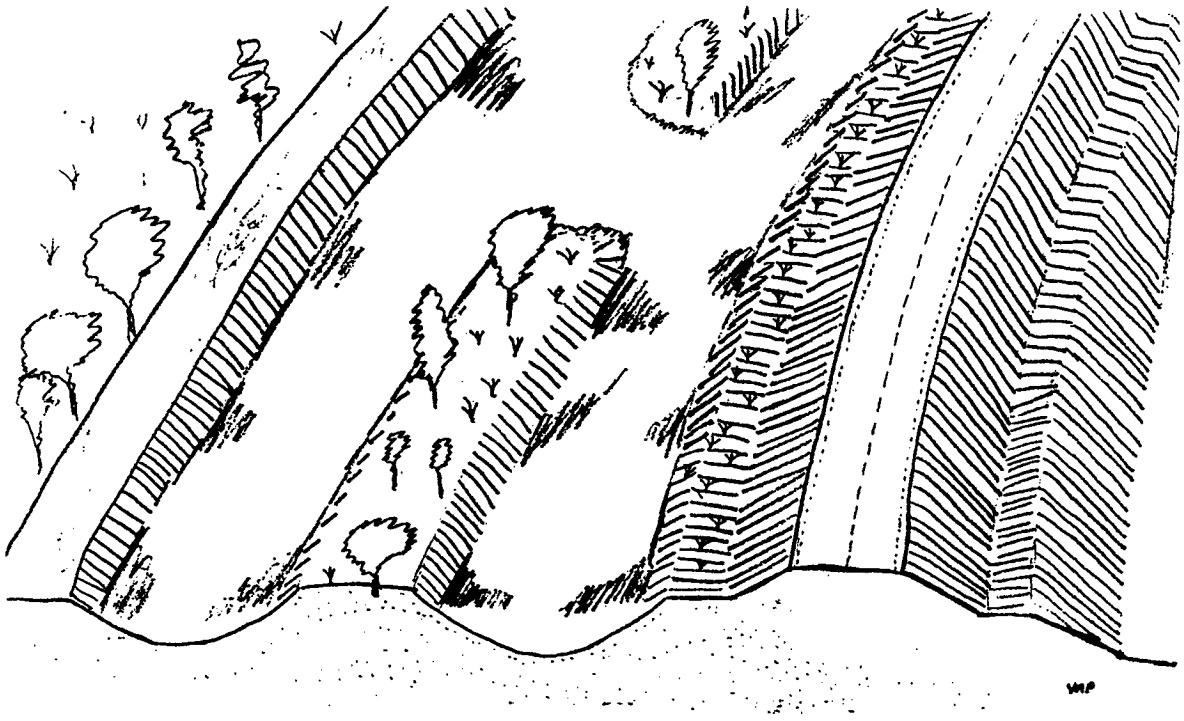
# DELTA LEVEE SYSTEM INTEGRITY COMMON PROGRAM



# DRAFT COMPONENT REPORT
## August 1997

**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**

CALFED
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CALFED/197

# DELTA LEVEE SYSTEM INTEGRITY COMMON PROGRAM

## Foreword

This common program, like all components of the Programs' 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 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 Common Program:

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

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

Common Program - Individual programs to address ecosystem restoration, Delta levee system integrity, water use efficiency, and water quality which are virtually identical in every CALFED alternative. Each of the goals and targets of these programs will not vary to any significant degree regardless of which alternative is implemented.

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 encapsulated in filter fabric that is placed on the slope and landside toe of a levee prior to placement of 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, whole ecosystem plan for restoration and management of the Bay-Delta.

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 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, to carbon dioxide.

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.

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.

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

Slurry cutoff wall - 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.

Stability berm - Earth fill placed against the levee slope 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.

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 drain - A trench along the landside toe of the levee filled with crushed rock encapsulated in filter fabric. The toe drain reduces saturation of the levee, controls seepage, and prevents boils.

# DRAFT
# CALFED Bay-Delta Program

# DELTA LEVEE SYSTEM INTEGRITY COMMON 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 one of the most visible and critical features 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 common 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 Common Program is to supplement and improve Delta levee maintenance, improvement, and emergency management practices, as well as to develop a long-term mechanism for equitably distributing the costs of assuring long-term levee system integrity.

## 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. Common programs will be 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
- Ecosystem
- Economic activities
- Existing land use
- Infrastructure
- Water supply operations
- Water quality

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

The focus of the Delta Levee System Integrity Common 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 common program aims to integrate ecosystem restoration and levee improvement activities.

## Background

Delta islands, 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) resulted in a need to increase levee heights to maintain protection. This increased height, 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 is includes over 700,000 acres, 700 miles of meandering waterways and over 1,100 miles of levees.

1849 Settlers begin 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 passes 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 authorizes 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.

1933 Congress authorizes the Central Valley Water Project (CVP).

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

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

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

1951 The Delta-Mendota Canal, which exports water from the Delta via the Tracy Pumping Plant to the San-Joaquin valley, is 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, is 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, is 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, is completed.

1967 Oroville Dam and Reservoir, which provide increased channel flows during low-flow periods, is 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.

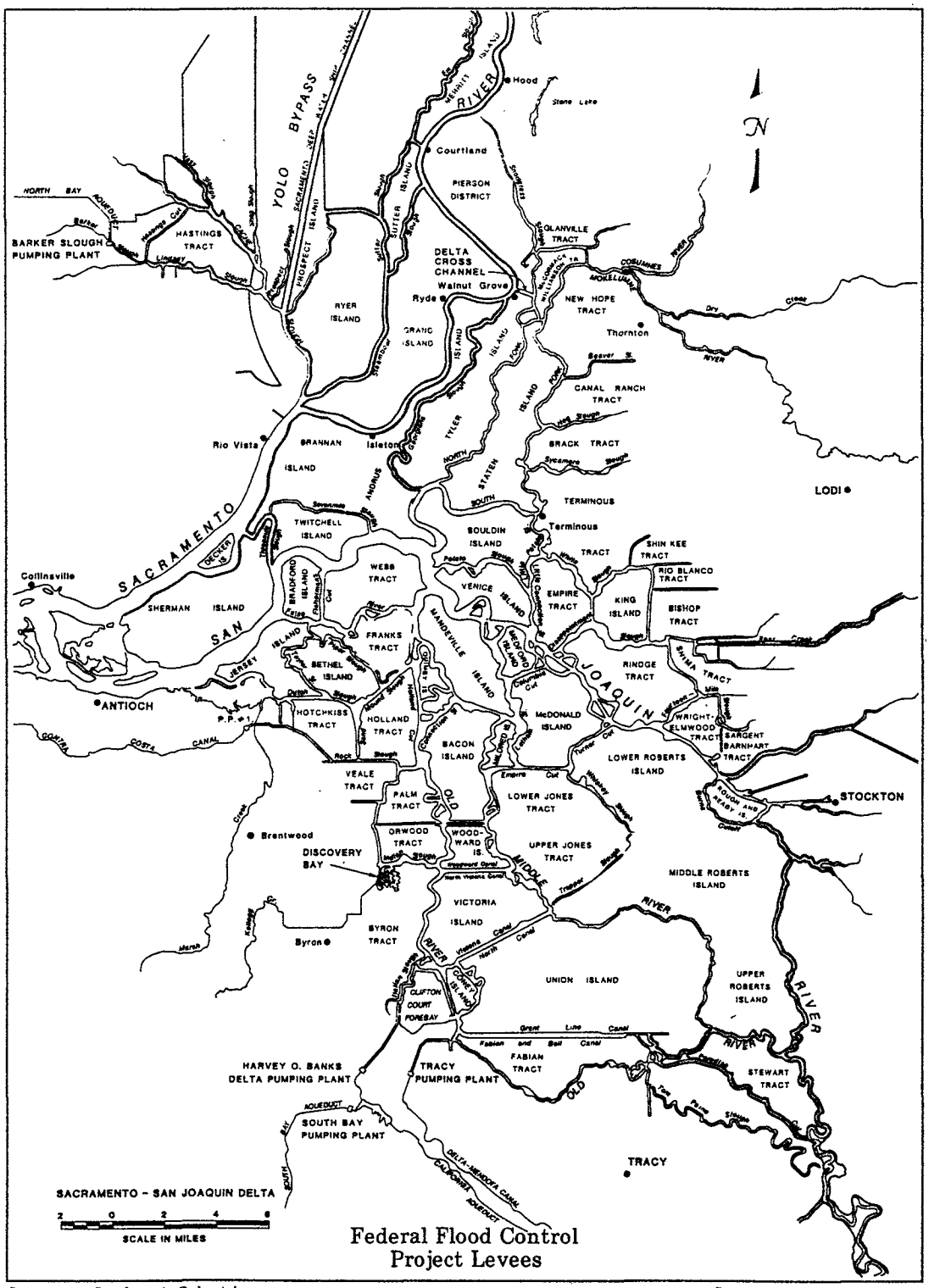
The first stage of the Harvey O. Banks Delta Pumping Plant, another unit of the SWP, is completed along with the John E. Skinner Fish Facility. Diversions from the Delta to the California and South Bay aqueducts of the SWP begin.

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

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

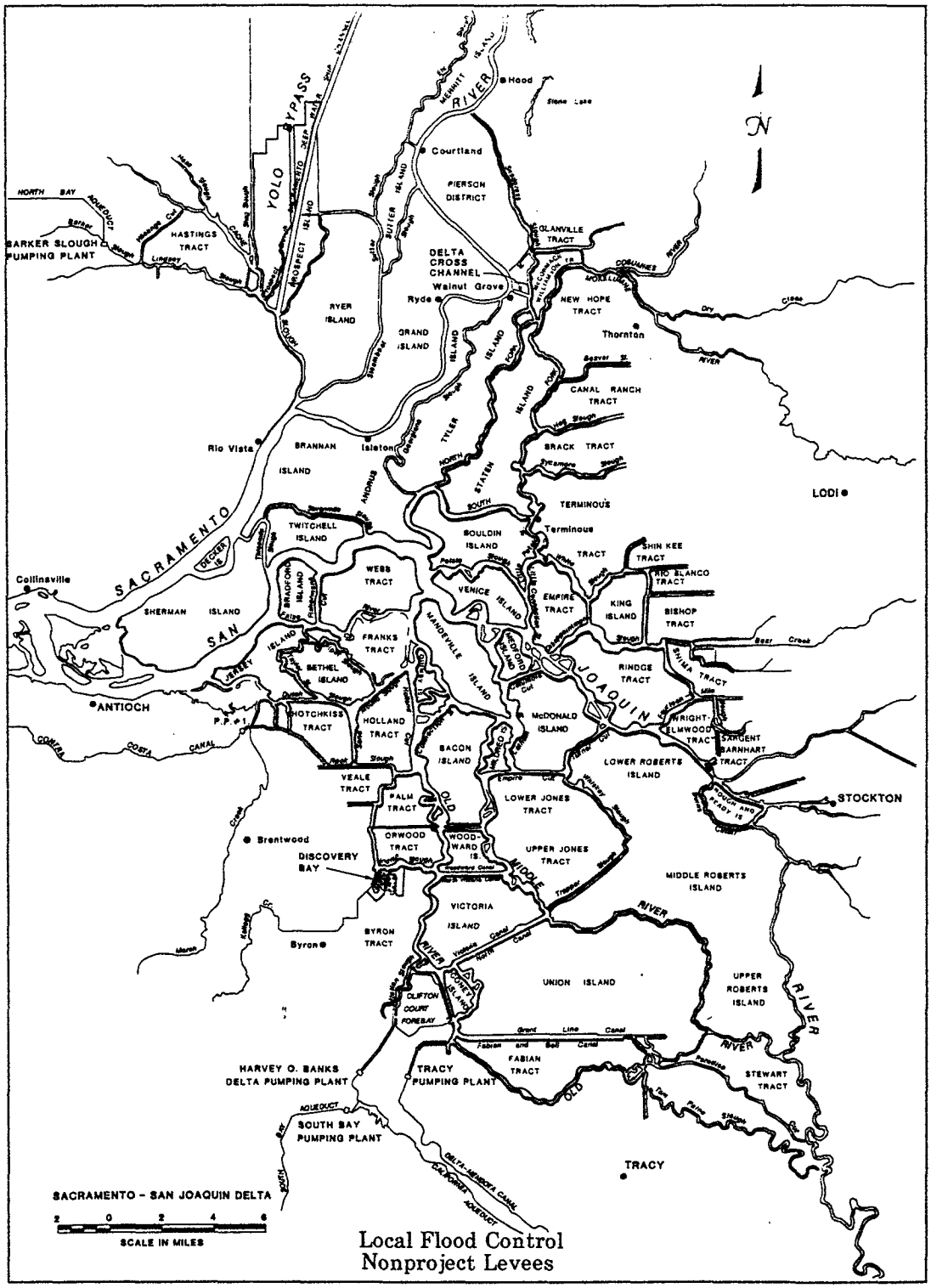
Suisun Marsh salinity control gates, which aid in controlling water quality in the marsh for protection of waterfowl, is completed.

## FIGURE 1




*Sacramento–San Joaquin Delta Atlas* *Department of Water Resources*

## FIGURE 2



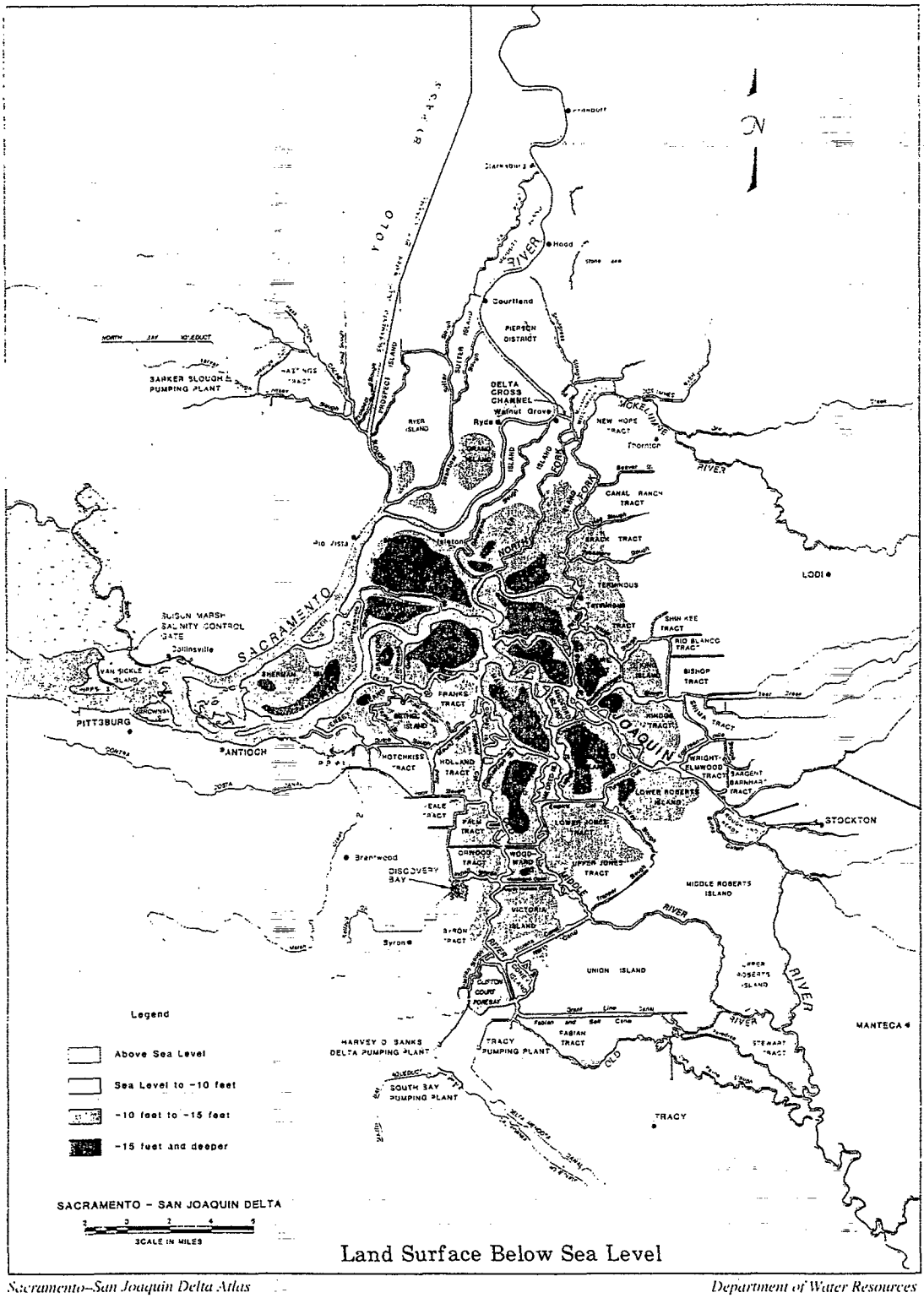

*Sacramento–San Joaquin Delta Atlas* *Department of Water Resources*

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. 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 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.

## FIGURE 3

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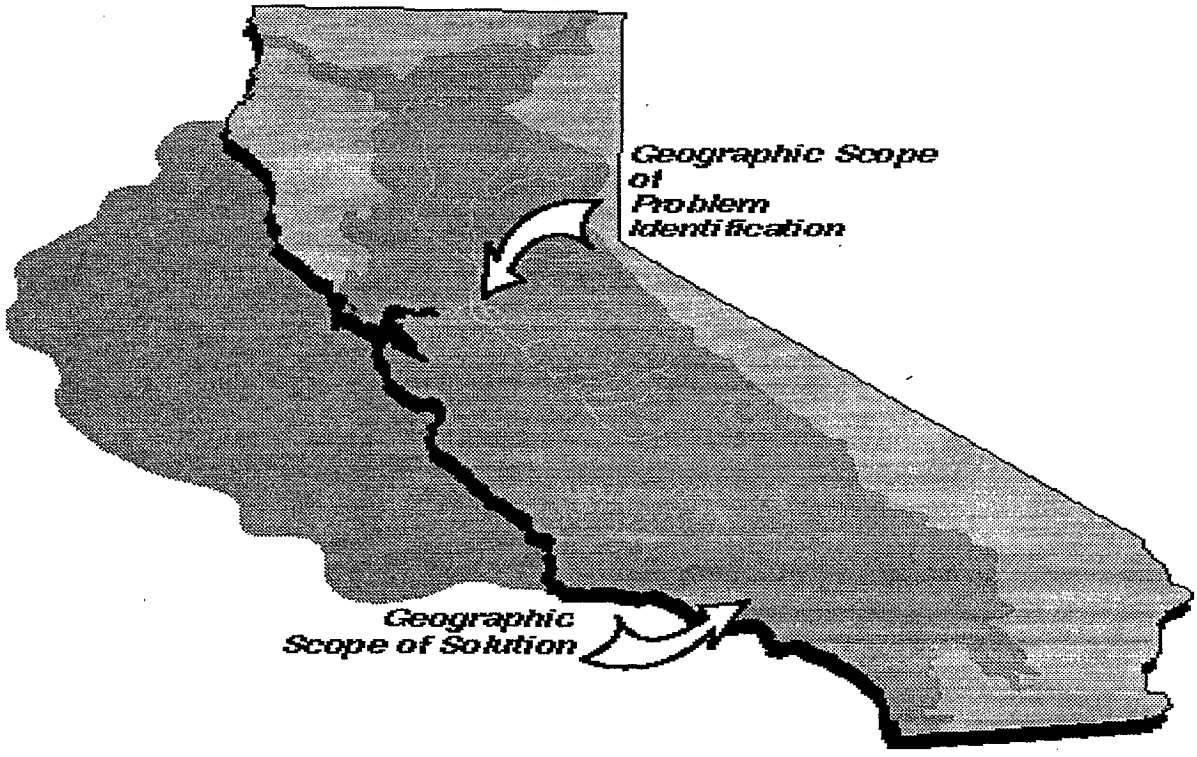
The Delta Protection Commission (DPC) was established by the Delta Protection Act of 1992. The Act acknowledges that agricultural land within the Delta is of significant value as open space and habitat for waterfowl using the Pacific Flyway. The commission has prepared a regional long-term resource management 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 within the boundaries of the Delta are required to be consistent with the DPC regional plan. The Safe, Clean, Reliable Water Supply Act 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 Common 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 4**



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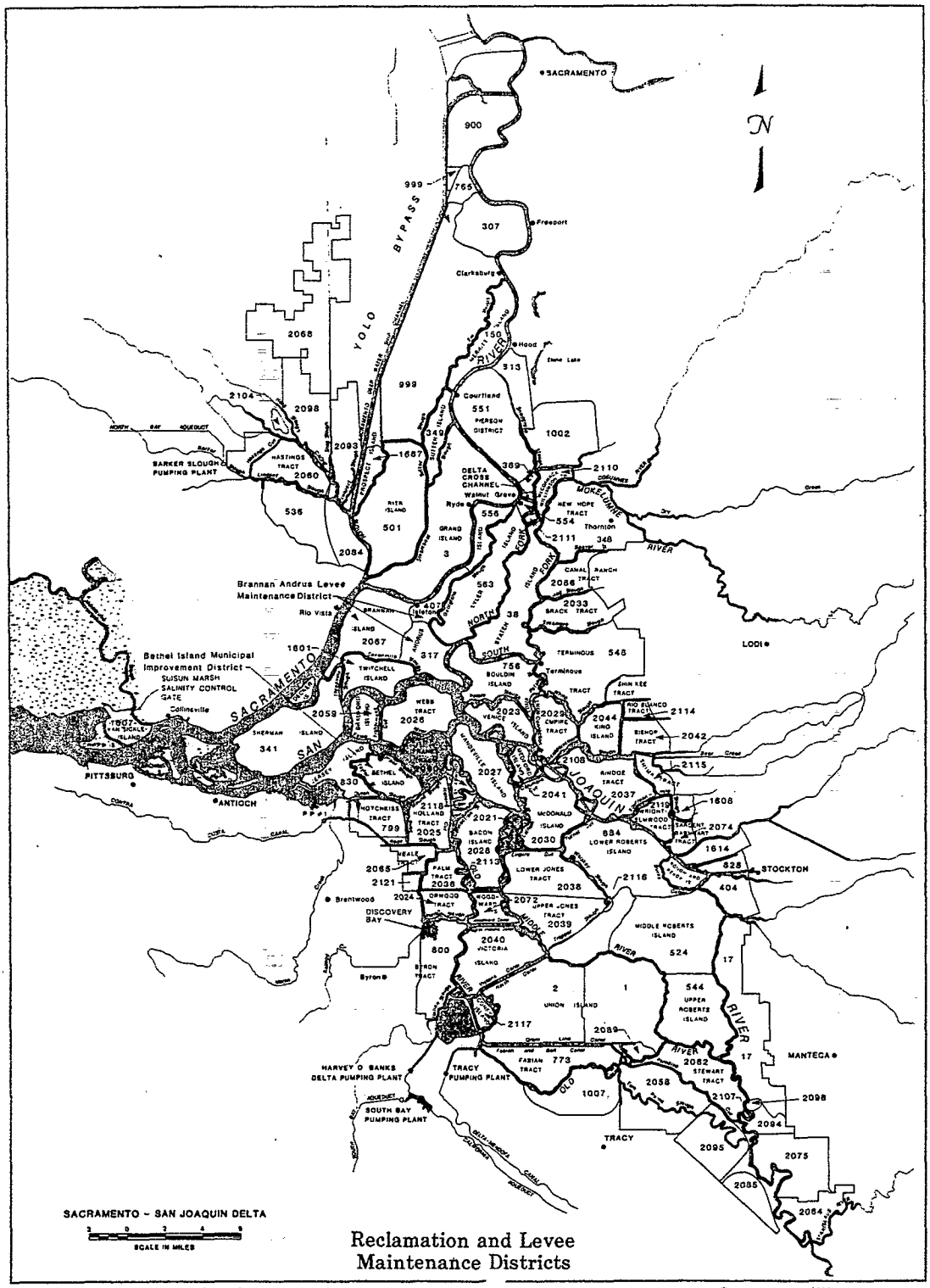


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## Implementation Strategy

The general approach for the Delta Levee System Integrity Common Program will be built upon a foundation of existing State, federal, and local agency programs. The focus of this common program is to supplement and improve these existing programs when 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, the understanding is not sufficient to warrant full-scale implementation of proposed actions, and additional research is needed to identify potential solutions. 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 common 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.

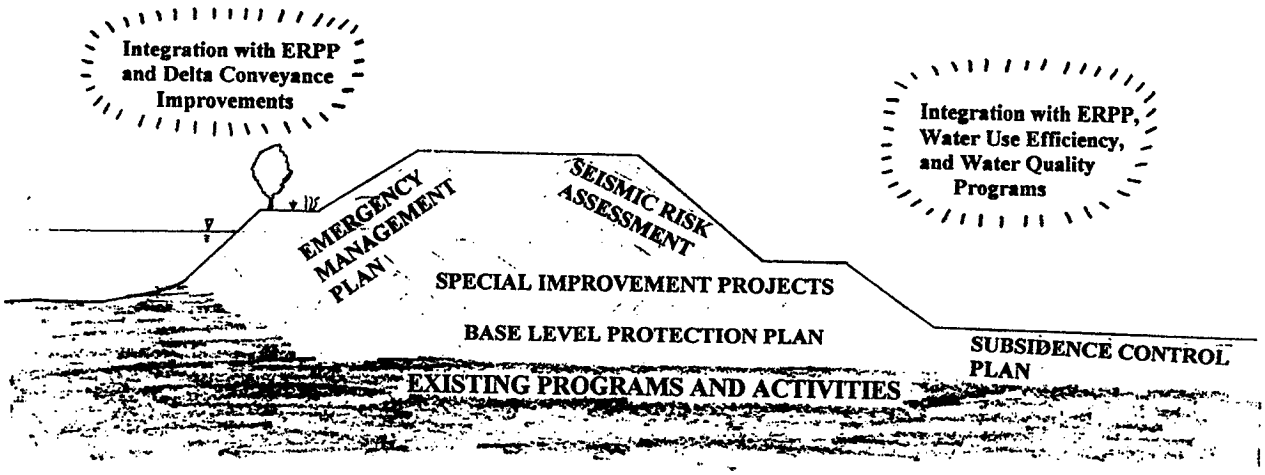
Full implementation of this common program will meet minimum federal flood control project levee performance criteria for project and non-project levees in the Delta. Over several decades, a phased process will coordinate potential improvement actions with ecosystem restoration and conveyance improvements. 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.

## Common Program Elements

The specific elements of the Delta Levee System Integrity Common 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 6




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 common 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 |
|---|---|---|
| Promote maintenance and enhancement of the Delta levee system. | Improve Delta levee system stability to meet federal flood control project criteria | Modify levee cross sections by raising levee height, widening levee crown, flattening levee slopes, or constructing stability berms. |
| Reduce degradation of the levee system and prevent long-term loss of habitat. | Establish uniform levee maintenance criteria to improve erosion and seepage control. | Provide slope protection, relocate irrigation ditches, install drainage systems or slurry cut-off walls. |
| | Establish uniform guidelines for protection, and enhancement of existing habitat. | Coordinate maintenance and improvement actions with the Ecosystem Restoration Program Plan to enhance and restore habitat areas. |
| Establish State, federal, and local cost-sharing plan to assure long-term Delta levee system integrity. | Identify necessary funding requirements and beneficiaries to provide equitable distribution of maintenance and improvement costs. | Develop a phasing sequence for implementation of proposed actions to improve flood protection. |

This plan will build upon existing programs and activities to meet minimum federal flood control project levee performance criteria for project and non-project levees in the Delta. Local reclamation districts are responsible for maintaining and improving Delta levees and provide the primary source of resources through assessments imposed on local property owners. The federal government provides limited resources for maintenance of federal flood control projects. 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. Please see Appendix B for more detailed information on this element of the common program.

**Delta Levee Special Improvement Projects**

| Implementation Objective | Target | Action |
|---|---|---|
| Enhance flood protection for islands providing multiple resource benefits | Improve stability of Delta levees and improve flood conveyance capacity to safely pass inflows into the Delta. | Modify levee cross sections by raising levee height, widening levee crown, flattening levee slopes, or constructing stability berms.<br><br>Modify channel configurations, constructing cut-off levees, and create bypass systems. |
| Promote integration of habitat restoration. | Establish criteria for including habitat restoration in special projects. | Coordinate special improvement actions with the Ecosystem Restoration Program Plan to enhance and restore habitat areas. |
| Establish a priority plan for implementation of special projects. | Identify public benefits provided by Delta islands and rank the islands by these attributes. | Develop a phasing sequence for implementation of proposed special projects and integration of habitat restoration actions. |



These projects will provide increased flood protection beyond the Delta Levee Base Level Protection Plan for Delta islands which have many public benefits. The State increased its role in Delta levee flood control improvements when it established the Special Flood Control Project Program. Delta islands that protect water quality; agricultural production; life and personal property; cultural resources; recreation; the ecosystem; and local and statewide infrastructure, will be ranked separately for each of these resources.

Program staff, in coordination with stakeholders, the public, and State and federal agencies, will seek input in preparing island rankings. These rankings will be used by policy makers to use in developing an overall balanced priority plan for Delta Levee Special Improvement Projects. This priority plan will identify the relationships between the resources potentially affected by flooding of each Delta island and the phasing sequence of special improvement projects to provide increased flood protection. Please see Appendix C for more detailed information on this element of the common program.

**Delta Island Subsidence Control Plan**

| Implementation Objective | Target | Action |
|---|---|---|
| Establish subsidence control zones on islands with peat soils. | Modify agricultural practices within 300-500 yards of landside levee slope to reduce subsidence. | Purchase conservation easements adjacent to levees. |
| | | Implement less intensive agricultural practices. |
| | Identify demonstration projects to restore interior island elevations. | Implement pilot project for shallow flooding of peat soils. |
| | | Implement pilot project to increase organic surface material. |
| Promote integration of habitat restoration. | Establish criteria for including habitat restoration in subsidence control projects. | Coordinate subsidence control actions with the Ecosystem Restoration Program Plan to enhance and restore habitat areas. |
| Establish a priority plan for implementation of subsidence control actions. | Identify areas critical for controlling subsidence and rank these areas for importance to protect public benefits. | Develop a phasing sequence for implementation of proposed subsidence control projects. |



This plan will promote island subsidence reduction to provide long-term reliability of Delta levees through coordination with existing program and activities. The State increased its role in subsidence investigations when it established the Special Flood Control Project Program.

Program staff, in cooperation with stakeholders, the public, and State and federal agencies, will evaluate subsidence rates and depth of organic soils for Delta islands, and will develop an implementation plan. This plan will identify actions and a phasing sequence to address island subsidence. Please see Appendix D for more detailed information on this element of the common program.

**Delta Levee Emergency Management Plan**

| Implementation Objective | Target | Action |
|---|---|---|
| Enhance planning and resource allocation prior to disaster event | Identify guidelines for funding and participation | Purchase materials in advance and place in strategic locations. |
| | | Develop contracts for equipment in advance |
| | Identify guidelines for multi-agency participation | Implement agreements for participation and coordination |
| Enhance planning and resource allocation for recovery efforts following a disaster event | Identify repair and recovery criteria to coordinate and fund post-disaster efforts. | Identify resource area recovery and rehabilitation plans |
| | | Prepare updated flood risk assessments. |
| Establish State, federal, and local cost-sharing plan to assure long-term Delta levee emergency management protection. | Identify necessary funding requirements and beneficiaries to provide equitable distribution of emergency management preparation and recovery costs. | Develop a phasing sequence for implementation of proposed emergency management actions. |



This plan will build upon existing emergency management activities to protect critical Delta resources in the event of a disaster. 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.

Program staff will work with stakeholders, the public, and State and federal agencies, in identifying pre-emergency and post-disaster recovery measures such as establishing a multi-agency emergency management team; and guidelines for participation and cooperation. Please see Appendix E for more detailed information for this element of the common program.

**Delta Levee Seismic Risk Assessment**

| Implementation Objective | Target | Action |
|---|---|---|
| Enhance understanding of Delta levee performance during an earthquake. | Perform analysis of recent seismic data. | Prepare updated seismic ground motion mapping, and updating seismic risk assessments.<br><br>Perform dynamic testing of levee material properties, and levee stability analysis. |
| Enhance performance of the Delta levee system during an earthquake. | Improve stability of Delta levees by cost-effective measures to improve performance during an earthquake | Modify levee cross sections by raising levee height, widening levee crown, flattening levee slopes, or constructing stability berms. |
| Establish an implementation plan for seismic actions. | Identify areas critical for improving seismic performance of Delta levees. | Develop a phasing sequence for implementation of proposed seismic actions. |

This assessment will identify and increase the understanding of the risk to Delta resources during catastrophic seismic events and develop recommendations to improve the stability of Delta levees.

To define further the relative risk of catastrophic events and the performance of Delta levees, the Department of Water Resources' Seismic Investigation may be 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.

