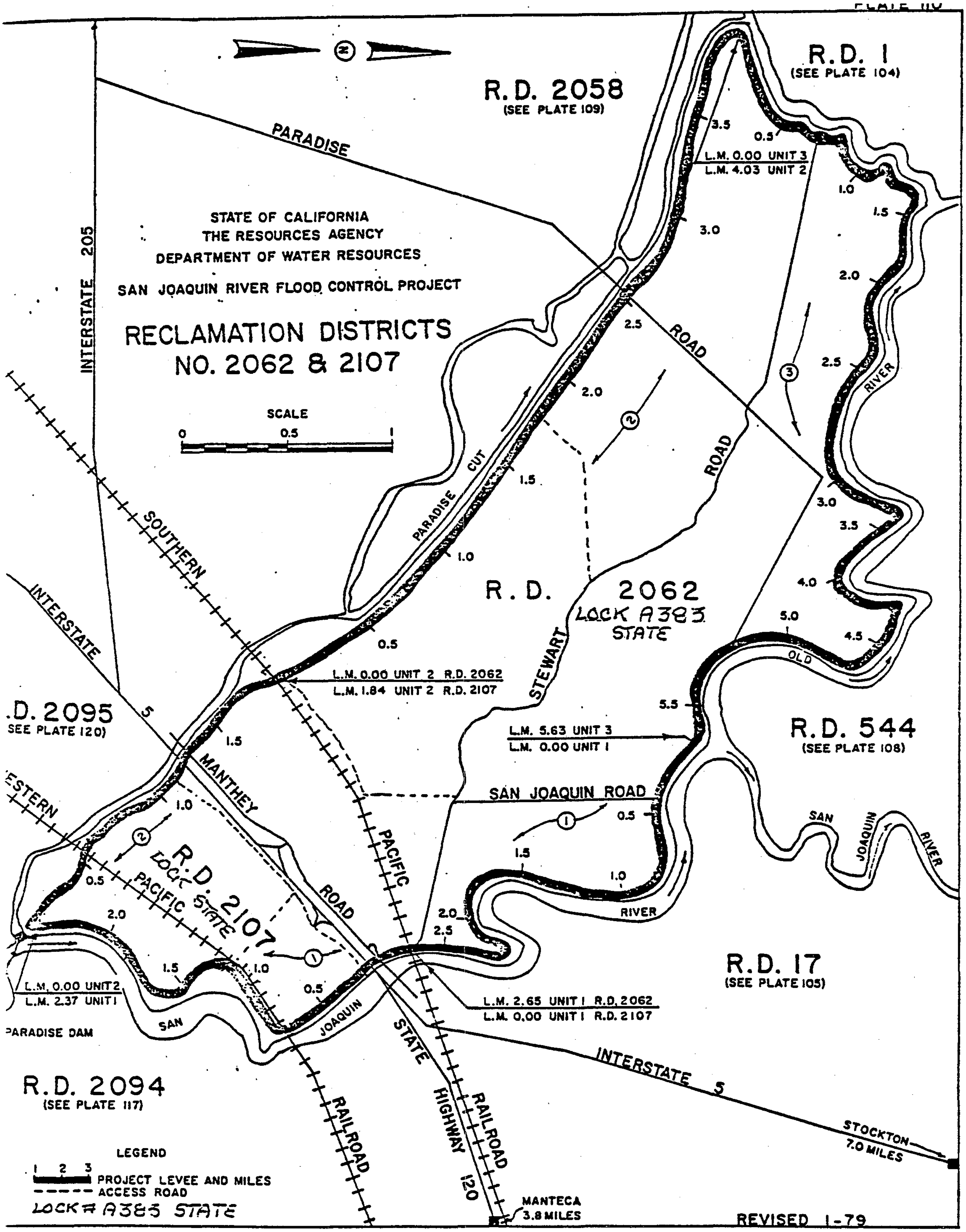
52

C—007223

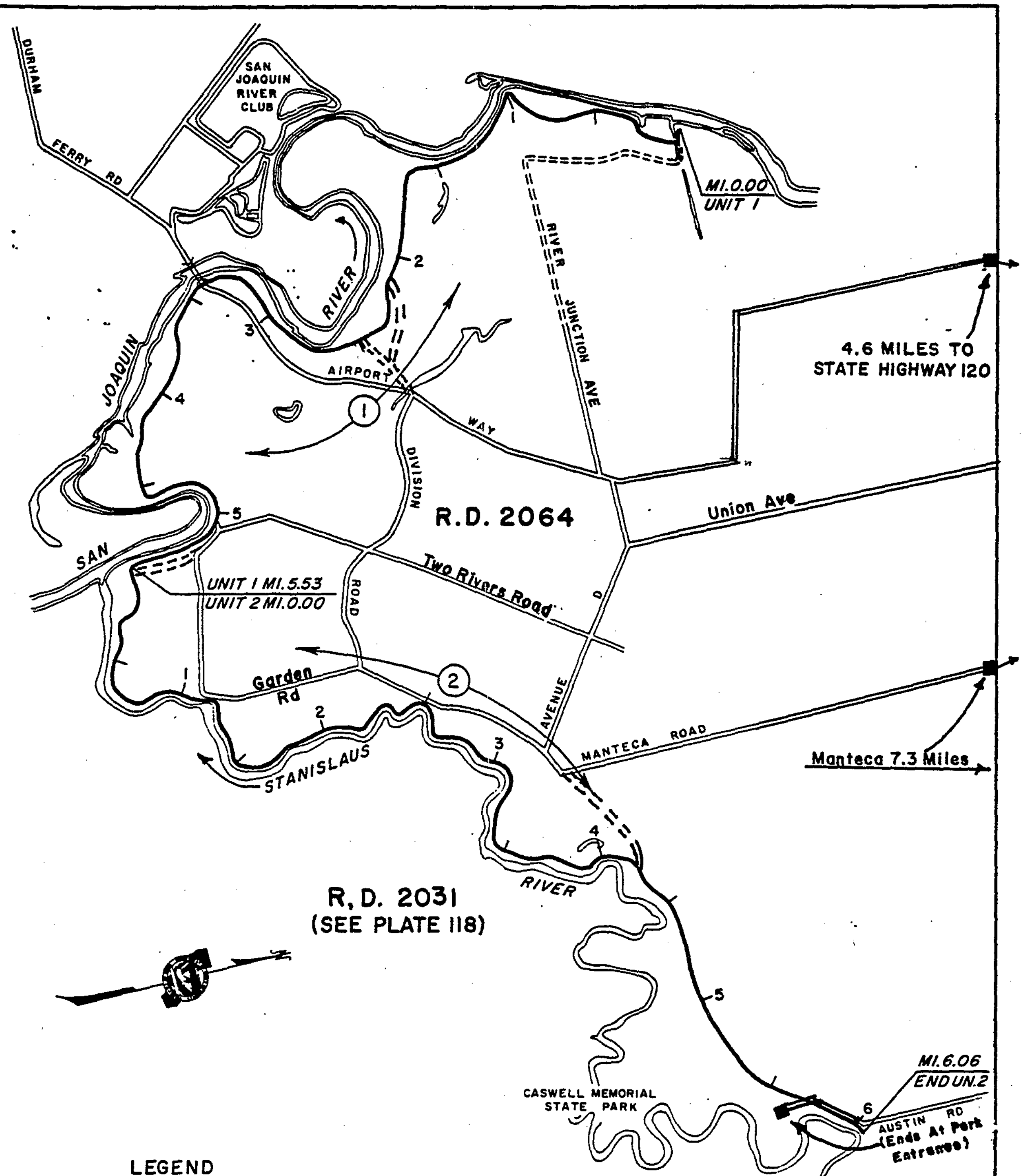


C—007224

C-007224


STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN RIVER FLOOD CONTROL PROJECT
RECLAMATION DISTRICTS
NO. 2062 & 2107
SCALE
0 0.5 1
R.D. 2058
(SEE PLATE 109)
R.D. 1
(SEE PLATE 104)
PARADISE
ROAD
INTERSTATE 205
L.M. 0.00 UNIT 3
L.M. 4.03 UNIT 2
PARADISE CUT
SOUTHERN
PACIFIC
RAILROAD
STEWART
R.D. 2062
LOCK A383
STATE
OLD
RIVER
R.D. 544
(SEE PLATE 108)
L.M. 0.00 UNIT 2 R.D. 2062
L.M. 1.84 UNIT 2 R.D. 2107
L.M. 5.63 UNIT 3
L.M. 0.00 UNIT 1
.D. 2095
SEE PLATE 120)
INTERSTATE 5
MANTHEY
ROAD
SAN JOAQUIN ROAD
WESTERN
PACIFIC
R.D. 2107
LOCK STATE
SAN JOAQUIN RIVER
R.D. 17
(SEE PLATE 105)
L.M. 2.65 UNIT I R.D. 2062
L.M. 0.00 UNIT I R.D. 2107
L.M. 0.00 UNIT 2
L.M. 2.37 UNIT 1
PARADISE DAM
STATE HIGHWAY 120
RAILROAD
INTERSTATE 5
STOCKTON
7.0 MILES
MANTECA
3.8 MILES
R.D. 2094
(SEE PLATE 117)
LEGEND
PROJECT LEVEE AND MILES
ACCESS ROAD
LOCK # A383 STATE
REVISED 1-79

C-007225



LEGEND

- AREA PROJECT LEVEE & MILES
- AREA LEVEE UNIT NUMBER
- = = = = ACCESS ROADS

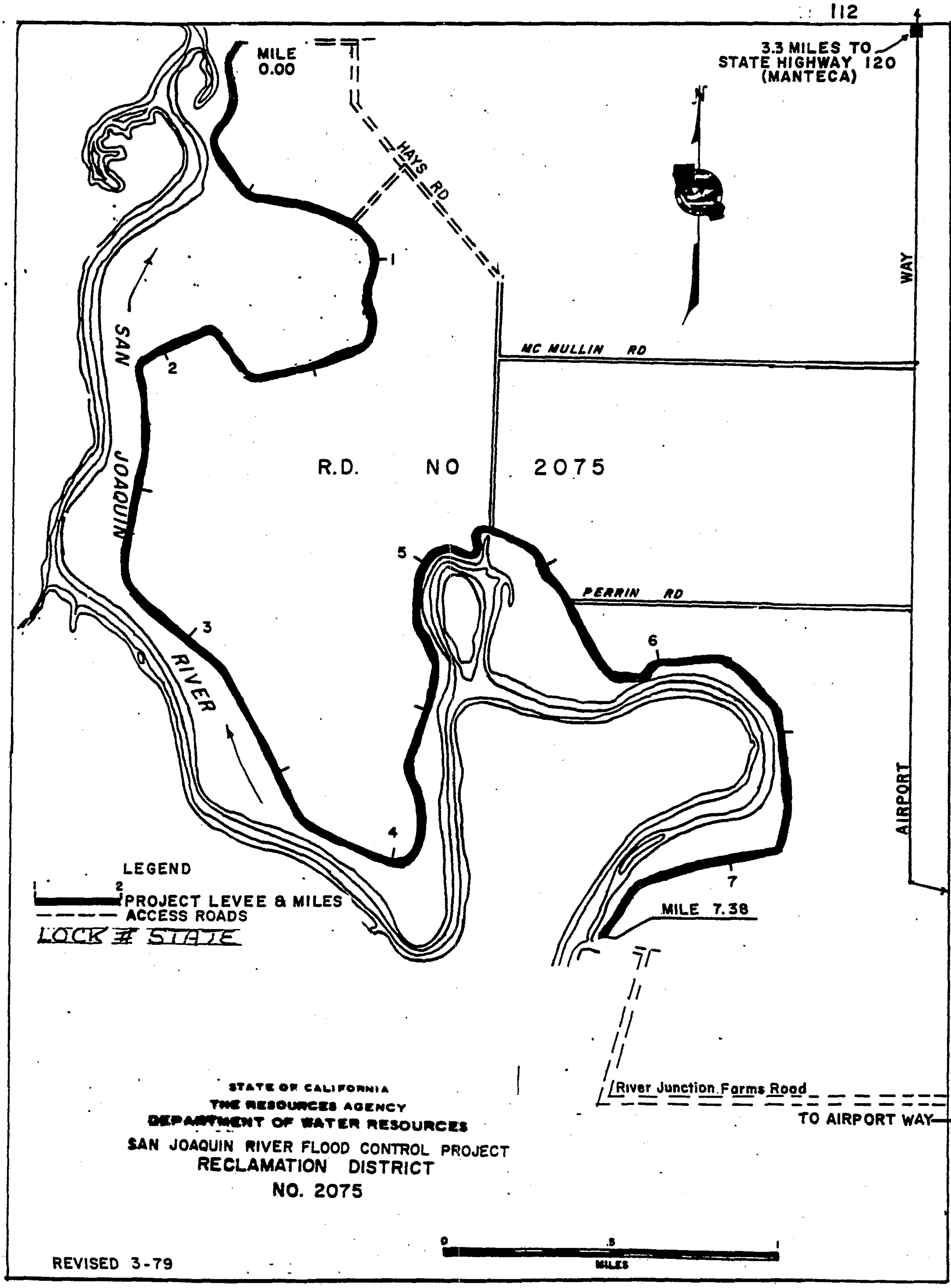
LOCK # ~~2396~~ 3381

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

SAN JOAQUIN RIVER FLOOD CONTROL PROJECT
RECLAMATION DISTRICT NO. 2064

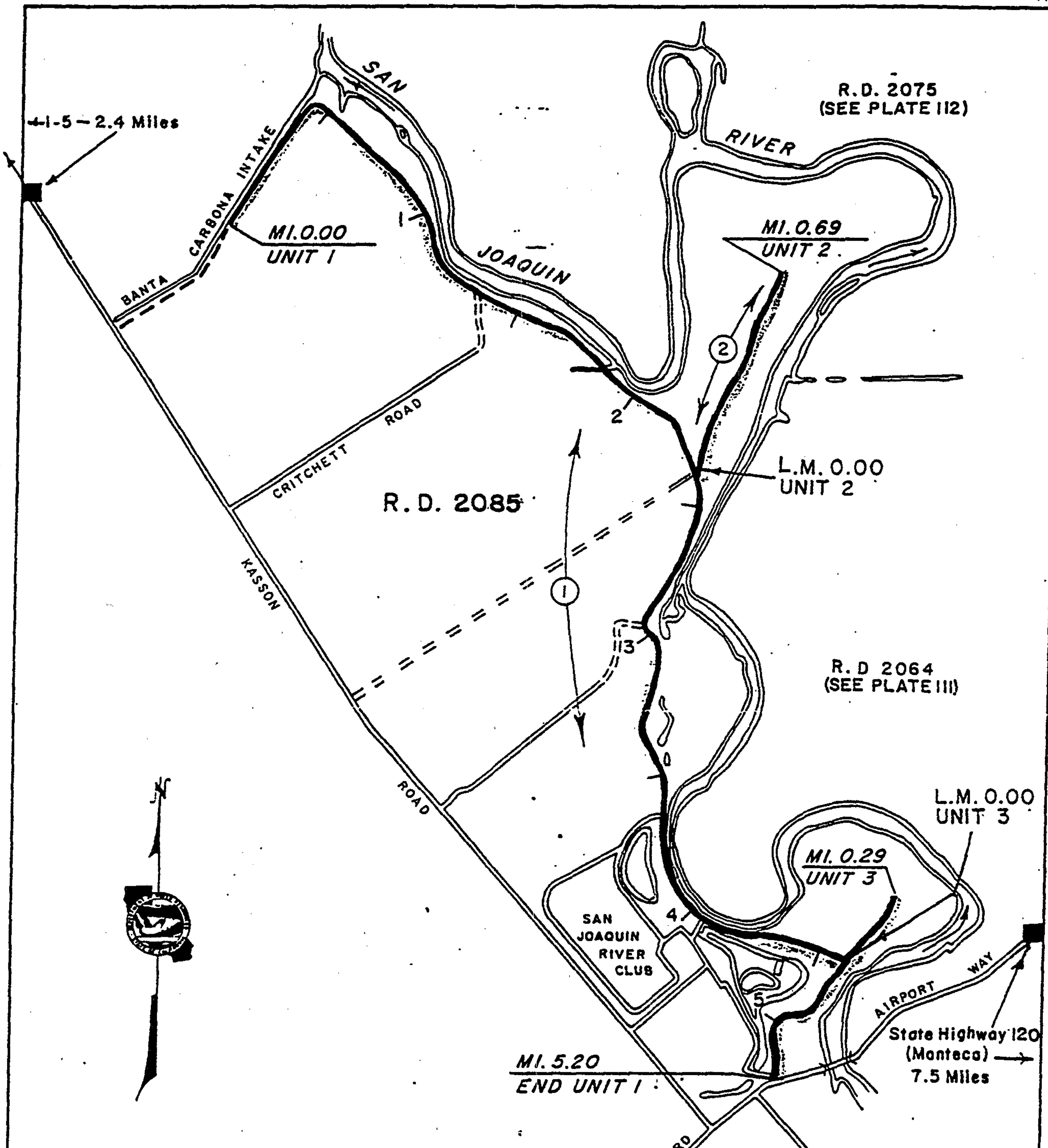
SCALE IN MILES
1 .5 0 1

REVISED 3-79



3.3 MILES TO STATE HIGHWAY 120 (MANTECA)
MILE 0.00
HAYS RD
MC MULLIN RD
PERRIN RD
SAN JOAQUIN RIVER
R.D. NO 2075
MILE 7.38
AIRPORT WAY
River Junction Farms Road
TO AIRPORT WAY
1
2
3
4
5
6
7
LEGEND
PROJECT LEVEE & MILES
ACCESS ROADS
LOCK # STATE
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN RIVER FLOOD CONTROL PROJECT
RECLAMATION DISTRICT
NO. 2075
REVISED 3-79
0
.5
1
MILES