Program staff will work in cooperation 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, implement and coordinate recommendations with other program actions, and enhance coordination between agencies; stakeholders; and the public. Please see Appendix F for more detailed information for this element of the common 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 Common 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 Common 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 Common 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 COMMON PROGRAM

CALFED
Bay-Delta Program

DRAFT
September 5, 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 vulnerability of Bay-Delta system functions. 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 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, 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 could 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 rushed 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 rate and area of the mixing zone.

Failure of Delta levees can result either from catastrophic events such as earthquakes and floods, or from gradual deterioration. 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 from catastrophic island inundation and resultant salinity intrusion. (See Water Supply Problem Statement.)

2. **Export water supply** can be interrupted as a result from 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 COMMON PROGRAM

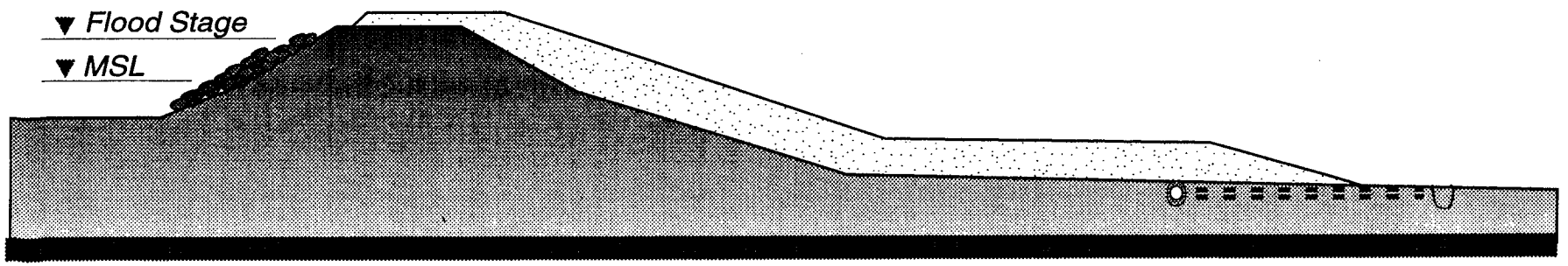
CALFED
Bay-Delta Program

DRAFT
September 5, 1997

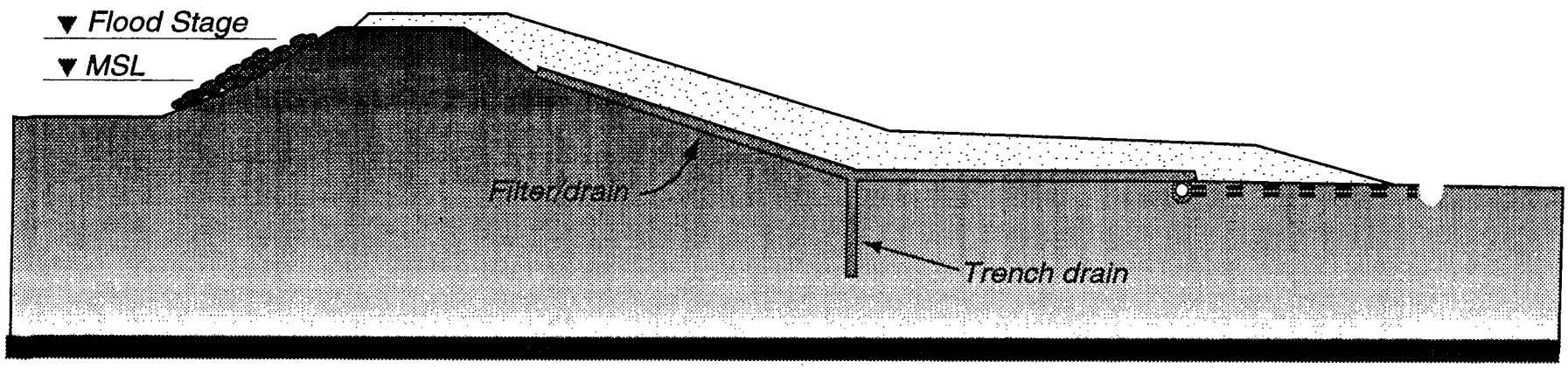


D-031469

# Examples of Levee and Habitat Improvements

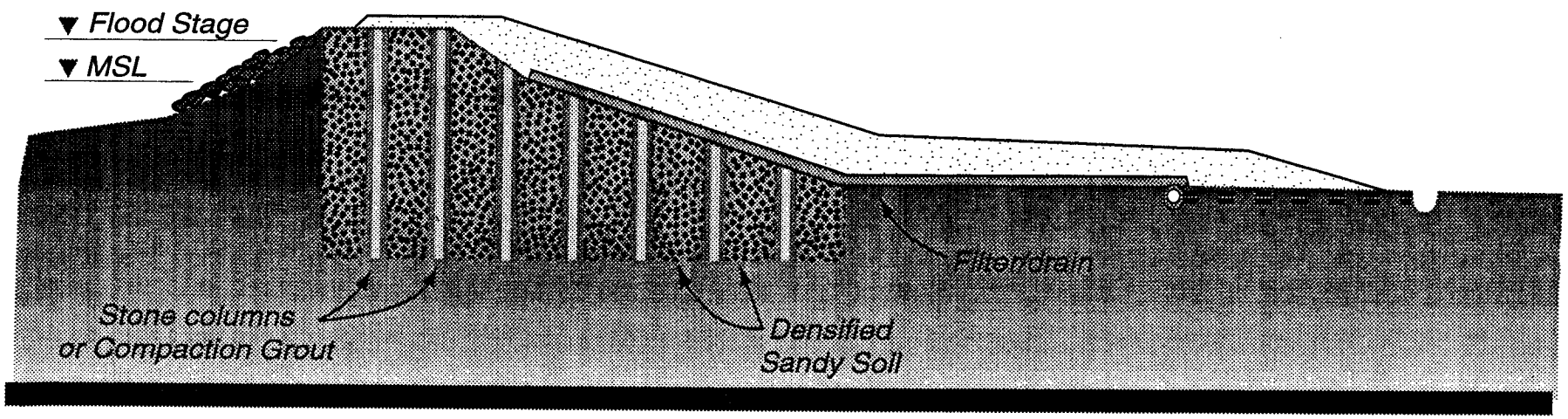


# Examples of Levee and Habitat Improvements




D—031471

# Examples of Levee and Habitat Improvements



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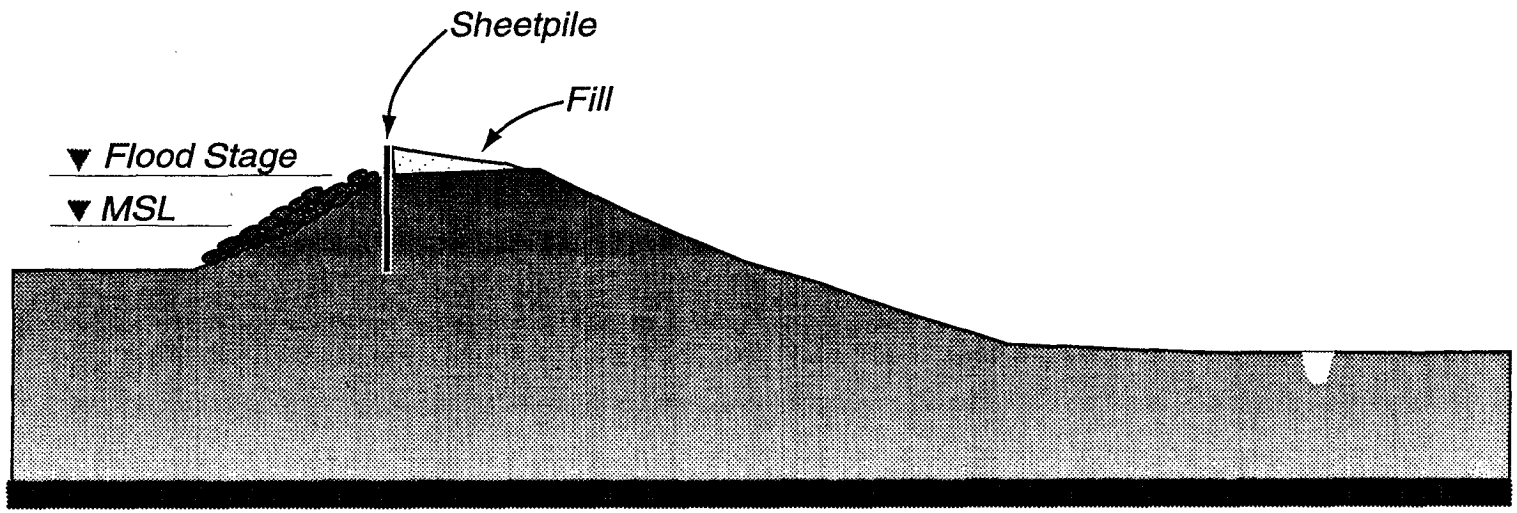
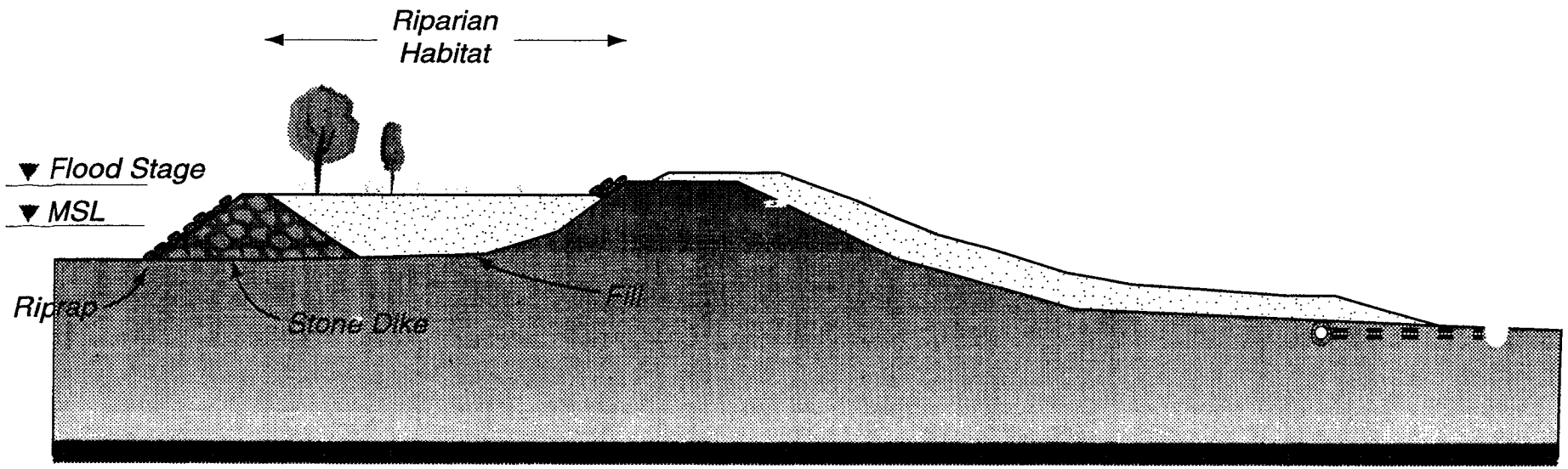
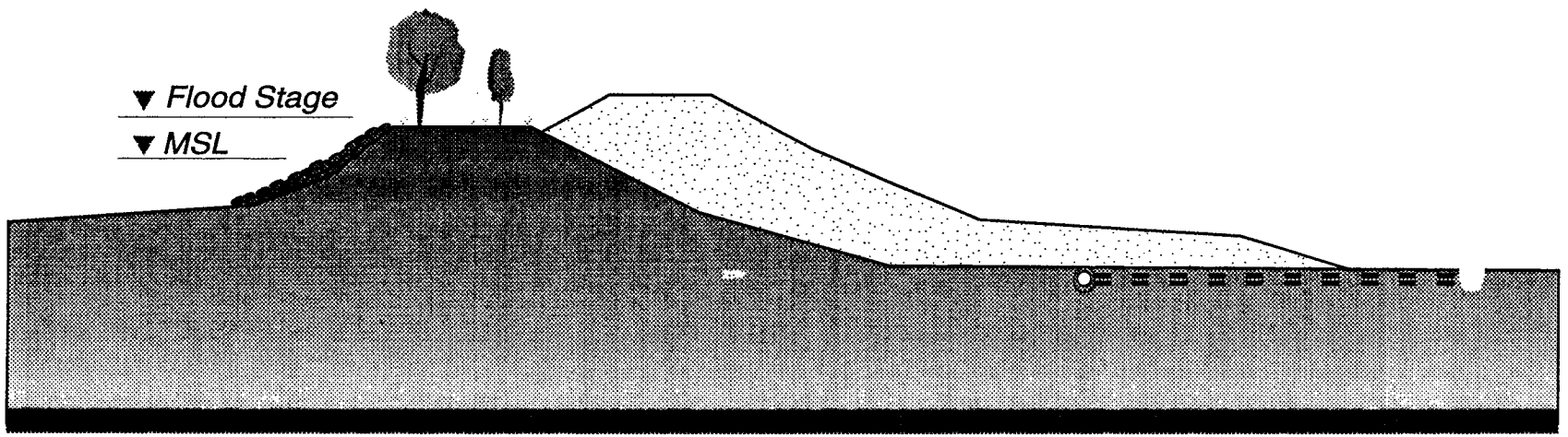


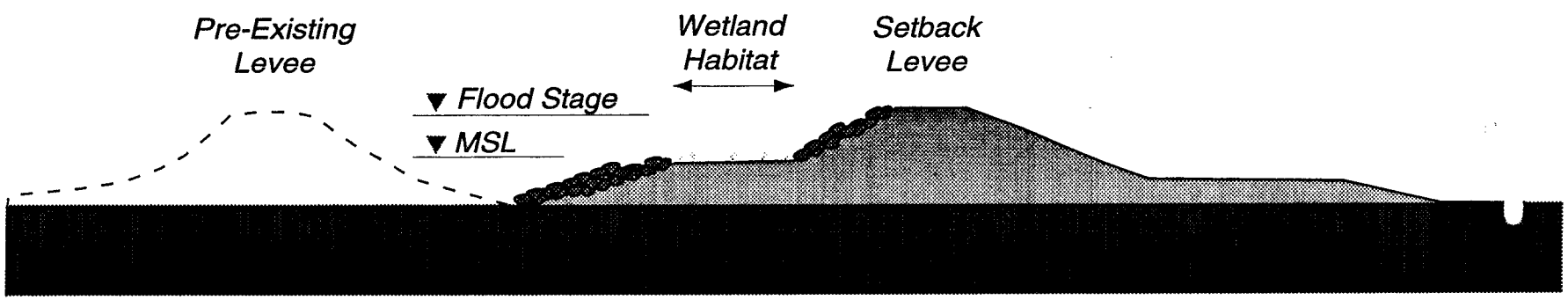
# Examples of Levee and Habitat Improvements



# Examples of Levee and Habitat Improvements



# Examples of Levee and Habitat Improvements




D—031476

# APPENDIX C

# DELTA LEVEE SPECIAL IMPROVEMENT PROJECTS

## DELTA LEVEE SYSTEM INTEGRITY COMMON PROGRAM





D-031477

# APPENDIX D

# DELTA ISLAND SUBSIDENCE CONTROL PLAN

# DELTA LEVEE SYSTEM INTEGRITY COMMON PROGRAM

# APPENDIX E

# DELTA LEVEE EMERGENCY MANAGEMENT PLAN

## DELTA LEVEE SYSTEM INTEGRITY COMMON PROGRAM

CALFED
Bay-Delta Program

DRAFT
September 5, 1997



D-031479

# 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 common program, like all components of the Programs' 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.

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## Introduction

The recognition of the Delta as an area of national significance will continue to increase as public investment such as habitat restoration is implemented and public interest increases. The overall framework for implementation of the emergency management approach will provide the flexibility to protect these resources efficiently and in a timely manner as well as the ability to adapt to changing conditions. The Emergency Management Plan will build upon existing State, federal, and local agency emergency management responsibilities to protect Delta resources in the event of a disaster. An effective emergency management plan which identifies preventive measures and post-disaster recovery measures can enhance existing emergency activities to protect and recover areas with significant public investment and benefits in the Delta. This plan will be integrated with existing emergency management systems, and identify pre-emergency and post-disaster recovery measures.

## Background:

The most recognizable threat to Delta islands and resources in the Delta is seen as inundation due to winter flood events. In addition, there are other potential disasters which threaten these same resources in the form of seismic events, fire, toxic spills, and failure of Delta levees during low flow periods. Approximately 20 islands have flooded since the 1960's, including McCormack-Williamson and Dead Horse islands which were also flooded during the storms of 1997, and several Delta islands were inundated more than once during this period. 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 which present a potential threat to Delta islands and critical resources. 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. Delta resources are under constant threat from various potential disaster events.

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 is intended to facilitate priority setting, inter-agency cooperation, and the efficient flow of resources and information. However, only the Governor can declare a State of Emergency with the Governor's Office of Emergency Services serving as the coordinator for State agency response. When the incident appears to potentially exceed the resources of the local responsible agency, on-site evaluations are conducted to determine what, if any, additional emergency support is warranted. Cities and/or 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 could not provide a sustained effort during a large disaster event. The majority of local agencies do not have the resources to address disaster events, and existing agreements may provide a means for additional resources from surrounding communities and counties. The federal government provides financial assistance through the Federal Emergency Management Agency under declaration of a Presidential Disaster; however, other federal agencies may provide assistance and/or resources under existing authorities.

The overall focus of current emergency response activity is primarily on sites under eminent threat which can reduce opportunities to allocate resources to areas under less threatening conditions to prevent incidents from escalating beyond existing available resources. The overall existing emergency procedures and approach can potentially result in delays of initial resource allocation and funding which are critical to efficiently address most disaster events and reduce future resource needs by preventing additional damages.

## 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 1**

| Implementation Objective | Target | Action |
|---|---|---|
| Enhance planning and resource allocation prior to disaster event | Identify guidelines for funding and participation | Purchase materials in advance and place in strategic locations. |
| | | Develop contracts for equipment in advance |
| | Identify guidelines for multi-agency participation | Implement agreements for participation and coordination |
| Enhance planning and resource allocation for recovery efforts following a disaster event | Identify repair and recovery criteria to coordinate and fund post-disaster efforts. | Identify resource area recovery and rehabilitation plans |
| | | Prepare updated flood risk assessments. |
| Establish State, federal, and local cost-sharing plan to assure long-term Delta levee emergency management protection. | Identify necessary funding requirements and beneficiaries to provide equitable distribution of emergency management preparation and recovery costs. | Develop a phasing sequence for implementation of proposed emergency management actions. |

This plan will build upon existing emergency management activities to protect critical Delta resources in the event of a disaster. This plan will focus on pre-emergency actions, including initial local response, and post-disaster event actions. The plan will identify total disaster response funding needs for the Delta. This plan can provide an incentive for local participants to continue investment and provide protection for multiple resources.

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, 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 event enhance emergency assistance protecting life and property, preventing additional damages and reducing subsequent costs. Examples of preventive measures include identification of potential staging areas, advance collection and placement of materials, and identification of specific emergency actions.

- 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.

Priorities

Protection

Phasing Sequence

Preventive

Initial

Event

Post-event

# APPENDIX F

# DELTA LEVEE SEISMIC RISK ASSESSMENT

## DELTA LEVEE SYSTEM INTEGRITY COMMON PROGRAM

CALFED
Bay-Delta Program

DRAFT
September 5, 1997



D-031488

# DELTA LEVEE SEISMIC RISK ASSESSMENT

**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 common program, like all components of the Programs' 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.

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**FOR DISCUSSION PURPOSES ONLY**

**DRAFT**

## Introduction

The recognition of the Delta as an area of national significance will continue to increase as public investment such as habitat restoration is implemented and public interest increases. The general approach of this assessment is to identify and increase the understanding of the risk to Delta resources during catastrophic seismic events and develop a workplan to improve the stability of Delta levees. This assessment will build upon existing State, and federal agency seismic activities associated with the Delta to develop recommendations for 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.

## Background:

The most recognizable threat to Delta islands and resources in the Delta is seen as inundation due to winter flood events. In addition, seismic events threaten these same resources in the form of failure of Delta levees as a result of slumping or liquefaction of underlying soils. 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 which present a potential threat to Delta islands and critical resources. A potential threat to Delta water quality is the failure of Delta levees during low flow periods as a result of a seismic event. This type of disaster can result in intrusion of salinity from the Bay, as occurred during the 1972 inundation of Brannan/Andrus Island.

The following activities have been undertaken by the Department of Water Resources Division of Engineering since completion of their Phase I Report Seismic Stability Evaluation of the Sacramento-San Joaquin Delta Levees in 1992 to reduce some of the unknowns which influence the evaluation of levee stability during earthquake shaking.

- 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.

- 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



D-031493

| Implementation Objective | Target | Action |
|---|---|---|
| Enhance understanding of Delta levee performance during an earthquake. | Perform analysis of recent seismic data. | Prepare updated seismic ground motion mapping, and updating seismic risk assessments.<br><br>Perform dynamic testing of levee material properties, and levee stability analysis. |
| Enhance performance of the Delta levee system during an earthquake. | Improve stability of Delta levees by cost-effective measures to improve performance during an earthquake | Modify levee cross sections by raising levee height, widening levee crown, flattening levee slopes, or constructing stability berms. |
| Establish an implementation plan for seismic actions. | Identify areas critical for improving seismic performance of Delta levees. | Develop a phasing sequence for implementation of proposed seismic actions. |

To define further the relative risk of catastrophic events and the performance of Delta levees, the Department of Water Resources' Seismic Investigation may be 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.

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 workplan and summary report using this technical report and suggestions from the consulting board. The workplan 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?

1.1) What is the magnitude of an event likely to produce levee failure in the Delta?

[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 workplan and report for CALFED.

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

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

2.1) What regions of the Delta, in order of priority, require improvements?

2.2) What are recommended actions, in order of priority, for these regions?

3) 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?

3.1) What order of priority should these actions be undertaken?

**Priorities**

**Phasing Sequence**

Program staff will work in cooperation 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, implement and coordinate recommendations with other program actions, and enhance coordination between agencies; stakeholders; and the public.

The following activities have been identified for completion by the Department of Water Resources Division of Engineering in preparation of their report to the Consulting Board to the Department of Water Resources Sacramento-San Joaquin Levees.

- Refine the seismic stability evaluations of Delta Levees based on new information.
- Prepare report to address technical seismic questions.

- Convene Consulting Board to Department of Water Resources Sacramento-San Joaquin Levees.

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

- Updating seismicity 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.

**Existing Programs**

# APPENDIX G

# DELTA LEVEES AND CHANNELS COST ESTIMATES

## DELTA LEVEE SYSTEM INTEGRITY COMMON PROGRAM

CALFED
Bay-Delta Program

DRAFT
September 5, 1997



D-031498

FOR DISCUSSION PURPOSES ONLY

# DELTA LEVEE AND CHANNELS COST ESTIMATES

**Foreword:**

This paper provides a preliminary estimate of the costs for implementation of the CALFED Bay-Delta Program's Delta Levee System Integrity Common Program. The cost estimates are for the earthwork needed to provide uniform federal flood control project levees to protect Delta resources.

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



CALFED
Bay-Delta Program



D-031499

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**FOR DISCUSSION PURPOSES ONLY**

## Introduction

The following preliminary cost estimates are for implementation of each element of the Delta Levee System Integrity Common Program. These estimates are provide in ranges to represent the variability .....

## Cost Estimates

### Levee Earthwork

These preliminary estimates are for the earthwork portion of levee improvements necessary to implement the Delta Levee System Integrity Common Program. The summary identifies cost for implementing the levee improvements alone; implementing levee improvements with ERPP restoration actions; and implementing improvements with ERPP restoration actions and Delta conveyance alternatives.

**Assumptions:**

- Quantities are based on "typical" levee section for non-project levees and proposed levee improvement cross sections.

- The ERPP restoration actions and the Delta conveyance actions are not additive to the levee common program quantities. The ERPP actions replace proposed levee improvements and are included in the total common program cost. The Delta conveyance improvements are in lieu of proposed levee improvements and are not included in the total common program cost and will be included in other program cost estimates.

- Levees for areas which meet federal flood control criteria, such as Holland Tract and Sargent Barnhart, are assumed not to require significant improvement costs. Federal Flood Control Project Levees, such as Sacramento River Levees are also assumed not to require significant improvement costs unless identified in the USACE's 1993 Sacramento River Flood Control Project Systems Evaluation Report - Lower Sacramento.



D-031502

| Earthwork Costs (Millions) | | |
|---|---|---|
| | Low | High |
| Base Level<br>Delta Levee Improvements | 1740 | 2240 |
| ERPP Actions<br>Alternatives 1& 2 | 425 | 485 |
| ERPP Actions<br>Alternative 3<br>w/5000 cfs I.F. | 485 | 550 |
| ERPP Actions<br>Alternative 3<br>w/15000 cfs I.F. | 730 | 795 |
| Alternatives<br>1A, 1B, 1C | 1890 | 2360 |
| Alternatives<br>2A, 2B | 1775 | 2220 |
| Alternatives<br>2D, 2E | 1690 | 2120 |
| Alternatives<br>3A, 3B, 3E | 1820 | 2280 |
| Alternatives<br>3H | 1650 | 2070 |
| Alternative<br>3I | 1860 | 2325 |

## Draft Estimate of Levee Improvement Costs (Millions) for CALFED Alternatives 1 to 3

| Island Name | Earthwork | | Earthwork | | Earthwork | | Earthwork | | Earthwork | | Earthwork | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Alt.1a, 1b, 1c | | Alt. 2a, 2b | | Alt. 2d, 2e | | Alt. 3a, 3b, 3e | | Alternative 3h | | Alternative 3i | |
| | Low | High | Low | High | Low | High | Low | High | Low | High | Low | High |
| Andrus, Upper; RD 556 | 1.35 | 1.75 | 1.35 | 1.75 | 1.35 | 1.75 | 1.35 | 1.75 | 1.35 | 1.75 | 1.35 | 1.75 |
| Bacon; RD 2028 | 38.6 | 50 | 38.6 | 50 | 38.6 | 50 | 38.6 | 50 | 38.6 | 50 | 38.6 | 50 |
| Bear Creek | | | | | | | | | | | | |
| Bethany | | | | | | | | | | | | |
| Bethel Island MID | 31 | 40.2 | 31 | 40.2 | 31 | 40.2 | 31 | 40.2 | 31 | 40.2 | 31 | 40.2 |
| Bishop; RD 2042 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bishop East | | | | | | | | | | | | |
| Bixler; RD 2121 | | | | | | | | | | | | |
| Boggs Dist; RD 404 | 3.2 | 4.2 | 3.2 | 4.2 | 3.2 | 4.2 | 3.2 | 4.2 | 3.2 | 4.2 | 3.2 | 4.2 |
| Borrow Pond Area | | | | | | | | | | | | |
| Bouldin; RD 756 | 48.6 | 63 | 36.4 | 47.2 | 0 | 0 | 36.4 | 47.2 | 0 | 0 | 48.6 | 63 |
| Brack; RD 2033 | 48.7 | 55.3 | 48.7 | 55.3 | 0 | 0 | 48.7 | 55.3 | 0 | 0 | 48.7 | 55.3 |
| Bradford; RD 2059 | 30.4 | 35.2 | 30.4 | 35.2 | 30.4 | 35.2 | 30.4 | 35.2 | 30.4 | 35.2 | 30.4 | 35.2 |
| Brannan-Andrus RDs 2067/317/407 | 49.8 | 57.9 | 49.8 | 57.9 | 49.8 | 57.9 | 49.8 | 57.9 | 49.8 | 57.9 | 49.8 | 57.9 |
| Byron; RD 800 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cache Haas; RD 2098 | 10.8 | 10.8 | 10.8 | 10.8 | 10.8 | 10.8 | 10.8 | 10.8 | 10.8 | 10.8 | 10.8 | 10.8 |
| Canal Ranch; RD 2086 | 40.5 | 47.9 | 40.5 | 47.9 | 0 | 0 | 40.5 | 47.9 | 0 | 0 | 40.5 | 47.9 |
| Chipps Island | | | | | | | | | | | | |
| Clifton Court | | | | | | | | | | | | |
| Collinsville | | | | | | | | | | | | |
| Coney; RD 2117 | 14.6 | 18.9 | 14.6 | 18.9 | 14.6 | 18.9 | 14.6 | 18.9 | 0 | 0 | 14.6 | 18.9 |
| Deadhorse; RD 2111 | 7 | 9.1 | 7 | 9.1 | 7 | 9.1 | 7 | 9.1 | 7 | 9.1 | 7 | 9.1 |
| Delta Mendota | | | | | | | | | | | | |
| Decker | 11.1 | 14.4 | 11.1 | 14.4 | 11.1 | 14.4 | 11.1 | 14.4 | 11.1 | 14.4 | 11.1 | 14.4 |
| Drexler | 10.8 | 14 | 10.8 | 14 | 10.8 | 14 | 10.8 | 14 | 10.8 | 14 | 10.8 | 14 |
| Egbert; RDs 536 and 2084 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| Ehrheart; RD 813 | 12.7 | 16.4 | 12.7 | 16.4 | 12.7 | 16.4 | 12.7 | 16.4 | 12.7 | 16.4 | 12.7 | 16.4 |
| Empire; RD 2029 | 25.6 | 33.2 | 25.6 | 33.2 | 25.6 | 33.2 | 25.6 | 33.2 | 25.6 | 33.2 | 25.6 | 33.2 |
| Fabian; RD 773 | 50.8 | 65.8 | 50.8 | 65.8 | 50.8 | 65.8 | 50.8 | 65.8 | 50.8 | 65.8 | 50.8 | 65.8 |
| Fay; RD 2113 | 4.3 | 5.6 | 4.3 | 5.6 | 4.3 | 5.6 | 4.3 | 5.6 | 4.3 | 5.6 | 4.3 | 5.6 |
| Frank, Little | 12.3 | 14.8 | 12.3 | 14.8 | 12.3 | 14.8 | 12.3 | 14.8 | 12.3 | 14.8 | 12.3 | 14.8 |
| Glanville; RD 1002 | 35.1 | 45.5 | 35.1 | 45.5 | 35.1 | 45.5 | 35.1 | 45.5 | 35.1 | 45.5 | 35.1 | 45.5 |
| Glide; RD 765 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Grand; RD 3 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 |
| Harbor Cove (Atlas); RD 2126 | 5.1 | 6.6 | 5.1 | 6.6 | 5.1 | 6.6 | 5.1 | 6.6 | 5.1 | 6.6 | 5.1 | 6.6 |
| Harveys; RD 1609 | 33.5 | 43.4 | 33.5 | 43.4 | 33.5 | 43.4 | 33.5 | 43.4 | 33.5 | 43.4 | 33.5 | 43.4 |
| Hastings; RD 2060 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 |
| Holland; RD 2025 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Holland Land; RD 999 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Holt; RD 2116 | 1.1 | 1.4 | 1.1 | 1.4 | 1.1 | 1.4 | 1.1 | 1.4 | 1.1 | 1.4 | 1.1 | 1.4 |
| Hotchkiss; RD 799 | 17 | 22 | 17 | 22 | 17 | 22 | 17 | 22 | 17 | 22 | 17 | 22 |
| Jersey; RD 830 | 42.1 | 54.6 | 42.1 | 54.6 | 42.1 | 54.6 | 42.1 | 54.6 | 42.1 | 54.6 | 42.1 | 54.6 |
| Jones, Lower; RD 2038 | 24.3 | 31.5 | 24.3 | 31.5 | 24.3 | 31.5 | 24.3 | 31.5 | 24.3 | 31.5 | 24.3 | 31.5 |