C — 0 0 7 2 2 7



LEGEND

- PROJECT LEVEE
- AREA PROJECT LEVEE & MILES
- AREA LEVEE UNIT NUMBER
- NON-PROJECT LEVEE
- ACCESS ROAD

LOCK# X217.1. STATE

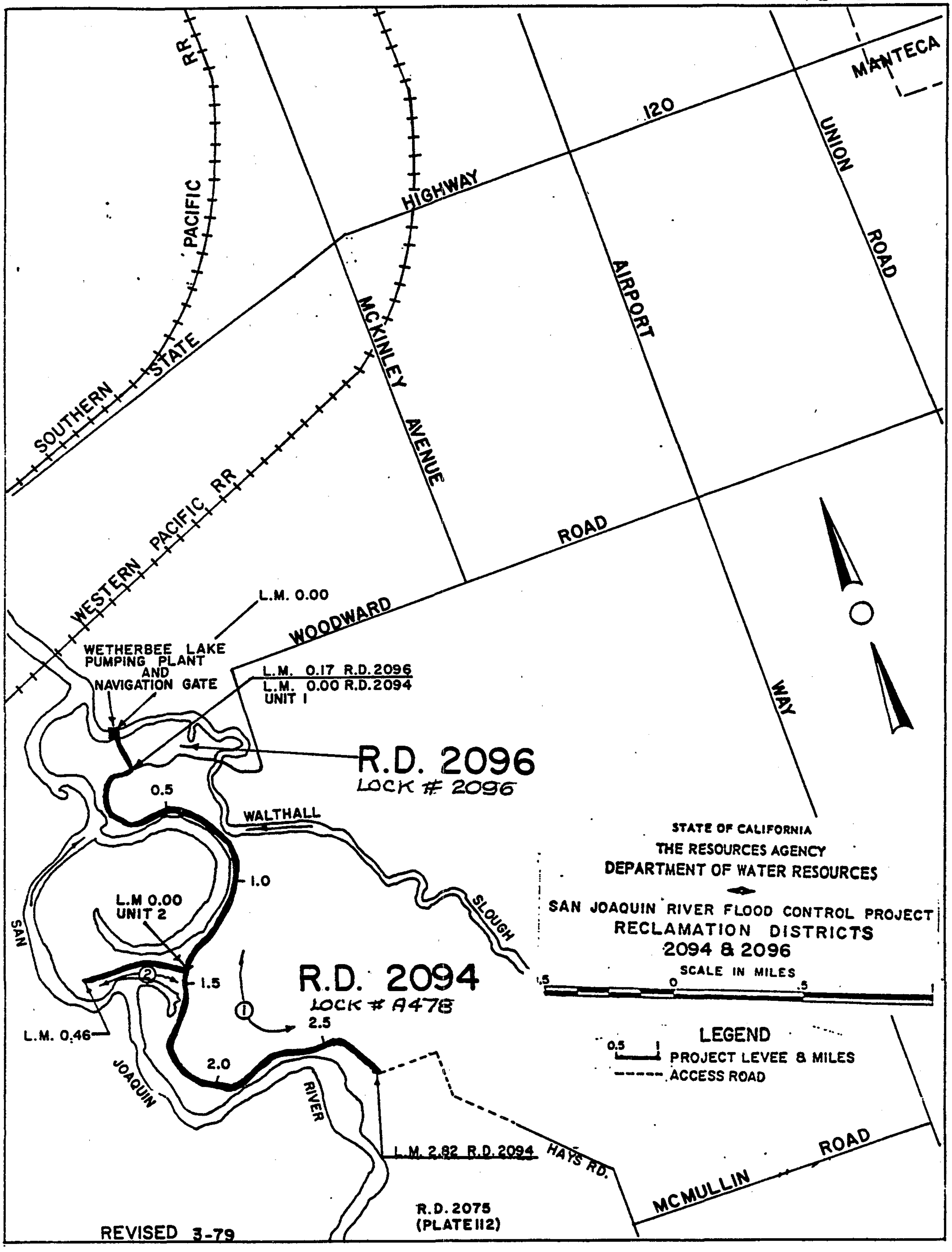
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

SAN JOAQUIN RIVER FLOOD CONTROL PROJECT
RECLAMATION DISTRICT
R.D. 2085

SCALE IN MILES
.5 0 .5 1

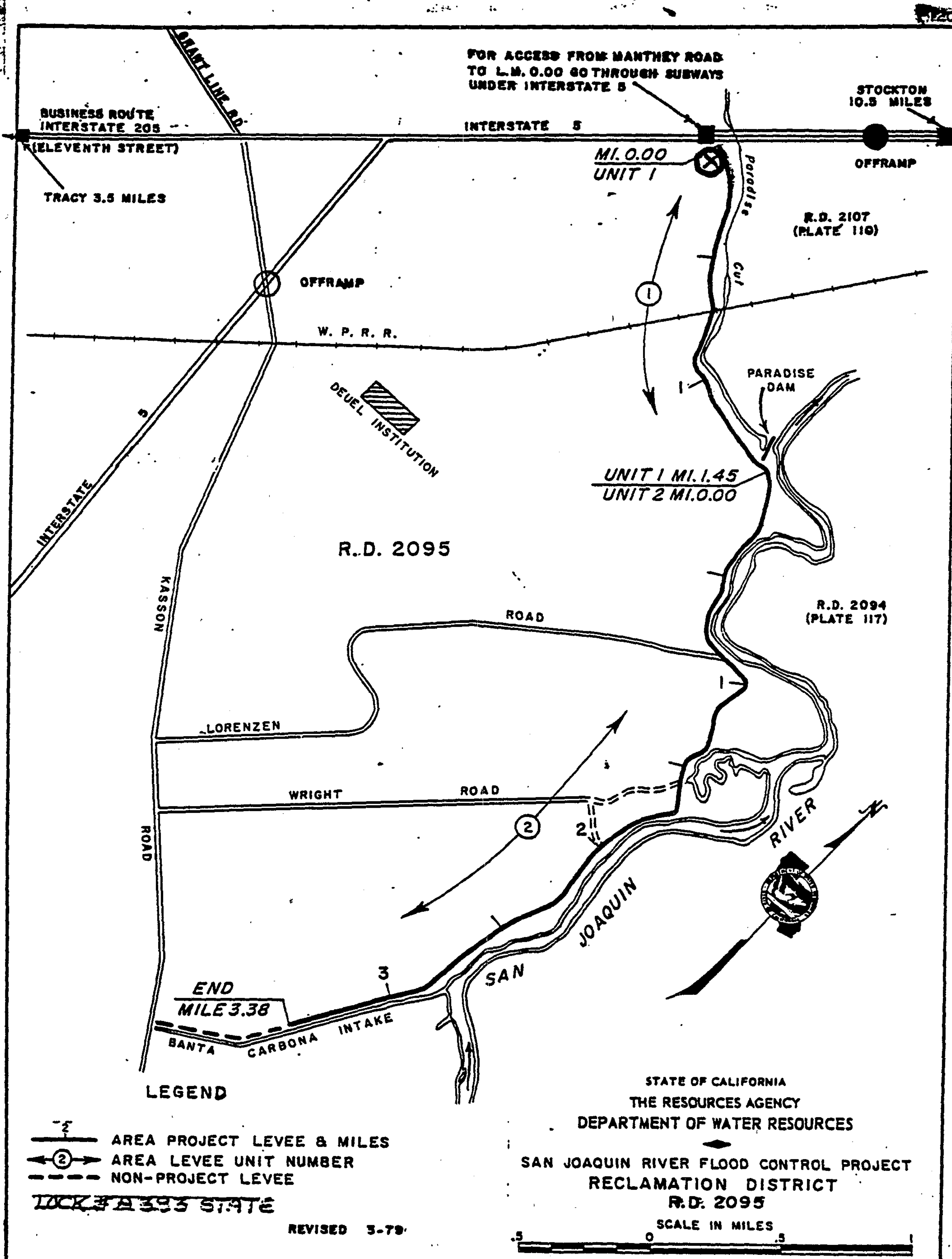
REVISED 3-79

C—007228



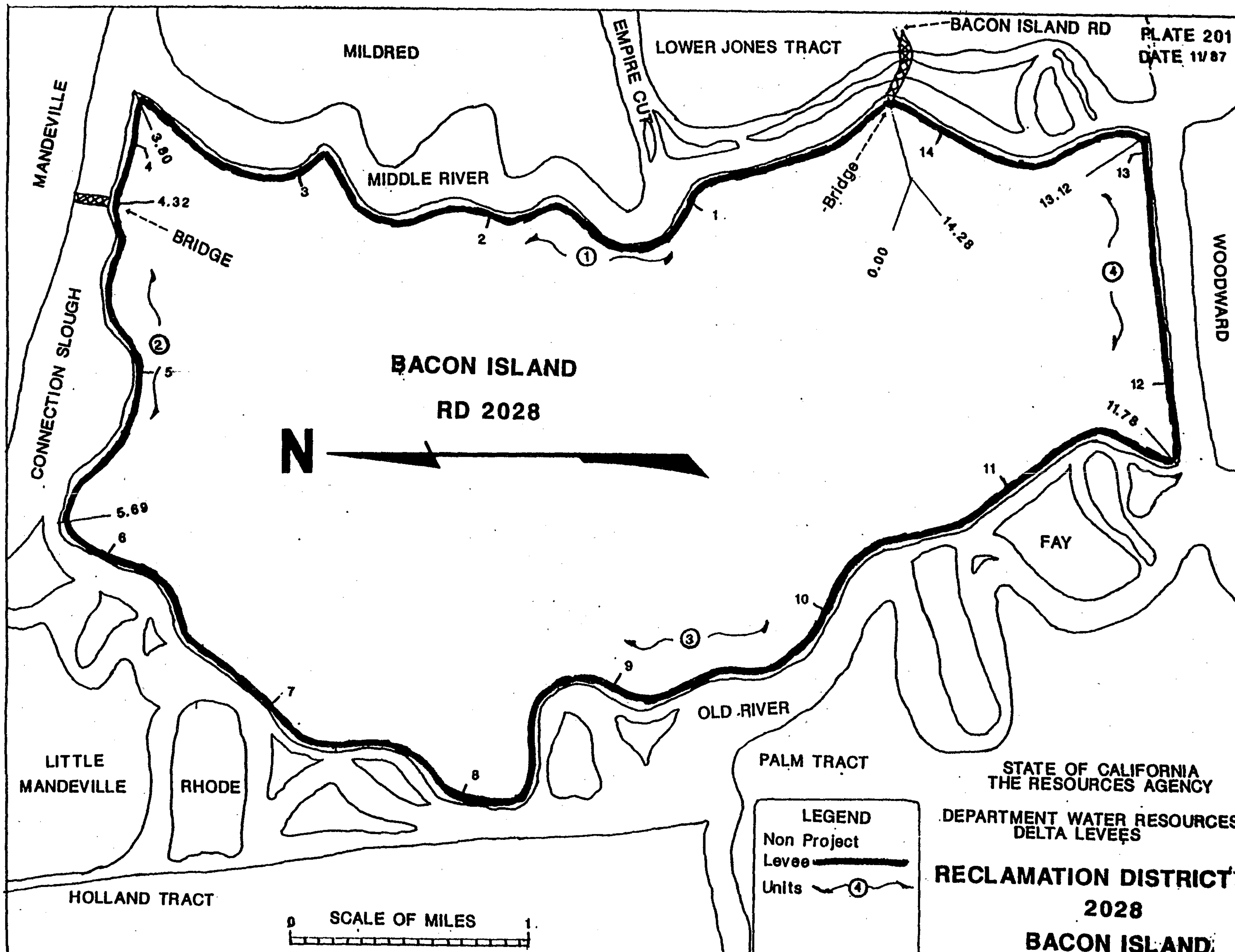
MANTECA
SOUTHERN PACIFIC RR
STATE
HIGHWAY 120
UNION ROAD
AIRPORT WAY
MCKINLEY AVENUE
WESTERN PACIFIC RR
WOODWARD ROAD
L.M. 0.00
WETHERBEE LAKE PUMPING PLANT AND NAVIGATION GATE
L.M. 0.17 R.D. 2096
L.M. 0.00 R.D. 2094
UNIT I
R.D. 2096
LOCK # 2096
0.5
WALTHALL SLOUGH
1.0
L.M 0.00
UNIT 2
1.5
R.D. 2094
LOCK # A478
2.5
2.0
L.M. 0.46
SAN JOAQUIN RIVER
L.M. 2.82 R.D. 2094
HAYS RD.
MCMULLIN ROAD
R.D. 2075
(PLATE 112)
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN RIVER FLOOD CONTROL PROJECT
RECLAMATION DISTRICTS
2094 & 2096
SCALE IN MILES
.5 0 .5 1
LEGEND
0.5 PROJECT LEVEE & MILES
ACCESS ROAD
REVISED 3-79

C-007229



120
FOR ACCESS FROM MANTHEY ROAD TO L.M. 0.00 GO THROUGH SUBWAYS UNDER INTERSTATE 5
BUSINESS ROUTE INTERSTATE 205 (ELEVENTH STREET)
TRACY 3.5 MILES
GRANT LINE RD.
INTERSTATE 5
STOCKTON 10.5 MILES
OFFRAMP
MI. 0.00 UNIT 1
Paradise Cut
R.D. 2107 (PLATE 110)
OFFRAMP
W. P. R. R.
PARADISE DAM
DEUEL INSTITUTION
INTERSTATE 5
UNIT 1 MI. 1.45
UNIT 2 MI. 0.00
R.D. 2095
KASSON ROAD
R.D. 2094 (PLATE 117)
ROAD
LORENZEN
WRIGHT ROAD
SAN JOAQUIN RIVER
END MILE 3.38
BANTA CARBONA INTAKE
LEGEND
AREA PROJECT LEVEE & MILES
AREA LEVEE UNIT NUMBER
NON-PROJECT LEVEE
REVISED 3-79
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN RIVER FLOOD CONTROL PROJECT
RECLAMATION DISTRICT
R.D. 2095
SCALE IN MILES
.5
0
.5
1

C—007230


MILDRED
EMPIRE CUT
LOWER JONES TRACT
BACON ISLAND RD
PLATE 201
DATE 11/87
MANDEVILLE
MIDDLE RIVER
3.60
4
3
4.32
BRIDGE
2
1
Bridge
14
0.00
14.28
13.12
13
WOODWARD
CONNECTION SLOUGH
BACON ISLAND
RD 2028
N
5
12
11.78
11
5.69
6
FAY
10
9
7
8
OLD RIVER
PALM TRACT
LITTLE MANDEVILLE
RHODE
HOLLAND TRACT
SCALE OF MILES
0
1
LEGEND
Non Project Levee
Units
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
RECLAMATION DISTRICT 2028
BACON ISLAND

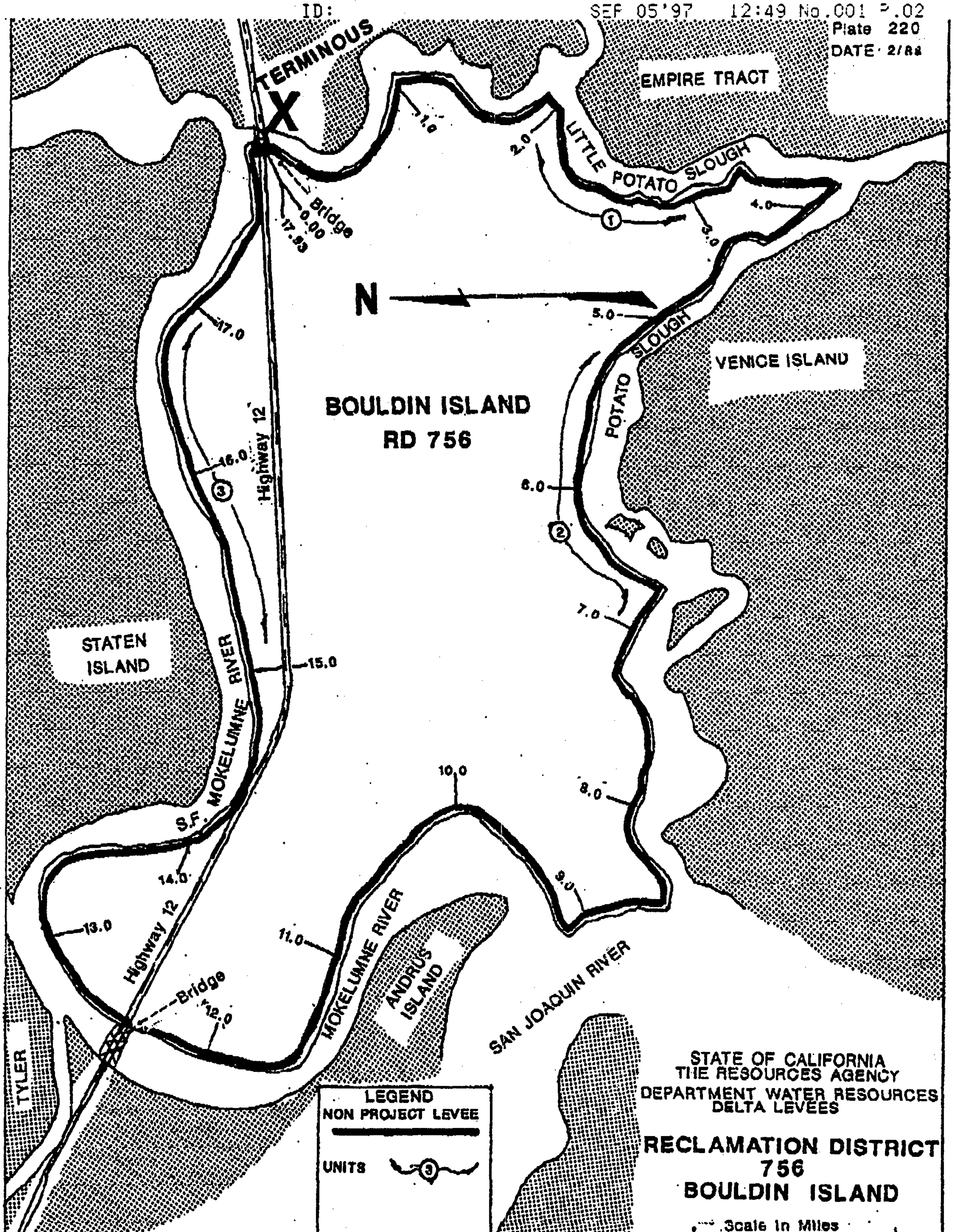


Plate 220
DATE 2/88
TERMINOUS
EMPIRE TRACT
LITTLE POTATO SLOUGH
POTATO SLOUGH
VENICE ISLAND
BOULDIN ISLAND
RD 756
N
Highway 12
Bridge
0.00
17.83
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
STATEN ISLAND
S.F. MOKELUMNE RIVER
MOKELUMNE RIVER
ANDRUS ISLAND
SAN JOAQUIN RIVER
TYLER
LEGEND
NON PROJECT LEVEE
UNITS
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
RECLAMATION DISTRICT
756
BOULDIN ISLAND
Scale in Miles

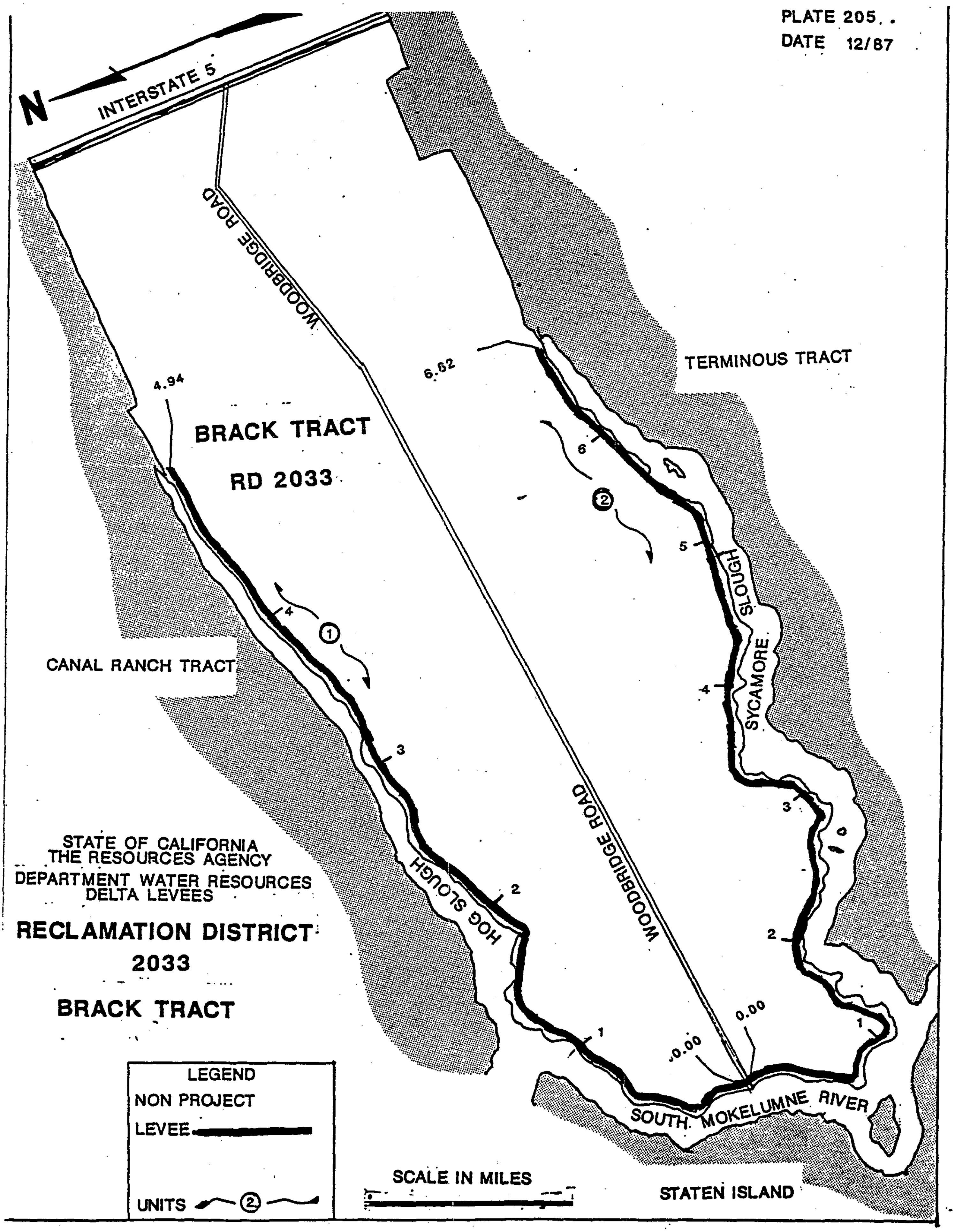
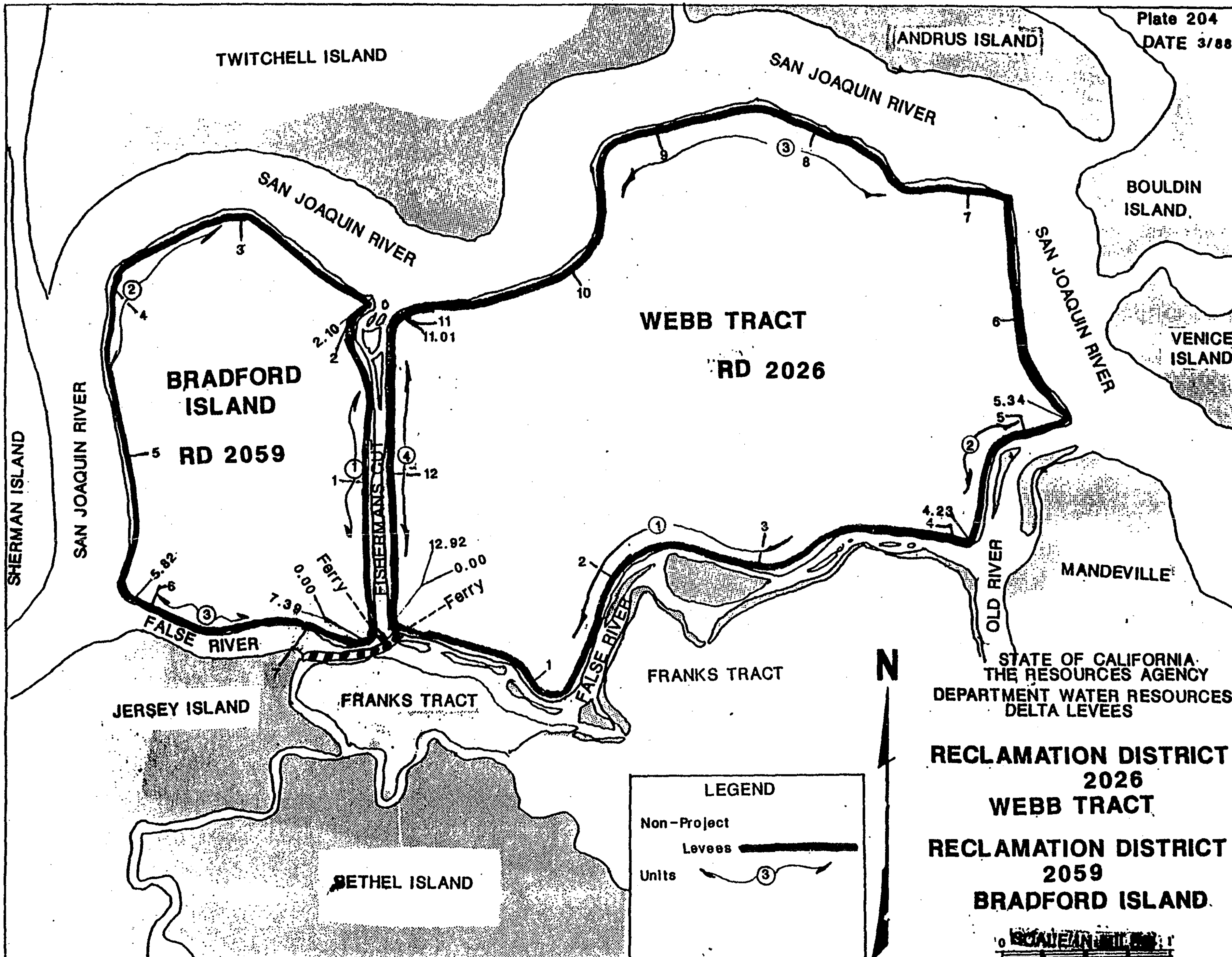


PLATE 205
DATE 12/87
N
INTERSTATE 5
WOODBRIDGE ROAD
TERMINOUS TRACT
6.62
4.94
BRACK TRACT
RD 2033
6
2
5
SLOUGH
SYCAMORE
4
1
CANAL RANCH TRACT
3
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
RECLAMATION DISTRICT
2033
BRACK TRACT
HOG SLOUGH
WOODBRIDGE ROAD
2
1
0.00
0.00
SOUTH MOKELUMNE RIVER
LEGEND
NON PROJECT
LEVEE
UNITS
SCALE IN MILES
STATEN ISLAND

C—007233



C-007234

C—007234

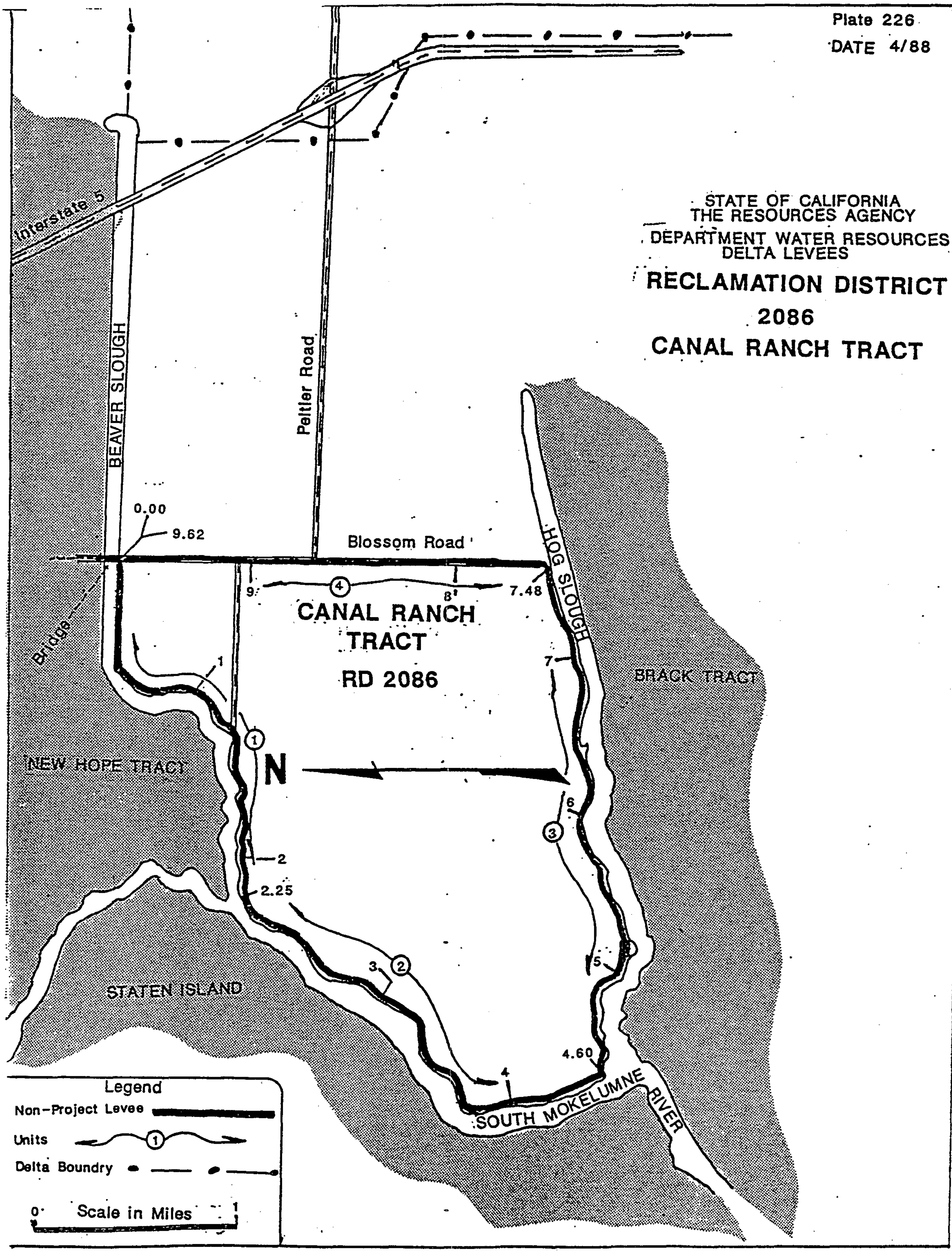


Plate 226
DATE 4/88
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
RECLAMATION DISTRICT
2086
CANAL RANCH TRACT
Interstate 5
BEAVER SLOUGH
Peltier Road
Blossom Road
HOG SLOUGH
0.00
9.62
7.48
9
8
4
CANAL RANCH
TRACT
RD 2086
Bridge
1
7
BRACK TRACT
NEW HOPE TRACT
N
6
3
2
2.25
2
3
5
STATEN ISLAND
4.60
4
SOUTH MOKELUMNE RIVER
Legend
Non-Project Levee
Units
Delta Boundry
0
Scale in Miles
1