## Draft Estimate of Levee Improvement Costs (Millions) for CALFED Alternatives 1 to 3

| Island Name | Earthwork Alt.1a, 1b, 1c | | Earthwork Alt. 2a, 2b | | Earthwork Alt. 2d, 2e | | Earthwork Alt. 3a, 3b, 3e | | Earthwork Alternative 3h | | Earthwork Alternative 3i | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Low | High | Low | High | Low | High | Low | High | Low | High | Low | High |
| Jones, Upper; RD 2039 | 25.1 | 32.6 | 25.1 | 32.6 | 25.1 | 32.6 | 25.1 | 32.6 | 25.1 | 32.6 | 25.1 | 32.6 |
| Kasson; RD 2085 | 25.9 | 30.6 | 25.9 | 30.6 | 25.9 | 30.6 | 25.9 | 30.6 | 25.9 | 30.6 | 25.9 | 30.6 |
| Kimball Island | | | | | | | | | | | | |
| King; RD 2044 | 24.6 | 31.9 | 24.6 | 31.9 | 24.6 | 31.9 | 24.6 | 31.9 | 24.6 | 31.9 | 24.6 | 31.9 |
| Libby McNeil; RD 388 | | | | | | | | | | | | |
| Liberty; RD 2093 | 39.1 | 50.8 | 39.1 | 50.8 | 39.1 | 50.8 | 39.1 | 50.8 | 39.1 | 50.8 | 39.1 | 50.8 |
| Lisbon; RD 307 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Little Mandeville; RD 2118 | | | | | | | | | | | | |
| Los Medanos | | | | | | | | | | | | |
| Maintenance Area 9 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 |
| Mandeville; RD 2027 | 38.6 | 50 | 38.6 | 50 | 38.6 | 50 | 38.6 | 50 | 38.6 | 50 | 38.6 | 50 |
| McCormack-Williamson; RD 2110 | 23.8 | 30.8 | 0 | 0 | 0 | 0 | 23.8 | 30.8 | 0 | 0 | 23.8 | 30.8 |
| McMullin; RD 2075 | | | | | | | | | | | | |
| McDonald; RD 2030 | 37 | 48 | 37 | 48 | 37 | 48 | 37 | 48 | 37 | 48 | 37 | 48 |
| Medford; RD 2041 | 18.9 | 24 | 18.9 | 24 | 18.9 | 24 | 18.9 | 24 | 18.9 | 24 | 18.9 | 24 |
| Merritt; RD 150 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Mildred; RD 2021 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Montezuma Flats | | | | | | | | | | | | |
| Montezuma Island | | | | | | | | | | | | |
| Mossdale 2; RD 2107 | 13 | 15.4 | 13 | 15.4 | 13 | 15.4 | 13 | 15.4 | 13 | 15.4 | 13 | 15.4 |
| Naglee Burke; RD 1007 | 22.4 | 29 | 22.4 | 29 | 22.4 | 29 | 22.4 | 29 | 22.4 | 29 | 22.4 | 29 |
| New Hope; RD 348 | 63.5 | 78.6 | 63.5 | 78.6 | 63.5 | 78.6 | 37.1 | 46.4 | 63.5 | 78.6 | 63.5 | 78.6 |
| Oakley | | | | | | | | | | | | |
| Orwood; RD 2024 | 17 | 22 | 17 | 22 | 8.3 | 10.8 | 17 | 22 | 8.3 | 10.8 | 8.3 | 10.8 |
| Palm; RD 2036 | 20.2 | 26.2 | 20.2 | 26.2 | 9.7 | 12.6 | 20.2 | 26.2 | 9.7 | 12.6 | 9.7 | 12.6 |
| Paradise; RD 2095 | 21.6 | 26.1 | 21.6 | 26.1 | 21.6 | 26.1 | 21.6 | 26.1 | 21.6 | 26.1 | 21.6 | 26.1 |
| Pescadero; RD 2058 | 5.9 | 7.7 | 5.9 | 7.7 | 5.9 | 7.7 | 5.9 | 7.7 | 5.9 | 7.7 | 5.9 | 7.7 |
| Peters; RD 2104 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 |
| Pierson; RD 561 | 30.6 | 35.2 | 8.6 | 11.2 | 30.6 | 35.2 | 30.6 | 35.2 | 30.6 | 35.2 | 30.6 | 35.2 |
| Prospect; RD 1667 | 19.2 | 24.8 | 19.2 | 24.8 | 19.2 | 24.8 | 19.2 | 24.8 | 19.2 | 24.8 | 19.2 | 24.8 |
| Quimby; RD 2090 | 18.9 | 24.5 | 18.9 | 24.5 | 18.9 | 24.5 | 18.9 | 24.5 | 18.9 | 24.5 | 18.9 | 24.5 |
| Randall; RD 755 | | | | | | | | | | | | |
| Ringge; RD 2037 | 42.7 | 55.3 | 42.7 | 55.3 | 42.7 | 55.3 | 42.7 | 55.3 | 42.7 | 55.3 | 42.7 | 55.3 |
| Rio Blanco; RD 2114 | 11.3 | 14.7 | 11.3 | 14.7 | 11.3 | 14.7 | 11.3 | 14.7 | 11.3 | 14.7 | 11.3 | 14.7 |
| River Junction; RD 2064 | 30.4 | 35.9 | 30.4 | 35.9 | 30.4 | 35.9 | 30.4 | 35.9 | 30.4 | 35.9 | 30.4 | 35.9 |
| Roberts, Lower; RD 684 | 43.2 | 56 | 43.2 | 56 | 43.2 | 56 | 43.2 | 56 | 43.2 | 56 | 43.2 | 56 |
| Roberts, Middle; RD 524 | 42.7 | 52.4 | 42.7 | 52.4 | 42.7 | 52.4 | 42.7 | 52.4 | 42.7 | 52.4 | 42.7 | 52.4 |
| Roberts, Upper; RD 544 | 45.5 | 55.1 | 45.5 | 55.1 | 45.5 | 55.1 | 45.5 | 55.1 | 45.5 | 55.1 | 45.5 | 55.1 |
| Rough and Ready | | | | | | | | | | | | |
| Ryer; RD 501 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 |
| Sacramento Deepwater | | | | | | | | | | | | |
| Sargent Barnhart; RD 2074 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sherman; RD 341 | 31.1 | 33.9 | 31.1 | 33.9 | 31.1 | 33.9 | 31.1 | 33.9 | 31.1 | 33.9 | 31.1 | 33.9 |

## Draft Estimate of Levee Improvement Costs (Millions) for CALFED Alternatives 1 to 3

| Island Name | Earthwork Alt.1a, 1b, 1c | | Earthwork Alt. 2a, 2b | | Earthwork Alt. 2d, 2e | | Earthwork Alt. 3a, 3b, 3e | | Earthwork Alternative 3h | | Earthwork Alternative 3i | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Low | High | Low | High | Low | High | Low | High | Low | High | Low | High |
| Sherman West | | | | | | | | | | | | |
| Shima; RD 2116 | 17.8 | 23.1 | 17.8 | 23.1 | 17.8 | 23.1 | 17.8 | 23.1 | 17.8 | 23.1 | 17.8 | 23.1 |
| Shin Kee | 9.7 | 12.6 | 9.7 | 12.6 | 9.7 | 12.6 | 9.7 | 12.6 | 9.7 | 12.6 | 9.7 | 12.6 |
| SJCFCD Five Mile Slough | | | | | | | | | | | | |
| SJCFCD Fourteen Mile Slough | | | | | | | | | | | | |
| SJCFCD Mosher Slough | | | | | | | | | | | | |
| San Joaquin River; RD 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Smith Tract; RD 1614 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Smith Ranch; RD 1608 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spinner Island | | | | | | | | | | | | |
| Stark; RD 2089 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Staten; RD 38 | 64.9 | 83.6 | 40.5 | 52 | 58.3 | 75.5 | 52.8 | 67.8 | 64.9 | 83.6 | 64.9 | 83.6 |
| Stewart; RD 2062 | 40.6 | 51 | 40.6 | 51 | 40.6 | 51 | 40.6 | 51 | 40.6 | 51 | 40.6 | 51 |
| Sutter; RD 349 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Terminous; RD 548 | 56.7 | 73.5 | 56.7 | 73.5 | 56.7 | 73.5 | 56.7 | 73.5 | 56.7 | 73.5 | 56.7 | 73.5 |
| Tinsley; RD 2108 | | | | | | | | | | | | |
| Twitchell; RD 1601 | 52.3 | 58.3 | 52.3 | 58.3 | 52.3 | 58.3 | 52.3 | 58.3 | 52.3 | 58.3 | 52.3 | 58.3 |
| Tyler; RD 563 | 42 | 52 | 12.6 | 13.8 | 42 | 52 | 27.1 | 32.7 | 0 | 0 | 42 | 52 |
| Union, East; RD 1 | 37.8 | 49 | 37.8 | 49 | 37.8 | 49 | 37.8 | 49 | 37.8 | 49 | 37.8 | 49 |
| Union, West; RD 2 | 43.7 | 56.7 | 43.7 | 56.7 | 43.7 | 56.7 | 43.7 | 56.7 | 43.7 | 56.7 | 43.7 | 56.7 |
| Van Sickle; RD 1607 | 10.3 | 13.3 | 10.3 | 13.3 | 10.3 | 13.3 | 10.3 | 13.3 | 10.3 | 13.3 | 10.3 | 13.3 |
| Veale; RD 2065 | 15.4 | 19.6 | 15.4 | 19.6 | 15.4 | 19.6 | 15.4 | 19.6 | 15.4 | 19.6 | 15.4 | 19.6 |
| Venice; RD 2023 | 37.4 | 47.6 | 37.4 | 47.6 | 37.4 | 47.6 | 37.4 | 47.6 | 37.4 | 47.6 | 37.4 | 47.6 |
| Victoria; RD 2040 | 40.8 | 52.8 | 40.8 | 52.8 | 32.7 | 42.3 | 40.8 | 52.8 | 40.8 | 52.8 | 32.7 | 42.3 |
| Walnut Grove; RD 554 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Walthall; RD 2094 | | | | | | | | | | | | |
| Webb; RD 2026 | 17.6 | 19.2 | 17.6 | 19.2 | 17.6 | 19.2 | 17.6 | 19.2 | 17.6 | 19.2 | 17.6 | 19.2 |
| Weber; RD 828 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| West Island | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| West Sacramento; RD 900 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Wetherbee; RD 2096 | | | | | | | | | | | | |
| Winter; RD 2122 | 13 | 16.8 | 13 | 16.8 | 13 | 16.8 | 13 | 16.8 | 13 | 16.8 | 13 | 16.8 |
| Woodward; RD 2072 | 23.8 | 30.8 | 23.8 | 30.8 | 23.8 | 30.8 | 23.8 | 30.8 | 23.8 | 30.8 | 23.8 | 30.8 |
| Wright-Elmwood; RD 2119 | 19.2 | 24.8 | 19.2 | 24.8 | 19.2 | 24.8 | 19.2 | 24.8 | 19.2 | 24.8 | 19.2 | 24.8 |
| Yolano; RD 2068 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Yolo Bypass Unit 4 | | | | | | | | | | | | |
| Total Costs: | 1887 | 2361 | 1775 | 2221 | 1692 | 2121 | 1822 | 2278 | 1650 | 2069 | 1860 | 2326 |

## Draft Estimate of Levee Miles and Cost of Levee Earthwork for CALFED Alternatives 1, 2, and 3

| Island/Reclamation District | Levee Miles | Less Project | Corps Estimate Project Levee Sacto System Fix (millions) [1] | Less Local/Other | Current Design Level | Common Program Improvements (same for all alternatives) [2] | | ERPP Modifications Alternatives 1&2 | | ERPP Modifications Alt 3 with 5,000 cfs | | ERPP Modifications Alt 3 with 15,000 cfs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Low | High | Low | High | Low | High | Low | High |
| Andrus, Upper; RD 556 | 11.7 | 11.2 | 0 | 0 | | 1.35 | 1.75 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bacon; RD 2028 | 14.3 | 0 | | 0 | HMP | 38.6 | 50 | 0 | 0 | 5.5 | 6 | 5.5 | 6 |
| Bear Creek | 2.5 | 2.5 | | 0 | | | | | | | | | |
| Bethany | 5.2 | 0 | | 5.2 | unknown | | | | | | | | |
| Bethel Island MID | 11.5 | 0 | | 0 | none | 31 | 40.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bishop; RD 2042 | 7.8 | 0 | | 0 | HMP/FEMA100-yr | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bishop East | 0.6 | 0 | | 0.6 | unknown | | | | | | | | |
| Bixler; RD 2121 | 6.2 | 0 | | 0 | unknown | | | | | | | | |
| Boggs Dist; RD 404 | 5.3 | 4.1 | | 0 | HMP | 3.2 | 4.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Borrow Pond Area | 2 | 0 | | 2 | unknown | | | | | | | | |
| Bouldin; RD 756 | 18 | 0 | | 0 | none | 48.6 | 63 | 0 | 0 | 0 | 0 | 0 | 0 |
| Brack; RD 2033 | 10.8 | 0 | | 0 | none | 29.2 | 37.8 | 43.6 | 48.7 | 43.6 | 48.7 | 43.6 | 48.7 |
| Bradford; RD 2059 | 7.4 | 0 | | 0 | none | 20 | 25.9 | 20.5 | 22.3 | 20.5 | 22.3 | 20.5 | 22.3 |
| Brannan-Andrus RDs ~~2067/317/407~~ | 29.4 | 19.3 | 22.5 | 0 | HMP | 49.8 | 57.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| Byron; RD 800 | 19.3 | 0 | | 9.6 | HMP/PL-99 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cache Haas; RD 2098 | 11.6 | 11.6 | 10.8 | 0 | Project | 10.8 | 10.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| Canal Ranch; RD 2086 | 9.6 | 0 | | 0 | none | 25.9 | 33.6 | 28.7 | 32.6 | 28.7 | 32.6 | 28.7 | 32.6 |
| Chipps Island | 2.6 | 0 | | 2.6 | unknown | | | | | | | | |
| Clifton Court | 9.2 | 0 | | 9.2 | | | | | | | | | |
| Collinsville | 1.1 | 0 | | 0 | unknown | | | | | | | | |
| Coney; RD 2117 | 5.4 | 0 | | 0 | HMP | 14.6 | 18.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| Deadhorse; RD 2111 | 2.6 | 0 | | 0 | HMP | 7 | 9.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Delta Mendota | 2.1 | 0 | | 2.1 | unknown | | | | | | | | |
| Decker | 4.1 | 0 | | 4.1 | unknown | 11.1 | 14.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Drexler | 4 | 0 | | 4 | unknown | 10.8 | 14 | 0 | 0 | 0 | 0 | 20 | 20 |
| Egbert; RDs 538 and 2084 | 10.7 | 10.7 | 0.8 | 0 | none | 0.8 | 0.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ehrheart; RD 813 | 4.7 | 0 | | 0 | none | 12.7 | 16.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Empire; RD 2029 | 9.5 | 0 | | 0 | none | 25.6 | 33.2 | 0 | 0 | 5.5 | 6.5 | 5.5 | 6.5 |
| Fabian; RD 773 | 18.8 | 0 | | 0 | none | 50.8 | 65.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fay; RD 2113 | 1.6 | 0 | | 0 | none | 4.3 | 5.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Frank, Little | 3.5 | 0 | | 3.5 | unknown | 9.45 | 12.2 | 5.5 | 6 | 5.5 | 6 | 5.5 | 6 |
| Glanville; RD 1002 | 13 | 0 | | 0 | HMP | 35.1 | 45.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Glide; RD 765 | 1.7 | 1.7 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Grand; RD 3 | 29 | 29 | 1.7 | 0 | PL-99/FEMA100-yr | 1.7 | 1.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| Harbor Cove (Atlas); RD 2126 | 1.9 | 0 | | 0 | unknown | 5.1 | 6.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Harveys; RD 1609 | 12.4 | 0 | | 12.4 | unknown | 33.5 | 43.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hastings; RD 2060 | 16 | 16 | 2.1 | 0 | PL-99/FEMA100-yr | 2.1 | 2.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Holland; RD 2025 | 11 | 0 | | 0 | Bull 192-82/PL-99 | 0 | 0 | 0 | 0 | 5.5 | 6 | 5.5 | 6 |
| Holland Land; RD 999 | 33.4 | 33.4 | 0.2 | | | 0.2 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Holt; RD 2116 | 0.4 | 0 | | | none | 1.1 | 1.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hotchkiss; RD 799 | 6.3 | 0 | | | none | 17 | 22 | 0 | 0 | 0 | 0 | 0 | 0 |





D—031507

## Draft Estimate of Levee Miles and Cost of Levee Earthwork for CALFED Alternatives 1, 2, and 3

| Island/Reclamation District | Levee Miles | Less Project | Corps Estimate Project Levee Sacto System Fix (millions) [1] | Less Local/Other | Current Design Level | Common Program Improvements (same for all alternatives) [2] | | ERPP Modifications Alternatives 1&2 | | ERPP Modifications Alt 3 with 5,000 cfs | | ERPP Modifications Alt 3 with 15,000 cfs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Low | High | Low | High | Low | High | Low | High |
| Jersey; RD 830 | 15.6 | 0 | | | none | 42.1 | 54.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jones, Lower; RD 2038 | 9 | 0 | | | HMP | 24.3 | 31.5 | 0 | 0 | 0 | 0 | 5.5 | 6 |
| Jones, Upper; RD 2039 | 9.3 | 0 | | | HMP | 25.1 | 32.6 | 0 | 0 | 0 | 0 | 5.5 | 6 |
| Kasson; RD 2085 | 6.2 | 6.2 | | | | 16.7 | 21.7 | 25.9 | 30.6 | 25.9 | 30.6 | 25.9 | 30.6 |
| Kimball Island | 1.9 | | | 1.9 | | | | | | | | | |
| King; RD 2044 | 9.1 | 0 | | | HMP | 24.6 | 31.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| Libby McNeil; RD 369 | 1.9 | 0.8 | | 0 | | | | | | | | | |
| Liberty; RD 2093 | 14.5 | 0 | | | unknown | 39.1 | 50.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lisbon; RD 307 | 6.7 | 6.7 | 0 | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Little Mandeville; RD 2118 | 4.5 | 0 | | | none | | | | | | | | |
| Los Medanos | 5.6 | 0 | | 5.6 | | | | | | | | | |
| Maintenance Area 9 | 19.6 | 19.6 | 6.4 | | | 6.4 | 6.4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mandeville; RD 2027 | 14.3 | 0 | | | HMP | 38.6 | 50 | 0 | 0 | 22 | 24 | 22 | 24 |
| McCormack-Williamson; RD 2110 | 8.8 | 0 | | | none | 23.8 | 30.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| McMullin; RD 2075 | 7.5 | 7.5 | | | | | | | | | | | |
| McDonald; RD 2030 | 13.7 | 0 | | | HMP | 37 | 48 | 0 | 0 | 11 | 12 | 11 | 12 |
| Medford; RD 2041 | 5.9 | 0 | | | none | 15.9 | 20.6 | 5.7 | 6.8 | 5.7 | 6.8 | 5.7 | 6.8 |
| Merritt; RD 150 | 18.1 | 18.1 | 0.2 | | PL-99 | 0.2 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mildred; RD 2021 | 7.3 | | | | see comments | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Montezuma Flats | 1.9 | 0 | | 1.9 | | | | | | | | | |
| Montezuma Island | 0.4 | 0 | | 0.4 | | | | | | | | | |
| Mossdale 2; RD 2107 | 4.2 | 4.2 | 0 | | FEMA100-yr | 0 | 0 | 13 | 15.4 | 13 | 15.4 | 13 | 15.4 |
| Naglee Burke; RD 1007 | 8.3 | 0 | | | none | 22.4 | 29 | 0 | 0 | 0 | 0 | 0 | 0 |
| New Hope; RD 348 | 18.6 | 0 | | | none | 50.2 | 65.1 | 26 | 30 | 26 | 30 | 26 | 30 |
| Oakley | 6.7 | 0 | | 0 | | | | | | | | | |
| Orwood; RD 2024 | 6.3 | 0 | | | none | 17 | 22 | 0 | 0 | 0 | 0 | 5.5 | 6 |
| Palm; RD 2036 | 7.5 | 0 | | | none | 20.2 | 26.2 | 0 | 0 | 0 | 0 | 5.5 | 6 |
| Paradise; RD 2095 | 4.9 | 4.9 | | | | 13.2 | 17.2 | 16.5 | 19.5 | 16.5 | 19.5 | 49 | 51.4 |
| Pescadero; RD 2058 | 15.4 | 6.7 | | | HMP | 5.9 | 7.7 | 0 | 0 | 0 | 0 | 32.5 | 32.5 |
| Peters; RD 2104 | 8.4 | 8.4 | 8.3 | | | 8.3 | 8.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pierson; RD 561 | 14 | 6.8 | 0 | | FEMA100-yr | 19.4 | 25.2 | 22 | 24 | 22 | 24 | 22 | 24 |
| Prospect; RD 1667 | 10 | 2.9 | | | none | 19.2 | 24.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| Quimby; RD 2080 | 7 | 0 | | | HMP | 18.9 | 24.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Randall; RD 755 | 1.9 | 1.9 | | | | | | | | | | | |
| Rindge; RD 2037 | 15.8 | 0 | | | HMP | 42.7 | 55.3 | 0 | 0 | 11 | 12 | 11 | 12 |
| Rio Blanco; RD 2114 | 4.2 | 0 | | | none | 11.3 | 14.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| River Junction; RD 2064 | 11.9 | 11.9 | | | | 32.1 | 41.6 | 30.4 | 35.9 | 30.4 | 35.9 | 30.4 | 35.9 |
| Roberts, Lower; RD 684 | 16 | 0 | | | HMP | 43.2 | 56 | 0 | 0 | 0 | 0 | 0 | 0 |
| Roberts, Middle; RD 524 | 12.2 | 6.1 | | | none | 32.9 | 42.7 | 26.2 | 31 | 26.2 | 31 | 43.7 | 48 |
| Roberts, Upper; RD 544 | 15 | 10.6 | | | none | 40.5 | 52.5 | 33.6 | 39.7 | 33.6 | 39.7 | 98.9 | 105 |
| Rough and Ready | 5.5 | | | 3.2 | see comments | | | | | | | | |





D—031508

## Draft Estimate of Levee Miles and Cost of Levee Earthwork for CALFED Alternatives 1, 2, and 3

| Island/Reclamation District | Levee Miles | Less Project | Corps Estimate Project Levee Sacto System Fix (millions) [1] | Less Local/Other | Current Design Level | Common Program Improvements (same for all alternatives) [2] | | ERPP Modifications Alternatives 1&2 | | ERPP Modifications Alt 3 with 5,000 cfs | | ERPP Modifications Alt 3 with 15,000 cfs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Low | High | Low | High | Low | High | Low | High |
| Ryer; RD 501 | 20.6 | 20.6 | 1.6 | | PL-99 | 1.6 | 1.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sacramento Deepwater | 26 | | | 26 | | | | | | | | | |
| Sargent Barnhart; RD 2074 | 6 | 1.5 | | 1 | FEMA100-yr | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sherman; RD 341 | 19.5 | 9.7 | 0.9 | | none | 26.5 | 34.3 | 30.2 | 33 | 30.2 | 33 | 30.2 | 33 |
| Sherman West | 5.5 | 0 | | 5.5 | | | | | | | | | |
| Shima; RD 2115 | 6.6 | 0 | | | HMP | 17.8 | 23.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shin Kee | 3.6 | 0 | | 3.6 | | 9.7 | 12.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| SJCFCD Five Mile Slough | 1.4 | 0 | | 0 | | | | | | | | | |
| SJCFCD Fourteen Mile Slough | 2 | 0 | | 0 | | | | | | | | | |
| SJCFCD Mosher Slough | 4.1 | 0 | | 0 | | | | | | | | | |
| San Joaquin River; RD 17 | 16.2 | 16.2 | 0 | | FEMA100-yr | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Smith Tract; RD 1614 | 2.2 | 0 | | | HMP/FEMA 100-yr | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Smith Ranch; RD 1608 | 4.3 | 0 | | 0 | FEMA100-yr | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spinner Island | 0.8 | | | 0.8 | | | | | | | | | |
| Stark; RD 2089 | 3.5 | 2.8 | 0 | | HMP/FEMA 100-yr | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Staten; RD 38 | 25.4 | 0 | | | none | 68.6 | 88.9 | 4.4 | 5.2 | 4.4 | 5.2 | 4.4 | 5.2 |
| Stewart; RD 2062 | 12.3 | 12.3 | | | PL-99 | 33.2 | 43 | 14.6 | 17.2 | 14.6 | 17.2 | 55.4 | 58 |
| Sutter; RD 349 | 12.5 | 12.5 | 0.3 | | PL-99 | 0.3 | 0.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Terminous; RD 548 | 21 | 0 | | 4.9 | HMP | 56.7 | 73.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tinsley; RD 2108 | | | | | none | | | | | | | | |
| Twitchell; RD 1601 | 14.04 | 2.5 | 7.9 | | HMP | 31.2 | 40.4 | 40.1 | 42.5 | 40.1 | 42.5 | 40.1 | 42.5 |
| Tyler; RD 563 | 23.06 | 12.2 | 6.7 | | HMP | 29.3 | 38 | 13.2 | 14.6 | 13.2 | 14.6 | 13.2 | 14.6 |
| Union, East; RD 1 | 14 | 1 | | | HMP | 37.8 | 49 | 0 | 0 | 0 | 0 | 0 | 0 |
| Union, West; RD 2 | 16.2 | 0 | | | HMP | 43.7 | 56.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| Van Sickle; RD 1607 | 3.8 | 0 | | | none | 10.3 | 13.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Veale; RD 2065 | 5.7 | 0 | | 0 | none | 15.4 | 19.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Venice; RD 2023 | 12.3 | 0 | | | HMP | 33.2 | 43 | 8.2 | 9.8 | 8.2 | 9.8 | 8.2 | 9.8 |
| Victoria; RD 2040 | 15.1 | 0 | | | HMP | 40.8 | 52.8 | 0 | 0 | 0 | 0 | 11 | 12 |
| Walnut Grove; RD 554 | 6.1 | 1 | | 1.5 | FEMA 100-yr | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Walthall; RD 2094 | 3.3 | 3.3 | | | | | | | | | | | |
| Webb; RD 2026 | 12.9 | 0 | | | HMP/Bull 192-82 | 34.8 | 45.2 | 17.6 | 19.2 | 17.6 | 19.2 | 17.6 | 19.2 |
| Weber; RD 828 | 1.7 | 0 | | | HMP/FEMA 100-yr | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| West Island | 3 | 0 | | 3 | | | | | | | | | |
| West Sacramento; RD 900 | 13.6 | 13.6 | | | FEMA 100-yr | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Wetherbee; RD 2096 | 0.2 | 0.2 | | | | | | | | | | | |
| Winter; RD 2122 | 4.8 | 0 | | | none | 13 | 16.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| Woodward; RD 2072 | 8.8 | 0 | | | HMP | 23.8 | 30.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| Wright-Elmwood; RD 2119 | 7.1 | 0 | | | HMP | 19.2 | 24.8 | 0 | 0 | 0 | 0 | 0 | 0 |
| Yolano; RD 2068 | 8.7 | 8.7 | 0 | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Yolo Bypass Unit 4 | 3.6 | 3.6 | | | | | | | | | | | |

## Draft Estimate of Levee Miles and Cost of Levee Earthwork for CALFED Alternatives 1, 2, and 3

| Island/Reclamation District | Levee Miles | Less Project | Corps Estimate Project Levee Sacto System Fix (millions) [1] | Less Local/Other | Current Design Level | Common Program Improvements (same for all alternatives) [2] | | ERPP Modifications Alternatives 1&2 | | ERPP Modifications Alt 3 with 5,000 cfs | | ERPP Modifications Alt 3 with 15,000 cfs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Low | High | Low | High | Low | High | Low | High |
| | Total Levee Miles | Total Project Levees | Total Project Sac Levee Fix Estimate | Total Local/Other Levees | Total Cost Levee Upgrades (Millions) | | | | | | | | |
| | 1125 | 385 | 70.40 | 115 | | 1740 | 2238 | 426 | 484 | 486 | 551 | 728 | 794 |

[1] From US Army Corps of Engineers 1993 System Final Report - Lower Sacramento

[2] Includes US Army Corps of Engineers Estimate for project Levee Repairs

**Cost Summarization for Delta Levee Improvements With Habitat Benefits for Alternatives 1 and 2**

| Island Name | Proposed Improvement | Type | Location (levee mile) | Miles | Habitat Acres | Habitat Cost in Millions |
|---|---|---|---|---|---|---|
| Pierson RD 551 | 4 miles of Snodgrass setback | N | Lambert Rd south | 4 | 12 | 22M - 24M |
| New Hope RD 348 | S. Fk Mokelumne levee imp | L | l.m. 7.72 - 4.54 | 3.18 | 15.9 | 17.5M- 20.7M |
| New Hope RD 348 | Beaver Sl levee setback | N | l.m. 4.54 - 3 | 1.54 | 4.62 | 8.5 M- 9.25M |
| Canal Ranch RD2086 | S. Fk Mokelumne levee imp | L | l.m. 2.25 - 4.60 | 2.35 | 11.75 | 12.9M- 15.3M |
| Canal Ranch RD2086 | Hog Slough levee setback | N | l.m. 4.60 - 7.48 | 2.88 | 8.64 | 15.8M- 17.3M |
| Brack RD 2033 | S. Fk Mokelumne levee imp | L | l.m. 1.3-0.00&0.00-1 | 2.3 | 11.5 | 12.7M- 15M |
| Brack RD 2033 | Sycamore Sl levee setback | N | l.m. 1 - 6.62 | 6.62 | 19.86 | 30.9M- 33.7M |
| Staten RD 38 | Isl tip cut-off SE corner 0.8m | L | straight line lm 10-13 | 0.8 | 4 | 4.4M - 5.2M |
| Tyler RD 563 | Georgiana Sl levee setback | N | l.m. 8 - 6 | 2 | 6 | 11M - 12M |
| Tyler RD 563 | Georgiana Sl tip cut-off 0.4m | L | straight line lm 10-8.5 | 0.4 | 2 | 2.2M - 2.6M |
| Sherman RD 341 | San Joaquin R levee setback | N | l.m. 5.5 - 0 | 5.5 | 16.5 | 30.2M - 33M |
| Twitchell RD 1601 | Three Mile Sl wave wall prot | G | l.m. 0 - 2.47 | 2.47 | 0 | 16.5M |
| Twitchell RD 1601 | San Joaquin R levee setback | N | l.m. 7 - 8.5&9.5-11.9 | 3.9 | 11.7 | 21.4M- 23.4M |
| Twitchell RD 1601 | Isl tip cut-off on San Joaq R | L | straight lne lm 8.5-9.5 | 0.4 | 2 | 2.2M - 2.6M |
| Bradford RD 2059 | San Joaquin R levee setback | N | l.m 5.82 - 2.10 | 3.72 | 11.16 | 20.5M -22.3M |
| Little Franks Tract | Piper Slough levee imprmnt | L | south levee by Bethel | 1 | 5 | 5.5M - 6M |
| Webb RD 2026 | San Joaquin R levee setback | N | l.m. 10 - 6.8 | 3.2 | 9.6 | 17.6M -19.2M |
| Venice RD 2023 | Isl tip cut-off on San Joaq R | L | straight lne lm 7.5-9.3 | 0.8 | 4 | 4.4M - 5.2M |
| Venice RD 2023 | Isl tip cut-off on San Joaq R | L | straight lm11.5-12.3 | 0.7 | 3.5 | 3.8M - 4.6M |
| Medford RD 2041 | Middle River levee impr | L | l.m. 1.74 - 0.7 | 1.04 | 5.2 | 5.7M - 6.8M |
| Middle Roberts 524 | San Joaquin R levee impr | L | l.m. 1.5 - 6.26 | 4.76 | 23.8 | 26.2M - 31M |
| Upper Roberts 544 | San Joaquin R levee impr | L | l.m. 0 - 6.11 | 6.11 | 30.55 | 33.6M -39.7M |
| Stewart RD 2062 | San Joaquin R levee impr | L | l.m. 0 (unit 1) -2.65 | 2.65 | 13.25 | 14.6M -17.2M |
| Mossdale 2 RD2107 | San Joaquin R levee impr | L | l.m. 0 (unit 1) -2.37 | 2.37 | 11.85 | 13M - 15.4M |
| Paradise RD 2095 | San Joaquin R levee impr | L | l.m 0 (unit 2) - 3 | 3 | 15 | 16.5M -19.5M |
| Kasson RD 2085 | San Joaquin R levee impr | L | l.m 0.5 (unit 1) - 5.20 | 4.7 | 23.5 | 25.9M -30.6M |
| River Junct RD2064 | San Joaquin R levee impr | L | l.m. 0 (unit 1) - 5.53 | 5.53 | 27.65 | 30.4M -35.9M |
| | | | **Totals =** | **77.92** | **310.5** | **$426M - $484M** |