C—007235

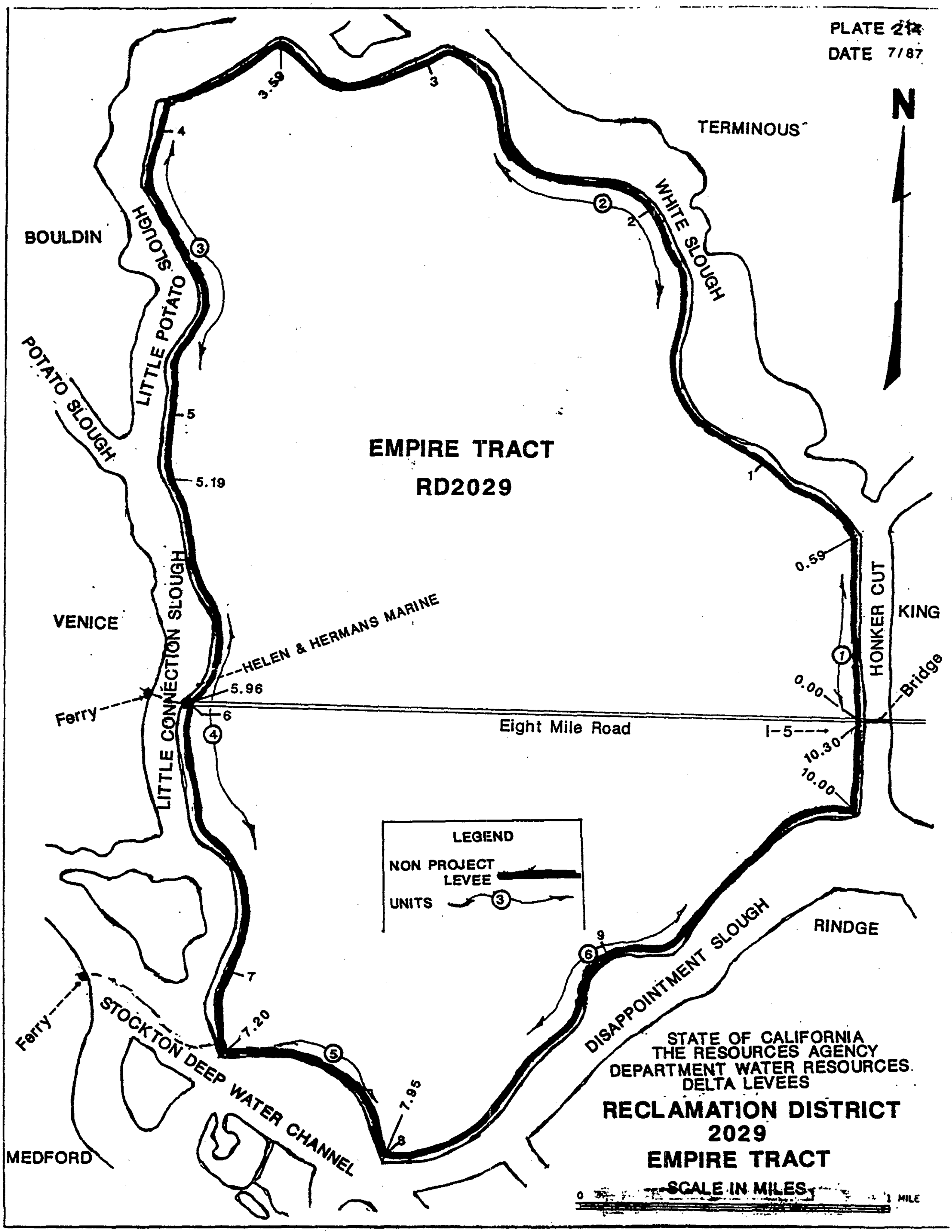
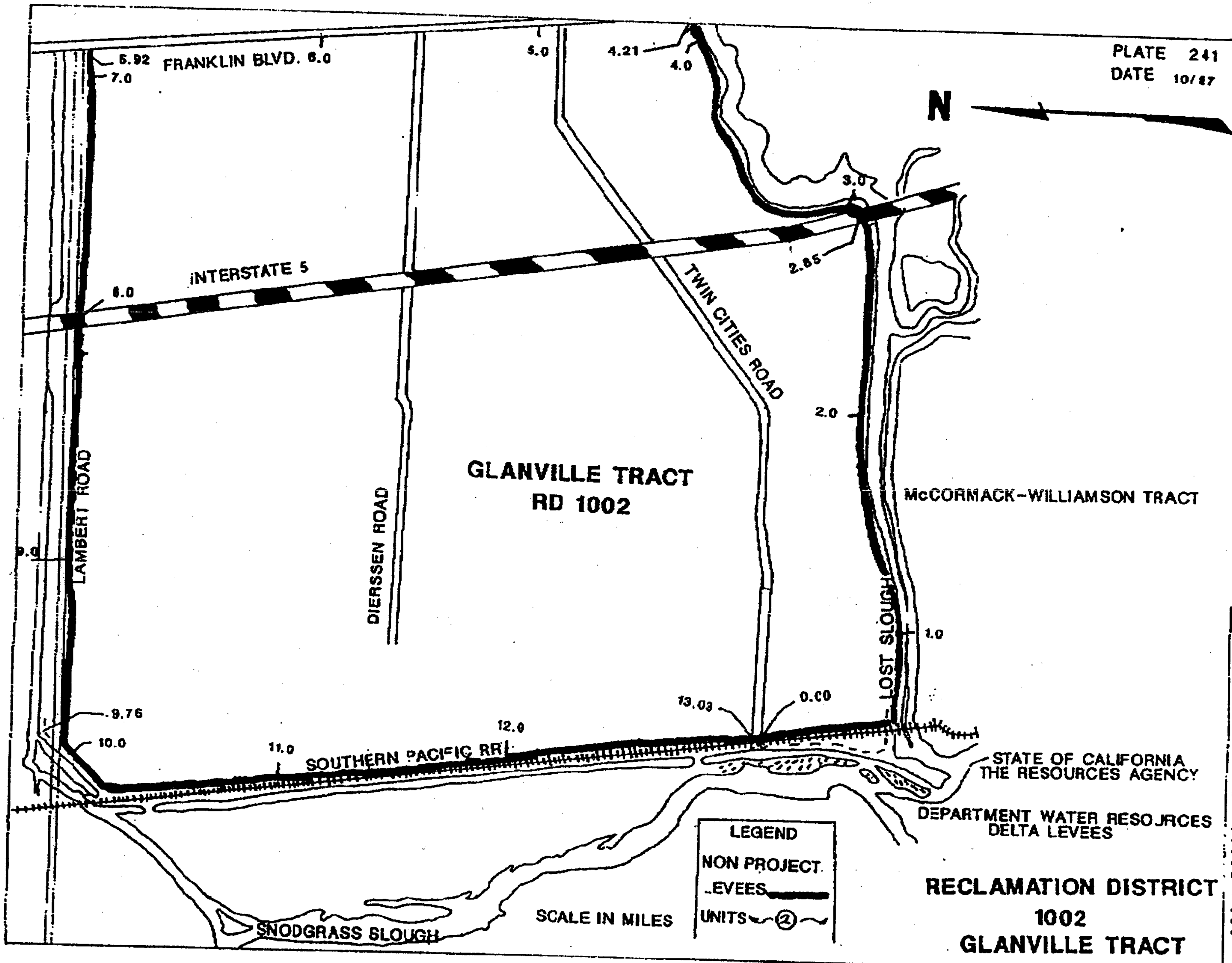


PLATE 21
DATE 7/87
N
TERMINOUS
BOULDIN
LITTLE POTATO SLOUGH
POTATO SLOUGH
WHITE SLOUGH
EMPIRE TRACT
RD2029
VENICE
LITTLE CONNECTION SLOUGH
HELEN & HERMANS MARINE
HONKER CUT
KING
Bridge
Ferry
Eight Mile Road
I-5
LEGEND
NON PROJECT LEVEE
UNITS
RINDGE
DISAPPOINTMENT SLOUGH
STOCKTON DEEP WATER CHANNEL
MEDFORD
3.59
3
4
5
5.19
5.96
6
7
7.20
7.95
8
9
10.00
10.30
0.00
0.59
1
2
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
RECLAMATION DISTRICT
2029
EMPIRE TRACT
SCALE IN MILES
0
1 MILE

C—007236



SEP 05 '97 12:51 No.001 P.03

ID:

C—007237

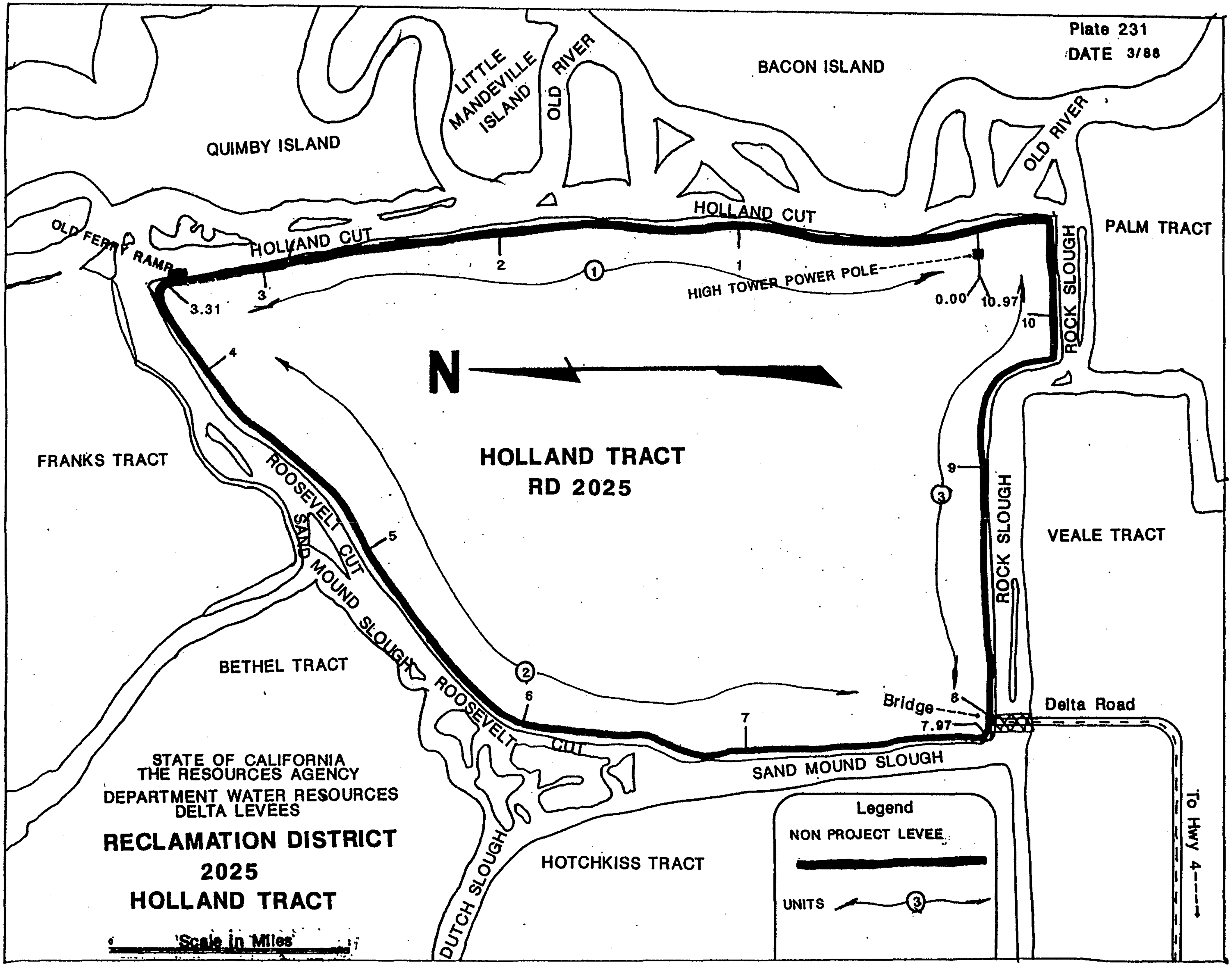
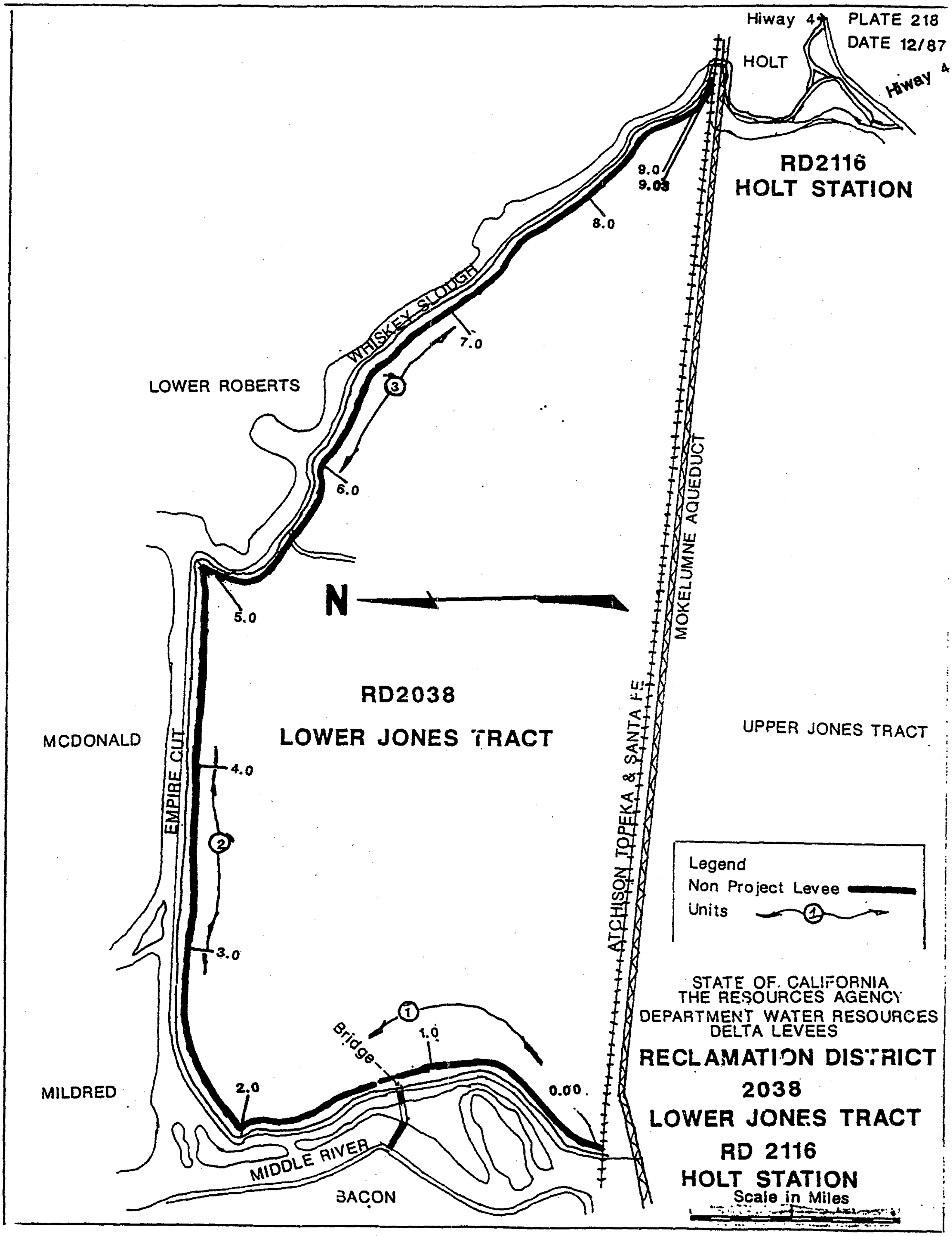
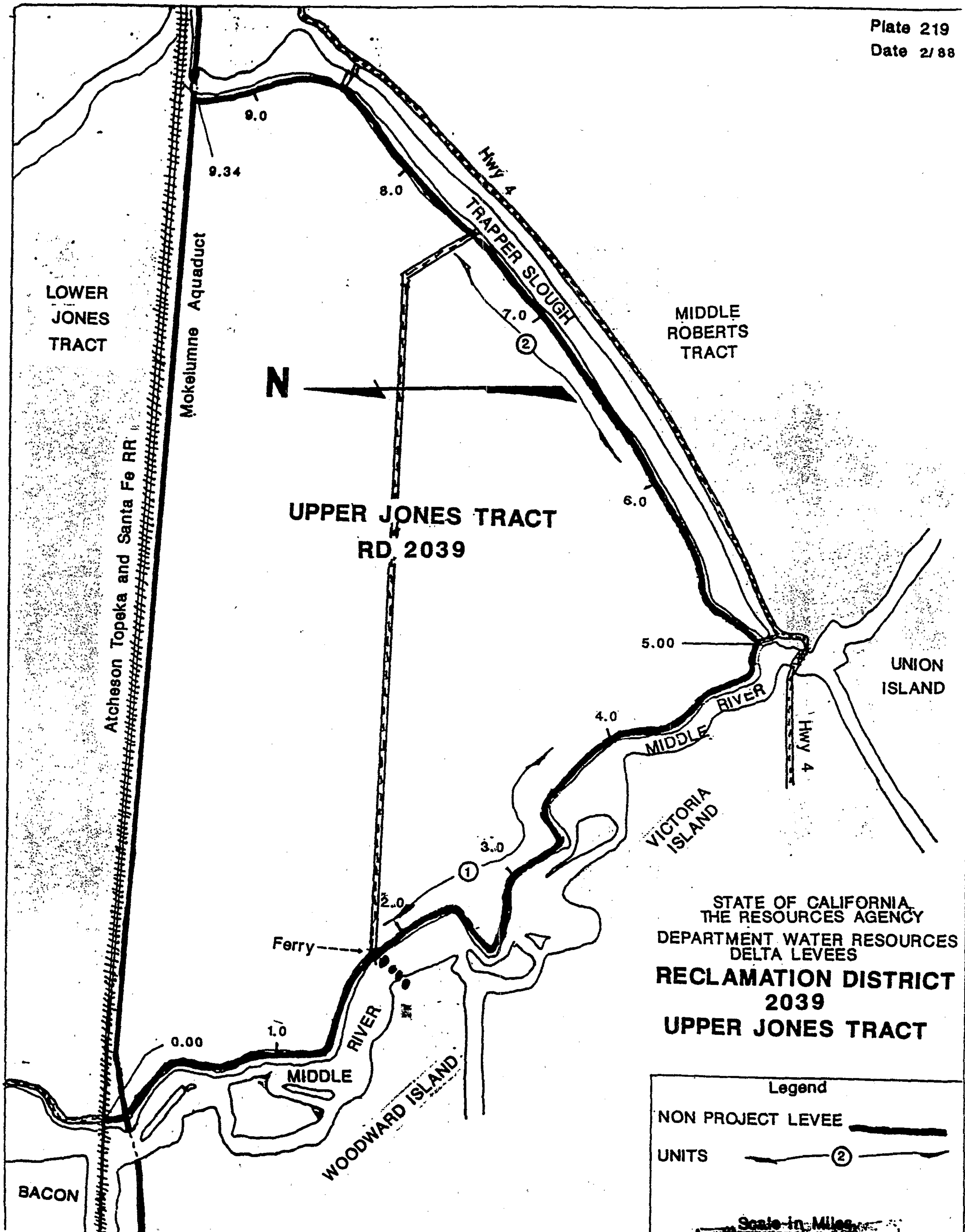