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**Cost Summarization for Delta Levee Improvements With Habitat Benefits for Alternatives 3 With 5,000 CFS Isolated Facility**

| Island Name | Proposed Improvement | Type | Location (levee mile) | Miles | Habitat Acres | Cost in Millions |
|---|---|---|---|---|---|---|
| Pierson RD 551 | 4 miles of Snodgrass setback | N | Lambert Rd south | 4 | 12 | 22M - 24M |
| New Hope RD 348 | S. Fk Mokelumne levee imp | L | l.m. 7.72 - 4.54 | 3.18 | 15.9 | 17.5M- 20.7M |
| New Hope RD 348 | Beaver Sl levee setback | N | l.m. 4.54 - 3 | 1.54 | 4.62 | 8.5 M- 9.25M |
| Canal Ranch RD2086 | S. Fk Mokelumne levee imp | L | l.m. 2.25 - 4.60 | 2.35 | 11.75 | 12.9M- 15.3M |
| Canal Ranch RD2086 | Hog Slough levee setback | N | l.m. 4.60 - 7.48 | 2.88 | 8.64 | 15.8M- 17.3M |
| Brack RD 2033 | S. Fk Mokelumne levee imp | L | l.m. 1.3-0.00&0.00-1 | 2.3 | 11.5 | 12.7M- 15M |
| Brack RD 2033 | Sycamore Sl levee setback | N | l.m. 1 - 6.62 | 6.62 | 19.86 | 30.9M- 33.7M |
| Staten RD 38 | Isl tip cut-off SE corner 0.8m | L | straight line lm 10-13 | 0.8 | 4 | 4.4M - 5.2M |
| Tyler RD 563 | Georgiana Sl levee setback | N | l.m. 8 - 6 | 2 | 6 | 11M - 12M |
| Tyler RD 563 | Georgiana Sl tip cut-off 0.4m | L | straight line lm 10-8.5 | 0.4 | 2 | 2.2M - 2.6M |
| Sherman RD 341 | San Joaquin R levee setback | N | l.m. 5.5 - 0 | 5.5 | 16.5 | 30.2M - 33M |
| Twitchell RD 1601 | Three Mile Sl wave wall prot | G | l.m. 0 - 2.47 | 2.47 | 0 | 16.5M |
| Twitchell RD 1601 | San Joaquin R levee setback | N | l.m. 7 - 8.5&9.5-11.9 | 3.9 | 11.7 | 21.4M- 23.4M |
| Twitchell RD 1601 | Isl tip cut-off on San Joaq R | L | straight lne lm 8.5-9.5 | 0.4 | 2 | 2.2M - 2.6M |
| Bradford RD 2059 | San Joaquin R levee setback | N | l.m 5.82 - 2.10 | 3.72 | 11.16 | 20.5M -22.3M |
| Little Franks Tract | Piper Slough levee imprmnt | L | south levee by Bethel | 1 | 5 | 5.5M - 6M |
| Webb RD 2026 | San Joaquin R levee setback | N | l.m. 10 - 6.8 | 3.2 | 9.6 | 17.6M -19.2M |
| Venice RD 2023 | Isl tip cut-off on San Joaq R | L | straight lne lm 7.5-9.3 | 0.8 | 4 | 4.4M - 5.2M |
| Venice RD 2023 | Isl tip cut-off on San Joaq R | L | straight lm11.5-12.3 | 0.7 | 3.5 | 3.8M - 4.6M |
| Medford RD 2041 | Middle River levee impr | L | l.m. 1.74 - 0.7 | 1.04 | 5.2 | 5.7M - 6.8M |
| Middle Roberts 524 | San Joaquin R levee impr | L | l.m. 1.5 - 6.26 | 4.76 | 23.8 | 26.2M - 31M |
| Upper Roberts 544 | San Joaquin R levee impr | L | l.m. 0 - 6.11 | 6.11 | 30.55 | 33.6M -39.7M |
| Stewart RD 2062 | San Joaquin R levee impr | L | l.m. 0 (unit 1) -2.65 | 2.65 | 13.25 | 14.6M -17.2M |
| Mossdale 2 RD2107 | San Joaquin R levee impr | L | l.m. 0 (unit 1) -2.37 | 2.37 | 11.85 | 13M - 15.4M |
| Paradise RD 2095 | San Joaquin R levee impr | L | l.m 0 (unit 2) - 3 | 3 | 15 | 16.5M -19.5M |
| Kasson RD 2085 | San Joaquin R levee impr | L | l.m 0.5 (unit 1) - 5.20 | 4.7 | 23.5 | 25.9M -30.6M |
| River Junct RD2064 | San Joaquin R levee impr | L | l.m. 0 (unit 1) - 5.53 | 5.53 | 27.65 | 30.4M -35.9M |
| Mandeville RD 2027 | Old River levee impr | N | l.m. 7 - 11 | 4 | 12 | 22M - 24M |
| Holland RD 2025 | Sand Mound Sl levee impr | N | l.m. 6 - 5 | 1 | 3 | 5.5M - 6M |
| Bacon RD 2028 | Old River levee impr | N | l.m. 10 - 8 | 2 | 6 | 11M - 12M |
| McDonald RD 2030 | Middle River levee impr | N | l.m. 10 - 8 | 2 | 6 | 11M - 12M |
| Empire RD 2029 | Little Connection Sl levee | L | l.m. 6.5 - 7.5 | 1 | 5 | 5.5M - 6.5M |
| Rindge RD 2037 | San Joaquin R levee impr | N | l.m. 5 - 7 | 2 | 6 | 11M - 12M |
| | | | **Totals =** | **89.92** | **348.5** | **$492M - $556.5M** |

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**Cost Summarization for Delta Levee Improvements With Habitat Benefits for Alternatives 3 With 15,000 CFS Isolated Facility**

| Island Name | Proposed Improvement | Type | Location (levee mile) | Miles | Habitat Acres | Habitat Cost in Millions |
|---|---|---|---|---|---|---|
| Pierson RD 551 | 4 miles of Snodgrass setback | N | Lambert Rd south | 4 | 12 | 22M - 24M |
| New Hope RD 348 | S. Fk Mokelumne levee imp | L | l.m. 7.72 - 4.54 | 3.18 | 15.9 | 17.5M- 20.7M |
| New Hope RD 348 | Beaver Sl levee setback | N | l.m. 4.54 - 3 | 1.54 | 4.62 | 8.5 M- 9.25M |
| Canal Ranch RD2086 | S. Fk Mokelumne levee imp | L | l.m. 2.25 - 4.60 | 2.35 | 11.75 | 12.9M- 15.3M |
| Canal Ranch RD2086 | Hog Slough levee setback | N | l.m. 4.60 - 7.48 | 2.88 | 8.64 | 15.8M- 17.3M |
| Brack RD 2033 | S. Fk Mokelumne levee imp | L | l.m. 1.3-0.00&0.00-1 | 2.3 | 11.5 | 12.7M- 15M |
| Brack RD 2033 | Sycamore Sl levee setback | N | l.m. 1 - 6.62 | 6.62 | 19.86 | 30.9M- 33.7M |
| Staten RD 38 | Isl tip cut-off SE corner 0.8m | L | straight line lm 10-13 | 0.8 | 4 | 4.4M - 5.2M |
| Tyler RD 563 | Georgiana Sl levee setback | N | l.m. 8 - 6 | 2 | 6 | 11M - 12M |
| Tyler RD 563 | Georgiana Sl tip cut-off 0.4m | L | straight line lm 10-8.5 | 0.4 | 2 | 2.2M - 2.6M |
| Sherman RD 341 | San Joaquin R levee setback | N | l.m. 5.5 - 0 | 5.5 | 16.5 | 30.2M - 33M |
| Twitchell RD 1601 | Three Mile Sl wave wall prot | G | l.m. 0 - 2.47 | 2.47 | 0 | 16.5M |
| Twitchell RD 1601 | San Joaquin R levee setback | N | l.m. 7 - 8.5&9.5-11.9 | 3.9 | 11.7 | 21.4M- 23.4M |
| Twitchell RD 1601 | Isl tip cut-off on San Joaq R | L | straight lne lm 8.5-9.5 | 0.4 | 2 | 2.2M - 2.6M |
| Bradford RD 2059 | San Joaquin R levee setback | N | l.m 5.82 - 2.10 | 3.72 | 11.16 | 20.5M -22.3M |
| Little Franks Tract | Piper Slough levee imprmnt | L | south levee by Bethel | 1 | 5 | 5.5M - 6M |
| Webb RD 2026 | San Joaquin R levee setback | N | l.m. 10 - 6.8 | 3.2 | 9.6 | 17.6M -19.2M |
| Venice RD 2023 | Isl tip cut-off on San Joaq R | L | straight lne lm 7.5-9.3 | 0.8 | 4 | 4.4M - 5.2M |
| Venice RD 2023 | Isl tip cut-off on San Joaq R | L | straight lm11.5-12.3 | 0.7 | 3.5 | 3.8M - 4.6M |
| Medford RD 2041 | Middle River levee impr | L | l.m. 1.74 - 0.7 | 1.04 | 5.2 | 5.7M - 6.8M |
| Middle Roberts 524 | San Joaquin R levee impr | L | l.m. 1.5 - 6.26 | 4.76 | 23.8 | 26.2M - 31M |
| Upper Roberts 544 | San Joaquin R levee impr | L | l.m. 0 - 6.11 | 6.11 | 30.55 | 33.6M -39.7M |
| Stewart RD 2062 | San Joaquin R levee impr | L | l.m. 0 (unit 1) -2.65 | 2.65 | 13.25 | 14.6M -17.2M |
| Mossdale 2 RD2107 | San Joaquin R levee impr | L | l.m. 0 (unit 1) -2.37 | 2.37 | 11.85 | 13M - 15.4M |
| Paradise RD 2095 | San Joaquin R levee impr | L | l.m 0 (unit 2) - 3 | 3 | 15 | 16.5M -19.5M |
| Kasson RD 2085 | San Joaquin R levee impr | L | l.m 0.5 (unit 1) - 5.20 | 4.7 | 23.5 | 25.9M -30.6M |
| River Junct RD2064 | San Joaquin R levee impr | L | l.m. 0 (unit 1) - 5.53 | 5.53 | 27.65 | 30.4M -35.9M |
| | | | | | | |
| Mandeville RD 2027 | Old River levee impr | N | l.m. 7 - 11 | 4 | 12 | 22M - 24M |
| Holland RD 2025 | Sand Mound Sl levee impr | N | l.m. 6 - 5 | 1 | 3 | 5.5M - 6M |
| Bacon RD 2028 | Old River levee impr | N | l.m. 10 - 8 | 2 | 6 | 11M - 12M |
| McDonald RD 2030 | Middle River levee impr | N | l.m. 10 - 8 | 2 | 6 | 11M - 12M |
| Empire RD 2029 | Little Connection Sl levee | L | l.m. 6.5 - 7.5 | 1 | 5 | 5.5M - 6.5M |
| Rindge RD 2037 | San Joaquin R levee impr | N | l.m. 5 - 7 | 2 | 6 | 11M - 12M |

| | | | | | | |
|---|---|---|---|---|---|---|
| Palm RD 2036 | Old River levee impr | N | l.m. 4 - 5 | 1 | 3 | 5.5M - 6M |
| Orwood RD 2024 | Old River levee impr | N | l.m. 0.5 - 1.5 | 1 | 3 | 5.5M - 6M |
| Lower Jones RD2038 | Middle River levee impr | N | l.m. 1 - 0 | 1 | 3 | 5.5M - 6M |
| Upper Jones RD2039 | Middle River levee impr | N | l.m. 0 - 1 | 1 | 3 | 5.5M - 6M |
| Victoria RD 2040 | Old River levee impr | N | l.m. 7 - 9 | 2 | 6 | 11M - 12M |
| Paradise RD 2095 | Tom Paine Sl levee impr | O | none | 6.5 | 26 | 32.5M |
| Pescadero RD 2058 | Tom Paine Sl levee impr | O | none | 6.5 | 26 | 32.5M |
| Stewart RD 2062 | Paradise Cut levee impr | O | l.m. 0 - 4.03 | 4.03 | 16.12 | 20.2M |
| Stewart RD 2062 | Old River levee impr | O | l.m. 5.63 (unit 3) -1.5 | 4.13 | 16.5 | 20.6M |
| Upper RobertsRD544 | Middle River levee impr | O | l.m. 1.14 - 14.2 | 13.06 | 52.2 | 65.3M |
| MiddleRobertsRD524 | Middle River levee impr | O | none | 3.5 | 14 | 17.5M |
| Drexler | Middle River levee impr | O | none | 4 | 16 | 20M |
| | | | **Totals =** | **137.6** | **533.3** | **$723M - $801M** |

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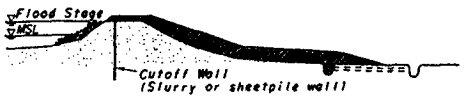
# TABLE 4-1: EXAMPLES OF LEVEE AND HABITAT IMPROVEMENTS



| LEVEE IMPROVEMENT EXAMPLES | PURPOSE | APPLICABLE AREAS | POSITIVES | NEGATIVES |
|---|---|---|---|---|
|  <br>A. Placement of Fill on Levee Crown and Landside Slope in Firm Mineral Soil Foundation Areas | o Increases freeboard and flood protection.<br>o Increases landside slope stability.<br>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.<br>b. Levee improvements stay within general footprint of existing levee and drain ditch.<br>c. Relatively easily maintained as a flood control levee.<br>d. Provides small increase in seismic stability. | a. Requires import of mineral soil.<br>b. Represents a significant cost.<br>c. Provides no environmental enhancement.<br>d. Provides no significant increase in seismic stability.<br>e. Addition of fill may result in short-term instability and/or cracking if levee/foundation system is weak. |
|  <br>B. Placement of Fill on Levee Crown and Landside Slope, Together with Landside Berm in Soft Foundation Areas | o Increases freeboard and flood protection.<br>o Increases landside slope stability.<br>o Lengthens seepage path.<br>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.<br>b. Relatively easily maintained as a flood control levee.<br>c. Provides limited increase in seismic stability. | a. Requires significant import of mineral soil.<br>b. Represents a significant cost.<br>c. Provides no environmental enhancement.<br>d. Provides only slight increase in seismic stability.<br>e. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used.<br>f. Seepage system may need to be modified.<br>g. Infringes on inboard farm land or habitat areas. |
|  <br>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.<br>o Increases landside slope stability.<br>o Significantly lengthens seepage path, stops concentrated seepage areas.<br>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.<br>b. Provides significant improvement in control of seepage problems in levee.<br>c. Relatively easily maintained as a flood control levee.<br>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.<br>b. Placement of fill represents a significant cost.<br>c. Construction of cutoff wall represents a major cost.<br>d. Provides no environmental enhancement.<br>e. Levee and foundation may still be unstable during earthquake loading.<br>f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used.<br>g. Construction of cutoff wall may result in hydraulic fracturing and/or levee cracking if not carried out carefully.<br>h. Lowered ground water inboard of wall may result in differential settlement and cracking.<br>i. Seepage system may need to be modified. |



D-031515

# TABLE 4-1: EXAMPLES OF LEVEE AND HABITAT IMPROVEMENTS



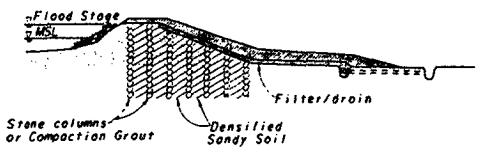
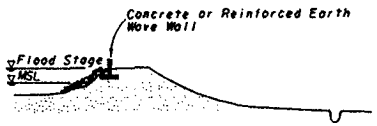
| LEVEE IMPROVEMENT EXAMPLES | PURPOSE | APPLICABLE AREAS | POSITIVES | NEGATIVES |
|---|---|---|---|---|
|  <br>D. Placement of FW on Levee Crown, on Landside Slope, and in Landside Berm in Soft Foundation Areas - Together with Filter/Drain System on Landside Slope | o Increases freeboard and flood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



D-031516

# TABLE 4-1: EXAMPLES OF LEVEE AND HABITAT IMPROVEMENTS



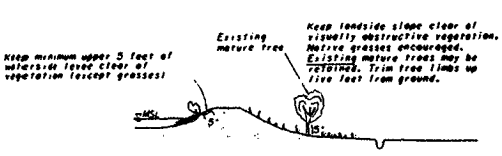
| LEVEE IMPROVEMENT EXAMPLES | PURPOSE | APPLICABLE AREAS | POSITIVES | NEGATIVES |
|---|---|---|---|---|
|  <br>F. Placement of Fill on Levee Crown, on Landside Slope, and in Landside Berm in Soft Foundation Areas - Together with Filter/Drain System on Landside Slope. Densification of Levee and Foundation Soils Using Vibroreplacement (Stone Columns) or Compaction Grouting. | o Increases freeboard and flood protection.<br>o Increases landside slope stability.<br>o Lengthens seepage path, stabilizes concentrated leaks and prevents piping erosion through levee.<br>o Placement of berm accounts for soft foundation.<br>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.<br>b. Provides significant improvement in control of seepage problems in levee.<br>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.<br>b. Placement of fill represents a significant cost.<br>c. Construction of filter/drain represents additional cost.<br>d. Densification represents a major cost.<br>e. Provides no environmental enhancement.<br>f. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used.<br>g. Densification construction may cause levee distress or seepage problems if not carried out carefully.<br>h. Seepage system may need to be modified.<br>i. Seepage and filter/drain system may need to be maintained.<br>j. Infringes on inboard farm land or habitat areas. |
|  <br>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.<br>b. Relatively inexpensive.<br>c. Can be constructed relatively quickly. | a. Provides no significant improvement in:<br>- overall freeboard.<br>- structural stability.<br>- seepage control.<br>- piping erosion.<br>- seismic stability.<br>b. Provides no environmental enhancement. |
|  <br>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.<br>b. Relatively inexpensive.<br>c. Can be constructed relatively quickly. | a. Provides no significant improvement in:<br>- overall freeboard.<br>- structural stability.<br>- seepage control.<br>- piping erosion.<br>- seismic stability.<br>b. Requires limited import of fill.<br>c. Provides no environmental enhancement.<br>d. Installation of sheetpile wall may result in cracking of levee if not carried out with care. |



D—031517

# TABLE 4-1: EXAMPLES OF LEVEE AND HABITAT IMPROVEMENTS



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



D—031518

# TABLE 4-1: EXAMPLES OF LEVEE AND HABITAT IMPROVEMENTS

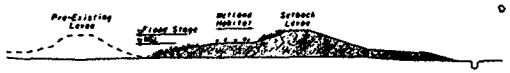
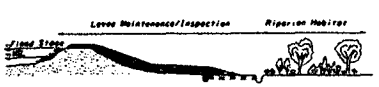
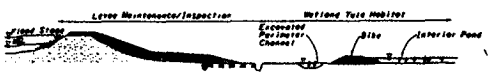


| LEVEE IMPROVEMENT EXAMPLES | PURPOSE | APPLICABLE AREAS | POSITIVES | NEGATIVES |
|---|---|---|---|---|
|  <br>L. Placement of FM on Levee Crown and Landside Slope. Together with Landside Berm in Soft Foundation Areas. Placement of FM between Channel Island and Levee to Create Waterside Wetland and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

D-031519

# TABLE 4-1: EXAMPLES OF LEVEE AND HABITAT IMPROVEMENTS



| LEVEE IMPROVEMENT EXAMPLES | PURPOSE | APPLICABLE AREAS | POSITIVES | NEGATIVES |
|---|---|---|---|---|
|  <br>O. Complete Setback of Levee to Improve Channel Capacity, Improve Levee Structural Stability and Provide Waterside Wetland Habitat. | o Increases channel capacity.<br>o Improves levee stability.<br>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.<br>b. New levee would be on engineered fill and would not liquefy during seismic events.<br>c. Provides Waterside Wetland Habitat. | a. Requires major import of mineral soil.<br>b. Fill placement and cost associated with levee setback greater than simply raising levee crown and adding berm.<br>c. Foundation liquefaction could still cause failure during future earthquake.<br>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.<br>e. Significantly infringes on inboard farm land or habitat areas. |
|  <br>P. Placement of Fill on Levee Crown and Landside Slope. Together with Landside Berm in Soft Foundation Areas. Creation of Landside Riparian Habitat. | o Increases freeboard and flood protection.<br>o Increases landside slope stability.<br>o Lengthens seepage path.<br>o Placement of berm accounts for soft foundation.<br>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.<br>b. Relatively easily maintained as a flood control levee.<br>c. Provides limited increase in seismic stability.<br>d. Provides Landside Riparian Habitat.<br>e. Reduces subsidence near levee by not tilling land in habitat area. | a. Requires significant import of mineral soil.<br>b. Represents a significant cost.<br>c. Provides only slight increase in seismic stability.<br>d. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used.<br>e. Seepage system may need to be modified.<br>f. Significantly infringes on inboard farm land and requires some land to be taken out of agricultural production. |
|  <br>O. Placement of Fill on Levee Crown and Landside 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.<br>o Increases landside slope stability.<br>o Lengthens seepage path.<br>o Placement of berm accounts for soft foundation.<br>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.<br>b. Relatively easily maintained as a flood control levee.<br>c. Provides limited increase in seismic stability.<br>d. Provides Landside Wetland Habitat.<br>e. Reduces subsidence near levee by keeping organic soils saturated. | a. Requires significant import of mineral soil.<br>b. Represents a significant cost.<br>c. Provides only slight increase in seismic stability.<br>d. Addition of fill may result in short-term instability and/or cracking if staged-construction is not used.<br>e. Seepage system may need to be modified.<br>f. Significantly infringes on inboard farm land and requires some land to be taken out of agricultural production.<br>g. Inland pond and dike systems require maintenance. |



D-031520

DEPARTMENT OF WATER RESOURCES

# SACRAMENTO RIVER FLOOD CONTROL PROJECT
## RECLAMATION DISTRICT NOS. 755, 551, 369 & 554

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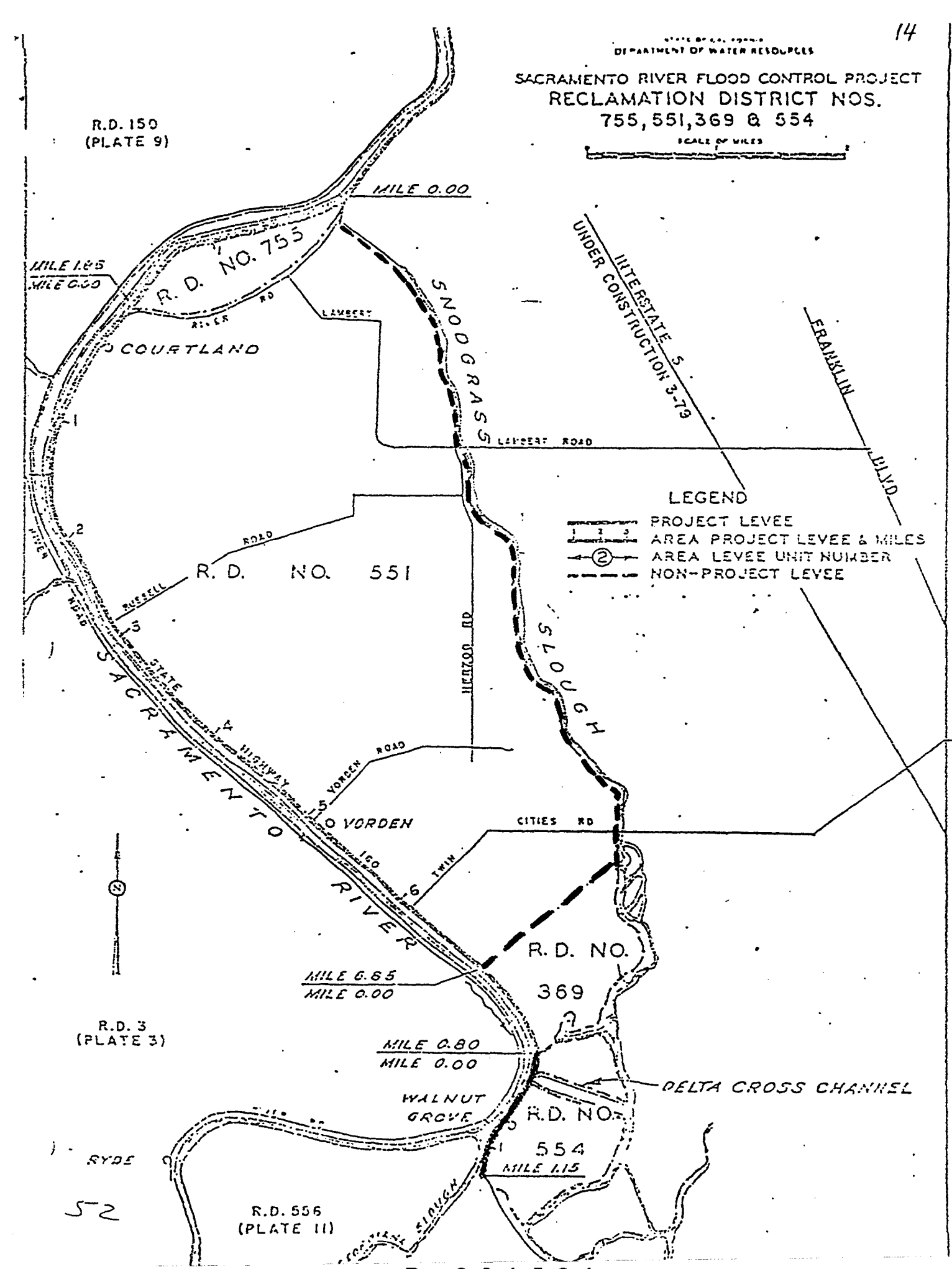
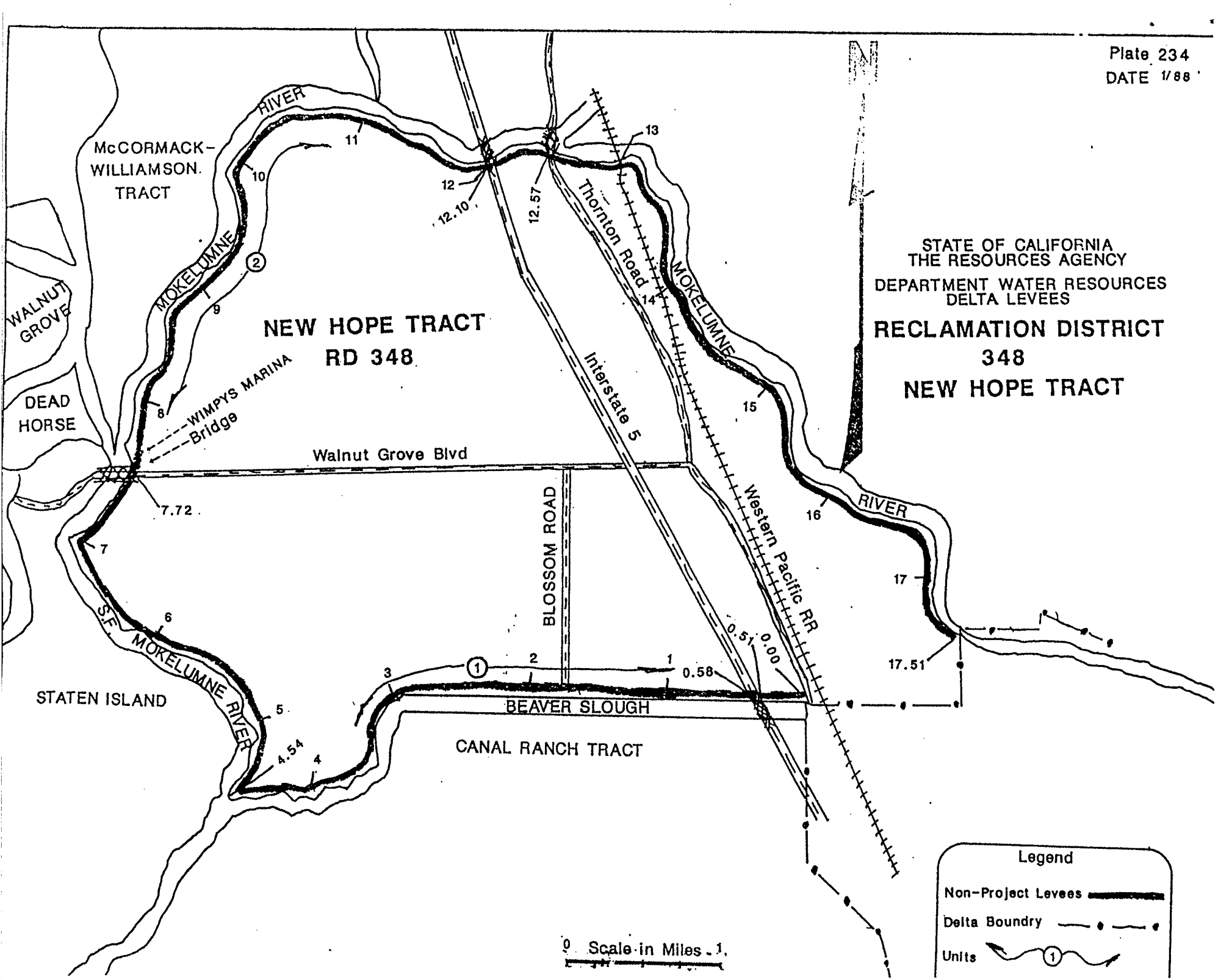



D—031521

D-031521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D-031522
D—031522
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
Thornton Road
Interstate 5
Western Pacific RR
BEAVER SLOUGH
11
10
12
12.10
12.57
13
14
15
16
17
17.51
9
8
7.72
7
6
5
4.54
4
3
2
1
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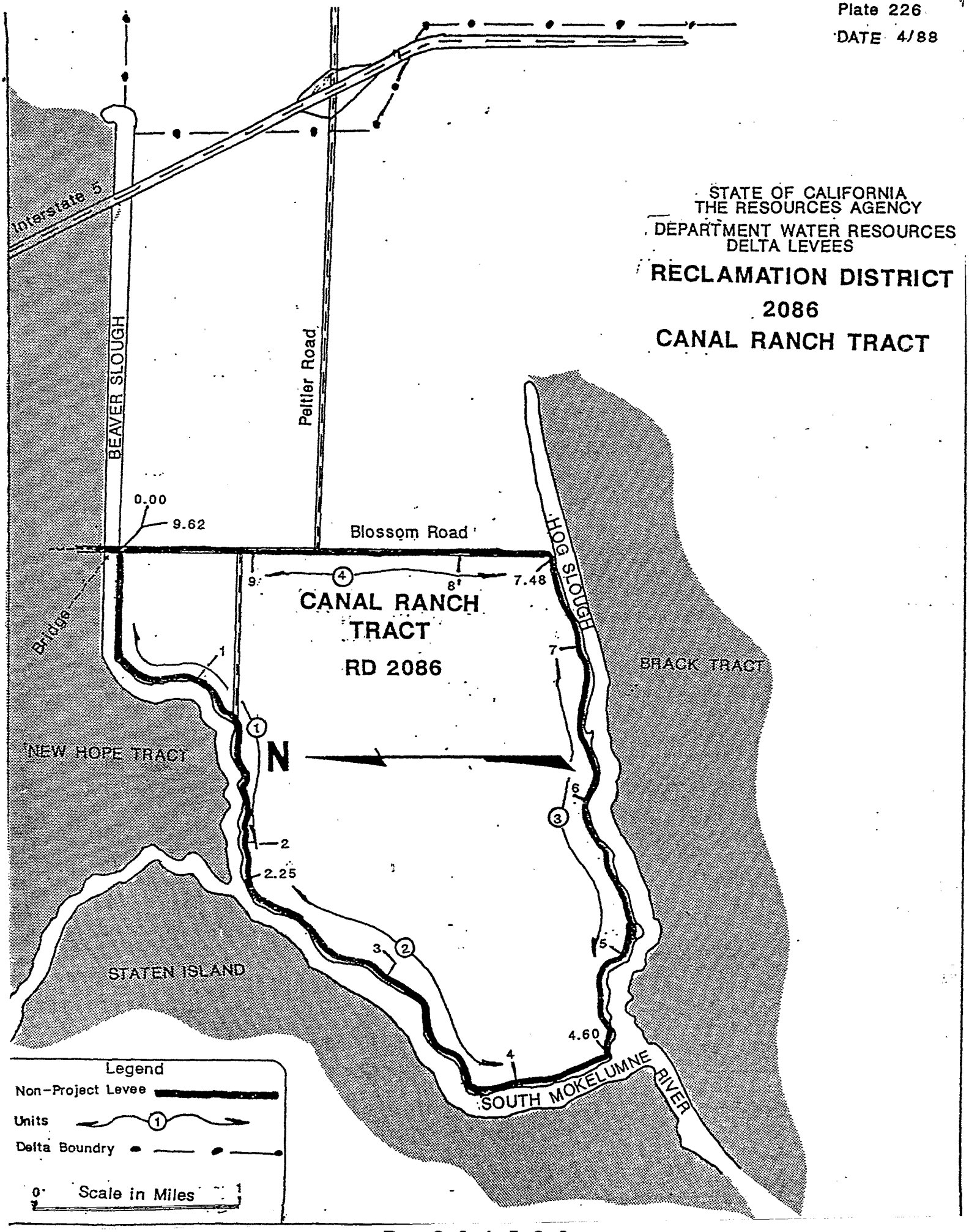
0.51
0.00
Legend
Non-Project Levees
Delta Boundry
Units
0 Scale in Miles 1

Plate 226
DATE 4/88

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES

# RECLAMATION DISTRICT 2086
# CANAL RANCH TRACT




D-031523

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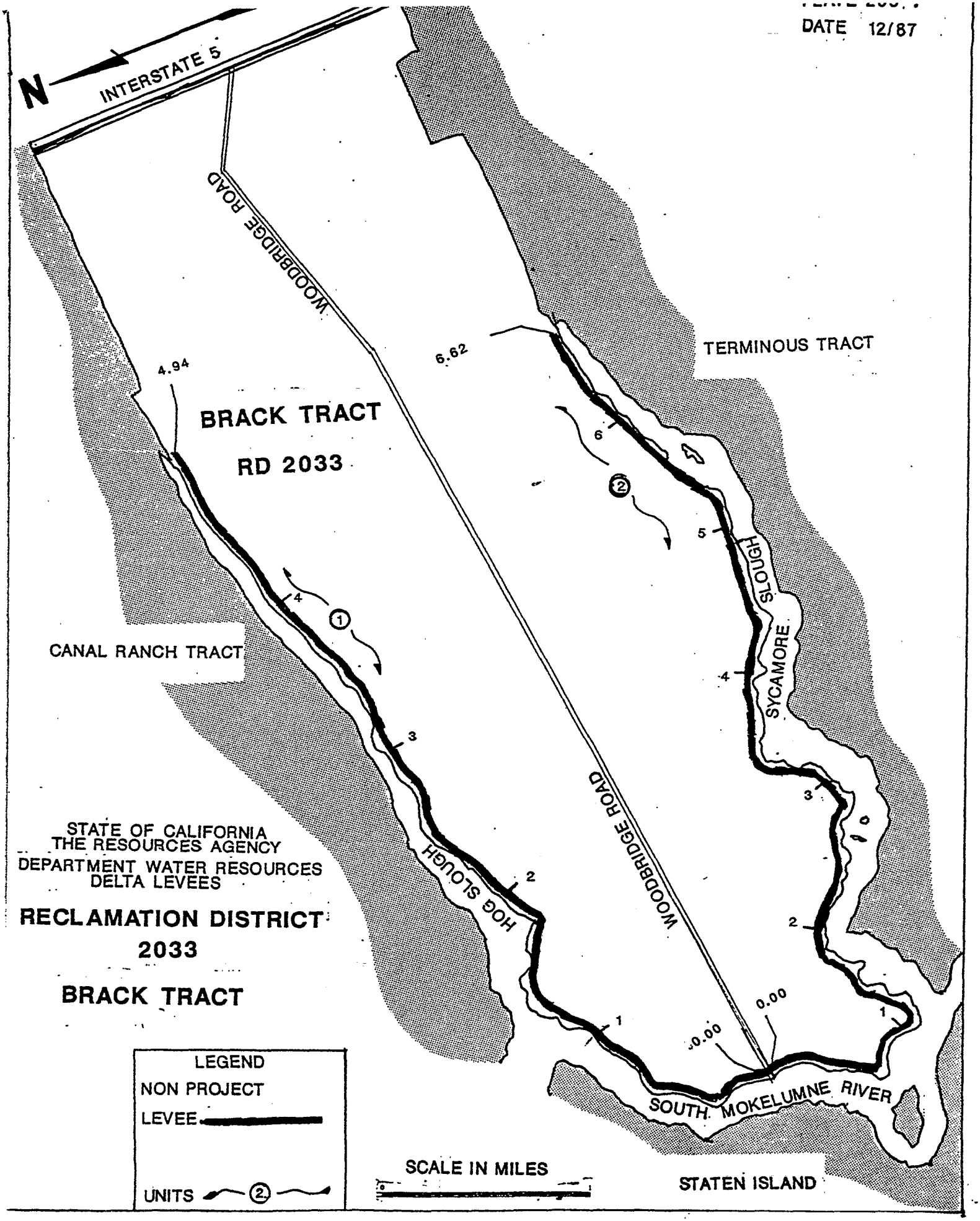
DATE 12/87

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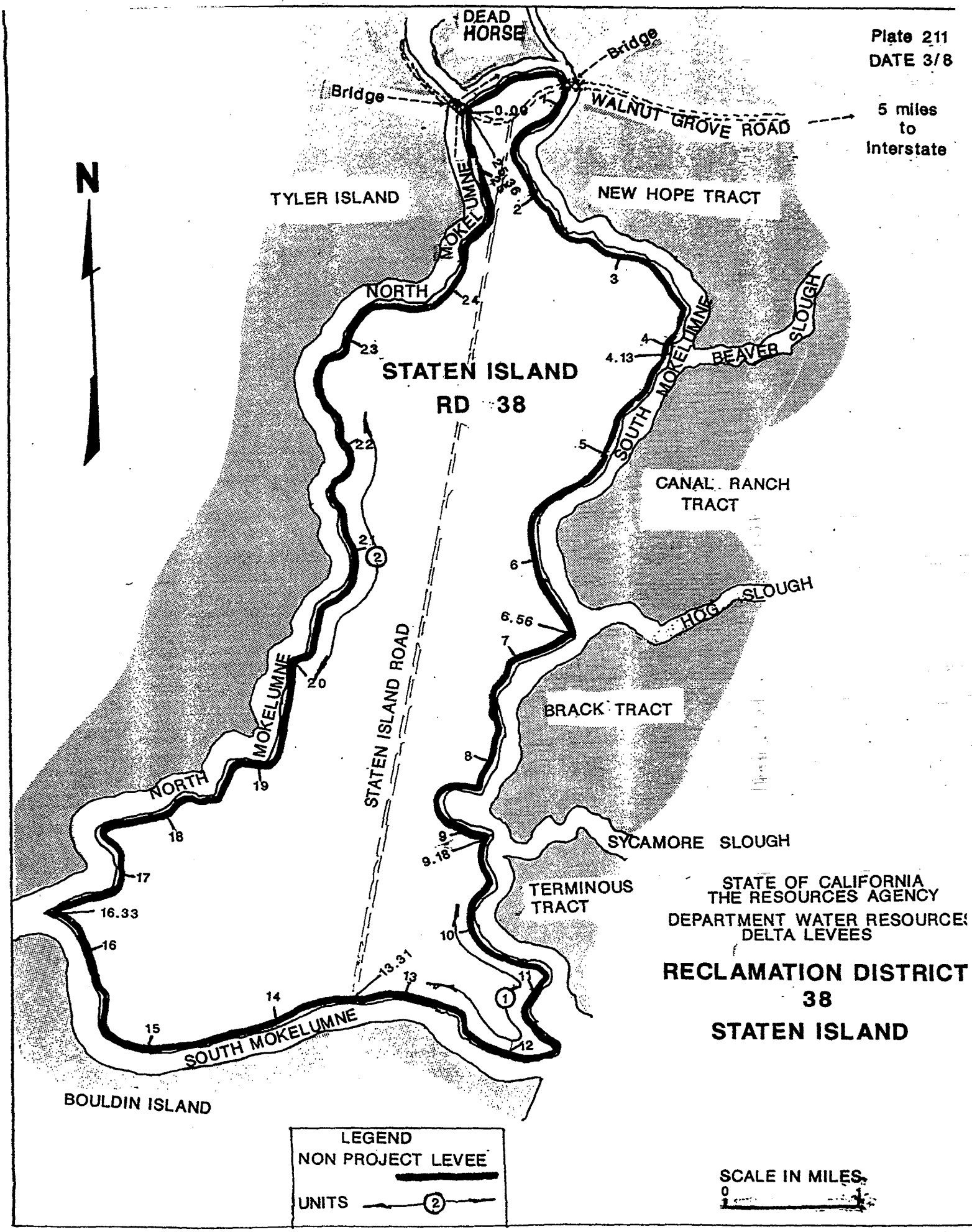


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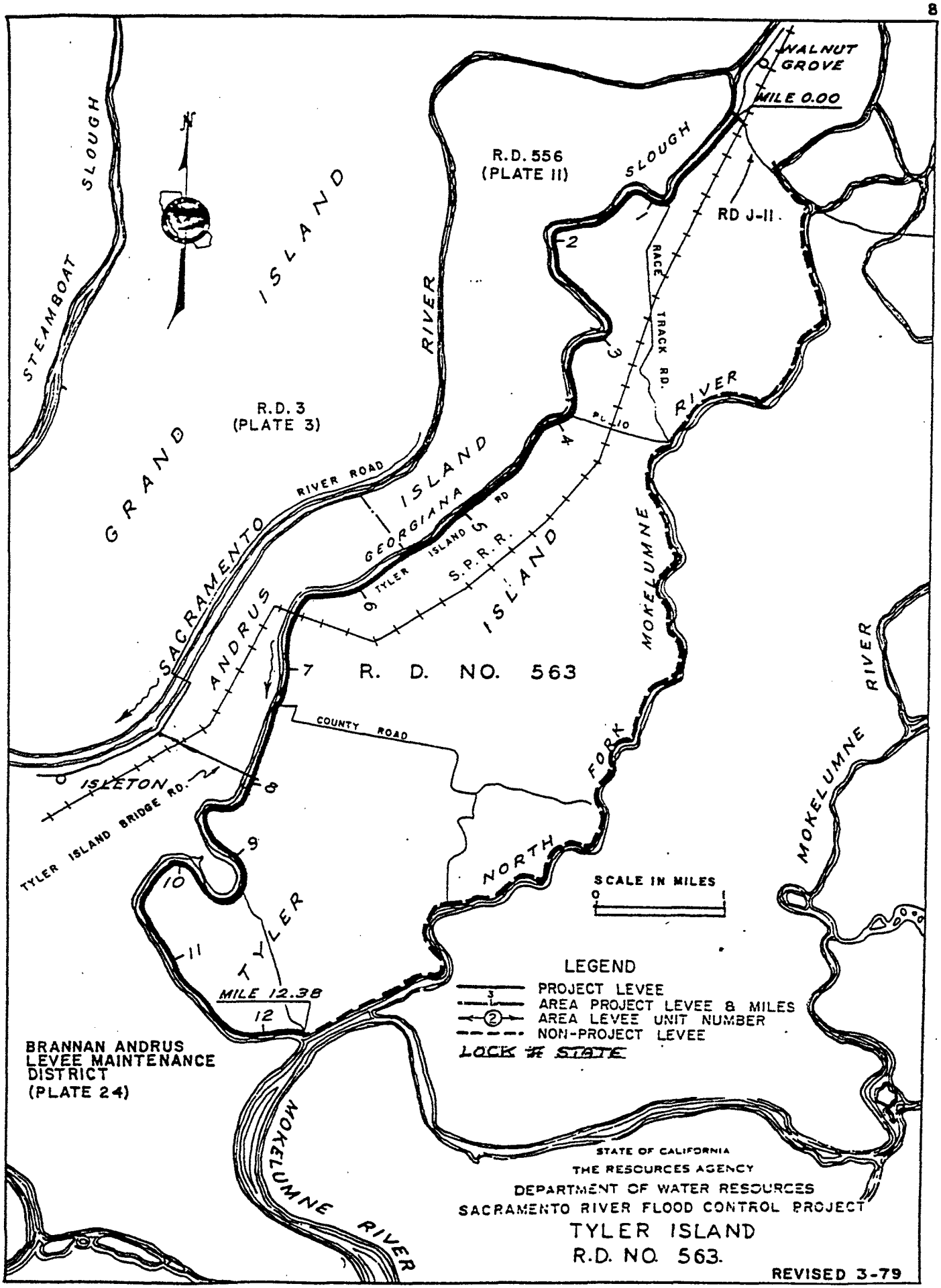
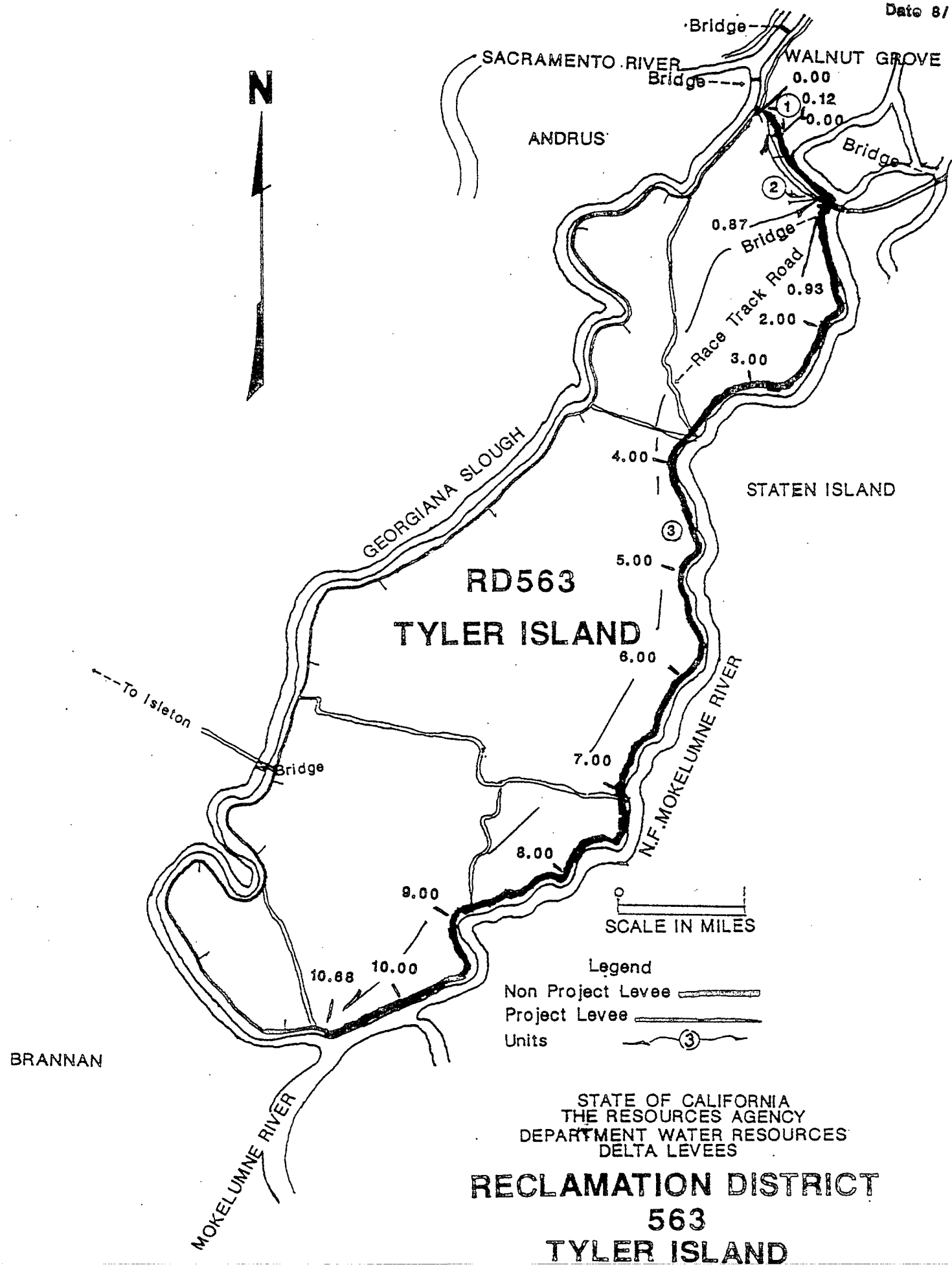
D-031525




D—031526

D-031526

Plate 210
Date 8/86




STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES

# RECLAMATION DISTRICT 563 TYLER ISLAND

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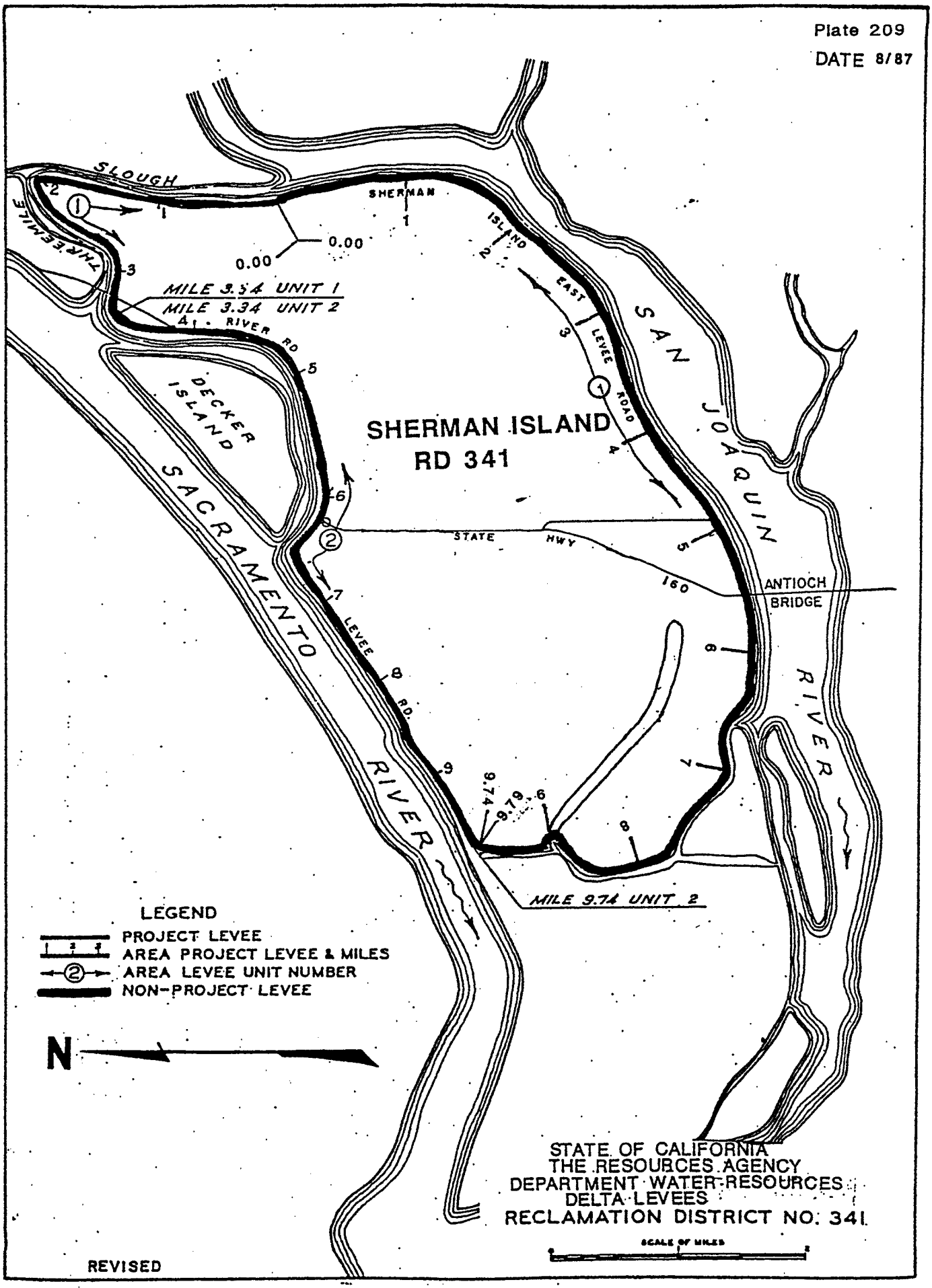
D-031527

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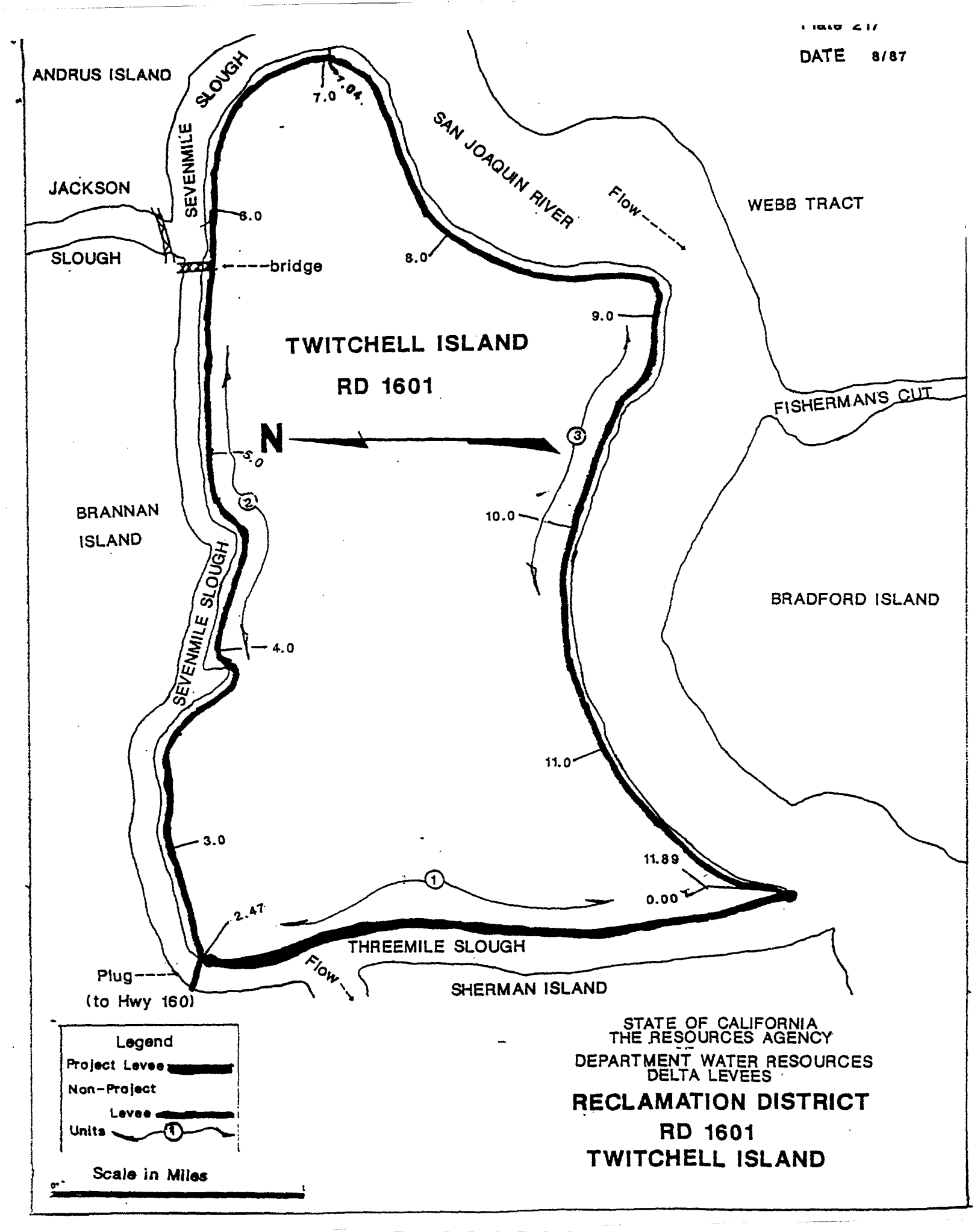


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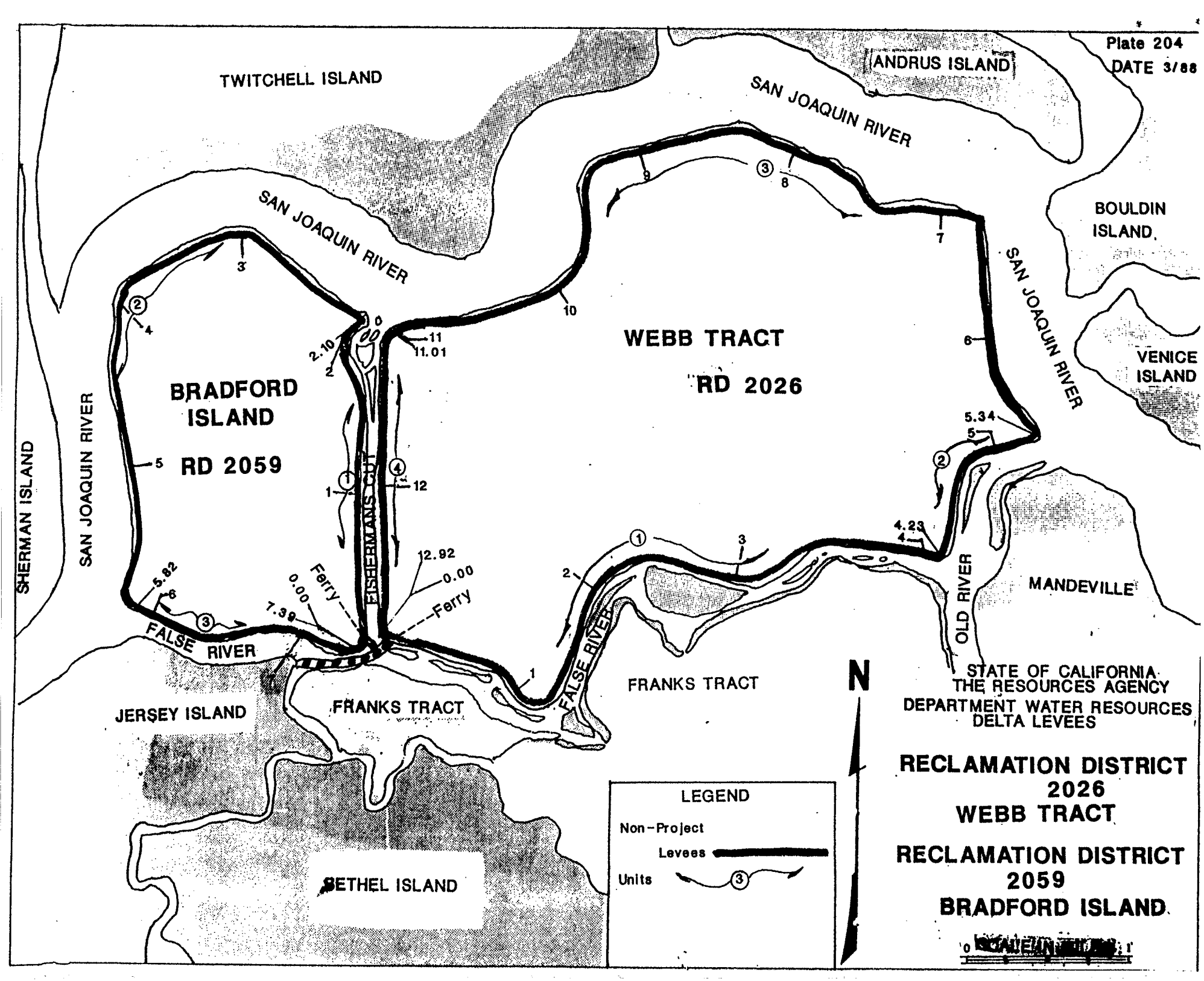
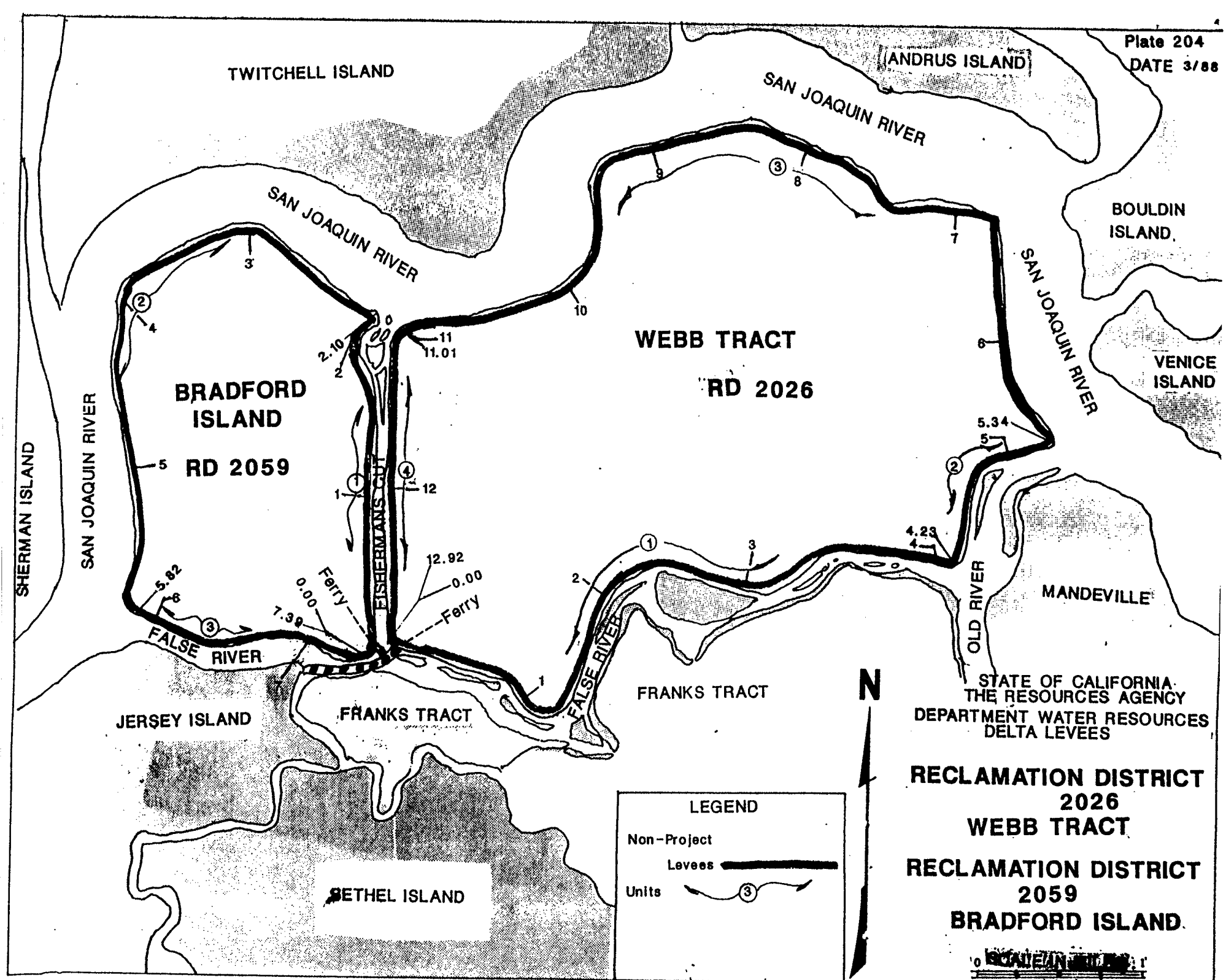