Plate 231
DATE 3/88
BACON ISLAND
LITTLE MANDEVILLE ISLAND
OLD RIVER
QUIMBY ISLAND
OLD RIVER
HOLLAND CUT
PALM TRACT
OLD FERRY RAMP
HOLLAND CUT
2
1
1
HIGH TOWER POWER POLE
3
3.31
0.00
10.97
10
ROCK SLOUGH
4
N
FRANKS TRACT
HOLLAND TRACT
RD 2025
ROOSEVELT CUT
SAND MOUND SLOUGH
5
9
3
ROCK SLOUGH
VEALE TRACT
BETHEL TRACT
2
6
ROOSEVELT CUT
7
Bridge
8
7.97
Delta Road
SAND MOUND SLOUGH
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
RECLAMATION DISTRICT
2025
HOLLAND TRACT
Scale in Miles
DUTCH SLOUGH
HOTCHKISS TRACT
Legend
NON PROJECT LEVEE
UNITS
3
To Hwy 4


Hiway 4
PLATE 218
DATE 12/87
HOLT
Hiway 4
RD2116
HOLT STATION
9.0
9.03
8.0
WHISKEY SLOUGH
7.0
LOWER ROBERTS
3
6.0
MOKELUMNE AQUEDUCT
N
5.0
RD2038
LOWER JONES TRACT
UPPER JONES TRACT
MCDONALD
EMPIRE CUT
4.0
2
ATCHISON TOPEKA & SANTA FE
Legend
Non Project Levee
Units
3.0
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
1
Bridge
1.0
RECLAMATION DISTRICT
2038
LOWER JONES TRACT
RD 2116
HOLT STATION
MILDRED
2.0
0.00
MIDDLE RIVER
BACON
Scale in Miles



STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES

RECLAMATION DISTRICT 2039
UPPER JONES TRACT

Legend	
NON PROJECT LEVEE	
UNITS	②

Scale in Miles

C−007240

C-007240

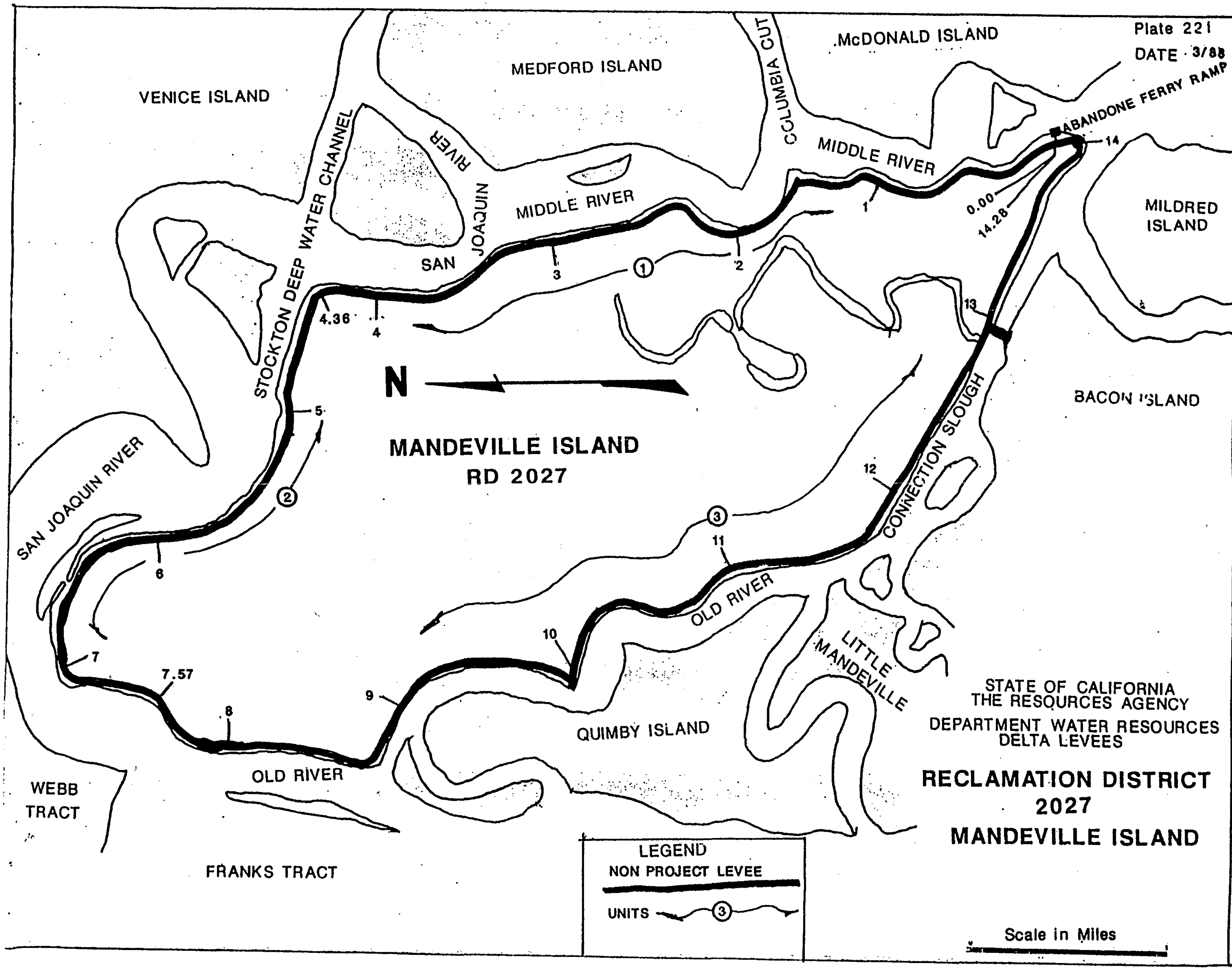


Plate 221
DATE 3/88
ABANDONE FERRY RAMP
McDONALD ISLAND
MEDFORD ISLAND
VENICE ISLAND
COLUMBIA CUT
MIDDLE RIVER
MIDDLE RIVER
SAN JOAQUIN RIVER
STOCKTON DEEP WATER CHANNEL
MILDRED ISLAND
BACON ISLAND
N
MANDEVILLE ISLAND
RD 2027
SAN JOAQUIN RIVER
CONNECTION SLOUGH
OLD RIVER
LITTLE MANDEVILLE
QUIMBY ISLAND
OLD RIVER
WEBB TRACT
FRANKS TRACT
0.00
14.28
4.36
7.57
1
2
3
4
5
6
7
8
9
10
11
12
13
14
LEGEND
NON PROJECT LEVEE
UNITS
Scale in Miles
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
RECLAMATION DISTRICT
2027
MANDEVILLE ISLAND

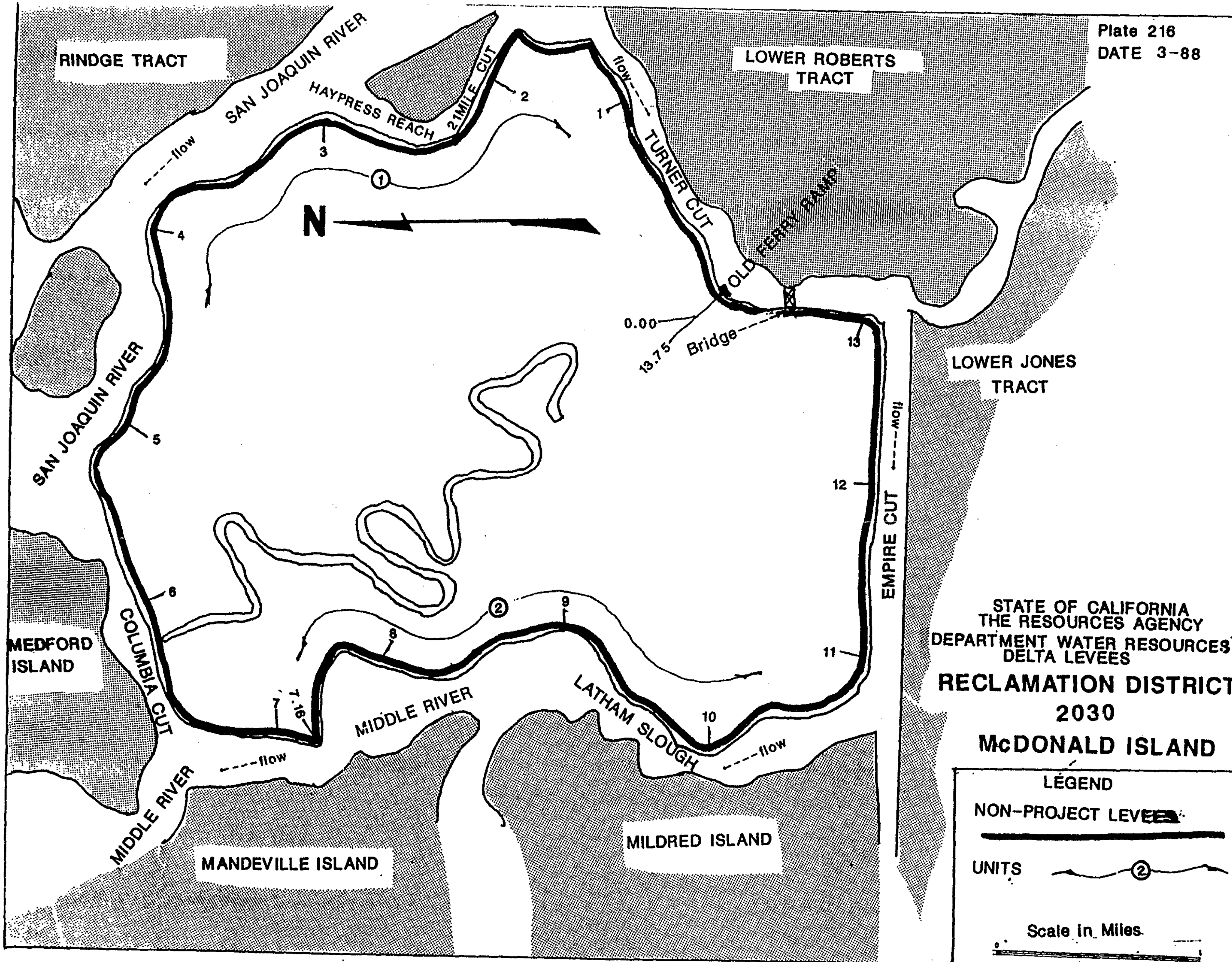
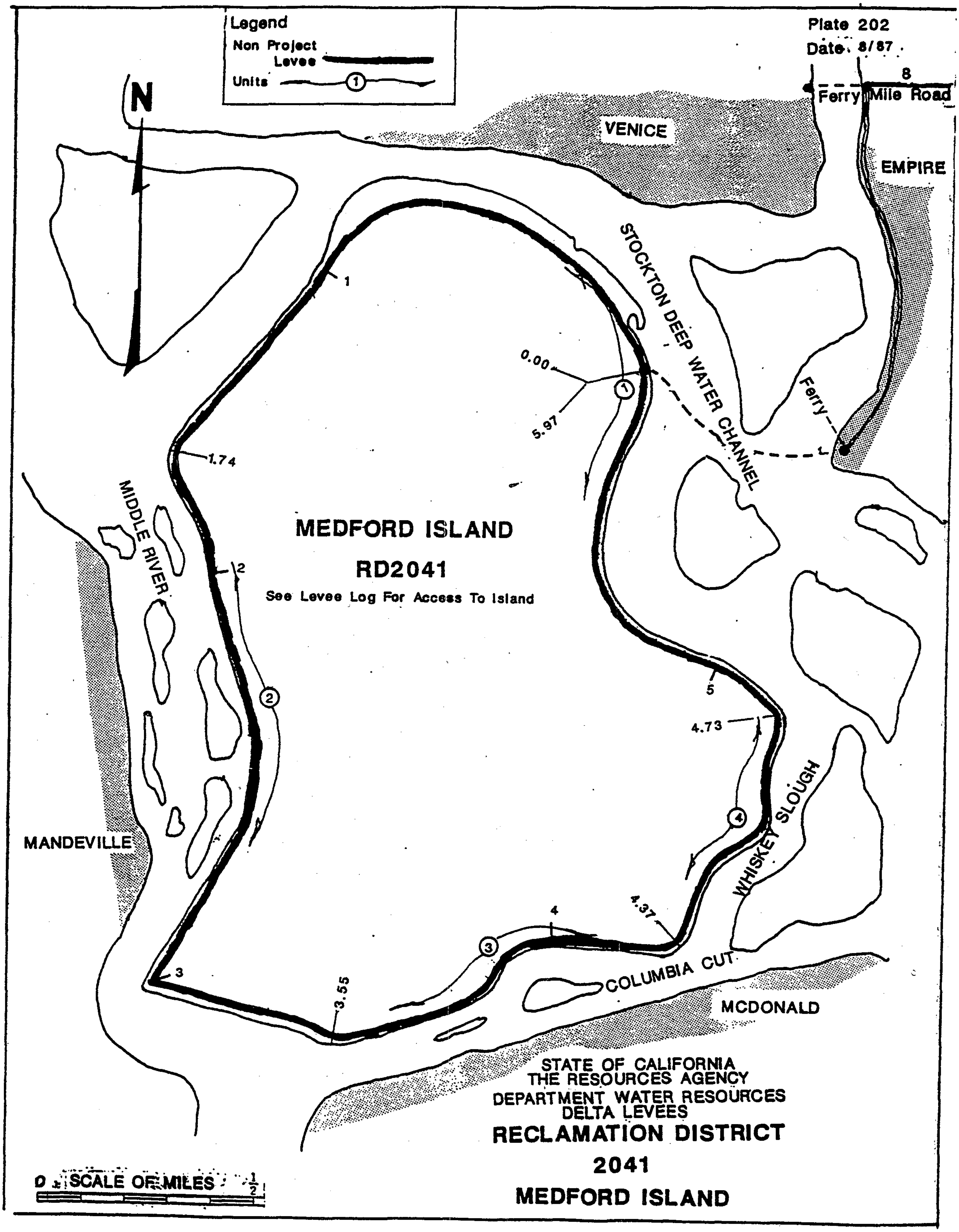


Plate 216
DATE 3-88
RINDGE TRACT
SAN JOAQUIN RIVER
HAYPRESS REACH
21MILE CUT
LOWER ROBERTS TRACT
flow
TURNER CUT
OLD FERRY RAMP
N
0.00
13.75
Bridge
LOWER JONES TRACT
EMPIRE CUT
SAN JOAQUIN RIVER
MEDFORD ISLAND
COLUMBIA CUT
MIDDLE RIVER
LATHAM SLOUGH
MIDDLE RIVER
MANDEVILLE ISLAND
MILDRED ISLAND
1
2
3
4
5
6
7
7.16
8
9
10
11
12
13
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
RECLAMATION DISTRICT
2030
McDONALD ISLAND
LEGEND
NON-PROJECT LEVEES
UNITS
Scale in Miles



C—007243

C-007243

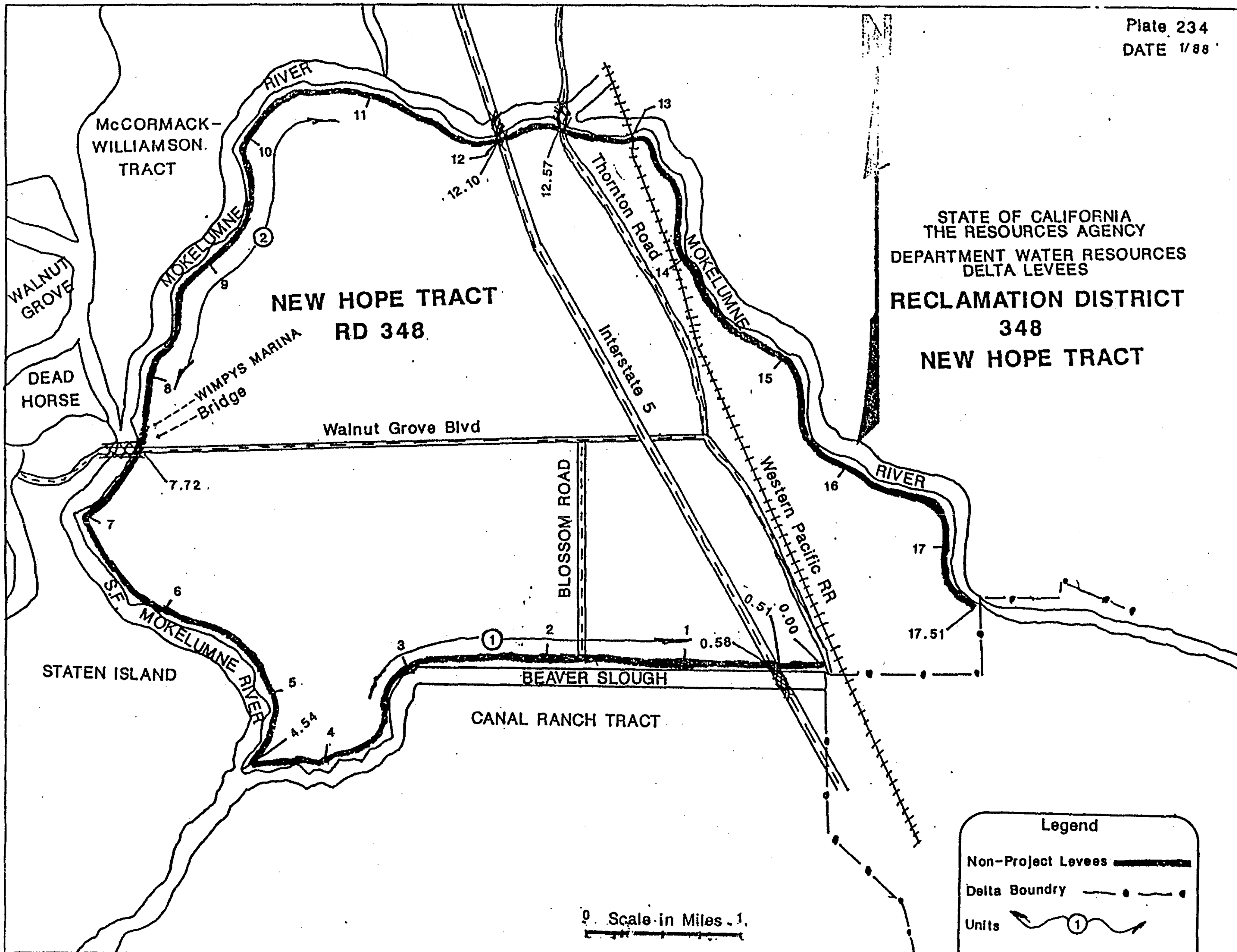


Plate 234
DATE 1/88
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
RECLAMATION DISTRICT
348
NEW HOPE TRACT
NEW HOPE TRACT
RD 348
McCORMACK-
WILLIAMSON
TRACT
WALNUT
GROVE
DEAD
HORSE
STATEN ISLAND
CANAL RANCH TRACT
MOKELUMNE RIVER
S.F. MOKELUMNE RIVER
WIMPYS MARINA
Bridge
Walnut Grove Blvd
BLOSSOM ROAD
Interstate 5
Thornton Road
Western Pacific RR
BEAVER SLOUGH
12.10
12.57
7.72
4.54
0.51
0.00
0.58
17.51
Legend
Non-Project Levees
Delta Boundry
Units
0 Scale in Miles 1