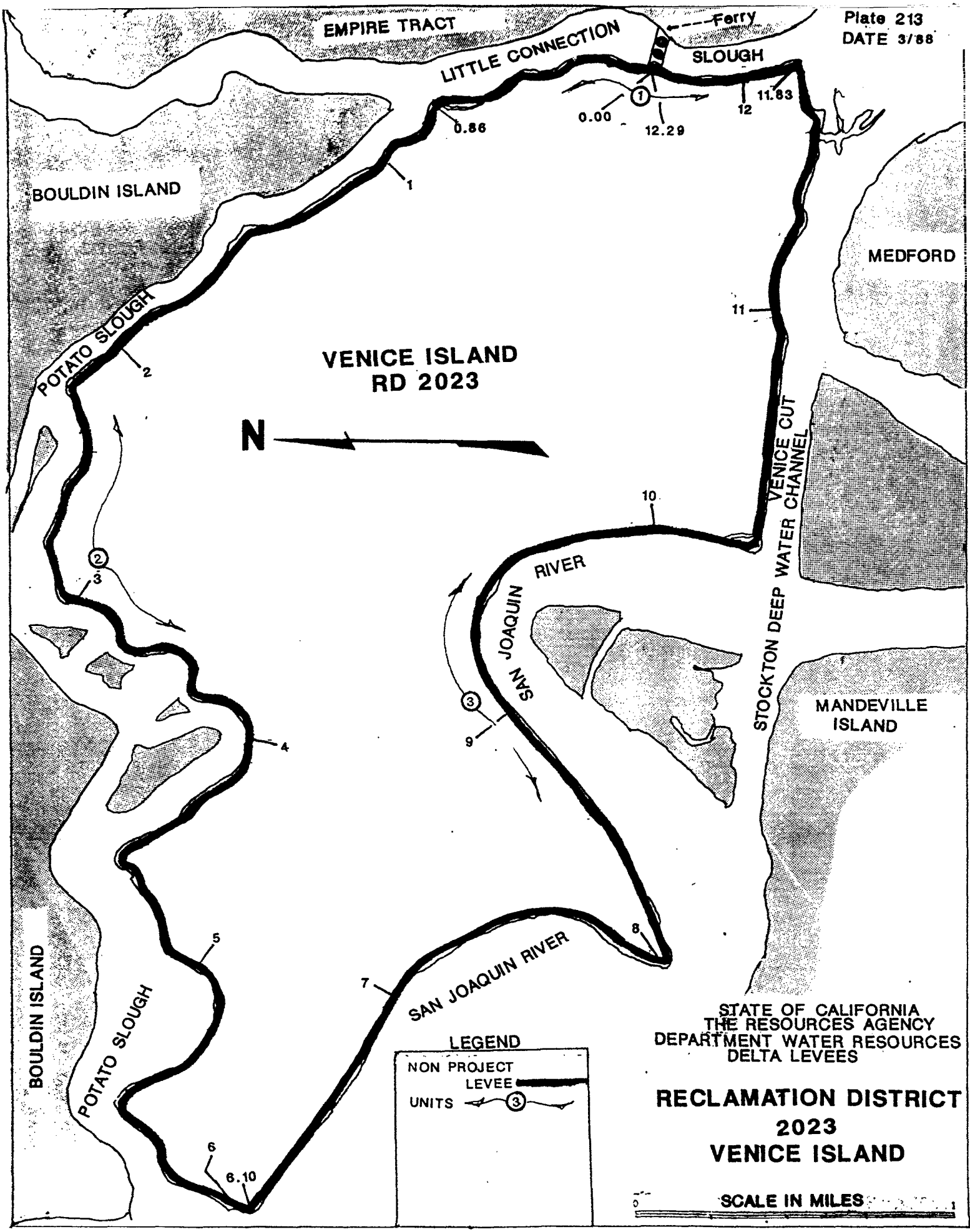

D-031530

D—031530



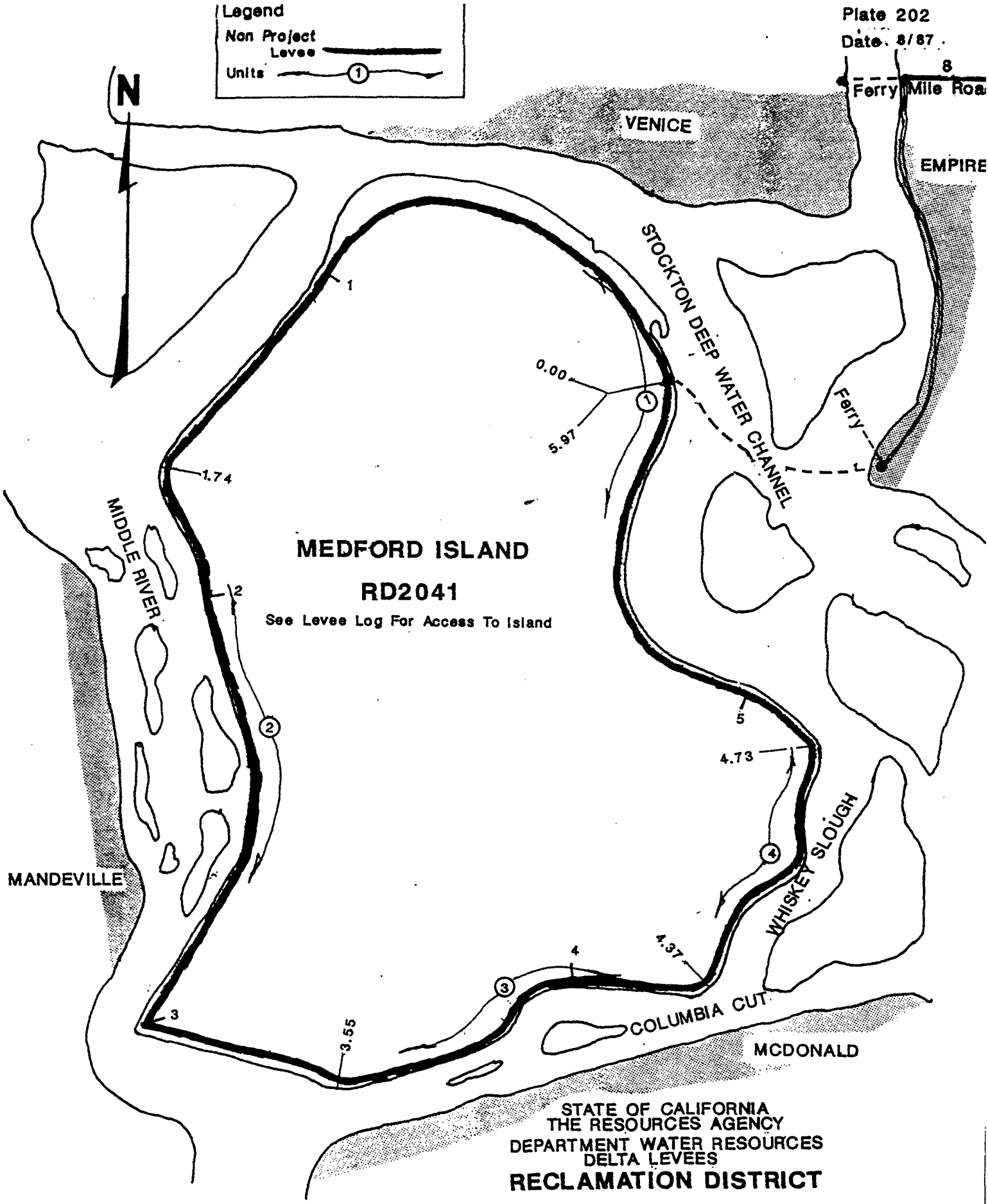

D-031531

D—031531




D—0 3 1 5 3 2

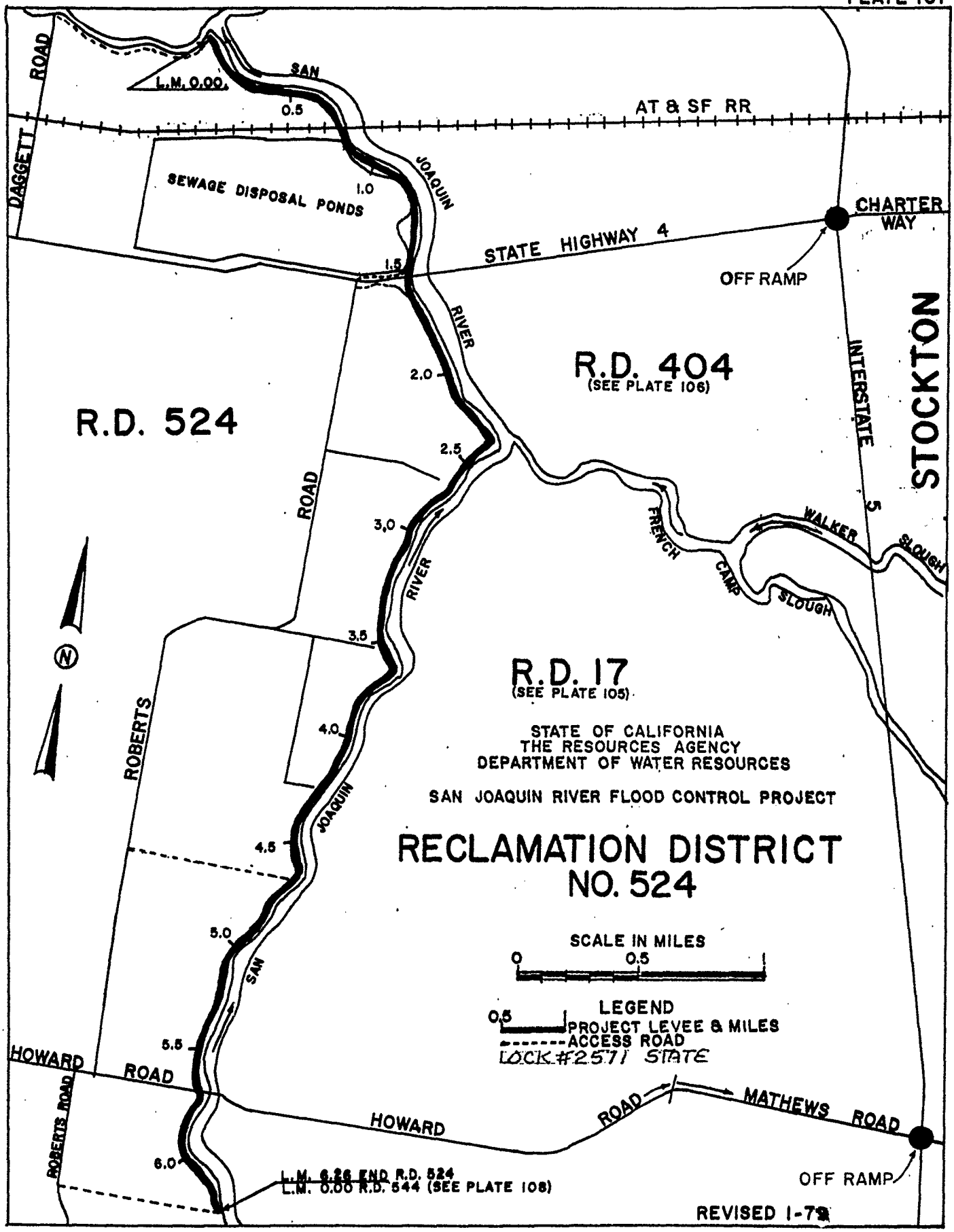
D-031532




D—0 3 1 5 3 3

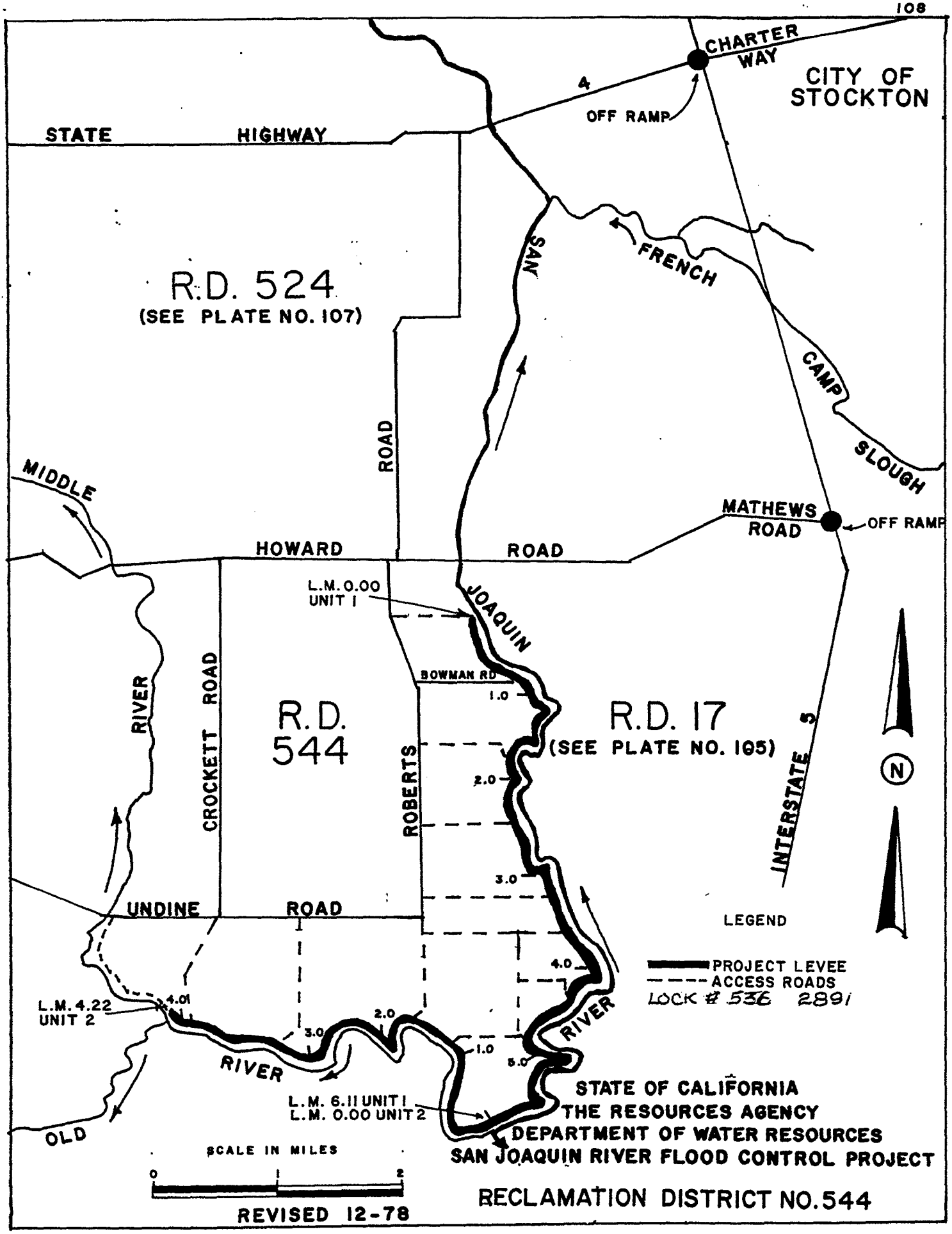
D-031533

PLATE 107



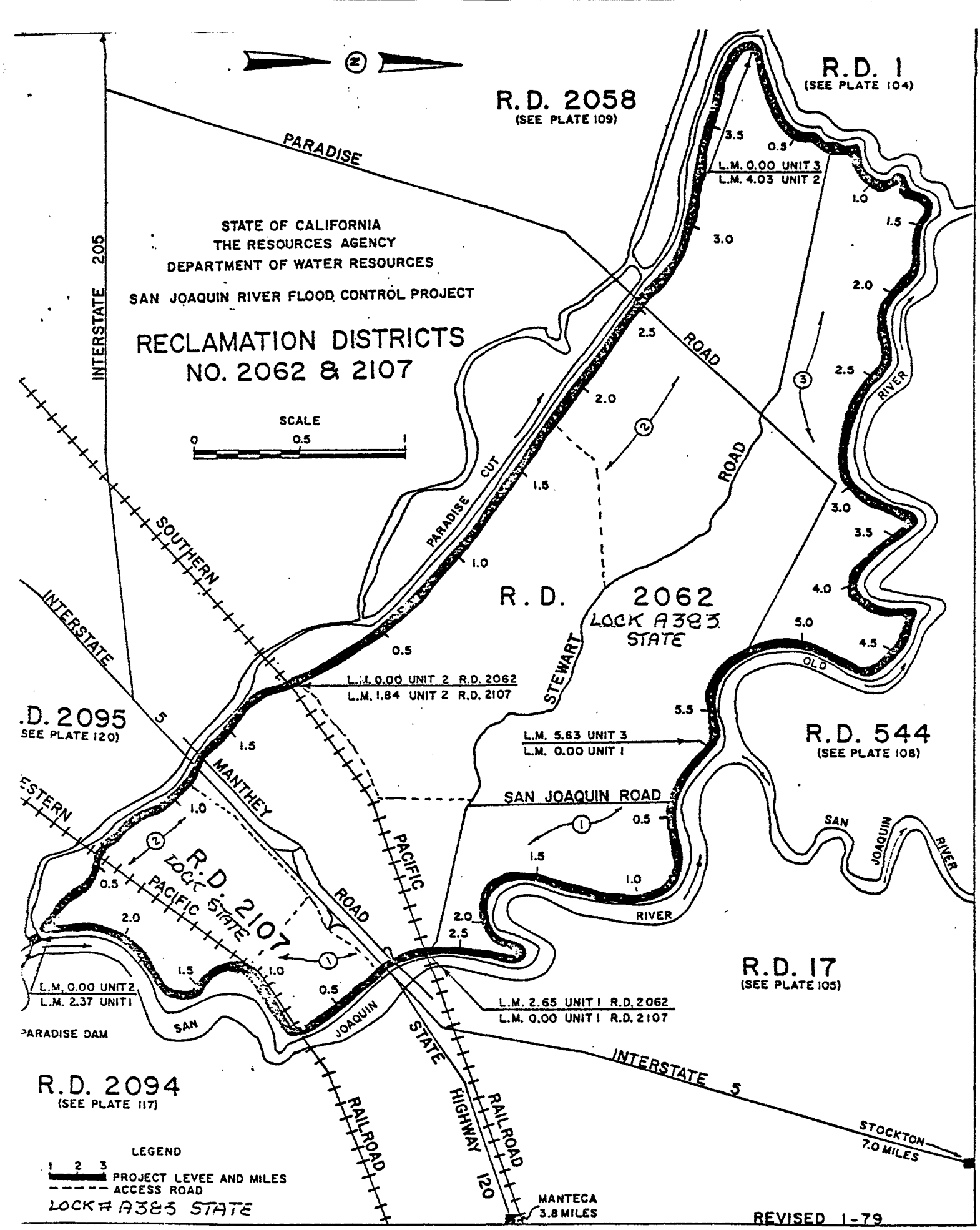

D—031534

D-031534



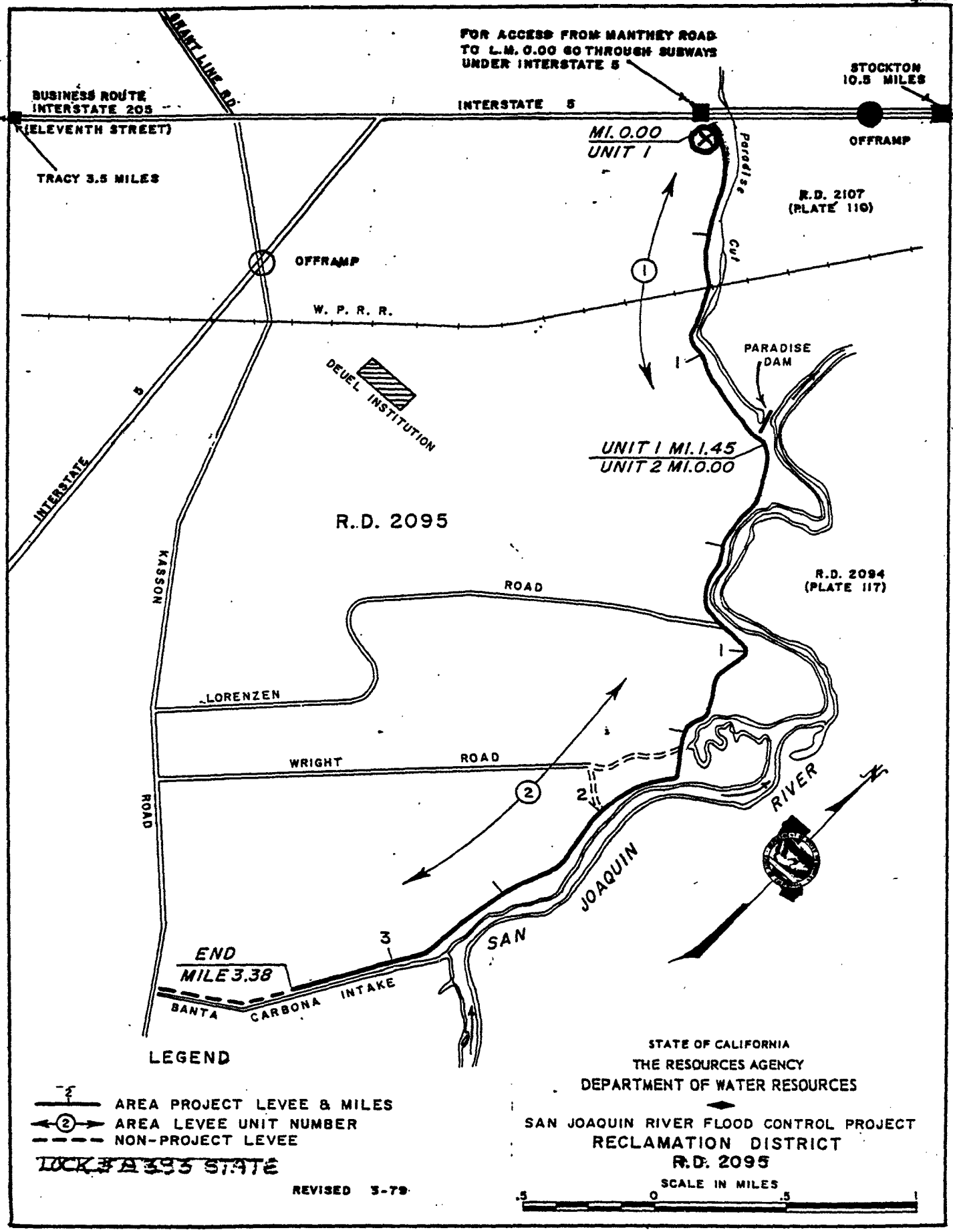

D—031535

D-031535




D—0 3 1 5 3 6

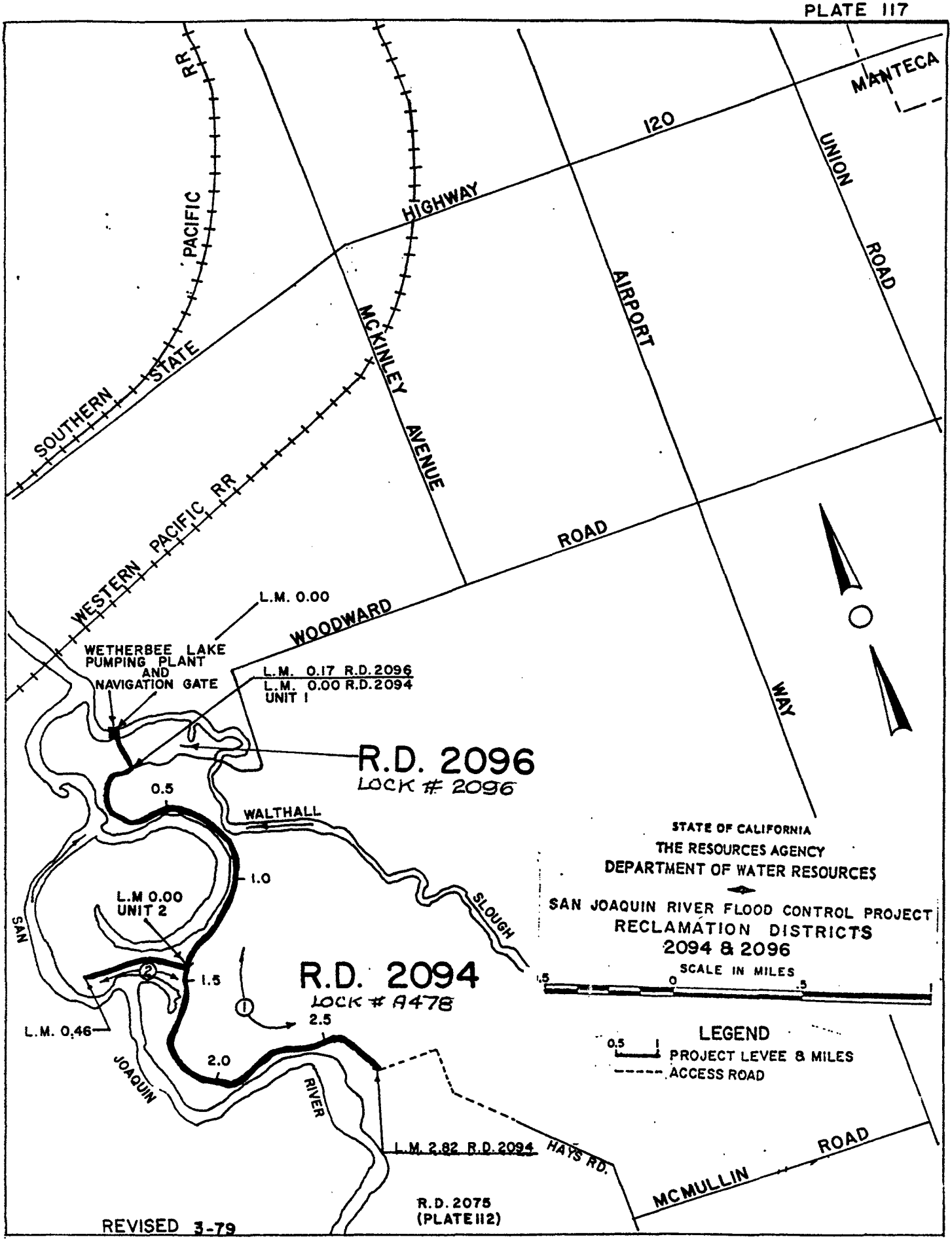
D-031536




D—031537

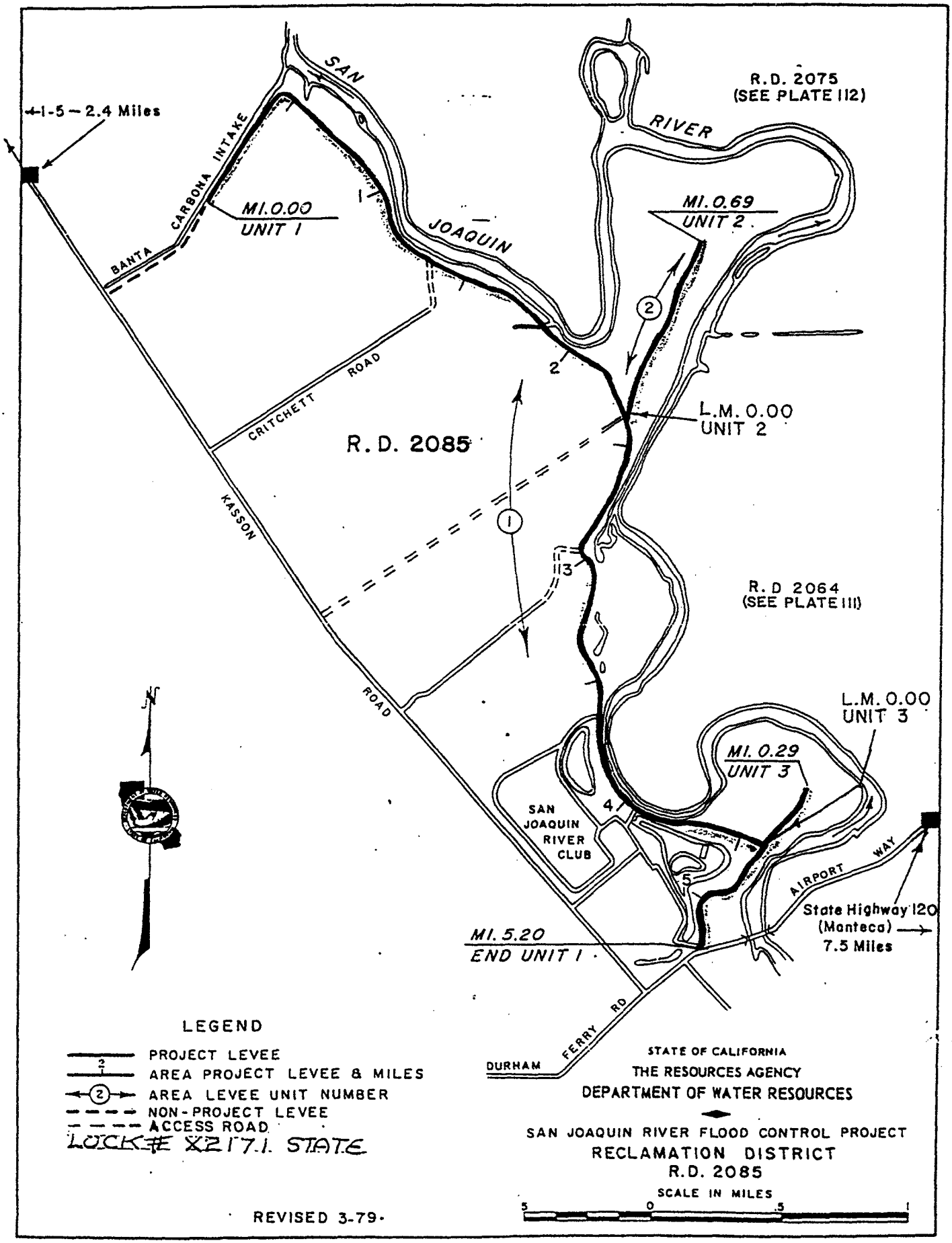
D-031537

PLATE 117



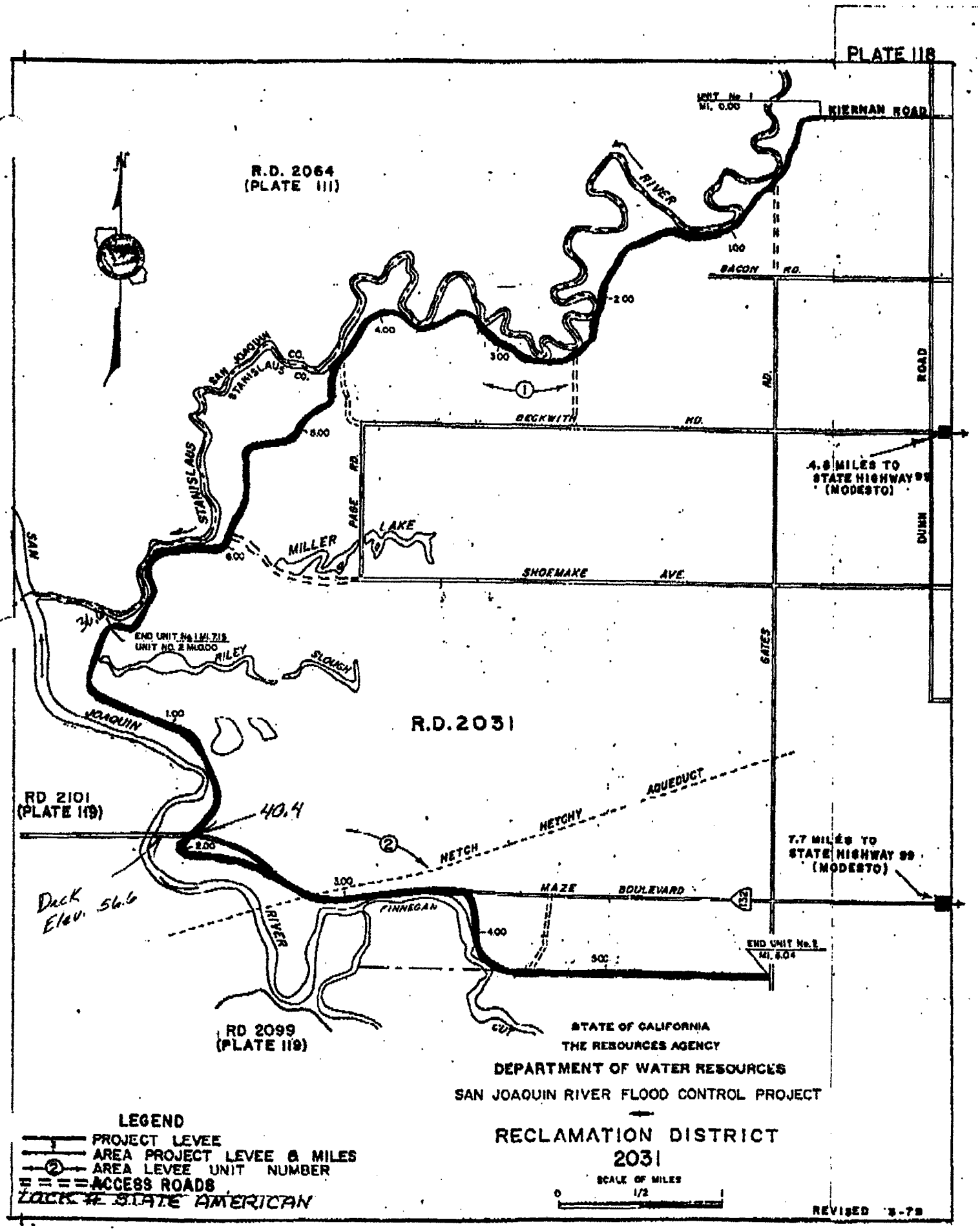

D—031538

D-031538



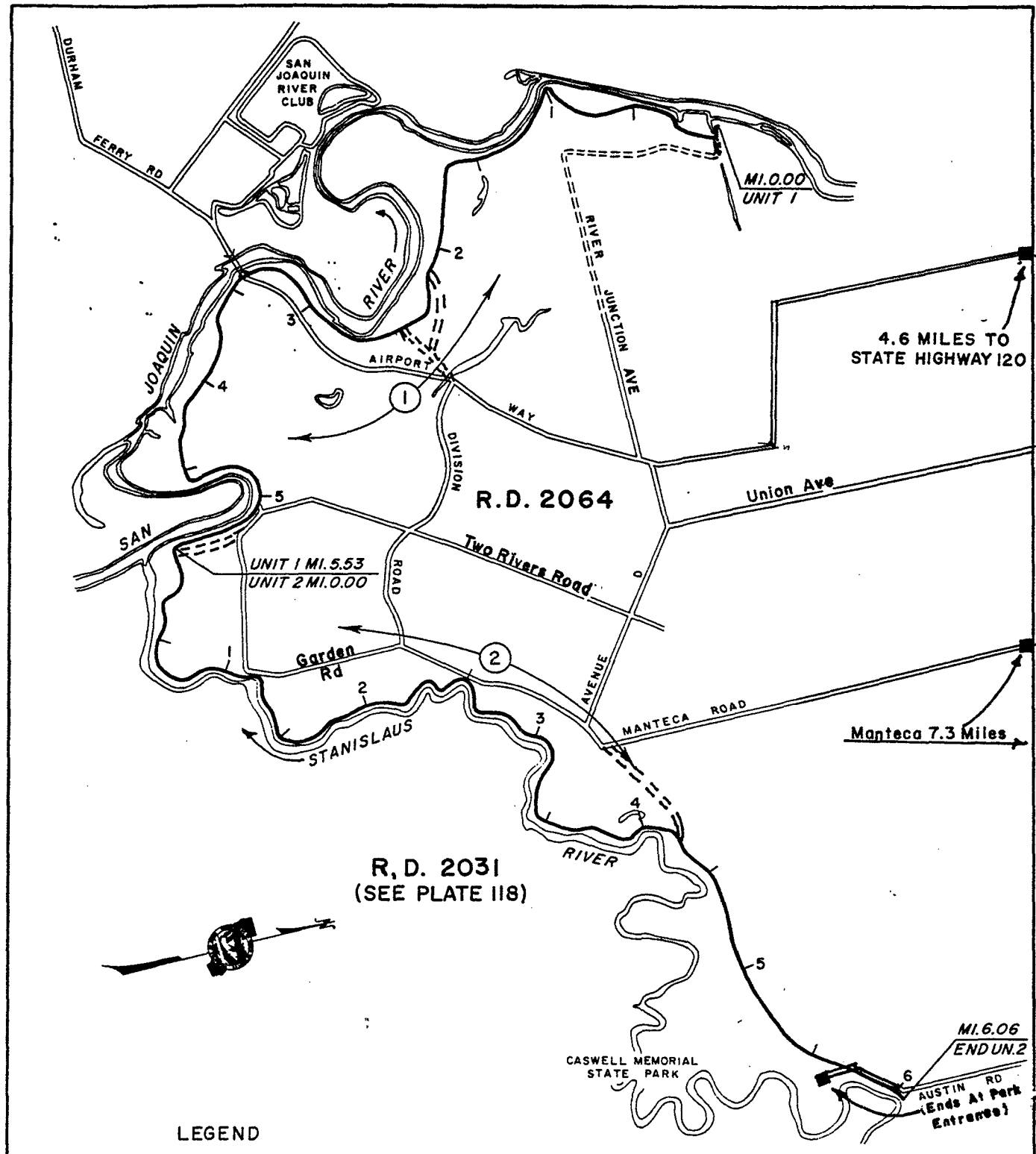

D—031539

D-031539




D—031540

D-031540




LEGEND

3 — AREA PROJECT LEVEE & MILES
(2) — AREA LEVEE UNIT NUMBER
= = = = ACCESS ROADS

LOCK # 2396 3381

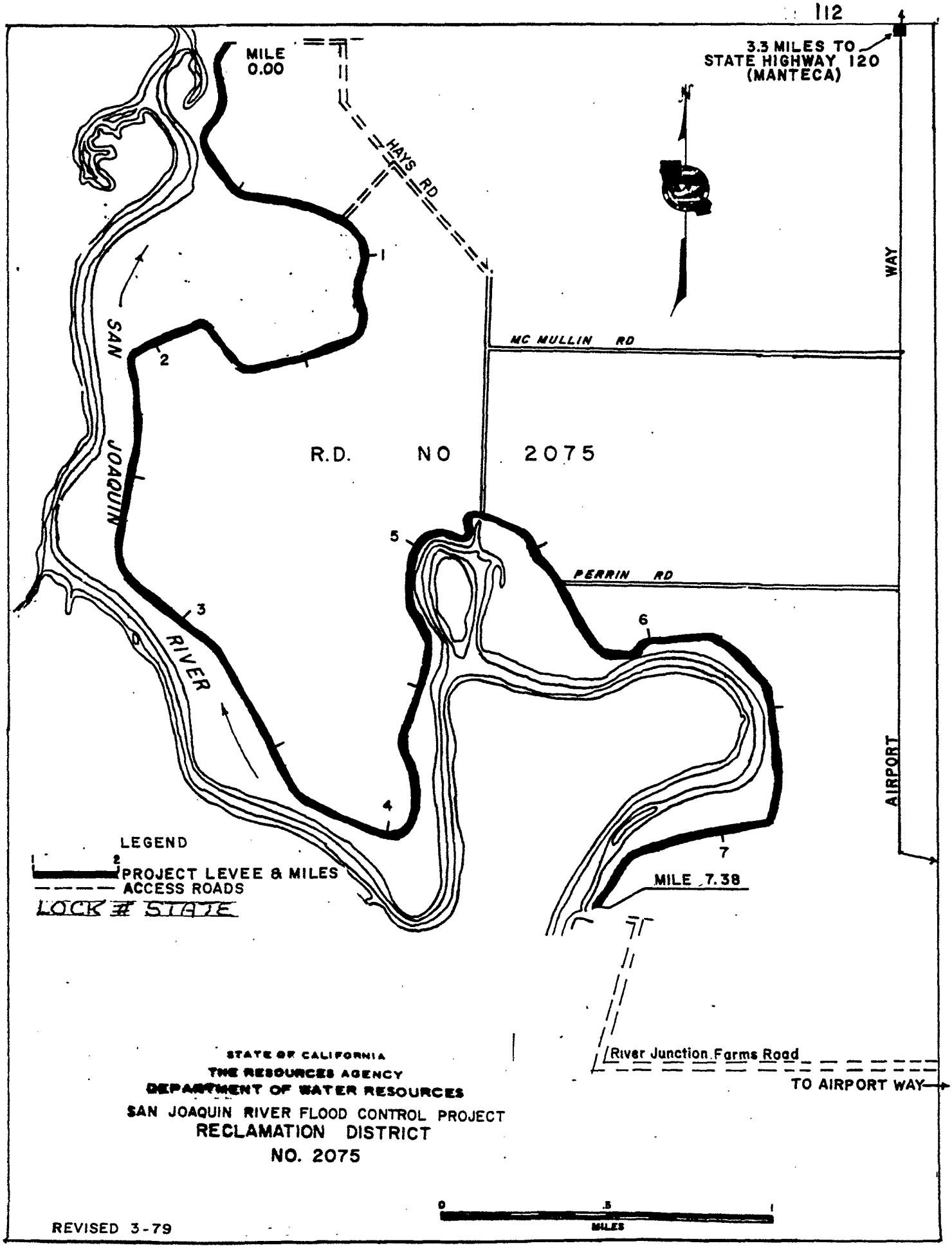
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN RIVER FLOOD CONTROL PROJECT
RECLAMATION DISTRICT NO. 2064

SCALE IN MILES
1 .5 0 1

REVISED 3-79

D—031541

D-031541




STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN RIVER FLOOD CONTROL PROJECT
RECLAMATION DISTRICT
NO. 2075

REVISED 3-79

D—0 3 1 5 4 2

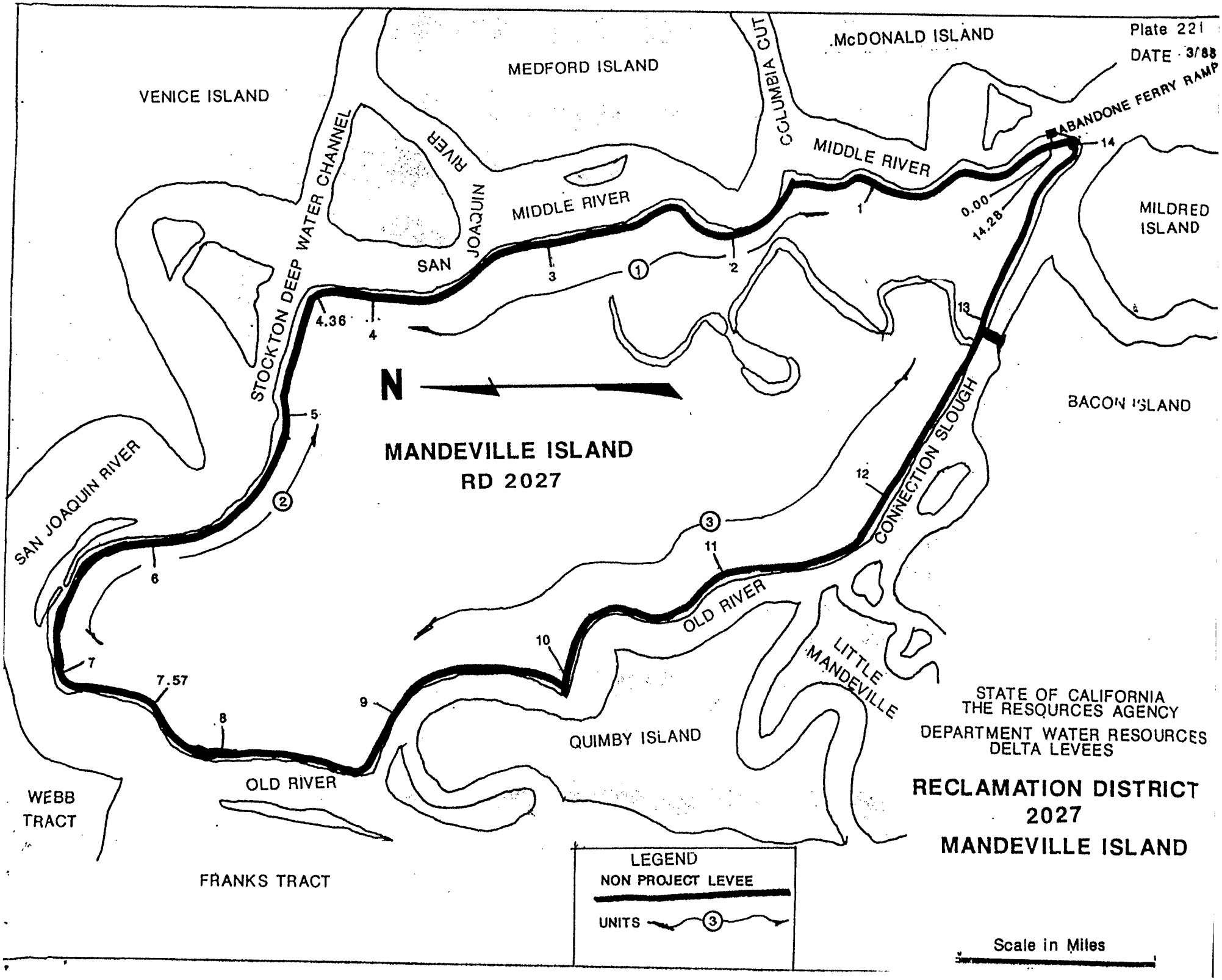


Plate 221
DATE 3/88
D-031543
VENICE ISLAND
MEDFORD ISLAND
McDONALD ISLAND
COLUMBIA CUT
ABANDONE FERRY RAMP
MIDDLE RIVER
MILDRED ISLAND
SAN JOAQUIN RIVER
STOCKTON DEEP WATER CHANNEL
MIDDLE RIVER
0.00
14.28
4.36
N
MANDEVILLE ISLAND
RD 2027
BACON ISLAND
CONNECTION SLOUGH
SAN JOAQUIN RIVER
OLD RIVER
LITTLE MANDEVILLE
7.57
QUIMBY ISLAND