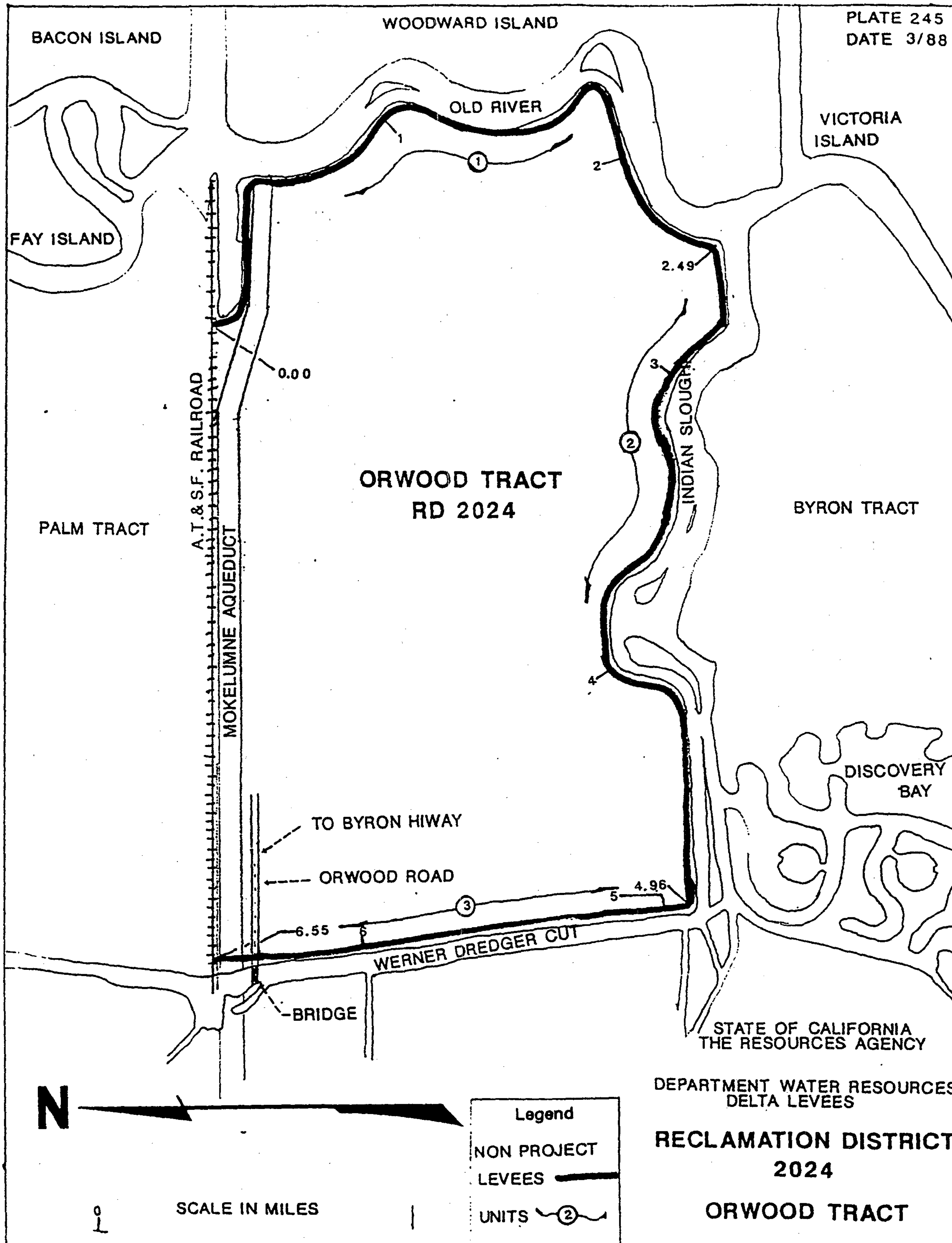


PLATE 245
DATE 3/88
BACON ISLAND
WOODWARD ISLAND
OLD RIVER
VICTORIA ISLAND
FAY ISLAND
0.00
1
2
2.49
3
4
4.96
5
6
6.55
INDIAN SLOUGH
ORWOOD TRACT
RD 2024
BYRON TRACT
PALM TRACT
A.T.&S.F. RAILROAD
MOKELUMNE AQUEDUCT
DISCOVERY BAY
TO BYRON HIWAY
ORWOOD ROAD
WERNER DREDGER CUT
BRIDGE
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
N
Legend
NON PROJECT LEVEES
UNITS
SCALE IN MILES
0
1
RECLAMATION DISTRICT
2024
ORWOOD TRACT

C-007245

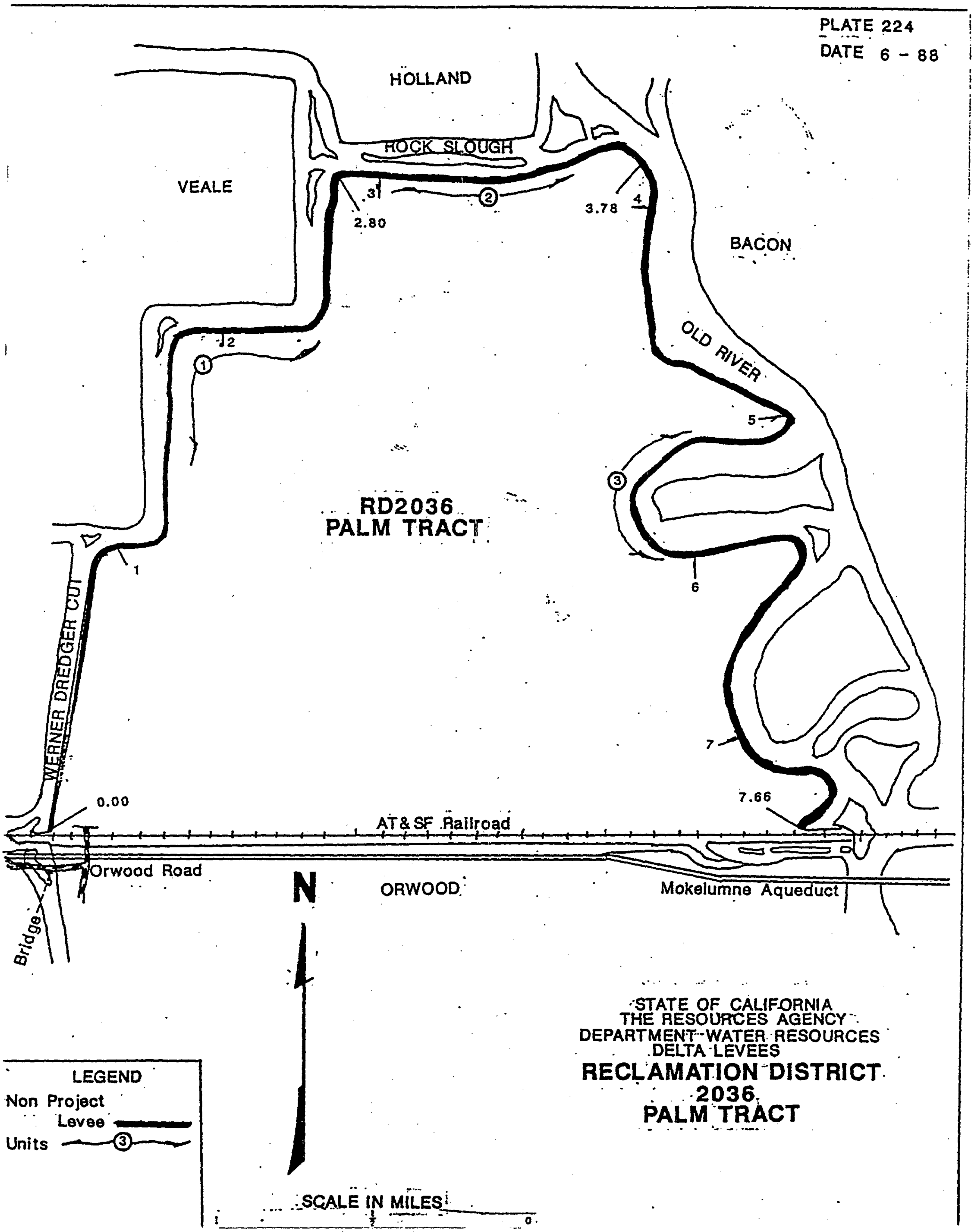
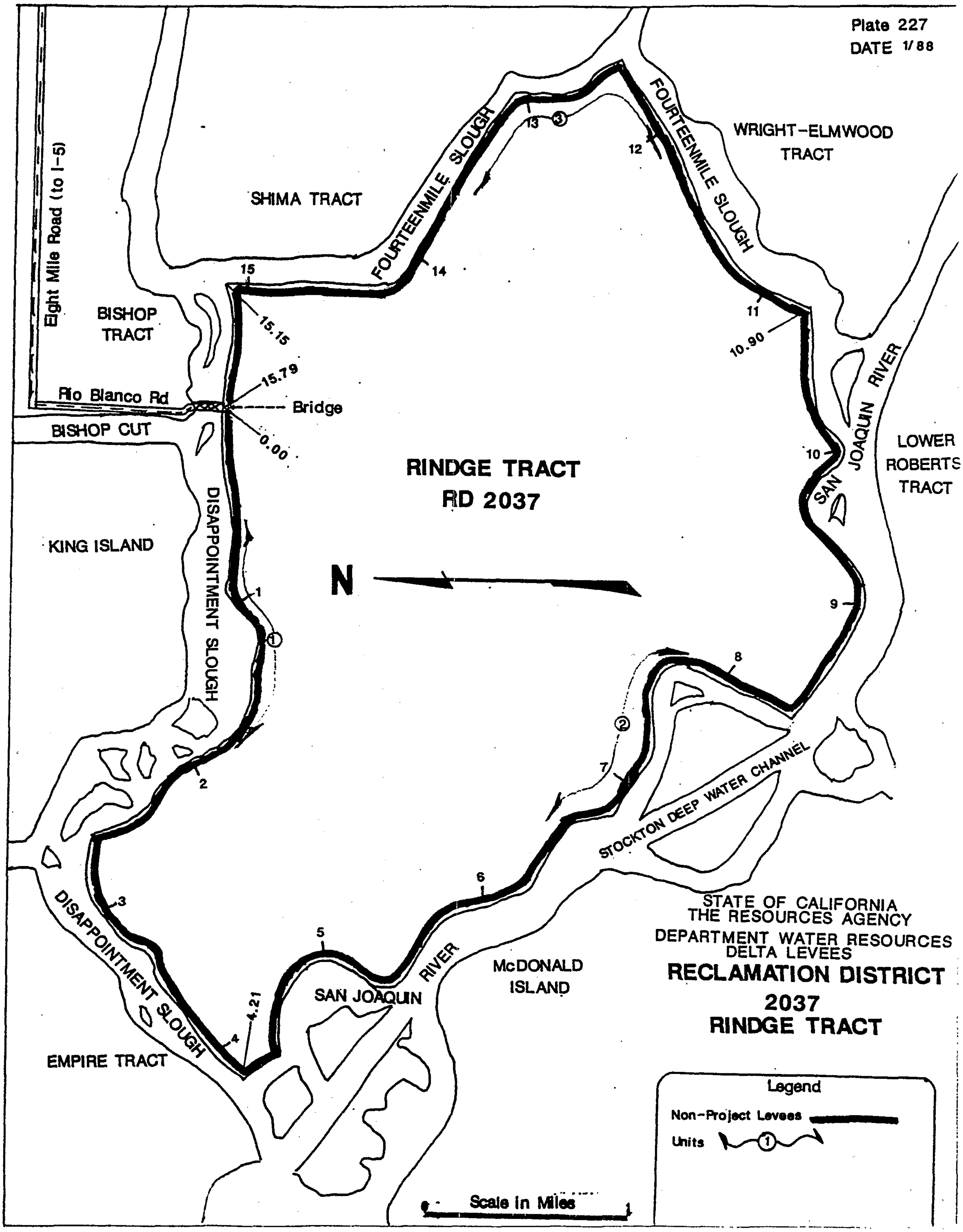


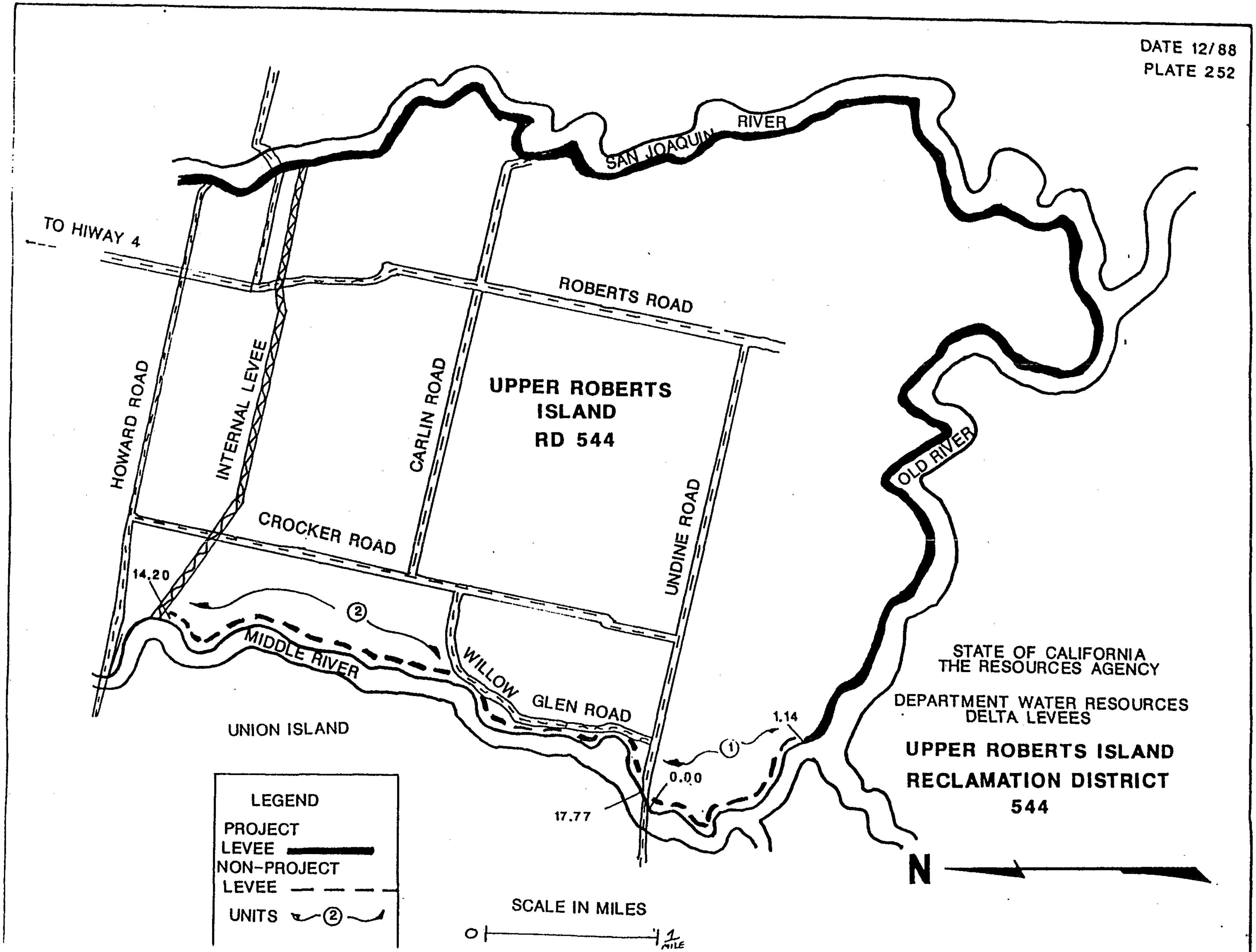
PLATE 224
DATE 6 - 88
HOLLAND
ROCK SLOUGH
VEALE
BACON
OLD RIVER
2.80
3.78
7.66
0.00
1
2
3
4
5
6
7
RD2036
PALM TRACT
WERNER DREDGER CUT
AT & SF Railroad
Orwood Road
ORWOOD
Mokelumne Aqueduct
Bridge
N
LEGEND
Non Project Levee
Units
SCALE IN MILES
1
½
0
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
RECLAMATION DISTRICT 2036
PALM TRACT

C—007246



C—007247

C-007247


DATE 12/88
PLATE 252
SAN JOAQUIN RIVER
TO HIWAY 4
ROBERTS ROAD
HOWARD ROAD
INTERNAL LEVEE
CARLIN ROAD
UPPER ROBERTS ISLAND RD 544
OLD RIVER
UNDINE ROAD
CROCKER ROAD
14.20
2
MIDDLE RIVER
WILLOW GLEN ROAD
1.14
1
0.00
17.77
UNION ISLAND
LEGEND
PROJECT LEVEE
NON-PROJECT LEVEE
UNITS
SCALE IN MILES
0
1 MILE
N
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
UPPER ROBERTS ISLAND
RECLAMATION DISTRICT
544

C—007248

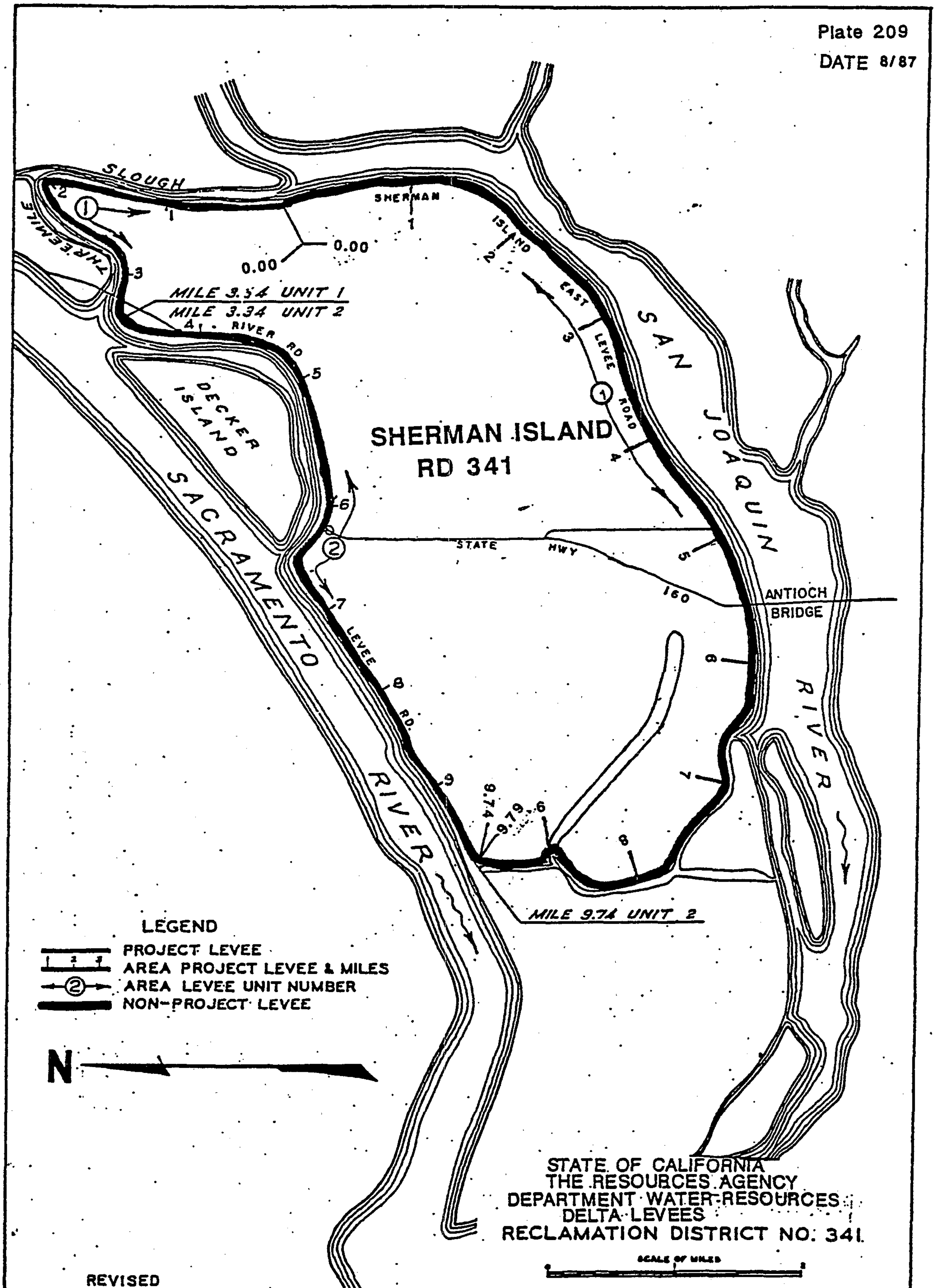
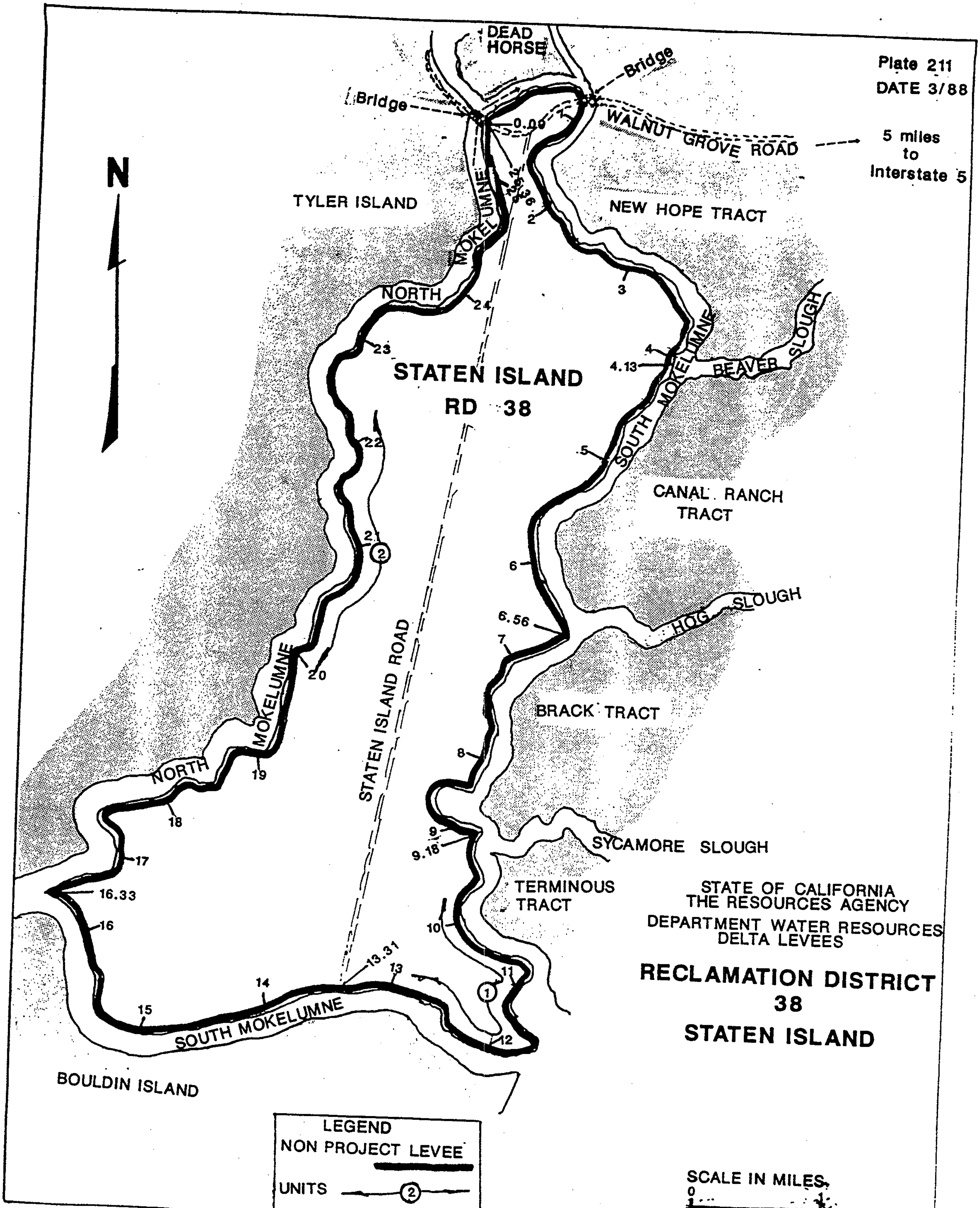


Plate 209
DATE 8/87
SLOUGH
THREEMILE
SHERMAN
ISLAND
EAST
LEVEE
ROAD
0.00
0.00
MILE 3.54 UNIT 1
MILE 3.34 UNIT 2
RIVER RD
SAN JOAQUIN
DECKER ISLAND
SHERMAN ISLAND
RD 341
SACRAMENTO
RIVER
STATE HWY
160
ANTIOCH
BRIDGE
LEVEE RD.
RIVER
9.74
9.79
MILE 9.74 UNIT 2
LEGEND
PROJECT LEVEE
AREA PROJECT LEVEE & MILES
AREA LEVEE UNIT NUMBER
NON-PROJECT LEVEE
N
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
RECLAMATION DISTRICT NO. 341
REVISED

C—007249



C—007250

C-007250

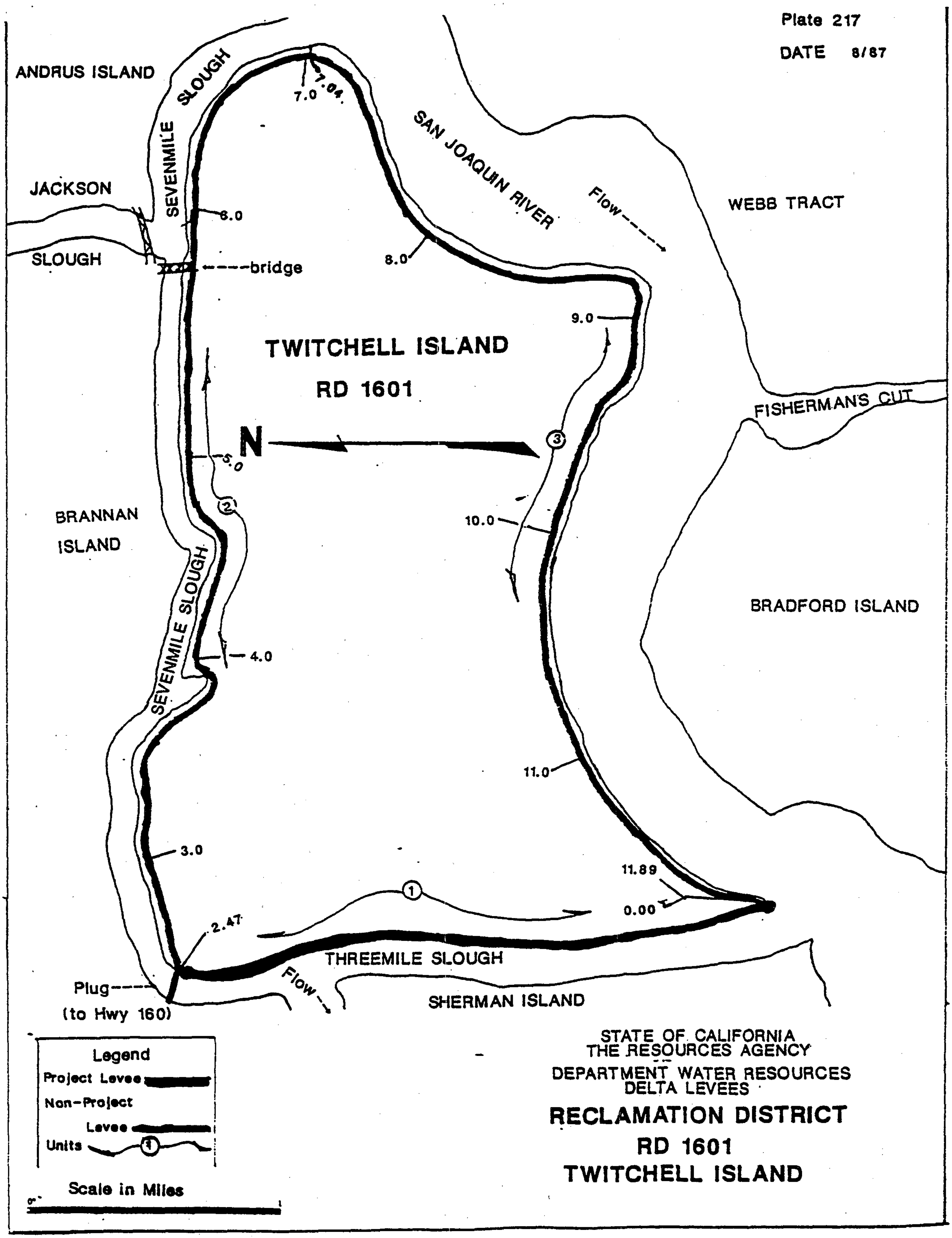
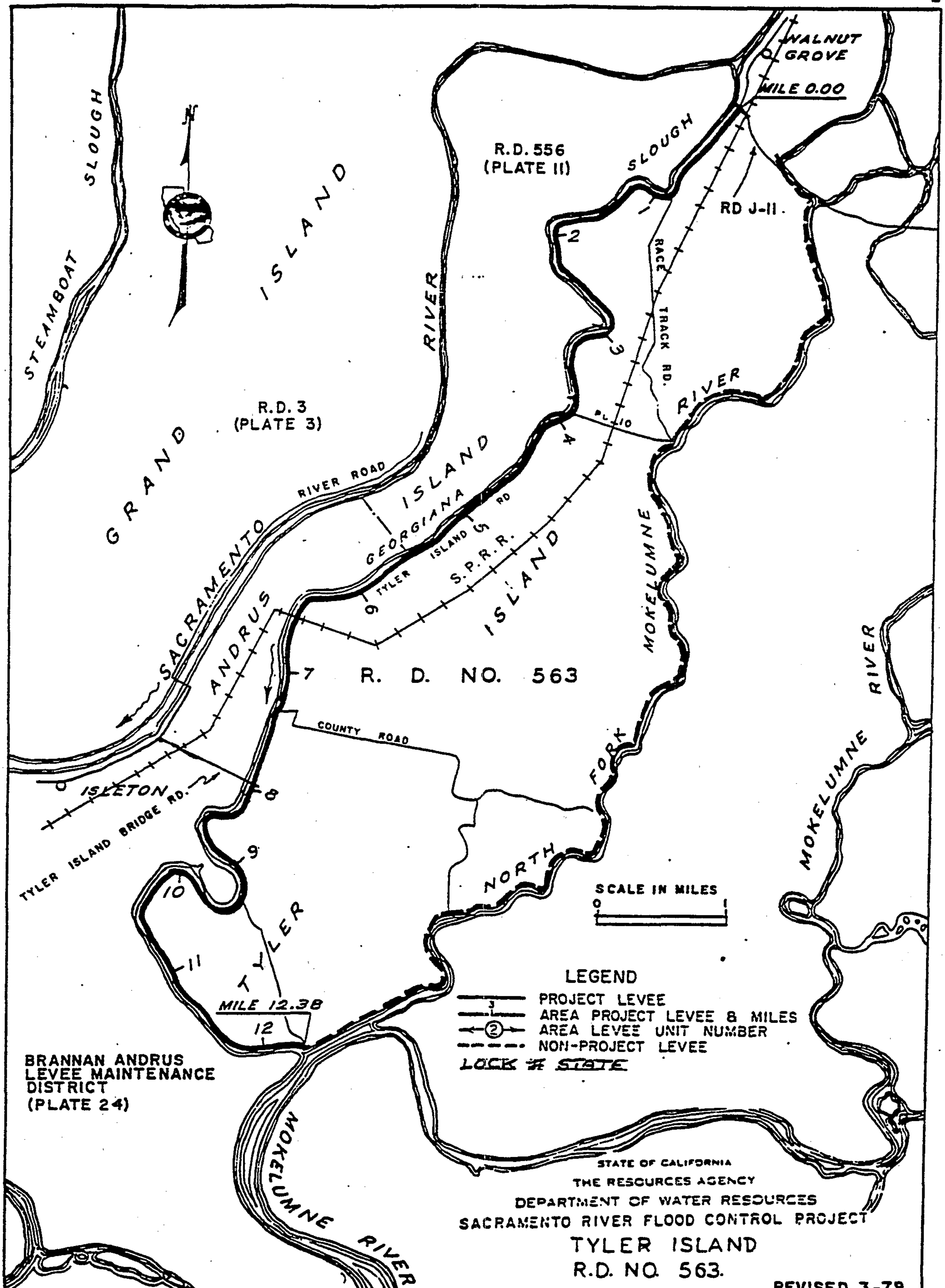