OLD RIVER
WEBB TRACT
FRANKS TRACT
LEGEND
NON PROJECT LEVEE
UNITS
Scale in Miles
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
RECLAMATION DISTRICT
2027
MANDEVILLE ISLAND
D—031543

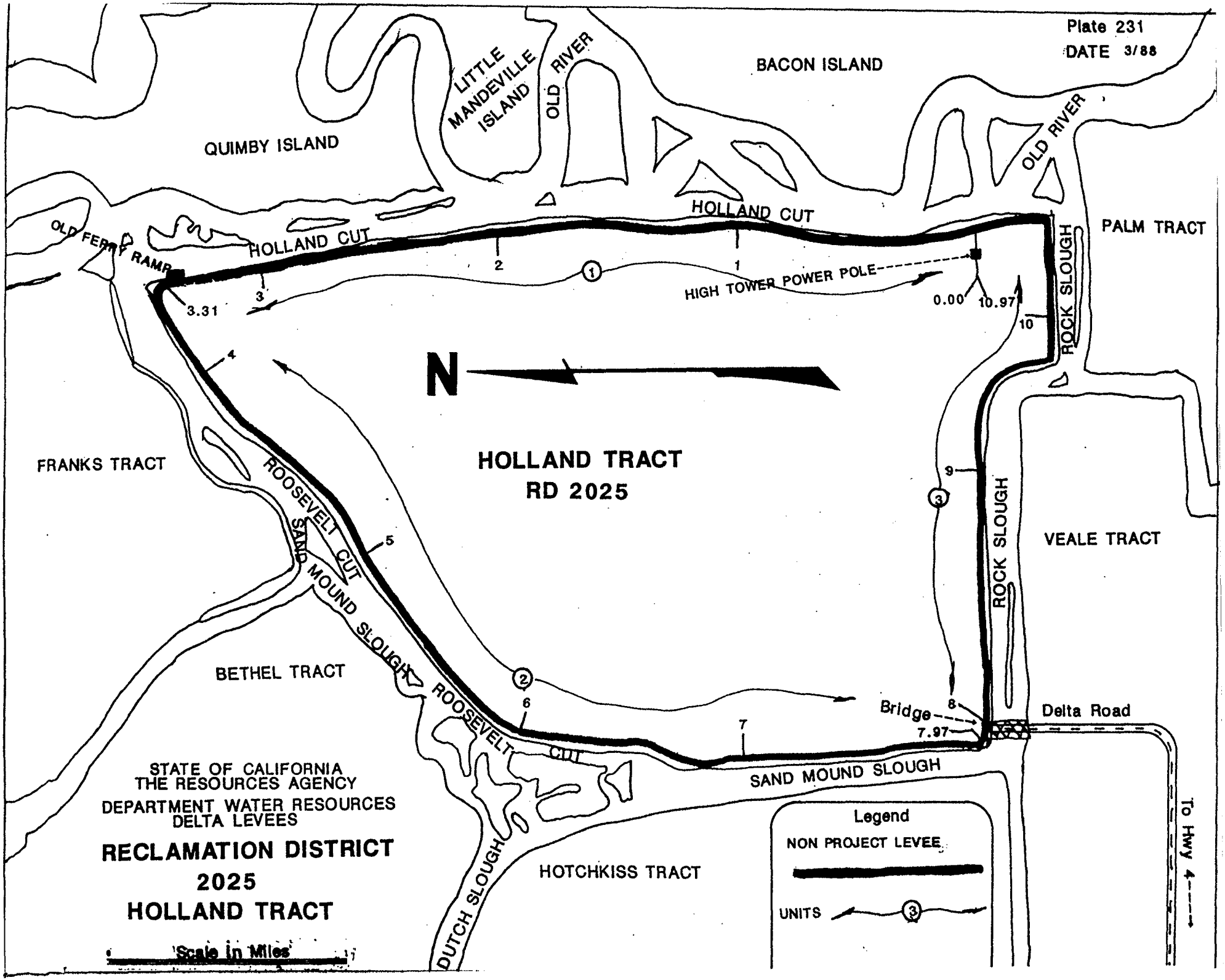
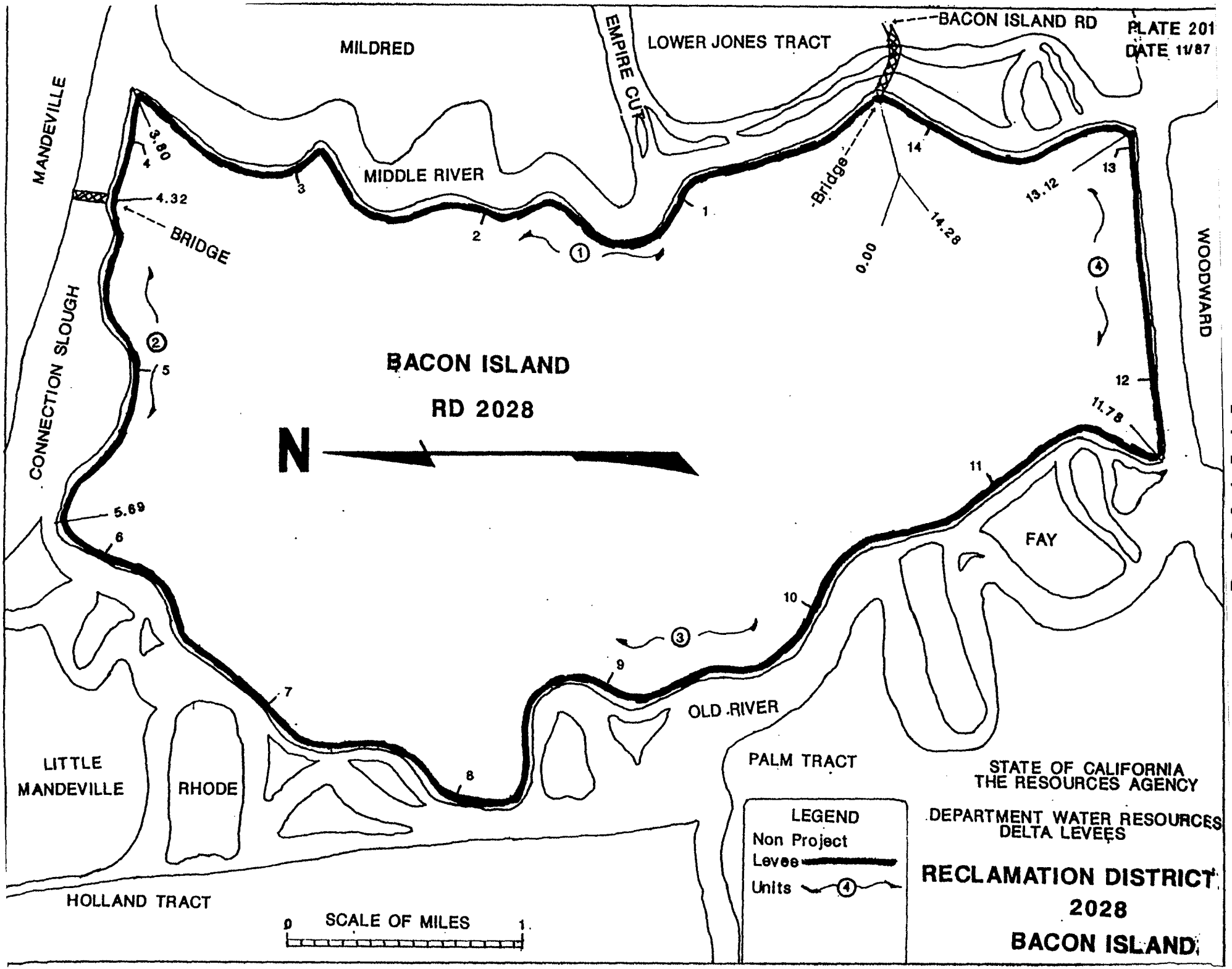


Plate 231
DATE 3/88
D-031544
D—031544
LITTLE MANDEVILLE ISLAND
OLD RIVER
BACON ISLAND
QUIMBY ISLAND
OLD RIVER
HOLLAND CUT
OLD FERRY RAMP
HOLLAND CUT
PALM TRACT
HIGH TOWER POWER POLE
3.31
0.00
10.97
ROCK SLOUGH
N
HOLLAND TRACT
RD 2025
FRANKS TRACT
ROOSEVELT CUT
SAND MOUND SLOUGH
ROCK SLOUGH
VEALE TRACT
BETHEL TRACT
ROOSEVELT CUT
Bridge
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
To Hwy 4


MILDRED
EMPIRE CUT
LOWER JONES TRACT
BACON ISLAND RD
PLATE 201
DATE 11/87
MANDEVILLE
MIDDLE RIVER
3.80
4.32
BRIDGE
Bridge
0.00
14.28
13.12
WOODWARD
CONNECTION SLOUGH
BACON ISLAND
RD 2028
N
5.69
11.78
FAY
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
D-031545
D—031545

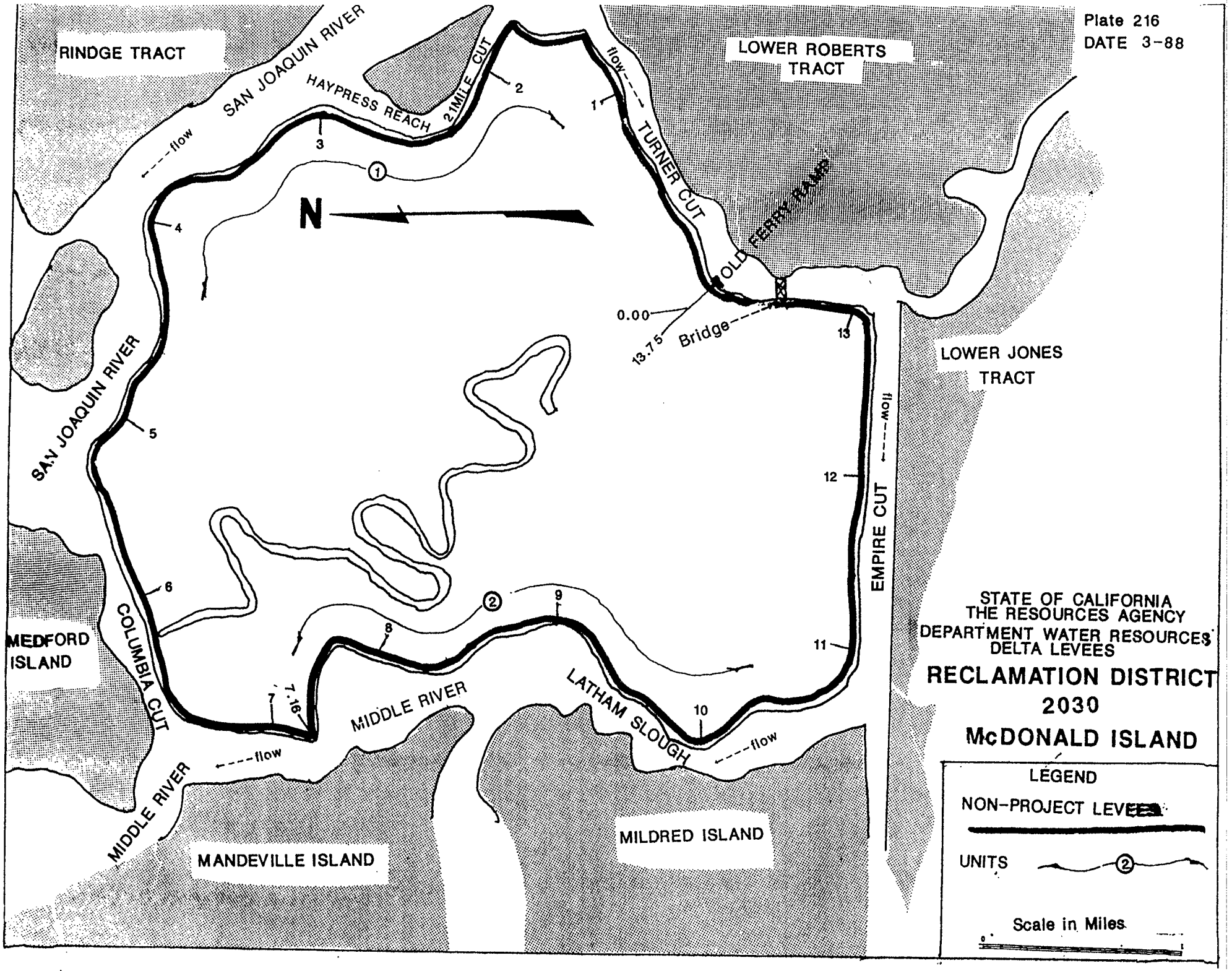
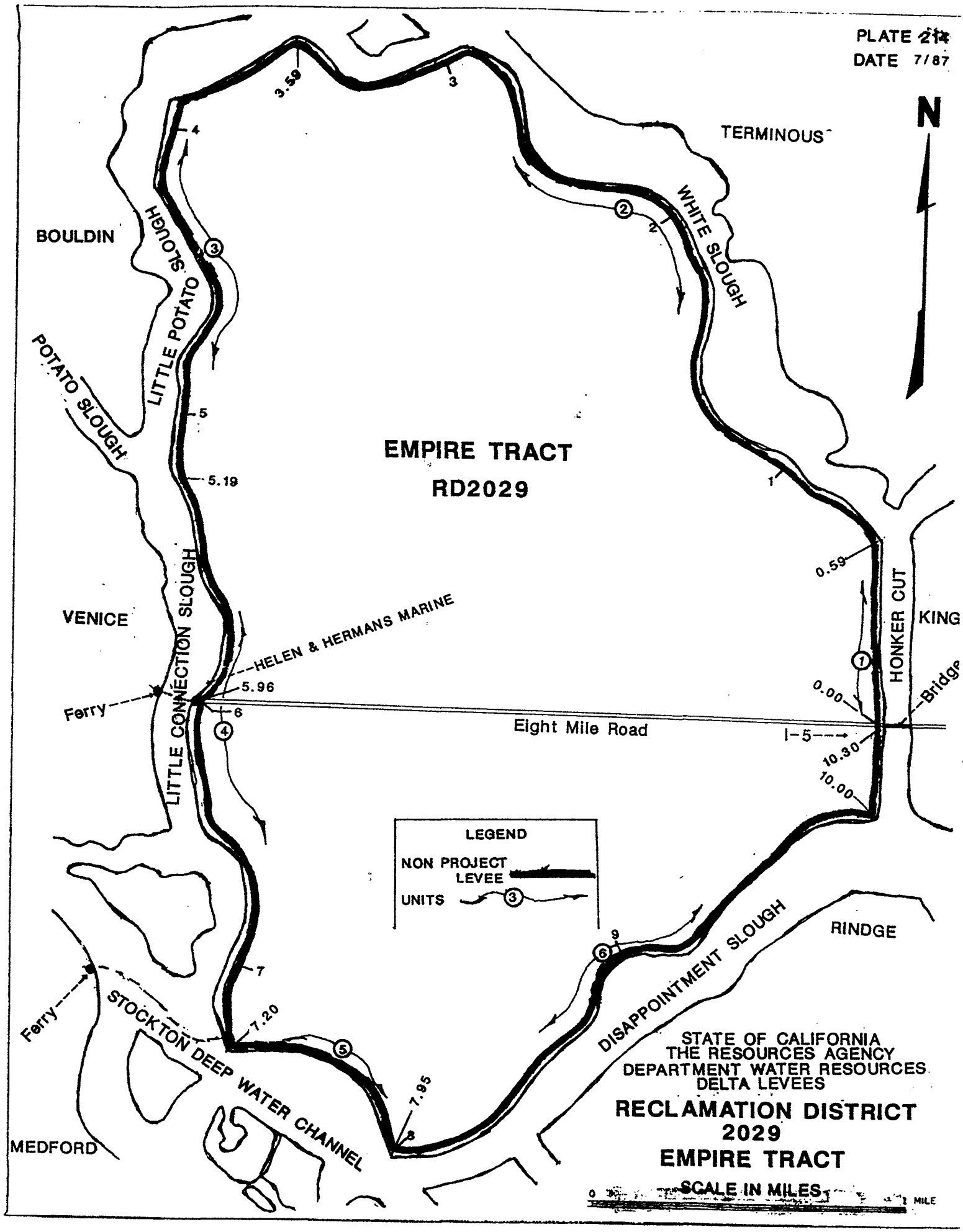
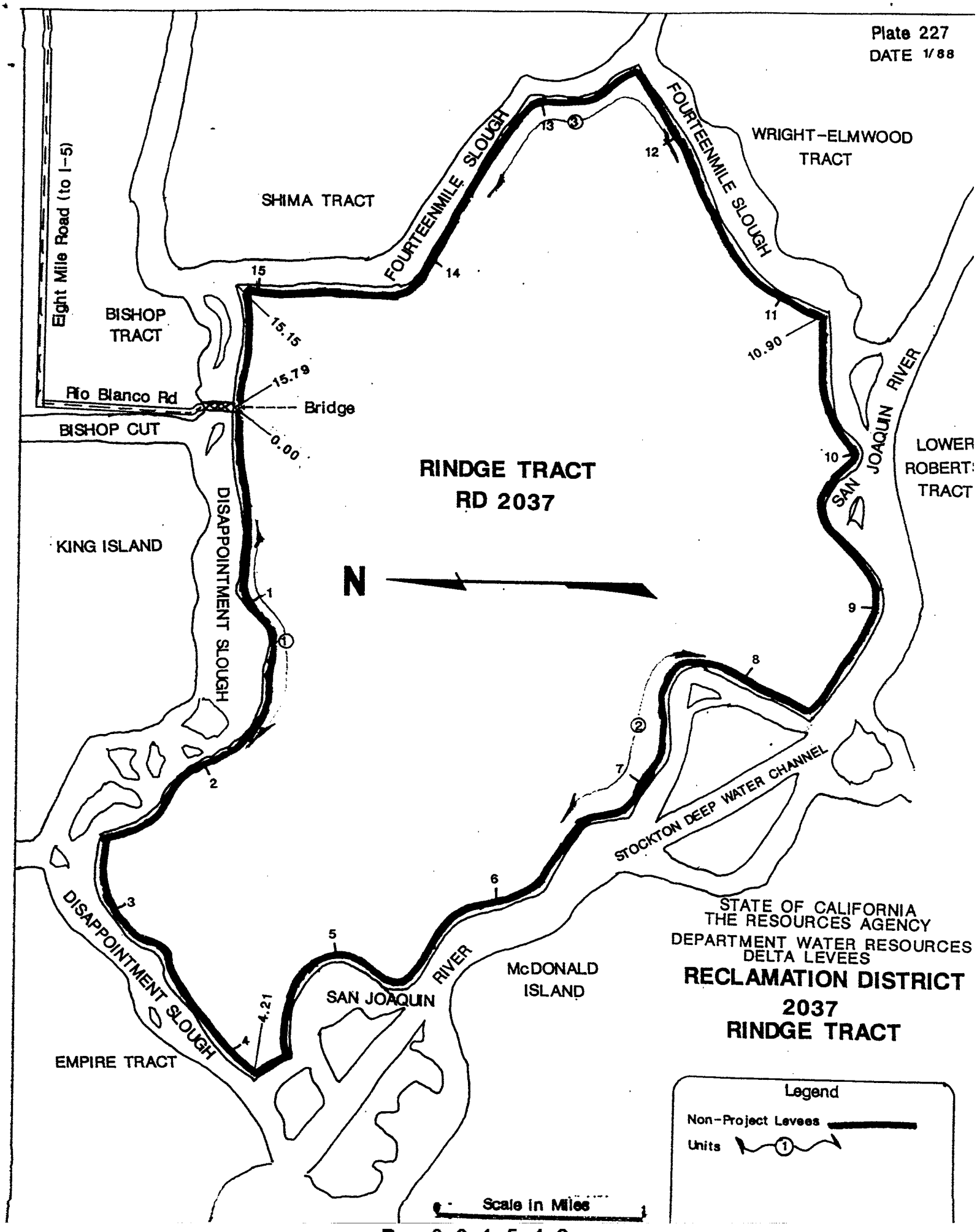


Plate 216
DATE 3-88
RINDGE TRACT
SAN JOAQUIN RIVER
HAYPRESS REACH
2 MILE CUT
LOWER ROBERTS TRACT
TURNER CUT
OLD FERRY RAMP
flow
N
0.00
13.75
Bridge
LOWER JONES TRACT
EMPIRE CUT
SAN JOAQUIN RIVER
COLUMBIA CUT
MEDFORD ISLAND
MIDDLE RIVER
LATHAM SLOUGH
MIDDLE RIVER
MANDEVILLE ISLAND
MILDRED ISLAND
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
RECLAMATION DISTRICT
2030
McDONALD ISLAND
LEGEND
NON-PROJECT LEVEE
UNITS
Scale in Miles
D-031546
D-031546




D—0 3 1 5 4 7

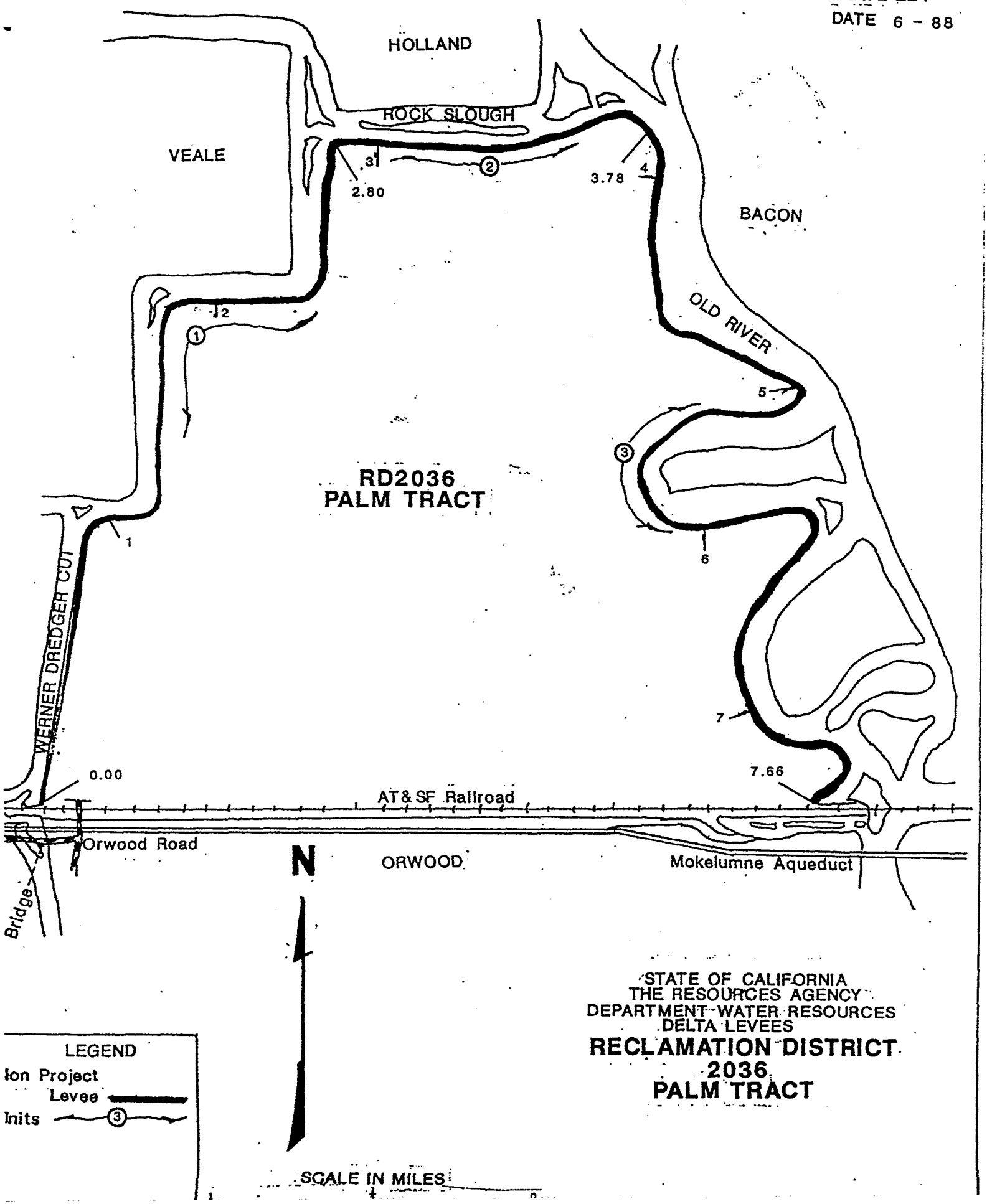
D-031547




D-031548

D-031548

PLATE 224
DATE 6 - 88

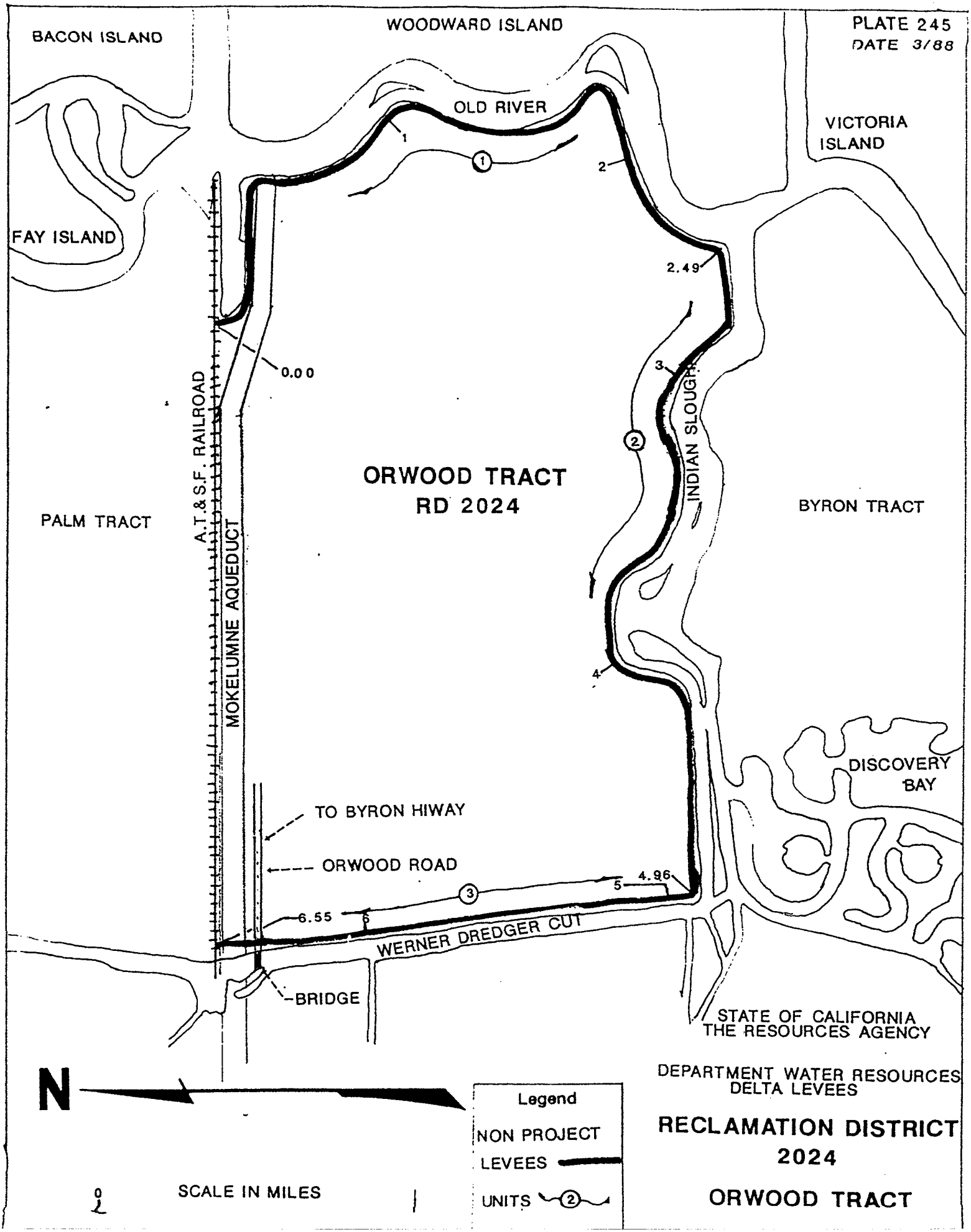



STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES

**RECLAMATION DISTRICT 2036**
**PALM TRACT**

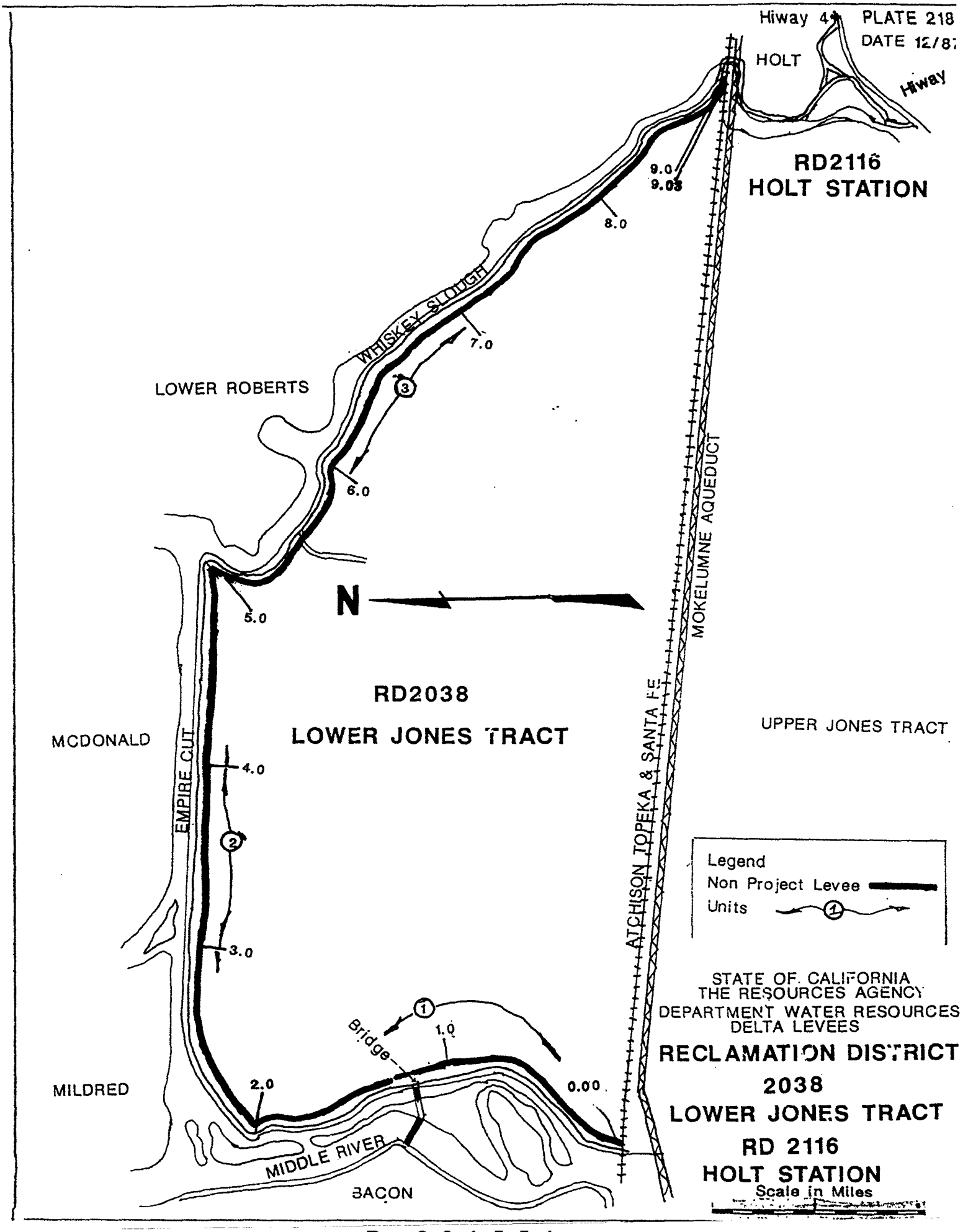
D — 0 3 1 5 4 9

D-031549



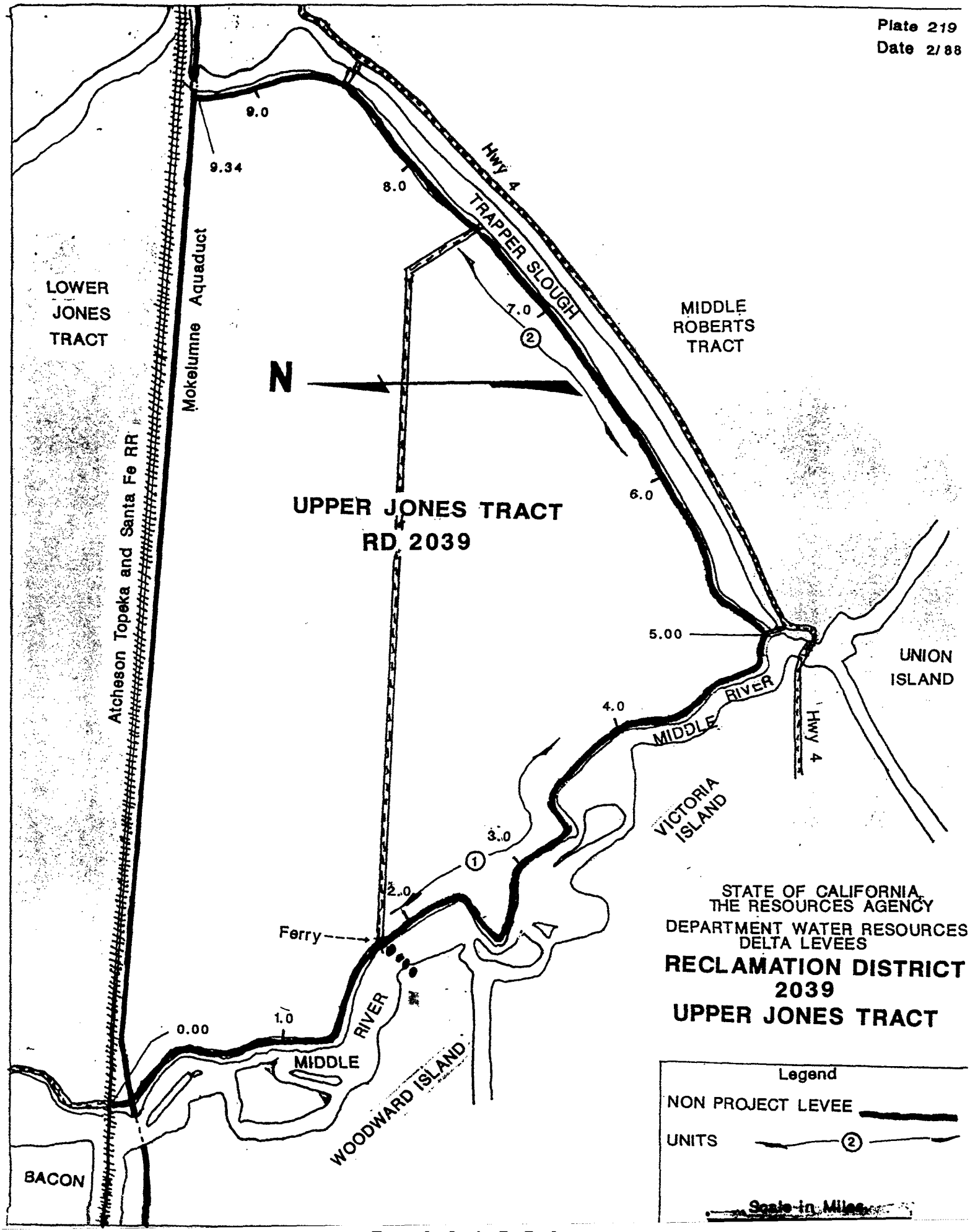

D—0 3 1 5 5 0

D-031550



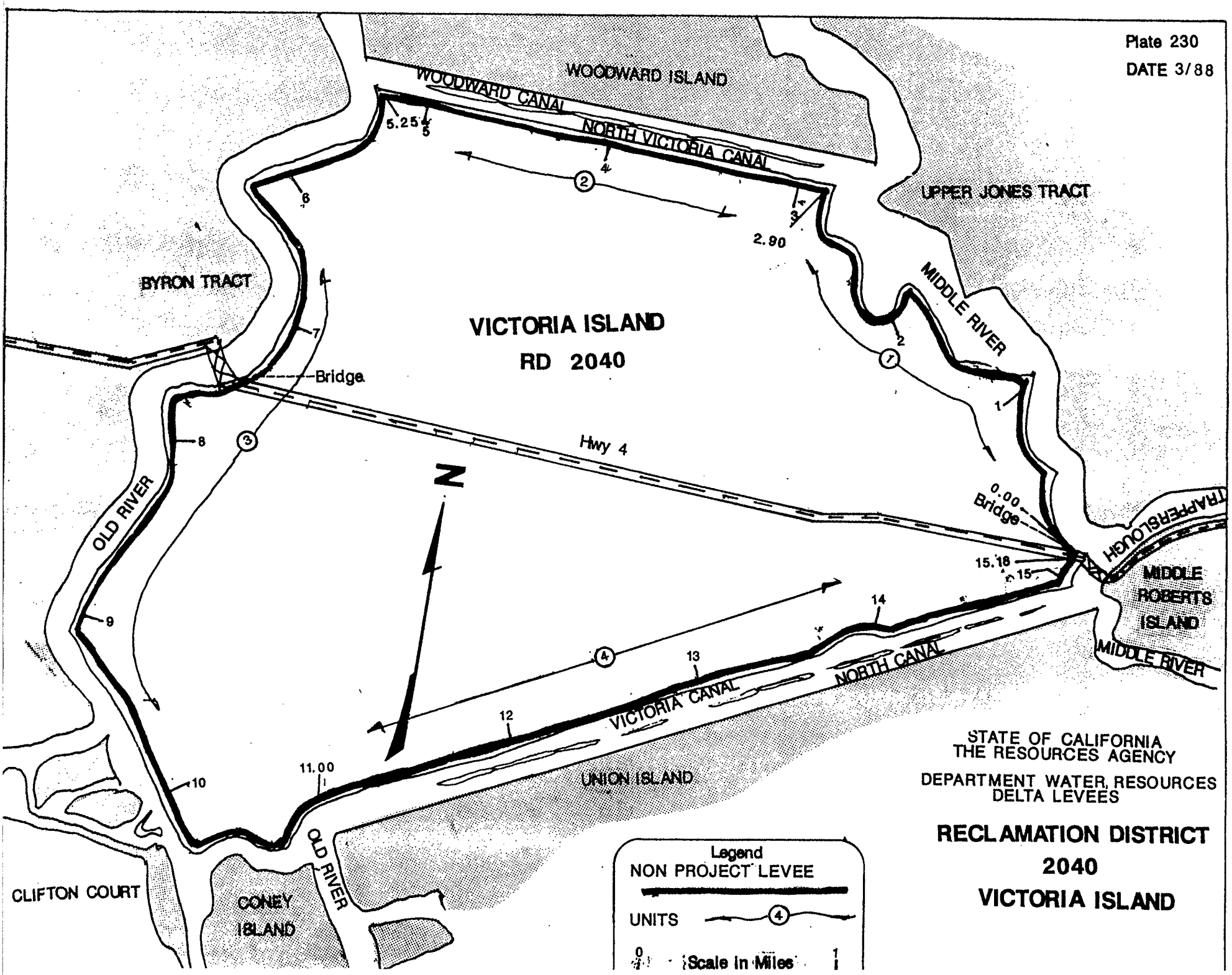

D—0 3 1 5 5 1

D-031551




D—031552

D-031552




D-031553

D—031553

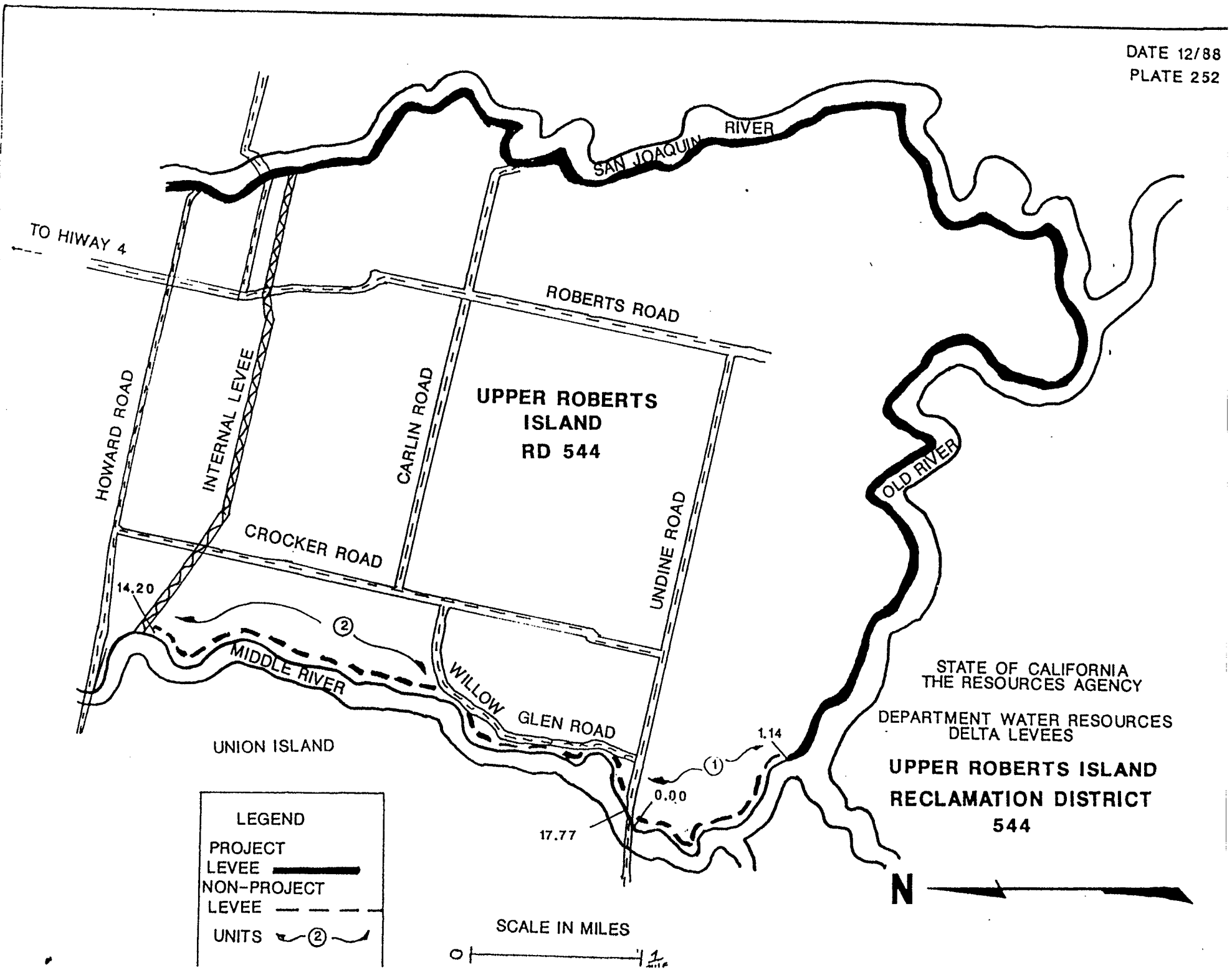
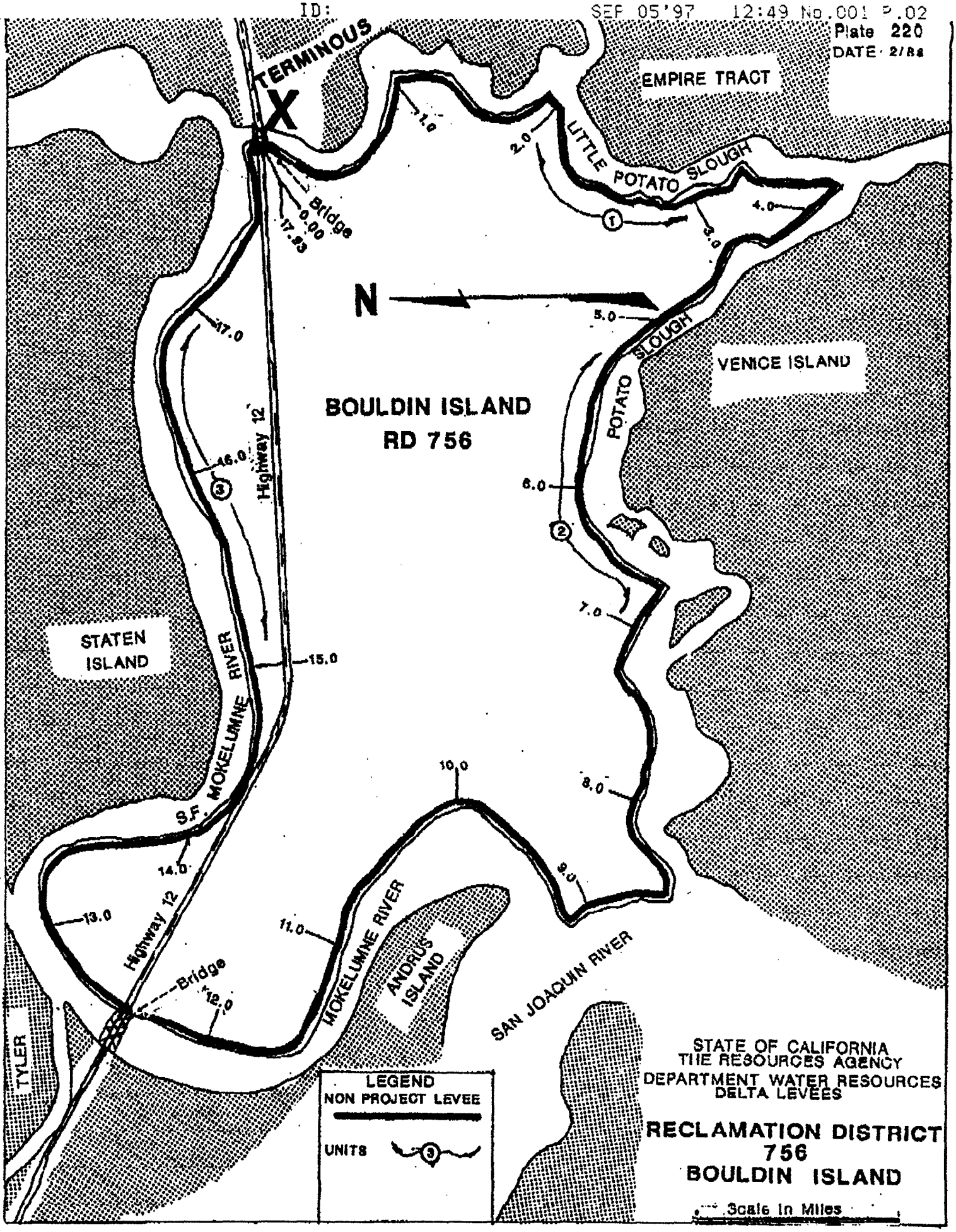

DATE 12/88
PLATE 252
D-031554
D—031554
SAN JOAQUIN RIVER
TO HIWAY 4
ROBERTS ROAD
HOWARD ROAD
INTERNAL LEVEE
CARLIN ROAD
UPPER ROBERTS ISLAND
RD 544
UNDINE ROAD
OLD RIVER
CROCKER ROAD
14.20
MIDDLE RIVER
WILLOW GLEN ROAD
UNION ISLAND
1.14
0.00
17.77
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
UPPER ROBERTS ISLAND
RECLAMATION DISTRICT
544
N
LEGEND
PROJECT LEVEE
NON-PROJECT LEVEE
UNITS
SCALE IN MILES
0
1

Plate 220
DATE 2/88




D—031555

D-031555

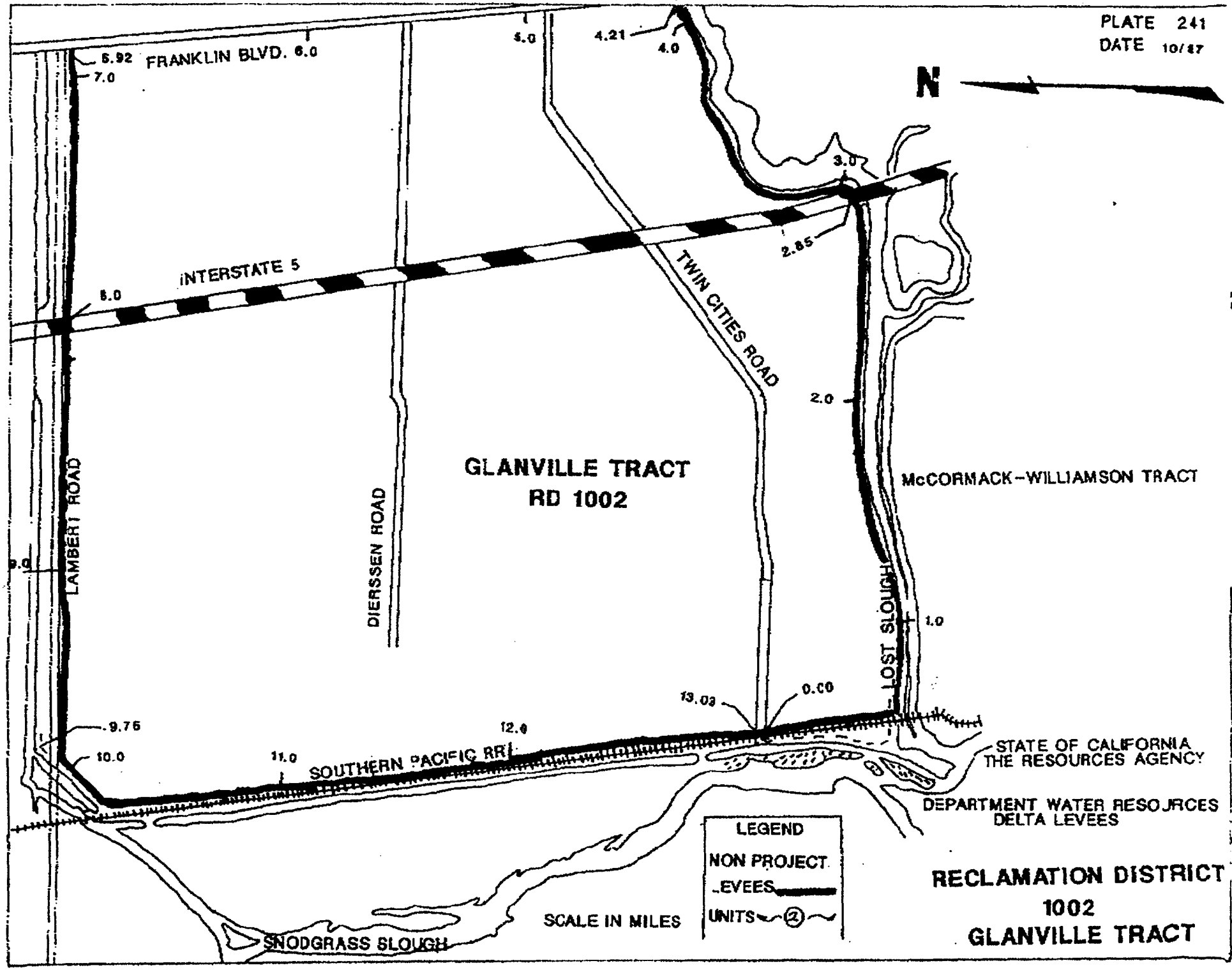
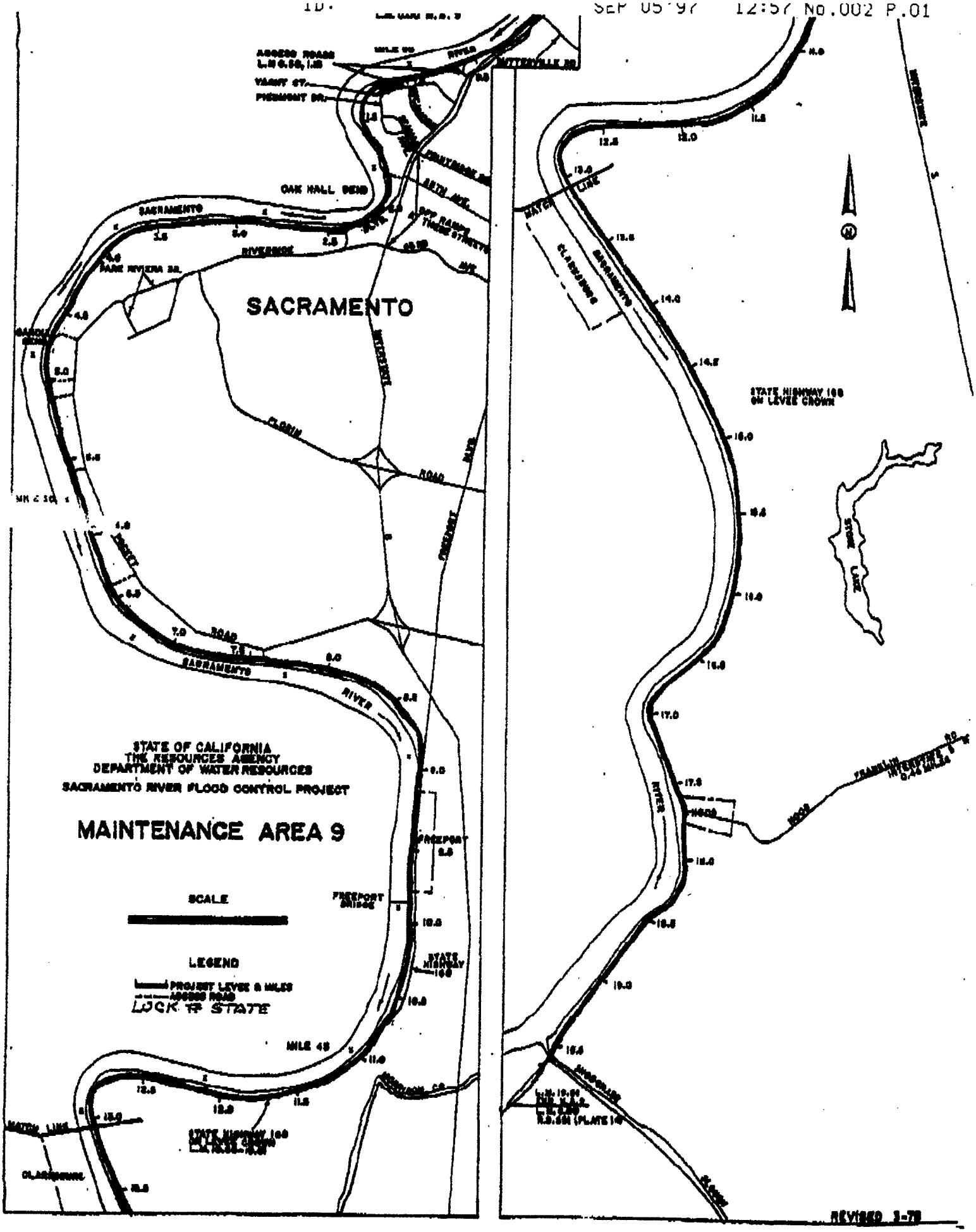


PLATE 241
DATE 10/87
N
FRANKLIN BLVD.
INTERSTATE 5
TWIN CITIES ROAD
LAMBERT ROAD
DIERSSEN ROAD
LOST SLOUGH
GLANVILLE TRACT
RD 1002
McCORMACK-WILLIAMSON TRACT
SOUTHERN PACIFIC RR
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT WATER RESOURCES
DELTA LEVEES
SNODGRASS SLOUGH
LEGEND
NON PROJECT LEVEES
UNITS
SCALE IN MILES
RECLAMATION DISTRICT
1002
GLANVILLE TRACT

D-031556




D—0 3 1 5 5 7

D-031557