Plate 217
DATE 8/87
ANDRUS ISLAND
SEVENMILE SLOUGH
7.0
7.04
SAN JOAQUIN RIVER
JACKSON
SLOUGH
6.0
bridge
Flow
WEBB TRACT
8.0
9.0
TWITCHELL ISLAND
RD 1601
FISHERMAN'S CUT
N
3
5.0
2
BRANNAN
ISLAND
10.0
SEVENMILE SLOUGH
BRADFORD ISLAND
4.0
11.0
3.0
11.89
1
0.00
2.47
THREEMILE SLOUGH
Flow
Plug
(to Hwy 160)
SHERMAN ISLAND
Legend
Project Levee
Non-Project
Levee
Units
Scale in Miles
0
1
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
RECLAMATION DISTRICT
RD 1601
TWITCHELL ISLAND

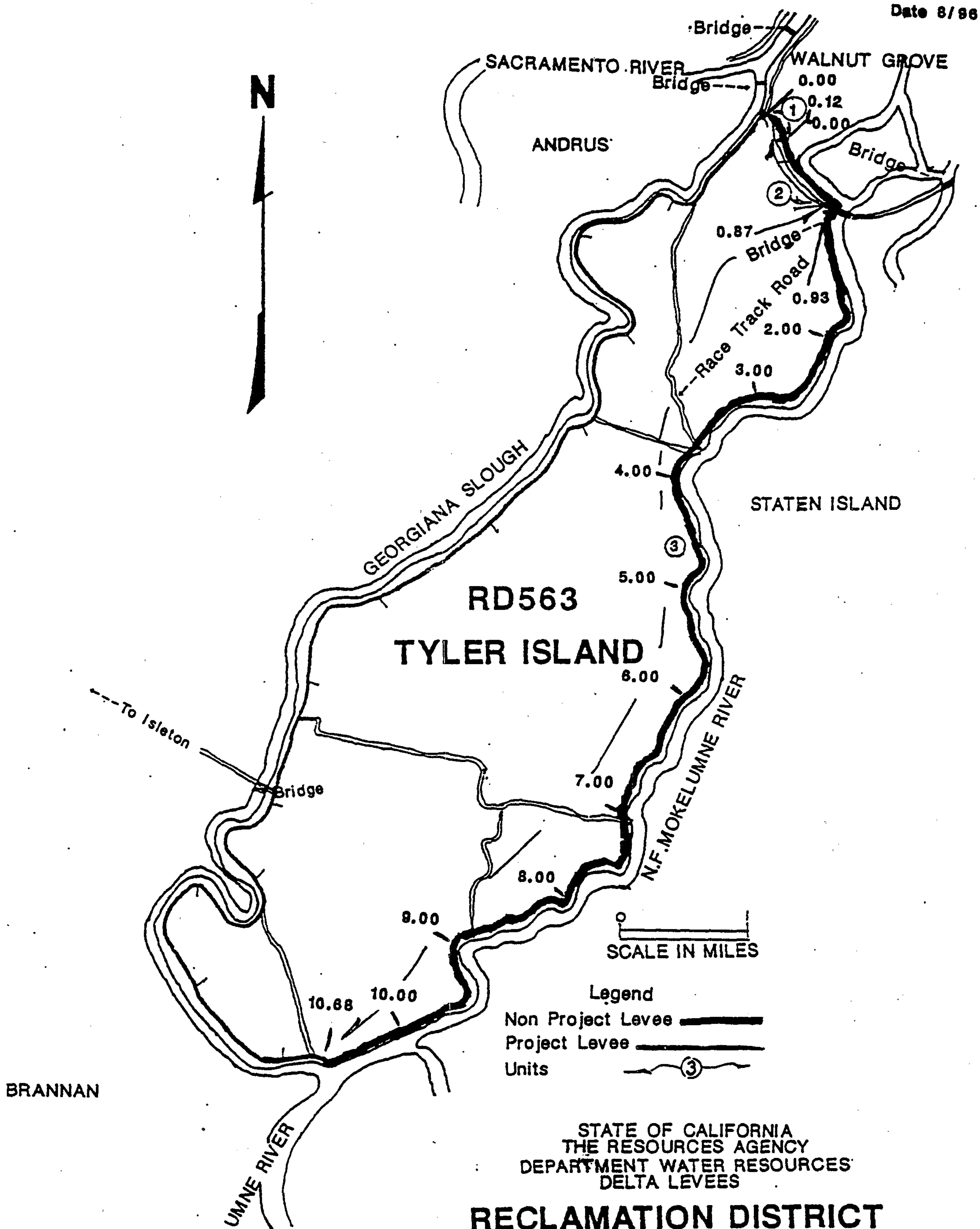
C—007251



STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SACRAMENTO RIVER FLOOD CONTROL PROJECT
TYLER ISLAND
R.D. NO. 563.

REVISED 3-79

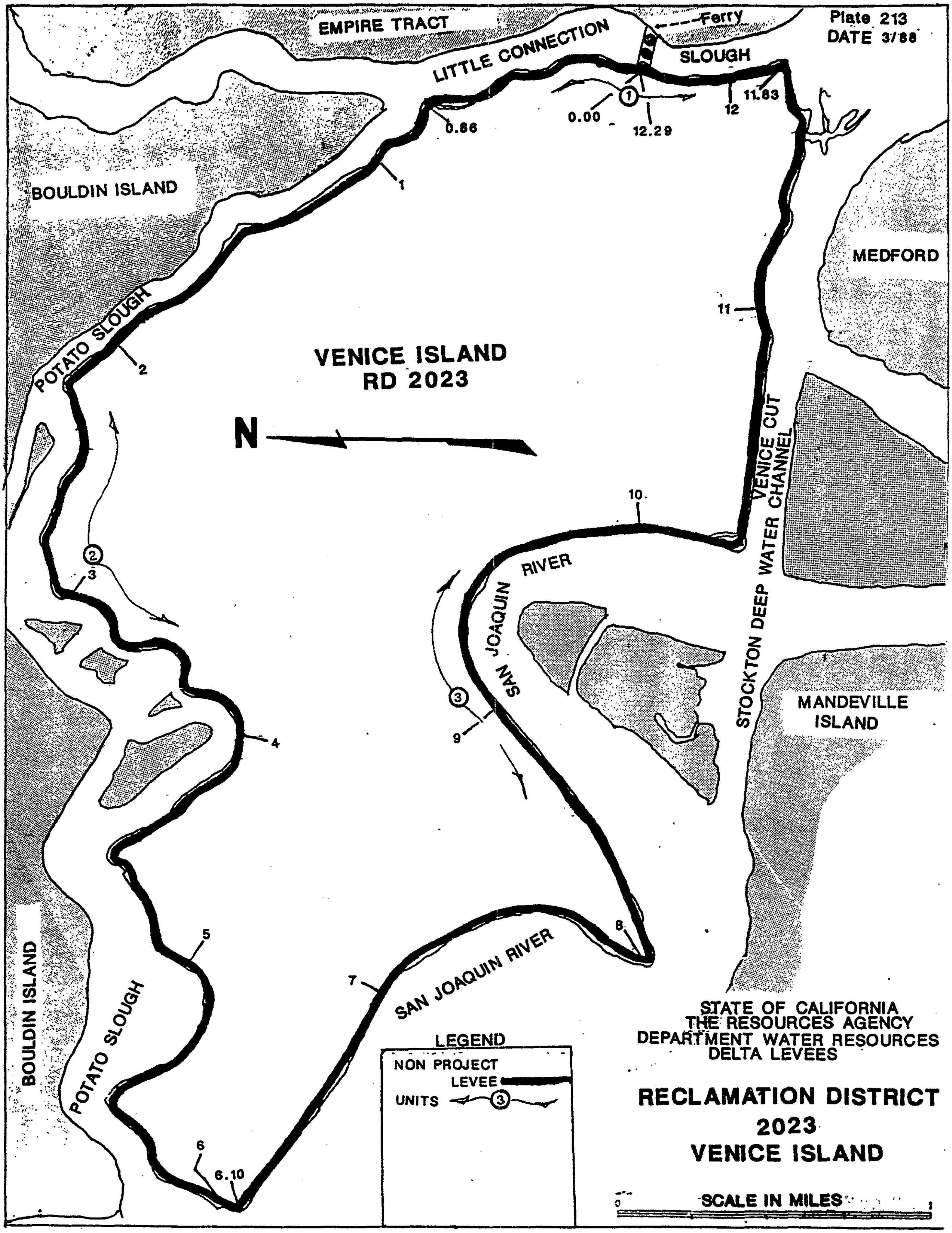
Plate 210
Date 8/96



STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES

RECLAMATION DISTRICT 563 TYLER ISLAND

C-007253



STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES

RECLAMATION DISTRICT
2023
VENICE ISLAND

C—007254

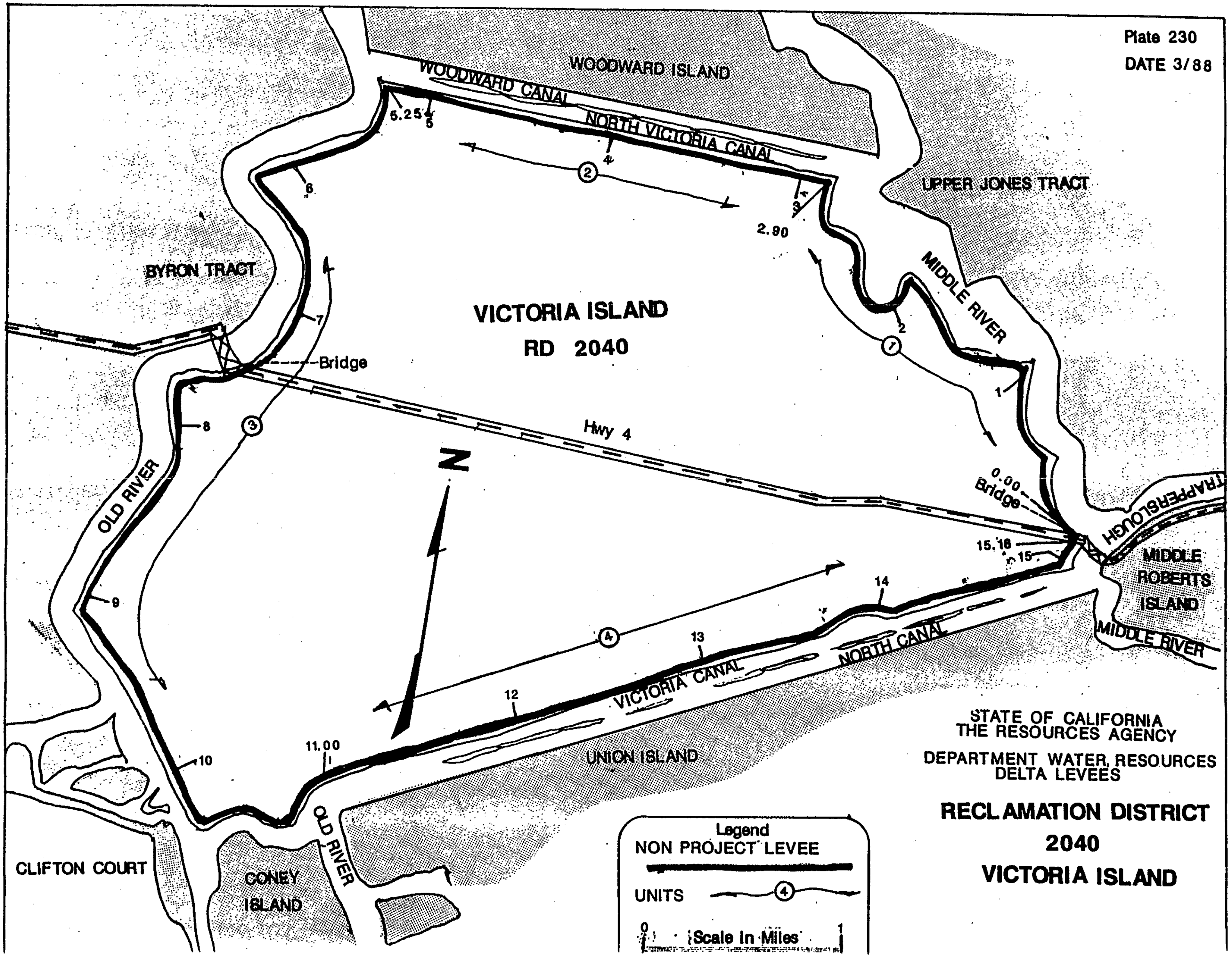
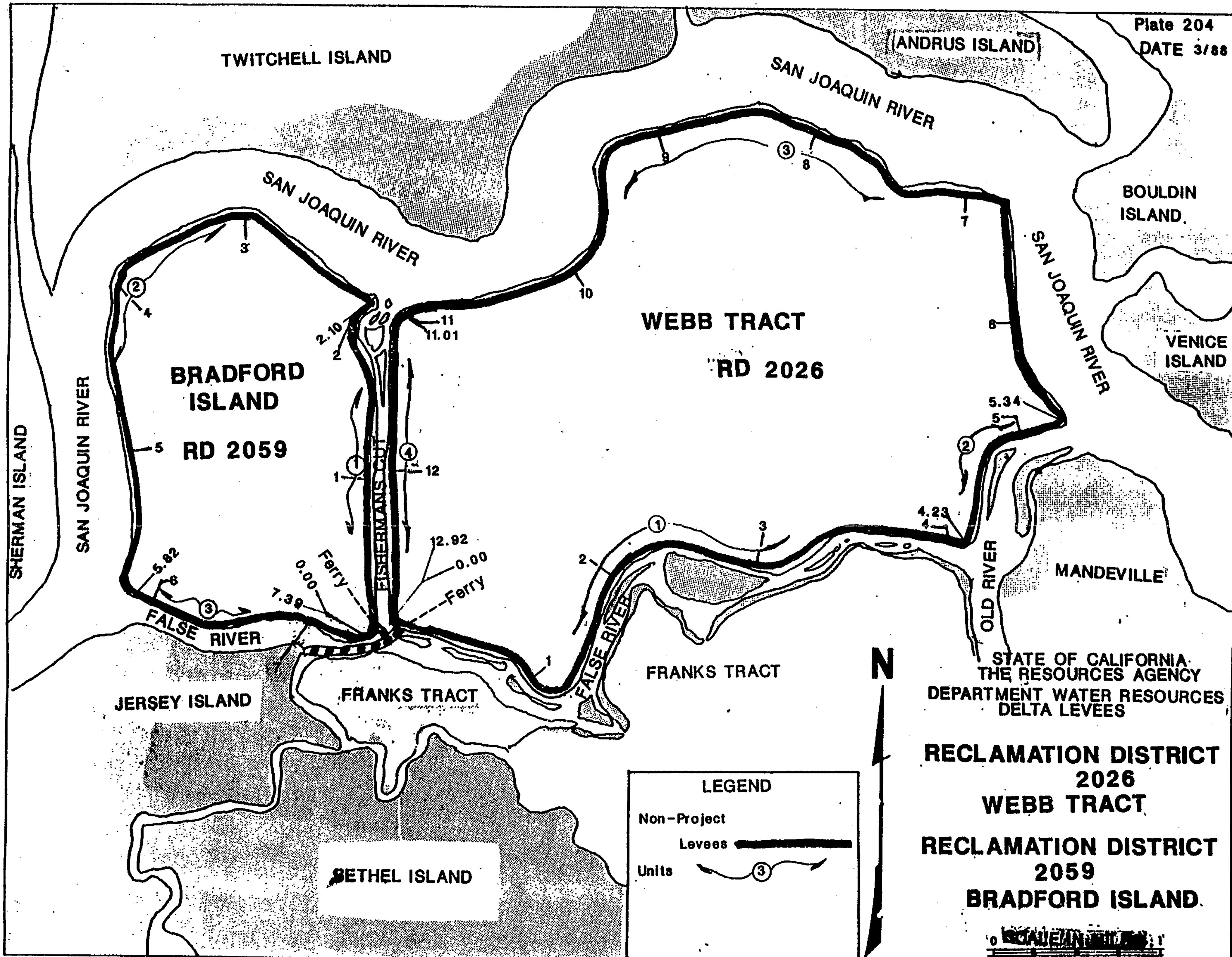


Plate 230
DATE 3/88
WOODWARD ISLAND
WOODWARD CANAL
NORTH VICTORIA CANAL
UPPER JONES TRACT
MIDDLE RIVER
BYRON TRACT
VICTORIA ISLAND
RD 2040
Bridge
Hwy 4
OLD RIVER
N
0.00
Bridge
TRAPPERSLOUGH
MIDDLE ROBERTS ISLAND
MIDDLE RIVER
NORTH CANAL
VICTORIA CANAL
UNION ISLAND
CLIFTON COURT
CONEY ISLAND
OLD RIVER
Legend
NON PROJECT LEVEE
UNITS
Scale in Miles
5.25
2.90
15.18
11.00
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
RECLAMATION DISTRICT
2040
VICTORIA ISLAND

C-007255



C-007256

C — 007256